BUREAU INTERNATIONAL DES POIDS ET MESURES

Annual Report of the BIPM Time Section

Rapport annuel de la Section du temps du BIPM

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[1] : Tables also available through the internet network, ftp 62.161.69.5 or http://www.bipm.org

[2] : Tables only available through the internet network, ftp 62.161.69.5 or http://www.bipm.org

Practical information about the BIPM Time Section

The Time Section of the BIPM issues two periodic publications. These are the monthly *Circular T* and the *Annual Report of the BIPM Time Section*. In addition, BIPM TWSTFT Reports give technical details about the TWSTFT links computed at the BIPM. The complete texts of *Circular T*, the TWSTFT Reports and most tables of the present Annual Report are available from BIPM website, http://www.bipm.org.

La Section du temps du BIPM produit deux publications périodiques : la Circulaire T, *mensuelle, et le* Rapport annuel de la Section du temps du BIPM. *De plus, des rapports techniques sur les liens TWSTFT calculés par le BIPM sont publiés régulièrement. Les circulaires, les rapports du TWSTFT et la plupart des tableaux de ce rapport annuel sont disponibles par utilisation du site internet du BIPM, http://www.bipm.org.*

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Electronic access to the BIPM Time Section, data and publications

A large number of publications and data files from the BIPM Time Section are available from the website (http://www.bipm.org) or by anonymous ftp (62.161.69.5 or ftp2.bipm.org, user anonymous, e-mail address as password). If using ftp, cd pub/tai to access the tai directory and the subdirectories listed below.

The Time Section ftp server

The files are found in the three subdirectories **data**, **publication**, and **scale**; further details are given below.

In the following directories XY represents the last two digits of the year number (19XY or 20XY); ZT equals to 01 for Jan., 02 for Feb. ....12 for Dec.; XX, XXX are ordinal numbers; results of the computation of TAI over the two-month interval Z of the year (Z =1 for Jan.-Feb., 2 for Mar.- Apr., etc...) until Nov.-Dec. 1997.

Data- all data used for the computation of TAI, arranged in yearly directories, starting May 1999. See readme.txt for details.

Publication- the latest issues of the Time Section

publications	filename
Acronyms of laboratories	acronyms.pdf
Leap seconds	leaptab.txt
Circular T	cirt.XXX
Fractional frequency of EAL from primary frequency standards	etXY.ZT
Weights of clocks participating in the computation of TAI	wXY.ZT
Rates relative to TAI of clocks participating in the computation of TAI	rXY.ZT
Values of the differences between TAI and the local atomic scale of the given laboratory, including relevant notes	TAI - lab
Values of the differences between UTC and its local representation by the given laboratory, including relevant notes	UTC - lab
Values of the differences between TAI and UTC and the respective local scales, evaluated for two-month periods until the end of 1997	TAIXYZ
[UTC(lab1) - UTC(lab2)] obtained by the TWSTFT link, as published in the BIPM TWSTFT reports	lab1 - lab2.tw
BIPM Two-Way Satellite Time and Frequency Transfer Reports	twstftXX.pdf
Most recent schedules for common-view observations of GPS and	schgps.XX
GLONASS satellites	schglo.XX

Older files can be accessed directly from the ftp site (62.161.69.5 or ftp2.bipm.org).

Scale- time scales data

Content	**filename**
Rates of clocks contributing to TAI	RTAIXY.ar
Time Dissemination Services	TIMESERVICES.DOC
Time Signals	TIMESIGNALS.DOC
TT(BIPMXY) computed in the year 19XY or 20XY	TTBIPM.XY
Weights of clocks contributing to TAI	WTAIXY.ar
Starting 1993:	
Difference between the normalized frequencies of EAL and TAI	EALTAIXY.ar
TAI frequency	FTAIXY.ar (for 1993,1994)
Measurements of the duration of the TAI scale interval	UTAIXY.ar (starting 1995)
Mean duration of TAI scale interval	SITAIXY.ar (1993-1997)
Mean fractional deviation of the TAI scale interval from that of TT duration of TAI scale interval	SITAIXY.ar (starting 1998)
[*TAI - GPS time*] and [*UTC - GPS time*]	UTCGPSXY.ar
[*TAI - GLONASS time*] and [*UTC - GLONASS time*]	UTCGLOXY.ar
Until 1992:	
Local representations of UTC: Values of [*UTC - UTC*(*lab*)]	UTC.XY
Local values of [*TAI - TA*(*lab*)]	TA.XY

Starting with the BIPM Time Section Annual Report for 1999, some tables traditionally included in the printed version are only available in electronic form.

For any comment or query send a message to: tai@bipm.org

Leap seconds

Secondes intercalaires

Since 1 January 1988, the maintenance of International Atomic Time, TAI, and of Coordinated Universal Time, UTC (with the exception of decisions and announcements concerning leap seconds of UTC) has been the responsibility of the International Bureau of Weights and Measures (BIPM) under the authority of the International Committee for Weights and Measures (CIPM). The dates of leap seconds of UTC are decided and announced by the International Earth Rotation and Reference Systems Service (IERS), which is responsible for the determination of Earth rotation parameters and the maintenance of the related celestial and terrestrial reference systems. The adjustments of UTC and the relationship between TAI and UTC are given in Tables 1 and 2 of this volume.

Depuis le 1er janvier 1988, l'établissement du Temps atomique international, TAI, et du Temps universel coordonné, UTC, (à l'exception de l'annonce des secondes intercalaires de l'UTC) est placé sous la responsabilité du Bureau international des poids et mesures (BIPM) et du Comité international des poids et mesures (CIPM). Le choix des dates et l'annonce des secondes intercalaires de l'UTC constituent quelques-unes des missions du Service international de la rotation terrestre et des systèmes de référence (IERS), qui est responsable de la détermination des paramètres de la rotation terrestre et de la conservation des systèmes de référence terrestre et céleste associés. Les ajustements de l'UTC et la relation entre le TAI et l'UTC sont donnés dans les tableaux 1 et 2 de ce volume.

Further information about leap seconds can be obtained from the IERS:

Des renseignements sur les secondes intercalaires peuvent être obtenus auprès de l'IERS à l'adresse suivante :

IERS Earth Orientation Product Center
Dr Daniel GAMBIS
Observatoire de Paris
61, avenue de l'Observatoire
75014 Paris, France

Telephone: + 33 1 40 51 22 26
Telefax: + 33 1 40 51 22 91
iers@obspm.fr
http://hpiers.obspm.fr
Anonymous ftp: hpiers.obspm.fr or 145.238.100.28

Establishment of International Atomic Time and of Coordinated Universal Time

1. Data and computation

International Atomic Time (TAI) and Coordinated Universal Time (UTC) are obtained from a combination of data from some 230 atomic clocks kept by about 65 laboratories spread worldwide. The data are regularly reported to the BIPM by about 50 timing centres which maintain a local UTC, UTC(k) (see Table 3). The data are in the form of time differences [*UTC*(*k*) - *Clock*] taken at 5 day intervals at 0h UTC for Modified Julian Dates (MJD) ending in 4 and 9, at 0h UTC ; these dates are referred here as 'standard dates'. The equipment maintained by the timing centres is detailed in Table 4.

An iterative algorithm produces a free atomic time scale, EAL (Echelle Atomique Libre), defined as a weighted average of clock readings. The processing is carried out and subsequently treats one month blocks of data [1], [2] (two-month blocks were used before 1998). The weighting procedure and clock frequency prediction are chosen so that EAL is optimized for long-term stability. No attempt is made to ensure the conformity of the EAL scale interval with the second of the International System of Units.

2. Accuracy

The duration of the scale interval of EAL is evaluated by comparison with the data of primary caesium standards, correcting their proper frequency as needed to account for known effects (e.g. general relativity, blackbody radiation). TAI is then derived from EAL by adding a linear function of time with a convenient slope to ensure the accuracy of the TAI scale interval. The frequency offset between TAI and EAL is changed when necessary to maintain accuracy, the magnitude of the changes being of the same order as the frequency fluctuations resulting from the instability of EAL. This operation is referred to as the 'steering of TAI'. Table 5 gives the normalized frequency offsets between EAL and TAI. Measurements of the duration of the TAI scale interval and estimates of its mean duration are reported in Tables 6 and 7.

3. Availability

TAI and UTC are made available in the form of time differences with respect to the local time scales UTC(k), which approximate UTC, and TA(k), the independent local atomic time scales. These differences, [*TAI* - *TA*(*k*)] and [*UTC* - *UTC*(*k*)], are computed for the standard dates and are available from the BIPM website (see p. 5 of this volume).

The computation of TAI is carried out every month and the results are published monthly in *Circular T*. When preparing the Annual Report, the results shown in *Circular T* may be revised taking into account any subsequent improvements made to the data.

4. Time links

The BIPM organizes the international network of time links, which takes the form of local stars within a continent, joined by long-distance links (see Figure). In 2003, the network of time links used by the BIPM was non-redundant and relied on observation of GPS satellites in common views and on two-way satellite time and frequency transfer (TWSTFT). Most time links are based on GPS satellite common views. Clock comparison by using multi-channel dual-frequency GPS geodetic type receivers has been incorporated into TAI in 2003. Three of these links are regularly used in the computation of TAI. Nine TWSTFT links participate in the computation of TAI. For those links performed with more than one technique, one of them is considered as official for TAI and the others are calculated as a back-up. GPS links in TAI with single-frequency receivers are corrected using the ionospheric maps produced by the International GPS Service (IGS); all GPS links are corrected using the IGS precise operational satellite ephemerides. The techniques of clock comparison used in the calculation of TAI allow the value of [*UTC(k1) - UTC(k2)*] to be determined with a Type A uncertainty of 1 ns or less (in typical conditions). The BIPM also publishes an evaluation of [*UTC - GPS time*] which is accessible via the BIPM website.

The BIPM regularly publishes an evaluation of [*UTC - GLONASS time*], also available from the BIPM website, using current observations of the GLONASS system at the NMi Van Swinden Laboratorium, the Netherlands.

International GPS tracking schedules are published by the BIPM about every six months, and tracking schedules for GLONASS are also established. The list of the schedules is reported in this volume and their content is available from the website (see p. 5 of this volume).

5. Time scales established in retrospect

For the most demanding applications, such as millisecond pulsar timing, the BIPM issues atomic time scales in retrospect. These are designated TT(BIPMxx) where 19xx or 20xx is the year of computation [3]. The successive versions of TT(BIPMxx) are both updates and revisions: they may differ for common dates. These time scales are available on request from the BIPM or via website (see p. 5 of this volume).

Notes

Tables 8 and 9 of this report give the rates relative to TAI and the weights of the clocks contributing to TAI in 2003.

The yellow pages, at the end of this volume, give indications about time signal emissions and time dissemination services.

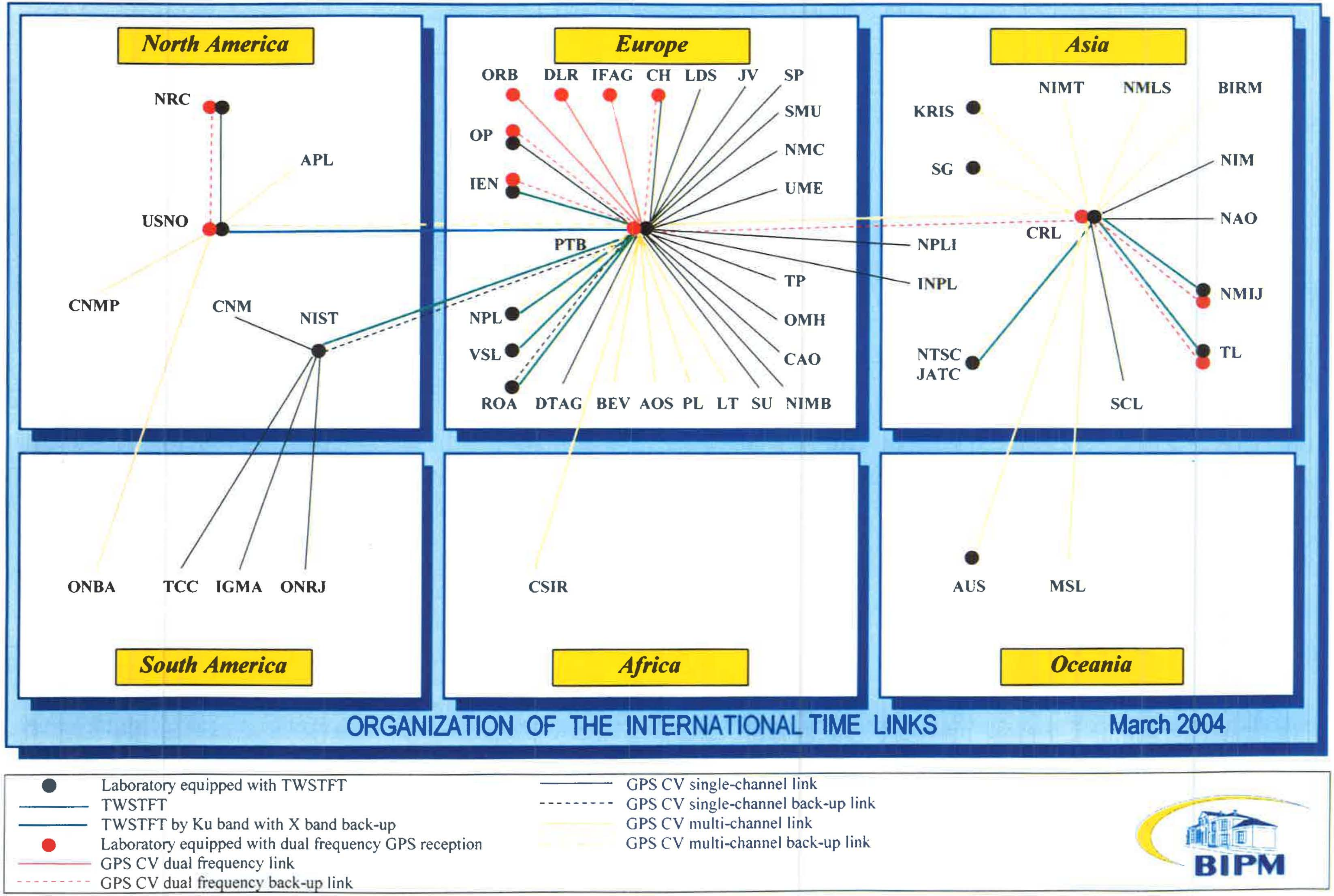
The report of the BIPM Time Section for the period July 2002- June 2003, published in the *Director's Report on the Activity and Management of the BIPM*, 2003, Tome 4 is reproduced after the yellow pages. All the publications mentioned in this report are available on request from the BIPM.

References

[1] C. Thomas and J. Azoubib, TAI computation : study of an alternative choice for implementing an upper limit of clock weights, *Metrologia*, 1996, **33**, 227-240.

[2] J. Azoubib, A revised way of fixing an upper limit to clock weights in TAI computation, *Report to the 15th meeting of the CCTF*, available on request.

[3] B. Guinot, Atomic time scales for pulsar studies and other demanding applications, *Astron. Astrophys.*, 1988, **192**, 370-373.


North America
NRC
APL
USNO
CNMP
CNM
NIST
Europe
ORB
DLR
IFAG
CH
LDS
JV
SP
SMU
NMC
UME
OP
IEN
PTB
NPLI
INPL
TP
OMH
CAO
NPL
VSL
ROA
DTAG
BEV
AOS
PL
LT
SU
NIMB
Asia
NIMT
NMLS
BIRM
KRIS
SG
NIM
NAO
CRL
NMIJ
TL
NTSC
JATC
SCL
South America
ONBA
TCC
IGMA
ONRJ
Africa
CSIR
Oceania
AUS
MSL
ORGANIZATION OF THE INTERNATIONAL TIME LINKS
March 2004
Laboratory equipped with TWSTFT
TWSTFT
TWSTFT by Ku band with X band back-up
Laboratory equipped with dual frequency GPS reception
GPS CV dual frequency link
GPS CV dual frequency back-up link
GPS CV single-channel link
GPS CV single-channel back-up link
GPS CV multi-channel link
GPS CV multi-channel back-up link
BIPM

Etablissement du Temps atomique international et du Temps universel coordonné

1. Données et mode de calcul

Le Temps atomique international (TAI) et le Temps universel coordonné (UTC) sont obtenus par une combinaison de données provenant de quelque 230 horloges atomiques conservées par environ 65 laboratoires répartis dans le monde entier, et fournies régulièrement au BIPM par environ 50 laboratoires de temps qui maintiennent un UTC local, UTC(k) (liste donnée dans le tableau 3). Ces données prennent la forme de différences de temps [UTC(k) - Horloge] *enregistrées de 5 jours en 5 jours pour les dates juliennes modifiées (MJD) se terminant par 4 et 9, à 0h UTC, 'dates normales'. L'équipement maintenu par ces laboratoires de temps est décrit dans le tableau 4.*

Un algorithme itératif qui traite en temps différé des blocs de 1 mois de données [1], [2] produit une échelle atomique libre, EAL, définie comme étant une moyenne pondérée de lectures d'horloges (jusqu'en 1997 des blocs de deux mois étaient utilisés). Le choix de la pondération et du mode de prédiction de fréquence optimise la stabilité de l'EAL à long terme. Il n'est pas tenté d'assurer la conformité de l'intervalle unitaire de l'EAL avec la seconde du Système international d'unités.

2. Exactitude

La durée de l'intervalle unitaire de l'EAL est évaluée par comparaison aux données d'étalons de fréquence à césium primaires, après correction de leur propre fréquence pour tenir compte des effets connus (par exemple relativité générale, rayonnement du corps noir). Ensuite le TAI se déduit de l'EAL par l'addition d'une fonction linéaire du temps dont la pente est convenablement choisie pour assurer l'exactitude de l'intervalle unitaire du TAI. Le décalage de fréquence entre le TAI et l'EAL est changé quand c'est nécessaire pour maintenir l'exactitude, les changements ayant le même ordre de grandeur que les fluctuations de fréquence qui résultent de l'instabilité de l'EAL. Cette opération est désignée par l'expression 'pilotage du TAI'. Le tableau 5 donne les différences de fréquences normalisées entre l'EAL et le TAI. Des mesures de la durée de l'intervalle unitaire du TAI et des estimations de sa durée moyenne sont données dans les tableaux 6 et 7.

3. Disponibilité

Le TAI et l'UTC sont disponibles sous forme de différences de temps avec les échelles locales de temps UTC(k), approximation de l'UTC, et TA(k), temps atomique local indépendant. Ces différences, [TAI - TA(k)] *et* [UTC - UTC(k)], *calculées pour les dates normales sont disponibles sur le site Internet du BIPM.*

Le calcul du TAI est fait tous les mois et les résultats sont publiés mensuellement dans la Circulaire T *du BIPM. Quand le Rapport annuel est préparé, les résultats de la* Circulaire T *peuvent être révisés, en tenant compte des améliorations de données connues après la publication de la* Circulaire T.

4. Liaisons horaires

Le BIPM organise le réseau international de comparaisons horaires selon un schéma en étoile au niveau des continents, et en liaisons à longue distance. En 2003, le système des liaisons horaires *utilisé par le BIPM était non-redondant et reposait sur l'observation des satellites du GPS en vues simultanées et sur la technique d'aller et retour sur satellite de télécommunications (TWSTFT). La plupart des liaisons se fait par vues simultanées des satellites du GPS. Dans le courant de l'année 2003 des liaisons horaires calculées avec des récepteurs GPS de type géodésique, multi-canaux et bi-fréquence ont été incorporées au TAI. Trois de ces liaisons sont utilisées régulièrement dans le calcul de TAI. Neuf liaisons TWSTFT ont été introduites dans le calcul du TAI. Dans les cas où plusieurs techniques participent à une liaison horaire, une d'entre elles est considérée comme étant officielle, et les autres sont calculées pour sauvegarde. Les liaisons par GPS mono-fréquence sont corrigées à l'aide des cartes ionosphériques produites par l'IGS; toutes les liaisons par GPS sont corrigées en utilisant des éphémerides précises et opérationnelles des satellites produites par l'IGS. Les techniques de comparaison d'horloges utilisées dans le calcul de TAI permettent de déterminer la valeur de* [UTC(k_1) - UTC(k_2)] *avec une incertitude de Type A de 1 ns ou mieux, dans des conditions usuelles. Le BIPM publie aussi une évaluation de* [UTC - temps du GPS] *dont les valeurs sont disponibles sur le réseau internet.*

Le BIPM publie régulièrement une évaluation de [UTC - temps du GLONASS]*, accessible par anonymous ftp and sur le site web du BIPM et déduite des observations habituelles du système GLONASS, réalisées au NMi Van Swinden Laboratorium, Pays-Bas.*

Le BIPM publie tous les six mois des programmes de poursuite des satellites du GPS, ainsi que des programmes pour les satellites du GLONASS. La liste de ces programmes est reproduite dans ce rapport et leur contenu est disponible sur le réseau internet.

5. Echelles de temps établies rétrospectivement

Pour les applications les plus exigeantes, comme le chronométrage des pulsars milliseconde, le BIPM produit des échelles de temps rétrospectivement, désignées par TT(BIPMxx), 19xx ou 20xx étant l'année du calcul [3]. Les versions successives de TT(BIPMxx) ne sont pas seulement des mises à jour, mais aussi des révisions, de sorte qu'elles peuvent différer pour les dates communes. Ces échelles de temps sont disponibles sur demande faite au BIPM ou par utilisation du réseau internet.

Notes

Les tableaux 8 et 9 de ce rapport donnent les fréquences relatives au TAI et les poids des horloges qui ont contribué au calcul en 2003.
Les pages jaunes, à la fin de ce volume, concernent les émissions de signaux horaires.

Le rapport (juillet 2002 - juin 2003) de la section du temps du BIPM publié dans le Rapport du directeur sur l'activité et la gestion du Bureau international des poids et mesures (BIPM), 2003, Tome 4, est reproduit après les pages jaunes. Toutes les publications qui y sont mentionnées sont disponibles sur demande au BIPM.

Les références sont données dans le texte anglais, page 9.

Table 1. Relative frequency offsets and step adjustments of UTC, up to 31 December 2004

Date (at 0h UTC)	Offsets	Steps/s
1961 Jan. 1	-150×10^{-10}	
1961 Aug. 1	"	+0.050
1962 Jan. 1	-130×10^{-10}	
1963 Nov. 1	"	-0.100
1964 Jan. 1	-150×10^{-10}	
1964 Apr. 1	"	-0.100
1964 Sep. 1	"	-0.100
1965 Jan. 1	"	-0.100
1965 Mar. 1	"	-0.100
1965 Jul. 1	"	-0.100
1965 Sep. 1	"	-0.100
1966 Jan. 1	-300×10^{-10}	
1968 Feb. 1	"	+0.100
1972 Jan. 1	0	-0.107 7580
1972 Jul. 1	"	-1
1973 Jan. 1	"	-1
1974 Jan. 1	"	-1
1975 Jan. 1	"	-1
1976 Jan. 1	"	-1
1977 Jan. 1	"	-1
1978 Jan. 1	"	-1
1979 Jan. 1	"	-1
1980 Jan. 1	"	-1
1981 Jul. 1	"	-1
1982 Jul. 1	"	-1
1983 Jul. 1	"	-1
1985 Jul. 1	"	-1
1988 Jan. 1	"	-1
1990 Jan. 1	"	-1
1991 Jan. 1	"	-1
1992 Jul. 1	"	-1
1993 Jul. 1	"	-1
1994 Jul. 1	"	-1
1996 Jan. 1	"	-1
1997 Jul. 1	"	-1
1999 Jan. 1	"	-1

Table 2. Relationship between TAI and UTC, up to 31 December 2004

Limits of validity (at 0h UTC)	[*TAI - UTC*] / s
1961 Jan. 1 - 1961 Aug. 1	1.422 8180 + (MJD - 37300) x 0.001 296
1961 Aug. 1 - 1962 Jan. 1	1.372 8180 + " "
1962 Jan. 1 - 1963 Nov. 1	1.845 8580 + (MJD - 37665) x 0.001 1232
1963 Nov. 1 - 1964 Jan. 1	1.945 8580 + " "
1964 Jan. 1 - 1964 Apr. 1	3.240 1300 + (MJD - 38761) x 0.001 296
1964 Apr. 1 - 1964 Sep. 1	3.340 1300 + " "
1964 Sep. 1 - 1965 Jan. 1	3.440 1300 + " "
1965 Jan. 1 - 1965 Mar. 1	3.540 1300 + " "
1965 Mar. 1 - 1965 Jul. 1	3.640 1300 + " "
1965 Jul. 1 - 1965 Sep. 1	3.740 1300 + " "
1965 Sep. 1 - 1966 Jan. 1	3.840 1300 + " "
1966 Jan. 1 - 1968 Feb. 1	4.313 1700 + (MJD - 39126) x 0.002 592
1968 Feb. 1 - 1972 Jan. 1	4.213 1700 + " "
1972 Jan. 1 - 1972 Jul. 1	10 (integral number of seconds)
1972 Jul. 1 - 1973 Jan. 1	11
1973 Jan. 1 - 1974 Jan. 1	12
1974 Jan. 1 - 1975 Jan. 1	13
1975 Jan. 1 - 1976 Jan. 1	14
1976 Jan. 1 - 1977 Jan. 1	15
1977 Jan. 1 - 1978 Jan. 1	16
1978 Jan. 1 - 1979 Jan. 1	17
1979 Jan. 1 - 1980 Jan. 1	18
1980 Jan. 1 - 1981 Jul. 1	19
1981 Jul. 1 - 1982 Jul. 1	20
1982 Jul. 1 - 1983 Jul. 1	21
1983 Jul. 1 - 1985 Jul. 1	22
1985 Jul. 1 - 1988 Jan. 1	23
1988 Jan. 1 - 1990 Jan. 1	24
1990 Jan. 1 - 1991 Jan. 1	25
1991 Jan. 1 - 1992 Jul. 1	26
1992 Jul. 1 - 1993 Jul. 1	27
1993 Jul. 1 - 1994 Jul. 1	28
1994 Jul. 1 - 1996 Jan. 1	29
1996 Jan. 1 - 1997 Jul. 1	30
1997 Jul. 1 - 1999 Jan. 1	31
1999 Jan. 1 -	32

Table 3. Acronyms and locations of the timing centres which maintain a local approximation of UTC, UTC(k), and/or an independent local time scale, TA(k)

AOS	Astrogeodynamical Observatory, Space Research Centre P.A.S. Borowiec, Poland
APL	Applied Physics Laboratory, Laurel, Maryland, USA
AUS	Consortium of laboratories in Australia
BEV	Bundesamt für Eich- und Vermessungswesen, Vienna, Austria
BIRM	Beijing Institute of Radio Metrology and Measurement, Beijing, P. R. China
CAO	Stazione Astronomica di Cagliari (Cagliari Astronomical Observatory) Cagliari, Italy
CH	METrology and Accreditation Switzerland (METAS)
CNM	Centro Nacional de Metrología, Querétaro, Mexico (CENAM)
CNMP	Centro Nacional de Metrología, de Panamá, Panamá
CRL (1)	Communications Research Laboratory, Tokyo, Japan
CSIR	Council for Scientific and Industrial Research, Pretoria, South Africa
DLR	Deutsche Zentrum für Luft- und Raumfahrt (German Aerospace Centre) Oberpfaffenhofen, Germany
DTAG	Deutsche Telekom AG, Darmstadt, Germany
F	Commission Nationale de l'Heure, Paris, France
GUM	Główny Urząd Miar (Central Office of Measures), Warsaw, Poland
IEN	Istituto Elettrotecnico Nazionale Galileo Ferraris, Turin, Italy
IFAG	Bundesamt für Kartographie und Geodäsie (Federal Agency for Cartography and Geodesy), Fundamental station, Wettzell, Kötzting, Germany
IGMA	Instituto Geográfico Militar, Buenos Aires, Argentina
INPL	National Physical Laboratory, Jerusalem, Israel
JATC	Joint Atomic Time Commission, Lintong, P.R. China
JV	Justervesenet, Norwegian Metrology and Accreditation Service, Kjeller, Norway
KRIS	Korea Research Institute of Standards and Science, Daejeon, Rep. of Korea
LDS	University of Leeds, Leeds, United Kingdom
LT	Lithuanian National Metrology Institute, Vilnius, Lithuania
MSL	Measurement Standards Laboratory, Lower Hutt, New Zealand
NAO	National Astronomical Observatory, Misuzawa, Japan
NIM	National Institute of Metrology, Beijing, P.R. China
NIMB	National Institute of Metrology, Bucharest, Romania
NIMT	National Institute of Metrology, Bangkok, Thailand
NIST	National Institute of Standards and Technology, Boulder, Colo., USA
NMC	National Centre of Metrology, Sofiya, Bulgary
NMIJ	National Metrology Institute of Japan, Tsukuba, Japan
NML	National Measurement Laboratory, Sydney, Australia
NMLS	National Metrology Laboratory of SIRIM Berhad, Shah Alam, Malaysia

(1) In April 2004 CRL became NICT (National Institute of Information and Communications Technology, Tokyo, Japan)

Table 3. Acronyms and locations of the timing centres which maintain a local approximation of UTC, UTC(k), and/or an independent local time scale, TA(k) (Cont.)

