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.fr.

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

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*. The complete text of *Circular T* and most tables of the present Annual Report are available through the internet network.
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. *Les circulaires et la plupart des tableaux de ce rapport annuel sont disponibles par utilisation du réseau internet.*

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Foreword

The present issue of the Annual Report of the BIPM Time Section has been modified to make it more suitable to the needs of users.

The traditional tables containing values of [*TAI-TA*(*k*)] and [*UTC-UTC*(*k*)] every five days for each contributing laboratory are no more given in this publication. They are accessible in a user friendly format on the BIPM web site or via anonymous ftp. The same has been done with tables giving the data necessary to calculate GPS time and GLONASS time relative to both TAI and UTC.

Within the next year a poll will be addressed to the BIPM Time Section users and contributing laboratories to evaluate the conveniency of publishing in the future this Annual Report only on electronic form.

Avant-propos

Cette édition du Rapport Annuel de la Section du Temps du BIPM a subi des modifications pour le rendre plus adapté aux besoins des utilisateurs.

Les traditionnels tableaux donnant les valeurs de [TAI-TA(k)] *et de* [UTC-UTC(k)] *tous les cinq jours pour chaque laboratoire n'apparaissent plus dans cette publication. Ils sont accessibles sur le site web du BIPM ou par ftp anonyme, ainsi que les tableaux qui fournissent les éléments nécessaires au calcul du temps GPS et du temps GLONASS par rapport à TAI et à UTC.*

Dans le courant de l'année prochaine un questionnaire sera adressé aux utilisateurs et aux laboratoires participants pour évaluer les avantages de publier dans le futur ce Rapport Annuel sous forme électronique uniquement.

Access to the BIPM Time Section data via anonymous FTP

The BIPM Time Section is making available several publications and data files via anonymous ftp.
You can access it via the BIPM Web site http://www.bipm.fr or with the following procedure :
ftp 62.161.69.5 or ftp2.bipm.fr, user anonymous
system requests that you enter your identity as a password
cd pub/tai to access the tai subdirectory and get the readme.txt file listed below.

Listing of the readme.txt file: last update : 25 April 2000

BUREAU INTERNATIONAL DES POIDS ET MESURES - TIME SECTION

The tai subdirectory offers via anonymous ftp (ftp2.bipm.fr, node 62.161.69.5) informations of interest for the time and frequency community. This service presently contains three subdirectories:

data Data used for the computation of TAI, arranged in yearly directories, since May 1999. See data/readme.txt for more information.

In the following directories XY represents the last two digits of the year number (19XY or 20XY)

publication The latest issues of the Time Section publications:

publication	filename
Circular T#XXX	cirt.XXX
GPS schedule #XX	schgps.XX
GLONASS schedule #XX	schglo.XX
Results of the computation of TAI over the two-month interval Z of the year (Z = 1 for Jan-Feb, 2 for Mar-Apr, etc.) until Nov-Dec 1997	TAI.XYZ
Weights and rates relative to TAI of clocks in the computation of TAI over the one-month interval ZT of the year (ZT = 01 for Jan, 02 for Feb,..., 12 for Dec) starting Jan 1998	wXY.ZT rXY.ZT

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
Independent local atomic time scales: values of [TAI-TA(lab)], in separate files for each laboratory, starting Jan. 1998	TAI-lab
Notes on [TAI-TA(lab)], starting Jan. 1998	notes.TAI
Local representations of UTC: values of [UTC-UTC(lab)], in separate files for each laboratory, starting Jan. 1998	UTC-lab
Notes on [UTC-UTC(lab)] , starting Jan. 1998	notes.UTC
[TAI-GPS time] and [UTC-GPS time]	UTCGPSXY.ar
[TAI-GLONASS time] and [UTC-GLONASS time]	UTCGLOXY.ar
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 any comment or query send a message to : tai@bipm.fr

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 Bureau International des Poids et Mesures (BIPM) under the authority of the Comité International des Poids et Mesures (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 for 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.

Information on IERS can be obtained from:

Des renseignements sur l'IERS peuvent être obtenus à l'adresse suivante:

Central Bureau of IERS
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
Electronic mail : iers@obspm.fr
World Wide Web : 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 and regularly reported to the BIPM by about 50 timing centres maintaining a local UTC, UTC(k) (list in Table 3). This data is in the form of time differences [*UTC*(*k*) - *Clock*] taken at 5 day intervals for Modified Julian Dates (MJD) ending in 4 and 9, at 0h UTC, dates designated here as 'standard dates'. The equipment maintained by these timing centres is detailed in Table 4.

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

2. Accuracy

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

3. Availability

TAI and UTC are made available in the form of time differences with respect to the local time scales UTC(k), which approximate UTC, and TA(k), which are independent local atomic time scales. These differences, [*TAI* - *TA*(*k*)] and [*UTC* - *UTC*(*k*)], are computed for the standard dates ; they are available through the internet network.

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

4. Time links

In 1999, the network of time links used by the BIPM was non-redundant and mainly relied on the observation of GPS satellites in common views. For this purpose, international GPS tracking schedules are published by the BIPM about every six months. Tracking schedules for GLONASS are also established. The list of the schedules is reported in this volume and their content is available through the internet network.

One TWSTFT link between PTB abd TUG was introduced from July 1999. This link was differentially calibrated by a portable TWSTFT station.

Laboratories regularly send their GPS observations to the BIPM where they are processed following a unified procedure. Strict common views, synchronized to within 1 s, are used to remove the clock-dither noise brought about by the voluntary degradation, Selective Availability, of GPS signals.

The BIPM organizes the international GPS network which takes the form of local stars within a continent joined by two long-distance links, OP-CRL and OP-NIST, chosen because measured ionospheric delays are routinely available for these three sites. Since 1 July 1999 ionospheric corrections are computed for long distance links using the total electronic content maps produced by the International GPS Service (IGS). Precise GPS satellites ephemerides, produced by the IGS with a delay of a few days, are also routinely used for these long-distance links. 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 internet network.

The BIPM regularly publishes an evaluation of [*UTC* - *GLONASS time*], available via anonymous ftp and on the BIPM web site, using current observations of the GLONASS system at the NMi Van Swinden Laboratorium, The Netherlands.

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 [2]. 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 the internet network.

Notes

Tables 8 and 9 of this report give the rates relative to TAI and the weights of the contributing clocks to TAI in 1999.

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

The report of the BIPM Time Section, for the year October 1998 - September 1999, to be published in 'Comité International des Poids et Mesures, Report of the 88th Meeting, 1999, Tome 67, BIPM Publications', 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] B. Guinot, Atomic time scales for pulsar studies and other demanding applications, *Astron. Astrophys.*, 1988, **192**, 370-373.

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 0hUTC, '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] 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 fréquence propre 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, compte-tenu des améliorations de données connues après la publication de la* Circulaire T.

4. <u>Liaisons horaires</u>

En 1999, le système des liaisons horaires utilisé par le BIPM était non-redondant et reposait principalement sur l'observation des satellites du GPS en vues simultanées. Dans ce but, le BIPM publie tous les six mois des programme 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.

La liaison de temps par aller et retour sur le satellite INTELSAT 706 entre PTB et TUG a été introduite en 1999. Cette liaison a été étalonnée de manière différentielle à l'aide d' une station portable TWSTFT.

Les laboratoires envoient régulièrement leurs données au BIPM où les calculs sont effectués d'une manière unifiée. On utilise des observations en vues simultanées strictes, c'est-à-dire synchronisées à la seconde près, ceci afin de supprimer la dégradation des signaux des horloges embarquées, due à l'implantation de 'l'accés sélectif'.

Le BIPM organise le réseau international de comparaisons horaires utilisant le GPS selon un schéma en étoile au niveau des continents, et en deux liaisons à longue distance, OP-CRL et OP-NIST, choisies parce que des données de retards ionosphériques mesurés sont disponibles pour ces trois sites. A partir du 1er juillet 1999 on calcule les corrections ionosphériques pour les liaisons à longue distance à l'aide des cartes du contenu électronique total produites par l'IGS. Des éphémérides précises des satellites du GPS, produites par l'IGS et accessibles en quelques jours, sont aussi utilisées de manière courante pour ces deux liaisons. 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.*

5. <u>Echelles de temps établies rétrospectivement</u>

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 [2]. 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 1999.

Les pages jaunes, à la fin de ce volume, concernent les émissions de signaux horaires.

Le rapport à un an (octobre 1998 - septembre 1999) de la section du temps du BIPM à paraître dans 'Comité international des poids et mesures, Procès-verbaux 88e session, 1999, Tome 67, 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 13.

TABLE 1. FREQUENCY OFFSETS AND STEP ADJUSTMENTS OF UTC, UNTIL 30 JUNE 2000

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

TABLE 2. RELATIONSHIP BETWEEN TAI AND UTC, UNTIL 30 June 2000

LIMITS OF VALIDITY (AT 0h UTC)	*TAI - UTC* (IN SECONDS)
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), OR/AND AN INDEPENDENT LOCAL TIME SCALE, TA(K)

AMC	Alternate Master Clock station, Colorado Springs, Colorado, USA
AOS	Astronomiczne Obserwatorium Szerokosciowe, Borowiec, Polska
APL	Applied Physics Laboratory, Laurel, MA, USA
AUS	Consortium of laboratories in Australia
BEV	Bundesamt für Eich - und Vermessungswesen, Wien, Oesterreich
BIRM	Beijing Institute of Radio Metrology and Measurement, Beijing, P. R. China
CAO	Cagliari Astronomical Observatory , Cagliari, Italia
CH	Consortium of laboratories in Switzerland
CNM	Centro Nacional de Metrologia, Queretaro, Mexico
CRL	Communications Research Laboratory, Tokyo, Japan
CSAO	Shaanxi Astronomical Observatory, Lintong, P.R. China
CSIR	Council for Scientific and Industrial Research, Pretoria, South Africa
DLR	Deutsche Forschungsanstalt fuer Luft-und Raumfahrt, Oberpfaffenhofen, Deutschland
DTAG	Deutsche Telecom AG, Darmstadt, Deutschland
F	Commission Nationale de l'Heure, Paris, France
GUM	Glówny Urzad Miar, Central Office of Measures, Warszawa, Polska
IEN	Istituto Elettrotecnico Nazionale Galileo Ferraris, Torino, Italia
IFAG	Bundesamt fuer Kartographie und Geodaesie, Fundamentalstation, Wettzell, Deutschland
IGMA	Instituto Geografico Militar, Buenos-Aires, Argentina
INPL	National Physical Laboratory, Jerusalem, Israel
IPQ	Institute Português da Qualidade (Portuguese Institute for Quality), Monte de Caparica, Portugal.
JATC	Joint Atomic Time Commission, Lintong, P.R. China
KRIS	Korea Research Institute of Standards and Science, Taejon, Rep. of Korea
LDS	The University of Leeds, Leeds, United Kingdom
MSL	Measurement Standards Laboratory, Lower Hutt, New Zealand
NAO	National Astronomical Observatory, Misuzawa, Japan
NIM	National Institute of Metrology, Beijing, P.R. China
NIST	National Institute of Standards and Technology, Boulder, CO, USA
NML	National Measurement Laboratory, Sydney, Australia
NPL	National Physical Laboratory, Teddington, United Kingdom
NPLI	National Physical Laboratory, New-Delhi, India
NRC	National Research Council of Canada, Ottawa, Canada
NRLM	National Research Laboratory of Metrology, Tsukuba, Japan
OMH	Orszagos Mérésügyi Hivatal, Budapest, Hungary
ONBA	Observatorio Naval, Buenos-Aires, Argentina

TABLE 3. ACRONYMS AND LOCATIONS OF THE TIMING CENTRES WHICH MAINTAIN A LOCAL APPROXIMATION OF UTC, UTC(K), OR/AND AN INDEPENDENT LOCAL TIME SCALE, TA(K) (CONT.)

