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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Contents

[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, 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, www.bipm.org.*

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REPORT ON THE ANSWERS TO THE QUESTIONNAIRE

A questionnaire was distributed with the Annual Report of the BIPM Time Section for 2000. The aim was to have the opinion of its recipients concerning the presentation, usefulness and completeness of this publication. We received 29 answers, that is less than 10 % of the recipients.

72 % of the responders consult the ftp/BIPM web site, in mean about 10 times in 2000. The most requested information has been the weights and rates of clocks, the *Circular T* and the GPS and GLONASS tracking schedules. There are no particular difficulties to access to the internet files.

The responses indicate that the paper version of the Annual Report is far from being useless. In coincidence with the most required tables on the web site, tables of clock weights and rates are the most consulted on the paper volume, together with the equipment and source of UTC(*k*), the differences between normalized frequencies of EAL and TAI and the frequency offsets and step adjustments of UTC.

A question concerned the possibility of issuing in the future only an electronic version of the *Annual Report of the BIPM Time Section*. Taking into consideration that the answers are equally divided, the traditional publication of the report will not be discontinued.

We will progressively incorporate new information as suggested in the answers. Starting by the present issue we include, as annexes to Table 6, yearly reports of operation of primary frequency standards; these reports are provided by the laboratories.

Electronic access to the BIPM Time Section data

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. And XX, XXX are ordinal numbers.

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
Leap seconds	leaptab.txt
Acronyms of laboratories	acronyms.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	TAI - XYZ
[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**
TT(BIPMXY) computed in the year 19XY or 20XY	TTBIPM.XY
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
[*TAI - GPS time*] and [*UTC - GPS time*]	UTCGPSXY.ar
[*TAI - GLONASS time*] and [*UTC - GLONASS time*]	UTCGLOXY.ar
Time Dissemination Services	TIMESERVICES.DOC
Time Signals	TIMESIGNALS.DOC
Rates of clocks contributing to TAI	RTAIXY.ar
Weights of clocks contributing to TAI	WTAIXY.ar
Until 1992:	
Local representations of UTC: Values of [*UTC - UTC(lab)*]	UTC.XY
Local values of [*TAI - TA(lab)*]	TA.XY

For the period 1993-1998, these files are issued from tables in the BIPM Time Section Annual Report. The Annual Reports published up to 1998 additionally include the following tables:

Frequency offsets and step adjustments of UTC
Relationship between TAI and UTC
Acronyms and locations of the timing centres which maintain a UTC(*k*) and/or TA(*k*)
Equipment and source of UTC(*k*) of the laboratories contributing to TAI
International GPS tracking schedules (until the Annual Report for 1997)
International GLONASS tracking schedules (until the Annual Report for 1997)
Corrections for homogeneous use of the clock rates published
in the current and previous annual reports
Statistical data on the weights of the clocks contributing to TAI

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

Frequency offsets and step adjustments of UTC
Relationship between TAI and UTC
Acronyms and locations of the timing centres which maintain a UTC(*k*) and/or TA(*k*)
Equipment and source of UTC(*k*) of the laboratories contributing to TAI
Corrections for homogeneous use of the clock rates published in the current and previous annual reports
Statistical data on the weights of the clocks contributing to TAI
Information compiled about worldwide time signals and time dissemination services
Report on the scientific work of the BIPM Time Section.

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 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 (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 around 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; these dates are referred here as "standard dates". The equipment maintained by the timing centres is detailed in Table 4.

An iterative algorithm also produces a free atomic time scale, EAL (Echelle Atomique Libre), defined as a weighted average of clock readings. This 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 method of clock frequency prediction are chosen so that EAL is optimized for long-term stability. No attempt is made to ensure 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, black-body 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. 6 of this voulme).

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 to take 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 2001, the network of time links used by the BIPM was non-redundant and relied on the 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.

Since July 1999 several TWSTFT links have been introduced into the computation of TAI; the links USNO/NPL, NIST/PTB, NPL/PTB and VSL/PTB have been used in the computation of TAI during 2001. All GPS links in TAI are corrected using the ionospheric maps and precise operational satellite ephemerides produced by the International GPS Service (IGS). The ultimate precision of one single measurement of [$UTC(k_1)$ − $UTC(k_2)$], obtained at the BIPM with these procedures, is about 2 ns for short distances and 4 ns for long distances. The BIPM also publishes an evaluation of [*UTC − GPS time*] which is accessible via the Time section website (see p.6 of this volume).

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. 6 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. 6 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 2001.

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

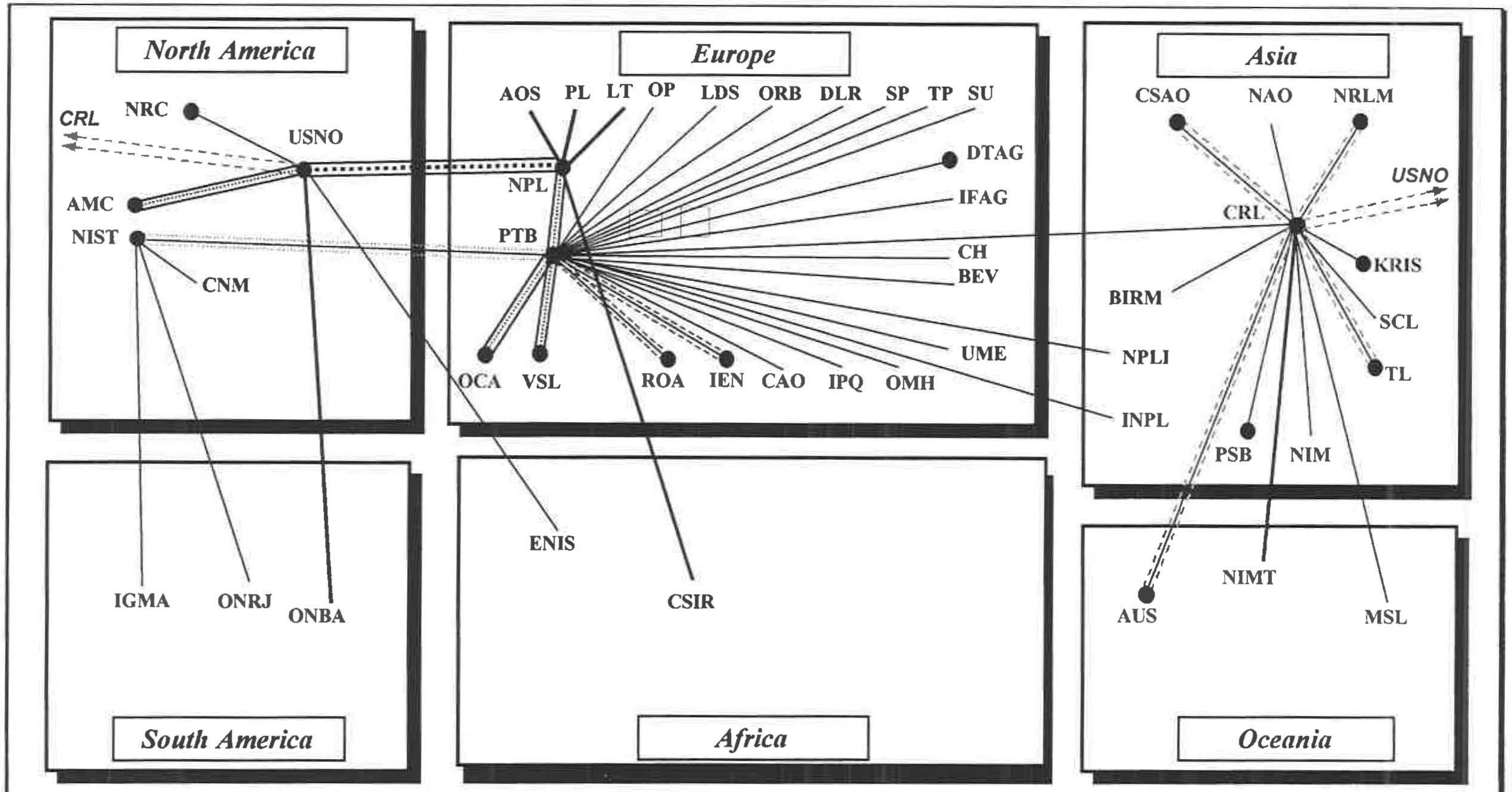
The report of the BIPM Time Section for the period July 2000 to June 2001, published in the *Director's Report on the Activity and Management of the BIPM*, 2001, Tome 2, is reproduced after the yellow pages. All the publications mentioned in this report are available on request from the BIPM.

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 session 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.



ORGANIZATION OF THE INTERNATIONAL TIME LINKS December 2001

TWSTFT	GPS CV single-channel
TWSTFT back-up link	GPS CV single-channel back-up link
TWSTFT link in preparation	GPS CV multi-channel
OCA/PTB link not used for computation of TAI	GPS CV multi-channel back-up link
● Laboratory equipped with TWSTFT	

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 0 h 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 2001, 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.

Depuis Juillet 1999 plusieurs liaisons TWSTFT ont été progressivement introduites dans le calcul du TAI ; les liaisons USNO/NPL, NIST/PTB, NPL/PTB et VSL/PTB ont été utilisées pour le calcul du TAI au cours de l'année 2001. Toutes les liaisons GPS sont corrigées à l'aide des cartes ionosphériques et des éphémerides précises et opérationnelles des satellites produites par l'IGS. La précision ultime d'une mesure unique [UTC(k_1) - UTC(k_2)] *est alors d'environ 2 ns pour les liaisons à courte distance et d'environ 4 ns pour les liaisons à longue distance. 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 2001.
Les pages jaunes, à la fin de ce volume, concernent les émissions de signaux horaires.

Le rapport (juillet 2000 - juin 2001) de la section du temps du BIPM publié dans 'Rapport du directeur sur l'activité et la gestion du Bureau international des poids et mesures (BIPM), Tome 2, Publications du BIPM', 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 12.

Table 1. Relative frequency offsets and step adjustments of UTC, up to 31 December 2002

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 December 2002

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)

AMC	Alternate Master Clock station, Colorado Springs, Colo., USA
AOS	Astronomiczne Obserwatorium Szerokosciowe (Borowiec Astrogeodynamic Observatory), Borowiec, Poland
APL	Applied Physics Laboratory, Laurel, Mass., 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	Consortium of laboratories in Switzerland
CNM	Centro Nacional de Metrología, Querétaro, Mexico
CRL	Communications Research Laboratory, Tokyo, Japan
CSAO (1)	Shaanxi Astronomical Observatory, Lintong, P.R. China
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
IPQ	Institute Português da Qualidade, Monte de Caparica, Portugal.
JATC	Joint Atomic Time Commission, Lintong, P.R. China
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
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 (2)	National Metrology Institute of Japan, Tsukuba, Japan
NML	National Measurement Laboratory, Sydney, Australia

(1) Since January 2002 has been changed to National Time Service Center of China (NTSC)

(2) Formerly NRLM

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
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
PSB	National Measurement Center, Singapore Productivity and Standards Board, Singapore
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig, Germany
ROA	Real Instituto y Observatorio de la Armada, San Fernando, Spain
SCL	Standards and Calibration Laboratory, Hong Kong
SMU	Slovenský metrologićký 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
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	Van Swinden Laboratorium, Delft, the Nederlands

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

TABLE 4. EQUIPMENT AND SOURCE OF UTC(K) OF THE LABORATORIES CONTRIBUTING TO TAI IN 2001

Ind. Cs : Industrial Cs standard

Lab. Cs : Laboratory Cs standard

H-maser : Hydrogen maser

* means 'yes'

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links		
				GPS	GLONASS	Two-Way
AOS	1 Ind. Cs	1 Cs + micro-phase-stepper		*	*	
AUS	13 Ind. Cs 4 H-masers 1 Linear Ion Trap Standard (2)	1 Cs	*	*		*
BEV (b)	2 Ind. Cs 1 Ind. Rb	1 Cs		*		
BIRM	2 Ind. Cs 2 H-maser	1 H-maser		*	*	
CAO	2 Ind. Cs	1 Cs		*		
CH	7 Ind. Cs (3)	all the Cs	*	*		
CNM	2 Ind. Cs	1 Cs		*		
CRL	15 Ind. Cs 1 Lab. Cs 2 H-masers	9 Cs	*	*	*	*
CSAO	6 Ind. Cs	all the Cs	*	*	*	*
CSIR	2 Ind. Cs	1 Cs		*	*	
DLR (b)	1 Ind. Cs 1 H-masers	1 H-maser		*	* (4)	
DTAG	3 Ind. Cs	1 Cs		*		
IEN	5 Ind. Cs	1 Cs + micro-phase-stepper	*	*	*	*

TABLE 4. EQUIPMENT AND SOURCE OF UTC(K)... (CONT.)

Ind. Cs : Industrial Cs standard

Lab. Cs : Laboratory Cs standard

H-maser : Hydrogen maser

* means 'yes'

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links		
				GPS	GLONASS	Two-Way
IFAG (b)	5 Ind. Cs 3 H-masers	1 Cs + micro-phase-stepper		*		
IGMA	4 Ind. Cs	1 Cs + micro-phase-stepper		* (a)		
INPL	3 Ind. Cs	1 Cs		*		
IPQ	3 Ind. Cs	1 Cs		*	*	
JATC	6 Ind. Cs (5)	1 Cs + micro-phase-stepper	*	*	*	*
KRIS	3 Ind. Cs 1 H-maser	1 Cs + micro-phase-stepper	*	*	*	
LDS (6)	1 Ind. Cs	1 Cs		*	*	
LT (7)	1 Ind. Cs	1 Cs		*		
MSL	3 Ind. Cs	1 Cs		*	*	
NAO (b)	4 Ind. Cs 1 H-maser	1 Cs + micro-phase-stepper		*		
NIM	3 Ind. Cs	1 Cs + micro-phase-stepper		*		
NIMT (8)	1 Ind. Cs	1 Cs + micro-phase-stepper		*		
NIST	20 Ind. Cs 2 Lab. Cs 5 H-masers	11 Cs 5 H-maser	*	*	*	*

TABLE 4. EQUIPMENT AND SOURCE OF UTC(K)... (CONT.)

Ind. Cs : Industrial Cs standard

Lab. Cs : Laboratory Cs standard

H-maser : Hydrogen maser

* means 'yes'

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links		
				GPS	GLONASS	Two-Way
NMC (9)	1 Ind. Cs	1 Cs		* (a)		
NMIJ (10)	4 Ind. Cs 1 Lab. Cs	1 Cs		*	*	*
NPL	3 Ind. Cs 2 H-maser	1 H-maser		*	*	*
NPLI (b)	3 Ind. Cs	1 Cs		*	*	
NRC	2 Ind. Cs 3 Lab. Cs 2 H-masers	1 Lab. Cs + micro-phase-stepper (11)	*	*		*
OMH	1 Ind. Cs	1 Cs		*		
ONBA (b)	2 Ind. Cs	1 Cs + micro-phase-stepper		*		
ONRJ	2 Ind. Cs	1 Cs		*		
OP	5 Ind. Cs 3 Lab. Cs 2 H-maser	1 Cs + micro-phase-stepper	* (12)	*		
ORB	3 Ind. Cs 2 H-maser	1 H-maser from MJD = 52212		*		
PL (13)	6 Ind. Cs	1 Cs	*	*		
PSB	3 Ind. Cs	1 Cs + micro-phase-stepper		*		
PTB	3 Ind. Cs 4 Lab. Cs (14) 3 H-masers	1 Lab. Cs	* (15)	*		*
ROA (b)	5 Ind. Cs	all the Cs		*		*

TABLE 4. EQUIPMENT AND SOURCE OF UTC(K)... (CONT.)

Ind. Cs : Industrial Cs standard

Lab. Cs : Laboratory Cs standard

H-maser : Hydrogen maser

* means 'yes'

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links		
				GPS	GLONASS	Two-Way
SCL	1 Ind. Cs	1 Cs + micro-phase-stepper		*		
SMU	1 Ind. Cs	1 Cs		*		
SP	5 Ind. Cs (16)	1 Cs + micro-phase-stepper		*		
SU	1 Lab. Cs 10 H-masers	6 H-masers	* (17)	*	*	
TL (b)	5 Ind. Cs 2 H-masers	1 Cs + micro-phase-stepper		*	*	*
TP	4 Ind. Cs	1 Cs + output frequency steering		*		
UME	3 Ind. Cs	1 Cs		*		
USNO	71 Ind. Cs 15 H-masers	UTC(USNO,MC) is an H-maser + frequency synthesizer steered to UTC(USNO) (18)	* (18)	*	*	*
VSL	4 Ind. Cs	1 Cs + micro-phase-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 2001):

* National Measurement Laboratory (NML, Sydney)	4 Cs, 2 H-masers.
Australian laboratories intercompared by GPS are:	
* National Measurement Laboratory Melbourne branch (NMLMEL, Melbourne)	1 Cs,
* Canberra Deep Space Communication Complex (CDSCC, Camberra)	1 Cs, 2 H-masers, 1 Linear Ion Trap Standard (LITS)
* Telstra Corporation Ltd (TELSTRA, Melbourne)	4 Cs,
* Australian Defence Force Calibration Laboratory (ADF, Sydney)	1 Cs,
* Australian Land Information Group, Yarragadee Observatory (Yarragadee, Western Australia)	1 Cs.
Australian laboratories intercompared by TV are:	
* VMS International (Sydney)	1 Cs,

(3) CH. The standards are located as follows (at the end of 2001):

* Swiss Federal Office of Metrology and Accreditation (METAS, Bern)	6 Cs,
* Neuchatel Observatoiry (ON, Neuchatel)	1 Cs,

They are intercompared by GPS (METAS-ON) and linked to the foreign laboratories through the Swiss Federal Office of Metrology and Accreditation.

(4) DLR. The GLONASS receiver is not connected to UTC(DLR)

(5) JATC. The standards are located at Shaanxi Astronomical Observatory (CSAO). The link between UTC(JATC) and UTC(CSAO) is obtained by internal connection.