NPL	National Physical Laboratory, Teddington, United Kingdom
NPLI	National Physical Laboratory, New Delhi, India
NRC	National Research Council of Canada, Ottawa, Canada
NTSC	National Time Service Center of China, Lintong, P.R. China
OMH	Országos Mérésügyi Hivatal (National Office of Measures) Budapest, Hungary
ONBA	Observatorio Naval, Buenos Aires, Argentina
ONRJ	Observatório Nacional, Rio de Janeiro, Brazil
OP	Observatoire de Paris (Paris Observatory), Paris, France
ORB	Observatoire Royal de Belgique (Royal Observatory of Belgium) Brussels, Belgium
PL	Consortium of laboratories in Poland
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig, Germany
ROA	Real Instituto y Observatorio de la Armada, San Fernando, Spain
SCL	Standards and Calibration Laboratory, Hong Kong
SG	Standards, Productivity and Innovation Board, Singapore
SMU	Slovenský metrologický ústav (Slovak Institute of Metrology) Bratislava, Slovakia
SP	Sveriges Provnings- och Forskningsinstitut (Swedish National Testing and Research Institute), Borås, Sweden
SU	Institute of Metrology for Time and Space (IMVP), NPO "VNIIFTRI" Mendeleevo, Moscow Region, Russia
TCC	TIGO Concepción Chile, Chile
TL	Telecommunication Laboratories, Chung-Li, Taiwan
TP	Institute of Radio Engineering and Electronics, Academy of Sciences of the Czech Republic, Prague, Czech Republic
UME	Ulusai Metroloji Enstitüsü, Marmara Research Center, (National Metrology Institute), Gebze Kocaeli, Turkey
USNO	U.S. Naval Observatory, Washington D.C., USA
VSL	NMi Van Swinden Laboratorium, Delft, the Nederlands

Note: Most of the timing centres in the table can be accessed through the BIPM website, at "Useful links".

Table 4. Equipment and source of UTC(k) of the laboratories contributing to TAI in 2003

Ind. Cs : Industrial caesium standard
Ind. Rb : Industrial rubidium standard
Lab. Cs : Laboratory caesium standard
H-maser : Hydrogen maser
SF : single frequency receiver
DF : dual frequency receiver
* means 'yes'

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links			
				GPS		GLONASS	Two-Way
				SF	DF		
AOS	1 Ind. Cs	1 Cs + microphase-stepper		*		*	
APL	3 Ind. Cs 1 H-maser	1 Cs		*			
AUS	11 Ind. Cs 4 H-masers 1 Linear Ion Trap Standard (2)	1 Cs		*	*		*
BEV	3 Ind. Cs 2 Ind. Rb	1 Cs		*			
BIRM (b)	2 Ind. Cs 2 H-masers	1 H-maser		*		*	
CAO	2 Ind. Cs	1 Cs		*			
CH	4 Ind. Cs (3) 1 H-maser	all the Cs 1 H-maser	*	*	*		
CNM	3 Ind. Cs 1 H-maser	1 Cs		*			
CNMP	2 Ind. Cs	1 Cs		*			
CRL	18 Ind. Cs 3 H-masers 1 Lab. Cs	12 Cs	*	*	*	*	*
CSIR	3 Ind. Cs	1 Cs		*		*	
DLR	1 Ind. Cs 5 H-masers	1 Cs			*		
DTAG	3 Ind. Cs	1 Cs		*			
IEN	4 Ind. Cs 2 H-masers	1 Cs + microphase-stepper	*	*	*	*	*
IFAG	5 Ind. Cs 3 H-masers	1 Cs + microphase-stepper		*	*		
IGMA	3 Ind. Cs	1 Cs + microphase-stepper			(a) *		
INPL	3 Ind. Cs	1 Cs		*			
JATC	6 Ind. Cs (4)	1 Cs + microphase-stepper	*	*	*	*	*
JV	4 Ind. Cs	1 Cs		*			
KRIS	4 Ind. Cs 1 H-maser	1 Cs + microphase-stepper	*	*	*	*	*

Table 4. Equipment and source of UTC(k) of the laboratories contributing to TAI in 2003 (Cont.)

Ind. Cs : Industrial caesium standard
Ind. Rb : Industrial rubidium standard
Lab. Cs : Laboratory caesium standard
H-maser : Hydrogen maser
SF : single frequency receiver
DF : dual frequency receiver
* means 'yes'

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links			
				GPS		GLONASS	Two-Way
				SF	DF		
LDS	1 Ind. Cs	1 Cs		*		*	
LT	1 Ind. Cs	1 Cs		*			
MSL	3 Ind. Cs	1 Cs		*	*	*	
NAO (b)	4 Ind. Cs 1 H-maser	1 Cs + microphase-stepper		*			
NIM	3 Ind. Cs	1 Cs + microphase-stepper		*			
NIMB	1 Ind. Cs	1 Cs		*			
NIMT	1 Ind. Cs	1 Cs		*			
NIST	5 Ind. Cs 1 Lab. Cs 5 H-masers	4 Cs 5 H-masers	*	*		*	*
NMC	1 Ind. Cs	1 Cs		(a) *			
NMIJ	4 Ind. Cs 1 Lab. Cs 2 H-masers	1 Cs		*			*
NMLS	5 Ind. Cs	1 Cs + microphase-stepper			*	*	
NPL	3 Ind. Cs 2 H-masers	1 H-maser		*	*		*
NPLI (b)	3 Ind. Cs	1 Cs		*		*	
NRC	2 Ind. Cs 3 Lab. Cs 3 H-masers	1 Lab. Cs + microphase-stepper (5)	*	*	*		*
NTSC	6 Ind. Cs	all the Cs	*	*	*	*	*
OMH	1 Ind. Cs	1 Cs		*			
ONBA	2 Ind. Cs	1 Cs + microphase-stepper		*			
ONRJ	3 Ind. Cs	1 Cs		*			
OP	6 Ind. Cs 3 Lab. Cs 2 H-masers	1 Cs + microphase-stepper	(6) *	*	*		*

Table 4. Equipment and source of UTC(k) of the laboratories contributing to TAI in 2003 (Cont.)

Ind. Cs : Industrial caesium standard
Ind. Rb : Industrial rubidium standard
Lab. Cs : Laboratory caesium standard
H-maser : Hydrogen maser
SF : single frequency receiver
DF : dual frequency receiver
* means 'yes'

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links			
				GPS		GLONASS	Two-Way
				SF	DF		
ORB	3 Ind. Cs 2 H-masers	1 H-maser			*		
PL (7)	7 Ind. Cs 1 H-maser	1 Cs	*	*			
PTB	3 Ind. Cs 3 Lab. Cs (8) 3 H-masers	1 Lab. Cs	(9) *	*	*		*
ROA	5 Ind. Cs	all the Cs		*			*
SCL	2 Ind. Cs	1 Cs + microphase-stepper		*			
SG	3 Ind. Cs	1 Cs + microphase-stepper		*			
SMU	1 Ind. Cs	1 Cs		*			
SP	6 Ind. Cs (10) 1 H-maser	1 Cs + microphase-stepper		*			*
SU	1 Lab. Cs 10 H-masers	6 H-masers	(11) *	*		*	
TCC	2 Ind. Cs 2 H-masers	1 Cs		*			
TL	7 Ind. Cs 2 H-masers	1 Cs + microphase-stepper		*	*	*	*
TP	4 Ind. Cs	1 Cs + output frequency steering		*			
UME	3 Ind. Cs	1 Cs		*			
USNO	71 Ind. Cs 16 H-masers	1 H-maser + frequency synthesizer steered to UTC(USNO) (12)	(12) *	*	*	*	*
VSL	4 Ind. Cs	1 Cs + microphase-stepper		*		*	*

Notes

(1) When several clocks are indicated as source of UTC(k), laboratory k computes a software clock, steered to UTC. Often a physical realization of UTC(k) is obtained using a Cs clock and a micro-phase-stepper.

(2) AUS Some of the standards are located as follows (at the end of 2003):
* National Measurement Laboratory (NML, Sydney) — 4 Cs, 2 H-maser.

Australian laboratories intercompared by GPS are:
* National Measurement Laboratory Melbourne branch (NMLMEL, Melbourne) — 1 Cs,
* Telstra Corporation Ltd (TELSTRA, Melbourne) — 3 Cs,
* Australian Land Information Group, Yarragadee Observatory (Yarragadee, Western Australia) — 1 Cs.
* Canberra Deep Space Communication Complex (CDSCC, Canberra) — 1 Cs, 2 H-maser, 1 Linear Ion Trap Standard (LITS)

Australian laboratories intercompared by TV are:
* VMS International (Sydney) — 1 Cs,

(3) CH All the standards are located in Bern at METAS (METrology and Accreditation Switzerland, situation at the end of 2003).

(4) JATC The standards are located at National Time Service Center, (NTSC). The link between UTC(JATC) and UTC(NTSC) is obtained by internal connection.

(5) NRC In 2003, UTC(NRC) was derived from NRC CsVIA.

(6) OP The French atomic time scale TA(F) is computed by the BNM-SYRTE with data from 25 industrial caesium clocks located as follows (at the end of 2003) :
* Centre Electronique de l'Armement (CELAR, Rennes) — 2 Cs,
* Centre National d'Etudes Spatiales (CNES, Toulouse) — 3 Cs,
* France Telecom Recherche et Developpement (Lannion) — 2 Cs,
* Agilent (Massy) — 2 Cs,
* Observatoire de la Côte d'Azur (OCA, Grasse) — 2 Cs,
* Observatoire de Paris (BNM-SYRTE, Paris) — 6 Cs,
* Observatoire de Besançon (OB, Besançon) — 3 Cs,
* Tekelec Technologies (TKL, Les Ulis, Paris) — 1 Cs,
* Direction des Constructions Navales (DCN, Brest) — 4 Cs.

All laboratories are linked via GPS receivers

(7) PL Stands for a consortium of Polish time laboratories:
* Główny Urząd Miar (Central Office of Measures) (GUM, Warsaw) — 3 Cs
* Astrogeodynamical Observatory, Space Research Center P.A.S (AOS, Borowiec) — 1 Cs
* Instytut Łączności (Institute of Telecommunications) (IŁ, Warsaw) — 1 Cs
* Centrum Badawczo-Rozwojowe TPSA (Research & Development Centre of the Polish Telecom) (CBR, Warsaw) — 2 Cs
* 1st Specialized Metrology Center of Polish Air and Air Defence Forces (SOM, Warsaw) — 1 H-maser

An independent atomic time scale TA(PL) has been computed by GUM and AOS, with data from industrial caesium clocks and hydrogen maser : the eight above and additionally:
* Time and Frequency Standard Laboratory of the Semiconductor Physics Institute (LT, Vilnius, Lithuania) — 1 Cs

Notes (Cont.)

(8) PTB The laboratory Cs, PTB CS1, PTB CS2 and PTB CS3, are operated continuously as clocks. PTB CS3 is no longer evaluated as a primary clock and contributes to EAL only like any commercial clock . PTB CSF1 is a fountain frequency standard using laser cooled caesium atoms. It is intermittently operated as a frequency standard. Contributions to TAI are made through comparisons with one of PTB's hydrogen masers.
Until further notice, TA(PTB) and UTC(PTB) are derived from PTB CS2, TA(PTB) directly, UTC(PTB) including steering.

(9) PTB *TA(PTB)-UTC(PTB)* is published in PTB Time Service Bulletin.

(10) SP The standards are located as follows (at the end of 2003):

* Swedish National Testing and Research Institute (SP, Borås)	3 Cs, 1 H-maser
* STUPI AB (Stockholm)	1 Cs,
* Pendulum Instruments AB (Stockholm)	1 Cs,
* Onsala Space Observatory (Onsala)	1 H-maser.

(11) SU *TA(SU)-UTC(SU)* = 29.172 759 000 s from MJD 52640 to 53004.

(12) USNO The time scales A.1(MEAN) and UTC(USNO) are computed by USNO. They are determined by a weighted average of Cs clocks and H-masers located at the USNO. A.1(MEAN) is a free atomic time scale, while UTC(USNO) is steered to UTC. Included in the total number of USNO atomic standards are the clocks located at the USNO Alternate Master Clock in Colorado Springs, CO.

(a) GPS link via local restitution of GPS time.

(b) Information based on the Annual Report for 2002, not confirmed by the laboratory.

Table 5. Differences between the normalized frequencies of EAL and TAI, up to May 2004

(File available on http://www.bipm.org under the name EALTAI03.AR, which contains values since the beginning of the steering)

Date	MJD	[f(EAL) - f(TAI)] x 10-13
1990 Apr 28 - 1990 Jun 27	48009 - 48069	7.80
1990 Jun 27 - 1990 Aug 26	48069 - 48129	7.75
1990 Aug 26 - 1991 Feb 22	48129 - 48309	7.70
1991 Feb 22 - 1991 Apr 23	48309 - 48369	7.625
1991 Apr 23 - 1991 Aug 31	48369 - 48499	7.55
1991 Aug 31 - 1991 Oct 30	48499 - 48559	7.50
1991 Oct 30 - 1992 Apr 27	48559 - 48739	7.45
1992 Apr 27 - 1992 Jun 26	48739 - 48799	7.40
1992 Jun 26 - 1993 Apr 22	48799 - 49099	7.35
1993 Apr 22 - 1995 Feb 21	49099 - 49769	7.40
1995 Feb 21 - 1995 Apr 22	49769 - 49829	7.39
1995 Apr 22 - 1995 Jun 21	49829 - 49889	7.38
1995 Jun 21 - 1995 Aug 30	49889 - 49959	7.37
1995 Aug 30 - 1995 Oct 29	49959 - 50019	7.36
1995 Oct 29 - 1995 Dec 28	50019 - 50079	7.35
1995 Dec 28 - 1996 Feb 26	50079 - 50139	7.34
1996 Feb 26 - 1996 Apr 26	50139 - 50199	7.33
1996 Apr 26 - 1996 Jun 30	50199 - 50264	7.32
1996 Jun 30 - 1996 Aug 29	50264 - 50324	7.31
1996 Aug 29 - 1996 Oct 28	50324 - 50384	7.295
1996 Oct 28 - 1996 Dec 27	50384 - 50444	7.280
1996 Dec 27 - 1997 Feb 25	50444 - 50504	7.265
1997 Feb 25 - 1997 Apr 26	50504 - 50564	7.250
1997 Apr 26 - 1997 Jun 30	50564 - 50629	7.230
1997 Jun 30 - 1997 Aug 29	50629 - 50689	7.210
1997 Aug 29 - 1997 Oct 28	50689 - 50749	7.190
1997 Oct 28 - 1997 Dec 27	50749 - 50809	7.170
1997 Dec 27 - 1998 Jan 31	50809 - 50844	7.160
1998 Jan 31 - 1998 Feb 25	50844 - 50869	7.150
1998 Feb 25 - 1998 Mar 27	50869 - 50899	7.140
1998 Mar 27 - 1999 Feb 25	50899 - 51234	7.130
1999 Feb 25 - 1999 Dec 27	51234 - 51539	7.140
1999 Dec 27 - 2000 May 30	51539 - 51694	7.130
2000 May 30 - 2000 Sep 27	51694 - 51814	7.120
2000 Sep 27 - 2000 Nov 26	51814 - 51874	7.110
2000 Nov 26 - 2001 Jan 30	51874 - 51939	7.100
2001 Jan 30 - 2001 Apr 30	51939 - 52029	7.090
2001 Apr 30 - 2001 Jul 29	52029 - 52119	7.080
2001 jul 29 - 2001 Sep 27	52119 - 52179	7.070
2001 Sep 27 - 2001 Nov 26	52179 - 52239	7.060
2001 Nov 26 - 2002 Jan 30	52239 - 52304	7.050
2002 Jan 30 - 2002 Mar 31	52304 - 52364	7.040
2002 Mar 31 - 2002 Jun 30	52364 - 52424	7.030
2002 Jun 30 - 2002 Jul 29	52424 - 52484	7.020
2002 Jul 29 - 2002 Sep 27	52484 - 52544	7.010
2002 Sep 27 - 2002 Nov 26	52544 - 52604	7.000
2002 Nov 26 - 2003 Jan 30	52604 - 52669	6.990
2003 Jan 30 - 2003 Mar 31	52669 - 52729	6.980
2003 Mar 31 - 2003 May 30	52729 - 52789	6.970
2003 May 30 - 2003 Sep 27	52789 - 52909	6.960
2003 Sep 27 - 2003 Nov 26	52909 - 52969	6.950
2003 Nov 26 - 2004 Jan 30	52969 - 53034	6.940
2004 Jan 30 - 2004 Mar 30	53034 - 53094	6.930
2004 Mar 30 - 2004 May 29	53094 - 53154	6.920

As the time scales UTC and TAI differ by an integral number of seconds (see Tables 1 and 2), UTC is necessarily subjected to the same intentional frequency adjustment as TAI.

Table 6. Measurements of the duration of the TAI scale interval

(File available on http://www.bipm.org under the name UTAI03.AR)

TAI is a realization of coordinate time TT. The following tables give the fractional deviation d of the scale interval of TAI from that of TT (in practice the SI second on the geoid), i.e. the fractional frequency deviation of TAI with the opposite sign: $d = -y_{TAI}$.

In this table, d is obtained on the given periods of estimation by comparison of the TAI frequency with that of the individual primary frequency standards (PFS) CRL-O1, IEN-CSF1, NIST-F1, PTB-CS1, PTB-CS2, PTB-CSF1, SYRTE-FO2, SYRTE-FOM, and SYRTE-JPO for the year 2003.
Previous calibrations are available in the successive annual reports of the BIPM Time Section volumes 1 to 15.

Each comparison is provided with the following information:
u_A is the uncertainty originating in the instability of the PFS,
u_B is the combined uncertainty from systematic effects,
Ref(u_B) is a reference giving information on the stated value of u_B,
$u_{link/lab}$ is the uncertainty in the link between the PFS and the clock participating to TAI, including the uncertainty due to dead-time,
$u_{link/TAI}$ is the uncertainty in the link to TAI,
u is the quadratic sum of all four uncertainty values.

In this table, a frequency over a time interval is defined as the ratio of the end-point phase difference to the duration of the interval.

The typical characteristics of the calibrations of the TAI frequency provided by the different primary standards over 2003 are indicated below.

Primary Standard	Type /selection	Typical type B std. uncertainty	Operation	Comparison with	Typical duration of comparison
CRL-01	Beam /Opt.	4×10^{-15}	Discontinuous	UTC(CRL)	15 d
IEN-CSF1	Fountain	1.5×10^{-15}	Discontinuous	H maser	10 d
NIST-F1	Fountain	0.6×10^{-15}	Discontinuous	H maser	30 d
PTB-CS1	Beam /Mag.	8×10^{-15}	Continuous	TAI	30 d
PTB-CS2	Beam /Mag.	12×10^{-15}	Continuous	TAI	30 d
PTB-CSF1	Fountain	1×10^{-15}	Discontinuous	H maser	15 d
SYRTE-F02	Fountain	0.6×10^{-15}	Discontinuous	H maser	5 to 30 d
SYRTE-FOM	Fountain	0.8×10^{-15}	Discontinuous	H maser	5 to 30 d
SYRTE-JPO	Beam /Opt.	8×10^{-15}	Discontinuous	H maser	10-20 d

More detailed information on the characteristics and operation of individual PFS may be found in the annexes supplied by the individual laboratories.

Table 6. (Cont.)

Standard	Period of estimation	d (10^{-15})	u_A (10^{-15})	u_B (10^{-15})	Ref(u_B)	$u_{link/lab}$ (10^{-15})	$u_{link/TAI}$ (10^{-15})	u (10^{-15})	Notes
CRL-01	52839 52854	1.8	5.2	4.3	[1]	0.8	2.0	7.1	
IEN-CSF1	52744 52754	22.4	1.3	2.0	[2]	0.4	3.0	3.9	(1)
IEN-CSF1	52934 52944	10.3	0.6	1.1		0.4	3.0	3.3	
NIST-F1	52679-52694	11.1	1.2	0.7	[3]	0.3	2.0	2.5	
NIST-F1	52694-52709	8.6	1.2	0.7		0.3	2.0	2.5	
NIST-F1	52869 52904	13.4	0.8	0.5		0.3	0.9	1.3	
NIST-F1	52969 52999	9.4	0.5	0.4		0.2	1.0	1.2	
PTB-CS1	52639-52669	-4.6	5.0	8.0	[4]	0.0	1.0	9.5	(2)
PTB-CS1	52669-52694	-1.2	5.0	8.0		0.0	1.2	9.5	
PTB-CS1	52694-52729	-2.6	5.0	8.0		0.0	0.9	9.5	
PTB-CS1	52729-52759	7.9	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	52759-52789	11.3	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	52789-52819	3.5	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	52819 52849	7.6	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	52849 52879	9.8	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	52879 52909	-0.5	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	52909 52939	-5.7	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	52939 52969	6.4	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	52969 53004	0.9	5.0	8.0		0.0	0.9	9.5	
PTB-CS2	52639-52669	5.1	3.0	12.0	[5]	0.0	1.0	12.4	(2)
PTB-CS2	52669-52694	0.6	3.0	12.0		0.0	1.2	12.4	
PTB-CS2	52694-52729	3.7	3.0	12.0		0.0	0.9	12.4	
PTB-CS2	52729-52759	2.3	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	52759-52789	5.0	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	52789-52819	10.9	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	52819 52849	5.8	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	52849 52879	5.4	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	52879 52909	9.4	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	52909 52939	0.3	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	52939 52969	4.9	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	52969 53004	6.2	3.0	12.0		0.0	0.9	12.4	
PTB-CSF1	52929 52944	11.5	1.1	0.9	[6]	0.1	2.0	2.5	
SYRTE-F02	52699-52734	8.5	0.2	0.5	[7]	0.7	0.9	1.3	
SYRTE-F02	52764 52789	3.7	0.2	0.6		1.3	1.2	1.9	
SYRTE-F02	52824 52829	7.3	0.6	0.5		0.1	6.0	6.1	
SYRTE-F02	52884 52909	7.9	0.1	0.6		0.3	1.2	1.4	
SYRTE-FOM	52704-52709	14.0	0.6	0.8	[7]	2.0	6.0	6.4	
SYRTE-FOM	52739-52744	21.6	0.8	0.8		2.4	6.0	6.6	
SYRTE-FOM	52794 52819	3.9	1.5	0.8		1.0	1.2	2.3	
SYRTE-FOM	52824 52829	4.8	0.3	0.8		0.1	6.0	6.1	

Table 6. (Cont.)