ONRJ	Observatorio Nacional, Rio de Janeiro, Brazil
OP	Observatoire de Paris, Paris, France
ORB	Observatoire Royal de Belgique, Bruxelles, Belgique
PSB	National Measurement Center, Singapore Productivity and Standards Board, Singapore
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland
ROA	Real Instituto y Observatorio de la Armada, San Fernando, Espana
SCL	Standards and Calibration Laboratory, Hong Kong
SMU	Slovak Institute of Metrology, Bratislava, Slovakia
SO	Shanghai Observatory, Shanghai, P.R. China
SP	Swedish National Testing and Research Institute, Boras, 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 Czech Republic - Czech Republic
TUG	Technische Universität, Graz, Oesterreich
UME	Ulusai Metroloji Enstitüsü, Marmara Research Centre, National Metrology Institute, Gebze-Kocaeli, Turkey
USNO	U.S. Naval Observatory, Washington D.C., USA
VSL	Van Swinden Laboratorium, Delft, Nederland

TABLE 4. EQUIPMENT AND SOURCE OF UTC(K) OF THE LABORATORIES CONTRIBUTING TO TAI IN 1999.

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	2 Ind. Cs	1 Cs + micro-phase-stepper		*	*	
APL	2 Ind. Cs 2 H-masers	1 Cs		*		*
AUS	19 Ind. Cs 4 H-masers (2)	1 Cs	*	*	*	*
BEV	2 Ind. Cs 1 Ind. Rb	1 Cs		*		
BIRM	2 Ind. Cs 2 H-maser	1 Cs		*	*	
CAO	3 Ind. Cs	1 Cs		*		
CH	9 Ind. Cs (3)	all the Cs	*	*		
CNM	6 Ind. Cs (4)	1 Cs		*		
CRL	11 Ind. Cs 1 Lab. Cs 2 H-masers	9 Cs	*	*	*	*
CSAO	6 Ind. Cs	all the Cs	*	*		*
CSIR	2 Ind. Cs	1 Cs		*	*	
DLR	1 Ind. Cs 1 H-masers	1 H-maser		*	* (5)	
DTAG	3 Ind. Cs	1 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
GUM	6 Ind. Cs	1 Cs		*		
IEN	5 Ind. Cs	1 Cs + micro-phase-stepper	*	*	*	*
IFAG (a)	5 Ind. Cs 3 H-masers	1 Cs + micro-phase-stepper		*		
IGMA	4 Ind. Cs	1 Cs + micro-phase-stepper		* (6)		
INPL	5 Ind. Cs	1 Cs	*	*		
IPQ	3 Ind. Cs	1 Cs		*		
JATC	6 Ind. Cs (7)	1 Cs + micro-phase-stepper	*	*		*
KRIS	3 Ind. Cs 1 H-maser	1 Cs + micro-phase-stepper	*	*	*	
LDS	1 Ind. Cs	1 Cs		*	*	
MSL	3 Ind. Cs	1 Cs		*		
NAO	4 Ind. Cs 1 H-maser	1 Cs + micro-phase-stepper		*		
NIM (a)	3 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
NPL	3 Ind. Cs 2 H-maser	1 H-maser		*	*	*
NPLI	3 Ind. Cs	1 Cs		*	*	
NRC	1 Ind. Cs 3 Lab. Cs 2 H-masers	1 Lab. Cs + micro-phase-stepper (8)	*	*		*
NRLM	4 Ind. Cs 1 Lab. Cs	1 Cs		*		*
OMH	1 Ind. Cs	1 Cs		*		
ONBA (9)	2 Ind. Cs	1 Cs + micro-phase-stepper		*		
ONRJ	7 Ind. Cs 2 H-masers	1 Cs		*		
OP	5 Ind. Cs 2 Lab. Cs 1 H-maser	1 Cs + micro-phase-stepper	* (10)	*		
ORB	3 Ind. Cs 2 H-maser	1 Cs + micro-phase-stepper		*	*	
PSB	2 Ind. Cs	1 Cs		*		
PTB	4 Ind. Cs 3 Lab. Cs (11) 3 H-masers	1 Lab. Cs	* (12)	*		*
ROA	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	2 Ind. Cs	1 Cs + micro-phase-stepper		*		
SMU	1 Ind. Cs	1 Cs		*		
SO	3 H-masers	1 H-maser + micro-phase-stepper	*	* (6)		
SP	3 Ind. Cs	1 Cs + micro-phase-stepper		*		
SU	1 Lab. Cs 10 H-masers	6 H-masers	* (13)	*	*	
TL	6 Ind. Cs	1 Cs + micro-phase-stepper		*	*	
TP	4 Ind. Cs	1 Cs + output frequency steering		*		
TUG	2 Ind. Cs	1 Cs		*		*
UME	3 Ind. Cs	1 Cs		*		
USNO	54 Ind. Cs 17 H-masers	UTC(USNO,MC) is an H-maser + frequency synthesizer steered to UTC(USNO) (14)	* (14)	*	*	*
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 1999):
* National Measurement Laboratory (NML, Sydney) 3 Cs, 2 H-masers.
Australian laboratories intercompared by GPS are:
* National Measurement Laboratory Melbourne branch (NMLMEL, Melbourne) 1 Cs,
* Camberra Deep Space Communication Complex (CDSCC, Camberra) 2 Cs, 2 H-masers,
* Telstra Corporation Ltd (TELSTRA, Perth) 1 Cs,
* Telstra Corporation Ltd (TELSTRA, Melbourne) 5 Cs,
* Hewlett-Packard (HP, Melbourne) 1 Cs,
* Australian Defence Industries Ltd (ADI, Sydney) 1 Cs,
* Australian Land Information Group, Yarragadee Observatory (Yarragadee, Western Australia) 2 Cs.
Australian laboratories intercompared by TV are:
* Philips Calibration Service (PHILIPS, Sydney) 1 Cs,
* TENIX Defence Systems Pty Ltd (TENIX, Williamstown) 1 Cs.

(3) CH . The standards are located as follows (at the end of 1999):
* Office Fédéral de Métrologie (OFMET, Bern) 8 Cs,
* Observatoire de Neuchâtel (ON, Neuchâtel) 1 Cs,
They are intercompared by GPS (OFMET-ON) and linked to the foreign laboratories through the Swiss Federal Office of Metrology.

(4) CNM . 4 of them broke down before June 1999

(5) DLR . The Glonass receiver is not connected to UTC(DLR)

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

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

(8) NRC . In 1999, UTC(NRC) was derived from NRC Cs VI C until April 13 and from NRC Cs VI A since then.

(9) ONBA. Linked by TV to IGMA.

NOTES (CONT.)

(10) 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 1999) :

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

Links by GPS : OP-OB, OP-OCA, OP-CNES, OP-CELAR, OP-HP, OP-TKL, OP-DCN, OP-CNET.
Other national links by the TV method.

(11) PTB . The laboratory Cs, PTB CS1, PTB CS2 and PTB CS3, are operated continuously as clocks. Until further notice, TA(PTB) is directly derived from PTB CS2.

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

(13) SU . TA(SU)-UTC(SU) = 29.172 759 000 s from 51179 to 51543

(14) USNO. The time scales A.1(MEAN) and UTC(USNO) are computed by USNO. They rely on a number of Cs clocks and H-masers. A.1(MEAN) is a free atomic time scale while UTC(USNO) is closely steered on UTC. In addition, a number of clocks are in operation at the Alternate Master Clock Station, Colorado Springs, Colorado; their data are used to compute TA(AMC).

TABLE 5. DIFFERENCES BETWEEN THE NORMALIZED FREQUENCIES OF EAL AND TAI, UNTIL APRIL 2000

(File available on http://www.bipm.fr under the name EALTAI99.AR)

Date	MJD	f(EAL) - f(TAI) in 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 Apr 30	51539 - 51664	7.130

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.fr under the name UTAI99.AR)

The following table gives the difference *d* between the duration of the TAI scale interval and the SI second as produced by the primary standards CRL-01, LPTF-JPO, LPTF-F01, NIST-7, NIST-F1, NRC CsVI A and C, NRLM-4, PTB CS1, PTB CS2, PTB CS3 and SU MCsR 102 for the period 1995-1999.
Previous calibrations are available in the successive annual reports of the BIPM Time Section volumes 1 to 11.

The frequencies of the primary frequency standards are corrected for the gravitational shift (of about 1×10^{-13} for an altitude of 1000 m), and for the black-body radiation shift (of about 2×10^{-14} for a temperature of 40 °C) when available (standards tagged with a *).

The characteristics of the calibrations of the TAI frequency provided by the different primary standards are as follows:

Standard	Unc. (1 σ)	Operation	Comparison With	Transfer to TAI
CRL-01*	1.0×10^{-14}	discontinuous	H maser	25 d
LPTF-JPO*	0.6×10^{-14}	discontinuous	UTC(OP)	10 d
LPTF-F01*	2.2×10^{-15}	discontinuous	H maser	5 d, 10 d or 30d
NIST-7*	0.7 or 1.0×10^{-14}	discontinuous	H maser	5 d or 10 d
NIST-F1*	0.1×10^{-14}	discontinuous	H maser	20 d
NRC CsVI A	$\approx 1 \times 10^{-13}$	continuous	TAI	60 d
NRC CsVI C	$\approx 1 \times 10^{-13}$	continuous	TAI	60 d
NRLM-4*	2.9×10^{-14}	discontinuous	TAI	5 d or 10 d
PTB CS1*(1)	3.0 or 0.7×10^{-14}	continuous	TAI	60 d
PTB CS2*	1.5×10^{-14}	continuous	TAI	60 d
PTB CS3*	1.4×10^{-14}	continuous	TAI	60 d
SU MCsR 102*	5×10^{-14}	discontinuous	UTC(SU)	60 d

(1) Until MJD = 49889, 1 $\sigma = 3.0 \times 10^{-14}$. From MJD = 50994, 1 $\sigma = 0.7 \times 10^{-14}$

Note :

The uncertainty quoted in this table is the type B standard uncertainty of the primary frequency standard, as declared to the BIPM by the laboratory. It does not include any additional uncertainty due to frequency transfer from the primary frequency standard to TAI.

TABLE 6. (CONT.)

d in 10^{-14} s

Interval for transfer to TAI	Central date of the calibration	CRL CRL-01*	LPTF JPO*	NIST NIST-7*	NRLM NRLM-4*	SU MCsR 102*	LPTF FO1*	NIST NIST-F1
49789-49799	1995 Mar 16			+2.0				
49809-49819	1995 Apr 5			+3.0				
49819-49829	1995 Apr 15			+2.9				
49829-49839	1995 Apr 25			+2.0				
49839-49849	1995 May 8			+2.2				
49899-49909	1995 Jul 7			+2.2				
49959-49969	1995 Sep 3			+3.3				
49959-50019	1995 Sep 30					+3.5		
49969-49979	1995 Sep 14						+1.4	
49979-49989	1995 Sep 24						+1.6	
49989-49999	1995 Oct 4						+1.8	
49999-50009	1995 Oct 14						+2.2	
50009-50019	1995 Oct 24						+1.4	
50029-50039	1995 Nov 13						+1.3	
50039-50049	1995 Nov 23						+1.1	
50049-50059	1995 Dec 3						+0.6	
50059-50069	1995 Dec 13						+1.1	
50069-50079	1995 Dec 23						+1.6	
50019-50029	1995 Nov 7			+2.2				
50019-50079	1995 Nov 30					+4.3		
50079-50084	1995 Dec 30			+2.5				
50094-50124	1996 Jan 27					+8.4		
50124-50154	1996 Feb 26					+2.4		
50144-50149	1996 Mar 4			+2.1				
50154-50184	1996 Mar 27					+1.9		
50199-50209	1996 May 1			+2.5				
50209-50214	1996 May 8						+1.8	
50214-50219	1996 May 13						+2.3	
50219-50224	1996 May 18						+2.2	
50439-50449	1996 Dec 27			+2.7				
50619-50629	1997 Jun 25			+1.7				
50739-50749	1997 Oct 23			-0.3				
50754-50784	1997 Nov 17						+0.99	
50869-50874	1998 Feb 27				-2.4			
50879-50889	1998 Mar 12			-0.9				
50889-50894	1998 Mar 19				-0.3			
50929-50964	1998 May 13			+1.2				
50934-50939	1998 May 3				-1.0			
50969-50979	1998 Jun 10				-0.7			
51014-51024	1998 Jul 25				-0.9			
51009-51039	1998 Jul 30			-1.1				
51019-51044	1998 Aug 6	-1.2						
51034-51044	1998 Aug 14				-1.9			
51099-51129	1998 Oct 28			-0.3				
51124-51134	1998 Nov 12				-3.9			
51149-51159	1998 Dec 7				-0.8			
51144-51174	1998 Dec 12			-0.1				

TABLE 6. (CONT.)