(6) LDS. The contribution was resumed in June 2001.

(7) LT. Lithuanian Time and Frequency Standard Laboratory, Vilnius, Lithuania.

(8) NIMT. National Institute of Metrology (Thailand), Bangkok, Thailand

(9) NMC. National Centre of Metrology, Sofia, Bulgaria.

(10) NMIJ. NMIJ/AIST National Metrology Institute of Japan / National Institute of Advanced Industrial Science and Technology, formerly NRLM

(11) NRC. In 2001, UTC(NRC) was derived from NRC Cs VI A

NOTES (CONT.)

(12) OP. The French atomic time scale TA(F) is computed by the BNM-LPTF with data from 21 industrial caesium clocks located as follows (at the end of 2000) :

* Centre Electronique de l'Armement (CELAR, Rennes)	1 Cs,
* Centre National d'Etudes Spatiales (CNES, Toulouse)	3 Cs,
* France Telecom Recherche et Developpement (Lannion)	3 Cs,
* Agilent (Massy)	2 Cs,
* Observatoire de la Côte d'Azur (OCA, Grasse)	2 Cs,
* Observatoire de Paris : Laboratoire Primaire du Temps et des Fréquences (BNM-LPTF, Paris)	5 Cs,
* Observatoire de Besançon (OB, Besançon)	2 Cs,
* Tekelec Technologies (TKL, Les Ulis, Paris)	1 Cs,
* Direction des Constructions Navales (DCN, Brest)	2 Cs.

All laboratories are linked via GPS receivers

(13) PL. This acronym has replaced GUM in *Circular T* from August 2001, and stands for a consortium of Polish time laboratories:

* Główny Urząd Miar (Central Office of Measures) (GUM, Warsaw)	3 Cs
* Obserwatorium Astrogeodynamiczne (Astrogeodynamical Observatory) (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)	1 Cs

Also since August 2001, an independent atomic time scale TA(PL) has been computed by GUM, with data from industrial caesium clocks: the six above and additionally:

* Time and Frequency Standard Laboratory of the Semiconductor Physics Institute (LT, Vilnius, Lithuania)	1 Cs

(14) PTB. The laboratory Cs, PTB CS1, PTB CS2 and PTB CS3, are operated continuously as clocks. 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.

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

(16) SP. The standards are located as follows (at the end of 2001):

* Swedish National Testing and Research Institute (SP, Boras)	4 Cs,
* STUPI AB (Stockholm)	1 Cs,

(17) SU. *TA(SU)-UTC(SU)* = 29.172 759 000 s from 51910 to 52274

(18) 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 2000, not confirmed by the laboratory.

Table 5. Differences between the normalized frequencies of EAL and TAI, up to April 2002

(File available on http://www.bipm.org under the name EALTAI01.AR)

Date	MJD	$[f(EAL) - f(TAI)] \times 10^{-13}$
until 1977 Jan 1	until 43144	0
1977 Jan 1 - 1977 Apr 26	43144 - 43259	10.0
1977 Apr 26 - 1977 Jun 25	43259 - 43319	9.8
1977 Jun 25 - 1977 Aug 24	43319 - 43379	9.6
1977 Aug 24 - 1977 Oct 23	43379 - 43439	9.4
1977 Oct 23 - 1978 Oct 28	43439 - 43809	9.2
1978 Oct 28 - 1979 Jun 25	43809 - 44049	9.0
1979 Jun 25 - 1979 Aug 24	44049 - 44109	8.8
1979 Aug 24 - 1979 Oct 23	44109 - 44169	8.6
1979 Oct 23 - 1982 Apr 30	44169 - 45089	8.4
1982 Apr 30 - 1982 Jun 29	45089 - 45149	8.2
1982 Jun 29 - 1982 Aug 28	45149 - 45209	8.0
1982 Aug 28 - 1984 Feb 29	45209 - 45759	7.8
1984 Feb 29 - 1987 Apr 24	45759 - 46909	8.0
1987 Apr 24 - 1987 Dec 30	46909 - 47159	8.0125
1987 Dec 30 - 1989 Jun 22	47159 - 47699	8.0
1989 Jun 22 - 1989 Dec 29	47699 - 47889	7.95
1989 Dec 29 - 1990 Feb 27	47889 - 47949	7.90
1990 Feb 27 - 1990 Apr 28	47949 - 48009	7.85
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 Apr 30	52364 - 52394	7.030

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 UTAI01.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, LPTF-JPO, NIST-F1, PTB CS1, PTB CS2 and PTB CSF1 for the year 2001.
Previous calibrations are available in the successive annual reports of the BIPM Time Section volumes 1 to 13.

Each comparison is provided with the following information:
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_A is the uncertainty originating in the instability of the PFS,
$u_{link/lab}$ is the uncertainty in the link between the PFS and the clock participating to TAI,
$u_{link/TAI}$ 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 2001 are indicated below.

Primary Standard	Typical type B std. uncertainty	Operation	Comparison with	Typical duration of comparison
CRL-O1	4×10^{-15}	Discontinuous	UTC(CRL)	10 or 15 d
LPTF-JPO	6×10^{-15}	Discontinuous	H maser	15 to 30 d
NIST-F1	1×10^{-15}	Discontinuous	H maser	30 to 45 d
PTB CS1	8×10^{-15}	Continuous	TAI	30 d
PTB CS2	12×10^{-15}	Continuous	TAI	30 d
PTB CSF1	1×10^{-15}	Discontinuous	H maser	15 or 20 d

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

Standard	Period of estimation	d (10^{-15})	u_B (10^{-15})	Ref(u_B)	u_A (10^{-15})	$u_{link/lab}$ (10^{-15})	$u_{link/TAI}$ (10^{-15})	Notes	u (10^{-15})
CRL-01	51889-51899	-26.7	4.3	[1]	8.9	0.8	3.	(1)	10.4
CRL-01	52109-52124	+5.4	3.9		12.4	0.8	2.		13.2
CRL-01	52154-52164	+10.4	3.9		3.1	0.8	3.		5.9
LPTF-JPO	51964-51994	+3.5	6.4	[2]	0.5	0.3	1.	(2)	6.5
LPTF-JPO	51999-52024	+4.8	6.4		0.5	0.3	1.		6.5
LPTF-JPO	52024 52039	+7.7	6.4		0.5	0.3	2.		6.7
LPTF-JPO	52094 52114	+2.7	6.4		0.5	0.3	1.5		6.6
LPTF-JPO	52129 52149	+0.9	6.4		0.5	0.3	1.5		6.6
LPTF-JPO	52159 52179	+2.0	6.4		0.5	0.3	1.5		6.6
LPTF-JPO	52179 52209	+1.5	6.4		0.5	0.3	1.5		6.6
LPTF-JPO	52209 52239	-0.9	6.4		0.5	0.3	1.		6.5
NIST-F1	51939-51969	+4.6	1.6	[3]	0.9	0.3	1.0		2.1
NIST-F1	52079-52119	+8.6	1.0		0.9	0.2	0.8		1.6
NIST-F1	52209-52254	+10.5	0.7		1.0	0.2	0.7		1.4
PTB CS1	51909-51939	-5.3	8.	[4,6]	5.	0.	1	(3)	9.
PTB CS1	51939-51964	-1.2	8.		5.	0.	1.		9.
PTB CS1	51964-51999	+1.5	8.		5.	0.	1.		9.
PTB CS1	51999-52029	+4.4	8.		5.	0.	1.		9.
PTB CS1	52029-52059	-6.3	8.		5.	0.	1.		9.
PTB CS1	52059-52089	+4.5	8.		5.	0.	1.		9.
PTB CS1	52089-52119	+4.2	8.		5.	0.	1.		9.
PTB CS1	52119-52149	+5.0	8.		5.	0.	1.		9.
PTB CS1	52149-52179	-2.7	8.		5.	0.	1.		9.
PTB CS1	52179-52209	-6.7	8.		5.	0.	1.		9.
PTB CS1	52209-52239	-1.1	8.		5.	0.	1.		9.
PTB CS1	52239-52274	-1.0	8.		5.	0.	1.		9.
PTB CS2	51909-51939	+9.7	12.	[5,6]	3.	0.	1.	(3)	12.
PTB CS2	51939-51964	+8.0	12.		3.	0.	1.		12.
PTB CS2	51964-51999	+13.4	12.		3.	0.	1.		12.
PTB CS2	51999-52029	+0.2	12.		3.	0.	1.		12.
PTB CS2	52029-52059	+4.2	12.		3.	0.	1.		12.
PTB CS2	52059-52089	+10.6	12.		3.	0.	1.		12.
PTB CS2	52089-52119	+9.2	12.		3.	0.	1.		12.
PTB CS2	52119-52149	+3.5	12.		3.	0.	1.		12.
PTB CS2	52149-52179	+8.4	12.		3.	0.	1.		12.
PTB CS2	52179-52209	+8.7	12.		3.	0.	1.		12.
PTB CS2	52209-52239	+5.1	12.		3.	0.	1.		12.
PTB CS2	52239-52274	+5.6	12.		3.	0.	1.		12.
PTB CSF1	52009-52024	+6.7	2.0	[7]	1.0	0.	2.		3.0
PTB CSF1	52054-52069	+9.5	0.9		1.0	0.	2.	(2)	2.4
PTB CSF1	52109-52129	+10.8	1.0		1.0	0.	1.5		2.1
PTB CSF1	52154-52174	+11.2	1.0		1.0	0.	1.5		2.1
PTB CSF1	52209-52229	+12.7	1.0		1.0	0.	1.5		2.1

Notes:

(1) This evaluation was, by mistake, not included in the BIPM Annual Report Volume 13.

(2) Corrects the information published in Circular T for this evaluation.

(3) 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.

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Operation of CRL-O1

CRL-O1 is an optically pumped primary frequency standard. It has been developed under the cooperation between CRL Japan and NIST US. Its design is based on NIST 7 [1,2]. It has been operational since April 2000. Now we are preparing a paper on the accuracy evaluation of this standard [3].

Physical Effect	Bias (10^{-15})	Uncertainty (10^{-15})
Second-order Doppler	$\delta\nu_D \sim -300$	2
Second-order Zeeman	$\delta\nu_{QZ} \sim 1.5\text{x}10^5$	0.2
Cavity pulling	$\delta\nu_C \sim 0$	0.6
Cavity phase (end-to-end)	$\lvert \delta\nu_E \rvert$ 150	0.2
Blackbody	$\delta\nu_B \sim -20$	0.5
Gravitation	$\delta\nu_G \sim 8.2$	0.1
Uncorrected biases	0	3.5
Combined Type B Uncertainty		4.1

Table1: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	1.7
Beam Flux Variation	0.3
Microwave Leakage	1.0
DC Stark Shift	0.01
Spectral Purity	0.1
Modulation Synchronous Effects	
Detector/Demodulator	1.0
AM on Laser	1.0
Switching Transients	2.0
Combined Type B Uncertainty	3.5

Table 2: Details on the uncertainty of uncorrected biases

REFERENCES

[1]Lee W. D., et al., IEEE Trans. Instrum. Meas., Vol.44, No.2, pp.120-123 Apr. 1995.
[2] Shirley J .H., Lee W. D., Drullinger R. E., Metrologia, 2001, 38, 427-458.
[3] Hasegawa A., et al., to be submitted to Metrogia.

Operation of NIST-F1 in 2001

NIST-F1, the Cs fountain primary frequency standard at the National Institute of Standards and Technology (NIST), has been in operation since November 1998 [1], and the first formal report to the BIPM was made in November 1999 [2]. 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. Given that the standard is always changing we have chosen, for the time being, to include measurements at a range of atom densities in each formal evaluation. Each formal evaluation also includes a magnetic field map, and a check of such things as microwave leakage and light leaks. The main result of an evaluation is a value for the maser frequency at the zero atom density intercept and its uncertainty, which are obtained from a linear least mean square fit to the maser frequency versus atom density data. A specific spin exchange bias cannot be stated since there is no clear value of the many atom densities that should be used as the reference. However, the typical frequency shift from the lowest measured density (which makes up only a portion of the data obtained during an evaluation) to zero density is on the order of 1×10^{-15}.

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 (stability, frequency drift, etc.) 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 [3, 4]. 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 1×10^{-16}, and therefore the uncertainty introduced by the dead time dominates the value of $u_{link/lab}$, which ranged from 2×10^{-16} to 3×10^{-16} in 2001.

In 2001 three formal evaluations were made (February, July and December) and their durations ranged from 30 to 45 days. Significant improvements in operational reliability were made in 2001 as well as reductions in the combined uncertainty. The fractional run time improved from 48% of the evaluation period to 67%, and the combined uncertainty (quadrature sum of u_A and u_B) was reduced from 1.8×10^{-15} to 1.2×10^{-15}. The significant contributors to the systematic uncertainty, u_B, in the last evaluation of 2001 were; spin exchange at 4.8×10^{-16}, blackbody shift at 3×10^{-16}, fluorescent light shift and microwave leakage at 2×10^{-16}, and Zeeman and gravitation shift at 1×10^{-16}. Improvements made to the fountain in 2001 include; (1) atom number control through the state selection cavity and a number servo, (2) improved magnetic field map, and (3) increased reliability through new shutters and modifications made to the lasers. The number servo helped reduce both u_A and the spin exchange bias by improving the stability of the measurements, and the improved field map reduced the Zeeman bias uncertainty to 1×10^{-16}. Other useful efforts in 2001 were the measurement of quantum projection noise and an investigation of Majorana transitions.

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Operation of the PTB primary clocks in 2001

Type B uncertainty, u_B.

In 2001, the PTB CS1 and CS2 were in continuous service without any modification or disturbance. Their operation parameters were checked regularly, beam reversals were performed. No indications were found calling for a change of the relative frequency uncertainties, u_B, which are $8 \cdot 10^{-15}$ and $12 \cdot 20^{-15}$ for CS1 and CS2, respectively [1].

The fountain clock, CSF1, was operated intermittently. Throughout the year an additional state selection process has been used yielding a reduction of the uncertainty, u_B, from $1.4 \cdot 10^{-15}$ [2] to typically $1.0 \cdot 10^{-15}$. The u_B contributions given in the table [3] reflect standard operation conditions, but may vary slightly , e. g. when a larger than standard atom number is used.

Physical origin	Correction $[10^{-15}]$	Uncertainty $[10^{-15}]$
C-field	-46.4	< 0.1
Collisional shift	2.5	< 0.7
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, Electronics		
Light shift	-	0.2
Other collisions	-	0.2
	-	0.1
Total 1σ uncertainty u_B		1.0

Frequency instability u_A, final results.

The short-term frequency instability of the clocks was evaluated throughout 2001 by comparison with an active H maser. Concerning CS1 and CS2, a mean instability, $\sigma_y(\tau = 1h)$, of $77 \cdot 10^{-15}$ and of $66 \cdot 10^{-15}$, respectively, was measured in good agreement with the expectations which are based on signal strength, linewidth, and detector noise. In CSF1, the frequency instability was typically $\sigma_y(\tau = 1h) = 4 \cdot 10^{-15}$ durind the five measurement intervals.

References

1. Heindorff T., Bauch A., Hetzel P., Petit G., Weyers S., Metrologia, 2001, 38, 497-502
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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 SITAI01.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**, 87-93, using all available measurements from the most accurate primary frequency standards CRL-O1, LPTF-JPO, NIST-7, NIST-F1, NRLM-4, PTB CS1, PTB CS2, PTB CS3 and PTB CSF1, 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. 1999	51174-51209	+1.6	2.5
Feb. 1999	51209-51234	+2.3	2.5
Mar. 1999	51234-51264	+3.7	2.5
Apr. 1999	51264-51294	+3.8	2.4
May 1999	51294-51329	+3.9	2.3
Jun. 1999	51329-51359	+4.4	2.3
Jul. 1999	51359-51389	+4.8	2.2
Aug. 1999	51389-51419	+5.3	2.4
Sep. 1999	51419-51449	+5.4	2.3
Oct. 1999	51449-51479	+5.6	2.2
Nov. 1999	51479-51509	+5.0	2.0
Dec. 1999	51509-51539	+4.6	1.9
Jan. 2000	51539-51574	+4.5	2.0
Feb. 2000	51574-51599	+4.8	1.7
Mar. 2000	51599-51634	+5.6	1.9
Apr. 2000	51634-51664	+6.4	2.1
May 2000	51664-51694	+6.8	2.1
Jun. 2000	51694-51724	+6.2	2.1
Jul. 2000	51724-51754	+6.6	2.0
Aug. 2000	51754-51784	+7.3	1.4
Sep. 2000	51784-51814	+7.1	1.5
Oct. 2000	51814-51844	+7.2	1.5
Nov. 2000	51844-51874	+7.4	1.7
Dec. 2000	51874-51909	+5.4	1.8
Jan. 2001	51909-51939	+5.6	2.0
Feb. 2001	51939-51969	+4.9	1.5
Mar. 2001	51969-51999	+5.8	1.9
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	+8.3	1.6
Sep. 2001	52149-52179	+9.2	1.4
Oct. 2001	52179-52209	+8.1	1.7
Nov. 2001	52209-52239	+10.1	1.1
Dec. 2001	52239-52269	+8.9	1.7

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 36 File SCHGPS.36	implemented on MJD = 52002 (2001 April 3) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GPS Schedule no 37 File SCHGPS.37	implemented on MJD = 52212 (2001 October 30) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 11 File SCHGLO.11	implemented on MJD = 52002 (2001 April 3) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 12 File SCHGLO.12	implemented on MJD = 52212 (2001 October 30) 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 :

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

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:

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

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 the highest-elevation satellites are first corrected for precise satellite ephemerides and for delays derived from IGS ionospheric 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)*] provided on the BIPM internet network. 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 characterizing the dispersion of individual measurements; N: the number of measurements) is available from the BIPM website (see p. 6) under the name UTCGPS01.AR.