Standard	Period of estimation	d (10^{-15})	u_A (10^{-15})	u_B (10^{-15})	Ref(u_B)	$u_{link/lab}$ (10^{-15})	$u_{link/TAI}$ (10^{-15})	u (10^{-15})	Notes
SYRTE-JPO	52639-52659	13.1	2.0	8.0	[8]	0.3	1.5	8.4	
SYRTE-JPO	52664-52694	5.8	1.7	8.0		0.3	1.0	8.2	
SYRTE-JPO	52719-52729	13.2	1.1	8.0		0.3	3.0	8.6	
SYRTE-JPO	52729-52744	7.8	1.0	8.0		0.3	2.0	8.3	
SYRTE-JPO	52749-52764	11.1	0.6	8.0		0.3	2.0	8.3	
SYRTE-JPO	52824 52834	11.4	1.0	6.5		0.3	3.0	7.2	
SYRTE-JPO	52839 52849	16.6	1.0	6.5		0.3	3.0	7.2	
SYRTE-JPO	52889 52909	18.1	1.0	6.5		0.3	1.5	6.8	
SYRTE-JPO	52909 52919	16.8	1.0	6.5		0.3	3.0	7.2	
SYRTE-JPO	52959 52969	20.8	1.0	6.5		0.3	3.0	7.2	
SYRTE-JPO	52974 52984	22.0	0.7	6.5		0.3	3.0	7.2	
SYRTE-JPO	52989 53004	19.2	0.5	6.5		0.3	2.0	6.8	

Notes:

(1) IEN atomic caesium fountain.
(2) Continuously operating as a clock participating to TAI.

References:

[1] The evaluation procedure the type B uncertainty of CRL-O1 is based on that of NIST-7: Lee W.D. et al., *IEEE Trans. IM*-44, 120, 1995. See also Hasegawa A. et al., *Metrologia*, submitted.
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Operation of the BNM-SYRTE primary clocks in 2003

Uncertainty budget for uB

In 2003 the fountains clocks FO2 and FOM were operated intermittently and caesium beam clock JPO was operational in an almost continuous way. Evaluations of relative frequency uncertainties u_B were measured. Particularly the evaluation of the uncertainty of the effect of the cold collisions in FO2 clock was improved. Systematic effects shifting the frequency of the fountains are listed in Table I for FO2 with Cs and Table II for FOM and see ref [4] for JPO.

Physical origin	Correction $[10^{-16}]$	Uncertainty $[10^{-16}]$
2nd order Zeeman	-1773,0	+/- 5,2
Blackbody Radiation	173,0	+/- 2,3
Cold Collisions + cavity pulling	95,0	+/- 3,0
others	0,0	+/- 3,0
Total (1σ) uncertainty u_B		7,1

Table I: Accuracy budget of the FO2-CS fountain involved in the 2003 measurements.

Physical origin	Correction $[10^{-16}]$	Uncertainty $[10^{-16}]$
2nd order Zeeman	-351,9	+/- 2,4
Blackbody Radiation	191,0	+/- 2,5
Cold Collisions + cavity pulling	34,0	+/- 5,8
others	0,0	+/- 3,7
Total (1σ) uncertainty u_B		8

Table II: Accuracy budget of the FOM fountain involved in the 2003 measurements.

Evaluation of uA

The short-term frequency instability of the fountain clocks were evaluated throughout 2003 by comparison with an active H maser locked by a BVA quartz oscillator and also by a cryogenic oscillator. Experimentally the relative frequency stability for FO2 was measured to $\sigma_y(\tau) = 1{,}1\ \ 10^{-13}\,\tau^{-1/2}$ with BVA quartz oscillator and $\sigma_y(\tau) = 2{,}0\ \ 10^{-14}\,\tau^{-1/2}$ with cryogenic oscillator and for FOM $\sigma_y(\tau) = 1{,}7\ \ 10^{-13}\,\tau^{-1/2}$ with BVA quartz oscillator.

Evaluation of ul/lab

The uncertainty due to the H maser link lab for FO2 or FOM was evaluated to $0{,}1\ \ 10^{-15}$ and for JPO was evaluated to $0{,}3\ \ 10^{-15}$. The dead times uncertainties were included in ul/lab for each fountain clocks measurements.

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Operation of the CRL primary clocks in 2003

CRL-O1 is an optically pumped primary frequency standard, developed under the cooperation between CRL Japan and NIST US. Its design is based on NIST 7 [1, 2]. It has been in operation since April 2000 and is run only intermittently, not operated as a clock. In 2003, we have submitted a paper on the accuracy evaluation of this standard to Metrologia [3]. In the course of preparing the paper, and thanks to useful comments by the referees, many items of the uncertainty budget are revised. The revised uncertainty budget is shown below.

Physical Effect	Bias (10^{-15})	Uncertainty (10^{-15})
Second-order Doppler	$\delta\nu_D \sim -280$	2
Second-order Zeeman	$\delta\nu_{QZ} \sim 1.5\times10^5$	0.2
Cavity pulling	$\delta\nu_C \sim 0$	0.8
Cavity phase	$\delta\nu_E \sim \pm200$	3.6
Blackbody	$\delta\nu_B \sim -20$	0.5
Gravitation	$\delta\nu_G \sim 8.2$	0.1
Uncorrected biases	0	3.3
Combined Type B Uncertainty		5.4

Table 1: Uncertainty budget for uB

Effect	Uncertainty(10^{-15})
Magnetic Field Inhomogeneity	0.03
Rabi Pulling	0.02
Ramsey Pulling	0.002
Bloch-Siegert Shift	0.3
Fluorescent Light Shift	0.5
Majorana Transitions	1.3
Collisions	0.8
Beam Flux Variation	0.1
Microwave Leakage	1.0
DC Stark Shift	0.01
Spectral Purity	0.1
Modulation Synchronous Effects	
Detector/ Demodulator	1.5
AM on Laser	1.0
Switching Transients	2.0
Combined Type B Uncertainty	3.3

Table 2: Details on the uncertainty of uncorrected biases

References

[1] Lee W. D., Shirley J. H., Lowe J. P., Drullinger R. E., *IEEE Trans. Instrum. Meas.*, Vol. 44, No. 2, pp. 120-123 Apr. 1995.

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IEN-CsF1

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IEN-CsF1 was operated for the first time as a primary frequency standard during 2003, with two TAI calibration reported to BIPM (circular T 185 and 191).
A typical fountain accuracy budget is the following:

Effect	Correction ($x10^{-15}$)	Uncertainty ($x10^{-15}$)
2^{nd} Zeeman	-47.09	0.04
Blackbody Radiation	30.10	0.07
Atomic Density	3	1.2
Gravitational Potential	-26.4	0.1
Others Effects	-	< 1
Total	-40.4	1.6

There are several measurement that are done each accuracy evaluation, while others are performed only rarely as a clock characterization and assumed stable (specifically the null-shift experiments).
DC Zeeman shift We map, before each accuracy measurement, with low frequency transitions ($\Delta F=0$, $\Delta m=\pm1$) the magnetic field in the atom flight region; the mapped field is then used to estimate the quadratic Zeeman shift experienced by the atoms.
The possible AC Zeeman shift generated by the cavity heater (operated in AC to shield the spurious magnetic field with the aid of the skin effect) was measured to be lower than $6x10^{-16}$.
Atomic density We make a calibration of the atomic density frequency shift with differential measurement before and after each frequency measurement. The fountain is then operated at low atomic density. The differential technique is applied as follows: the fountain is operated alternatively one our at high density and one our at low density for approximately three days, the resulting calibration accuracy is approximately 30%. Since the atomic number and detection efficiency stability can drift during the measurement, we make a second calibration after the frequency measurement and, if the case is given, we enlarge the density shift bias uncertainty.
Gravitational Shift The elevation of IEN-CsF1 on the Geoid is measured to be 242.5(.5) m as the results of the data obtained with our geodetic GPS receiver and with the Geoid height tabulated by NIMA (EGM96).
Blackbody radiation We have recalculated the BBR shift and measured it on the fountain; our results in agreement among them, do not agree with the previously used value. In fact our theoretical and experimental values for β are:

$$\beta_{theo} = (-1.49 \pm .07) \times 10^{14}$$
$$\beta_{\exp} = (-1.43 \pm .11) \times 10^{14}$$

Waiting for a general discussion on these results, and to allow comparison with other frequency standards, up to now we have used, for the BBR correction, the value recommended by BIPM in 1996 (-1.69(4))
Type A uncertainty IEN-CSF1 is generally operated by comparing its frequency with that of a BVA quartz oscillator phase locked to an H-maser. The short term stability is limited by the quartz at $3x10^{-13}\tau^{-1/2}$. The loading time, and hence the number of atoms, is chosen as low as possible not to degrade this performance.
Lab link uncertainty During the two evaluations performed in 2003, IEN-CSF1 was operate nearly continuously, with a dead time close to 5%. The good stability of the maser on those period allows to reduce the link uncertainty to the order of few units in 10^{-16}, making this uncertainty negligible at the accuracy level of the standard.

[1] F. Levi, L. Lorini, D. Calonico, A. Godone, Systematic shift uncertainty evaluation of IEN CsF1 primary frequency standard, IEEE trans. on I&M Vol. 52 2 p 267, (2003)
[2] F. Levi, *et.al.* Godone IEN-CsF1 Accuracy evaluation of IEN-CsF1 and Two Way Frequency comparison, Proceeding of 2003 IEEE-FCS, Tampa (FL).
[3] S. Micalizio *et. al.* Blackbody radiation shift of the ^{133}Cs hyperfine transition frequency *to appear on* PRA.

Operation of NIST-F1 in 2003

NIST-F1, the Cs fountain primary frequency standard at the National Institute of Standards and Technology (NIST), has been in operation since November 1998, and the first formal report to the BIPM was made in November 1999 [1]. During a formal evaluation the frequency of one of the hydrogen masers at NIST is measured by NIST-F1 and the results, along with all relevant uncertainties, are reported to the BIPM. NIST-F1 is not operated as a clock and is run only intermittently. The standard is constantly evolving, and both hardware and software improvements are continually being made. In some formal evaluations we have used a range of atom densities along with a least squares fit to determine the frequency at zero density. However, if no major changes have been made to the fountain since the previous evaluation, we may make mainly low density measurements and use the previous slope, along with any new high density data, to perform an extrapolation to zero density. The typical frequency shift from the lowest measured density to zero density is now on the order of $5x10^{-16}$. Each formal evaluation also includes a magnetic field map, and a check of such things as microwave leakage and light leaks.

NIST operates an ensemble of five active, cavity tuned hydrogen masers. This provides a very stable frequency reference, which allows us to accurately characterize the performance of the reference maser. With this information, and the fact that the masers are quite stable, we can tolerate a relatively large amount of fountain dead time [2, 3]. This allows us to use longer evaluation intervals in order to reduce the frequency uncertainty introduced by the noise in transferring the result to TAI. Frequency noise in the NIST internal measurement system has an uncertainty well under $1x10^{-16}$, and therefore the uncertainty introduced by the dead time dominates the value of $u_{link/lab}$, which ranged from $2x10^{-16}$ to $3x10^{-16}$ in 2003.

Four formal evaluations were carried out in 2003. In addition, between March and August 2003, NIST-F1 underwent significant improvements, including an extensive cleaning and vacuum upgrade. Some parts of the vacuum system were replaced, new graphite getters and vacuum instrumentation were installed and the system was fully baked out. Improved temperature control and instrumentation were installed, along with improved magnetic field control. These enhancements resulted in the ability to obtain a larger range of atom densities, and a general overall improvement in performance. The fluorescence light shift uncertainty was reduced due to improved shuttering and fibering, the spin exchange uncertainty was reduced due to better signal to noise and a greater range of atom densities, and the black body uncertainty was reduced due to improved temperature instrumentation. Later in the year improvements to the molasses optics were made and this resulted in a larger molasses. Consequently we can now operate with a factor of 2 larger atom number with only a modest increase in atom density. As a result we have improved our statistical uncertainty with essentially no degradation in the systematic uncertainty of the spin exchange shift. Also in 2003 a new bias caused by pulsed heaters was observed and reported [4].

The run in December 2003 had the lowest uncertainty ever reported for NIST-F1. The combined uncertainty was $6.7x10^{-16}$ for this run, with the statistical uncertainty, u_A, being equal to $5.0x10^{-16}$, and the systematic uncertainty, u_B, equal to $4.4x10^{-16}$. The significant contributors to the systematic uncertainty in the December evaluation were; spin exchange at $2.7x10^{-16}$, blackbody shift at $2.6x10^{-16}$, microwave leakage at $1.8x10^{-16}$, and Zeeman and gravitation shift at $1x10^{-16}$. Combined with a dead time uncertainty of $2.0x10^{-16}$ and a link to TAI uncertainty of $1.0x10^{-15}$, the overall reported uncertainty was $1.22x10^{-15}$. As of January 2004 this is the lowest total uncertainty for any standard reported in Circular T.

REFERENCES

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3 R.J. Douglas and J.S. Boulanger, "Standard Uncertainty for Average Frequency Traceability," *in Proc. 11th European Freq. and Time Forum.*, pp 345-349, 1997.

4 S.R. Jefferts, T.P. Heavner, E.A. Donley and T.E. Parker, "Measurement of Dynamic End-to-End Cavity Phase Shifts in Cesium Fountain Frequency Standards," *to be published in IEEE Trans. on Ultrasonics, Ferroelectrics, and Frequency Control.*

Operation of the PTB primary clocks in 2003

PTB's primary clocks with a thermal beam

The operation of PTB CS1 was slightly disturbed during 2003. A partial blocking of the caesium atomic beam in CS1 caused a decrease in the clock's signal-to-noise ratio, leading to an increased frequency instability. This was monitored in comparisons with an active hydrogen maser. It may have caused the reduced statistical weight in ALGOS during some months in 2003. The problem was remedied in late September 2003 which required a stop of the operation for three days. After the repair, the average CS1 relative frequency instability, $\sigma_y(\tau = 1\text{h})$, has been again $75 \cdot 10^{-15}$. The uncertainty $u_A(\tau=30\text{d, CS1})$ was conservatively estimated as $5 \cdot 10^{-15}$ for all periods and did not have to be increased even during the period of disturbed operation.

PTB CS2 was in continuous clock operation without any modification or disturbance. $u_A(\tau=30\text{d, CS2}) = 3 \cdot 10^{-15}$ is still valid, proven by local instability measurement with a hydrogen maser as a reference.

The clocks' operation parameters were checked regularly, beam reversals were performed. No indications were found calling for a modification of the previously stated relative frequency uncertainties, u_B, which are $8 \cdot 10^{-15}$ and $12 \cdot 10^{-15}$ for CS1 and CS2, respectively [1]. The clocks are operated continuously, and time differences UTC(PTB)-clock in the standard ALGOS format are reported so that $u_{l/lab}$ is zero.

PTB's caesium fountain clock CSF1

In total 392 data points representing a comparison between the fountain clock CSF1 and the hydrogen maser of the lab were collected during 2003. The total measurement time was 81.5% of the 365 days of the year. The u_B contributions given in the table below [2] reflect standard operation conditions which are kept when the TAI scale unit is compared to the CSF1 second. Only one comparison of that time was performed in 2003 as the study of previously undetected systematic frequency shifts was given highest priority. Up to now, no such effects could be clearly identified, and the Table is still considered valid. A few measurements of the TAI scale unit shall again be performed in 2004.

Physical origin	Correction[10^{-15}]	Uncertainty [10^{-15}]
C-field	-46.2	< 0.1
Collisional shift	5.8	< 0.5
Blackbody shift	16.6	0.2
First-order Doppler effect	-	0.5
Majorana transition	-	< 0.1
Rabi-pulling	-	< 0.1
Ramsey-pulling	-	< 0.1
Microwave leakage	-	0.2
Microwave spectral impurities,	-	0.2
Electronics	-	
Light shift	-	0.2
Other collisions	....	0.1
Gravitational redshift	-8.7	...0.1
Combined 1σ uncertainty u_B		0.9

The CSF1 frequency instability was $\sigma_y(\tau=1\text{h}) = 3.7 \cdot 10^{-15}$ during routine operation in 2003. The frequency difference *y*(CSF1#HM) for averaging times of 15 days in between standard dates (MJD ending on 4 or 9) was reported, in parallel with time differences UTC(PTB)#HM in ALGOS format. HM is one of the hydrogen masers available at PTB. $u_A(\tau=15\text{d, CSF1})$ is conservatively estimated as $1 \cdot 10^{-15}$, $u_{l/lab}$ is negligible.

References

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Table 7. Mean fractional deviation of the TAI scale interval from that of TT

(File available on http://www.bipm.org under the name SITAI03.AR)

The fractional deviation d of the scale interval of TAI from that of TT (in practice the SI second on the geoid), and its relative uncertainty, are computed by the BIPM for all the intervals of computation of TAI, according to the method described in 'Azoubib J., Granveaud M., Guinot B., *Metrologia*,1977, **13**, pp. 87-93', using all available measurements from the most accurate primary frequency standards CRL-O1, IEN-CSF1, NIST-7, NIST-F1, NRLM-4, PTB-CS1, PTB-CS2, PTB-CS3, PTB-CSF1, SYRTE-FO2, SYRTE-FOM and SYRTE-JPO consistently corrected for the black-body radiation shift.
In this computation, a model for the instability of EAL is needed. Starting in 1998, it has been expressed as the quadratic sum of three components: a white frequency noise $6.0\times10^{-15}/\sqrt{(\tau)}$, a flicker frequency noise 0.6×10^{-15} and a random walk frequency noise $1.6\times10^{-16}\times\sqrt{(\tau)}$, with τ in days. The relation between EAL and TAI is given in Table 5.

Month	Interval	$d/10^{-15}$	uncertainty/10^{-15}
Jan. 2001	51909-51939	+5.5	2.0
Feb. 2001	51939-51964	+4.8	1.5
Mar. 2001	51964-51999	+5.7	1.8
Apr. 2001	51999-52029	+6.6	1.6
May 2001	52029-52059	+6.7	1.8
Jun. 2001	52059-52089	+8.2	1.5
Jul. 2001	52089-52119	+8.9	1.2
Aug. 2001	52119-52149	+8.4	1.6
Sep. 2001	52149-52179	+9.2	1.4
Oct. 2001	52179-52209	+8.2	1.7
Nov. 2001	52209-52239	+10.2	1.1
Dec. 2001	52239-52274	+9.3	1.7
Jan. 2002	52274-52304	+9.7	1.9
Feb. 2002	52304-52329	+10.2	1.5
Mar. 2002	52329-52364	+10.6	1.4
Apr. 2002	52364-52394	+9.7	1.7
May 2002	52394-52424	+10.2	1.7
Jun. 2002	52424-52454	+9.5	1.9
Jul. 2002	52454-52484	+10.8	1.5
Aug. 2002	52484-52514	+8.9	1.9
Sep. 2002	52514-52544	+8.8	1.4
Oct. 2002	52544-52574	+8.7	1.7
Nov. 2002	52574-52604	+9.7	1.6
Dec. 2002	52604-52639	+10.6	1.5
Jan. 2003	52639-52669	+9.5	1.9
Feb. 2003	52669-52694	+9.0	1.6
Mar. 2003	52694-52729	+8.9	1.0
Apr. 2003	52729-52759	+10.0	1.5
May 2003	52759-52789	+6.8	1.4
Jun. 2003	52789-52819	+6.2	1.5
Jul. 2003	52819-52849	+8.2	1.7
Aug. 2003	52849-52879	+10.2	1.7
Sep. 2003	52879-52909	+10.3	0.9
Oct. 2003	52909-52939	+9.7	1.5
Nov. 2003	52939-52969	+10.5	1.6
Dec. 2003	52969-53004	+9.9	1.0

Independent local atomic time scales

Local atomic time scales are established by the time laboratories which contribute with the appropriate clock data to the BIPM. The differences between TAI and the atomic scale maintained by each laboratory are available on http://www.bipm.org or via anonymous ftp 62.161.69.5. For each time laboratory 'lab' a separate file TAI-lab is provided ; it contains the respective values of the differences [*TAI-TA*(*lab*)] in nanoseconds, for the standard dates, starting on 1 January 1998.

The file NOTES.TAI provides information concerning the time laboratories contributing to the calculation of TAI since 1 January 1998. This file should be considered as complementary to the individual files TAI-lab.

For dates between April 1996 and December 1997, the values of [*TAI-TA*(*lab*)] are given in yearly files, each one giving also values of [*UTC-UTC*(*lab*)].

Local representations of UTC

The time laboratories which submit data to the BIPM keep local representations of UTC. The computed differences between UTC and each local representation are available on http://www.bipm.org or via anonymous ftp 62.161.69.5. For each time laboratory 'lab' a separate file UTC-lab is provided ; it contains the values of the differences [*UTC-UTC*(*lab*)] in nanoseconds, for the standard dates, starting on 1 January 1998.

The file NOTES.UTC provides information concerning the time laboratories since 1 January 1998. This file should be considered as complementary to the individual files UTC-lab.

For dates between April 1996 and December 1997, the values of [*UTC-UTC*(*lab*)] are given in yearly files, each one giving also values of [*TAI-TA*(*lab*)].

International GPS and GLONASS Tracking Schedules

(Files available on http://www.bipm.org)

GPS Schedule no 40 File SCHGPS.40	implemented on MJD = 52732 (2003 April 3) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GPS Schedule no 41 File SCHGPS.41	implemented on MJD = 52911 (2003 September 29) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 15 File SCHGLO.15	implemented on MJD = 52732 (2003 April 3) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 16 File SCHGLO.16	implemented on MJD = 52911 (2003 September 29) at 0h UTC	Reference date MJD = 50722 (1997 October 1)

[*TAI - GPS time*] and [*UTC - GPS time*]

The GPS satellites disseminate a common time scale designated 'GPS time'. The relation between GPS time and TAI is

$$[TAI - GPS\ time] = 19\ \mathrm{s} + C_0,$$

where the time difference of 19 seconds is kept constant and C_0 is a quantity of the order of tens of nanoseconds, varying with time.

The relation between GPS time and UTC involves a variable number of seconds as a consequence of the leap seconds of the UTC system and is as follows:

From 1999 January 1, 0h UTC until further notice:

$$[UTC - GPS\ time] = -13\ \mathrm{s} + C_0.$$

Here C_0 is given at 0h UTC every day.

C_0 is computed as follows. The GPS data recorded at the Paris Observatory for highest-elevation satellites are first corrected for precise satellite ephemerides and for ionospheric delays derived from IGS maps, and then smoothed to obtain daily values of [*UTC*(*OP*) - *GPS time*] at 0h UTC. Daily values of C_0 are then derived by linear interpolation of [*UTC* - *UTC*(*OP*)]. The combined standard uncertainty of the daily C_0 values is of the order of 10 ns.

A table giving daily values of C_0 at 0h UTC and the parameters used in its characterization (σ: standard deviation charcterizing the dispersion of individual measurements; *N*: the number of measurements) is available from the BIPM website (see page 5) under the name UTCGPS03.AR.

[*UTC - GLONASS time*] and [*TAI - GLONASS time*]

The GLONASS satellites disseminate a common time scale designated 'GLONASS time'. The relation between GLONASS time and UTC is

$$[UTC - GLONASS\ time] = 0\ \mathrm{s} + C_1,$$

where the time difference 0 s is kept constant by the application of leap seconds so that GLONASS time follows the UTC system, and C_1 is a quantity of the order of several hundred nanoseconds (tens of microseconds until 1997 July 1), which varies with time.

The relation between GLONASS time and TAI involves a variable number of seconds and is as follows:

From 1999 January 1, 0h UTC, until further notice:

$$[TAI - GLONASS\ time] = 32\ \mathrm{s} + C_1.$$

Here C_1 is given at 0h UTC every day.

C_1 is computed as follows. The GLONASS data recorded at the NMi Van Swinden Laboratorium, Delft, The Netherlands for the highest-elevation satellites are smoothed to obtain daily values of [*UTC(VSL) - GLONASS time*] at 0h UTC. Daily values of C_1 are then derived by linear interpolation of [*UTC - UTC(VSL)*] provided on the BIPM internet network.

To ensure the continuity of C_1 estimates, the following corrections are applied:

+1285 ns from 1997 January 1 (MJD 50449) to 1999 March 22 (MJD 51259)
+107 ns for 1999 March 23 and March 24 (MJD 51260 and MJD 51261)
0 ns since 1999, March 25 (MJD 51262).

The combined standard uncertainty of the daily C_1 values is of the order of several hundred nanoseconds.

A table giving daily values of C_1 at 0h UTC and the parameters used in its characterization (σ: standard deviation charcterizing the dispersion of individual measurements; *N*: the number of measurements) is available from the BIPM website (see page 5) under the name UTCGLO03.AR

Table 8A. Rates relative to TAI of contributing clocks in 2003

(File available on http://www.bipm.org under the name RTAI03.AR)

Mean clock rates relative to TAI are computed for one-month intervals ending at the MJD dates given in the table. When an intentional frequency adjustment has been applied to a clock, the data prior to this adjustment are corrected, so that Table 8A gives homogeneous rates for the whole year 2003. For studies including the clock rates of previous years. Corrections must be brought to the data published in the Annual Report for 1988 to 2002, and in the BIH Annual Reports for the previous years. These corrections are given in Table 8B. Unit is ns/day, " -" denotes that the clock was not used, "*" denotes that the related rate was influenced by a frequency jump.