d in 10^{-14} s

Interval for transfer to TAI	Central date of the calibration	CRL CRL-01*	LPTF JPO*	NIST NIST-7*	NRLM NRLM-4*	SU MCsR 102*	LPTF FO1*	NIST NIST-F1
51174-51184	1999 Jan 1				-2.0			
51209-51239	1999 Feb 15			+0.1				
51219-51229	1999 Feb 15				-4.3			
51299-51329	1999 May 16			-0.7				
51339-51359	1999 Jun 20		+0.8					
51359-51369	1999 Jul 5				-1.7			
51359-51389	1999 Jul 15			-0.7				
51379-51389	1999 Jul 25		+1.0					
51399-51409	1999 Aug 14				-3.3			
51439-51449	1999 Sep 23				-0.6			
51439-51469	1999 Oct 3			+0.1				
51444-51464	1999 Oct 3		+0.7					
51499-51519	1999 Nov 27							+0.2
51504-51514	1999 Nov 27				-4.2			
51519-51539	1999 Dec 17			+0.1				

TABLE 6. (CONT.)

d in 10^{-14} s

Interval for transfer to TAI	Central date of the calibration	NRC CsVIA	NRC CsVIC	PTB CS1*	PTB CS2*	PTB CS3*
49709-49769	1995 Jan 22			+2.5	+2.7	
49769-49829	1995 Mar 23	-7.5	-1.7	-0.1	+3.0	
49829-49889	1995 May 22	-10.7	-6.1	+3.5	+2.0	
49889-49959	1995 Jul 26	-11.6	-5.0		+3.5	
49959-50019	1995 Sep 29	-11.1	-5.8		+2.7	+4.9
50019-50079	1995 Nov 28	-9.2	-6.3		+2.5	+4.3
50079-50139	1996 Jan 27	-15.7	-8.2		+3.1	
50139-50199	1996 Mar 27	-17.6	-7.2		+2.8	
50199-50264	1996 May 28	-15.5	-5.9		+2.6	
50264-50324	1996 Jul 30	-15.6	-7.7		+2.9	+5.6
50324-50384	1996 Sep 28	-13.7	-2.5		+2.2	+2.6
50384-50444	1996 Nov 27	-12.5	-5.3		+2.9	+5.0
50444-50504	1997 Jan 26	-10.9	+1.7		+2.8	+5.6
50504-50564	1997 Mar 27	-11.0	+2.4		+2.8	+4.5
50564-50629	1997 May 28	-11.0	-0.5		+2.6	+4.9
50629-50689	1997 Jul 30	-11.2	+0.7		+0.4	+3.4
50689-50749	1997 Sep 28	-12.1	+0.7		+1.4	+3.8
50749-50809	1997 Nov 27	-12.3	+0.5		+0.5	+2.5
50809-50844	1998 Jan 13	-12.6	+0.6		+0.6	+1.6
50844-50869	1998 Feb 12	-13.6	-0.4		+0.6	+0.8
50869-50899	1998 Mar 12	-13.1	+0.2		+0.2	+3.3
50899-50929	1998 Apr 11	-13.5	-0.1		-0.1	+0.5
50929-50964	1998 May 13	-12.2	+0.3		+0.4	+0.1
50964-50994	1998 Jun 15	-13.4	-0.4		-0.3	+0.8
50994-51024	1998 Jul 15	-13.4	+0.1	-0.3	+0.2	+0.5
51024-51054	1998 Aug 14	-15.1	+0.2	-0.7	+0.5	+1.7
51054-51084	1998 Sep 13		+1.5	-0.8	+0.2	+2.4
51084-51114	1998 Oct 13		+0.4	-0.2	-0.6	+2.6
51114-51144	1998 Nov 12		+0.2	-1.0	-0.1	+4.0
51144-51174	1998 Dec 12		-0.1	-0.4	+0.1	+1.7
51174-51209	1999 Jan 14		+0.2	-1.5	-0.1	+3.9
51209-51234	1999 Feb 13	+2.8	+1.2	+0.2	+0.6	+3.4
51234-51264	1999 Mar 12	+1.5	+1.0	+0.1	+0.2	+3.9
51264-51294	1999 Apr 11	-0.7		-0.1	+0.5	+1.9
51294-51329	1999 May 14	-1.3		-0.3	-0.1	+2.7
51329-51359	1999 Jun 15	-0.4		-0.4	+0.5	+1.4
51359-51379	1999 Jul 10			+0.1		
51359-51389	1999 Jul 15				+0.3	+1.9
51389-51419	1999 Aug 14				+0.8	+2.2
51419-51449	1999 Sep 13	-0.7			+0.3	+2.2
51449-51479	1999 Oct 13	-0.8			+1.0	+2.7
51479-51509	1999 Nov 12	+0.3			+0.8	+3.5
51509-51539	1999 Dec 12	-1.8			+0.5	

TABLE 7. MEAN DURATION OF THE TAI SCALE INTERVAL IN SI SECOND ON THE ROTATING GEOID

(File available on http://www.bipm.fr under the name SITAI99.AR)

The estimate of the mean duration of the TAI scale interval in SI second on the rotating geoid, and its relative uncertainty are computed by the BIPM according to the method described in 'Azoubib J., Granveaud M., Guinot B., Metrologia 13, 1977, pp. 87-93', using all available measurements from the most accurate primary frequency standards CRL-01, LPTF-F01, LPTF-JPO, NIST-7, NIST-F1, NRLM-4, PTB CS1, PTB CS2, PTB CS3 and SU MCsR 102, consistently corrected for the black-body radiation shift.

For the months	Mean duration in s	Relative uncertainty
1994 Jan - Feb	1 + 1.7x10^{-14}	0.9x10^{-14}
1994 Mar - Apr	+ 1.8	0.9
1994 May - Jun	+ 2.1	0.9
1994 Jul - Aug	+ 2.3	0.9
1994 Sep - Oct	+ 2.0	0.8
1994 Nov - Dec	+ 2.0	0.8
1995 Jan - Feb	1 + 2.3x10^{-14}	0.7x10^{-14}
1995 Mar - Apr	+ 2.4	0.5
1995 May - Jun	+ 2.4	0.5
1995 Jul - Aug	+ 2.4	0.6
1995 Sep - Oct	+ 2.1	0.4
1995 Nov - Dec	+ 1.7	0.4
1996 Jan - Feb	1 + 2.2x10^{-14}	0.6x10^{-14}
1996 Mar - Apr	+ 2.3	0.6
1996 May - Jun	+ 2.4	0.5
1996 Jul - Aug	+ 2.6	0.7
1996 Sep - Oct	+ 2.5	0.8
1996 Nov - Dec	+ 2.6	0.7
1997 Jan - Feb	1 + 2.6x10^{-14}	0.7x10^{-14}
1997 Mar - Apr	+ 2.4	0.8
1997 May - Jun	+ 2.1	0.7
1997 Jul - Aug	+ 1.6	0.8
1997 Sep - Oct	+ 1.1	0.7
1997 Nov - Dec	+ 0.9	0.4
1998 Jan - Feb	1 + 0.5x10^{-14}	0.5x10^{-14}
1998 Mar - Apr	+ 0.1	0.5
1998 May - Jun	- 0.0	0.5
1998 Jul - Aug	- 0.4	0.4
1998 Sep - Oct	- 0.3	0.4
1998 Nov - Dec	- 0.4	0.4
1999 Jan - Feb	1 - 0.2x10^{-14}	0.4x10^{-14}
1999 Mar - Apr	+ 0.0	0.4
1999 May - Jun	+ 0.1	0.3
1999 Jul - Aug	+ 0.3	0.4
1999 Sep - Oct	+ 0.4	0.4
1999 Nov - Dec	+ 0.3	0.3

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.fr 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.fr 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.fr)

GPS Schedule no 32 File SCHGPS.32	implemented on MJD = 51267 (1999 March 30) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GPS Schedule no 33 File SCHGPS.33	implemented on MJD = 51452 (1999 October 1) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 07 File SCHGLO.07	implemented on MJD = 51267 (1999 March 30) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 08 File SCHGLO.08	implemented on MJD = 51452 (1999 October 1) 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 as '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 order 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 1997 July 1, 0h UTC, until 1999 January 1, 0h UTC :

$$[UTC - GPS\ time] = -12\ \text{s} + C_0.$$

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 taken at the Paris Observatory, from satellites with highest elevation, are first corrected for precise satellite ephemerides and for measured ionospheric delays, and then smoothed to obtain daily values of [*UTC(OP) - GPS time*] at 0h UTC. Daily values of C_0 are derived from them using linear interpolation of [*UTC - UTC(OP)*] provided on the BIPM internet network. The global uncertainty of daily C_0 values is of order 10 ns.

The tables giving daily values of C_0 at 0h UTC as well as the standard deviation σ Which characterizes the dispersion of individual measurements, and the number N of measurements used to estimate the corresponding C_0 value are available on http://www.bipm.fr under the name UTCGPS99.AR.

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

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

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

where the time difference 0 s is kept constant as a consequence of the leap seconds applied to GLONASS time in order to follow the UTC system, and C_1 is a quantity of order several hundreds of 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 1997 July 1, 0h UTC, until 1999 January 1, 0h UTC :

$$[TAI - GLONASS\ time] = 31\ \mathrm{s} + C_1,$$

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

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

Here C_1 is given at 0h UTC every day.

C_1 is computed as follows: the GLONASS data taken at the NMi Van Swinden Laboratorium, Delft, The Netherlands, for highest elevation, are smoothed to obtain daily values of [*UTC*(*VSL*)-*GLONASS time*] at 0h UTC. Daily values of C_1 are then derived from them using 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 global uncertainty of daily C_1 values is of order several hundreds nanoseconds.

The tables giving daily values of C_1 at 0h UTC, as well as the standard deviation σ which characterizes the dispersion of individual measurements, and the number N of measurements used to estimate the corresponding C_1 value are available on http://www.bipm.fr under the name UTCGLO99.AR.

TABLE. 8A. RATES RELATIVE TO TAI OF CONTRIBUTING CLOCKS IN 1999

(File available on http://www.bipm.fr under the name RTAI99.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 1999. For studies including the clock rates of previous years, corrections must be brought to the data published in the Annual Reports for 1988 to 1998, 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		51209	51234	51264	51294	51329	51359
AMC	35	173	-16.61	-17.29	-13.92	-14.45	-13.81	-14.77
AMC	35	231	7.57	9.89	8.20	***	***	***
AMC	35	266	-14.83	-15.13	-14.46	-15.65	-15.71	-15.03
AMC	35	268	-15.43	-19.52	-19.85	-19.89	-20.04	***
AMC	35	389	-30.68	-30.80	-29.87	***	***	***
AMC	35	416	-17.06	-17.46	-17.75	-18.24	-19.37	-19.67
AMC	35	703	***	***	***	***	***	***
AMC	35	717	7.79	6.89	7.37	6.42	6.92	7.33
AMC	35	762	-24.46	-25.24	-25.32	-27.94	-28.30	***
AMC	35	765	-6.41	-6.74	-6.43	-7.41	-7.29	-6.55
AMC	40	713	-15.25	-15.32	-15.01	-15.27	-14.93	-14.55
AMC	40	714	-39.87	-40.10	-39.92	-40.21	-39.96	-39.87
AMC	40	716	***	***	***	***	***	***
AOS	23	67	14.16	30.75	16.36	8.55	38.72	-14.50
APL	35	904	0.13	-16.11	-7.92	***	8.75	6.19
AUS	35	299	-1.43	-3.69	-0.79	-0.85	-3.18	-3.01
AUS	36	249	***	1.73	0.45	1.66	***	***
AUS	36	340	-2.27	-2.23	0.70	-0.52	-1.91	-3.98
AUS	36	654	***	-29.87	-30.70	-30.53	-30.85	-30.18
AUS	36	1035	8.51	3.65	7.13	5.81	***	***
AUS	36	1141	***	***	-3.51	-2.02	-3.16	-1.80
AUS	40	5403	***	18.69	14.79	18.69	***	***
AUS	40	7501	26.34	26.12	***	***	***	***
AUS	40	7502	10.68	10.29	12.85	***	***	***
BEV	35	1065	-0.08	0.09	-0.31	1.06	3.29	-0.03
CAO	35	939	-3.92	-1.16	-0.28	1.08	1.31	1.37
CAO	35	1270	***	***	***	***	***	1.80
CH	16	77	-142.75	-132.02	-127.75	-123.44	-126.83	-124.22
CH	17	206	-2.78	0.75	6.12	-3.58	3.80	11.34
CH	21	179	0.94	5.73	7.60	8.74	11.45	3.95
CH	21	194	-50.14	-46.45	-56.37	-58.26	-59.16	-55.37
CH	21	217	109.47	119.91	107.60	106.61	99.62	102.47
CH	21	243	75.39	118.01	92.85	95.77	58.90	***
CH	21	265	98.34	181.44	154.14	137.27	55.81	***
CH	31	403	-71.03	-70.53	-76.18	-76.31	-64.80	-65.92