[*TAI – GLONASS time*] AND [*UTC – GLONASS time*]

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

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

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:

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

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 characterizing the dispersion of individual measurements; N: the number of measurements) is available from the BIPM website (see p. 6) under the name UTCGLO01.AR.

Table 8A. Rates relative to TAI of contributing clocks in 2001

(File available on http://www.bipm.org under the name RTAI01.AR)

Mean clock rates relative to TAI are computed for one-month intervals ending at the 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 2001. For studies including the clock rates of previous years, corrections must be brought to the data published in the Annual Report for 1988 to 2000, 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.

lab.	clock		51939	51964	51999	52029	52059	52089
AOS	23	67	13.97	2.98	-6.08	-5.32	7.68	-4.52
AUS	36	249	-3.65	-4.34	-7.30	-9.29	9.13	***
AUS	36	299	***	***	***	***	18.96	19.06
AUS	36	340	-0.04	-0.39	-1.56	-0.33	-1.18	0.88
AUS	36	654	-29.09	-28.51	-28.91	-28.40	-27.87	-28.18
AUS	36	1035	***	4.34	***	***	3.61	3.97
AUS	36	1141	1.09	0.90	1.12	-0.59	0.17	1.22
AUS	40	5401	21.60	21.64	22.20	20.19	22.10	***
AUS	40	5402	-21.08	-14.31	-16.42	***	***	***
AUS	40	5403	-23.13	-28.72	8.97	25.66	27.93	***
AUS	99	1	***	***	***	***	***	***
BEV	16	71	***	***	***	***	***	***
BEV	35	1065	0.96	-0.15	-0.42	0.46	-1.02	-0.75
CAO	35	939	0.01	0.97	2.78	0.29	1.88	1.11
CAO	35	1270	3.10	3.13	***	2.77	***	***
CH	17	206	10.94	16.39	14.42	0.58	26.41	28.11
CH	21	179	24.67	***	***	***	***	***
CH	21	194	-49.56	-48.68	-52.90	-45.67	-49.72	-45.07
CH	21	217	128.96	138.59	133.82	130.81	124.22	131.75
CH	31	403	-64.90	-61.82	-61.80	-57.41	-52.35	-53.61
CH	35	413	7.98	5.75	4.48	-0.43	-6.56	-7.91
CH	35	771	7.89	8.33	8.25	7.83	7.70	6.26
CH	36	354	53.66	53.61	54.67	54.06	45.67	45.88
CNM	35	237	***	2.05	1.09	1.20	0.98	0.73
CNM	35	382	-0.38	-0.09	1.17	0.32	0.86	***
CNM	36	1537	***	***	***	***	***	***
CRL	35	112	1.75	-1.65	-1.57	0.11	-0.27	-0.49
CRL	35	144	14.56	15.46	15.61	15.34	15.57	15.61
CRL	35	332	10.14	10.87	10.56	12.39	11.38	11.51
CRL	35	342	6.35	6.82	6.80	6.22	6.39	6.00
CRL	35	343	11.13	11.69	12.04	12.76	13.41	12.91
CRL	35	715	-2.01	-1.70	-2.67	-1.99	-2.44	-2.77
CRL	35	732	-2.08	-1.95	-1.87	-0.82	-2.05	-1.34
CRL	35	907	14.94	13.91	14.91	15.29	14.08	13.14
CRL	35	908	9.01	10.03	10.54	10.26	9.61	9.74

Table 8A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
AOS	23	67	***	***	***	***	***	***
AUS	36	249	***	***	-1.35	-0.67	***	***
AUS	36	299	17.82	19.52	20.56	18.68	19.51	20.26
AUS	36	340	2.04	0.50	0.36	-0.28	-1.48	-0.66
AUS	36	654	-26.43	-28.04	-27.58	-26.87	-28.69	-27.83
AUS	36	1035	4.39	4.04	4.59	3.50	4.08	4.94
AUS	36	1141	1.34	1.85	1.96	1.13	1.66	1.31
AUS	40	5401	***	15.80	15.46	15.96	17.01	17.15
AUS	40	5402	***	-21.67	-21.05	***	***	***
AUS	40	5403	***	-0.98	-7.29	-6.39	***	***
AUS	99	1	***	-0.29	7.55	10.65	***	***
BEV	16	71	***	-23.58	-38.86	-43.02	-11.59	15.27
BEV	35	1065	-0.28	0.62	0.12	0.89	1.59	0.65
CAO	35	939	***	***	1.31	1.27	1.52	0.57
CAO	35	1270	***	***	2.12	2.42	1.78	0.70
CH	17	206	28.14	15.07	16.24	31.70	25.08	-2.74
CH	21	179	***	***	***	***	***	***
CH	21	194	-54.04	-50.91	-48.31	-48.92	-49.36	-45.55
CH	21	217	129.72	130.72	139.14	136.30	131.30	136.86
CH	31	403	-55.80	-55.46	-56.54	-56.67	-57.24	-57.97
CH	35	413	-10.81	-11.56	-13.88	-12.93	-14.16	-13.99
CH	35	771	8.49	8.59	8.07	7.48	8.13	7.57
CH	36	354	44.64	46.28	44.98	45.35	45.16	46.71
CNM	35	237	0.74	0.44	1.30	-0.44	1.93	***
CNM	35	382	***	***	***	***	***	***
CNM	36	1537	-18.62	-18.73	-17.39	-19.66	-16.02	-19.79
CRL	35	112	-0.08	-1.38	-0.01	-1.13	-0.87	-0.29
CRL	35	144	15.47	15.14	15.72	16.08	16.25	14.99
CRL	35	332	11.17	11.58	12.52	12.03	12.59	12.65
CRL	35	342	6.06	5.29	5.53	***	***	***
CRL	35	343	12.67	12.22	13.31	13.18	14.16	14.11
CRL	35	715	-1.13	-2.16	-2.04	-1.40	-1.66	-1.10
CRL	35	732	-1.16	-2.03	-1.25	-1.67	-1.73	-0.33
CRL	35	907	14.13	13.74	14.51	13.76	15.66	14.98
CRL	35	908	9.45	8.21	9.46	10.74	8.99	8.64

Table 8A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
CSAO	35	1007	-8.89	-8.57	-8.49	-9.22	-8.68	-9.02
CSAO	35	1008	14.24	14.22	15.93	16.13	15.43	16.42
CSAO	35	1011	-2.66	-2.94	-4.50	-4.59	-5.08	-4.56
CSAO	35	1016	0.99	0.28	2.03	1.99	1.26	1.91
CSAO	35	1017	0.71	1.47	1.79	1.61	1.06	0.81
CSAO	35	1018	14.21	13.59	14.07	13.90	13.39	13.68
DLR	40	7424	-35.53	-34.36	-33.84	-34.02	-33.25	***
DTAG	36	136	***	***	***	***	***	***
DTAG	36	345	***	***	***	***	***	***
DTAG	36	465	***	***	***	***	***	***
F	35	122	5.58	6.17	6.76	6.68	7.39	7.09
F	35	124	2.42	2.08	2.68	2.53	2.52	2.61
F	35	131	5.70	6.23	6.70	5.31	6.47	5.15
F	35	158	16.84	16.37	16.90	16.11	16.32	16.99
F	35	172	***	***	***	***	***	***
F	35	198	***	***	4.74	4.78	6.66	5.88
F	35	355	1.22	1.15	0.44	1.06	0.27	0.38
F	35	385	9.24	8.31	9.63	8.83	9.41	11.20
F	35	396	4.56	4.70	5.04	4.53	5.20	4.91
F	35	469	***	***	***	***	***	***
F	35	489	***	***	***	***	***	***
F	35	536	-5.80	-5.66	-6.03	-6.05	-6.05	-6.31
F	35	609	25.07	25.18	25.32	25.39	***	***
F	35	770	12.05	11.98	11.42	12.57	12.58	12.29
F	35	774	***	***	***	***	***	***
F	35	781	-20.18	-20.12	-19.59	-20.39	-19.30	-19.84
F	35	819	26.54	24.82	26.21	24.81	23.49	24.45
F	35	859	3.26	4.02	3.21	2.33	1.70	2.75
F	35	1177	-9.94	-8.97	-9.39	-9.42	-11.35	-11.81
F	35	1178	6.63	6.57	7.46	6.44	5.82	5.08
F	35	1222	7.09	7.72	7.86	7.01	7.17	6.16
F	35	1321	9.48	10.31	10.66	10.58	10.27	11.05
F	35	1556	-17.38	-17.32	-16.84	-16.37	***	***
F	40	805	-48.31	-47.25	-46.88	-48.17	-49.34	-51.75
F	40	816	-15.18	-16.10	-16.97	-17.87	-20.25	-22.08
GUM	18	746	65.79	63.00	62.11	-3.72	-1.37	-5.92
GUM	23	67	***	***	***	***	***	***
GUM	35	502	-10.11	-7.57	-8.30	-9.40	-9.41	-9.08
GUM	35	745	1.96	2.27	***	***	***	***
GUM	35	761	0.21	-1.78	-2.23	2.84	-0.05	1.12
GUM	35	1120	0.16	-0.07	-0.10	-0.99	-0.32	-0.32
GUM	35	1362	***	-3.27	-2.29	-2.66	***	***
GUM	35	1660	***	***	***	***	***	***
IEN	35	219	13.37	12.74	12.45	13.47	13.49	13.54
IEN	35	505	10.11	9.87	9.91	9.64	9.50	9.96

Table 8A. (Cont.)

lab.	clock	52119	52149	52179	52209	52239	52274
CSAO	35 1007	-10.61	-10.47	-10.58	-10.07	-9.16	-10.47
CSAO	35 1008	16.97	16.62	17.02	16.25	17.01	16.74
CSAO	35 1011	-4.73	-4.58	-5.99	-6.57	-5.99	-6.03
CSAO	35 1016	1.65	2.50	1.82	2.53	2.58	0.91
CSAO	35 1017	1.12	1.33	1.27	0.80	0.52	0.67
CSAO	35 1018	13.17	14.04	13.19	12.98	13.86	12.96
DLR	40 7424	***	***	***	***	***	***
DTAG	36 136	***	***	-1.63	-0.38	-1.57	0.32
DTAG	36 345	***	***	1.64	1.80	-1.23	0.57
DTAG	36 465	***	***	-5.21	-1.18	2.94	3.66
F	35 122	7.20	7.11	7.57	9.56	8.86	9.45
F	35 124	2.85	2.90	2.70	2.80	2.14	2.08
F	35 131	3.51	3.64	3.06	2.57	2.26	2.30
F	35 158	15.98	16.01	16.94	16.68	16.47	16.26
F	35 172	***	***	6.26	6.69	6.63	7.45
F	35 198	6.23	6.46	8.25	8.87	8.61	8.40
F	35 355	0.59	0.36	0.88	0.80	0.75	0.19
F	35 385	11.72	12.74	13.32	13.09	13.62	12.51
F	35 396	5.32	4.95	5.94	6.07	6.11	6.74
F	35 469	***	-0.35	0.38	1.03	0.79	***
F	35 489	***	12.45	12.38	11.54	12.13	***
F	35 536	-6.78	-6.24	***	***	***	***
F	35 609	***	***	***	-2.43	-3.30	-3.65
F	35 770	11.23	11.13	***	***	***	***
F	35 774	***	-22.03	-23.78	-22.73	-22.65	-23.65
F	35 781	-20.38	***	***	***	***	***
F	35 819	23.95	23.38	23.59	23.75	22.45	22.47
F	35 859	2.99	4.09	2.82	1.13	0.88	-1.20
F	35 1177	-11.52	-13.09	-11.55	-11.93	-10.99	-10.28
F	35 1178	4.65	5.29	4.62	4.20	5.78	6.77
F	35 1222	7.54	7.44	7.66	7.81	7.55	8.50
F	35 1321	10.97	10.67	10.85	10.26	9.93	10.64
F	35 1556	-15.45	-14.47	-15.33	-15.60	-15.01	-15.95
F	40 805	-55.91	-60.18	-62.13	-62.32	-62.44	-60.30
F	40 816	-24.23	-25.45	-26.01	-26.61	-26.15	-25.53
GUM	18 746	-5.78	-28.51	-9.04	-3.66	3.54	-4.06
GUM	23 67	***	-6.83	-12.10	11.76	90.17	***
GUM	35 502	-10.76	-9.84	-9.96	-11.26	-10.43	-12.16
GUM	35 745	***	***	***	***	***	***
GUM	35 761	-2.01	-0.07	-3.29	-1.23	-3.06	-2.73
GUM	35 1120	-0.91	0.47	-0.53	-1.05	-0.61	-0.90
GUM	35 1362	***	***	***	***	***	***
GUM	35 1660	***	***	-1.62	-0.67	-0.84	-2.89
IEN	35 219	14.07	***	***	12.12	12.31	11.61
IEN	35 505	0.49	0.67	10.01	8.20	***	***

Table 8A. (Cont.)

lab.	clock	51939	51964	51999	52029	52059	52089
IEN	35 1115	-9.62	-10.21	-10.24	-9.80	-10.12	-10.27
IEN	35 1373	-2.04	-3.05	-2.10	-2.24	-1.90	-1.67
IFAG	36 1034	-12.96	-11.58	-10.46	-8.27	-13.12	-16.24
IFAG	36 1167	***	-10.18	-9.41	-9.44	-10.06	-5.91
IFAG	36 1173	-0.34	-0.17	0.85	0.22	-3.71	-4.18
IFAG	36 1629	***	***	5.90	4.23	6.28	6.54
IFAG	40 4401	49.00	65.46	82.71	82.51	83.45	55.64
IFAG	40 4403	***	19.80	63.93	91.74	86.19	92.61
IFAG	40 4413	***	***	***	***	***	92.61
IGMA	14 2403	9.64	-11.08	-2.24	-13.91	-8.32	-21.98
IGMA	16 112	28.91	45.41	43.97	49.32	57.17	41.79
IGMA	35 631	17.71	17.25	14.95	17.17	16.85	14.87
IGMA	35 645	14.18	13.87	12.79	13.04	14.81	15.65
INPL	35 1021	-2.89	-3.10	***	***	***	***
INPL	35 1652	***	***	***	-6.73	-8.47	-10.09
KRIS	36 321	4.79	4.99	5.06	5.53	3.85	3.90
KRIS	36 739	-12.34	-10.79	-9.24	-12.49	-10.62	-10.61
KRIS	36 1135	13.13	13.08	14.37	16.68	17.16	18.83
KRIS	40 5623	28.31	27.80	29.71	29.91	27.99	27.81
LDS	35 289	***	***	***	***	***	***
LT	35 1362	***	***	***	***	***	-2.27
MSL	12 933	37.27	45.57	***	36.32	35.98	29.81
MSL	35 1025	-11.18	-10.64	-12.22	-10.08	-10.83	-10.65
MSL	36 274	6.67	8.53	5.17	8.56	3.58	5.33
NAO	35 779	17.08	17.62	18.15	18.11	17.36	17.86
NAO	35 1206	9.28	11.38	10.30	9.98	11.01	10.81
NAO	35 1214	8.40	8.81	8.24	9.32	9.17	10.06
NAO	35 1689	***	***	***	***	-1.22	-0.95
NIM	35 479	10.46	9.68	10.51	9.86	10.25	9.56
NIM	35 1238	4.46	4.09	***	4.02	4.56	3.14
NIM	35 1239	10.32	10.70	11.76	10.44	10.43	9.14
NIST	35 132	-2.78	-3.02	-3.43	-2.06	***	***
NIST	35 182	-11.97	-12.04	-11.82	-12.01	-12.07	-11.88
NIST	35 408	***	***	***	***	***	***
NIST	35 1074	-8.52	-7.61	-7.65	-7.90	-7.77	-7.91
NIST	40 201	27.84	28.70	29.15	29.22	29.38	29.59
NIST	40 203	12.81	13.58	14.35	15.48	16.47	17.16
NIST	40 204	0.91	1.14	1.50	1.95	2.34	2.49
NIST	40 205	-19.03	-19.19	***	-19.65	-20.27	-20.71
NIST	40 222	-13.70	-13.62	-13.64	-13.48	-13.40	-13.56
NMC	35 1501	-4.42	-3.80	-1.93	-3.03	-3.79	-3.66
NPL	35 784	5.29	5.09	6.34	5.35	6.32	6.14
NPL	35 1275	4.40	4.37	3.29	3.06	3.29	5.46
NPL	36 404	11.83	14.58	12.71	13.45	13.91	13.54
NPL	40 1701	-1.33	-1.24	-0.99	-1.01	-0.69	-1.49

Table 8A. (Cont.)