The first two digits of the clock code indicate its type:

12 HEWLETT-PACKARD 5061A
13 EBAUCHES, OSCILLATOM B5000
14 HEWLETT-PACKARD 5061A OPT. 4
16 OSCILLOQUARTZ 3200
17 OSCILLOQUARTZ 3000
15 DATUM/SYMMETRICOM Cs III
4x HYDROGEN MASERS
9x PRIMARY CLOCKS AND PROTOTYPES
21 OSCILLOQUARTZ 3210
23 OSCILLOQUARTZ EUDICS 3020
30 HEWLETT-PACKARD 5061B
31 HEWLETT-PACKARD 5061B OPT. 4
34 H-P 5061A/B with 5071A tube
35 H-P/AGILENT 5071A High perf.
36 H-P/AGILENT 5071A Low perf.
50 FREQ. AND TIME SYSTEMS INC. 4065A
51 DATUM/SYMMETRICOM 4065 B
52 DATUM/SYMMETRICOM 4065 C

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
AUS	36	299	21.59	19.27	20.37	19.39	19.79	19.94	18.32	19.66	19.37	19.50	18.06	19.27
AUS	36	340	-1.81	-1.02	-0.62	-0.79	-2.54	0.85	-1.93	-1.04	-0.43	-0.71	-0.95	-0.61
AUS	36	654	-24.28	-24.95	-24.11	-24.53	-22.79	-24.25	-23.74	-22.88	-23.40	-22.92	-24.18	-22.80
AUS	36	1035	4.90	4.53	5.85	5.00	4.18	7.19	-	6.08	4.84	4.37	5.25	-
AUS	36	1141	2.27	1.20	1.98	3.74	1.13	-	-	-	-	-	-	-
AUS	40	5401	26.43	26.36	-	26.59	25.02	-	-	-	-	-	-	22.76
AUS	40	5402	-13.73	-	-	-	-	6.06	-	5.07	-1.50	5.83	14.02	13.11
AUS	40	5403	-6.23	-10.67	-	-	-12.31	-10.44	-10.76	-	-	-	-	-
AUS	99	1	-	-23.00	-	-	-	-	-65.78	-28.45	-	-	-	-
BEV	16	71	2.13*	-7.85*	-16.55	-10.17	-25.04	-42.98	-48.96	-11.91	-9.84	-16.84	24.01	66.84

Table 8A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
BEV	35 1065	0.60	-	-	1.63	1.43	1.76	-	-	-1.54	-3.13	-2.51	-4.92
BEV	35 1793	-1.30	-0.80	-	-	-	0.02	0.07	-0.99	0.88	0.36	0.21	0.02
CAO	35 939	-	-	-	-	-	-1.08	0.29	-1.19	-0.53	-2.81	-2.15	2.04
CAO	35 1270	-	-	-	-	-	-5.21	-6.02	-5.44	-6.87	-6.83	-8.95	-9.30
CH	21 194	-34.03	-36.79	-31.41	-26.25	-29.39	-23.69	-25.84	-26.17	-19.94	-20.13	-18.01	-15.34
CH	21 217	166.49	163.84	-	-	-	-	-	-	-	-	-	-
CH	31 403	-56.98	-60.68	-	-	-	-	-	-	-	-	-	-
CH	35 413	-18.32	-20.19	-19.54	-19.22	-	-	-	-	-	-	-	-
CH	35 771	9.31	11.05	8.90	9.11	10.31	-	-	7.30	7.86	7.41	7.53	7.75
CH	36 354	46.16	46.87	47.46	46.04	45.05	45.27	46.13	45.74	43.27	45.32	43.16	44.58
CH	40 5701	-	-	-	-	-46.21	-	-	-52.81	-54.67	-56.43	-58.52	-60.05
CNM	35 1705	-1.15	-1.16	-0.43	-0.73	-0.74	0.10	-0.05	-0.82	-0.07	-2.04	-1.70	0.02
CNM	35 1815	-	1.48*	0.37*	0.72*	0.26*	0.21*	0.38*	0.91*	0.86	-0.87	-0.04	1.54
CNM	36 1537	-18.88	-20.44	-18.79	-19.73	-19.67	-18.78	-18.39	-19.81	-19.59	-21.62	-18.93	-21.97
CNM	40 7301	-	10.70*	6.31*	2.65*	-0.65*	-0.96	-1.53	-2.63	-7.75	-21.04	-22.43	-16.70
CNMP	36 1752	-	-	-	-	-	-	-	-	-	-	-11.37	-11.41
CRL	35 112	-0.01	0.41	0.39	-0.75	-0.94	-0.57	-0.12	0.18	0.10	-0.53	0.49	1.23
CRL	35 144	15.77	15.68	15.53	16.25	15.26	15.84	15.53	15.93	15.19	16.33	16.46	-
CRL	35 332	13.55	14.29	13.99	14.13	14.71	14.18	14.78	15.98	14.63	15.34	15.29	15.94
CRL	35 342	6.13	7.90	8.26	7.91	7.57	7.75	8.48	7.57	8.71	7.78	8.15	8.36
CRL	35 343	13.39	12.71	13.92	14.17	12.44	13.48	13.27	14.78	12.76	13.57	13.19	12.55
CRL	35 715	6.38	6.07	5.73	6.05	5.29	4.30	5.01	4.53	5.50	5.25	5.04	6.05
CRL	35 732	1.12	1.72	2.15	2.28	2.54	3.31	2.04	4.44	3.71	3.85	4.48	4.76
CRL	35 907	12.75	13.33	13.87	13.34	11.75	11.45	12.02	-	-	-	-	-7.88
CRL	35 908	6.61	6.21	6.53	-	-	-	6.55	4.97	5.01	4.91	5.70	6.00
CRL	35 1778	8.69	9.46	8.79	9.06	8.91	9.81	9.24	9.29	9.30	9.63	9.99	9.95
CRL	35 1789	8.10	9.01	8.49	8.78	8.62	8.38	7.91	8.30	8.41	8.32	8.26	8.03
CRL	35 1790	-7.13	-7.22	-7.18	-7.45	-8.66	-8.14	-7.87	-8.32	-8.30	-8.15	-7.78	-8.38
DLR	35 1714	-	-	-	-	-	-	-	-0.29	0.34	0.17	-0.24	0.31
DTAG	36 136	14.77	15.83	15.91	14.52	13.47	11.47	14.05	16.67	14.11	-0.08	3.82	11.68

Table 8A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
DTAG	36 345	-3.91	-13.05	-13.98	-12.72	-12.75	-11.70	-12.80	-12.58	-12.59	-0.95	-4.10	-1.65
DTAG	36 465	1.29*	1.38*	3.08*	-0.62*	-0.18*	0.70*	0.42*	1.13*	0.33*	0.58*	-0.14	0.27
F	16 106	-9.05	-8.16	-11.18	-	-	-	-	-	-	-	-	-
F	35 122	13.69	13.32	12.88	13.28	13.65	14.75	14.18	14.06	14.34	13.53	13.44	13.83
F	35 124	2.57	2.19	3.03	3.32	3.21	3.34	3.43	3.72	3.38	4.53	4.55	4.48
F	35 131	-	-	14.89	15.19	15.24	15.68	14.87	15.49	15.26	15.11	14.58	14.61
F	35 158	12.92	12.98	12.63	12.76	13.15	12.85	13.37	13.05	13.20	13.84	13.13	13.53
F	35 172	9.40	9.51	9.65	10.26	9.97	9.86	9.97	10.09	10.21	9.45	9.59	9.95
F	35 198	9.56	9.00	9.01	9.41	9.05	9.56	9.70	9.90	9.83	10.43	9.64	9.40
F	35 355	0.46	0.64	0.25	0.45	-	-	-	-	-	-	-	-
F	35 385	14.49	15.06	15.79	15.80	15.81	17.33	15.77	15.19	15.75	14.46	-	-
F	35 396	7.00	8.22	7.88	8.21	6.35	7.42	7.26	7.24	7.64	7.05	6.74	6.35
F	35 469	5.26	5.64	4.66	5.41	-	-	-	-	-	-	-	-
F	35 489	-	-	-	-	-	-	19.16	20.34	19.54	19.98	20.65	20.36
F	35 520	16.79	15.96	14.52	15.57	15.28	14.82	12.84	15.64	15.78	16.19	16.14	16.29
F	35 536	4.36	4.74	4.48	5.11	4.72	4.39	5.34	5.02	5.22	5.37	5.45	5.51
F	35 609	-	-	-	-	-	-	-	-	-	-	-	-9.04
F	35 770	-	16.53	15.57	15.18	14.84	14.85	14.97	15.12	15.54	15.24	14.82	15.23
F	35 774	-21.00	-21.42	-22.49	-21.97	-22.55	-20.76	-22.27	-20.84	-	-	-	-
F	35 781	21.20	20.81	20.57	20.94	20.38	21.32	20.76	20.95	20.47	20.94	20.15	20.95
F	35 819	-	-	-	-	-	6.08	5.96	4.37	4.46	5.41	5.02	4.57
F	35 1029	-	-	-	-	16.66	15.45	16.24	16.91	16.50	16.28	17.36	16.77
F	35 1177	-	-	-14.55	-	-	-14.81	-13.83	-13.67	-14.39	-14.04	-14.52	-14.90
F	35 1178	-	-	5.53	-	-	4.69	4.82	4.84	5.26	5.12	4.69	5.07
F	35 1222	-	-	-	5.19	5.45	6.22	5.47	4.16	6.07	5.48	5.46	4.96
F	35 1321	8.81	9.52	9.46	9.30	-	-	-	-	8.71	8.37	7.59	7.63
F	35 1556	-	-15.52	-16.48	-16.88	-18.39	-19.74	-19.61	-21.02	-19.26	-19.32	-17.56	-16.73
F	40 805	-	-	-54.63	-54.25	-54.49	-56.82	-61.32	-64.90	-65.09	-64.26	-62.53	-61.25
F	40 816	-25.63	-25.02	-25.91	-25.84	-26.79	-25.41	-23.43	-18.41	-15.76	-	-	-30.49
IEN	35 219	14.64	14.93	15.29	15.26	14.74	15.30	15.03	15.32	14.55	14.73	16.29	15.58

Table 8A. (Cont.)

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
IEN	35	505	-8.95	-7.77	-7.41	-7.60	-8.59	-8.42	-8.41	-9.52	-9.19	-9.54	-7.33	-7.65
IEN	35	1115	-8.69	-8.42	-8.58	-6.78	-6.13	-6.66	-5.83	-5.12	-4.77	-4.62	-8.11	-
IEN	35	1373	-0.18	0.24	-0.25	1.59	-0.56	0.31	-8.49	0.24	0.44	-1.40	-0.92	-1.47
IEN	40	1101	-	-	-	-	-	-	4.94	14.84	24.41	34.42	43.65	39.68
IEN	40	1102	-	-	-	-	-	-	-	71.25	8.49	6.34	5.48	-3.16
IFAG	36	1167	-8.65	-6.88	-7.64	-7.79	-7.51	-5.19	-3.70	-6.27	-3.70	-7.56	-8.21	-7.07
IFAG	36	1173	-2.03	-2.07	-2.65	-1.03	1.44	-4.45	-4.69	-7.01	-2.97	-0.81	0.62	-9.03
IFAG	36	1629	3.65	4.37	3.86	4.88	6.06	3.74	4.42	5.18	5.39	6.99	6.33	5.31
IFAG	36	1732	-3.24	-2.58	-2.91	-2.70	-3.02	-2.41	-2.41	-2.42	-1.71	-1.81	-1.91	-1.88
IFAG	36	1798	-3.31	-2.76	-3.23	-3.28	-2.34	-1.94	-1.40	-2.55	-2.71	-2.56	-2.45	-3.18
IFAG	40	4401	184.85	192.37	217.46	242.46	266.26	-	-	21.42	36.40	49.38	9.18	25.92
IFAG	40	4403	145.51	152.20	141.80	176.82	195.05	-	-	-0.58	10.56	18.44	-	-
IFAG	40	4418	-15.52	-8.86	-4.17	0.89	4.80	8.27	10.00	10.92	14.01	17.35	21.02	23.48
IGMA	16	112	37.99	40.05	40.56	39.37	46.91	39.36	49.02	32.74	39.96	49.76	41.53	38.35
IGMA	35	674	0.18	0.82	-0.03	-0.27	-0.10	0.00	0.11	-0.10	-0.02	-0.13	0.23	0.00
IGMA	35	676	-5.83	-5.63	-6.43	-6.45	-5.98	-5.64	-5.95	-5.91	-5.69	-5.33	-4.76	-4.98
INPL	35	1652	-9.58	-9.84	-9.96	-6.34	-8.66	-5.49	-	-6.32	-5.38	-8.60	-5.37	-4.61
JV	21	216	-	-	-	-24.82	-24.66	-23.98	-	-26.55	-27.68	-	8.06	7.65
JV	21	387	-	-	-	44.84	15.62	58.02	-	34.35	42.70	-	-3.97	-16.09
JV	36	1277	-	-	-	-	-23.69	-	-	-22.06	-24.29	-	-	-
JV	51	2040	-	-	-	-92.22	-94.10	-92.10	-	-	-	-	58.74	59.86
KRIS	36	321	-	-	4.62	4.54	4.68	5.01	4.94	5.11	2.91	4.66	5.54	3.82
KRIS	36	739	-	-	-12.68	-12.92	-13.37	-14.34	-14.58	-13.22	-14.81	-13.36	-12.99	-12.24
KRIS	36	1135	-	-	30.56	32.03	33.26	34.07	31.00	34.71	33.02	35.32	35.49	31.42
KRIS	36	1783	-	-	-	-	-	-	-	-	-	-	5.96	5.10
KRIS	40	5623	-	-	34.04	34.23	34.89	35.45	35.57	35.98	36.45	36.52	37.23	37.47
LDS	35	289	5.73	6.19	5.16	3.98	4.67	4.72	3.81	5.42	6.39	5.62	5.92	7.03
LT	35	1362	1.16	2.37	-0.31	-0.02	-0.59	0.87	0.76	1.82	2.27	2.89	0.75	1.86
MSL	12	933	57.25	51.46	27.38	8.66	12.01	10.71	2.14	2.13	5.00	8.11	2.70	1.09
MSL	35	1025	-6.82	-7.23	-6.72	-6.85	-7.73	-6.63	-	-7.80	-8.85	-	-	-

Table 8A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
MSL	36 274	4.74	5.67	4.74	6.93	5.14	6.53	8.27	6.05	6.07	5.06	6.04	5.48
NAO	35 779	1.89	1.50	1.27	1.31	1.47	0.84	1.57	1.75	-	-	2.38	1.45
NAO	35 1206	13.71	13.93	14.38	14.32	14.14	14.77	14.72	15.60	-	-	14.95	16.80
NAO	35 1214	11.28	10.08	10.56	10.66	10.47	10.61	10.70	11.31	-	-	-5.63	-7.34
NAO	35 1689	-0.90	-0.89	-0.40	-1.60	-0.50	-0.54	-1.02	-0.91	-	-	-1.16	0.47
NIM	35 479	4.29	4.18	4.23	4.11	4.04	4.10	4.13	3.92	4.04	3.05	0.03	4.29
NIM	35 1238	3.84	3.25	3.38	3.57	3.56	3.81	3.51	3.49	3.75	3.12	4.17	3.90
NIM	35 1239	4.02	4.29	4.50	4.04	4.04	3.69	4.19	3.91	3.98	3.01	4.45	4.74
NIMB	35 600	-1.62	-2.50	-3.53	-2.00	-	-3.65	-4.04	19.11	-1.24	-1.82	-4.36	-0.17
NIST	15 9866	-	-10.42	-7.12	-7.50	-10.69	-14.55	-20.07	-24.94	-29.97	-34.40	-39.00	-42.70
NIST	35 132	-0.47	-0.56	-0.47	-0.24	-0.47	-0.14	-0.35	-0.69	-0.32	-0.81	-1.48	-0.74
NIST	35 182	-11.46	-11.28	-11.22	-11.43	-11.97	-10.41	-10.46	-11.17	-11.23	-11.40	-10.81	-10.63
NIST	35 408	-1.16	-1.62	-1.88	-0.90	-1.76	-0.93	-1.39	-1.92	-1.81	-1.96	-1.74	-1.57
NIST	35 1074	-8.38	-5.96	-6.16	-6.91	-7.02	-6.77	-9.31	-	-24.20	-20.83	-19.59	-18.76
NIST	40 201	16.12	15.38	14.48	13.82	13.21	12.94	12.37	11.95	11.72	11.57	11.91	12.24
NIST	40 203	35.00	36.01	36.92	38.16	39.36	40.61	41.51	42.52	43.55	44.41	45.68	46.75
NIST	40 204	8.40	8.75	9.08	9.45	9.64	9.98	10.17	10.25	10.58	10.69	11.13	11.33
NIST	40 205	-23.87	-23.86	-24.04	-24.10	-24.18	-24.17	-24.33	-24.50	-24.59	-24.87	-24.75	-24.94
NIST	40 222	-11.67	-11.62	-11.48	-11.16	-10.91	-10.62	-10.50	-10.30	-10.10	-10.04	-9.65	-9.45
NMC	35 1501	-1.74	-1.80	-1.58	-3.08	-3.46	-3.59	-2.66	-2.99	-1.84	-1.09	-4.47	-4.63
NMIJ	35 224	1.92	-1.71	-1.18	-2.27	-1.94	-1.67	0.16	1.47	0.20	0.18	0.66	0.27
NMIJ	35 459	1.02	0.91	0.83	-	-	-	-0.68	-0.37	-0.50	-0.11	-0.17	0.16
NMIJ	35 1273	-9.57	-9.55	-10.42	-10.52	-10.20	-10.65	-10.07	-9.89	-9.72	-9.86	-9.33	-9.51
NMIJ	35 1466	-	-	-	-	-	-	10.29	10.84	10.02	10.17	9.86	9.94
NMIJ	40 5014	-	-	-	-	-	-	-0.12	0.11	-0.06	-0.56	-0.37	-1.59
NMLS	35 1659	-3.37	-3.01	-3.84	9.62	1.40	2.41	-0.91	1.18	0.40	-0.19	0.25	-1.87
NPL	35 784	4.02	4.32	5.11	5.13	3.88	4.18	5.43	4.71	4.54	4.96	4.46	4.03
NPL	35 1275	0.16	0.75	0.99	0.07	0.88	0.82	1.20	-0.27	-0.22	0.26	-0.53	-1.03
NPL	36 404	12.18	12.58	9.84	11.96	12.09	12.11	12.26	12.41	11.24	10.30	12.66	8.96
NPL	40 1701	-1.18*	-0.74*	-1.62*	-1.38*	-1.21*	-1.09*	-1.05*	-0.91*	-0.66*	-0.53*	-0.25	-0.17

Table 8A. (Cont.)

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
NPL	40	1708	2.16	2.22	1.50	2.34	3.57	3.94	3.78	3.87	3.95	3.94	3.97	3.42
NPLI	35	725	-	9.86	8.72	9.85	8.67	-	-0.10	-0.10	8.04	-	-	-
NRC	35	234	16.55	15.93	16.03	16.59	17.34	16.34	16.22	15.64	15.49	16.49	16.45	16.27
NRC	35	372	23.43	23.00	23.58	23.04	24.00	21.89	20.52	21.16	22.90	23.11	24.10	23.59
NRC	90	61	1.01	-1.03	-0.15	-0.64	-0.11	0.02	0.22	-0.29	0.16	-0.11	0.18	0.32
NTSC	35	1007	-8.38	-	-	-	-	-	-	-	-	-	-	-
NTSC	35	1008	19.46	19.79	19.17	18.86	19.92	19.85	19.04	18.97	19.65	-	-	-
NTSC	35	1011	-6.62	-5.66	-5.02	-	-	-	-	-	-	-	-	-
NTSC	35	1016	3.15	2.59	2.66	3.26	3.73	3.57	3.72	-	-	-	-	-
NTSC	35	1017	-1.28	-0.25	0.18	-0.12	0.07	1.23	0.49	0.61	-	-	-	-
NTSC	35	1018	12.65	12.81	12.39	13.18	13.00	13.74	12.45	12.87	12.14	12.70	12.15	12.82
NTSC	35	1818	-	-1.36	-1.92	-2.70	-	-	-	-	-24.59	-23.75	-23.40	-23.15
NTSC	35	1820	-	-10.99	-11.31	-11.33	-11.29	-10.81	-9.20	-8.18	-6.85	-7.17	-	-
NTSC	35	1823	-	-	-	-	-	-	-	-	2.70	2.26	1.83	1.10
OMH	36	849	0.47	1.23	2.79	1.49	2.66	5.33	-	7.17	3.73	2.06	1.69	3.31
ONRJ	35	903	2.83	2.27	2.90	1.49	2.10	2.45	2.16	1.60	2.37	1.66	2.25	-
ORB	35	201	1.97	1.69	2.36	2.04	5.00	3.31	2.99	3.91	3.36	4.58	1.30	3.86
ORB	35	202	7.60	7.11	5.09	4.95	7.60	8.74	6.84	7.16	7.97	4.61	9.78	10.00
ORB	35	593	65.82	65.33	63.32	65.14	67.60	67.70	66.96	66.31	67.60	69.41	68.76	68.48
ORB	40	2601	-0.78*	-0.04*	-1.00*	-1.52*	-1.62*	0.55*	-0.16*	-0.17*	-1.17	0.51	-0.19	-0.45
PL	35	441	2.69*	2.65*	2.44*	1.38*	1.13*	1.15*	0.56*	-0.48*	0.36*	-0.05*	-0.56*	11.00
PL	35	502	-	-	-	-	-	-	-2.20	-2.30	-2.24	-2.29	-2.62	-2.82
PL	35	761	-3.38	-1.12	-2.25	-1.49	-4.18	-2.52	-0.48	-1.70	-1.11	-1.06	-3.06	-3.23
PL	35	1120	-0.87*	-0.59*	-0.29*	0.85*	-0.12*	-0.54*	-0.90*	-0.79*	-0.62	-1.28	-0.91	-1.34
PL	35	1660	-0.79*	0.06*	-0.12*	0.07*	-0.34*	-0.03*	-0.23*	0.84	1.09	0.38	-0.68	-0.63
PL	35	1709	-	-	-	-	-0.01	0.14	-0.66	-1.00	-0.63	-0.88	-0.43	0.05
PL	35	1746	-0.41*	0.06*	-0.57*	0.03	-0.82	0.15	-0.82	-0.02	-0.04	-0.16	-0.43	-0.94
PL	40	4002	-	-	-	-	-	-	-	-	-	-	-	5.83
PTB	35	128	-2.34	-2.76	-2.63	-2.57	-2.77	-2.28	-2.86	-2.90	-1.88	-2.20	-2.03	-2.21
PTB	35	415	3.32	3.68	3.37	3.19	3.01	3.64	1.76	3.76	3.47	3.18	3.17	3.25

Table 8A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
PTB	35 1072	13.38	13.08	13.10	13.83	12.59	14.86	13.96	13.51	-	12.48	13.53	-
PTB	40 502	54.52	56.40	55.47	127.05	427.10	-	-	-	-	-	-	-
PTB	40 505	-1.00	-0.66	-0.19	-0.30	1.25	1.47	3.36	3.34	4.19	4.30	5.71	-13.10
PTB	40 510	8.12*	8.91*	9.39*	10.10*	9.82*	11.18*	9.07*	12.57*	16.84*	18.01*	18.96*	3.87
PTB	92 1	1.96	1.66	1.84	0.79	0.54	1.19	0.79	0.65	1.54	1.95	0.96	1.42
PTB	92 2	0.96	1.42	1.16	1.21	1.08	0.42	0.92	0.90	0.63	1.46	1.11	0.88
PTB	92 3	0.23	0.90	0.17	0.82	-0.37	0.92	0.10	0.97	0.79	1.39	-	-
ROA	14 1569	51.45	41.21	43.61	49.35	52.04	57.99	61.09	59.86	57.71	48.50	42.56	36.88
ROA	35 583	0.14*	-1.25*	-1.92*	-1.70*	-2.21*	-2.22*	-1.47*	-1.29*	-1.65*	-1.67*	-1.62*	-1.65
ROA	35 718	-12.05	-12.77	-11.39	-12.07	-11.65	-12.09	-13.55	-12.78	-12.86	-12.17	-12.59	-13.11
ROA	36 1488	6.17	7.56	5.50	7.39	6.35	5.55	7.50	4.58	5.70	6.64	7.26	6.95
ROA	36 1490	5.75	8.23	8.23	8.03	6.88	6.73	7.60	6.51	7.04	7.30	6.30	7.75
SCL	35 621	0.45	0.09	-0.24	-0.51	-0.07	0.64	0.45	0.73	-0.25	-0.17	-0.49	-0.59
SCL	35 745	-7.15	-7.37	-7.81	-8.19	-6.97	-6.60	-6.91	-6.44	-6.28	-5.31	-5.59	-4.93
SG	35 1035	0.62*	0.18*	1.68	5.56	5.15	5.27	-	-	5.15	4.62	5.94	4.98
SG	35 1127	-1.09	-1.15	-0.74	-1.20	-0.82	-0.98	-	-	0.68	-0.51	0.08	0.29
SG	36 522	-8.59	-10.25	-10.89	-7.70	-8.56	-7.49	-	-	9.97	8.17	-	-8.54
SMU	36 1063	-6.92	-4.19	-3.73	-4.21	-5.11	-5.42	-5.89	-5.89	-5.48	-5.23	-4.76	-4.64
SP	19 197	89.35	85.03	79.85	77.74	73.26	69.38	73.86	75.67	81.59	77.11	67.33	66.72
SP	35 641	10.62	10.80	9.63	9.92	9.65	9.95	-	-	6.53	7.59	7.31	7.91
SP	35 1188	15.43	15.89	15.45	14.70	13.88	14.77	-	-	14.90	14.34	14.90	13.88
SP	35 1642	14.76	13.62	13.66	13.92	14.58	12.95	-	-	15.63	14.66	14.61	14.70
SP	36 1175	-0.28	1.49	0.35	1.84	4.83	4.76	0.80	-1.27	-0.72	-1.10	-1.44	-1.60
SP	40 7201	-	-	13.66	23.55	28.59	34.21	-	-	37.54	47.68	50.20	53.69
SP	40 7218	-	-	-	-9.59	-12.53	-15.19	-18.39	-22.09	-24.52	-27.42	-30.51	-33.26
SU	40 3802	8.33	8.91	9.33	10.32	10.29	10.91	11.37	11.67	12.19	12.50	13.08	13.38
SU	40 3803	-26.21*	-26.67*	-28.19*	-28.56*	-28.95*	-29.35*	-29.76*	-30.35*	-30.85*	-32.04*	-32.97*	-32.38
SU	40 3805	57.72	58.92	59.62	60.87	61.41	61.44	61.43	61.55	61.83	62.46	63.31	63.89
SU	40 3807	-	85.41*	84.92*	83.68*	82.78*	82.76*	82.82*	83.34*	83.03	83.23	83.58	83.75
SU	40 3810	51.85*	53.52*	53.56*	55.45*	56.89*	58.48*	59.46*	58.38*	58.26	57.88	57.41	57.16

Table 8A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
SU	40 3825	68.17	68.50	68.31	70.82	72.29	73.25	74.34	75.39	76.36	77.10	78.98	79.60
SU	40 3827	67.21	66.66	66.81	67.88	68.35	68.71	68.45	68.79	68.51	69.07	68.18	67.96
SU	40 3831	13.94	14.46	15.60	16.28	16.61	17.18	18.36	19.37	19.60	20.46	20.78	21.62
SU	40 3837	36.55	37.13	37.38	38.22	38.50	38.70	39.24	39.03	40.13	40.55	40.97	41.24
TCC	35 768	-	-	-	-	-	-	-	-	-	-	-	-9.72
TCC	35 1028	-7.79	-7.60	-8.08	-6.68	-7.25	-6.12	-7.11	-4.62	-5.90	-	-	-
TCC	35 1881	-	-	-	-	-	-	-	-	-	-	-	-5.52
TCC	40 8620	7.87	10.02	11.29	13.18	14.26	15.71	16.51	17.61	17.06	20.10	20.09	21.54
TCC	40 8624	-12.95	-12.70	-13.15	-12.77	-13.72	-13.34	-13.99	-14.56	-16.21	-14.72	-16.03	-16.35
TL	35 160	-9.93	-10.82	-9.02	-9.51	-8.68	-8.85	-9.94	-8.40	-8.71	-7.68	-8.19	-7.94
TL	35 300	11.12	9.95	10.35	9.90	9.64	9.65	9.00	8.25	7.98	8.79	7.38	7.03
TL	35 474	22.65	22.16	22.55	22.54	21.90	21.94	21.22	22.04	22.05	22.25	22.88	22.28
TL	35 809	-	-	-	-	-	-	-	-	-	-	0.93	1.62
TL	35 1012	-14.28	-13.12	-13.53	-12.21	-14.01	-12.79	-14.66	-	-	-	-	-
TL	35 1132	-	-	-	-	-	-	-	-	-	-	-3.05	-2.75
TL	35 1498	14.83	13.80	14.16	14.35	14.41	14.69	13.85	14.41	13.78	14.37	14.78	13.84
TL	35 1500	9.22	8.94	8.87	8.95	8.53	9.06	8.02	8.63	9.03	-	-	-
TL	35 1712	-0.03	0.34	0.50	0.43	0.21	-0.05	0.39	0.99	0.51	0.20	1.20	0.93
TL	40 3052	-5.05*	-4.08*	-2.26*	-0.81*	0.29*	1.18	0.22	-	-	-	-	-
TL	40 3053	-	-	-	-	-	-	-	-	-	-	-1.22	-1.91
TP	35 163	21.78	22.58	22.50	21.90	22.74	22.35	22.47	22.44	-	-	-	20.43
TP	35 326	-	-	-23.39	-20.99	-22.26	-21.11	-21.47	-21.42	-20.71	-20.56	-20.89	-21.35
TP	35 1227	3.05	3.10	2.69	2.73	2.97	3.93	3.83	3.98	3.90	3.41	2.92	3.29
TP	36 154	13.78	12.10	12.98	12.27	13.15	12.89	12.51	12.18	12.54	12.26	11.53	13.73
UME	35 252	1.30	0.15	1.06	0.55	-	-	-	-	-	-	-	-
UME	35 872	-1.19	-1.04	-2.06	-1.32	-	-	-	-	-	-	-	-
USNO	35 101	-4.05	-4.19	-4.13	-4.95	-5.02	-5.39	-5.10	-5.19	-4.23	-3.81	-3.19	-2.33
USNO	35 104	17.79	18.77	17.57	17.56	18.92	17.90	18.56	17.35	17.58	18.00	17.44	17.51
USNO	35 108	8.42	8.05	8.93	9.07	8.90	9.75	9.08	10.45	9.11	10.57	8.00	9.65
USNO	35 114	-	-	-	-	-	-	-	-98.78	-97.99	-97.58	-97.20	-96.12

Table 8A. (Cont.)