TABLE 8A. (CONT.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
AMC	35	173	-13.33	-14.08	-13.29	-14.73	-14.37	-14.44
AMC	35	231	***	***	***	***	***	***
AMC	35	266	-15.76	***	***	***	***	***
AMC	35	268	***	***	***	***	***	-14.67
AMC	35	389	***	-33.41	-31.51	-32.29	-32.49	-32.20
AMC	35	416	-20.15	-21.23	-18.14	-19.78	***	***
AMC	35	703	***	***	***	***	***	-7.97
AMC	35	717	7.33	6.40	***	***	***	***
AMC	35	762	***	-26.15	-26.06	-25.92	-25.69	-27.12
AMC	35	765	-7.06	-7.36	-6.63	-7.50	-6.69	-7.17
AMC	40	713	-14.35	-14.39	-13.75	-14.33	-13.49	-13.77
AMC	40	714	-39.82	-39.90	-39.03	-39.83	-39.12	-39.41
AMC	40	716	***	***	***	***	***	247.93
AOS	23	67	4.28	-8.80	-35.80	-50.30	-43.87	-38.69
APL	35	904	8.03	6.32	6.29	6.53	5.93	6.28
AUS	35	299	-3.54	-2.93	-3.39	-2.71	-3.39	-1.52
AUS	36	249	-0.82	***	***	-1.99	-2.27	-2.38
AUS	36	340	***	-2.45	-3.18	-3.02	-3.89	-2.52
AUS	36	654	-29.83	-29.40	-29.72	-29.29	-29.12	-30.19
AUS	36	1035	6.73	5.09	1.35	2.23	7.51	***
AUS	36	1141	***	***	-1.78	-2.06	-3.12	-3.98
AUS	40	5403	2.50	1.60	3.69	-2.49	-10.17	-14.87
AUS	40	7501	0.20	3.26	4.07	***	5.88	6.41
AUS	40	7502	-17.20	-14.15	-14.02	***	-13.22	-13.92
BEV	35	1065	-0.06	-0.04	-1.59	-1.51	-1.29	-1.02
CAO	35	939	1.70	1.11	***	***	***	***
CAO	35	1270	-0.08	-0.05	***	***	***	***
CH	16	77	-142.88	-143.38	-166.48	-181.50	-170.96	-170.49
CH	17	206	7.33	24.27	10.68	-1.45	-0.08	2.44
CH	21	179	7.35	12.71	11.57	12.52	14.47	12.26
CH	21	194	-55.66	-56.43	-55.94	-57.65	-57.54	-51.43
CH	21	217	105.35	108.50	117.54	111.40	113.98	123.55
CH	21	243	***	***	***	***	***	***
CH	21	265	***	***	***	***	***	***
CH	31	403	-67.32	-66.04	-63.53	-63.49	-62.04	-62.01

TABLE 8A. (CONT.)

LAB.	CLOCK		51209	51234	51264	51294	51329	51359
CH	35	413	14.29	16.47	15.33	13.94	14.39	16.78
CH	35	771	15.08	17.27	16.57	16.41	15.76	11.60
CH	36	354	55.02	54.45	54.92	56.10	55.35	55.64
CNM	35	237	***	***	***	***	***	***
CNM	35	238	-6.58	-6.10	-6.59	-5.56	-7.10	-9.07
CNM	35	378	-23.02	-23.21	-23.54	-23.67	***	***
CNM	35	382	-7.08	-7.42	-6.06	-7.99	-7.69	***
CRL	35	112	18.60	19.31	19.73	19.91	19.32	21.01
CRL	35	144	14.93	15.59	15.30	15.62	15.21	15.53
CRL	35	332	28.73	28.55	28.15	28.62	28.73	28.38
CRL	35	342	12.61	12.32	11.81	11.87	11.09	10.72
CRL	35	343	11.50	11.76	11.83	10.90	10.90	11.27
CRL	35	715	5.75	5.04	5.10	4.10	3.50	3.67
CRL	35	732	-19.11	-18.97	-20.62	-19.36	-21.15	-21.67
CRL	35	907	20.14	20.47	20.45	21.07	20.09	***
CRL	35	908	11.95	12.03	10.90	11.99	11.83	11.91
CSAO	35	1007	-2.23	-3.09	-3.91	-3.40	-4.48	-4.37
CSAO	35	1008	6.50	7.64	6.94	7.70	7.31	6.86
CSAO	35	1011	-5.63	-2.84	-2.18	-4.09	-4.26	-3.01
CSAO	35	1016	-2.29	-2.47	-2.28	-1.04	-1.22	-0.97
CSAO	35	1017	0.31	1.01	1.43	1.53	1.53	0.78
CSAO	35	1018	-8.76	-6.67	***	***	***	***
DLR	40	7424	-15.85	-17.00	-17.23	***	***	-18.75
DTAG	36	136	11.49	10.51	10.28	11.14	11.21	10.73
DTAG	36	345	-2.80	-1.34	-0.17	-1.47	-1.24	-1.95
DTAG	36	465	0.07	-0.50	0.41	0.74	1.41	3.60
F	16	106	-17.13	-15.81	-11.82	-11.21	***	***
F	35	122	-14.05	-13.33	-13.68	-13.02	***	***
F	35	124	***	-2.25	-2.56	-2.15	-2.52	-2.42
F	35	131	6.31	6.86	7.13	6.94	8.88	9.13
F	35	158	11.98	11.17	10.45	10.29	10.60	9.72
F	35	172	1.63	2.46	1.80	1.73	2.34	3.44
F	35	198	4.98	4.17	4.26	4.96	4.64	5.05
F	35	355	3.05	3.97	2.73	3.08	2.48	2.15
F	35	385	7.46	6.32	2.78	3.02	3.90	4.20
F	35	396	5.79	5.55	6.06	5.95	5.54	4.98
F	35	469	-3.09	-3.19	-2.32	-0.95	-1.22	-2.99
F	35	489	8.52	8.58	9.43	10.81	10.31	8.50
F	35	521	-11.09	-10.86	-10.91	-10.63	-11.51	-11.50
F	35	536	-6.53	-6.99	-6.40	-6.85	-6.02	-5.74
F	35	609	19.47	19.95	20.35	19.77	19.43	18.95
F	35	770	13.20	13.30	13.25	13.17	12.74	12.49
F	35	781	-21.87	-22.65	-22.72	-21.70	-22.43	-22.05
F	35	819	17.00	17.76	16.63	18.51	17.49	16.78
F	35	859	***	***	***	17.72	15.73	15.54

TABLE 8A. (CONT.)

LAB.	CLOCK	51389	51419	51449	51479	51509	51539
CH	35 413	***	***	***	***	***	***
CH	35 771	12.91	12.76	13.17	13.98	14.66	14.88
CH	36 354	55.00	55.90	54.63	56.22	56.73	54.06
CNM	35 237	***	1.89	2.72	2.00	1.80	2.46
CNM	35 238	3.41	11.95	***	***	***	***
CNM	35 378	***	***	***	***	***	***
CNM	35 382	-0.62	-0.15	0.37	-0.69	0.82	-0.14
CRL	35 112	19.83	20.31	20.39	20.57	20.38	21.41
CRL	35 144	15.35	15.44	15.32	15.87	15.18	15.49
CRL	35 332	29.00	29.40	30.05	29.85	30.41	***
CRL	35 342	11.40	10.92	9.99	10.58	***	***
CRL	35 343	11.68	11.87	11.51	11.65	11.42	11.47
CRL	35 715	2.10	1.06	1.49	1.20	0.92	1.38
CRL	35 732	-21.35	-21.73	-21.59	-22.60	-22.64	-22.72
CRL	35 907	15.09	15.13	15.39	14.66	14.57	15.39
CRL	35 908	11.80	11.49	11.64	11.15	10.82	9.88
CSAO	35 1007	-4.86	-4.96	-6.51	-7.03	-6.21	-6.96
CSAO	35 1008	8.04	8.57	8.12	8.33	10.21	9.01
CSAO	35 1011	-2.87	-4.00	-4.36	-3.78	-3.42	-3.77
CSAO	35 1016	-0.52	-0.45	-0.45	-1.62	0.14	-1.35
CSAO	35 1017	0.98	2.33	1.52	1.75	2.26	0.84
CSAO	35 1018	***	***	***	***	***	***
DLR	40 7424	***	-28.13	-29.65	-31.13	-31.76	-32.19
DTAG	36 136	11.37	13.05	12.12	11.80	***	***
DTAG	36 345	-0.85	-1.94	-2.14	-3.29	-2.54	-0.34
DTAG	36 465	2.42	-0.80	-1.07	-0.18	-0.62	-1.31
F	16 106	***	***	***	***	***	***
F	35 122	***	***	***	***	***	***
F	35 124	-2.28	-3.38	-3.13	-3.93	-2.62	-3.67
F	35 131	9.24	8.17	8.25	6.37	6.31	6.88
F	35 158	10.13	9.28	***	***	***	***
F	35 172	1.85	2.64	3.18	2.20	3.33	2.63
F	35 198	5.80	6.93	6.89	5.60	7.31	6.72
F	35 355	3.15	3.36	2.52	2.08	2.22	2.38
F	35 385	4.38	4.77	4.93	5.41	5.76	6.34
F	35 396	5.88	6.54	5.64	5.85	5.73	5.23
F	35 469	-2.21	-2.28	-3.01	-3.03	-1.52	-1.12
F	35 489	9.32	8.92	9.35	8.23	8.48	9.28
F	35 521	-10.67	-11.94	-12.72	-11.15	-11.77	-11.34
F	35 536	-7.08	-6.03	-5.86	-6.95	-5.92	-5.84
F	35 609	18.15	18.27	19.07	18.71	19.64	19.68
F	35 770	13.42	12.38	13.16	13.12	12.76	12.13
F	35 781	-22.17	-19.97	-21.78	-21.38	-20.27	-18.94
F	35 819	***	***	15.99	16.17	17.18	16.15
F	35 859	14.10	13.10	13.07	12.97	13.26	12.18

TABLE 8A. (CONT.)

LAB.	CLOCK	51209	51234	51264	51294	51329	51359
F	35 1177	***	***	***	***	-10.77	-9.97
F	35 1178	***	***	***	***	-2.02	-2.37
F	35 1321	***	***	***	***	***	***
F	40 816	0.77	0.33	-0.93	-1.66	-2.37	-2.51
GUM	14 1144	-20.73	-7.66	-20.88	-45.34	-32.16	-27.95
GUM	31 652	-5.26	2.73	2.18	1.78	-1.06	2.60
GUM	35 441	-0.91	0.39	-0.50	-0.54	-0.19	-0.90
GUM	35 502	-2.20	-1.16	-1.45	-2.63	-1.60	-3.12
GUM	35 761	***	***	***	***	***	***
GUM	35 1120	***	***	***	***	***	***
IEN	35 219	24.51	25.77	24.95	24.77	24.63	24.25
IEN	35 505	1.59	1.40	1.26	1.53	0.92	0.39
IEN	35 1115	-7.68	-8.50	-8.52	-8.70	-9.22	-8.30
IEN	35 1373	***	***	***	***	***	***
IFAG	16 131	41.51	***	***	***	***	***
IFAG	16 173	194.86	201.60	177.22	***	***	***
IFAG	36 1034	-8.81	-12.26	-11.13	-9.87	-8.60	-10.57
IFAG	36 1173	-4.29	-1.26	-4.06	-2.57	-4.93	-3.60
IFAG	36 1176	-13.79	-13.06	-15.07	-14.37	-12.45	-10.18
IFAG	40 4401	***	***	-5.27	17.71	42.58	***
IFAG	40 4403	***	***	11.72	-23.17	8.85	38.69
IFAG	40 4413	***	***	-9.05	-22.11	1.55	113.00
IGMA	14 2403	-12.42	-7.64	-9.03	1.25	-1.46	-7.80
IGMA	16 112	48.93	49.57	44.55	39.75	37.40	45.59
IGMA	35 631	16.71	17.18	15.75	16.73	16.59	17.67
IGMA	35 645	14.59	14.58	14.05	14.33	13.51	13.58
INPL	35 1021	***	***	-1.48	-4.02	-2.73	-3.98
IPQ	35 125	***	***	***	***	***	-6.62
IPQ	35 615	***	***	***	***	***	10.03
IPQ	35 1030	***	***	***	***	***	7.98
KRIS	36 321	5.22	5.37	5.61	5.14	4.86	4.78
KRIS	36 739	-13.22	-11.99	-13.21	-12.72	-12.07	-12.87
KRIS	36 1135	8.70	8.53	8.20	11.83	10.81	8.28
KRIS	40 5623	23.16	23.24	22.85	23.55	24.96	27.60
LDS	35 289	2.48	2.45	1.51	1.69	3.38	3.42
MSL	12 933	20.74	12.77	8.89	7.23	9.65	20.58
MSL	35 1025	-10.15	-9.74	-9.09	-10.32	-9.69	-9.64
MSL	36 274	9.63	7.95	7.76	4.03	4.61	6.28
NAO	14 1315	***	***	-148.85	-132.12	-139.69	-138.30
NAO	35 779	19.28	17.25	17.96	17.78	18.80	17.60
NAO	35 1206	***	***	***	10.55	8.65	8.70
NAO	35 1214	3.26	2.91	3.50	4.90	5.06	5.30
NIM	12 614	45.65	36.17	39.93	***	***	***
NIM	35 479	10.87	10.20	9.13	***	***	***
NIM	35 1238	***	***	***	***	***	***

TABLE 8A. (CONT.)