lab.	clock	52119	52149	52179	52209	52239	52274
IEN	35 1115	-10.30	-8.79	-9.43	-8.92	-10.40	-9.27
IEN	35 1373	-0.86	-0.68	-0.56	-1.15	-1.48	-0.46
IFAG	36 1034	-16.23	-16.35	-15.15	-15.51	-13.85	-12.48
IFAG	36 1167	16.17	-5.27	-5.53	-4.27	-8.84	-8.05
IFAG	36 1173	-4.90	-3.51	-5.02	-5.72	5.94	0.86
IFAG	36 1629	5.92	4.16	5.23	6.53	4.06	2.60
IFAG	40 4401	63.69	0.56	18.99	36.17	63.01	105.19
IFAG	40 4403	31.26	83.25	11.42	12.81	29.38	55.54
IFAG	40 4413	38.98	13.72	49.01	77.21	45.90	58.70
IGMA	14 2403	-4.21	7.54	13.57	18.35	-18.21	-18.62
IGMA	16 112	41.47	39.59	48.36	36.53	52.30	38.71
IGMA	35 631	14.14	13.55	12.60	14.40	14.46	14.36
IGMA	35 645	16.42	16.53	14.10	15.93	16.82	19.82
INPL	35 1021	***	***	***	***	***	***
INPL	35 1652	-10.79	-11.78	-13.08	-10.68	-9.40	-8.12
KRIS	36 321	6.12	4.55	5.17	5.82	5.14	6.80
KRIS	36 739	-8.42	-10.29	-11.01	-11.77	-9.27	-9.95
KRIS	36 1135	16.91	19.04	21.37	21.13	19.71	19.75
KRIS	40 5623	29.50	30.07	28.99	29.30	29.46	29.84
LDS	35 289	6.88	***	5.36	5.58	5.41	5.32
LT	35 1362	***	-4.68	-2.53	-3.67	-3.59	-4.64
MSL	12 933	32.39	34.35	33.10	***	44.55	***
MSL	35 1025	-9.60	-10.67	-11.00	***	-10.93	***
MSL	36 274	5.65	7.26	4.80	***	4.47	***
NAO	35 779	17.28	18.74	17.19	19.09	19.26	18.37
NAO	35 1206	11.51	11.23	11.81	12.13	12.11	12.67
NAO	35 1214	10.36	10.09	9.67	9.62	9.14	9.60
NAO	35 1689	-0.97	-1.84	-1.76	-1.21	-1.40	-1.71
NIM	35 479	10.07	10.50	10.70	8.11	6.13	4.30
NIM	35 1238	4.02	4.26	4.87	3.47	3.27	1.47
NIM	35 1239	9.77	10.39	10.15	7.92	6.67	4.78
NIST	35 132	-0.98	-1.54	-0.35	-1.30	0.09	-0.23
NIST	35 182	-11.58	-11.75	-12.08	-11.96	-12.07	-11.99
NIST	35 408	-2.38	-2.71	-2.01	-1.45	-1.65	-1.00
NIST	35 1074	-7.61	-8.08	-8.01	-7.96	-8.08	-7.62
NIST	40 201	29.92	32.69	34.54	34.17	33.21	32.10
NIST	40 203	18.01	18.99	19.80	20.75	21.46	22.44
NIST	40 204	2.92	3.19	3.52	4.20	4.41	4.69
NIST	40 205	-20.90	-21.13	-21.33	-21.42	-21.74	-21.92
NIST	40 222	-13.46	-13.37	-13.33	-13.12	-13.26	-13.18
NMC	35 1501	-1.56	-1.32	-3.88	-1.72	-0.26	-1.97
NPL	35 784	5.69	5.62	5.90	5.20	6.09	5.51
NPL	35 1275	4.70	3.43	3.10	3.11	2.69	2.80
NPL	36 404	***	12.37	10.93	11.94	13.76	12.11
NPL	40 1701	-1.46	-1.68	-1.63	-1.27	-1.29	-0.88

Table 8A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
NPL	40	1708	0.65	0.07	0.36	0.24	0.29	0.64
NPLI	35	725	***	***	***	***	***	***
NRC	35	234	16.87	17.20	16.78	17.24	17.08	16.54
NRC	40	304	14.79	15.32	15.18	14.50	14.31	14.58
NRC	90	61	0.29	1.10	-0.17	0.29	0.30	0.79
NRLM	35	224	***	-10.70	-11.15	-10.32	-10.69	-10.68
NRLM	35	523	***	0.18	-0.44	-0.15	0.16	-0.20
NRLM	35	1273	***	-9.49	-9.50	-8.24	-8.09	-7.44
OMH	36	849	2.63	4.62	2.39	2.36	3.25	1.57
ONRJ	35	903	3.09	4.11	2.50	1.98	1.81	2.46
ORB	35	201	1.49	3.29	3.39	4.43	2.53	1.65
ORB	35	202	6.69	7.46	6.21	3.31	7.72	6.97
ORB	35	593	***	***	63.98	63.07	63.23	63.09
ORB	40	2601	-6.86	-7.15	-7.76	-7.80	-10.98	-12.08
PSB	35	1035	3.98	0.55	-0.96	-0.42	-0.02	2.91
PSB	35	1127	***	***	***	***	***	***
PSB	36	522	***	***	***	***	***	***
PTB	35	128	-2.20	-2.17	-1.04	-0.97	-0.11	-0.59
PTB	35	415	***	***	***	***	3.90	3.49
PTB	35	1072	9.88	10.54	11.11	11.23	11.11	11.48
PTB	40	502	***	***	***	***	***	-4.49
PTB	40	505	-0.26	-1.03	-0.87	0.13	0.04	0.35
PTB	40	537	-9.60	-8.80	-8.44	-6.64	-4.17	***
PTB	92	1	2.11	1.32	1.15	1.12	2.13	1.11
PTB	92	2	0.73	0.86	0.16	1.45	1.08	0.57
PTB	92	3	***	***	***	***	***	***
ROA	14	1569	71.29	32.22	30.05	27.98	28.03	36.26
ROA	35	583	2.58	0.57	-0.93	-2.00	***	***
ROA	35	718	8.66	7.45	7.87	7.32	***	***
ROA	36	1488	2.28	-0.45	0.36	0.16	0.48	0.31
ROA	36	1490	5.79	6.63	3.72	3.56	4.29	4.50
SCL	35	621	-2.78	-2.49	-3.27	-2.66	-2.42	-2.47
SMU	36	1063	-2.26	-3.95	-3.23	-5.02	-4.45	-3.09
SP	16	137	108.44	55.67	53.19	14.78	21.12	37.46
SP	35	641	-17.55	-17.99	-17.88	-15.45	-16.51	-16.90
SP	35	1188	21.99	21.00	20.74	19.67	19.48	19.06
SP	35	1642	***	13.51	13.06	12.69	13.64	14.47
SP	36	1175	-1.69	-0.44	-0.82	-1.96	-0.40	0.21
SU	40	3802	22.05	23.15	23.98	24.72	25.55	***
SU	40	3803	-6.42	-7.57	-8.81	-10.00	-10.46	***
SU	40	3805	29.20	30.54	31.99	33.34	34.68	***
SU	40	3806	7.66	7.88	8.12	8.03	8.02	***
SU	40	3807	36.98	37.39	37.41	37.43	37.45	***
SU	40	3810	7.78	9.97	12.10	14.27	16.59	***
SU	40	3811	-22.40	-22.40	-22.38	-22.63	-22.64	***

Table 8A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
NPL	40	1708	0.90	1.13	1.06	1.21	0.93	1.35
NPLI	35	725	***	10.82	***	***	***	9.81
NRC	35	234	16.52	17.04	16.83	17.07	16.46	16.84
NRC	40	304	13.84	14.67	14.77	14.74	15.64	16.13
NRC	90	61	1.67	-0.14	1.27	0.63	-0.04	0.94
NRLM	35	224	-9.72	-10.37	-11.16	-11.20	-10.89	-9.95
NRLM	35	523	0.10	-0.38	-1.01	-0.56	-0.25	-0.62
NRLM	35	1273	-7.20	-7.02	-7.73	-7.70	-7.14	-7.84
OMH	36	849	2.99	3.99	3.62	3.50	2.15	3.79
ONRJ	35	903	1.93	3.00	2.30	2.35	2.26	3.11
ORB	35	201	3.14	2.53	2.17	2.68	2.91	2.55
ORB	35	202	7.12	5.69	7.47	8.01	9.54	10.22
ORB	35	593	63.00	64.07	63.71	64.82	64.99	65.76
ORB	40	2601	***	***	-6.88	-2.99	-1.08	-1.14
PSB	35	1035	2.52	3.03	2.84	3.02	3.62	3.55
PSB	35	1127	-1.73	-0.62	0.06	0.08	-0.96	-0.25
PSB	36	522	-3.30	-9.01	-7.15	-8.07	-9.62	-8.26
PTB	35	128	-0.80	-0.23	0.17	-0.08	-0.44	-0.91
PTB	35	415	3.70	3.02	2.59	3.93	3.82	4.06
PTB	35	1072	11.52	12.22	12.93	14.33	12.64	12.61
PTB	40	502	-4.24	-3.70	***	***	***	***
PTB	40	505	0.97	1.03	0.20	0.08	-0.33	***
PTB	40	537	***	***	6.82	5.88	***	11.26
PTB	92	1	1.11	1.12	1.80	2.09	1.51	1.51
PTB	92	2	0.69	1.24	0.71	0.75	0.91	1.04
PTB	92	3	0.62	-0.50	0.26	0.79	-1.38	0.08
ROA	14	1569	45.71	49.11	52.31	51.40	44.98	37.42
ROA	35	583	***	***	***	***	***	***
ROA	35	718	***	***	***	***	***	***
ROA	36	1488	-0.73	0.46	0.48	-2.26	0.78	-0.86
ROA	36	1490	3.87	4.29	3.37	4.99	6.50	6.81
SCL	35	621	-2.63	-2.08	-2.19	-2.20	-1.66	-1.14
SMU	36	1063	-5.34	-4.33	***	***	-4.46	-4.82
SP	16	137	***	70.17	78.12	70.79	48.86	33.05
SP	35	641	***	-17.66	-18.23	-17.67	-17.86	-17.82
SP	35	1188	***	19.39	19.02	17.99	18.47	18.46
SP	35	1642	***	14.36	14.37	14.44	15.13	15.01
SP	36	1175	0.22	0.04	-1.48	-1.19	-1.36	-1.60
SU	40	3802	***	***	26.14	27.03	27.16	27.73
SU	40	3803	***	***	-19.80	-20.66	-19.84	-20.65
SU	40	3805	***	***	39.09	40.57	41.79	43.14
SU	40	3806	***	***	8.97	9.26	8.91	8.99
SU	40	3807	***	***	38.23	38.75	38.96	39.37
SU	40	3810	***	***	24.33	26.88	28.99	31.46
SU	40	3811	***	***	***	***	***	***

Table 8A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
SU	40	3825	***	***	***	***	***	***
SU	40	3837	***	***	***	***	***	***
TL	35	160	***	***	***	***	***	***
TL	35	300	***	***	***	***	***	***
TL	35	809	***	-7.04	-7.69	-7.66	-7.75	***
TL	35	1012	-13.15	-15.33	-14.84	-13.87	-14.05	-13.64
TL	35	1498	15.17	15.36	14.36	16.28	15.40	15.29
TL	35	1500	20.07	20.97	16.93	9.41	29.99	9.84
TL	40	3052	***	***	***	***	***	***
TL	40	3053	***	28.60	***	***	***	***
TP	35	163	***	***	***	***	***	***
TP	35	1227	1.97	0.74	1.98	2.77	1.55	1.49
TP	36	154	13.37	12.35	13.56	13.31	14.46	13.15
TP	36	163	-6.05	-5.48	-4.90	-2.83	-5.11	***
TP	36	326	-5.89	-5.05	-5.35	-4.81	-4.54	-6.54
UME	35	251	***	***	0.68	-6.98	4.70	3.23
UME	35	252	0.80	-23.96	-0.38	-7.94	3.27	0.98
UME	35	872	-877.28	-380.41	0.42	-6.56	3.75	2.71
USNO	35	101	12.03	11.63	11.74	***	***	-2.94
USNO	35	104	17.50	16.79	18.06	17.46	17.79	17.37
USNO	35	106	-13.11	-13.39	-13.28	-13.27	-12.72	-13.01
USNO	35	108	6.46	6.28	5.90	6.75	5.63	6.88
USNO	35	114	24.51	24.54	23.99	23.72	24.67	23.92
USNO	35	120	0.31	0.31	0.15	-0.27	-0.26	0.69
USNO	35	142	4.63	4.79	4.52	4.93	5.13	5.96
USNO	35	146	-2.93	-2.22	-3.11	-2.83	-3.39	-3.12
USNO	35	148	5.59	5.61	6.51	6.38	6.82	6.89
USNO	35	150	0.66	0.98	1.40	1.54	3.10	2.68
USNO	35	152	15.46	14.21	11.86	11.16	10.94	10.69
USNO	35	153	12.65	12.73	12.36	12.11	***	***
USNO	35	156	16.81	16.18	15.83	16.27	15.89	17.08
USNO	35	161	-19.21	-18.31	-18.08	-18.60	-18.07	-18.10
USNO	35	164	***	***	-2.86	-2.16	-2.31	-2.25
USNO	35	165	4.84	4.98	4.09	3.81	4.30	4.03
USNO	35	166	-1.33	-0.35	-0.67	-0.55	-1.02	-1.33
USNO	35	167	3.95	3.50	3.25	3.20	2.93	2.97
USNO	35	169	14.74	15.63	14.85	14.81	16.11	14.34
USNO	35	171	1.97	1.40	1.69	1.43	0.81	0.76
USNO	35	173	-11.88	-12.87	-12.63	-13.17	-12.88	-13.12
USNO	35	213	15.03	14.32	14.03	14.39	13.85	14.29
USNO	35	217	-1.84	-1.84	***	***	-1.41	-1.87
USNO	35	225	0.57	0.63	0.19	0.33	0.95	0.55
USNO	35	226	19.36	19.61	19.61	20.08	19.82	19.44
USNO	35	227	5.71	6.17	5.44	***	***	6.79
USNO	35	229	-0.71	-0.68	-0.47	-0.16	0.72	1.21

Table 8A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
SU	40	3825	***	***	***	***	46.43	48.98
SU	40	3837	***	***	***	***	29.21	29.76
TL	35	160	***	***	-12.48	-13.30	-12.56	-13.50
TL	35	300	***	***	9.67	9.75	11.99	11.98
TL	35	809	***	-3.57	-4.30	-4.30	-3.91	-3.46
TL	35	1012	-15.63	-17.28	-16.02	-14.99	-16.69	-16.86
TL	35	1498	15.13	15.48	15.12	13.95	15.31	15.38
TL	35	1500	9.89	10.69	39.20	9.73	10.18	10.84
TL	40	3052	36.19	37.75	39.12	50.37	42.41	43.97
TL	40	3053	***	***	34.07	24.83	35.71	36.75
TP	35	163	***	***	***	17.17	16.16	15.85
TP	35	1227	2.59	3.21	2.70	1.96	2.34	2.85
TP	36	154	10.08	12.32	13.12	13.90	13.67	12.53
TP	36	163	***	***	***	***	***	***
TP	36	326	-4.14	-6.02	-5.27	-4.62	-4.06	-3.53
UME	35	251	***	***	0.39	-0.22	-0.10	0.06
UME	35	252	***	***	-1.04	-0.50	-1.21	-1.92
UME	35	872	***	***	-0.81	-0.12	0.56	-0.04
USNO	35	101	-4.51	-4.72	-4.51	-4.93	-5.05	-5.44
USNO	35	104	18.69	17.73	17.41	17.93	18.09	17.71
USNO	35	106	-14.06	-13.34	-13.29	-12.92	-13.66	-13.52
USNO	35	108	6.55	6.62	7.52	7.36	7.59	7.35
USNO	35	114	23.39	23.88	23.79	23.40	23.19	22.98
USNO	35	120	0.34	-0.68	-0.67	0.06	0.33	0.09
USNO	35	142	5.32	5.82	5.35	5.02	5.66	5.43
USNO	35	146	-4.25	-3.77	-3.06	-3.75	-3.09	-3.57
USNO	35	148	6.24	6.14	7.14	7.62	7.25	7.40
USNO	35	150	2.47	3.59	4.48	4.38	5.05	4.93
USNO	35	152	11.34	11.92	11.64	11.33	12.77	11.65
USNO	35	153	15.10	15.82	14.86	15.18	15.19	14.67
USNO	35	156	16.88	16.74	16.95	16.43	16.81	16.14
USNO	35	161	-18.53	-18.54	-18.78	-18.72	-18.76	-18.83
USNO	35	164	-2.47	-2.33	-2.95	-3.15	-3.28	-3.74
USNO	35	165	3.68	3.45	2.89	4.30	3.61	2.90
USNO	35	166	-1.48	-1.16	-1.10	-0.27	-1.18	-1.91
USNO	35	167	3.06	3.96	3.69	3.48	3.01	5.13
USNO	35	169	15.54	14.65	14.43	15.44	15.21	14.26
USNO	35	171	0.21	0.38	0.19	0.83	-0.39	0.43
USNO	35	173	-13.33	-13.12	-13.53	-13.32	-12.19	-12.96
USNO	35	213	14.12	14.12	13.11	14.39	13.22	12.80
USNO	35	217	-2.22	-2.38	-3.07	-2.94	-2.38	-3.10
USNO	35	225	1.15	0.86	1.27	0.70	0.74	0.91
USNO	35	226	19.86	19.79	19.54	20.05	20.71	20.38
USNO	35	227	6.77	6.64	5.91	6.19	6.11	5.61
USNO	35	229	1.59	1.75	2.72	2.83	2.67	3.14

Table 8A. (Cont.)