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
USNO	35	120	0.54	-0.08	-1.47	-1.35	-0.08	-0.32	0.20	-0.29	-0.75	-0.73	-0.22	-0.79
USNO	35	142	5.35	5.68	4.22	4.71	5.31	5.40	5.38	4.93	4.37	4.85	5.43	5.37
USNO	35	146	-3.13	-4.11	-2.43	-3.18	-3.35	-1.59	-2.07	-3.10	-2.26	-2.32	-3.89	-3.86
USNO	35	148	10.49	13.90	13.19	12.67	12.04	12.44	11.48	12.60	11.55	11.97	11.44	12.81
USNO	35	150	4.92	4.06	6.54	5.32	5.92	5.64	5.64	6.49	7.23	6.77	6.89	7.98
USNO	35	152	10.86	11.53	11.64	10.59	12.08	11.90	11.84	11.58	11.34	11.42	11.28	11.07
USNO	35	153	14.10	13.45	13.70	14.34	13.71	13.34	14.10	13.47	13.14	13.41	12.66	13.01
USNO	35	156	16.82	16.51	16.43	15.28	16.53	15.78	16.79	16.10	17.05	16.72	16.75	17.64
USNO	35	161	-18.92	-17.57	-17.90	-18.23	-18.06	-18.23	-17.98	-18.69	-18.12	-18.37	-18.12	-17.88
USNO	35	164	-4.08	-4.32	-3.91	-4.19	-4.41	-3.92	-4.89	-4.32	-4.79	-	-	6.23
USNO	35	165	1.06	1.59	2.02	1.96	1.53	0.82	1.47	1.54	0.30	-0.25	0.08	0.16
USNO	35	166	-1.74	-1.69	-2.70	-3.07	-2.96	-2.28	-2.52	-2.76	-1.60	-1.45	-2.73	-2.66
USNO	35	167	3.94	3.84	3.10	2.47	3.06	2.54	-	-	4.29	4.88	3.61	3.98
USNO	35	169	14.14	14.96	14.84	14.84	13.82	14.36	-	-	-10.70	-9.52	-9.28	-9.01
USNO	35	171	0.48	0.66	0.14	0.44	-0.36	0.52	0.20	-	-	0.04	-	-
USNO	35	173	-12.83	-13.16	-12.96	-12.47	-12.18	-12.45	-12.20	-12.61	-12.58	-12.14	-12.32	-12.54
USNO	35	213	8.00	6.95	6.61	7.07	6.20	6.99	7.10	6.21	6.40	6.93	9.22	8.50
USNO	35	217	-1.43	-2.24	-0.72	-0.69	-1.01	-0.88	-0.99	-0.88	-	-	-0.40	-0.70
USNO	35	225	-0.88	-1.47	2.80	-0.90	-0.95	-1.54	-1.57	-1.56	-1.09	-1.53	-1.83	-1.10
USNO	35	226	21.41	22.37	25.76	19.77	20.84	20.97	20.92	21.34	20.69	20.74	20.62	20.94
USNO	35	227	5.62	5.04	5.22	5.53	5.20	5.30	5.12	5.58	5.33	5.53	5.20	5.40
USNO	35	229	7.25	8.22	8.45	8.59	9.00	8.47	8.92	9.53	10.00	9.82	10.84	10.68
USNO	35	231	-12.42	-10.95	-11.83	-11.20	-11.78	-11.83	-10.36	-9.83	-9.59	-10.70	-8.93	-9.97
USNO	35	233	-0.70	0.02	-0.49	-0.39	-0.10	-0.65	-0.41	-0.91	-0.08	-0.11	0.59	0.85
USNO	35	242	20.01	20.18	19.88	19.54	20.23	20.33	20.15	20.03	20.06	21.96	20.38	20.76
USNO	35	244	18.32	18.04	17.94	18.00	18.95	18.43	18.36	18.42	18.42	18.91	18.49	18.30
USNO	35	249	3.83	4.78	4.34	3.50	4.46	4.31	3.65	4.62	4.34	4.14	4.28	3.63
USNO	35	253	7.42	6.52	8.28	8.20	8.32	8.70	9.43	8.99	9.73	9.39	10.99	10.31
USNO	35	254	9.39	9.24	8.85	9.22	9.07	8.67	9.31	9.10	9.10	9.55	8.52	9.22
USNO	35	255	6.44	6.64	7.15	7.44	6.91	6.50	6.65	-	-	6.13	5.61	6.41

Table 8A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
USNO	35 256	13.87	14.37	13.82	13.83	13.82	12.64	13.78	13.04	12.77	13.25	13.45	13.33
USNO	35 260	13.22	12.72	-	-	13.05	12.01	13.25	13.80	13.40	-	-	-0.74
USNO	35 268	2.28	1.42	1.82	2.94	2.33	2.11	3.78	2.97	2.49	3.57	2.55	3.03
USNO	35 270	-10.13	-10.33	-11.04	-10.51	-11.13	-11.12	-11.48	-10.75	-11.05	-10.53	-11.09	-10.93
USNO	35 279	1.57	1.57	1.19	1.04	1.75	1.51	1.44	1.24	1.90	1.50	1.94	2.35
USNO	35 389	-23.33	-23.45	-23.99	-24.15	-23.89	-24.02	-25.01	-25.43	-25.63	-25.65	-24.32	-24.74
USNO	35 392	7.24	7.64	7.58	8.11	7.18	7.79	7.86	7.28	8.05	7.84	8.49	8.20
USNO	35 394	10.61	10.36	11.39	11.51	11.74	11.44	11.16	11.64	11.45	10.91	11.12	-
USNO	35 416	-24.04	-23.73	-24.48	-23.57	-23.48	-23.35	-23.30	-23.62	-23.88	-23.93	-24.79	-24.06
USNO	35 417	9.14	9.81	8.77	9.50	8.96	9.53	9.56	9.09	8.15	7.66	8.20	8.99
USNO	35 703	-7.75	-7.88	-7.82	-7.99	-8.46	-8.06	-8.22	-7.95	-7.64	-7.44	-7.16	-7.34
USNO	35 717	-15.04	-14.51	-14.76	-14.57	-14.71	-14.88	-14.87	-14.06	-14.09	-14.72	-14.18	-14.06
USNO	35 762	-4.79	-4.68	-4.63	-4.66	-4.19	-4.95	-4.57	-4.37	-4.52	-4.57	-5.13	-5.13
USNO	35 763	-15.05	-15.39	-15.27	-16.07	-15.21	-15.25	-15.15	-15.12	-15.05	-14.52	-14.45	-15.27
USNO	35 765	-9.59	-8.49	-8.65	-7.59	-7.57	-7.69	-7.88	-7.03	-6.90	-6.67	-6.54	-7.01
USNO	35 1096	25.79	25.11	26.10	26.32	26.69	26.68	25.66	27.55	26.45	29.89	27.21	26.22
USNO	35 1097	9.45	9.94	11.01	11.05	11.10	9.59	9.89	9.98	9.18	9.05	9.94	9.64
USNO	35 1125	23.20	-	-	21.85	21.70	21.39	20.59	20.93	21.44	21.41	20.01	20.16
USNO	35 1327	7.72	9.14	8.83	8.39	8.98	9.39	8.93	8.32	8.94	9.63	10.17	9.46
USNO	35 1328	6.52	7.12	6.26	5.63	6.47	5.44	5.62	5.34	5.86	5.88	6.14	6.76
USNO	35 1331	-5.48	-5.39	-5.45	-4.85	-5.36	-5.45	-3.91	-3.94	-4.73	-3.63	-3.00	-3.91
USNO	35 1438	2.62	2.89	2.64	2.37	2.40	2.21	2.04	2.02	1.49	1.79	2.68	2.73
USNO	35 1459	-2.28	-2.39	-3.02	-2.74	-2.45	-2.70	-2.72	-2.54	-3.41	-3.45	-3.39	-3.84
USNO	35 1462	8.67	9.10	9.98	9.73	10.21	9.52	10.49	10.16	9.71	9.75	9.90	9.55
USNO	35 1463	7.01	10.06	10.39	10.39	10.46	10.64	10.74	10.56	9.99	10.55	9.97	11.27
USNO	35 1468	-0.28	-1.10	-0.58	-0.62	-0.22	-0.20	0.10	-0.96	-1.12	-1.06	-0.76	-0.29
USNO	35 1481	3.08	3.37	2.91	3.50	3.47	2.74	3.70	4.63	3.50	3.29	6.67	6.03
USNO	35 1543	9.45	7.78	8.47	8.59	8.38	8.60	9.27	9.56	8.79	9.02	9.23	9.84
USNO	35 1573	7.08	7.88	6.78	7.00	6.95	6.84	5.86	6.73	7.17	7.38	7.14	5.07
USNO	35 1575	-3.11	-3.68	-3.16	-2.52	-2.84	-2.80	-2.82	-2.39	-2.08	-1.74	-1.83	-1.14

Table 8A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
USNO	35 1655	-13.48	-14.60	-14.01	-13.11	-13.47	-13.79	-13.39	-13.44	-13.48	-13.63	-12.77	-13.30
USNO	35 1692	5.32	4.99	5.56	5.58	5.58	5.42	4.84	4.89	4.89	-	-	4.43
USNO	35 1694	1.72	0.81	1.32	-	-	0.41	0.45	0.10	0.18	0.31	-0.35	-0.06
USNO	35 1696	3.65	3.94	3.46	3.77	3.67	3.38	4.07	3.60	3.54	3.50	2.96	3.77
USNO	35 1697	-0.44	-0.74	-0.58	-0.77	0.12	-0.19	-1.13	-0.01	0.08	0.61	0.25	0.70
USNO	35 1698	12.41	12.90	12.80	13.01	13.14	12.96	13.15	13.33	12.45	11.97	13.60	13.37
USNO	40 701	-27.70	-27.50	-27.64	-27.64	-27.56	-27.52	-27.54	-27.52	-27.50	-27.38	-27.50	-27.11
USNO	40 702	-10.49	-10.43	-10.48	-10.45	-10.41	-9.73	-8.99	-10.15	-10.13	-10.07	-10.15	-9.43
USNO	40 703	0.31	4.20	0.92	0.78	-1.00	-	-	-98.85	-98.90	-104.58	-104.21	-114.09
USNO	40 704	6.22	6.52	6.67	6.88	6.98	7.26	7.33	7.40	7.63	7.85	7.98	8.15
USNO	40 705	-43.55	-43.43	-43.53	-43.67	-43.92	-44.06	-44.23	-44.49	-44.52	-44.62	-44.76	-44.86
USNO	40 708	16.28	16.67	17.00	17.45	17.66	18.06	18.42	18.71	19.03	19.48	19.69	20.14
USNO	40 709	-17.93	-	-	-	-24.73	-25.36	-25.25	-25.08	-24.82	-24.56	-	-
USNO	40 710	39.38	39.86	39.98	40.45	40.71	40.99	41.47	41.95	42.40	42.92	43.38	43.84
USNO	40 711	134.65	136.41	138.23	140.31	142.26	144.09	145.82	147.48	149.18	150.90	152.62	154.56
USNO	40 712	-6.60	-	-	-5.21	-5.04	-4.96	-4.92	-4.86	-4.76	-4.56	-4.51	-4.35
USNO	40 713	-6.15	-5.73	-5.85	-5.38	-5.14	-4.94	-4.77	-4.52	-4.28	-4.15	-3.45	-3.22
USNO	40 714	-41.90	-41.42	-41.49	-40.97	-40.75	-40.57	-40.30	-40.10	-39.78	-39.55	-39.22	-39.03
USNO	40 715	-14.40	-14.10	-13.97	-13.72	-13.55	-13.36	-13.12	-12.96	-12.76	-12.53	-12.44	-12.21
USNO	40 716	205.15	205.32	205.01	205.24	205.28	205.24	205.21	205.23	205.26	205.25	205.33	205.19
USNO	40 718	120.16	119.92	119.43	119.05	118.71	118.47	118.25	117.99	117.81	117.64	-	117.52
USNO	40 719	-59.71	-58.54	-57.41	-56.06	-54.78	-53.47	-52.31	-51.30	-50.24	-49.06	-48.02	-46.69
USNO	40 720	-	-	-	-	-	-	-	-46.70	-47.82	-48.75	-49.69	-50.11
VSL	35 179	6.20	7.44	8.32	9.22	9.13	8.78	8.31	7.11	7.13	8.57	8.14	7.63
VSL	35 456	-	-	-	19.80	17.68	16.97	16.54	16.73	16.13	17.69	16.93	17.11
VSL	35 548	9.49	10.38	10.58	10.17	9.80	11.65	11.22	11.42	11.00	11.29	10.95	11.26
VSL	35 731	17.04	16.87	16.94	16.65	17.09	16.84	16.84	16.77	17.16	18.14	17.31	17.74

Table 8B. Corrections for an homogeneous use of the clock rates published in the current and previous Annual Reports

Each line refers to the same clock working without interruption.

	clock nø		2002 corr. (ns/d)	2001 corr. (ns/d)	2000 corr. (ns/d)	1999 corr. (ns/d)
AUS	36	340				3.28
BEV	16	71	+1.04 (1)			
IGMA	16	112		-0.50	-0.50	-0.50 (2)
LT	35	1362		+3.28 (3)		
NPL	40	1701	-3.00	-4.00	-4.80	-6.60 (4)
ORB	40	2601	-1.73	-6.03 (5)		
PL	35	441	+2.16			
PL	35	761			-4.32 (6)	
PL	35	1120	+1.64	+1.64	+9.25	+9.25
PL	35	1660	+0.58	-0.44 (7)		
PL	35	1746	+4.40			
PTB	40	510	-2.50			
ROA	35	583	-1.64			
SG	35	1035	-4.00	-4.00	-4.00	
SU	40	3802		-26.00 (8)		
SU	40	3803	-6.50 (9)			
SU	40	3810	-3.00	-1.00 (10)		
TL	40	3052	-69.12			

(1) A correction of +1.04 ns/d has to be applied for the last 5 months of 2002.
(2) A correction of -0.50 ns/d has to be applied for the last 5 two-month intervals of 1996, in 1997 and 1998.
(3) A correction of +3.28 ns/d has to be applied for the last 5 months of 2001.
(4) A correction of -8.20 ns/d has to be applied in 1998. A correction of -11.00 has to be applied in 1997, a correction of -12.2 ns/d has to be applied in 1996, a correction of -8.55 ns/d has to be applied in 1995, 1994, 1993 and 1992, and a correction of +18.45 ns/d has to be applied in 1991.
(5) A correction of -6.03 ns/d has to be applied for the last four months of 2001.
(6) A correction of -4.32 ns/d has to be applied for the last two months of 2000.
(7) A correction of -0.44 ns/d has to be applied for the last four months of 2001.
(8) A correction of -26.00 ns/d has to be applied for the last four months of 2001.
(9) A correction of -6.50 ns/d has to be applied for the last month of 2002.
(10) A correction of -1.00 ns/d has to be applied for the last four months of 2001.

Table 9A. Relative weights (in percent) of contributing clocks in 2003

(File available on http://www.bipm.org under the name WTAI03.AR)

Clock weights are computed for one-month intervals ending at the MJD dates given in the table, "-" denotes that the clock was not used.

The first two digits of the clock code indicate its type:

12 HEWLETT-PACKARD 5061A	4x HYDROGEN MASERS	34 H-P 5061A/B with 5071A tube
13 EBAUCHES, OSCILLATOM B5000	9x PRIMARY CLOCKS AND PROTOTYPES	35 H-P/AGILENT 5071A High perf.
14 HEWLETT-PACKARD 5061A OPT. 4	21 OSCILLOQUARTZ 3210	36 H-P/AGILENT 5071A Low perf.
16 OSCILLOQUARTZ 3200	23 OSCILLOQUARTZ EUDICS 3020	50 FREQ. AND TIME SYSTEMS INC. 4065A
17 OSCILLOQUARTZ 3000	30 HEWLETT-PACKARD 5061B	51 DATUM/SYMMETRICOM 4065 B
15 DATUM/SYMMETRICOM Cs III	31 HEWLETT-PACKARD 5061B OPT. 4	52 DATUM/SYMMETRICOM 4065 C

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
AUS	36	299	0.279	0.263	0.256	0.241	0.237	0.244	0.171	0.217	0.217	0.252	0.186	0.180
AUS	36	340	0.179	0.162	0.162	0.154	0.116	0.115	0.115	0.119	0.146	0.215	0.244	0.261
AUS	36	654	0.150	0.330	0.288	0.287	0.243	0.311	0.436	0.400	0.421	0.426	0.397	0.374
AUS	36	1035	0.034	0.046	0.059	0.073	0.082	0.089	-	0.000	0.000	0.000	0.000	-
AUS	36	1141	0.158	0.156	0.153	0.140	0.169	-	-	-	-	-	-	-
AUS	40	5401	0.000	0.000	-	0.000	0.000	-	-	-	-	-	-	0.000
AUS	40	5402	0.014	-	-	-	-	0.000	-	0.000	0.000	0.000	0.000	0.002
AUS	40	5403	0.000	0.001	-	-	0.000	0.000	0.000	-	-	-	-	-
AUS	99	1	-	0.000	-	-	-	-	0.000	0.000	-	-	-	-
BEV	16	71	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BEV	35	1065	0.334	-	-	0.000	0.000	0.000	-	-	0.000	0.000	0.000	0.000
BEV	35	1793	0.601	0.861	-	-	-	0.000	0.000	0.000	0.000	0.171	0.249	0.333
CAO	35	939	-	-	-	-	-	0.000	0.000	0.000	0.000	0.057	0.069	0.041
CAO	35	1270	-	-	-	-	-	0.000	0.000	0.000	0.000	0.125	0.047	0.037
CH	21	194	0.040	0.043	0.030	0.000	0.013	0.008	0.008	0.007	0.006	0.006	0.005	0.004

Table 9A. (Cont.)

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
CH	21	217	0.042	0.041	–	–	–	–	–	–	–	–	–	–
CH	31	403	0.029	0.018	–	–	–	–	–	–	–	–	–	–
CH	35	413	0.025	0.033	0.063	0.073	–	–	–	–	–	–	–	–
CH	35	771	0.307	0.244	0.270	0.298	0.281	–	–	0.000	0.000	0.000	0.000	1.087
CH	36	354	0.654	0.755	0.841	0.591	0.000	0.280	0.275	0.295	0.000	0.139	0.094	0.094
CH	40	5701	–	–	–	–	0.000	–	–	0.000	0.000	0.000	0.000	0.008
CNM	35	1705	0.064	0.057	0.059	0.060	0.062	0.074	0.082	0.102	0.161	0.303	0.384	0.367
CNM	35	1815	–	0.000	0.000	0.000	0.000	0.238	0.310	0.419	0.546	0.281	0.313	0.319
CNM	36	1537	0.125	0.133	0.154	0.149	0.179	0.322	0.406	0.390	0.376	0.000	0.181	0.124
CNM	40	7301	–	0.000	0.000	0.000	0.000	0.003	0.004	0.004	0.004	0.000	0.001	0.001
CNMP	36	1752	–	–	–	–	–	–	–	–	–	–	0.000	0.000
CRL	35	112	1.072	1.082	1.096	0.979	0.723	0.789	0.742	0.774	0.831	0.816	0.729	0.500
CRL	35	144	0.542	0.535	0.507	0.493	0.445	0.672	1.101	1.111	1.136	1.131	1.121	–
CRL	35	332	1.106	0.957	0.825	0.720	0.493	0.581	0.456	0.000	0.310	0.408	0.396	0.398
CRL	35	342	0.000	0.629	0.564	0.592	0.637	0.717	0.593	0.588	0.487	0.534	0.516	0.501
CRL	35	343	0.471	0.327	0.371	0.454	0.277	0.281	0.274	0.268	0.332	0.363	0.390	0.336
CRL	35	715	0.247	0.297	0.300	0.341	0.303	0.206	0.173	0.143	0.191	0.230	0.257	0.349
CRL	35	732	0.540	0.409	0.326	0.273	0.281	0.211	0.223	0.000	0.140	0.162	0.154	0.146
CRL	35	907	0.435	0.466	0.539	0.564	0.000	0.276	0.224	–	–	–	–	0.000
CRL	35	908	0.155	0.133	0.134	–	–	–	0.000	0.000	0.000	0.000	0.149	0.203
CRL	35	1778	1.106	0.755	0.987	1.082	1.082	1.070	0.968	0.951	0.920	0.940	1.121	1.087
CRL	35	1789	0.440	0.228	0.227	0.223	0.239	0.274	0.271	0.300	0.342	0.696	1.121	1.087
CRL	35	1790	0.767	0.810	0.861	0.775	0.000	0.340	0.310	0.354	0.317	0.343	0.418	0.463
DLR	35	1714	–	–	–	–	–	–	–	0.000	0.000	0.000	0.000	0.897
DTAG	36	136	0.000	0.005	0.006	0.008	0.011	0.014	0.016	0.017	0.021	0.000	0.007	0.007
DTAG	36	345	0.000	0.000	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.007
DTAG	36	465	0.000	0.058	0.073	0.047	0.049	0.061	0.067	0.081	0.092	0.101	0.123	0.116
F	16	106	0.000	0.079	0.041	–	–	–	–	–	–	–	–	–
F	35	122	0.200	0.320	0.737	1.082	1.082	0.000	0.684	0.750	0.674	0.702	0.650	0.741
F	35	124	1.106	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	0.000	0.502	0.433

Table 9A. (Cont.)