LAB.	CLOCK	51389	51419	51449	51479	51509	51539
F	35 1177	-10.81	-10.28	-11.85	-12.98	-11.81	-11.78
F	35 1178	-1.45	-0.20	-1.09	-0.11	0.91	1.12
F	35 1321	8.79	8.14	7.39	6.57	8.13	7.70
F	40 816	-3.14	***	***	-2.48	-2.09	-2.09
GUM	14 1144	-31.11	-52.80	-142.85	***	***	***
GUM	31 652	-3.55	-3.23	-1.01	-0.14	-12.94	-10.54
GUM	35 441	-2.09	-2.28	0.00	-0.58	0.58	-0.37
GUM	35 502	-3.77	-4.45	-3.14	-4.09	-6.35	-6.24
GUM	35 761	***	0.86	1.90	-1.89	-0.13	1.69
GUM	35 1120	-4.48	-8.17	-5.40	-8.58	-12.83	-13.07
IEN	35 219	24.59	25.44	25.93	24.75	25.64	25.10
IEN	35 505	0.79	0.49	0.39	0.27	0.83	1.06
IEN	35 1115	-8.47	-7.44	-8.07	-3.68	-5.66	-7.49
IEN	35 1373	***	***	***	***	8.67	7.18
IFAG	16 131	***	***	***	***	***	***
IFAG	16 173	***	***	***	***	***	***
IFAG	36 1034	-11.21	-12.18	-13.68	-8.68	-12.22	-11.88
IFAG	36 1173	-7.22	0.66	0.40	-3.08	-4.15	-1.01
IFAG	36 1176	-11.30	-12.65	-13.61	-10.40	-8.69	***
IFAG	40 4401	-322.36	-219.35	-64.11	-71.29	-73.54	-99.06
IFAG	40 4403	28.53	56.55	53.29	26.66	73.24	70.57
IFAG	40 4413	2.35	20.13	68.77	-92.54	-151.94	-46.61
IGMA	14 2403	-16.17	-28.43	-21.74	-23.52	-30.99	-18.41
IGMA	16 112	42.48	47.30	48.13	45.67	43.86	50.89
IGMA	35 631	16.15	15.14	15.99	15.33	15.93	17.06
IGMA	35 645	13.18	12.27	12.55	12.80	12.14	13.38
INPL	35 1021	-0.47	0.02	-0.23	-0.63	-0.27	-13.81
IPQ	35 125	-5.89	-5.38	-4.92	-5.26	***	***
IPQ	35 615	10.87	10.17	10.20	10.25	10.28	9.93
IPQ	35 1030	8.80	8.17	8.30	8.06	9.15	8.97
KRIS	36 321	4.60	5.02	3.19	4.41	5.36	6.53
KRIS	36 739	-12.87	-12.23	-11.15	-12.53	-12.10	-11.69
KRIS	36 1135	11.47	12.07	13.60	10.15	7.78	8.76
KRIS	40 5623	29.33	26.89	26.66	26.59	26.70	27.47
LDS	35 289	2.65	2.44	2.27	2.52	1.92	0.39
MSL	12 933	20.34	20.76	6.64	19.39	23.16	***
MSL	35 1025	-10.70	-10.45	-10.89	-7.65	-10.61	***
MSL	36 274	7.93	7.79	8.82	12.45	10.95	***
NAO	14 1315	-125.30	-86.32	-62.84	-63.70	-61.47	-75.39
NAO	35 779	16.50	18.31	17.35	17.30	17.63	15.30
NAO	35 1206	8.28	9.32	8.02	7.67	9.11	6.64
NAO	35 1214	6.03	8.08	7.43	6.74	6.42	5.04
NIM	12 614	***	***	***	***	***	***
NIM	35 479	***	***	10.14	12.91	12.42	13.01
NIM	35 1238	***	***	4.83	6.59	4.38	4.01

TABLE 8A. (CONT.)

LAB.	CLOCK		51209	51234	51264	51294	51329	51359
NIM	35	1239	9.64	10.76	10.23	***	***	***
NIST	35	132	-9.35	***	***	***	***	***
NIST	35	182	-6.99	-6.61	-7.26	-7.48	-7.05	-7.92
NIST	35	408	-10.93	-10.47	-10.60	-10.29	-10.45	-10.26
NIST	35	1074	-9.90	-9.18	-10.25	-9.44	-10.60	-10.52
NIST	40	201	19.81	20.07	20.26	20.49	20.70	21.00
NIST	40	203	5.58	5.55	5.45	5.53	5.55	5.70
NIST	40	204	-3.48	-3.10	-2.90	-2.60	-2.52	-2.22
NIST	40	205	***	***	-10.11	-10.55	-11.13	-11.62
NIST	40	222	-738.97	-738.97	-739.11	-739.25	-739.42	-739.45
NIST	50	2008	-74.95	-77.06	-75.76	-77.06	-81.32	-83.16
NPL	35	123	4.39	5.02	4.59	4.07	4.28	3.53
NPL	35	784	6.16	5.86	5.55	5.35	6.13	6.92
NPL	35	1275	3.61	4.44	4.12	3.73	3.67	7.57
NPL	36	404	-2.97	-3.90	-0.25	-4.38	-3.31	-5.51
NPL	40	1701	-1.45	-1.47	-1.32	-1.11	-1.17	-1.19
NPL	40	1708	-1.35	-1.40	-1.55	-1.50	-1.66	-1.62
NRC	35	234	***	4.80	4.74	5.16	4.49	***
NRC	35	372	9.90	10.31	9.53	9.74	7.27	9.19
NRC	40	303	***	***	***	***	***	***
NRC	40	304	***	***	7.78	8.00	7.58	7.71
NRC	90	61	***	-3.34	-2.26	-0.37	0.19	-0.62
NRC	90	63	-1.14	-1.97	-1.83	***	***	***
NRLM	35	224	9.81	8.94	7.65	9.13	9.67	8.55
NRLM	35	459	2.68	2.52	2.55	3.24	3.28	3.05
NRLM	35	523	2.27	1.97	0.83	2.05	1.62	1.22
OMH	36	849	5.99	4.63	1.64	3.81	3.37	2.84
ONRJ	35	903	2.48	2.80	2.60	2.73	2.95	2.08
ORB	35	201	-0.45	0.33	0.45	-2.02	-0.38	-0.44
ORB	35	202	5.91	4.65	6.03	6.53	7.27	7.74
ORB	35	593	29.80	30.77	29.59	30.20	30.08	29.77
ORB	40	2601	-200.42	-205.68	-211.12	-210.45	-208.79	-208.02
PSB	35	267	18.23	17.15	***	17.01	15.84	16.80
PSB	35	277	6.26	7.16	***	3.85	3.54	3.37
PTB	35	128	14.73	14.62	14.53	15.39	13.90	14.96
PTB	35	271	9.45	8.08	8.37	8.82	8.53	8.50
PTB	35	415	1.20	1.08	0.93	1.74	1.21	2.02
PTB	35	1072	6.13	6.67	6.36	7.08	7.02	***
PTB	40	502	***	***	7.95	-7.29	-18.33	***
PTB	40	505	-2.43	-3.97	-4.00	-3.53	-3.08	-2.42
PTB	40	537	13.16	12.09	14.98	12.45	9.95	7.07
PTB	92	1	2.76	1.25	1.35	1.54	1.68	1.81
PTB	92	2	1.55	0.93	1.32	1.07	1.54	1.03
PTB	92	3	-1.81	-1.36	-1.78	-0.07	-0.77	0.36
ROA	14	896	38.30	40.01	40.08	43.85	45.24	48.44

TABLE 8A. (CONT.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
NIM	35	1239	***	***	10.18	10.75	10.59	11.76
NIST	35	132	***	***	***	***	***	***
NIST	35	182	-7.40	-9.36	***	***	***	***
NIST	35	408	-10.69	-10.51	-9.47	-9.86	-9.82	-9.17
NIST	35	1074	-9.44	-10.00	-9.84	-9.80	-9.32	-9.29
NIST	40	201	21.46	21.75	22.17	22.23	22.83	23.23
NIST	40	203	6.05	6.10	6.37	6.37	6.73	7.12
NIST	40	204	-1.84	-1.65	-1.27	-1.08	-0.41	-0.27
NIST	40	205	-11.94	-12.42	-12.83	-13.60	-13.89	-14.30
NIST	40	222	-739.32	-739.32	-739.19	-739.43	-739.23	-739.15
NIST	50	2008	-85.30	-87.87	-90.93	-88.63	-94.15	-93.66
NPL	35	123	***	***	***	***	***	***
NPL	35	784	6.22	6.82	6.47	4.82	4.86	4.65
NPL	35	1275	7.65	4.29	7.00	6.98	4.33	1.85
NPL	36	404	-4.94	-5.17	-4.58	-2.75	-1.19	***
NPL	40	1701	-1.22	-1.35	-1.09	-0.88	-0.59	-0.28
NPL	40	1708	-1.40	-1.36	-1.12	-1.29	-0.95	-1.04
NRC	35	234	***	***	***	***	***	28.38
NRC	35	372	***	***	7.86	8.47	8.80	7.15
NRC	40	303	***	***	2.90	3.15	4.69	5.20
NRC	40	304	***	***	9.00	9.20	8.47	9.64
NRC	90	61	***	***	-0.37	-0.22	-1.20	0.64
NRC	90	63	***	***	***	***	***	***
NRLM	35	224	9.01	9.92	8.07	7.15	7.65	7.19
NRLM	35	459	3.15	3.90	3.64	2.81	4.08	5.08
NRLM	35	523	1.18	1.44	1.97	0.17	1.78	1.48
OMH	36	849	4.49	3.98	4.39	3.08	1.52	***
ONRJ	35	903	1.25	***	***	1.88	1.48	***
ORB	35	201	-2.35	***	***	0.48	3.36	3.20
ORB	35	202	5.54	***	***	7.91	9.32	5.96
ORB	35	593	29.99	***	***	30.05	32.35	***
ORB	40	2601	-206.85	***	***	-206.32	-206.35	-206.80
PSB	35	267	16.46	***	***	15.83	15.86	15.93
PSB	35	277	2.10	***	***	4.38	4.44	2.11
PTB	35	128	13.33	15.27	13.49	12.44	***	***
PTB	35	271	8.19	7.37	8.08	8.25	8.48	7.63
PTB	35	415	0.93	1.82	1.26	2.00	2.68	1.94
PTB	35	1072	***	***	***	***	***	***
PTB	40	502	***	***	-54.86	-23.71	***	***
PTB	40	505	-0.90	0.15	0.21	0.17	0.76	1.47
PTB	40	537	0.45	-1.00	-6.34	-13.30	-20.87	-33.24
PTB	92	1	1.28	1.37	2.29	1.47	1.37	1.57
PTB	92	2	1.14	0.80	1.19	0.63	0.75	1.07
PTB	92	3	-0.07	-0.28	-0.36	-0.76	-1.44	***
ROA	14	896	50.61	53.77	56.83	61.32	60.91	61.20

TABLE 8A. (CONT.)