lab.	clock	51939	51964	51999	52029	52059	52089
USNO	35 231	***	***	***	-9.94	-10.81	-10.69
USNO	35 233	-0.76	-0.56	-1.72	-1.04	-0.54	-0.92
USNO	35 242	14.16	14.73	14.60	15.33	15.19	15.43
USNO	35 244	15.08	16.41	15.73	15.65	15.78	16.59
USNO	35 249	8.01	8.35	6.92	7.28	7.02	6.39
USNO	35 253	2.56	3.16	2.69	3.02	3.05	2.81
USNO	35 254	***	***	***	8.68	9.05	9.32
USNO	35 255	8.52	8.13	7.31	6.54	6.88	7.14
USNO	35 256	14.54	15.71	15.13	16.22	16.18	16.23
USNO	35 260	10.29	10.56	10.39	10.44	***	***
USNO	35 268	2.97	2.22	1.55	0.95	1.38	1.15
USNO	35 270	-11.96	-11.50	-11.54	-11.68	-11.20	-11.89
USNO	35 279	2.33	2.54	1.61	1.97	1.71	2.29
USNO	35 389	-30.88	-30.90	-33.06	-33.44	-32.97	***
USNO	35 392	5.33	5.54	5.00	5.73	5.06	5.30
USNO	35 394	15.99	16.46	17.27	17.76	15.80	***
USNO	35 416	-24.28	-24.14	-24.64	-24.18	-24.49	***
USNO	35 417	16.15	17.38	17.62	18.28	***	***
USNO	35 703	***	***	-3.79	-4.87	-4.96	-4.36
USNO	35 717	-10.80	-10.43	-10.64	-10.27	-8.94	-9.31
USNO	35 762	-28.58	-29.56	-31.56	-30.63	-30.13	-30.20
USNO	35 763	-17.88	-17.50	-17.44	-16.85	-16.58	-16.59
USNO	35 765	-6.81	-6.48	-6.93	***	***	-4.82
USNO	35 1096	19.35	20.38	20.00	21.68	21.11	21.19
USNO	35 1097	8.39	7.75	8.23	7.88	8.48	8.62
USNO	35 1125	23.06	22.30	22.58	22.82	23.63	22.64
USNO	35 1327	***	***	0.05	1.07	1.40	1.19
USNO	35 1328	***	***	3.69	3.90	3.23	4.52
USNO	35 1331	-5.13	-5.05	-6.93	-6.89	-7.12	-6.52
USNO	35 1438	0.02	0.43	0.31	-0.31	***	***
USNO	35 1459	-1.35	-1.55	-0.74	-0.90	-1.43	-0.56
USNO	35 1462	7.51	6.93	7.32	7.57	7.06	8.08
USNO	35 1463	5.92	6.65	6.64	6.48	6.37	7.32
USNO	35 1468	-1.66	-1.51	-1.65	-1.87	-1.01	-1.31
USNO	35 1481	0.31	-0.10	-0.55	0.58	0.27	0.22
USNO	35 1543	***	***	9.80	9.71	9.70	10.35
USNO	35 1573	***	***	8.77	9.06	8.52	8.68
USNO	35 1575	***	***	-6.49	-7.06	-7.23	-6.34
USNO	35 1655	***	***	***	***	***	***
USNO	35 1692	***	***	***	***	***	8.11
USNO	35 1694	***	***	***	***	***	1.78
USNO	35 1696	***	***	***	***	***	9.97
USNO	35 1697	***	***	***	***	***	0.18
USNO	35 1698	***	***	***	***	***	11.91
USNO	40 701	-27.60	-27.62	-28.09	-28.60	-28.10	-27.96

Table 8A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
USNO	35	231	-11.11	-10.99	***	***	-11.86	-11.48
USNO	35	233	-1.35	-0.89	-0.88	-0.80	-0.79	-0.73
USNO	35	242	16.17	16.75	17.02	17.10	16.89	17.90
USNO	35	244	16.77	16.50	15.40	16.60	15.73	16.41
USNO	35	249	5.79	6.27	6.72	5.40	5.47	5.26
USNO	35	253	2.63	3.64	3.93	3.81	4.16	4.02
USNO	35	254	9.10	9.32	9.02	9.26	9.30	9.40
USNO	35	255	6.59	6.41	5.99	5.57	6.30	6.59
USNO	35	256	16.02	15.56	15.74	16.72	15.21	16.37
USNO	35	260	***	***	12.23	12.15	12.55	12.72
USNO	35	268	2.37	1.10	1.99	1.69	0.62	0.82
USNO	35	270	-11.93	-11.26	-11.49	-10.90	-11.06	-10.92
USNO	35	279	2.92	2.99	1.20	2.05	1.59	1.92
USNO	35	389	***	***	-28.26	-28.59	-28.95	-28.58
USNO	35	392	4.79	5.08	5.23	5.08	5.19	5.06
USNO	35	394	***	10.42	12.14	10.20	10.40	10.32
USNO	35	416	***	***	-25.78	-25.40	-24.79	-24.45
USNO	35	417	18.72	***	***	5.35	5.37	6.73
USNO	35	703	-3.65	-3.98	-3.43	-4.62	-5.04	-4.04
USNO	35	717	-8.47	-8.21	-9.59	-8.83	-9.48	-8.84
USNO	35	762	-30.17	***	***	-3.95	-4.21	-4.75
USNO	35	763	-17.21	-16.76	-16.28	-16.74	-16.18	-16.01
USNO	35	765	-7.89	-8.69	-10.28	-10.92	-11.22	-11.69
USNO	35	1096	22.34	22.35	21.89	22.98	24.16	23.23
USNO	35	1097	8.24	9.27	8.84	9.03	9.65	9.59
USNO	35	1125	22.76	22.87	23.59	22.77	22.79	22.76
USNO	35	1327	1.05	2.26	2.50	3.00	3.01	3.89
USNO	35	1328	3.88	4.19	4.84	4.80	5.39	4.70
USNO	35	1331	-5.81	-6.46	-6.29	-6.44	-5.89	-6.43
USNO	35	1438	0.19	0.27	0.44	0.87	1.25	1.82
USNO	35	1459	-1.96	-1.25	-1.50	-1.31	-1.59	-1.36
USNO	35	1462	7.78	7.74	7.47	8.00	8.65	8.98
USNO	35	1463	6.93	7.17	6.82	7.26	6.71	7.29
USNO	35	1468	-0.94	0.08	0.63	-0.07	0.19	***
USNO	35	1481	0.58	0.57	0.59	0.80	1.17	0.88
USNO	35	1543	9.84	10.88	10.43	9.79	8.83	10.17
USNO	35	1573	9.11	9.35	10.37	10.08	***	***
USNO	35	1575	-6.80	-6.27	-6.06	-6.13	-5.94	-5.26
USNO	35	1655	***	***	***	-15.05	-14.88	-14.86
USNO	35	1692	9.47	9.58	9.74	10.14	9.05	8.81
USNO	35	1694	0.49	0.64	0.55	0.00	0.66	1.06
USNO	35	1696	8.17	7.75	6.67	6.88	6.56	6.24
USNO	35	1697	0.17	-0.58	-0.35	0.13	-0.47	-0.31
USNO	35	1698	11.35	11.73	12.07	12.55	12.31	12.68
USNO	40	701	-28.98	-29.59	-29.03	-28.52	-28.46	-28.40

Table 8A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
USNO	40	702	-9.22	-9.26	-9.45	-9.52	-9.49	-9.49
USNO	40	703	-0.34	***	***	2.35	2.12	1.83
USNO	40	704	-44.96	-44.67	-44.78	-44.58	***	***
USNO	40	705	-34.20	-34.31	-34.66	-34.65	-34.72	-32.89
USNO	40	708	7.77	8.25	8.33	8.67	9.11	9.56
USNO	40	709	-41.93	-41.31	-40.65	-39.46	-38.95	-38.37
USNO	40	710	28.20	28.76	28.66	29.21	29.74	30.28
USNO	40	711	95.48	96.86	98.26	100.13	101.60	103.14
USNO	40	712	-8.61	-8.49	-8.67	-8.54	-8.49	-8.34
USNO	40	713	-11.18	-11.03	-10.70	-10.49	-10.32	-10.08
USNO	40	714	-45.24	-45.29	-45.26	-45.27	-45.24	-45.12
USNO	40	715	-18.33	-17.99	-18.14	-18.01	-17.75	-17.52
USNO	40	716	235.28	233.53	231.50	229.01	227.12	226.00
USNO	40	718	***	***	***	146.28	144.24	142.24
VSL	35	179	7.59	7.08	8.68	***	***	8.04
VSL	35	456	20.45	21.06	20.89	***	***	20.39
VSL	35	548	***	***	***	***	***	11.60
VSL	35	731	16.50	18.10	17.52	***	***	16.71

Table 8A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
USNO	40	702	-9.68	-9.68	-9.79	-9.71	-9.81	-9.83
USNO	40	703	1.86	1.92	1.90	1.90	1.78	1.48
USNO	40	704	***	***	***	***	3.63	3.85
USNO	40	705	***	***	***	***	-40.68	-40.82
USNO	40	708	9.80	10.27	10.59	11.00	11.17	11.64
USNO	40	709	-36.75	-36.08	***	***	-30.68	-30.82
USNO	40	710	30.62	31.20	31.58	32.15	32.46	33.00
USNO	40	711	104.62	106.42	107.98	109.65	110.99	112.75
USNO	40	712	-8.41	-8.27	-8.30	-8.10	-8.14	-7.94
USNO	40	713	-9.96	-9.65	-9.51	-9.32	-9.19	-8.73
USNO	40	714	-45.08	-44.93	-45.11	-44.75	-44.54	-44.24
USNO	40	715	-17.51	-17.29	-17.20	-16.93	-16.89	-16.53
USNO	40	716	224.57	222.27	217.80	215.44	213.52	212.49
USNO	40	718	140.09	138.27	136.37	134.95	132.94	131.52
VSL	35	179	9.56	8.10	7.21	7.73	7.69	7.13
VSL	35	456	20.02	19.52	20.25	19.85	20.46	20.50
VSL	35	548	11.47	10.27	10.02	10.42	10.25	9.71
VSL	35	731	18.02	18.07	17.47	17.18	17.14	18.49

The clocks are designated by their type (2 digits) and serial number in the type. The codes for the types are:

- 12 HEWLETT-PACKARD 5061A
- 13 EBAUCHES, OSCILLATOM B5000
- 14 HEWLETT-PACKARD 5061A OPT. 4
- 16 OSCILLOQUARTZ 3200
- 17 OSCILLOQUARTZ 3000
- 18 FREQ. AND TIME SYSTEMS INC. 4000
- 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 HEWLETT-PACKARD 5071A High perf.
- 36 HEWLETT-PACKARD 5071A Low perf.
- 50 FREQ. AND TIME SYSTEMS INC. 4065A

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.

	2001	2000		1999		1998			
	clock nø	clock nø	corr. (ns/d)	clock nø	corr. (ns/d)	clock nø	corr. (ns/d)		
AUS	36 340	36 340		36 340	3.28				
CH	17 206	17 206		17 206		17 206(1)			
GUM	35 502	35 502		35 502		35 502(2)	-6.57		
	35 761	35 761	-4.32(3)						
	35 1120	35 1120	+7.61	35 1120	+7.61				
IEN	35 505	35 505	+9.85	35 505	+12.06	35 505(4)	+14.79		
	35 1373	35 1373	-9.30	13 1373	-9.30				
NPL	40 1701	40 1701	-0.80	40 1701	-2.60	40 1701(5)	-4.20		
ORB	40 2601	40 2601	+185.66	40 2601	+185.66(6)				
PTB	40 505	40 505		40 505	-7.78	40 505(7)	-12.10		
ROA	14 1569	14 1569		14 1569		14 1569(8)			
	35 583	35 583		35 583		35 583(9)	+0.55	35 583(9)	-0.55
	36 1488	36 1488	-7.66						
SU	40 3803	40 3803	+1.00						

(1) A correction of +78.00 ns/d has to be applied in 1994, 1993 and in 1992.

(2) A correction of -6.57 ns/d has to be applied in 1997.

(3) A correction of -4.32 ns/d has to be applied for the last two-month interval of 2000.

(4) A correction of +14.79 ns/d has to be applied in 1996 and a correction of +10.96 ns/d has to be applied in 1995.

(5) A correction of -7.00 has to be applied in 1997, a correction of -8.2 ns/d has to be applied in 1996, a correction of -4.55 ns/d has to be applied in 1995, 1994, 1993 and 1992, and a correction of +22.45 ns/d has to be applied in 1991.

(6) A correction of +185.66 ns/d has to be applied for the last three two-month intervals of 1999.

(7) A correcton of -25.06 ns/d has to be applied in 1997.

(8) A correction of - 6.00 ns/d has to be applied in 1994.

(9) A correction of -0.55 ns/d has to be applied in 1997 and a correction of +2.15 ns/d has to be applied in 1996 and 1995.

Table 9A. Relative weights (in percent) of contributing clocks in 2001

(File available on http://www.bipm.org under the name WTAI01.AR)

Clocks weights are computed for one-month intervals ending at the dates given in the table.

***** denotes that the clock was not used

lab.	clock		51939	51964	51999	52029	52059	52089
AOS	23	67	0.002	0.003	0.003	0.004	0.004	0.005
AUS	36	249	0.000	0.000	0.000	0.026	0.000	*****
AUS	36	299	*****	*****	*****	*****	0.000	0.000
AUS	36	340	0.188	0.175	0.124	0.127	0.115	0.114
AUS	36	654	0.990	0.935	0.930	0.994	0.976	1.117
AUS	36	1035	*****	0.000	*****	*****	0.000	0.000
AUS	36	1141	0.990	0.935	1.064	0.917	1.058	1.025
AUS	40	5401	0.990	0.935	1.064	0.596	0.730	*****
AUS	40	5402	0.000	0.023	0.029	*****	*****	*****
AUS	40	5403	0.000	0.000	0.000	0.000	0.000	*****
AUS	99	1	*****	*****	*****	*****	*****	*****
BEV	16	71	*****	*****	*****	*****	*****	*****
BEV	35	1065	0.445	0.511	0.468	0.623	0.502	0.512
CAO	35	939	0.660	0.698	0.460	0.490	0.501	0.503
CAO	35	1270	0.000	0.000	*****	0.000	*****	*****
CH	17	206	0.017	0.026	0.024	0.014	0.008	0.006
CH	21	179	0.094	*****	*****	*****	*****	*****
CH	21	194	0.051	0.039	0.035	0.029	0.033	0.025
CH	21	217	0.018	0.000	0.005	0.005	0.006	0.005
CH	31	403	0.454	0.323	0.257	0.000	0.000	0.018
CH	35	413	0.019	0.013	0.008	0.007	0.005	0.004
CH	35	771	0.000	0.000	0.000	0.540	0.579	0.245
CH	36	354	0.793	0.581	0.581	0.615	0.000	0.030
CNM	35	237	*****	0.000	0.000	0.000	0.000	0.523
CNM	35	382	0.990	0.935	1.064	1.070	1.058	*****
CNM	36	1537	*****	*****	*****	*****	*****	*****
CRL	35	112	0.000	0.000	0.000	0.000	0.075	0.109
CRL	35	144	0.990	0.935	1.064	1.070	1.058	1.117
CRL	35	332	0.371	0.410	0.722	0.411	0.380	0.432
CRL	35	342	0.990	0.935	1.064	1.070	1.058	1.117
CRL	35	343	0.235	0.265	0.542	0.561	0.376	0.311
CRL	35	715	0.638	0.664	0.458	0.576	0.730	0.638
CRL	35	732	0.597	0.625	0.589	0.961	0.850	1.117
CRL	35	907	0.990	0.935	1.064	1.070	0.979	0.000
CRL	35	908	0.715	0.667	0.568	0.589	0.554	0.578

Table 9A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
AOS	23	67	*****	*****	*****	*****	*****	*****
AUS	36	249	*****	*****	0.000	0.000	*****	*****
AUS	36	299	0.000	0.000	0.134	0.185	0.234	0.256
AUS	36	340	0.102	0.096	0.091	0.090	0.074	0.237
AUS	36	654	0.000	0.582	0.543	0.502	0.490	0.476
AUS	36	1035	0.000	0.000	0.936	0.741	0.947	0.838
AUS	36	1141	0.927	0.729	0.631	0.636	0.624	0.609
AUS	40	5401	*****	0.000	0.000	0.000	0.000	0.224
AUS	40	5402	*****	0.000	0.000	*****	*****	*****
AUS	40	5403	*****	0.000	0.000	0.000	*****	*****
AUS	99	1	*****	0.000	0.000	0.000	*****	*****
BEV	16	71	*****	0.000	0.000	0.000	0.000	0.000
BEV	35	1065	0.554	0.811	0.772	0.711	0.486	0.490
CAO	35	939	*****	*****	0.000	0.000	0.000	0.000
CAO	35	1270	*****	*****	0.000	0.000	0.000	0.000
CH	17	206	0.004	0.004	0.004	0.003	0.003	0.002
CH	21	179	*****	*****	*****	*****	*****	*****
CH	21	194	0.024	0.027	0.038	0.039	0.042	0.035
CH	21	217	0.005	0.005	0.005	0.010	0.013	0.014
CH	31	403	0.015	0.014	0.014	0.016	0.017	0.021
CH	35	413	0.003	0.003	0.003	0.003	0.003	0.004
CH	35	771	0.292	0.337	0.399	0.446	0.491	0.627
CH	36	354	0.019	0.016	0.013	0.013	0.013	0.014
CNM	35	237	0.608	0.554	0.692	0.390	0.389	*****
CNM	35	382	*****	*****	*****	*****	*****	*****
CNM	36	1537	0.000	0.000	0.000	0.000	0.058	0.061
CRL	35	112	0.141	0.151	0.182	0.212	0.232	0.270
CRL	35	144	1.124	1.093	1.093	1.042	1.000	0.962
CRL	35	332	0.495	0.721	0.594	0.587	0.527	0.476
CRL	35	342	1.124	0.964	1.019	*****	*****	*****
CRL	35	343	0.277	0.403	0.349	0.398	0.366	0.394
CRL	35	715	0.586	0.632	0.734	1.042	1.000	0.962
CRL	35	732	1.124	1.070	1.093	1.042	1.000	0.962
CRL	35	907	0.482	0.425	0.409	0.383	0.372	0.461
CRL	35	908	0.665	0.365	0.342	0.587	0.477	0.394