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
F	35	131	-	-	0.000	0.000	0.000	0.000	0.804	1.065	1.136	1.131	1.106	0.915
F	35	158	1.106	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
F	35	172	1.106	1.082	1.096	1.075	0.886	1.026	0.941	0.949	0.967	1.078	1.121	1.087
F	35	198	0.420	0.461	0.666	0.917	0.951	1.078	1.051	0.984	1.136	1.131	1.121	1.087
F	35	355	0.025	0.036	0.044	0.054	-	-	-	-	-	-	-	-
F	35	385	0.609	0.882	0.822	0.664	0.594	0.000	0.317	0.324	0.320	0.300	-	-
F	35	396	1.106	1.082	1.096	1.082	0.000	0.643	0.566	0.623	0.631	0.604	0.499	0.363
F	35	469	0.000	0.000	0.000	0.000	-	-	-	-	-	-	-	-
F	35	489	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.233	0.325
F	35	520	0.000	0.000	0.000	0.000	0.099	0.123	0.059	0.078	0.097	0.123	0.141	0.161
F	35	536	0.985	1.041	1.096	1.070	1.034	1.078	0.920	1.111	1.136	1.131	1.121	1.087
F	35	609	-	-	-	-	-	-	-	-	-	-	-	0.000
F	35	770	-	0.000	0.000	0.000	0.000	0.141	0.178	0.243	0.318	0.427	0.457	0.536
F	35	774	0.304	0.325	0.293	0.276	0.243	0.237	0.216	0.293	-	-	-	-
F	35	781	0.186	0.194	0.189	0.211	0.209	0.255	0.436	0.729	0.796	1.131	1.092	1.087
F	35	819	-	-	-	-	-	0.000	0.000	0.000	0.000	0.120	0.171	0.194
F	35	1029	-	-	-	-	0.000	0.000	0.000	0.000	0.222	0.347	0.303	0.393
F	35	1177	-	-	0.000	-	-	0.000	0.000	0.000	0.000	0.377	0.459	0.392
F	35	1178	-	-	0.000	-	-	0.000	0.000	0.000	0.000	1.131	1.121	1.087
F	35	1222	-	-	-	0.000	0.000	0.000	0.000	0.132	0.163	0.242	0.314	0.347
F	35	1321	0.000	0.357	0.349	0.323	-	-	-	-	0.000	0.000	0.000	0.000
F	35	1556	-	0.000	0.000	0.000	0.000	0.027	0.027	0.024	0.030	0.040	0.048	0.053
F	40	805	-	-	0.000	0.000	0.000	0.000	0.008	0.004	0.004	0.005	0.006	0.007
F	40	816	0.000	0.000	0.000	0.593	0.250	0.350	0.135	0.000	0.000	-	-	0.000
IEN	35	219	0.329	0.403	0.426	0.472	0.538	1.078	1.101	1.111	1.136	1.131	0.000	0.899
IEN	35	505	0.000	0.000	0.000	0.000	0.180	0.246	0.297	0.208	0.221	0.224	0.229	0.259
IEN	35	1115	0.266	0.333	0.381	0.332	0.233	0.216	0.154	0.114	0.084	0.085	0.081	-
IEN	35	1373	0.140	0.178	0.208	0.203	0.216	0.259	0.000	0.026	0.025	0.027	0.027	0.027
IEN	40	1101	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.000	0.000
IEN	40	1102	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.000

Table 9A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
IFAG	36 1167	0.044	0.047	0.051	0.055	0.054	0.054	0.043	0.046	0.070	0.071	0.068	0.067
IFAG	36 1173	0.032	0.035	0.034	0.036	0.041	0.035	0.029	0.021	0.021	0.026	0.031	0.019
IFAG	36 1629	0.170	0.179	0.188	0.198	0.262	0.232	0.215	0.231	0.226	0.203	0.182	0.179
IFAG	36 1732	0.596	0.862	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.078
IFAG	36 1798	0.191	0.284	0.317	0.343	0.421	0.480	0.401	0.478	0.526	0.671	0.675	0.579
IFAG	40 4401	0.000	0.000	0.000	0.000	0.000	-	-	0.000	0.000	0.000	0.000	0.000
IFAG	40 4403	0.000	0.000	0.000	0.000	0.000	-	-	0.000	0.000	0.000	-	-
IFAG	40 4418	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
IGMA	16 112	0.006	0.006	0.006	0.009	0.008	0.009	0.008	0.006	0.006	0.007	0.008	0.007
IGMA	35 674	0.165	0.232	0.223	0.207	0.223	0.253	0.267	0.381	0.565	0.873	1.121	1.087
IGMA	35 676	0.210	0.234	0.200	0.185	0.218	0.231	0.490	0.519	0.783	1.007	0.881	0.947
INPL	35 1652	0.158	0.285	0.552	0.000	0.109	0.060	-	0.000	0.000	0.000	0.000	0.031
JV	21 216	-	-	-	0.000	0.000	0.000	-	0.000	0.000	-	0.000	0.000
JV	21 387	-	-	-	0.000	0.000	0.000	-	0.000	0.000	-	0.000	0.000
JV	36 1277	-	-	-	-	0.000	-	-	0.000	0.000	-	-	-
JV	51 2040	-	-	-	0.000	0.000	0.000	-	-	-	-	0.000	0.000
KRIS	36 321	-	-	0.000	0.000	0.000	0.000	1.101	1.111	0.000	0.251	0.264	0.261
KRIS	36 739	-	-	0.000	0.000	0.000	0.000	0.088	0.129	0.123	0.174	0.207	0.206
KRIS	36 1135	-	-	0.000	0.000	0.000	0.000	0.035	0.033	0.045	0.045	0.045	0.048
KRIS	36 1783	-	-	-	-	-	-	-	-	-	-	0.000	0.000
KRIS	40 5623	-	-	0.000	0.000	0.000	0.000	0.187	0.174	0.149	0.164	0.138	0.127
LDS	35 289	0.207	0.253	0.374	0.325	0.318	0.320	0.255	0.255	0.207	0.217	0.254	0.199
LT	35 1362	0.312	0.265	0.268	0.262	0.231	0.240	0.223	0.206	0.177	0.150	0.153	0.154
MSL	12 933	0.007	0.007	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
MSL	35 1025	0.008	0.007	0.007	0.007	0.007	0.010	-	0.000	0.000	-	-	-
MSL	36 274	0.080	0.078	0.069	0.067	0.062	0.069	0.111	0.188	0.189	0.182	0.192	0.182
NAO	35 779	0.102	0.133	0.169	0.210	0.252	0.311	0.337	0.446	-	-	0.000	0.000
NAO	35 1206	0.512	0.730	0.795	0.953	1.082	1.078	1.101	0.000	-	-	0.000	0.000
NAO	35 1214	0.206	0.239	0.304	0.380	0.456	0.561	0.622	0.807	-	-	0.000	0.000
NAO	35 1689	0.360	0.455	0.411	0.466	0.501	0.590	0.656	0.685	-	-	0.000	0.000

Table 9A. (Cont.)

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
NIM	35	479	0.000	0.000	0.000	0.000	1.082	1.078	1.101	1.111	1.136	0.000	0.000	0.112
NIM	35	1238	0.000	0.000	0.000	0.000	1.060	1.078	1.101	1.111	1.136	1.131	1.121	1.087
NIM	35	1239	0.000	0.000	0.000	0.000	1.082	0.847	1.099	1.111	1.136	0.000	0.776	0.822
NIMB	35	600	0.000	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.001	0.001	0.001
NIST	15	9866	-	0.000	0.000	0.000	0.000	0.009	0.004	0.002	0.002	0.001	0.001	0.001
NIST	35	132	0.919	1.024	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	0.000	0.998
NIST	35	182	0.000	0.000	0.000	1.082	1.041	0.567	0.500	0.642	0.792	0.960	1.085	1.041
NIST	35	408	0.465	0.502	0.458	0.549	0.486	0.507	0.503	0.438	0.758	0.908	0.889	0.997
NIST	35	1074	0.148	0.141	0.132	0.129	0.131	0.138	0.095	-	0.000	0.000	0.000	0.000
NIST	40	201	0.009	0.010	0.010	0.011	0.012	0.014	0.015	0.018	0.023	0.033	0.045	0.068
NIST	40	203	0.017	0.017	0.016	0.015	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013
NIST	40	204	0.364	0.356	0.329	0.279	0.240	0.214	0.185	0.192	0.209	0.243	0.264	0.274
NIST	40	205	0.366	0.397	0.398	0.433	0.485	0.579	0.582	0.677	0.732	0.768	0.783	0.733
NIST	40	222	1.106	1.082	1.096	1.082	1.082	1.078	0.885	0.689	0.562	0.553	0.487	0.439
NMC	35	1501	0.082	0.090	0.081	0.080	0.084	0.109	0.143	0.253	0.273	0.261	0.157	0.118
NMIJ	35	224	0.000	0.000	0.030	0.027	0.029	0.035	0.040	0.047	0.056	0.068	0.077	0.094
NMIJ	35	459	0.000	0.494	0.659	-	-	-	0.000	0.000	0.000	0.000	1.121	1.087
NMIJ	35	1273	0.000	1.082	0.600	0.453	0.541	0.491	0.559	0.683	0.807	0.875	0.790	0.977
NMIJ	35	1466	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.470	0.555
NMIJ	40	5014	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.796	0.000
NMLS	35	1659	0.061	0.059	0.044	0.000	0.014	0.014	0.013	0.014	0.014	0.015	0.015	0.014
NPL	35	784	0.307	0.382	0.488	0.474	0.380	0.415	0.414	0.432	0.593	0.725	0.782	0.666
NPL	35	1275	0.186	0.206	0.204	0.202	0.350	0.389	0.414	0.315	0.269	0.341	0.452	0.304
NPL	36	404	0.044	0.045	0.040	0.040	0.040	0.049	0.053	0.057	0.094	0.108	0.117	0.000
NPL	40	1701	0.933	0.767	0.642	0.531	0.463	0.462	0.480	0.434	0.501	0.591	0.614	0.753
NPL	40	1708	0.639	0.762	0.665	0.653	0.442	0.320	0.247	0.213	0.185	0.181	0.234	0.273
NPLI	35	725	-	0.000	0.000	0.000	0.000	-	0.000	0.000	0.000	-	-	-
NRC	35	234	0.822	0.876	0.848	0.988	1.060	1.032	1.058	0.855	0.616	0.714	0.711	0.686
NRC	35	372	0.000	0.286	0.365	0.480	0.467	0.286	0.000	0.117	0.140	0.159	0.143	0.138
NRC	90	61	0.419	0.390	0.391	0.410	0.406	0.422	0.419	0.403	0.465	0.659	0.696	0.685

Table 9A. (Cont.)

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
NTSC	35	1007	1.106	-	-	-	-	-	-	-	-	-	-	-
NTSC	35	1008	0.327	0.282	0.327	0.497	0.420	0.398	0.370	0.416	0.416	-	-	-
NTSC	35	1011	1.106	1.082	0.903	-	-	-	-	-	-	-	-	-
NTSC	35	1016	0.595	0.593	0.737	0.738	0.637	0.704	0.664	-	-	-	-	-
NTSC	35	1017	0.210	0.207	0.200	0.199	0.196	0.191	0.195	0.215	-	-	-	-
NTSC	35	1018	0.461	1.030	1.096	1.082	1.082	1.078	1.101	1.111	1.038	1.050	0.805	0.802
NTSC	35	1818	-	0.000	0.000	0.000	-	-	-	-	0.000	0.000	0.000	0.000
NTSC	35	1820	-	0.000	0.000	0.000	0.000	1.078	0.000	0.072	0.042	0.043	-	-
NTSC	35	1823	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
OMH	36	849	0.070	0.061	0.060	0.053	0.052	0.051	-	0.000	0.000	0.000	0.000	0.015
ONRJ	35	903	0.213	0.240	0.236	0.560	0.706	0.808	0.883	0.682	0.737	0.634	0.659	-
ORB	35	201	0.115	0.138	0.162	0.396	0.000	0.205	0.194	0.187	0.199	0.187	0.137	0.139
ORB	35	202	0.063	0.064	0.062	0.077	0.075	0.079	0.073	0.097	0.101	0.092	0.070	0.060
ORB	35	593	0.112	0.116	0.119	0.163	0.000	0.101	0.088	0.103	0.097	0.078	0.066	0.065
ORB	40	2601	0.035	0.030	0.027	0.027	0.036	0.062	0.075	0.188	0.325	0.230	0.215	0.236
PL	35	441	0.317	0.322	0.447	0.000	0.223	0.170	0.115	0.078	0.074	0.076	0.079	0.000
PL	35	502	-	-	-	-	-	-	0.000	0.000	0.000	0.000	1.121	0.881
PL	35	761	0.128	0.118	0.124	0.133	0.113	0.157	0.135	0.183	0.166	0.177	0.156	0.134
PL	35	1120	0.563	0.715	0.672	0.656	0.494	0.421	0.269	0.228	0.241	0.206	0.181	0.152
PL	35	1660	0.120	0.144	0.152	0.170	0.181	0.191	0.175	0.164	0.150	0.161	0.157	0.153
PL	35	1709	-	-	-	-	0.000	0.000	0.000	0.000	0.291	0.371	0.506	0.598
PL	35	1746	0.195	0.233	0.228	0.257	0.239	0.410	0.371	0.670	0.974	1.108	1.010	0.939
PL	40	4002	-	-	-	-	-	-	-	-	-	-	-	0.000
PTB	35	128	0.318	0.491	0.616	0.559	0.554	0.562	0.459	0.634	1.136	1.131	1.121	1.087
PTB	35	415	0.082	0.110	0.120	0.171	0.264	0.264	0.198	0.253	0.245	0.328	0.607	0.585
PTB	35	1072	1.106	1.082	1.096	1.082	1.082	0.000	0.528	0.541	-	0.000	0.000	-
PTB	40	502	0.009	0.008	0.008	0.000	0.000	-	-	-	-	-	-	-
PTB	40	505	0.076	0.078	0.075	0.086	0.077	0.089	0.061	0.052	0.042	0.041	0.035	0.000
PTB	40	510	0.012	0.013	0.013	0.014	0.016	0.018	0.024	0.031	0.000	0.018	0.012	0.009
PTB	92	1	1.106	1.082	1.096	1.082	0.724	0.724	0.555	0.478	0.528	0.534	0.514	0.557

Table 9A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
PTB	92 2	1.106	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
PTB	92 3	1.106	1.082	1.090	1.082	0.972	0.974	0.831	0.812	0.809	0.756	-	-
ROA	14 1569	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003
ROA	35 583	0.188	0.234	0.275	0.322	0.315	0.399	0.371	0.404	0.395	0.412	0.396	0.387
ROA	35 718	0.059	0.051	0.061	0.066	0.076	0.085	0.100	0.125	0.128	0.185	0.312	0.366
ROA	36 1488	0.061	0.077	0.080	0.094	0.101	0.104	0.323	0.205	0.202	0.214	0.198	0.196
ROA	36 1490	0.074	0.091	0.106	0.124	0.155	0.177	0.169	0.147	0.149	0.159	0.163	0.270
SCL	35 621	0.859	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.046	1.087	0.892	0.669
SCL	35 745	0.050	0.520	0.447	0.416	0.467	0.462	0.495	0.560	0.543	0.355	0.278	0.226
SG	35 1035	0.853	1.018	0.773	0.000	0.060	0.047	-	-	0.000	0.000	0.000	0.000
SG	35 1127	0.397	0.285	0.247	0.205	0.188	0.177	-	-	0.000	0.000	0.000	0.000
SG	36 522	0.380	0.333	0.239	0.197	0.212	0.190	-	-	0.000	0.000	-	0.000
SMU	36 1063	0.525	0.363	0.237	0.207	0.217	0.225	0.196	0.193	0.218	0.232	0.233	0.227
SP	19 197	0.009	0.011	0.008	0.006	0.004	0.003	0.003	0.003	0.003	0.004	0.003	0.004
SP	35 641	0.010	0.011	0.012	0.012	0.014	0.016	-	-	0.000	0.000	0.000	0.000
SP	35 1188	0.051	0.046	0.040	0.036	0.034	0.037	-	-	0.000	0.000	0.000	0.000
SP	35 1642	0.277	0.237	0.211	0.284	0.313	0.295	-	-	0.000	0.000	0.000	0.000
SP	36 1175	0.215	0.197	0.193	0.163	0.000	0.050	0.047	0.042	0.039	0.039	0.037	0.034
SP	40 7201	-	-	0.000	0.000	0.000	0.000	-	-	0.000	0.000	0.000	0.000
SP	40 7218	-	-	-	0.000	0.000	0.000	0.000	0.003	0.003	0.003	0.002	0.002
SU	40 3802	0.076	0.073	0.072	0.063	0.062	0.063	0.057	0.058	0.057	0.063	0.071	0.077
SU	40 3803	0.000	0.000	0.000	0.154	0.132	0.116	0.097	0.084	0.074	0.060	0.056	0.060
SU	40 3805	0.015	0.014	0.013	0.012	0.012	0.014	0.014	0.017	0.022	0.032	0.045	0.067
SU	40 3807	-	0.000	0.000	0.000	0.000	0.047	0.056	0.077	0.096	0.128	0.155	0.185
SU	40 3810	0.007	0.006	0.006	0.005	0.005	0.005	0.005	0.006	0.007	0.011	0.016	0.024
SU	40 3825	0.011	0.011	0.011	0.010	0.009	0.009	0.009	0.009	0.009	0.011	0.012	0.011
SU	40 3827	0.778	0.437	0.442	0.533	0.530	0.507	0.513	0.442	0.412	0.364	0.378	0.366
SU	40 3831	0.048	0.051	0.043	0.039	0.037	0.037	0.031	0.030	0.031	0.032	0.033	0.030
SU	40 3837	0.068	0.070	0.071	0.067	0.066	0.072	0.069	0.080	0.082	0.088	0.091	0.089
TCC	35 768	-	-	-	-	-	-	-	-	-	-	-	0.000

Table 9A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
TCC	35 1028	0.000	0.000	0.000	0.272	0.376	0.247	0.304	0.000	0.136	-	-	-
TCC	35 1881	-	-	-	-	-	-	-	-	-	-	-	0.000
TCC	40 8620	0.000	0.000	0.000	0.011	0.010	0.010	0.009	0.009	0.010	0.010	0.009	0.010
TCC	40 8624	0.000	0.000	0.000	1.082	0.468	0.545	0.361	0.243	0.000	0.122	0.101	0.083
TL	35 160	0.094	0.120	0.093	0.083	0.073	0.074	0.092	0.114	0.212	0.305	0.284	0.252
TL	35 300	0.518	0.000	0.220	0.169	0.165	0.151	0.121	0.095	0.086	0.114	0.103	0.097
TL	35 474	0.000	0.000	0.000	0.191	0.196	0.226	0.175	0.217	0.263	0.339	0.383	0.793
TL	35 809	-	-	-	-	-	-	-	-	-	-	0.000	0.000
TL	35 1012	0.055	0.197	0.247	0.243	0.181	0.207	0.142	-	-	-	-	-
TL	35 1132	-	-	-	-	-	-	-	-	-	-	0.000	0.000
TL	35 1498	0.289	0.229	0.203	0.264	0.282	0.535	0.411	0.408	0.483	0.508	1.083	0.973
TL	35 1500	0.250	0.448	0.430	0.382	0.328	0.457	0.389	0.369	0.479	-	-	-
TL	35 1712	1.022	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
TL	40 3052	0.009	0.009	0.008	0.007	0.006	0.006	0.008	-	-	-	-	-
TL	40 3053	-	-	-	-	-	-	-	-	-	-	0.000	0.000
TP	35 163	0.060	0.085	0.147	0.280	0.333	0.545	0.570	0.791	-	-	-	0.000
TP	35 326	-	-	0.000	0.000	0.000	0.000	0.083	0.121	0.136	0.166	0.200	0.243
TP	35 1227	1.066	1.082	1.096	1.082	1.082	1.078	1.101	1.065	0.930	1.022	0.888	0.890
TP	36 154	0.294	0.274	0.278	0.272	0.461	0.495	0.448	0.407	0.565	0.588	0.414	0.356
UME	35 252	0.000	0.549	0.443	0.506	-	-	-	-	-	-	-	-
UME	35 872	0.144	0.182	0.142	0.133	-	-	-	-	-	-	-	-
USNO	35 101	1.106	1.082	1.068	0.924	0.810	0.622	0.538	0.492	0.568	0.560	0.411	0.237
USNO	35 104	0.749	0.780	0.585	0.509	0.540	0.652	0.632	0.485	0.436	0.466	0.575	0.503
USNO	35 108	0.668	0.768	0.933	0.762	0.701	0.547	0.504	0.300	0.305	0.381	0.298	0.299
USNO	35 114	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.088
USNO	35 120	0.778	0.665	0.000	0.212	0.240	0.241	0.232	0.245	0.230	0.272	0.333	0.444
USNO	35 142	0.870	0.927	0.000	0.394	0.562	0.606	0.724	0.777	0.560	0.615	0.759	0.807
USNO	35 146	1.106	1.082	0.837	0.883	0.892	0.000	0.378	0.378	0.390	0.424	0.331	0.273
USNO	35 148	0.307	0.000	0.065	0.061	0.064	0.068	0.066	0.076	0.086	0.105	0.134	0.206
USNO	35 150	0.563	0.699	0.000	0.212	0.177	0.188	0.190	0.161	0.123	0.141	0.144	0.183

Table 9A. (Cont.)

Lab.	Clock		52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
USNO	35	152	0.501	0.559	0.655	0.704	0.668	0.731	0.765	0.853	0.818	0.855	0.979	0.884
USNO	35	153	0.805	0.613	0.855	1.082	1.082	0.855	0.979	0.858	0.880	0.883	0.626	0.533
USNO	35	156	0.677	0.762	1.096	0.000	0.700	0.693	0.634	0.604	0.690	0.737	0.718	0.533
USNO	35	161	1.106	1.082	1.049	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
USNO	35	164	0.374	0.418	0.432	0.613	0.738	0.841	0.707	0.738	1.136	-	-	0.000
USNO	35	165	0.000	0.432	0.533	0.512	0.630	0.403	0.451	0.525	0.341	0.228	0.213	0.231
USNO	35	166	0.223	0.228	0.228	0.253	0.294	0.363	0.527	0.720	0.572	0.553	0.510	0.484
USNO	35	167	1.053	1.082	1.096	0.000	0.850	0.603	-	-	0.000	0.000	0.000	0.000
USNO	35	169	0.573	0.773	0.964	0.948	0.618	0.581	-	-	0.000	0.000	0.000	0.000
USNO	35	171	0.000	0.386	0.542	0.741	0.631	0.822	0.930	-	-	0.000	-	-
USNO	35	173	1.106	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
USNO	35	213	0.000	0.000	0.041	0.036	0.031	0.035	0.035	0.040	0.048	0.064	0.085	0.219
USNO	35	217	1.106	1.082	0.930	0.808	0.803	0.810	0.816	1.032	-	-	0.000	0.000
USNO	35	225	0.167	0.216	0.000	0.157	0.155	0.146	0.126	0.119	0.118	0.119	0.109	0.107
USNO	35	226	1.106	1.082	0.000	0.100	0.093	0.090	0.080	0.079	0.076	0.077	0.073	0.072
USNO	35	227	0.940	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
USNO	35	229	0.127	0.135	0.142	0.165	0.189	0.201	0.206	0.322	0.265	0.342	0.216	0.198
USNO	35	231	0.857	0.000	0.296	0.239	0.271	0.319	0.249	0.190	0.176	0.209	0.152	0.182
USNO	35	233	0.964	1.030	1.045	1.082	1.082	1.078	1.101	1.020	1.036	1.131	0.997	0.851
USNO	35	242	0.389	0.465	0.487	0.479	0.492	0.532	1.101	1.111	1.136	0.000	0.632	0.607
USNO	35	244	0.447	0.447	0.430	0.419	0.477	0.581	0.997	1.111	1.136	1.131	1.121	1.087
USNO	35	249	0.199	0.203	0.254	0.262	0.298	0.310	0.352	0.397	0.419	0.970	0.940	0.840
USNO	35	253	0.072	0.078	0.086	0.099	0.105	0.117	0.126	0.154	0.143	0.202	0.150	0.142
USNO	35	254	0.457	0.749	0.697	0.730	0.853	0.810	1.101	1.111	1.136	1.131	1.121	1.087
USNO	35	255	0.960	1.054	1.048	1.038	1.082	1.078	1.101	-	-	0.000	0.000	0.000
USNO	35	256	0.177	0.190	0.199	0.314	0.410	0.000	0.504	0.421	0.452	0.547	0.526	0.507
USNO	35	260	0.645	0.652	-	-	0.000	0.000	0.000	0.000	0.164	-	-	0.000
USNO	35	268	0.447	0.521	0.576	0.485	0.558	0.580	0.334	0.368	0.400	0.450	0.463	0.466
USNO	35	270	0.722	0.766	0.653	0.643	0.548	0.534	0.475	0.603	0.751	0.818	0.874	0.820
USNO	35	279	0.939	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087

Table 9A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
USNO	35 389	1.106	1.082	1.096	1.082	1.082	1.078	0.000	0.351	0.234	0.190	0.195	0.217
USNO	35 392	1.106	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
USNO	35 394	0.645	0.578	0.674	0.999	0.919	0.937	0.865	1.003	1.110	1.131	1.121	–
USNO	35 416	1.106	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	0.000	0.790
USNO	35 417	1.106	0.765	0.738	0.753	0.907	1.078	1.101	1.111	0.806	0.000	0.355	0.345
USNO	35 703	0.026	0.027	0.029	0.031	0.033	0.047	0.071	0.122	0.251	0.576	0.904	1.087
USNO	35 717	0.000	0.000	0.000	0.605	0.891	1.078	1.101	1.094	1.051	1.131	1.121	1.087
USNO	35 762	0.757	0.825	0.774	0.742	0.677	0.703	0.737	1.079	1.136	1.131	1.121	1.087
USNO	35 763	1.057	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
USNO	35 765	0.330	0.217	0.178	0.132	0.115	0.130	0.180	0.169	0.160	0.178	0.205	0.280
USNO	35 1096	0.271	0.599	0.578	0.512	0.441	0.411	0.448	0.301	0.366	0.000	0.138	0.133
USNO	35 1097	0.363	0.390	0.366	0.350	0.380	0.325	0.285	0.333	0.259	0.295	0.319	0.303
USNO	35 1125	1.106	–	–	0.000	0.000	0.000	0.000	0.229	0.339	0.504	0.278	0.249
USNO	35 1327	0.718	0.000	0.293	0.357	0.336	0.332	0.326	0.439	0.467	0.589	0.466	0.542
USNO	35 1328	0.000	0.000	0.282	0.277	0.250	0.254	0.243	0.306	0.323	0.373	0.421	0.485
USNO	35 1331	0.847	0.831	0.846	0.842	1.051	1.078	0.000	0.528	0.545	0.448	0.285	0.294
USNO	35 1438	1.106	1.082	1.096	1.082	1.082	1.078	1.101	1.111	0.757	0.748	0.764	0.767
USNO	35 1459	0.420	0.464	0.487	0.451	0.571	0.556	0.680	0.918	0.962	0.724	0.579	0.478
USNO	35 1462	0.465	0.403	0.400	0.389	0.475	0.470	0.474	0.473	0.462	0.490	0.482	0.870
USNO	35 1463	0.235	0.000	0.073	0.055	0.046	0.041	0.035	0.033	0.038	0.055	0.078	0.185
USNO	35 1468	1.106	0.810	0.915	0.968	0.994	1.020	1.101	1.111	0.830	0.778	0.723	0.931
USNO	35 1481	0.552	0.560	0.851	1.082	1.082	1.078	1.101	0.000	0.866	0.901	0.000	0.132
USNO	35 1543	0.799	0.000	0.176	0.151	0.153	0.160	0.150	0.177	0.206	0.302	0.409	0.619
USNO	35 1573	0.000	0.000	0.162	0.163	0.158	0.168	0.182	0.210	0.234	0.260	0.374	0.000
USNO	35 1575	0.389	0.571	0.634	0.547	0.858	0.973	1.101	1.020	0.970	0.817	0.655	0.494
USNO	35 1655	0.610	0.583	0.628	0.548	0.636	0.737	0.711	0.745	0.755	0.877	1.039	1.070
USNO	35 1692	0.145	0.181	0.206	0.226	0.322	0.379	0.338	0.459	0.425	–	–	0.000
USNO	35 1694	1.106	1.082	1.096	–	–	0.000	0.000	0.000	0.000	1.131	0.888	0.968
USNO	35 1696	0.441	0.545	0.479	0.628	0.646	0.620	0.748	0.791	0.993	0.934	0.976	1.087
USNO	35 1697	0.000	0.000	1.096	1.082	1.076	1.078	0.822	0.953	1.048	0.963	0.905	0.728

Table 9A. (Cont.)