LAB.	CLOCK	51209	51234	51264	51294	51329	51359
ROA	14 1569	-0.48	-2.93	5.74	8.00	13.38	27.68
ROA	31 422	6.92	8.04	7.11	5.24	4.37	8.03
ROA	35 583	1.95	1.11	1.03	0.33	0.50	1.34
ROA	35 718	7.58	8.17	7.19	6.97	6.29	8.45
SCL	14 2127	86.12	85.52	79.66	81.61	75.37	82.39
SCL	35 764	-7.10	-7.31	-6.45	-7.11	-7.72	-8.09
SMU	36 1063	-2.59	-2.61	-2.06	-3.36	-3.31	-2.73
SO	40 5102	-17.47	-16.65	-15.15	-17.53	-17.16	-14.49
SP	16 137	89.68	98.68	93.57	92.80	92.53	87.02
SP	35 641	-16.19	-15.74	-16.05	-15.69	-16.17	-14.87
SP	35 1188	18.06	18.25	18.20	18.73	18.41	18.24
SU	40 3802	***	9.50	9.37	9.73	9.32	9.81
SU	40 3805	***	***	***	16.26	16.20	15.98
SU	40 3806	***	5.52	5.40	5.98	5.03	4.97
SU	40 3808	***	-17.33	-17.97	-17.43	-17.90	-18.18
SU	40 3809	***	0.75	-0.27	0.53	0.04	0.18
SU	40 3811	***	***	***	***	***	***
SU	40 3812	***	-27.25	-27.50	-27.02	-26.89	-28.35
TL	34 438	274.77	291.13	302.83	273.32	290.05	324.73
TL	35 160	***	***	***	***	2.42	3.38
TL	35 300	11.98	14.89	14.43	14.43	15.27	14.78
TL	35 474	-2.89	-0.25	-0.19	-1.57	-2.00	-1.56
TL	35 809	-10.64	-8.84	-7.79	-8.55	-8.21	-7.52
TL	35 1012	-18.58	-17.83	-19.64	-18.87	-17.77	-18.46
TL	40 3052	***	***	***	***	***	***
TL	40 3053	***	***	***	***	***	***
TP	35 1227	-1.55	-2.14	-1.72	-1.45	-1.87	0.03
TP	36 154	13.98	13.20	12.97	15.20	13.14	11.88
TP	36 163	-0.57	-4.61	-3.24	-4.85	-5.00	-1.92
TP	36 326	-5.55	-6.18	-7.26	-7.10	-5.81	-6.68
TUG	14 1654	24.88	23.62	26.98	30.23	26.31	26.86
TUG	35 247	-0.67	-1.65	-1.21	-2.17	-1.94	-3.04
UME	35 251	16.92	18.57	16.60	18.76	17.34	18.20
UME	35 252	1.24	0.91	-0.07	0.26	0.42	0.81
UME	35 872	***	***	***	***	***	***
USNO	35 101	15.33	15.60	15.89	15.08	14.87	14.56
USNO	35 104	17.50	***	***	17.23	16.51	16.74
USNO	35 106	-14.05	-14.30	-14.35	-14.35	-13.63	-14.20
USNO	35 108	4.86	2.26	4.91	***	2.91	3.66
USNO	35 114	11.93	***	***	26.37	26.74	26.60
USNO	35 120	3.93	4.21	3.21	2.56	3.34	2.50
USNO	35 142	10.31	9.89	***	***	9.84	9.98
USNO	35 146	5.11	3.12	4.15	3.88	4.14	3.53
USNO	35 148	-4.14	-4.05	***	***	-4.17	-4.34
USNO	35 150	22.00	20.48	20.73	21.02	***	***

Table 8A. (Cont.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
ROA	14	1569	37.46	43.05	41.84	44.85	31.92	21.13
ROA	31	422	15.30	15.62	10.65	11.00	5.71	3.03
ROA	35	583	2.39	1.29	0.53	0.20	0.19	1.26
ROA	35	718	8.05	7.42	7.97	8.25	7.88	8.42
SCL	14	2127	85.33	120.22	115.59	115.07	***	***
SCL	35	764	-7.97	-8.04	-8.96	-9.30	-8.47	-8.72
SMU	36	1063	-3.12	***	***	***	***	***
SO	40	5102	-14.29	-14.23	***	***	***	***
SP	16	137	73.87	78.55	76.57	105.30	94.61	100.01
SP	35	641	-16.70	-15.54	-15.86	-16.02	-17.03	-16.48
SP	35	1188	19.11	19.40	18.89	19.75	19.83	20.83
SU	40	3802	9.53	10.21	10.67	***	***	***
SU	40	3805	15.71	15.94	16.07	***	***	***
SU	40	3806	5.38	5.45	6.24	***	***	***
SU	40	3808	-18.95	-18.48	-18.13	***	***	***
SU	40	3809	-0.16	-0.27	0.52	***	***	***
SU	40	3811	***	-19.42	-18.08	***	***	***
SU	40	3812	-29.26	-29.70	-29.62	***	***	***
TL	34	438	339.28	344.01	356.62	336.60	354.17	384.01
TL	35	160	2.08	2.33	3.35	7.37	2.72	2.10
TL	35	300	15.00	14.43	16.40	15.31	14.18	15.14
TL	35	474	-1.77	-1.82	-1.46	2.21	-1.69	-1.18
TL	35	809	-7.77	-7.40	-7.64	-3.16	-7.94	-7.59
TL	35	1012	-18.14	-17.70	-17.58	-13.65	-16.29	-16.03
TL	40	3052	***	3.50	4.64	8.61	6.43	7.54
TL	40	3053	***	8.19	***	***	11.86	12.31
TP	35	1227	0.09	0.27	0.00	0.95	0.31	1.16
TP	36	154	12.87	11.88	12.74	13.23	13.99	12.71
TP	36	163	-2.46	-3.15	-5.24	-5.58	-4.32	-6.24
TP	36	326	-5.49	-5.33	-7.60	-6.57	-4.94	-5.91
TUG	14	1654	25.08	27.12	28.27	36.52	41.44	35.03
TUG	35	247	-2.32	-3.10	-2.82	-3.33	-3.84	-3.06
UME	35	251	23.04	***	***	***	***	***
UME	35	252	0.18	***	***	-0.43	-0.72	-0.88
UME	35	872	***	***	***	-2.69	-6.68	-4.16
USNO	35	101	13.73	13.72	13.40	14.77	13.61	14.20
USNO	35	104	18.59	18.85	18.51	18.27	18.10	18.16
USNO	35	106	-13.40	-13.60	-13.68	-14.04	-12.32	-13.07
USNO	35	108	3.08	3.05	4.18	3.12	3.63	3.73
USNO	35	114	26.97	26.55	26.49	26.32	25.98	26.24
USNO	35	120	3.25	3.03	2.57	3.25	3.88	***
USNO	35	142	9.18	9.39	9.52	8.60	***	***
USNO	35	146	4.24	3.00	***	***	***	***
USNO	35	148	-3.72	***	***	-3.91	-2.56	-2.67
USNO	35	150	***	***	***	***	***	20.98

TABLE 8A. (CONT.)

LAB.	CLOCK	51209	51234	51264	51294	51329	51359
USNO	35 152	***	16.42	14.85	15.08	15.66	15.41
USNO	35 153	14.01	13.30	16.15	16.26	15.71	16.78
USNO	35 156	13.78	13.60	13.08	13.98	13.09	14.38
USNO	35 161	-14.29	-14.10	-15.68	-16.05	-15.68	-16.31
USNO	35 164	3.62	2.95	2.93	2.58	1.88	1.26
USNO	35 165	6.77	6.77	6.37	6.07	6.30	5.99
USNO	35 166	9.85	***	***	-1.54	-2.16	-1.88
USNO	35 167	6.30	6.13	6.60	5.74	5.87	6.25
USNO	35 169	14.27	14.53	14.42	15.35	14.98	14.18
USNO	35 171	21.43	21.00	20.78	21.12	22.34	***
USNO	35 213	***	14.75	15.63	14.80	14.54	***
USNO	35 217	-7.54	-7.97	-7.83	***	***	***
USNO	35 225	10.32	10.39	10.73	10.27	10.11	9.66
USNO	35 226	2.45	1.94	3.27	2.83	1.88	1.81
USNO	35 227	13.29	14.58	14.61	14.41	14.54	13.89
USNO	35 229	25.12	24.64	25.05	24.63	***	***
USNO	35 233	4.57	5.40	4.89	4.23	4.70	4.00
USNO	35 242	17.66	***	***	***	***	***
USNO	35 244	14.49	14.84	14.79	15.18	14.62	14.28
USNO	35 249	-2.46	-1.88	-1.21	-2.24	-2.04	-2.50
USNO	35 253	-7.06	-7.69	-7.77	-6.80	-8.52	***
USNO	35 254	-0.85	-0.33	-0.25	-0.72	-0.87	-1.10
USNO	35 255	-11.61	-11.35	-12.41	-12.12	-11.85	-12.07
USNO	35 256	-13.77	-13.42	-12.43	-13.00	-12.41	-12.89
USNO	35 260	8.76	7.74	8.06	***	***	***
USNO	35 270	10.57	11.26	10.00	10.75	10.74	10.59
USNO	35 279	-8.55	-8.94	-8.35	-8.50	-8.44	-9.08
USNO	35 392	10.28	11.11	12.36	12.73	13.45	***
USNO	35 394	15.04	14.92	15.34	15.40	15.00	14.75
USNO	35 417	***	18.32	18.18	18.46	18.21	17.77
USNO	35 1096	25.06	23.81	23.22	23.10	21.02	21.11
USNO	35 1097	8.23	8.19	7.35	6.53	6.57	6.60
USNO	35 1125	24.25	23.93	24.12	23.85	24.44	23.85
USNO	40 701	-27.35	-27.42	-27.42	-27.53	-27.44	-27.52
USNO	40 702	***	***	-6.72	-6.92	-7.12	***
USNO	40 703	-2.27	-2.27	-2.30	-2.20	-2.21	-2.05
USNO	40 704	-53.37	-53.77	-53.83	-53.90	-53.79	-53.49
USNO	40 705	-30.50	-31.74	-31.89	-32.10	-32.20	-32.11
USNO	40 708	1.98	1.94	2.03	2.12	2.18	2.62
USNO	40 709	-42.98	-42.34	-41.99	-41.39	-40.75	-40.15
USNO	40 710	17.72	18.08	18.29	18.52	18.96	19.25
USNO	40 711	58.96	60.31	61.53	62.92	64.38	65.97
USNO	40 712	-8.61	-8.74	-8.87	-8.97	-9.03	-9.05
USNO	40 715	-20.44	-20.47	-20.47	-20.52	-20.51	-20.42
USNO	40 718	141.36	140.23	139.05	139.05	136.84	135.75

TABLE 8A. (CONT.)