Table 9A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
CSAO	35	1007	0.567	0.702	0.711	0.891	1.058	1.117
CSAO	35	1008	0.211	0.262	0.175	0.169	0.176	0.185
CSAO	35	1011	0.508	0.441	0.353	0.363	0.324	0.337
CSAO	35	1016	0.740	0.829	0.562	0.540	0.541	0.668
CSAO	35	1017	0.701	0.662	0.628	0.693	0.635	0.607
CSAO	35	1018	0.458	0.368	0.373	0.422	0.413	0.476
DLR	40	7424	0.000	0.935	0.519	0.599	0.471	*****
DTAG	36	136	*****	*****	*****	*****	*****	*****
DTAG	36	345	*****	*****	*****	*****	*****	*****
DTAG	36	465	*****	*****	*****	*****	*****	*****
F	35	122	0.897	0.907	0.730	1.070	1.058	1.117
F	35	124	0.000	0.000	1.064	1.070	1.058	1.117
F	35	131	0.990	0.935	1.064	1.070	1.058	0.939
F	35	158	0.990	0.935	1.064	1.070	1.058	1.117
F	35	172	*****	*****	*****	*****	*****	*****
F	35	198	*****	*****	0.000	0.000	0.000	0.000
F	35	355	0.000	0.000	0.000	0.000	0.628	0.748
F	35	385	0.622	0.890	0.786	1.070	1.058	0.000
F	35	396	0.121	0.130	0.134	0.157	0.189	0.215
F	35	469	*****	*****	*****	*****	*****	*****
F	35	489	*****	*****	*****	*****	*****	*****
F	35	536	0.990	0.935	1.064	1.070	1.058	1.117
F	35	609	0.624	0.527	0.355	0.322	*****	*****
F	35	770	0.990	0.935	1.064	1.070	1.058	1.117
F	35	774	*****	*****	*****	*****	*****	*****
F	35	781	0.000	0.000	0.880	1.070	1.053	1.117
F	35	819	0.358	0.256	0.259	0.252	0.179	0.220
F	35	859	0.000	0.070	0.048	0.042	0.035	0.035
F	35	1177	0.000	0.066	0.072	0.097	0.118	0.133
F	35	1178	0.000	0.296	0.191	0.272	0.347	0.358
F	35	1222	0.000	0.000	1.052	1.070	1.058	0.749
F	35	1321	0.844	0.935	1.064	1.070	1.058	1.117
F	35	1556	0.000	0.276	0.337	0.481	*****	*****
F	40	805	0.000	0.000	0.000	0.000	0.153	0.055
F	40	816	0.972	0.935	0.836	0.541	0.000	0.000
GUM	18	746	0.000	0.000	0.000	0.000	0.000	0.000
GUM	23	67	*****	*****	*****	*****	*****	*****
GUM	35	502	0.072	0.073	0.067	0.076	0.099	0.166
GUM	35	745	0.000	0.000	*****	*****	*****	*****
GUM	35	761	0.000	0.000	0.087	0.055	0.076	0.094
GUM	35	1120	0.000	0.120	0.096	0.111	0.115	0.105
GUM	35	1362	*****	0.000	0.000	0.000	*****	*****
GUM	35	1660	*****	*****	*****	*****	*****	*****
IEN	35	219	0.000	0.000	0.000	0.000	0.663	0.870
IEN	35	505	0.505	0.465	0.381	0.394	0.368	0.405

Table 9A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
CSAO	35	1007	0.000	0.483	0.342	0.310	0.297	0.298
CSAO	35	1008	0.220	0.235	0.230	0.235	0.242	0.323
CSAO	35	1011	0.321	0.290	0.207	0.146	0.146	0.152
CSAO	35	1016	0.899	0.703	0.731	0.789	0.644	0.560
CSAO	35	1017	0.553	0.499	0.790	0.831	1.000	0.962
CSAO	35	1018	0.417	0.518	0.653	0.859	1.000	0.927
DLR	40	7424	*****	*****	*****	*****	*****	*****
DTAG	36	136	*****	*****	0.000	0.000	0.000	0.000
DTAG	36	345	*****	*****	0.000	0.000	0.000	0.000
DTAG	36	465	*****	*****	0.000	0.000	0.000	0.000
F	35	122	1.124	1.093	0.943	0.000	0.284	0.208
F	35	124	1.124	1.093	1.093	1.042	1.000	0.962
F	35	131	0.000	0.204	0.141	0.110	0.085	0.080
F	35	158	1.124	1.093	1.093	1.042	1.000	0.962
F	35	172	*****	*****	0.000	0.000	0.000	0.000
F	35	198	0.206	0.251	0.131	0.101	0.095	0.104
F	35	355	0.936	0.970	1.093	1.042	1.000	0.962
F	35	385	0.000	0.186	0.119	0.104	0.079	0.078
F	35	396	0.238	0.346	0.990	1.042	1.000	0.738
F	35	469	*****	0.000	0.000	0.000	0.000	*****
F	35	489	*****	0.000	0.000	0.000	0.000	*****
F	35	536	1.124	1.093	*****	*****	*****	*****
F	35	609	*****	*****	*****	0.000	0.000	0.000
F	35	770	1.124	1.037	*****	*****	*****	*****
F	35	774	*****	0.000	0.000	0.000	0.000	0.188
F	35	781	1.124	*****	*****	*****	*****	*****
F	35	819	0.201	0.182	0.161	0.173	0.148	0.134
F	35	859	0.035	0.040	0.049	0.055	0.122	0.000
F	35	1177	0.148	0.125	0.139	0.133	0.155	0.150
F	35	1178	0.321	0.342	0.326	0.258	0.237	0.226
F	35	1222	0.874	1.011	1.093	1.042	1.000	0.962
F	35	1321	1.124	1.093	1.093	1.042	1.000	0.962
F	35	1556	0.000	0.000	0.000	0.000	0.551	0.424
F	40	805	0.018	0.009	0.006	0.006	0.005	0.006
F	40	816	0.000	0.023	0.017	0.014	0.013	0.013
GUM	18	746	0.000	0.000	0.000	0.000	0.000	0.000
GUM	23	67	*****	0.000	0.000	0.000	0.000	*****
GUM	35	502	0.177	0.165	0.156	0.238	0.224	0.145
GUM	35	745	*****	*****	*****	*****	*****	*****
GUM	35	761	0.091	0.105	0.084	0.098	0.078	0.070
GUM	35	1120	0.148	0.138	0.150	0.189	0.294	0.851
GUM	35	1362	*****	*****	*****	*****	*****	*****
GUM	35	1660	*****	*****	0.000	0.000	0.000	0.000
IEN	35	219	0.724	*****	*****	0.000	0.000	0.000
IEN	35	505	0.379	0.593	1.093	0.000	*****	*****

Table 9A. (Cont.)

lab.	clock	51939	51964	51999	52029	52059	52089
IEN	35 1115	0.283	0.281	0.225	0.243	0.229	0.243
IEN	35 1373	0.990	0.935	1.064	1.070	1.058	1.117
IFAG	36 1034	0.142	0.136	0.109	0.000	0.154	0.089
IFAG	36 1167	*****	0.000	0.000	0.000	0.000	0.000
IFAG	36 1173	0.090	0.109	0.093	0.088	0.098	0.085
IFAG	36 1629	*****	*****	0.000	0.000	0.000	0.000
IFAG	40 4401	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
IFAG	40 4413	*****	*****	*****	*****	*****	0.000
IGMA	14 2403	0.002	0.002	0.002	0.002	0.002	0.002
IGMA	16 112	0.000	0.009	0.008	0.008	0.008	0.007
IGMA	35 631	0.760	0.688	0.405	0.469	0.561	0.401
IGMA	35 645	0.768	0.736	0.559	0.648	0.547	0.384
INPL	35 1021	0.000	0.527	*****	*****	*****	*****
INPL	35 1652	*****	*****	*****	0.000	0.000	0.000
KRIS	36 321	0.265	0.309	0.260	0.277	0.258	0.234
KRIS	36 739	0.672	0.613	0.367	0.326	0.354	0.351
KRIS	36 1135	0.112	0.125	0.101	0.099	0.099	0.075
KRIS	40 5623	0.729	0.822	0.537	0.431	0.487	0.470
LDS	35 289	*****	*****	*****	*****	*****	*****
LT	35 1362	*****	*****	*****	*****	*****	0.000
MSL	12 933	0.000	0.000	*****	0.000	0.000	0.000
MSL	35 1025	0.000	0.000	0.000	0.000	0.247	0.355
MSL	36 274	0.000	0.000	0.000	0.000	0.031	0.043
NAO	35 779	0.000	0.852	0.979	1.070	1.058	1.117
NAO	35 1206	0.000	0.236	0.283	0.412	0.439	0.507
NAO	35 1214	0.000	0.935	0.911	0.982	1.058	0.828
NAO	35 1689	*****	*****	*****	*****	0.000	0.000
NIM	35 479	0.191	0.269	0.282	0.391	0.490	0.575
NIM	35 1238	0.228	0.303	*****	0.000	0.000	0.000
NIM	35 1239	0.283	0.258	0.153	0.205	0.258	0.287
NIST	35 132	0.990	0.935	1.064	1.070	*****	*****
NIST	35 182	0.000	0.000	0.000	1.070	1.058	1.117
NIST	35 408	*****	*****	*****	*****	*****	*****
NIST	35 1074	0.990	0.935	1.064	1.070	1.058	1.117
NIST	40 201	0.271	0.229	0.169	0.178	0.185	0.198
NIST	40 203	0.000	0.000	0.000	0.000	0.077	0.067
NIST	40 204	0.272	0.262	0.214	0.212	0.201	0.217
NIST	40 205	0.281	0.294	*****	0.000	0.000	0.000
NIST	40 222	0.000	0.935	1.064	1.070	1.058	1.117
NMC	35 1501	0.000	0.000	0.000	0.000	0.170	0.242
NPL	35 784	0.990	0.935	1.064	1.070	1.058	1.117
NPL	35 1275	0.990	0.935	1.064	0.832	0.825	0.587
NPL	36 404	0.487	0.423	0.333	0.347	0.371	0.364
NPL	40 1701	0.990	0.935	1.064	1.070	1.058	1.117

Table 9A. (Cont.)

lab.	clock	52119	52149	52179	52209	52239	52274
IEN	35 1115	0.216	0.354	0.522	0.728	1.000	0.954
IEN	35 1373	0.811	0.588	0.525	0.623	0.598	0.529
IFAG	36 1034	0.064	0.049	0.043	0.040	0.037	0.038
IFAG	36 1167	0.000	0.002	0.003	0.003	0.004	0.004
IFAG	36 1173	0.068	0.062	0.053	0.048	0.000	0.022
IFAG	36 1629	0.183	0.139	0.180	0.216	0.183	0.114
IFAG	40 4401	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
IFAG	40 4413	0.000	0.000	0.000	0.000	0.000	0.000
IGMA	14 2403	0.002	0.002	0.001	0.001	0.002	0.001
IGMA	16 112	0.006	0.006	0.005	0.006	0.005	0.005
IGMA	35 631	0.250	0.156	0.098	0.093	0.089	0.087
IGMA	35 645	0.213	0.148	0.180	0.183	0.149	0.000
INPL	35 1021	*****	*****	*****	*****	*****	*****
INPL	35 1652	0.000	0.030	0.026	0.037	0.044	0.050
KRIS	36 321	0.230	0.218	0.218	0.535	0.547	0.404
KRIS	36 739	0.204	0.231	0.225	0.213	0.184	0.178
KRIS	36 1135	0.065	0.064	0.041	0.033	0.032	0.034
KRIS	40 5623	0.389	0.297	0.281	0.281	0.253	0.399
LDS	35 289	0.000	*****	0.000	0.000	0.000	0.000
LT	35 1362	*****	0.000	0.000	0.000	0.000	0.129
MSL	12 933	0.000	0.017	0.024	*****	0.000	*****
MSL	35 1025	0.299	0.370	0.436	*****	0.000	*****
MSL	36 274	0.055	0.066	0.072	*****	0.000	*****
NAO	35 779	1.124	1.093	1.093	0.832	0.588	0.581
NAO	35 1206	0.444	0.460	0.424	0.390	0.414	0.352
NAO	35 1214	0.599	0.589	0.657	0.667	0.700	0.714
NAO	35 1689	0.000	0.000	0.542	0.815	1.000	0.962
NIM	35 479	0.653	0.698	0.621	0.348	0.000	0.000
NIM	35 1238	0.000	0.468	0.455	0.469	0.432	0.000
NIM	35 1239	0.324	0.357	0.360	0.233	0.000	0.000
NIST	35 132	0.000	0.000	0.000	0.000	0.259	0.345
NIST	35 182	1.124	1.093	1.093	1.042	1.000	0.962
NIST	35 408	0.000	0.000	0.000	0.000	0.519	0.431
NIST	35 1074	1.124	1.093	1.093	1.042	1.000	0.962
NIST	40 201	0.200	0.000	0.000	0.052	0.049	0.054
NIST	40 203	0.056	0.046	0.040	0.037	0.031	0.028
NIST	40 204	0.220	0.226	0.249	0.232	0.210	0.199
NIST	40 205	0.000	0.309	0.315	0.340	0.309	0.290
NIST	40 222	1.124	1.093	1.093	1.042	1.000	0.962
NMC	35 1501	0.180	0.159	0.175	0.198	0.148	0.171
NPL	35 784	1.124	1.093	1.093	1.042	1.000	0.962
NPL	35 1275	0.631	0.615	0.498	0.441	0.329	0.293
NPL	36 404	*****	0.000	0.000	0.000	0.000	0.109
NPL	40 1701	1.124	1.093	1.093	1.042	1.000	0.962

Table 9A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
NPL	40	1708	0.990	0.935	1.064	1.070	1.058	1.117
NPLI	35	725	*****	*****	*****	*****	*****	*****
NRC	35	234	0.185	0.276	0.520	1.070	1.058	1.117
NRC	40	304	0.000	0.176	0.112	0.108	0.108	0.110
NRC	90	61	0.990	0.935	1.064	1.070	1.058	1.117
NRLM	35	224	*****	0.000	0.000	0.000	0.000	1.117
NRLM	35	523	*****	0.000	0.000	0.000	0.000	1.117
NRLM	35	1273	*****	0.000	0.000	0.000	0.000	0.194
OMH	36	849	0.230	0.248	0.190	0.193	0.189	0.158
ONRJ	35	903	0.068	0.081	0.086	0.107	0.123	0.144
ORB	35	201	0.577	0.514	0.433	0.355	0.357	0.342
ORB	35	202	0.391	0.376	0.319	0.000	0.165	0.174
ORB	35	593	*****	*****	0.000	0.000	0.000	0.000
ORB	40	2601	0.036	0.040	0.034	0.039	0.037	0.036
PSB	35	1035	0.649	0.000	0.057	0.059	0.066	0.078
PSB	35	1127	*****	*****	*****	*****	*****	*****
PSB	36	522	*****	*****	*****	*****	*****	*****
PTB	35	128	0.990	0.935	0.683	0.559	0.375	0.372
PTB	35	415	*****	*****	*****	*****	0.000	0.000
PTB	35	1072	0.651	0.476	0.301	0.244	0.222	0.199
PTB	40	502	*****	*****	*****	*****	*****	0.000
PTB	40	505	0.180	0.222	0.248	0.336	0.447	0.597
PTB	40	537	0.027	0.029	0.030	0.059	0.098	*****
PTB	92	1	0.990	0.935	1.064	1.070	1.058	1.117
PTB	92	2	0.990	0.935	1.064	1.070	1.058	1.117
PTB	92	3	*****	*****	*****	*****	*****	*****
ROA	14	1569	0.000	0.002	0.002	0.002	0.002	0.002
ROA	35	583	0.269	0.258	0.196	0.164	*****	*****
ROA	35	718	0.924	0.873	0.699	0.731	*****	*****
ROA	36	1488	0.099	0.116	0.120	0.153	0.181	0.374
ROA	36	1490	0.102	0.119	0.077	0.073	0.076	0.092
SCL	35	621	0.000	0.000	0.000	0.000	1.058	1.117
SMU	36	1063	0.347	0.333	0.326	0.306	0.299	0.294
SP	16	137	0.006	0.000	0.001	0.000	0.000	0.000
SP	35	641	0.990	0.935	1.064	0.000	0.668	0.639
SP	35	1188	0.990	0.935	0.493	0.271	0.180	0.134
SP	35	1642	*****	0.000	0.000	0.000	0.000	0.369
SP	36	1175	0.000	0.000	0.207	0.222	0.296	0.324
SU	40	3802	0.033	0.029	0.023	0.023	0.025	*****
SU	40	3803	0.000	0.000	0.000	0.036	0.037	*****
SU	40	3805	0.024	0.019	0.014	0.014	0.013	*****
SU	40	3806	0.990	0.935	1.064	1.070	1.058	*****
SU	40	3807	0.819	0.529	0.376	0.347	0.341	*****
SU	40	3810	0.009	0.007	0.006	0.005	0.005	*****
SU	40	3811	0.177	0.226	0.531	1.070	1.058	*****

Table 9A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
NPL	40	1708	1.124	1.093	1.093	1.042	1.000	0.962
NPLI	35	725	*****	0.000	*****	*****	*****	0.000
NRC	35	234	1.124	1.093	1.093	1.042	1.000	0.962
NRC	40	304	0.121	0.147	0.208	0.390	0.558	0.811
NRC	90	61	1.124	1.093	0.961	1.003	0.781	0.754
NRLM	35	224	0.771	0.999	0.866	0.833	0.897	0.962
NRLM	35	523	1.124	1.093	0.994	1.042	1.000	0.962
NRLM	35	1273	0.186	0.191	0.239	0.307	0.325	0.384
OMH	36	849	0.209	0.290	0.407	0.405	0.352	0.354
ONRJ	35	903	0.130	0.126	0.118	0.138	0.573	0.567
ORB	35	201	0.336	0.309	0.426	0.425	0.393	0.387
ORB	35	202	0.172	0.155	0.147	0.188	0.130	0.093
ORB	35	593	0.737	0.685	0.882	0.568	0.434	0.300
ORB	40	2601	*****	*****	0.000	0.000	0.000	0.000
PSB	35	1035	0.089	0.097	0.096	0.107	0.093	0.092
PSB	35	1127	0.000	0.000	0.000	0.000	0.219	0.312
PSB	36	522	0.000	0.000	0.000	0.000	0.017	0.024
PTB	35	128	0.381	0.351	0.307	0.305	0.351	0.557
PTB	35	415	0.000	0.000	0.367	0.489	0.603	0.721
PTB	35	1072	0.192	0.237	0.204	0.000	0.170	0.219
PTB	40	502	0.000	0.000	*****	*****	*****	*****
PTB	40	505	0.578	0.569	0.672	0.777	0.750	*****
PTB	40	537	*****	*****	0.000	0.000	*****	0.000
PTB	92	1	1.124	0.989	0.985	1.042	1.000	0.962
PTB	92	2	1.124	1.093	1.093	1.042	1.000	0.962
PTB	92	3	0.000	0.000	0.000	0.000	0.131	0.190
ROA	14	1569	0.002	0.002	0.001	0.002	0.002	0.002
ROA	35	583	*****	*****	*****	*****	*****	*****
ROA	35	718	*****	*****	*****	*****	*****	*****
ROA	36	1488	0.327	0.306	0.402	0.000	0.216	0.192
ROA	36	1490	0.094	0.129	0.114	0.116	0.170	0.174
SCL	35	621	1.124	1.093	1.093	1.042	1.000	0.962
SMU	36	1063	0.204	0.182	*****	*****	0.000	0.000
SP	16	137	*****	0.000	0.000	0.000	0.000	0.000
SP	35	641	*****	0.000	0.000	0.000	0.000	0.962
SP	35	1188	*****	0.000	0.000	0.000	0.000	0.309
SP	35	1642	*****	0.000	0.000	0.000	0.000	0.962
SP	36	1175	0.342	0.382	0.378	0.425	0.367	0.406
SU	40	3802	*****	*****	0.000	0.000	0.000	0.000
SU	40	3803	*****	*****	0.000	0.000	0.000	0.000
SU	40	3805	*****	*****	0.000	0.000	0.000	0.000
SU	40	3806	*****	*****	0.000	0.000	0.000	0.000
SU	40	3807	*****	*****	0.000	0.000	0.000	0.000
SU	40	3810	*****	*****	0.000	0.000	0.000	0.000
SU	40	3811	*****	*****	*****	*****	*****	*****