Lab.	Clock	52669	52694	52729	52759	52789	52819	52849	52879	52909	52939	52969	53004
USNO	35 1698	1.098	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.073	0.927	0.910
USNO	40 701	1.106	1.082	1.096	1.082	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
USNO	40 702	1.106	1.082	1.096	1.082	1.082	1.078	1.081	1.111	1.136	1.131	1.121	1.087
USNO	40 703	1.106	0.000	0.212	0.202	0.135	-	-	0.000	0.000	0.000	0.000	0.002
USNO	40 704	0.701	0.704	0.639	0.622	0.623	0.622	0.612	0.664	0.732	0.756	0.765	0.780
USNO	40 705	0.224	0.230	0.250	0.247	0.251	0.264	0.260	0.275	0.297	0.357	0.384	0.440
USNO	40 708	0.158	0.168	0.162	0.162	0.157	0.157	0.146	0.145	0.145	0.148	0.146	0.143
USNO	40 709	0.000	-	-	-	0.000	0.000	0.000	0.000	0.832	0.978	-	-
USNO	40 710	0.046	0.042	0.075	0.076	0.080	0.088	0.087	0.092	0.096	0.103	0.102	0.099
USNO	40 711	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.005	0.004	0.004
USNO	40 712	1.106	-	-	0.000	0.000	0.000	0.000	1.111	1.136	1.131	1.121	1.087
USNO	40 713	0.567	0.513	0.556	0.526	0.488	0.497	0.445	0.425	0.374	0.397	0.315	0.277
USNO	40 714	1.015	0.745	0.708	0.570	0.463	0.428	0.348	0.317	0.289	0.290	0.274	0.276
USNO	40 715	1.007	1.018	0.902	0.858	0.775	0.714	0.613	0.579	0.541	0.534	0.535	0.528
USNO	40 716	0.070	0.128	0.253	0.856	1.082	1.078	1.101	1.111	1.136	1.131	1.121	1.087
USNO	40 718	0.022	0.026	0.031	0.035	0.041	0.051	0.057	0.069	0.083	0.107	-	0.000
USNO	40 719	0.000	0.000	0.024	0.020	0.017	0.015	0.012	0.011	0.011	0.011	0.011	0.010
USNO	40 720	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.035
VSL	35 179	0.553	0.555	0.435	0.263	0.221	0.235	0.243	0.229	0.212	0.221	0.240	0.225
VSL	35 456	-	-	-	0.000	0.000	0.000	0.000	0.039	0.047	0.070	0.089	0.110
VSL	35 548	0.953	1.082	1.096	1.082	1.082	0.000	0.583	0.491	0.478	0.478	0.479	0.505
VSL	35 731	0.418	0.452	0.501	0.478	0.560	0.616	0.559	0.811	1.091	1.013	1.110	1.087

Table 9B. Statistical data on the weights attributed to the clocks in 2003

Interval		Number of clocks			Number of clocks with a given weight									
					Weight = 0*			Weight = 0**			Max weight			Max relative weight %
		HM	5071A	Total	HM	5071A	Total	HM	5071A	Total	HM	5071A	Total	
2003	Jan.	45	173	256	8	17	30	3	7	10	5	23	31	1.106
2003	Feb.	44	176	260	9	18	29	3	10	14	3	28	34	1.082
2003	Mar.	45	178	262	10	20	34	2	6	9	3	26	32	1.096
2003	Apr.	48	176	265	9	18	34	3	7	12	4	27	35	1.082
2003	May	51	171	265	11	14	34	3	5	10	4	28	34	1.082
2003	June	46	177	264	8	17	32	0	6	7	4	31	37	1.078
2003	July	46	173	255	6	20	28	0	5	7	2	30	35	1.101
2003	Aug.	51	172	264	10	22	39	1	5	8	4	26	33	1.111
2003	Sep.	52	175	267	10	31	48	3	0	6	4	26	32	1.136
2003	Oct.	51	170	258	10	24	38	1	6	10	4	26	32	1.131
2003	Nov.	49	174	263	8	25	40	1	5	8	4	25	31	1.121
2003	Dec.	53	177	270	6	28	40	5	2	10	4	27	32	1.087

Wmax=A/N, here N is the number of clocks,excluding those with a priori null weight, A=2.50

* A priori null weight (test interval of new clocks).

** Null weight resulting from the statistics.

HM designates hydrogen masers and 5071A designates H-P/Agilent 5071A units with high performance tube.

Clocks with missing data during a one-month interval of computation are excluded.

TIME SIGNALS

The time signal emissions reported here follow the UTC system, in accordance with the Recommendation 460-4 of the Radiocommunication Bureau (RB) of the International Telecommunication Union (ITU) unless otherwise stated.

Their maximum departure from the Universal Time UT1 is thus 0.9 second.

The following tables are based on information received at the BIPM in February and May 2004.

AUTHORITIES RESPONSIBLE FOR THE TIME SIGNAL EMISSIONS

Signal	Authority
BPM	Time and Frequency Division National Time Service Center, NTSC (Formely Shaanxi Astronomical Observatory, CSAO) Chinese Academy of Sciences P.O. Box 18 - Lintong Shaanxi 710600, China
BSF	National Standard Time and Frequency Laboratory Telecommunication Laboratories Chunghwa Telecom. Co., Ltd. No. 12, Ln.551, Ming-Tsu Road Sec. 5 Yang-Mei, Taoyuan, 326 Taiwan, Rep. of China
CHU	National Research Council of Canada Institute for National Measurement Standards – Frequency and Time Standards Ottawa, Ontario, K1A 0R6, Canada
DCF77	Physikalisch-Technische Bundesanstalt Time and Frequency Department, WG 4.42 Bundesallee 100 D-38116 Braunschweig Germany
EBC	Real Instituto y Observatorio de la Armada Cecilio Pujazón s/n 11.110 San Fernando Cádiz, Spain
HBG	METAS METrology and Accreditation Switzerland Electricity, Acoustic and Time Section Lindenweg 50 CH-3003 Bern-Wabern Switzerland
HLA	Time and Frequency Laboratory Korea Research Institute of Standards and Science Yusong P.O. Box 102, Taejon 305-600 Republic of Korea

Signal	Authority
IAM	Istituto Superiore delle Comunicazioni e delle Tecnologie dell'Informazione Viale America, 201 00144 - Roma, Italia
JJY	Japan Standard Time Group Communications Research Laboratory 2-1, Nukui-kitamachi 4-chome Koganei-shi, Tokyo 184-8795 Japan
LDS	School of Electronic and Electrical Engineering Leeds University Leeds LS2 9JT United Kingdom
LOL	Servicio de Hidrografía Naval Observatorio Naval Buenos Aires Av. España 2099 C1107AMA – Buenos Aires, Argentina
MSF	National Physical Laboratory Centre for Electromagnetic and Time Metrology Teddington, Middlesex TW11 0LW United Kingdom
RAB-99, RBU, RJH-63, RJH-69, RJH-77, RJH-86, RJH-90,RTZ,RWM,	Institute of Metrology for Time and Space (IMVP), FGUP "VNIIFTRI" Mendeleevo, Moscow Region 141570 Russia
STFS	National Physical Laboratory Dr. K.S. Krishnan Road New Delhi - 110012, India
TDF	FT R et D France Telecom Recherche et Développement Laboratoire RTA/D2M Technopole ANTICIPA 2, avenue Pierre Marzin 22307 - Lannion Cedex, France

Signal	Authority
WWV, WWVB, WWVH	Time and Frequency Division, 847.00 National Institute of Standards and Technology - 325 Broadway Boulder, Colorado 80305, U.S.A.
YVTO	Direccion de Hidrografía y Navegación Observatorio Cagigal Apartado Postal No 6745 Caracas, Venezuela

TIME SIGNALS EMITTED IN THE UTC SYSTEM

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
BPM	Pucheng China 35° 0'N 109° 31'E	2 500 5 000 10 000 15 000	7 h 30 m to 1 h continuous continuous 1 h to 9 h	Signals emitted in advance on UTC by 20 ms. Second pulses of 10 ms duration with 1 kHz modulation. Minute pulses of 300 ms duration with 1 kHz modulation. UTC time signals are emitted from minute 0 to 10, 15 to 25, 30 to 40, 45 to 55. UT1 time signals are emitted from minute 25 to 29, 55 to 59.
BSF (1)	Chung-Li Taiwan Rep. of China 24° 57'N 121° 09'E	5 000 15 000	continuous except interruption between minutes 35 and 40	From minute 5 to 10, 15 to 20, 25 to 30, 45 to 50, 55 to 60, second pulses of 5 ms duration without 1 kHz modulation. From minute 0 to 5, 10 to 15, ..., 50 to 55, second pulses of 5 ms duration with 1 kHz modulation. The 1 kHz modulation is interrupted 40 ms before and after the pulses. Minute pulses are extended to 300 ms duration. DUT1: ITU-R code by pulse lengthening.
CHU	Ottawa Canada 45° 18'N 75° 45'W	3 330 7 335 14 670	continuous	Second pulses of 300 cycles of a 1 kHz modulation, with 29th and 51st to 59th pulses of each minute omitted. Minute pulses are 0.5 s long. Hour pulses are 1.0 s long, with the following 1st to 10th pulses omitted. A bilingual (Fr. Eng.) announcement of time (UTC) is made each minute following the 50th second pulse. FSK code (300 bps, Bell 103) after 10 cycles of 1 kHz on seconds 31 to 39. Year, DUT1, leap second information, TAI-UTC and Canadian summer time format on 31, and time code on 32-39. Broadcast is single sideband; upper sideband with carrier reinsert. DUT1 : ITU-R code by double pulse.

(1) Information based on the Annual Report for 2002 not confirmed by the laboratory.

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
DCF77	Mainflingen Germany 50° 1'N 9° 0'E	77.5	continuous	At the beginning of each second (except the 59th second) the carrier amplitude is reduced to about 25 % for a duration of 0.1 s or 0.2 s. Coded transmission of year, month, day, hour, minute and day of the week in a BCD code from second marker No 21 to No 58 (The second marker durations of 0.1 s or 0.2 s correspond to a binary 0 or a binary 1 respectively). The coded time information is related to legal time of Germany and second markers 17 and 18 indicate if the transmitted time refers to UTC(PTB) + 2 h (summer time) or UTC(PTB) + 1 h (winter time). To achieve a more accurate time transfer and better use of the frequency spectrum available, an additional pseudo-random phase-shift keying of the carrier is superimposed to the AM second markers. No transmission of DUT1.
EBC	San Fernando Spain 36° 28'N 6° 12'W	15006 4998	10 h 00 m to 10 h 25 m 10 h 30 m to 10 h 55 m except Saturday, Sunday and national holidays.	Second pulses of 0.1 s duration of a 1 kHz modulation. Minute pulses of 0.5 s duration of 1 250 Hz modulation. DUT1: ITU-R code by double pulse.
HBG	Prangins Switzerland 46° 24'N 6° 15'E	75	continuous	At the beginning of each second (except the 59th second), the carrier is interrupted for a duration of 0.1 s or 0.2 s corresponding to "binary 0" or "binary 1", respectively, double pulse each minute. The number of the minute, hour, day of the month, day of the week, month and year are transmitted in BCD code from the 21st to the 58th second. The time signals are generated by the Swiss Federal Office of Metrology and Accreditation and in accordance with the legal time of Switzerland which is UTC(CH) + 1 h (Central European Time CET) or UTC(CH) + 2 h (Central European Summer Time CEST). In addition, CET and CEST are indicated by a binary 1 at the 18th or 17th second, respectively.
HLA	Taedok Science Town Rep. of Korea 36° 23'N 127° 22'E	5 000	continuous	Pulses of 9 cycles of 1 800 Hz modulation. 29th and 59th second pulses omitted. Hour identified by 0.8 s long 1 500 Hz tone. Beginning of each minute identified by a 0.8 s long 1 800 Hz tone. Voice announcement of hours and minutes each minute following the 52nd second pulse. BCD time code given on 100 Hz subcarrier. DUT1: ITU-R code by double pulse.

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
IAM	Roma Italy 41° 47'N 12° 27'E	5 000	7 h 30 m to 8 h 30 m 10h 30 m to 11 h 30 m except Sunday and national holidays. Advanced by 1 hour in summer.	Second pulses of 5 cycles of 1 kHz modulation. Minute pulses of 20 cycles. Voice announcements every 15 minutes beginning at 0 h 0 m. DUT1: ITU-R code by double pulse.
JJY	Miyakoji Fukushima Japan 37° 22'N 140° 51'E	40	Continuous	A1B type 0.2 s, 0.5 s and 0.8 s second pulses, spacings are given by the reduction of the amplitude of the carrier. Coded announcement of hour, minute, day of the year, year, day of the week and leap second. Transmitted time refers to UTC(CRL) + 9 h.
JJY	Fuji Saga Japan 33° 28'N 130° 11'E	60	Continuous	A1B type 0.2 s, 0.5 s and 0.8 s second pulses, spacings are given by the reduction of the amplitude of the carrier. Coded announcement of hour, minute, day of the year, year, day of the week and leap second same as JJY(40). Transmitted time refers to UTC(CRL) + 9 h.
LDS	Leeds United Kingdom 53 ° 48'N 1° 33'W	5 000	Continuous	Second pulse amplitude = 2.4 V (50 ohm), 5 ns rise time and 20 μs width. Initial clock synchronization: 50 ns of UTC.
LOL (2)	Buenos Aires Argentina 34° 37'S 58° 21'W	5 000 10 000 *15 000	11 h to 12 h 14 h to 15 h 17 h to 18 h 20 h to 21 h 23 h to 24 h	Second pulses of 5 cycles of 1000 Hz modulation. Second 59 is omitted. Annoucement of hours and minutes every 5 minutes, followed by 3 minutes of 1000 Hz or 440 Hz modulation. DUT1: ITU-R code by lengthening.
MSF	Rugby United Kingdom 52° 22'N 1° 11'W	60	Continuous, except for interruptions for maintenance from 10 h 0 m to 14 h 0 m on the first Tuesday of January, April, July and October. A longer period of maintenance during the summer is announced annually.	Interruptions of the carrier of 100 ms for the second pulses and of 500 ms for the minute pulses. The signal is given by the beginning of the interruption. BCD NRZ code, 1 bit/s (year, month, day of the month, day of the week, hour, minute) from second 17 to 59 in each minute, following the seconds interruption. DUT1: ITU-R code by double pulse.

(2) LOL. * discontinued for maintenance

Station	Location Latitude Longitude	Frequency (KHz)	Schedule (UTC)	Form of the signal
RAB-99	Khabarovsk Russia 48° 30'N 134° 50'E	25.0 25.1 25.5 23.0 20.5	02 h 06 m to 02 h 40 m 06 h 06 m to 06 h 40 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.
RBU	Moscow 55° 44'N 38° 12'E	200/3	Continuous	DXXXW type 0.1 s signals. The numbers of the minute, hour, day of the month, day of the week, month, year of the century, difference between the universal time and the local time, TJD and DUT1+dUT1 are transmitted each minute from the 1st to the 59th second. DUT1+dUT1 : by double pulse.
RJH-63	Krasnodar Russia 44° 46'N 39° 34'E	25.0 25.1 25.5 23.0 20.5	11 h 06 m to 11 h 40 m	A1N type signals are transmitted between minutes 9 and 20 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 9 and 11 ; 0.1 second pulses of 25 ms duration, 10 second pulses of 1 s duration and minute pulses of 10 s duration are transmitted between minutes 11 and 20.
RJH-69	Molodechno Belarus 54° 28'N 26° 47'E	25.0 25.1 25.5 23.0 20.5	07 h 06 m to 07 h 47 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.
RJH-77	Arkhangelsk Russia 64° 22'N 41° 35'E	25.0 25.1 25.5 23.0 20.5	09 h 06 m to 09 h 47 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.
RJH-86	Bishkek Kirgizstan 43° 03'N 73° 37'E	25.0 25.1 25.5 23.0 20.5	04 h 06 m to 04 h 47 m 10 h 06 m to 10 h 47 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
RJH-90	Nizhni Novgorod Russia 56° 11'N 43° 57'E	25.0 25.1 25.5 23.0 20.5	05 h 06 m to 05 h 47 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.
RTZ (3)	Irkutsk Russia 52° 26'N 103° 41'E	50	Winter schedule 22 h 00 m to 24 h 00 m 00 h 00 m to 21 h 00 m Summer schedule 21 h 00 m to 24 h 00 m 00 h 00 m to 20 h 00 m	A1X type second pulses of 0.1 s duration are transmitted between minutes 0 and 5. The pulses at the beginning of the minute prolonged to 0.5 s. DXXXW type 0.1s signals between minutes 30 and 59. The numbers of the minute, hour, day of the month, day of the week, month, year of the century, difference between the universal time and the local time, TJD and DUT1+dUT1 are transmitted each minute from the 1st to the 59th second. A1N type 0.1 second pulses of 0.02 s duration are transmitted at 59th minute. The pulses at the beginning of the second are prolonged to 40 ms and of the minute to 0.5 s. DUT1+dUT1: by double pulse.
RWM (3)	Moscow Russia 55° 44'N 38° 12'E	4 996 9 996 14 996	The station operates simultaneously on the three frequencies.	A1X type second pulses of 0.1 s duration are transmitted between minutes 10 and 20, 40 and 50. The pulses at the beginning of the minute are prolonged to 0.5 s. A1N type 0.1 s second pulses of 0.02 s duration are transmitted between minutes 20 and 30. The pulses at the beginning of the second are prolonged to 40 ms and of the minute to 0.5 ms. DUT1+dUT1: by double pulse.
STFS	Sikandrabad India 28° 28'N 77° 13'E	2 599 675	continuous	Pulse width modulated binary coded 5 kHz pulses carrying information on Indian Standard Time – IST (UTC+ 5 h 30 m), Time of Day and current position coordinates of the satellite. Pulse repetition rate is 100 pps. The above format is frequency modulated on the carrier.

(3) RTZ and RMW are the radiostations emitting DUT1 information in accordance with the ITU-R code and also giving an additional information, dUT1, which specifies more precisely the difference UT1-UTC down to multiples of 0.02 s, the total value of the correction being DUT1+dUT1.

Positive values of dUT1 are transmitted by the marking of *p* second markers within the range between the 21st and 24th second so that dUT1 = +*p* x 0.02 s.

Negative values of dUT1 are transmitted by the marking of *q* second markers within the range between the 31st and 34th second, so that dUT1 = -*q* x 0.02 s.

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
TDF (1)	Allouis France 47° 10'N 2° 12'E	162	continuous, except every Tuesday from 1 h to 5 h	Phase modulation of the carrier by +1 and -1 rd in 0.1 s every second except the 59th second of each minute. This modulation is doubled to indicate binary 1. The numbers of the minute, hour, day of the month, day of the week, month and year are transmitted each minute from the 21st to the 58th second, in accordance with the French legal time scale. In addition, a binary 1 at the 17th second indicates that the local time is 2 hours ahead of UTC (summer time); a binary 1 at the 18th second indicates that the local time is 1 hour ahead of UTC (winter time); a binary 1 at the 14th second indicates that the current day is a public holiday (Christmas, 14 July, etc...); a binary 1 at the 13th second indicates that the current day is a day before a public holiday.
WWV (1)	Fort-Collins CO, USA 40° 41'N 105° 2'W	2 500 5 000 10 000 15 000 20 000	continuous	Pulses of 5 cycles of 1 kHz modulation. 29th and 59th second pulses omitted. Hour is identified by 0.8 second long 1 500 Hz tone. Beginning of each minute identified by 0.8 second long 1 000 Hz tone. DUT1: ITU-R code by double pulse. BCD time code given on 100 Hz subcarrier, includes DUT1 correction.
WWVB (1)	Fort-Collins CO, USA 40° 40'N 105° 3'W	60	continuous	Second pulses given by reduction of the amplitude of the carrier, coded announcement of the date, time, DUT1 correction, daylight saving time in effect, leap year and leap second.
WWVH (1)	Kauai HI, USA 21° 59'N 159° 46'W	2 500 5 000 10 000 15 000	continuous	Pulses of 6 cycles of 1 200 Hz modulation. 29th and 59th second pulses omitted. Hour is identified by 0.8 second long 1 500 Hz tone. Beginning of each minute identified by 0.8 second long 1 200 Hz tone. DUT1: ITU-R code by double pulse. BCD time code given on 100 Hz subcarrier, includes DUT1 correction.
YVTO	Caracas Venezuela 10° 30'N 66° 55'W	5 000	continuous	Second pulses of 1 kHz modulation with 0.1 s duration. The minute is identified by a 800 Hz tone and a 0.5 s duration. Second 30 is omitted. Between seconds 40 and 50 of each minute, voice announcement of the identification of the station. Between seconds 52 and 57 of each minute, voice announcement of hour, minute and second.

(1) Information based on the Annual Report for 2002 not confirmed by the laboratory.

ACCURACY OF THE CARRIER FREQUENCY

Station	Relative uncertainty of the carrier frequency in 10^{-10}
BPM	0.01
BSF	0.1
CHU	0.05
DCF77	0.02
EBC	0.1
HBG	0.02
HLA	0.02
IAM	0.5
JJY	0.01
LDS	0.01
LOL	0.1
MSF	0.02
RAB-99, RJH-63	0.05
RBU	0.02
RJH-69, RJH-77	0.05
RJH-86, RJH-90	0.05
RTZ	0.05
RWM	0.1
STFS	0.1
TDF	0.02
WWV	0.01
WWVB	0.01
WWVH	0.01

TIME DISSEMINATION SERVICES

The following tables are based on information received at the BIPM in February and May 2004.

AUTHORITIES RESPONSIBLE FOR THE TIME DISSEMINATION SERVICES

AOS	Astrogeodynamical Observatory Borowiec near Poznań Space Research Centre P.A.S. PL 62-035 Kórnik Poland
AUS	Standards for Time and Frequency Project CSIRO National Measurement Laboratory PO Box 218 Lindfield NSW 2070 AUSTRALIA
BEV	Bundesamt für Eich- und Vermessungswesen Arltgasse 35 A-1160 Wien Vienna Austria
BNM-SYRTE	Bureau National de Métrologie – Systèmes de Référence Temps-Espace Observatoire de Paris 61, avenue de l'Observatoire 75014 Paris - France
CENAM	Centro Nacional de Metrología Km. 4.5 Carretera a Los Cués El Marqués, Querétaro, C.P. 76241 México - Mexico
CRL	Japan Standard Time Group Communications Research Laboratory 2-1, Nukui-kitamachi 4-chome Koganei-shi, Tokyo 184-8795 Japan
CSIR	Time and Frequency Laboratory CSIR – National Metrology Laboratory P.O. Box 395 Pretoria 0001 South Africa
GUM	Time and Frequency Laboratory Główny Urząd Miar Ul. Elektoralna 2 P.O. Box P-10 PL 00-950 Warszawa - Poland
IEN	Istituto Elettrotecnico Nazionale Galileo Ferraris Strada delle Cacce, 91 I - 10135 Torino Italie
INPL	National Physical Laboratory Danciger A bldg Givat - Ram, The Hebrew university 91904 Jerusalem ISRAEL

KRISS	Time and Frequency Group Division of Optical Metrology Korea Research Institute of Standards and Science P.O. Box 102, Yuseon Daejon 305-600. Republic of Korea
LT	Time and Frequency Standard Laboratory Semiconductor Physics Institute – State Metrology Service A. Goštauto 11 Vilnius – Lithuania
METAS	METrology and Accreditation Switzerland Electricity, Acoustic and Time Section Lindenweg 50 CH-3003 Bern-Wabern Switzerland
MSL	Measurement Standards Laboratory Industrial Research Gracefield Road PO Box 31-310 Lower Hutt – New Zealand
NIM	Time & Frequency Laboratories National Institute of Metrology 7, District 11 Heping street Beijing - Popular Republic of China
NIST	National Institute of Standards and Technology Time and Frequency Division, 847.00 325 Broadway Boulder, Colorado 80305, USA
NMLS	Time and Frequency Laboratory National Metrology Laboratory SIRIM Berhad, No. 1 Persiaran Dato' Menteri, P. O. Box 7035, 40911 Shah Alam - Malaysia
NPL	National Physical Laboratory Centre for Electromagnetic and Time Metrology Teddington, Middlesex TW11 0LW United Kingdom
NPLI	Time and Frequency Section National Physical Laboratory Dr.K.S.Krishnan Road New Delhi 110012 - India
NRC	National Research Council of Canada Institute for National Measurement Standards Frequency and Time Standards Bldg M-36, 1200 Montreal Rd. Ottawa, Ontario, K1A OR6, Canada
NTSC	National Time Service Center Chinese Academy of Sciences P.O. Box 18, Lintong Shaanxi 710600, China

ONBA	Servicio de Hidrografía Naval Observatorio Naval Buenos Aires Servicio de Hora Av. España 2099 C1107AMA – Buenos Aires, Argentina
ONRJ	Observatorio Nacional (CNPq) Departamento Serviço da Hora Rua General Bruce, 586, Sao Cristovao 20291- 030 – Rio de Janeiro, Brasil
ORB	Royal Observatory of Belgium Avenue Circulaire, 3 B-1180 Brussels Belgium
PTB	Physikalisch-Technische Bundesanstalt Time and Frequency Department, WG 4. 42 Bundesallee 100 D-38116 Braunschweig Germany
ROA	Real Instituto y Observatorio de la Armada Cecilio Pujazón s/n 11.100 San Fernando Cádiz, Spain
SG	National Metrology Centre Standards, Productivity and Innovation Board (SPRING Singapore) 1 Science Park Drive, Singapore 118221 Singapore
SP	SP Swedish National Testing and Research Institute Box 857 S-501 15 BORAS Sweden
TL	National Standard Time and Frequency Laboratory Telecommunication Laboratories Chunghwa Telecom. Co., Ltd. No. 12, Ln.551, Ming-Tsu Road Sec. 5 Yang-Mei, Taoyuan, 326 Taiwan, Rep. of China
TP	Institute of Radio Engineering and Electronics Czech Academy of Sciences Chaberská 57 182 51 Praha 8 Czech Republic
USNO	U.S. Naval Observatory 3450 Massachusetts Ave., N.W. Washington, D.C. 20392-5420 USA
VSL	NMi Van Swinden Laboratorium Postbus 654 2600 AR Delft Netherlands

TIME DISSEMINATION SERVICES

AOS

AOS Computer Time Service:
vega.cbk.poznan.pl (150.254.183.15)
Synchronization: NTP V3 primary (Caesium clock), PC Pentium, RedHat Linux
Service Area: Poland/Europe
Access Policy: open access
Contact: Jerzy Nawrocki (nawrocki@cbk.poznan.pl)
Robert Diak (kondor@cbk.poznan.pl)

Full list of time dissemination services is available on:
http://www.eecis.udel.edu/~mills/ntp/clock1.htm

AUS

Network Time Service
Computers connected to the Internet can be synchronized to UTC(AUS) using the NTP protocol. The NTP servers are either directly referenced to UTC(AUS) or via a GPS common view link.