LAB.	CLOCK	51389	51419	51449	51479	51509	51539
USNO	35 152	16.07	17.05	16.25	16.50	16.62	16.38
USNO	35 153	16.88	12.82	11.97	12.62	12.53	12.19
USNO	35 156	13.65	13.97	13.57	13.41	13.85	14.23
USNO	35 161	-16.38	-16.01	-15.96	-16.65	-16.12	-16.77
USNO	35 164	1.38	1.02	0.55	0.65	0.63	0.40
USNO	35 165	6.86	6.29	6.56	6.33	6.33	6.18
USNO	35 166	-1.68	-2.26	-2.48	-1.86	-1.98	-1.84
USNO	35 167	5.55	5.85	6.07	5.00	5.42	4.51
USNO	35 169	14.54	14.90	15.09	15.02	14.11	15.01
USNO	35 171	***	***	***	***	***	***
USNO	35 213	***	***	15.17	15.01	14.78	14.46
USNO	35 217	***	1.60	1.03	0.50	0.98	0.40
USNO	35 225	10.63	9.53	***	***	***	***
USNO	35 226	2.99	3.51	2.39	2.52	2.12	2.43
USNO	35 227	13.68	14.00	***	***	14.63	14.50
USNO	35 229	***	***	***	***	***	2.08
USNO	35 233	***	***	***	***	***	***
USNO	35 242	***	***	***	***	***	13.00
USNO	35 244	15.05	14.86	14.82	14.17	14.14	14.33
USNO	35 249	-4.79	***	***	-5.97	-5.22	-5.64
USNO	35 253	***	-7.16	***	***	***	***
USNO	35 254	-0.41	-0.66	-1.03	-1.33	0.30	-0.52
USNO	35 255	-11.81	-11.89	***	***	***	-12.48
USNO	35 256	-13.00	-12.65	-13.04	-14.23	-14.52	-13.73
USNO	35 260	***	11.98	11.49	11.07	12.01	11.08
USNO	35 270	11.41	10.64	10.89	9.42	10.16	10.28
USNO	35 279	-7.28	-8.04	-8.83	-8.23	-7.88	-7.77
USNO	35 392	***	***	***	***	6.48	5.98
USNO	35 394	15.13	15.75	15.34	15.57	14.84	13.56
USNO	35 417	15.40	15.23	15.87	15.83	15.43	15.87
USNO	35 1096	19.33	18.77	19.13	18.16	17.28	17.41
USNO	35 1097	7.54	7.05	7.64	7.32	6.70	7.23
USNO	35 1125	23.89	23.29	***	***	-4.06	-3.21
USNO	40 701	-27.49	-27.50	-27.41	-27.78	-27.56	-27.59
USNO	40 702	***	-1.88	-8.14	-8.39	-8.34	-8.37
USNO	40 703	-2.07	-1.94	-1.68	-1.88	-1.78	-1.64
USNO	40 704	-52.85	-51.98	-46.94	-47.07	-46.74	-46.62
USNO	40 705	-32.07	-32.10	-32.04	-29.20	-32.34	-32.47
USNO	40 708	2.95	3.22	3.47	3.37	3.90	4.21
USNO	40 709	-39.51	-38.90	-38.44	-38.18	-37.50	-37.04
USNO	40 710	19.33	19.82	20.42	20.65	21.33	21.76
USNO	40 711	67.35	68.78	70.34	71.56	73.16	74.77
USNO	40 712	-9.00	-8.96	-8.92	-9.18	-8.90	-8.77
USNO	40 715	-20.34	-20.24	-20.08	-20.34	-20.02	-19.95
USNO	40 718	134.69	***	***	***	***	***

TABLE 8A. (CONT.)

LAB.	CLOCK		51209	51234	51264	51294	51329	51359
USNO	40	722	-93.78	-96.49	-99.07	-101.74	-104.71	-107.17
VSL	35	179	16.72	16.52	15.35	15.76	17.39	2.57
VSL	35	456	26.15	26.27	26.76	22.85	26.63	26.08
VSL	35	548	3.06	2.38	2.64	3.65	5.86	4.70
VSL	35	731	15.03	14.81	14.93	14.16	16.85	18.03

TABLE 8A. (CONT.)

LAB.	CLOCK	51389	51419	51449	51479	51509	51539
USNO	40 722	-107.72	***	***	-117.28	-119.40	***
VSL	35 179	13.24	***	***	***	***	14.32
VSL	35 456	24.01	25.55	27.19	26.02	24.21	24.10
VSL	35 548	4.91	5.52	5.81	4.62	4.18	4.61
VSL	35 731	16.72	17.50	18.12	17.56	18.00	17.83

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.

	1999	1998		1997		1996	
	clock nø	clock nø	corr. (ns/d)	clock nø	corr. (ns/d)	clock nø	corr. (ns/d)
BEV	35 1065	35 1065	-31.71				
CH	17 206	17 206		17 206		17 206(1)	
CNM	35 238	35 238	-11.49	35 238	-11.49	35 238(2)	-11.49
	35 382	35 382	+19.28	35 382	+19.28		
DTAG	36 345	36 345		36 345	-2.76	36 345	-2.76
GUM	35 441	35 441	-2.68	35 441	+2.85	35 441(3)	+2.85
	35 502	35 502	-6.57	35 502	-6.57		
IEN	35 505	35 505	+2.21	35 505	+4.94	35 505(4)	+4.94
NPL	35 123	35 123		35 123		35 123(5)	
	36 404	36 404		36 404	-1.60	36 404(6)	-1.60
	40 1701	40 1701	-1.60	40 1701	-4.40	40 1701(7)	-5.60
NRLM	35 523	35 523		35 523		35 523(8)	
PTB	40 505	40 505	-4.32	40 0505	-17.28		
ROA	14 896	14 896		14 896		14 896(9)	
	14 1569	14 1569		14 1569		14 1569(10)	
	35 583	35 583	+0.55	35 583	-0.55	35 583(11)	+2.15
TUG	35 247	35 247		35 247	+12.58		

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

(2) A correction -11.49 ns/d has to be applied for the last two-month interval of 1996.

(3) A correction of +2.85 ns/d has to be applied in 1995.

(4) A correction of +1.11 ns/d has to be applied in 1995.

(5) A correction of -3.30 ns/d has to be applied in 1995, 1994 and 1993.

(6) A correction of -15.30 ns/d has to be applied in 1995 and in 1994 when the clock is named 35 404.

(7) A correction of -1.95 ns/d has to be applied in 1995, 1994, 1993 and 1992, and a correction of +25.05 ns/d has to be applied in 1991.

(8) A correcton of +2.76 ns/d has to be applied in 1995.

(9) A correction of - 31.00 ns/d has to be applied in 1994.

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

(11) A correction of +2.15 ns/d has to be applied in 1995.

TABLE. 9A. RELATIVE WEIGHTS (IN PERCENT) OF CONTRIBUTING CLOCKS IN 1999

(File available on http://www.bipm.fr under the name WTAI99.AR)

Clock weights are computed for one-month intervals ending at the dates given in the table. Since 1998 January 1, the maximum relative weight of a given clock cannot exceed 0.7 % .

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

LAB.	CLOCK	51209	51234	51264	51294	51329	51359
AMC	35 173	0.700	0.700	0.700	0.686	0.465	0.432
AMC	35 231	0.700	0.700	0.700	*****	*****	*****
AMC	35 266	0.700	0.700	0.700	0.700	0.700	0.700
AMC	35 268	0.569	0.459	0.410	0.468	0.419	*****
AMC	35 389	0.700	0.700	0.700	*****	*****	*****
AMC	35 416	0.700	0.700	0.700	0.700	0.700	0.700
AMC	35 703	*****	*****	*****	*****	*****	*****
AMC	35 717	0.700	0.700	0.700	0.700	0.700	0.700
AMC	35 762	0.700	0.700	0.700	0.610	0.392	*****
AMC	35 765	0.700	0.700	0.700	0.700	0.700	0.700
AMC	40 713	0.700	0.700	0.700	0.700	0.700	0.700
AMC	40 714	0.700	0.700	0.700	0.700	0.700	0.700
AMC	40 716	*****	*****	*****	*****	*****	*****
AOS	23 67	0.002	0.001	0.001	0.001	0.001	0.001
APL	35 904	0.000	0.000	0.000	*****	0.000	0.000
AUS	35 299	0.000	0.000	0.000	0.000	0.230	0.308
AUS	36 249	*****	0.000	0.000	0.000	*****	*****
AUS	36 340	0.000	0.000	0.000	0.000	0.245	0.196
AUS	36 654	*****	0.000	0.000	0.000	0.000	0.700
AUS	36 1035	0.000	0.000	0.000	0.000	*****	*****
AUS	36 1141	*****	*****	0.000	0.000	0.000	0.000
AUS	40 5403	*****	0.000	0.000	0.000	*****	*****
AUS	40 7501	0.000	0.000	*****	*****	*****	*****
AUS	40 7502	0.000	0.000	0.000	*****	*****	*****
BEV	35 1065	0.054	0.058	0.068	0.095	0.094	0.111
CAO	35 939	0.700	0.000	0.331	0.224	0.152	0.125
CAO	35 1270	*****	*****	*****	*****	*****	0.000
CH	16 77	0.018	0.010	0.006	0.006	0.005	0.006
CH	17 206	0.110	0.095	0.071	0.075	0.069	0.041
CH	21 179	0.084	0.046	0.031	0.032	0.027	0.029
CH	21 194	0.051	0.026	0.024	0.031	0.032	0.040
CH	21 217	0.016	0.009	0.008	0.010	0.010	0.012
CH	21 243	0.003	0.000	0.001	0.001	0.001	*****
CH	21 265	0.001	0.000	0.000	0.000	0.000	*****
CH	31 403	0.700	0.700	0.000	0.210	0.000	0.093

TABLE 9A. (CONT.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
AMC	35	173	0.482	0.554	0.660	0.700	0.700	0.700
AMC	35	231	*****	*****	*****	*****	*****	*****
AMC	35	266	0.700	*****	*****	*****	*****	*****
AMC	35	268	*****	*****	*****	*****	*****	0.000
AMC	35	389	*****	0.000	0.000	0.000	0.000	0.700
AMC	35	416	0.700	0.700	0.700	0.700	*****	*****
AMC	35	703	*****	*****	*****	*****	*****	0.000
AMC	35	717	0.700	0.700	*****	*****	*****	*****
AMC	35	762	*****	0.000	0.000	0.000	0.000	0.700
AMC	35	765	0.700	0.700	0.700	0.700	0.700	0.700
AMC	40	713	0.700	0.700	0.700	0.700	0.700	0.700
AMC	40	714	0.700	0.700	0.700	0.700	0.700	0.700
AMC	40	716	*****	*****	*****	*****	*****	0.000
AOS	23	67	0.001	0.001	0.001	0.003	0.004	0.004
APL	35	904	0.000	0.000	0.608	0.700	0.700	0.700
AUS	35	299	0.475	0.700	0.700	0.700	0.700	0.700
AUS	36	249	0.000	*****	*****	0.000	0.000	0.000
AUS	36	340	*****	0.000	0.000	0.000	0.000	0.700
AUS	36	654	0.700	0.700	0.700	0.700	0.700	0.700
AUS	36	1035	0.000	0.000	0.000	0.000	0.195	*****
AUS	36	1141	*****	*****	0.000	0.000	0.000	0.000
AUS	40	5403	0.000	0.000	0.000	0.000	0.045	0.033
AUS	40	7501	0.000	0.000	0.000	*****	0.000	0.000
AUS	40	7502	0.000	0.000	0.000	*****	0.000	0.000
BEV	35	1065	0.154	0.214	0.374	0.500	0.700	0.700
CAO	35	939	0.142	0.198	*****	*****	*****	*****
CAO	35	1270	0.000	0.000	*****	*****	*****	*****
CH	16	77	0.011	0.018	0.000	0.000	0.009	0.009
CH	17	206	0.050	0.000	0.027	0.038	0.048	0.062
CH	21	179	0.050	0.062	0.093	0.137	0.183	0.224
CH	21	194	0.056	0.078	0.104	0.183	0.245	0.273
CH	21	217	0.023	0.035	0.041	0.072	0.094	0.075
CH	21	243	*****	*****	*****	*****	*****	*****
CH	21	265	*****	*****	*****	*****	*****	*****
CH	31	403	0.112	0.120	0.120	0.140	0.145	0.150

TABLE 9A. (CONT.)