Table 9A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
SU	40	3825	*****	*****	*****	*****	*****	*****
SU	40	3837	*****	*****	*****	*****	*****	*****
TL	35	160	*****	*****	*****	*****	*****	*****
TL	35	300	*****	*****	*****	*****	*****	*****
TL	35	809	*****	0.000	0.000	0.000	0.000	*****
TL	35	1012	0.000	0.000	0.000	0.040	0.058	0.080
TL	35	1498	0.152	0.196	0.177	0.227	0.277	0.325
TL	35	1500	0.006	0.007	0.008	0.009	0.006	0.007
TL	40	3052	*****	*****	*****	*****	*****	*****
TL	40	3053	*****	0.000	*****	*****	*****	*****
TP	35	163	*****	*****	*****	*****	*****	*****
TP	35	1227	0.571	0.630	0.568	0.484	0.677	0.661
TP	36	154	0.717	0.579	0.565	0.753	0.743	0.918
TP	36	163	0.194	0.191	0.156	0.167	0.218	*****
TP	36	326	0.582	0.609	0.741	0.646	0.519	0.469
UME	35	251	*****	*****	0.000	0.000	0.000	0.000
UME	35	252	0.015	0.000	0.005	0.005	0.005	0.005
UME	35	872	0.000	0.000	0.000	0.000	0.000	0.000
USNO	35	101	0.990	0.911	0.848	*****	*****	0.000
USNO	35	104	0.229	0.217	0.205	0.269	0.376	0.508
USNO	35	106	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	108	0.142	0.147	0.159	0.310	0.421	0.867
USNO	35	114	0.840	0.839	0.762	0.735	0.765	0.772
USNO	35	120	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	142	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	146	0.549	0.633	0.566	0.813	1.058	1.117
USNO	35	148	0.990	0.935	1.064	1.070	1.056	0.989
USNO	35	150	0.226	0.235	0.201	0.219	0.168	0.162
USNO	35	152	0.696	0.579	0.000	0.118	0.086	0.070
USNO	35	153	0.990	0.935	1.064	1.070	*****	*****
USNO	35	156	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	161	0.603	0.624	0.588	0.793	0.883	1.117
USNO	35	164	*****	*****	0.000	0.000	0.000	0.000
USNO	35	165	0.914	0.935	0.939	0.769	0.778	0.679
USNO	35	166	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	167	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	169	0.990	0.935	1.064	1.070	1.058	0.945
USNO	35	171	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	173	0.000	0.000	0.000	0.000	0.531	0.653
USNO	35	213	0.990	0.935	0.979	1.070	1.058	1.117
USNO	35	217	0.990	0.935	*****	*****	0.000	0.000
USNO	35	225	0.156	0.177	0.171	0.289	0.682	1.117
USNO	35	226	0.217	0.226	0.209	0.255	0.364	0.753
USNO	35	227	0.025	0.023	0.020	*****	*****	0.000
USNO	35	229	0.074	0.069	0.056	0.059	0.058	0.057

Table 9A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
SU	40	3825	*****	*****	*****	*****	0.000	0.000
SU	40	3837	*****	*****	*****	*****	0.000	0.000
TL	35	160	*****	*****	0.000	0.000	0.000	0.000
TL	35	300	*****	*****	0.000	0.000	0.000	0.000
TL	35	809	*****	0.000	0.000	0.000	0.000	0.786
TL	35	1012	0.079	0.060	0.064	0.077	0.074	0.125
TL	35	1498	0.354	0.387	0.533	0.433	0.507	0.698
TL	35	1500	0.007	0.006	0.000	0.003	0.003	0.003
TL	40	3052	0.000	0.000	0.000	0.000	0.004	0.005
TL	40	3053	*****	*****	0.000	0.000	0.000	0.000
TP	35	163	*****	*****	*****	0.000	0.000	0.000
TP	35	1227	0.627	0.482	0.691	0.698	0.654	0.612
TP	36	154	0.000	0.248	0.248	0.246	0.224	0.210
TP	36	163	*****	*****	*****	*****	*****	*****
TP	36	326	0.440	0.401	0.484	0.462	0.370	0.387
UME	35	251	*****	*****	0.000	0.000	0.000	0.000
UME	35	252	*****	*****	0.000	0.000	0.000	0.000
UME	35	872	*****	*****	0.000	0.000	0.000	0.000
USNO	35	101	0.000	0.000	0.000	0.172	0.198	0.200
USNO	35	104	0.546	0.503	0.505	0.560	0.683	0.962
USNO	35	106	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	108	1.124	1.093	1.093	1.042	0.925	0.872
USNO	35	114	0.727	0.698	0.798	0.817	0.778	0.629
USNO	35	120	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	142	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	146	0.958	0.844	0.799	0.777	0.741	0.722
USNO	35	148	1.124	1.093	1.093	0.895	0.809	0.814
USNO	35	150	0.167	0.149	0.150	0.157	0.141	0.126
USNO	35	152	0.074	0.072	0.073	0.082	0.087	0.121
USNO	35	153	0.000	0.000	0.000	0.000	0.870	0.698
USNO	35	156	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	161	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	164	1.124	1.093	1.093	1.042	0.834	0.561
USNO	35	165	0.712	0.533	0.409	0.425	0.401	0.462
USNO	35	166	1.124	1.093	1.093	1.042	1.000	0.889
USNO	35	167	0.978	1.093	1.093	1.042	1.000	0.768
USNO	35	169	0.899	1.003	0.811	0.834	0.765	0.688
USNO	35	171	0.757	0.538	0.437	0.472	0.335	0.406
USNO	35	173	0.676	0.761	0.717	0.806	0.804	0.913
USNO	35	213	1.124	1.093	0.876	0.904	0.632	0.483
USNO	35	217	0.000	0.000	0.282	0.310	0.394	0.381
USNO	35	225	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	226	1.050	1.093	1.093	1.042	1.000	0.962
USNO	35	227	0.000	0.000	0.000	0.619	0.702	0.520
USNO	35	229	0.642	0.433	0.248	0.189	0.157	0.147

Table 9A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
USNO	35	231	*****	*****	*****	0.000	0.000	0.000
USNO	35	233	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	242	0.990	0.842	0.567	0.443	0.409	0.351
USNO	35	244	0.114	0.130	0.127	0.181	0.466	1.117
USNO	35	249	0.000	0.340	0.203	0.247	0.259	0.236
USNO	35	253	0.147	0.169	0.164	0.454	1.058	1.117
USNO	35	254	*****	*****	*****	0.000	0.000	0.000
USNO	35	255	0.990	0.935	1.064	0.000	0.484	0.513
USNO	35	256	0.214	0.201	0.188	0.166	0.145	0.152
USNO	35	260	0.990	0.935	1.064	1.070	*****	*****
USNO	35	268	0.000	0.000	0.000	0.000	0.217	0.274
USNO	35	270	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	279	0.000	0.000	0.000	0.473	0.654	0.851
USNO	35	389	0.990	0.935	0.000	0.000	0.280	*****
USNO	35	392	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	394	0.531	0.508	0.431	0.391	0.455	*****
USNO	35	416	0.990	0.935	1.064	1.070	1.058	*****
USNO	35	417	0.268	0.247	0.196	0.204	*****	*****
USNO	35	703	*****	*****	0.000	0.000	0.000	0.000
USNO	35	717	0.990	0.935	1.064	1.070	1.058	1.045
USNO	35	762	0.485	0.426	0.000	0.189	0.190	0.261
USNO	35	763	0.680	0.655	0.653	0.766	0.861	1.117
USNO	35	765	0.990	0.935	1.064	*****	*****	0.000
USNO	35	1096	0.378	0.282	0.223	0.209	0.183	0.185
USNO	35	1097	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	1125	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	1327	*****	*****	0.000	0.000	0.000	0.000
USNO	35	1328	*****	*****	0.000	0.000	0.000	0.000
USNO	35	1331	0.990	0.935	0.494	0.442	0.382	0.438
USNO	35	1438	0.107	0.120	0.116	0.383	*****	*****
USNO	35	1459	0.243	0.249	0.255	0.318	0.341	0.662
USNO	35	1462	0.990	0.935	1.064	1.070	1.058	1.117
USNO	35	1463	0.972	0.864	0.724	0.931	0.870	0.624
USNO	35	1468	0.533	0.523	0.449	0.623	0.615	0.590
USNO	35	1481	0.775	0.842	0.702	0.866	1.040	1.019
USNO	35	1543	*****	*****	0.000	0.000	0.000	0.000
USNO	35	1573	*****	*****	0.000	0.000	0.000	0.000
USNO	35	1575	*****	*****	0.000	0.000	0.000	0.000
USNO	35	1655	*****	*****	*****	*****	*****	*****
USNO	35	1692	*****	*****	*****	*****	*****	0.000
USNO	35	1694	*****	*****	*****	*****	*****	0.000
USNO	35	1696	*****	*****	*****	*****	*****	0.000
USNO	35	1697	*****	*****	*****	*****	*****	0.000
USNO	35	1698	*****	*****	*****	*****	*****	0.000
USNO	40	701	0.990	0.935	1.064	1.070	1.058	1.117

Table 9A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
USNO	35	231	0.000	0.491	*****	*****	0.000	0.000
USNO	35	233	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	242	0.275	0.241	0.208	0.229	0.261	0.231
USNO	35	244	1.056	0.920	0.917	0.871	1.000	0.962
USNO	35	249	0.190	0.186	0.202	0.242	0.228	0.210
USNO	35	253	1.124	1.093	1.093	1.042	0.772	0.962
USNO	35	254	0.000	1.093	1.093	1.042	1.000	0.962
USNO	35	255	0.451	0.378	0.296	0.244	0.230	0.294
USNO	35	256	0.193	0.339	0.579	1.031	0.871	0.819
USNO	35	260	*****	*****	0.000	0.000	0.000	0.000
USNO	35	268	0.326	0.342	0.416	0.517	0.428	0.423
USNO	35	270	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	279	0.713	0.681	0.576	0.699	0.698	0.765
USNO	35	389	*****	*****	0.000	0.000	0.000	0.000
USNO	35	392	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	394	*****	0.000	0.000	0.000	0.000	0.150
USNO	35	416	*****	*****	0.000	0.000	0.000	0.000
USNO	35	417	0.000	*****	*****	0.000	0.000	0.000
USNO	35	703	0.380	0.515	0.525	0.594	0.511	0.621
USNO	35	717	0.664	0.504	0.479	0.456	0.419	0.421
USNO	35	762	0.238	*****	*****	0.000	0.000	0.000
USNO	35	763	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	765	0.000	0.000	0.000	0.020	0.022	0.024
USNO	35	1096	0.251	0.218	0.208	0.217	0.158	0.158
USNO	35	1097	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	1125	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	1327	0.574	0.361	0.299	0.259	0.238	0.193
USNO	35	1328	0.647	0.860	0.688	0.764	0.562	0.671
USNO	35	1331	0.498	0.522	0.486	0.499	0.498	0.528
USNO	35	1438	0.000	0.000	0.000	0.000	0.754	0.428
USNO	35	1459	0.799	1.093	1.093	1.042	1.000	0.962
USNO	35	1462	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	1463	0.543	0.590	0.694	0.806	1.000	0.962
USNO	35	1468	0.766	0.964	0.608	0.563	0.474	*****
USNO	35	1481	1.124	1.093	1.093	1.042	1.000	0.962
USNO	35	1543	1.124	0.861	1.067	1.042	0.567	0.688
USNO	35	1573	1.124	1.093	0.512	0.542	*****	*****
USNO	35	1575	0.967	1.093	1.088	1.042	1.000	0.932
USNO	35	1655	*****	*****	*****	0.000	0.000	0.000
USNO	35	1692	0.000	0.000	0.000	0.240	0.304	0.345
USNO	35	1694	0.000	0.000	0.000	0.245	0.335	0.448
USNO	35	1696	0.000	0.000	0.000	0.065	0.073	0.080
USNO	35	1697	0.000	0.000	0.000	0.848	0.877	0.962
USNO	35	1698	0.000	0.000	0.000	0.827	1.000	0.962
USNO	40	701	1.124	0.000	0.527	0.540	0.543	0.597

Table 9A. (Cont.)

lab.	clock		51939	51964	51999	52029	52059	52089
USNO	40	702	0.990	0.935	1.064	1.070	1.058	1.117
USNO	40	703	0.990	*****	*****	0.000	0.000	0.000
USNO	40	704	0.990	0.935	1.064	1.070	*****	*****
USNO	40	705	0.284	0.285	0.242	0.233	0.377	0.672
USNO	40	708	0.500	0.494	0.436	0.507	0.497	0.435
USNO	40	709	0.022	0.021	0.018	0.020	0.023	0.027
USNO	40	710	0.157	0.137	0.117	0.127	0.130	0.128
USNO	40	711	0.013	0.013	0.011	0.011	0.011	0.011
USNO	40	712	0.990	0.935	1.064	1.070	1.058	1.117
USNO	40	713	0.990	0.935	0.868	0.895	0.890	0.801
USNO	40	714	0.990	0.935	1.064	1.070	1.058	1.117
USNO	40	715	0.990	0.935	1.064	1.070	1.058	1.117
USNO	40	716	0.043	0.032	0.021	0.016	0.012	0.011
USNO	40	718	*****	*****	*****	0.000	0.000	0.000
VSL	35	179	0.185	0.145	0.135	*****	*****	0.000
VSL	35	456	0.326	0.363	0.347	*****	*****	0.000
VSL	35	548	*****	*****	*****	*****	*****	0.000
VSL	35	731	0.990	0.935	0.986	*****	*****	0.000

Table 9A. (Cont.)

lab.	clock		52119	52149	52179	52209	52239	52274
USNO	40	702	1.124	1.093	1.093	1.042	1.000	0.962
USNO	40	703	0.000	1.093	1.093	1.042	1.000	0.962
USNO	40	704	*****	*****	*****	*****	0.000	0.000
USNO	40	705	*****	*****	*****	*****	0.000	0.000
USNO	40	708	0.361	0.292	0.238	0.218	0.201	0.199
USNO	40	709	0.030	0.034	*****	*****	0.000	0.000
USNO	40	710	0.123	0.119	0.116	0.119	0.113	0.119
USNO	40	711	0.011	0.010	0.009	0.010	0.009	0.008
USNO	40	712	1.124	1.093	1.093	1.042	1.000	0.962
USNO	40	713	0.721	0.655	0.540	0.630	0.693	0.650
USNO	40	714	1.124	1.093	1.093	1.042	1.000	0.962
USNO	40	715	1.124	1.093	1.093	1.042	1.000	0.962
USNO	40	716	0.009	0.008	0.006	0.005	0.004	0.004
USNO	40	718	0.000	0.012	0.010	0.010	0.008	0.007
VSL	35	179	0.000	0.000	0.000	0.144	0.186	0.197
VSL	35	456	0.000	0.000	0.000	0.835	0.976	0.962
VSL	35	548	0.000	0.000	0.000	0.198	0.244	0.236
VSL	35	731	0.000	0.000	0.000	0.363	0.446	0.420

The clocks are designated by their type (2 digits) and serial number in the type. The codes for the types are:

12 HEWLETT-PACKARD 5061A
13 EBAUCHES, OSCILLATOM B5000
14 HEWLETT-PACKARD 5061A OPT. 4
16 OSCILLOQUARTZ 3200
17 OSCILLOQUARTZ 3000
18 FREQ. AND TIME SYSTEMS INC. 4000
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 HEWLETT-PACKARD 5071A High perf.
36 HEWLETT-PACKARD 5071A Low perf.
50 FREQ. AND TIME SYSTEMS INC. 4065A

Table 9B. Statistical data on the weights attributed to the clocks in 2001

Interval	Number of clocks			Number of clock with a given weight									maximum
				0* weight			0** weight			maximum weight			relative
2001	HM	5071A	total	HM	5071A	total	HM	5071A	total	HM	5071A	total	weight
Jan.	40	141	216	7	26	38	2	3	7	12	44	61	0.990
Feb.	41	148	225	6	25	38	1	3	6	14	45	64	0.935
Mar.	39	153	227	5	28	39	1	3	5	11	37	52	1.064
Apr.	41	151	228	6	29	41	2	4	9	11	41	55	1.070
May	40	143	221	4	23	32	3	1	9	10	40	54	1.058
June	31	151	217	5	28	38	3	3	9	8	40	52	1.117
July	30	151	217	4	29	39	3	3	10	7	39	50	1.124
Aug.	33	156	230	6	31	47	4	0	5	8	39	49	1.093
Sep.	40	165	249	14	40	66	3	1	5	8	37	46	1.093
Oct.	39	169	250	12	34	58	3	2	7	8	39	49	1.042
Nov.	42	169	254	14	29	54	3	2	7	8	42	52	1.000
Dec.	42	165	247	14	21	39	3	3	9	8	43	53	0.962

* A priori null weight (test interval of new clocks).
** Null weight resulting from the statistics.
HM designates hydrogen masers and 5071A designates Hewlett-Packard 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 March 2002.