There are presently five servers available to the general public after contacting NML for authorization:

ntp.syd.nml.csiro.au	Sydney
ntp.adel.nml.csiro.au	Adelaide
ntp.bris.nml.csiro.au	Brisbane
ntp.hobart.nml.csiro.au	Hobart
ntp.perth.nml.csiro.au	Perth

Current information can be found on the web pages: www.nml.csiro.au

BEV

A NTP server is available; address: time.metrology.at;
more information on http://www.metrology.at

Provides a time dissemination service via phone and modem to synchronize PC clocks.
Uses the Time Distribution System from TUG. It has a baud rate of 1200 and everyone can use it with no cost.
Access phone number is +43 (0) 1 49110381
The system will be updated periodically (DUT1, Leap Second…).

BNM-SYRTE

BNM-SYRTE operates one primary time server using the "Network Time Protocol" (NTP) :
Hostname: ntp-p1.obspm.fr

Futher information at: http://opdaf1.obspm.fr/www/ntp_infos.html

CENAM

CENAM operates a voice automatic system that provides the local time for three different time zones for North America; Central Time, Mountain Time and Pacific Time as well the UTC(CNM). The access numbers are:

+52 442 211 0506: Central Time
+52 442 211 0507: Mountain Time
+52 442 211 0508: Pacific Time
+52 442 215 3902: UTC(CNM)

Telephone Code
CENAM provides a telephone code for setting time in computers. More information about this service please contact J. Mauricio López at jlopez@cenam.mx

Network Time Protocol
Operates one time server using the "Network Time Protocol", it is located at the Centro Nacional de Metrología, Querétaro, México. Further information at http://mensor.cenam.mx/site/InternetTime.htm

CRL (1)

Telephone Time Service (TTS)
Provides digital time code accessible by computer at 300/1200/2400 bps, 8 bits, no parity.
Access phone numbers: + 81 42 327 7592.

CSIR

Telephone Time Service (TTS)
Provides digital time code accessible by computer for setting time in computers. Measurement of telephone transmission delay is included.
Access phone numbers: + 27 12 349 1576, + 27 12 349 1577.
More information and software for accessing the service is available at http://www.nml.csir.co.za/

Network Time Service
Two NTP servers are available, tick.nml.csir.co.za and tock.nml.csir.co.za with an open access policy. More information is available at http://www.nml.csir.co.za/

GUM

Telephone Time Service providing the European time code by telephone modem for setting time in computers. Includes provision for compensation of propagation time delay.
Access phone number : +48 22 654 88 72

Network Time Service
Two NTP servers are available:
tempus1.gum.gov.pl
tempus2.gum.gov.pl
with an open access policy. It provides synchronization to UTC(PL).
Contact: timegum@gum.gov.pl

IEN

CTD Telephone Time Code
Time signals dissemination, according to the European Time code format, available via modem on regular dial-up connection.
Access phone number : 0039 011 3919 263 and 0039 011 3919 264.
Provides a synchronization to UTC(IEN) for computer clocks without compensation for the propagation time.
Software for the synchronization of computer clocks is available on IEN home page (www.ien.it).

Internet Time Service
The IEN operates two time servers using the "Network Time Protocol" (NTP); host names of the servers are npt1.ien.it and ntp2.it.
More information on this service can be found on the web pages: www.ien.it/ntp/index_i.shtml.

(1) Information based on the Annual Report for 2002, not confirmed by the laboratory.

INPL (1)	INPL is providing two electronic time dissemination services: 1. via telephone. The user must download a program from INPL ftp site (vms.huji.ac.il) 2. NTS via optic fiber to the Hebrew University which provides time on the internet. For details email clock@vms.huji.ac.il
KRISS	Telephone Time Service Provides digital time code to synchronize computer clocks to Korea Standard Time (=UTC(KRIS) + 9 h) via modem. Access phone numbers: + 82 42 863 7117, + 82 42 868 5116 Network Time Service KRISS operates three time servers using the NTP to synchronize computer clocks to Korea Standard Time via the Internet. Host name of the server : time.kriss.re.kr (203.254.163.74) Software for the synchronization of computer clocks is available at http://www.kriss.re.kr/time
LT	Network Time Service via NTP protocol NPT v3 DNS: laikas.pfi.lt Port 123 Synchronization from Caesium clock (1pps) System: Datum TymeServe 2100 NTP server Access policy: free Contact: Rimantas Miškini Mail: Laikas@pfi.lt http://www.pfi.lt/metrology/
METAS	Telephone Time Service The coded time information is referenced to UTC(CH) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". Access phone numbers: +41 31 323 32 25, +41 31 323 47 00. Network Time Protocol METAS operates a time server using the "Network Time Protocol"(NTP). Host name of the server : ntp.metas.ch Further information available at http://www.metas.ch
MSL	Network Time Service Computers connected to the Internet can be synchonized to UTC(MSL) using the NTP protocol. Access is available for users within New Zealand. The address of the server is msltime.irl.cri.nz Telephone Time Service A dial up computer time setting service for linking computers to UTC(MSL). The service uses a time code specific to New Zealand. Because it is a pay service, access is restricted to callers within New Zealand. Speaking Clock A speaking clock gives New Zealand time. Because it is a pay service, access is restricted to callers within New Zealand. Further information about these services can be found at http://www.irl.cri.nz/msl/services/time/index.html

(1) Information based on the Annual Report for 2002, not confirmed by the laboratory.

NIM (1)	Television Time Service The coded time information generated by one time code generator is inserted into the TV signal. It can be obtained by using a decode TV receiver. The time reference is UTC(NIM). Access TV channel: 1,2,8 of CCTV. Telephone Time Service The coded time information generated by NIM time code generator, referenced to UTC(NIM). Telephone Code provides digital time code at 1200 to 9600 bauds, 8 bits, no parity, 1 stop bit. Access phone number: 8610 6422 9086. Network Time Service Provides digital time code across the Internet using NTP.
NIST	Automated Computer Time Service (ACTS) Provides digital time code by telephone modem for setting time in computers. Free software and source code available for download from NIST. Includes provision for calibration of telephone time delay. Access phone numbers : +1 303 494 4774 and +1 808 335 4721. Further information at http://tf.nist.gov/timefreq/service/acts.htm Internet Time Service (ITS) Provides digital time code across the Internet using three different protocols: Network Time Protocol, Daytime Protocol, and Time Protocol. Geographically distributed set of time servers within the United States of America. Free Software and source code available for download from NIST. Further information at http://tf.nist.gov/timefreq/service/its.htm.
NMLS (1)	Telephone Time Service The coded time information is referenced to UTC(NMLS) and generated by a TUG type telephone time code generator using an ASCII-character code. The time protocols are sent in the "European Telephone Time Code" format. The service phone number is +60 3 55197063. Current service status is free of charge. Fees are made only on the provision of the software for accessing the service via modem dial-up. Network Time Protocol Version 3 The NTP time information is referenced to UTC(NMLS) and is currently generated by two Stratum-1 NTP servers, made available for public freely. The IP address for the servers are 202.190.27.9 and 202.190.27.10.
NPL	Telephone Time Service A TUG time code generator provides the European Telephone Time Code, referenced to UTC(NPL), by telephone modem. Access phone number: 0906 851 6333. Note: this is a premium rate number and can only be accessed from within the UK.

(1) Information based on the Annual Report for 2002, not confirmed by the laboratory.

NPLI	Telephone Time Service The coded time information generated by time code generator of NPLI, referenced to UTC(NPLI). Telephone Code provides digital time code (for the current time of Indian standard Time) at 1200 bauds, 8 bits, no parity, 1 stop bit. This service is known as TELECLOCK Service. Accessible by : a. an NPLI-developed Teleclock Receiver already available in the market. b. a Computer through Telephone Modem and NPLI-developed software. One-way Geostationary Satellite Time Service.
NRC	Telephone Code Provides digital time code by telephone modem for setting time in computers. Access phone number : +1 613 745 3900. Network Time Protocol Operates two time servers using the " Network Time Protocol ", each one being on different location and network. Host names : time.nrc.ca time.chu.nrc.ca Further information at http://inms-ienm.nrc-cnrc.gc.ca/time_services.html
NTSC	Network Time Service (NTS) Provides a synchronization to UTC(NTSC) computer clocks within China. Software for the synchronization of computer clocks is available on the NTSC Time and Frequency home page : http://time.sxso.ac.cn Access Policy: free Contact: Shaowu DONG (dongsw@ms.sxso.ac.cn).
ONBA	Speaking clock access phone number 113 (only accessible in Argentina). Hourly and half hourly radio-broadcast time signal. Internet time service at web site www.hidro.gov.ar/hora/hora.asp
ONRJ (1)	Telephone Voice Announcer (55) 21 5806037. Telephone Code (55) 21 5800677 provides digital time code at 300 bauds, 8 bits, no parity, 1 stop bit (Leitch CSD5300) Internet Time Service at the address : 200.20.186.75 SNTP at port 123 Time/UDP at port 37 Time/TCP at port 37 Daytime/TCP at port 13 WEB-based Time Services: 1) A real-time clock aligned to UTC(ONRJ) and corrected for internet transmission delay. Further information at: http://200.20.186.71/asp/relogio/horainicial.asp 2) Voice Announcer, in Portuguese, each ten seconds, after download of the Web page at: http://200.20.186.71.

(1) Information based on the Annual Report for 2002, not confirmed by the laboratory.

ORB	ORB provides a time dissemination via phone and modem to synchronize PC clocks on UTC(ORB). The system used is the Time Distribution System from TUG, which produces the telephone time code mostly used in Europe. The baud rate used is 1200. The access phone number is 32 (0) 2 373 03 20. The system is updated periodically with DUT1 and leap seconds
PTB	Telephone Time Service The coded time information is referenced to UTC(PTB) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the " European Telephone Time Code ". Access phone number : +49 531 51 20 38 . Internet Time Service The PTB operates two time servers using the " Network Time Protocol " (NTP). Software for the syncronization of computer clocks is available on the home pages of the PTB (www.ptb.de). Host names of the servers: ptbtime1.ptb.de ptbtime2.ptb.de
ROA	Telephone Code The coded time information is referenced to UTC(ROA) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". Access phone number : +34 956 599 429 Network Time Protocol Server : hora.roa.es Synchonized to UTC(ROA) better than 10 microseconds Service policy : free Server : ntp0.roa.es Synchonized to UTC(ROA) better than 10 microseconds Service policy : free Note : server used as prototype to check new software, hardware, etc.
SG	Web-based time service: Displays a real-time clock referenced to UTC(SG) at web-site http://www.SingaporeStandardTime.org.sg. User-selectable displays of local time (adjusted for daylight savings) of major cities worldwide and time differences between any two cities are also available at the web-site. Automated Computer Time Service (ACTS) Transmits digital time code (NIST format) via telephone & modem for setting time in computers. The coded time information is referenced to UTC(SG). Includes provision for correcting telephone time delays. Access phone number : +65 7799978. Information is available at http://www.SingaporeStandardTime.org.sg. Network Time Service (NeTS) Transmits digital time code via the Internet using three different protocols – Time, Daytime and NTP. Operates two time servers. Host names : NeTS.org.sg 203.117.180.35 Information available at http://www.SingaporeStandardTime.org.sg.

SP	Telephone Time Service The coded time information is referenced to UTC(SP) and generated by two TUG type time code generators using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". Access phone number: +46 33 41 57 83 Internet Time Service The coded time information is referenced to UTC(SP) and generated by two NTP servers using the Network Time Protocol (NTP). Access host names : ntp1.sp.se and ntp2.sp.se Speaking Clock The speaking clock service is operated by Telia AB in Sweden. The time announcement is referenced to UTC(SP) and disseminated from a computer based system operated and maintained at SP. Access phone number : 90510 (only accessible in Sweden). Access phone number : +4633 90510 (from outside Sweden). More information about these services are found at the web site www.sp.se
TL (1)	Speaking Clock Service Traceable to UTC(TL). Broadcast through PSTN (Public Switching Telephone Network) automatically and provides accurate voice time signal to public users. The Computer Time Service Provides digital time code by telephone modem for setting time in computers. Access phone number : +886 3 4245117. NTP Service TL operates a time server using the "Network Time Protocol (NTP)". Host name of the server : time.stdtime.gov.tw Further information at http://www.stdtime.gov.tw/english/e-home.htm
TP	Internet Time Service IREE operates a time server directly referenced to UTC(TP). Time information is accessible through Network Time Protocol (NTP). Server host name: time.ure.cas.cz More information at http:// www.ure.cas.cz/time
USNO	Telephone Voice Announcer +1 202 762-1401 Telephone Code +1 202 762-1594 provides digital time code at 1200 baud, 8 bits, no parity Automated data service for downloading files +1 202 762-1503 Web site for time and for data files: http://www.tycho.usno.navy.mil Network Time Protocol (NTP) see http://www.tycho.usno.navy.mil/ntp.html for software and site closest to you.
VSL	Telephone Time Service The coded time information is referenced to UTC(VSL) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". The access phone number is 0900 6171819. This is a toll number and therefore can only be accessed in the Netherlands.

(1) Information based on the Annual Report for 2002, not confirmed by the laboratory.

Director's Report on the Activity and Management of the BIPM, 2003, T. 4

(July 2002 – June 2003)

BIPM Publication

1 International Atomic Time (TAI) and Coordinated Universal Time (UTC)

The reference time scales International Atomic Time (TAI) and Coordinated Universal Time (UTC) have been computed from data reported regularly to the BIPM by the timing centres that maintain a local UTC; monthly results have been published in *Circular T*. Since May 2003 *Circular T* has provided time scales to a tenth of a nanosecond; information on the time links used in each monthly calculation is provided in a new table. The *Annual Report of the BIPM Time Section for 2002*, Volume 15, complemented by computer-readable files on the BIPM home page, give the definitive results for 2002.

2 Algorithms for time scales

The algorithm used for the calculation of time scales is an iterative process that starts by producing a free atomic scale (EAL) from which TAI is derived. Research concerning time-scale algorithms is conducted at the section with the aim of improving the long-term stability of EAL and the accuracy of TAI.

2.1 EAL stability

Some 84 % of clocks are now either commercial caesium clocks of the HP 5071A type or active, auto-tuned active hydrogen masers. In accordance with the report submitted to the CCTF Working Group on TAI, in January 2001 we started a process to improve the way of fixing the upper limit to clock weights in TAI computation. The final step in the process, setting the maximum relative weight to $2.5/N$, where N is the total number of participating clocks, was accomplished in July 2002. Such a choice for the maximum relative weight leads to a better discrimination between clocks and improves the stability of the resulting time scale. We thus expect an improvement in the stability of EAL in the near future.

Studies on the TAI algorithm continue. An estimator has been proposed to quantify the reliability achieved by assigning an upper limit to weights which can help in defining an optimal weighting scheme for TAI computation.

The medium-term stability of EAL, expressed in terms of an Allan deviation, is estimated to be 0.6×10^{-15} for averaging times of twenty to forty days over the period January 1999 to June 2003.

2.2 TAI accuracy

To characterize the accuracy of TAI, estimates are made of the relative departure, and its uncertainty, of the duration of the TAI scale interval from the SI second as produced on the rotating geoid by primary frequency standards. Since August 2002, individual measurements of the TAI frequency have been provided by nine primary frequency standards including five caesium fountains (IEN-CSF1, NIST-F1, PTB CSF1, SYRTE-FOM and SYRTE-FO2). Reports on the operation of the primary frequency standards have been published in the *Annual Report of the BIPM Time Section* since the beginning of 2002.

Since August 2002, the global treatment of individual measurements has led to a relative departure of the duration of the TAI scale unit from the SI second on the geoid ranging from $+0.6 \times 10^{-14}$ to $+1.0 \times 10^{-14}$, with a standard uncertainty of 0.2×10^{-14}.

Studies are being undertaken to better assess the accuracy of TAI and to optimize the contribution of the different primary frequency standards.

2.3 Independent atomic time scales

The BIPM staff has been involved in the organization and elaboration of the Polish independent atomic time scale TA(PL). Software specially devised for a limited number of clocks has been developed. For an averaging time of about one month, the stability of TA(PL) is approximately 4×10^{-15}.

3 Time links

The BIPM Time section organizes the international network of time links. Two techniques are at present used for clock comparison in TAI: common-views of GPS satellites, and two-way satellite time and frequency transfer (TWSTFT). Here, 52 % of the links are performed with the classical GPS common-view technique based on C/A-code measurements obtained from single-channel receivers; about 23 % of the links are obtained from observations with multichannel receivers, some of them being GPS and GLONASS dual-code dual-system ones, resulting in improved accuracy for time transfer. The TWSTFT technique provides some 17 % of the links in the computation of TAI.

A pilot experiment is under way aimed at testing the use of dual-frequency P-code measurements from geodetic-type GPS receivers for TAI links. In addition, the BIPM Time section continues to test other time and frequency comparison methods, such as those using phase measurements.

3.1 Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS) code measurements

i) Current work

The BIPM publishes an evaluation of the daily time differences [*UTC* – *GPS time*] and [*UTC* - *GLONASS time*] in its monthly *Circular T* and routinely issues GPS and GLONASS international common-view schedules. The international network of GPS common-view links used by the BIPM is made up of local networks within a continent. All GPS links are corrected for ionospheric delays using International GPS Service (IGS) maps, as well as for satellite positions using IGS post-processed precise satellite ephemerides.

ii) Determination of differential delays of GPS and GLONASS receivers

As part of our work we continue to check the differential delays between GPS receivers which operate on a regular basis in collaborating timing centres.

iii) Standards for GPS and GLONASS receivers

The Time section continues its active involvement in the work of the CCTF Working Group on GPS Time-Transfer Standards (CGGTTS). This has involved the ongoing development of technical guidelines for manufacturers of receivers used for timing in global navigation satellite systems. A staff member of the BIPM provides the secretariat of the CGGTTS.

iv) Multichannel GPS time links

Twelve multichannel GPS links are used in the computation of TAI.

v) IGS estimated ionospheric corrections

Ionospheric parameters estimated by the IGS are routinely used to correct all GPS links for ionospheric delays in regular TAI calculations. A study of the possible correlation between ionospheric parameters and apparent variations in the hardware delays of dual-frequency receivers is under way.

3.2 Phase and code measurements from geodetic-type receivers

It will be recalled that GPS and GLONASS time and frequency transfer may also be carried out using dual-frequency carrier-phase measurements in addition to code measurements. This technique, already in common use in the geodetic community, can be adapted to the needs of time and frequency transfer.

Studies continue at the BIPM using the Ashtech Z12-T GPS and Javad Legacy GPS/GLONASS receivers. The Javad serves as a reference with which the Z12-T is compared while at the BIPM. The method developed to perform the absolute calibration of the Z12-T hardware delays allows us to use this receiver for differential calibrations of similar receivers worldwide. Calibration trips started in January 2001 and have continued ever since. As of June 2003, twenty such calibrations have taken place concerning eighteen receivers. We plan to use data from such geodetic-type receivers for the time links of TAI and a pilot experiment has been initiated to this end, using procedures and software developed in collaboration with the ORB. As of June 2003, twelve laboratories regularly provide such data. These studies contribute to the IGS/BIPM Pilot Project for accurate time and frequency comparisons using GPS phase and code measurements, activities which have now been transferred to a new IGS working group on clock products.

One of the 3S Navigation receivers in operation at the BIPM is used to collect data for the International GLONASS Service Pilot Project (IGLOS-PP) sponsored by the IGS, in which the BIPM participates. The objective of this project is, among others, to produce post-processed precise GLONASS satellite ephemerides.

3.3 Two-way time and frequency transfer

Two meetings relating to TWSTFT activities have been held since October 2002. The BIPM collects two-way data from twelve operational stations and undertakes treatment of some two-way links. Nine TWSTFT links have been introduced into the computation of TAI; some others are in preparation for their introduction into TAI. The BIPM is also involved in the calibration of two-way time-transfer links by comparison with GPS. The Time section continues to issue BIPM TWSTFT reports and a staff member of the BIPM provides the secretariat for the CCTF Working Group on TWSTFT.

3.4 Uncertainties of TAI time links

Work was undertaken to evaluate the Type A and Type B uncertainties of TAI time links, with the aim of publishing them in *Circular T*. Mainly because of lack of calibration, the Type B uncertainties of GPS links can reach several tens of nanoseconds. This underlines the urgent need for calibration of TAI time links.

4 Pulsars

Collaboration is maintained with radio-astronomy groups observing pulsars and analysing pulsar data provided that it is of interest for us to study the potential capability of millisecond pulsars as a means of sensing the very long-term stability of atomic time. The Time section provides these groups with its post-processed realization of Terrestrial Time. The collaboration continues with the Observatoire Midi-Pyrénées (OMP) in Toulouse on a programme of survey observations.

5 Space-time references

Uniformity in the definition of space reference systems plays an increasingly important role in basic metrology, particularly for astro-geodetic techniques that contribute to the International Earth Rotation Service (IERS). Since 1 January 2001, a collaborative effort between the BIPM and the USNO (United States) provides the Conventions Product Centre (CPC) of the IERS. The new edition of the *IERS Conventions* (2003) has been finalized and will be published after its approval by the IERS Directing Board. This is a 150 page document summarizing the models, constants and procedures used for data analysis in the IERS, and for the astrometry-geodesy community at large.

Following the work of the BIPM/IAU Joint Committee on Relativity for Space-time Reference Systems and Metrology which ceased activity in 2001, efforts continue to promote the diffusion of the IAU Recommendations adopted in 2000.

Activities relating to the realization of reference frames for astronomy and geodesy are being developed by E.F. Arias in cooperation with the IERS and with Argentine laboratories.

6 Other studies

A test of Lorentz invariance was carried out in collaboration with the BNM-SYRTE (Paris Observatory) and the University of Western Australia by comparing the frequencies of a hydrogen maser and a cryogenic sapphire microwave oscillator. We determined the variation of the oscillator frequency as a function of its orientation (Michelson-Morley test) and of its velocity (Kennedy-Thorndike test) with respect to a preferred frame candidate. The limits obtained for the corresponding parameters of the Mansouri and Sexl test theory are of the same order as the best previous limits for the first test and represent a fiftyfold improvement for the second one. This project was carried out during a one-year stay of P. Wolf at the BNM-SYRTE on a CNES research grant. The experiment is still running under improved conditions while theoretical work is under way concerning the use of the experiment as a test of the recently developed standard model extension (SME) that parametrizes the violation of Lorentz invariance and CPT symmetry.

Under the same collaboration, studies remain in progress on the possible use for international timekeeping of highly stable and accurate space clocks, in particular those that will be operated within the ACES (Atomic Clock Ensemble in Space) experiment on board the International Space Station in 2006. With relative uncertainties expected in the low 10^{-16} region, such developments will be extremely important for the improvement of TAI accuracy and for experiments in fundamental physics. Recently the work has focused on preparing the data treatment for the ACES microwave link, which is expected to improve present frequency transfer capabilities by one order of magnitude or more.

7 Publications, lectures, travel: Time section

7.1 External publications

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9. Weiss M., Zhang V., Jensen M., Powers E., Klepczynski W., Lewandowski W., Ionospheric models and measurements for common-view time transfer, *Proc. IEEE/EIA Int. Freq. Contr. Symp.*, 2002, 517-521.

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7.2 BIPM publications

11. *Annual Report of the BIPM Time Section* (2002), 2003, **15**, 96 pp.

12. *Circular T* (monthly), 6 pp.

13. Azoubib J., Lewandowski W., *BIPM TWSTFT Reports*, 21 pp.

14. Petit G., Uncertainties on time links used for TAI, *TM 124*, March 2003.

15. Petit G., Jiang Z., Long-term comparison of GPS P3 links with other techniques used for TAI, *TM 126*, May 2003.

16. Lewandowski W., Moussay P., Determination of the differential time corrections between GPS time equipment located at the OP, NPL, VSL, OCA, *Rapport BIPM*-2003/04, 2003, 27 pp.

17. Lewandowski W., Moussay P., Determination of the differential time corrections between GPS time equipment located at the OP, NTSC, CRL, NMIJ, TL, NML, *Rapport BIPM*-2003/05, 2003, 30 pp.

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