AUTHORITIES RESPONSIBLE FOR THE TIME SIGNAL EMISSIONS

Signal	Authority
ATA	National Physical Laboratory Dr. K.S. Krishnan Road New Delhi - 110012, India
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 Lab. Zeit-und Frequenzuebertragung 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 Swiss Federal Office of Metrology and Accreditation Electricity, Acoustic and Time Section Lindenweg 50 CH-3003 Bern-Wabern Switzerland

Signal	Authority
HLA	Time and Frequency Laboratory Korea Research Institute of Standards and Science Yusong P.O. Box 102, Taejon 305-600 Republic of Korea
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
LOL	Servicio de Hidrografía Naval Observatorio Naval Buenos Aires 1107 – 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, ULA-4	Institute of Metrology for Time and Space (IMVP), GP "VNIIFTRI" Mendeleevo, Moscow Region 141570 Russia
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
VNG	National Standards Commission P.O. Box 282 North Ryde NSW 1670 Australia
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
ATA	Greater Kailash New Delhi India 28° 34'N 77° 19'E	10 000	continuous	Second pulses of 5 cycles of a 1 kHz modulation. Minute pulses of 100 ms duration. The time signals are advanced by 50 ms on UTC.
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	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.

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 .1 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. Fully operational since 1 October 2001
LOL (1)	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.
RAB-99	Khabarovsk Russia 48° 30'N 134° 50'E	25	Winter schedule 02 h 06 m to 02 h 20 m 06 h 06 m to 06 h 20 m Summer schedule 01 h 06 m to 01 h 20 m 05 h 06 m to 05 h 20 m	A1N type signals are transmitted between 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, 0.1 second pulses of 25 ms duration and minute pulses of 10 s duration are transmitted between minutes 11 and 20.

(1) LOL. * irregular ** discontinued for maintenance

Station	Location Latitude Longitude	Frequency (KHz)	Schedule (UTC)	Form of the signal
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	Winter schedule 11 h 06 m to 11 h 20 m Summer schedule 10 h 06 m to 10 h 20 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	Winter schedule 07 h 06 m to 07 h 22 m Summer schedule 06 h 06 m to 6 h 22 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	Winter schedule 09 h 06 m to 09 h 22 m Summer schedule 08 h 06 m to 08 h 22 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	Winter schedule 04 h 06 m to 04 h 22 m 10 h 06 m to 10 h 22 m Summer schedule 03 h 06 m to 03 h 22 m 09 h 06 m to 09 h 22 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-90	Nizhni Novgorod Russia 56° 11'N 43° 57'E	25	Winter schedule 05 h 06 m to 05 h 22 m Summer schedule 04 h 06 m to 04 h 22 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
RTZ (2)	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. 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 (2)	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.
TDF	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.

(2) 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
VNG (3)	Llandilo New South Wales Australia 33° 43'S 150° 48'E	2 500 5 000 8 638 12 984 16 000	continuous continuous continuous continuous 22 h to 10 h	Second pulses of 50 ms of 1 kHz modulation. Second pulses 55 to 58 of 5 ms of 1 kHz modulation. Second pulse at 59 is omitted. Minute pulses of 0.5 s of 1 kHz modulation. During minutes 5, 10, 15, ..., second pulses 50 to 58 are 5 ms long with 1 kHz modulation. BCD time code giving day of the year, hour and minute at the next minute is given between seconds 20 and 46. Voice announcement on 2 500, 5 000 and 16 000 kHz during minutes 15, 30, 45 and 60. Morse station identification on 8 638 and 12 984 kHz during minutes 15, 30, 45 and 60. DUT1: ITU-R code by double pulse.
WWV	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	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	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° 56'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.

(3) VNG: this service will cease on 1 July 2002.

ACCURACY OF THE CARRIER FREQUENCY

Station	Relative uncertainty of the carrier frequency in 10^{-10}
ATA	0.1
BPM	0.01
BSF	0.1
CHU	0.05
DCF77	0.02
EBC	0.1
HBG	0.1
HLA	0.02
IAM	0.5
JJY	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
TDF	0.02
VNG	0.1
WWV	0.05
WWVB	0.01
WWVH	0.01

TIME DISSEMINATION SERVICES

The following tables are based on information received at the BIPM in February and March 2002.

AUTHORITIES RESPONSIBLE FOR THE TIME DISSEMINATION SERVICES

AOS	Astrogeodynamical Observatory Borowiec near Poznan Space Research Centre P.A.S. PL 62-035 Kornik Poland
AUS	Standards for Time and Fraquency 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 LPTF	BNM-LPTF Observatoire de Paris 61, avenue de l'Observatoire 75014 Paris - France
CNM	Centro Nacional de Metrología Km. 4.5 Carretera a Los Cués El Marqués, Querétaro, C.P. 76241 México - Mexico
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 Standardsand Science P.O. Box 102, Yuseon Daejon 305-600. Republic of Korea
METAS	Swiss Federal Office of Metrology and Accreditation Electricity, Acoustic and Time Section Lindenweg 50 CH-3003 Bern-Wabern Switzerland
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
NPL	National Physical Laboratory Centre for Electromagnetic and Time Metrology Teddington, Middlesex TW11 0LW United Kingdom
NRC	National Research Council of Canada Institute for National Measurement Standards Frequency and Time Standards Bldg M-36, 1500 Montreal Road Ottawa, Ontario, K1A OR6, Canada
NTSC	National Time Service Center (formerly Shaanxi Astronomical Obsevatory, CSAO) Chine Academy of Sciences P.O. Box 18, Lintong Shaanxi 710600, China
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
PSB	National Measurement Centre Singapore Productivity and Standards Board 1 Science Park Drive Singapore
PTB	Physikalisch-Technische Bundesanstalt Lab. Zeit-und Frequenzuebertragung Bundesallee 100 D-38116 Braunschweig Germany

ROA	Real Instituto y Observatorio de la Armada Cecilio Pujazón s/n 11.100 San Fernando Cádiz, Spain
SP	SP Swedish National Testing and Research Institute Box 857 S-501 15 BORAS Sweden
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 three servers available to the general public: ntp.nml.csiro.au Sydney ntp.mel.nml.csiro.au Melbourne ntp.per.nml.csiro.au Perth Current information can be found on the web pages: www.nml.csiro.au
BEV	Provides a time dissemination service via phone and modem to synchronize PC clocks. Uses the Time Distribution System from TUG, which produces the telephone time code mostly used in Europe. 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...). Since February 2002 operates a NTP time server. The IP-Number is 217.19.37.20. For the moment you can only use this number, but in the future the name will be <time.metrology.at>.
BNM-LPTF	BNM-LPTF 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
CNM	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: Monition 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

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/services/tts.stm

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/services/ntp.stm

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

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 : 166 11 4615 up to July 31. Since Auguste 2001 The service can be accessed also from abroad at the numbers 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).

INPL

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 a time server 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

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

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

(2) Television 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

NIST

Automated Computer Time Service (ACTS)

Provides digital time code by telephone modem for setting time in computers.
Includes provision for calibration of telephone time delay.
Access phone numbers : +1 303 494 4774 and +1 808 335 4721
Further information at http://www.boulder.nist.gov/timefreq/.

Network Time Service (NTS)

Provides digital time code across the Internet using three different protocols. Geographically distributed set of time servers within the United States of America.
Further information at http://www.boulder.nist.gov/timefreq/.

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. Internet Time Service A service using the Network Time Protocol (NTP) is currently being established.
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://www.nrc.ca/inms/time/whatime.html.
NTSC	Network Time Service(NTS) Provides a synchronization to UTC(CSAO) for 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)
ONRJ	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
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

PSB

Web-based time service:

A real-time clock aligned to UTC(PSB) and corrected for Internet transmission delays. Further information at http://www.SingaporeStandardTime.org.sg.

Automated Computer Time Service (ACTS)

Transmits digital time code (NIST format) via telephone & modem for setting time in computers. The coded time information is synchronised to UTC(PSB). Includes provision for correcting telephone time delays. Access phone numbers : +65 7799978
Further information at http://www.SingaporeStandardTime.org.sg.

Network Time Service (NeTS)

Transmits digital time code via the Interrnet using three different protocols, i.e. Time, Daytime and NTP. Operates two time servers.
Host names : NeTS.org.sg
203.117.180.35
Further information at http://www.SingaporeStandardTime.org.sg.

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

It operates the European Telephone Code.
Access phone number : +34 956 599 429

Network Time Protocol

Server : ntp.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.

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)

More information about these services are found at the web site www.sp.se

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.

Director's Report on the Activity and Management of the BIPM, 2001, T. 2

(July 2000 – June 2001)

BIPM Publication

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

Reference time scales TAI and UTC have been computed regularly and published in the monthly *Circular T*. Definitive results for 2000 have been available in the form of computer-readable files on the BIPM home page and on printed volumes of the *Annual Report of the BIPM Time Section for 2000,* Volume **13** [26].

2 Algorithms for time scales

Research concerning time-scale algorithms includes studies to improve the long-term stability of the free atomic time scale EAL and the accuracy of TAI. Studies are being undertaken to evaluate the feasibility of providing quasi real-time predictions of UTC and TAI.

2.1 EAL stability

Some 80 % of clocks are now either commercial caesium clocks of the HP5071A type or active, auto-tuned hydrogen masers, and together they contribute 86 % to the total weight. The fixed value of 7×10^{-3} for the upper limit of clock weights in the calculation of TAI proved to be no longer appropriate as it does not allow an efficient discrimination between the best clocks. A new way of fixing the upper limit to clock weights in TAI computation has been used since January 2001. A report on this was submitted to the CCTF Working Group on TAI. The value of the maximum relative weight is now fixed at $2/N$, where N is the total number of clocks participating in TAI. It was shown, using real clock data over two and a half years, that such a choice for the maximum relative weight leads to a better discrimination between the clocks and improves the stability of the resulting time scale. We can thus expect an improvement in the stability of EAL in the near future.

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 2001.

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 [15]. Since August 2000, individual measurements of the TAI frequency have been provided by eight primary frequency standards including two Cs fountains (NIST-F1 and PTB CSF1). As a participant in the PTB's effort to publish the results of bilateral comparisons with TAI, the BIPM has contributed to joint PTB/BIPM reports submitted for publication [5].

Since August 2000 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 $+0.5 \times 10^{-14}$ to $+0.7 \times 10^{-14}$, with a standard uncertainty of 0.2×10^{-14}. Steps are being taken to reduce this offset without impeding the stability of TAI.

3 Time links

The classical GPS common-view technique based on C/A-code measure-ments obtained from single-channel receivers has been extended for use with multichannel dual-code dual-system (GPS and GLONASS) observations, to improve the accuracy of time transfer. Also, TWSTFT links are used in the computation of TAI. In addition, the BIPM Time section continues to test other time and frequency comparison methods, such as 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 single-time links used by the BIPM follows a pattern of local stars within a continent. All GPS links are corrected for ionospheric delays using IGS maps [24], as well as for satellite positions using IGS post-processed precise satellite ephemerides.

ii) Determination of differential delays of GPS and GLONASS receivers

Part of our work is to check the differential delays between GPS receivers which operate on a regular basis in collaborating timing centres. A series of differential calibrations of GPS equipment involving the European time laboratories equipped with two-way time-transfer stations began in June 1997. In December 1999, differential calibrations of GPS/GLONASS multichannel dual-code receivers were initiated involving laboratories in Australia, Europe, Japan, South Africa and the United States. The first trip ended in March 2000 and the results are under evaluation.

iii) Standards for GPS and GLONASS receivers

The Time section is actively involved in the work of the CCTF Group on Global navigation satellite systems Time Transfer Standards (CGGTTS). It has recently contributed to the 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 and GLONASS time links

Multichannel GPS links have been used in the computation of TAI since the beginning of 2000. The introduction of multichannel GPS+GLONASS links into TAI is also under study. Moreover, procedures for the use of multichannel GLONASS P-code and GLONASS precise ephemerides have been established.

3.2 Phase measurements

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 using an Ashtech Z12-T GPS receiver in operation at the BIPM have been continued. A method has been developed for performing the absolute calibration of Z12-T hardware delays and using it for differential calibration of similar receivers [16, 17, 20]. Two absolute calibration measurements of the Z12-T have been carried out at the U.S. Naval Research Laboratory (NRL) in May-June 2000 and April-May 2001 and the results are being compared. A trip was started in January

2001 to make differential calibrations of all similar receivers in time laboratories worldwide. A JPS Legacy GPS/GLONASS receiver, acquired in 2000, also serves as a reference with which the Z12-T is compared while at the BIPM. These studies are being conducted in the framework of the IGS/BIPM Pilot Project with a view to providing accurate time and frequency comparisons using GPS phase and code measurements.

The 3S Navigation receivers in operation at the BIPM have the capability of providing GLONASS phase measurements; software has been installed to allow automatic data retrieval. One such 3S receiver has been collecting data for IGEX'98 since October 1998. This experiment ended in 1999 and has been continued by 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 satellite time and frequency transfer (TWSTFT)

Two meetings related to TWSTFT activities have been held since October 2000. The BIPM collects two-way data from seven operational stations and undertakes treatment of some two-way links [4]. Five TWSTFT links have been introduced into the computation of TAI, and six other TWSTFT links 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 the issue of BIPM TWSTFT reports and a staff member of the BIPM provides the secretariat of the CCTF Working Group on TWSTFT.

4 Pulsars

Because millisecond pulsars have the potential to sense the very long-term stability of atomic time, collaboration is maintained with radio-astronomy groups observing pulsars and analysing pulsar data. The Time section provides these groups its post-processed realization of Terrestrial Time TT(BIPM2000). A small collaboration is continuing with the Observatoire Midi-Pyrénées (OMP) in Toulouse to complete the processing of a small programme of survey observations carried out over the past few years [22].

5 Space-time references

The BIPM/IAU Joint Committee on General Relativity for Space-time Reference Systems and Metrology (JCR) has collaborated with the IAU Working Group on relativity for celestial mechanics and astrometry (RCMA) on problems of astronomical relativistic space-time reference frames. The website (http://www.bipm.org/WG/CCTF/JCR) provides general information on the JCR. After discussion at the IAU Colloquium 180 in March 2000 [18], the report of the JCR was presented at the 24th IAU General Assembly in August 2000. The Resolutions prepared by the JCR were adopted as Resolution B1.5, "Extended relativistic framework for time transformations and realization of coordinate times in the solar system", and Resolution B1.9, "Redefinition of Terrestrial Time TT". The adoption of the new Resolutions by the IAU completes an important part of the original objectives of the JCR concerning time and frequency applications. The BIPM and the IAU therefore decided in January 2001 to terminate the Joint Committee and to continue to collaborate in the framework of the RCMA Working Group, renamed RCMAM (where the final M stands for metrology).

Uniformity in the definition of space reference systems is becoming of importance to basic metrology. Such uniformity is essential for activities that use sets of measurements that are not local, as is the case for astro-geodetic techniques contributing to the International Earth Rotation Service (IERS). In response to a call for participation in the IERS, the BIPM and the USNO have been working together to provide information for the Conventions Product Centre (CPC) of the IERS since 1 January 2001. Activities related to the realization of celestial reference frames and series of Earth rotation parameters are being developed by E.F. Arias in cooperation with the IERS [1, 9, 10, 23] and La Plata Observatory (Argentina) [7, 8].

6 Other studies

In collaboration with the BNM-LPTF/OP, scientists of the section are involved in the evaluation of the possible use for international time keeping 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 2003. Because of the micro-gravity environment such laser-cooled clocks are expected to reach relative uncertainties in the low 10^{-16} region, hence presenting an improvement by at least one order of magnitude with respect to current primary standards. They will therefore be of primordial interest for the establishment of TAI accuracy. Recently a complete theoretical treatment of the relevant relativistic corrections affecting the clocks as well as the time transfer has been carried out and published [6] in collaboration with the Observatoire de Paris and the École Normale Supérieure (ENS).

More generally the active field of atomic interferometry using laser-cooled atoms on the ground and on board satellites stimulates collaboration between the Time section and laboratories involved in these developments. As a consequence P. Wolf spent on a one-year secondment with the BNM-LPTF/OP on a CNES (Centre National d'Études Spatiales) grant to study possible applications of this technology in fundamental physics and metrology. A first study concerned the possibility of detecting gravitational waves using a space-borne gyroscope based on atom interferometry. The results (partly published) showed that such detection was unlikely given the present and expected state of the technology. The major part of the collaboration was then devoted to the investigation of systematic effects in primary frequency standards due to the quantization of external states of the atomic wave packets arising from the microwave recoil. Simple order of magnitude calculations show that such effects should give rise to shifts in relative frequency of at least a part in 10^{16} and up to a part in 10^{15} for increased microwave power, which is of the same order as the uncertainty of the best current frequency standards. However, a more detailed theory and numerical simulation showed that these shifts cancel to a large extent owing to multiple atomic wave interference in standing microwave fields. The same theory predicts an observable effect on the contrast of the interference pattern (Ramsey fringes) under certain conditions. Experiments are under way at the BNM-LPTF/OP to verify those predictions which would experimentally justify neglecting corrections arising from such recoil effects in the frequency evaluations of the best primary frequency standards.

7 Publications, lectures, travel: Time section

7.1 External publications

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7.2 BIPM publications

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