LAB.	CLOCK	51209	51234	51264	51294	51329	51359
CH	35 413	0.412	0.336	0.302	0.306	0.262	0.346
CH	35 771	0.359	0.348	0.340	0.466	0.525	0.000
CH	36 354	0.000	0.000	0.000	0.000	0.700	0.700
CNM	35 237	*****	*****	*****	*****	*****	*****
CNM	35 238	0.617	0.700	0.700	0.700	0.700	0.700
CNM	35 378	0.700	0.700	0.700	0.700	*****	*****
CNM	35 382	0.700	0.644	0.489	0.636	0.633	*****
CRL	35 112	0.345	0.303	0.316	0.426	0.496	0.466
CRL	35 144	0.700	0.700	0.700	0.700	0.700	0.700
CRL	35 332	0.700	0.700	0.700	0.700	0.700	0.700
CRL	35 342	0.700	0.700	0.700	0.700	0.700	0.700
CRL	35 343	0.700	0.700	0.700	0.700	0.700	0.700
CRL	35 715	0.258	0.254	0.303	0.498	0.505	0.532
CRL	35 732	0.463	0.424	0.296	0.386	0.350	0.343
CRL	35 907	0.700	0.700	0.700	0.700	0.700	*****
CRL	35 908	0.700	0.700	0.700	0.700	0.700	0.700
CSAO	35 1007	0.000	0.390	0.405	0.629	0.582	0.629
CSAO	35 1008	0.000	0.700	0.700	0.700	0.700	0.700
CSAO	35 1011	0.000	0.172	0.186	0.301	0.371	0.451
CSAO	35 1016	0.000	0.340	0.466	0.643	0.700	0.700
CSAO	35 1017	0.000	0.700	0.700	0.700	0.700	0.700
CSAO	35 1018	0.000	0.432	*****	*****	*****	*****
DLR	40 7424	0.134	0.108	0.102	*****	*****	0.000
DTAG	36 136	0.000	0.497	0.624	0.700	0.700	0.700
DTAG	36 345	0.700	0.700	0.700	0.700	0.700	0.700
DTAG	36 465	0.700	0.700	0.700	0.700	0.700	0.700
F	16 106	0.084	0.062	0.049	0.047	*****	*****
F	35 122	0.700	0.700	0.700	0.700	*****	*****
F	35 124	*****	0.000	0.000	0.000	0.000	0.700
F	35 131	0.484	0.452	0.440	0.693	0.700	0.700
F	35 158	0.700	0.700	0.700	0.700	0.700	0.700
F	35 172	0.700	0.700	0.700	0.700	0.700	0.700
F	35 198	0.700	0.700	0.700	0.700	0.700	0.700
F	35 355	0.700	0.700	0.700	0.700	0.700	0.700
F	35 385	0.420	0.321	0.297	0.346	0.359	0.368
F	35 396	0.700	0.700	0.700	0.700	0.700	0.700
F	35 469	0.000	0.000	0.000	0.000	0.374	0.497
F	35 489	0.000	0.000	0.000	0.000	0.385	0.482
F	35 521	0.000	0.000	0.000	0.000	0.700	0.700
F	35 536	0.700	0.700	0.700	0.700	0.700	0.700
F	35 609	0.700	0.700	0.700	0.700	0.700	0.700
F	35 770	0.700	0.700	0.700	0.700	0.700	0.700
F	35 781	0.700	0.700	0.700	0.700	0.700	0.700
F	35 819	0.700	0.700	0.700	0.700	0.700	0.700
F	35 859	*****	*****	*****	0.000	0.000	0.000

TABLE 9A. (CONT.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
CH	35	413	*****	*****	*****	*****	*****	*****
CH	35	771	0.404	0.428	0.505	0.678	0.700	0.700
CH	36	354	0.700	0.700	0.700	0.700	0.700	0.700
CNM	35	237	*****	0.000	0.000	0.000	0.000	0.700
CNM	35	238	0.000	0.000	*****	*****	*****	*****
CNM	35	378	*****	*****	*****	*****	*****	*****
CNM	35	382	0.000	0.000	0.000	0.000	0.700	0.700
CRL	35	112	0.700	0.700	0.700	0.700	0.700	0.700
CRL	35	144	0.700	0.700	0.700	0.700	0.700	0.700
CRL	35	332	0.700	0.700	0.700	0.700	0.700	*****
CRL	35	342	0.700	0.700	0.700	0.700	*****	*****
CRL	35	343	0.700	0.700	0.700	0.700	0.700	0.700
CRL	35	715	0.605	0.510	0.577	0.700	0.700	0.700
CRL	35	732	0.568	0.689	0.700	0.700	0.700	0.700
CRL	35	907	0.000	0.000	0.000	0.000	0.700	0.700
CRL	35	908	0.700	0.700	0.700	0.700	0.700	0.700
CSAO	35	1007	0.700	0.700	0.700	0.700	0.700	0.700
CSAO	35	1008	0.700	0.700	0.700	0.700	0.700	0.700
CSAO	35	1011	0.700	0.700	0.700	0.700	0.700	0.700
CSAO	35	1016	0.700	0.700	0.700	0.700	0.700	0.700
CSAO	35	1017	0.700	0.700	0.700	0.700	0.700	0.700
CSAO	35	1018	*****	*****	*****	*****	*****	*****
DLR	40	7424	*****	0.000	0.000	0.000	0.000	0.569
DTAG	36	136	0.700	0.700	0.700	0.700	*****	*****
DTAG	36	345	0.700	0.700	0.700	0.700	0.700	0.700
DTAG	36	465	0.700	0.700	0.700	0.700	0.700	0.700
F	16	106	*****	*****	*****	*****	*****	*****
F	35	122	*****	*****	*****	*****	*****	*****
F	35	124	0.700	0.700	0.700	0.700	0.700	0.700
F	35	131	0.700	0.700	0.700	0.700	0.700	0.700
F	35	158	0.700	0.700	*****	*****	*****	*****
F	35	172	0.700	0.700	0.700	0.700	0.700	0.700
F	35	198	0.700	0.700	0.700	0.700	0.700	0.700
F	35	355	0.700	0.700	0.700	0.700	0.700	0.700
F	35	385	0.510	0.635	0.700	0.700	0.700	0.700
F	35	396	0.700	0.700	0.700	0.700	0.700	0.700
F	35	469	0.700	0.700	0.700	0.700	0.700	0.700
F	35	489	0.700	0.700	0.700	0.700	0.700	0.700
F	35	521	0.700	0.700	0.700	0.700	0.700	0.700
F	35	536	0.700	0.700	0.700	0.700	0.700	0.700
F	35	609	0.700	0.700	0.700	0.700	0.700	0.700
F	35	770	0.700	0.700	0.700	0.700	0.700	0.700
F	35	781	0.700	0.700	0.700	0.700	0.700	0.700
F	35	819	*****	*****	0.000	0.000	0.000	0.000
F	35	859	0.000	0.221	0.318	0.502	0.700	0.700

TABLE 9A. (CONT.)

LAB.	CLOCK	51209	51234	51264	51294	51329	51359
F	35 1177	*****	*****	*****	*****	0.000	0.000
F	35 1178	*****	*****	*****	*****	0.000	0.000
F	35 1321	*****	*****	*****	*****	*****	*****
F	40 816	0.700	0.700	0.525	0.450	0.334	0.299
GUM	14 1144	0.009	0.009	0.009	0.000	0.006	0.006
GUM	31 652	0.000	0.000	0.002	0.004	0.005	0.005
GUM	35 441	0.700	0.700	0.700	0.700	0.700	0.700
GUM	35 502	0.378	0.311	0.315	0.700	0.700	0.700
GUM	35 761	*****	*****	*****	*****	*****	*****
GUM	35 1120	*****	*****	*****	*****	*****	*****
IEN	35 219	0.700	0.700	0.700	0.700	0.700	0.700
IEN	35 505	0.553	0.563	0.658	0.700	0.700	0.700
IEN	35 1115	0.112	0.088	0.078	0.106	0.101	0.106
IEN	35 1373	*****	*****	*****	*****	*****	*****
IFAG	16 131	0.012	*****	*****	*****	*****	*****
IFAG	16 173	0.000	0.000	0.001	*****	*****	*****
IFAG	36 1034	0.102	0.094	0.111	0.166	0.187	0.223
IFAG	36 1173	0.087	0.094	0.111	0.166	0.178	0.213
IFAG	36 1176	0.562	0.597	0.382	0.490	0.562	0.450
IFAG	40 4401	*****	*****	0.000	0.000	0.000	*****
IFAG	40 4403	*****	*****	0.000	0.000	0.000	0.000
IFAG	40 4413	*****	*****	0.000	0.000	0.000	0.000
IGMA	14 2403	0.017	0.023	0.028	0.030	0.026	0.025
IGMA	16 112	0.178	0.137	0.141	0.127	0.074	0.077
IGMA	35 631	0.638	0.652	0.700	0.700	0.700	0.700
IGMA	35 645	0.700	0.700	0.700	0.700	0.700	0.700
INPL	35 1021	*****	*****	0.000	0.000	0.000	0.000
IPQ	35 125	*****	*****	*****	*****	*****	0.000
IPQ	35 615	*****	*****	*****	*****	*****	0.000
IPQ	35 1030	*****	*****	*****	*****	*****	0.000
KRIS	36 321	0.700	0.700	0.700	0.700	0.700	0.700
KRIS	36 739	0.700	0.700	0.700	0.700	0.700	0.700
KRIS	36 1135	0.179	0.214	0.538	0.481	0.632	0.608
KRIS	40 5623	0.307	0.342	0.383	0.611	0.521	0.308
LDS	35 289	0.700	0.700	0.700	0.700	0.700	0.700
MSL	12 933	0.019	0.019	0.020	0.025	0.027	0.025
MSL	35 1025	0.534	0.511	0.585	0.700	0.700	0.700
MSL	36 274	0.198	0.198	0.218	0.189	0.171	0.337
NAO	14 1315	*****	*****	0.000	0.000	0.000	0.000
NAO	35 779	0.700	0.659	0.506	0.521	0.570	0.588
NAO	35 1206	*****	*****	*****	0.000	0.000	0.000
NAO	35 1214	0.700	0.700	0.700	0.683	0.494	0.480
NIM	12 614	0.011	0.009	0.010	*****	*****	*****
NIM	35 479	0.458	0.368	0.355	*****	*****	*****
NIM	35 1238	*****	*****	*****	*****	*****	*****

TABLE 9A. (CONT.)

LAB.	CLOCK	51389	51419	51449	51479	51509	51539
F	35 1177	0.000	0.000	0.700	0.700	0.700	0.700
F	35 1178	0.000	0.000	0.700	0.700	0.700	0.700
F	35 1321	0.000	0.000	0.000	0.000	0.700	0.700
F	40 816	0.363	*****	*****	0.000	0.000	0.000
GUM	14 1144	0.007	0.006	0.000	*****	*****	*****
GUM	31 652	0.009	0.014	0.021	0.033	0.056	0.147
GUM	35 441	0.700	0.700	0.700	0.700	0.700	0.700
GUM	35 502	0.700	0.700	0.700	0.700	0.700	0.700
GUM	35 761	*****	0.000	0.000	0.000	0.000	0.661
GUM	35 1120	0.000	0.000	0.000	0.000	0.134	0.147
IEN	35 219	0.700	0.700	0.700	0.700	0.700	0.700
IEN	35 505	0.700	0.700	0.700	0.700	0.700	0.700
IEN	35 1115	0.235	0.700	0.700	0.700	0.700	0.700
IEN	35 1373	*****	*****	*****	*****	0.000	0.000
IFAG	16 131	*****	*****	*****	*****	*****	*****
IFAG	16 173	*****	*****	*****	*****	*****	*****
IFAG	36 1034	0.338	0.458	0.439	0.566	0.700	0.700
IFAG	36 1173	0.249	0.288	0.345	0.468	0.670	0.700
IFAG	36 1176	0.648	0.700	0.700	0.700	0.700	*****
IFAG	40 4401	0.000	0.000	0.000	0.000	0.000	0.000
IFAG	40 4403	0.001	0.001	0.002	0.003	0.003	0.003
IFAG	40 4413	0.000	0.000	0.001	0.000	0.000	0.001
IGMA	14 2403	0.031	0.022	0.026	0.034	0.032	0.036
IGMA	16 112	0.110	0.127	0.154	0.212	0.261	0.237
IGMA	35 631	0.700	0.700	0.700	0.700	0.700	0.700
IGMA	35 645	0.700	0.700	0.700	0.700	0.700	0.700
INPL	35 1021	0.232	0.270	0.398	0.667	0.700	0.000
IPQ	35 125	0.000	0.000	0.000	0.700	*****	*****
IPQ	35 615	0.000	0.000	0.000	0.700	0.700	0.700
IPQ	35 1030	0.000	0.000	0.000	0.700	0.700	0.700
KRIS	36 321	0.700	0.700	0.700	0.700	0.700	0.700
KRIS	36 739	0.700	0.700	0.700	0.700	0.700	0.700
KRIS	36 1135	0.623	0.581	0.489	0.700	0.700	0.700
KRIS	40 5623	0.229	0.254	0.303	0.402	0.650	0.700
LDS	35 289	0.700	0.700	0.700	0.700	0.700	0.700
MSL	12 933	0.038	0.053	0.052	0.073	0.083	*****
MSL	35 1025	0.700	0.700	0.700	0.700	0.700	*****
MSL	36 274	0.439	0.589	0.700	0.577	0.609	*****
NAO	14 1315	0.007	0.000	0.001	0.001	0.002	0.002
NAO	35 779	0.618	0.700	0.700	0.700	0.700	0.700
NAO	35 1206	0.000	0.700	0.700	0.700	0.700	0.700
NAO	35 1214	0.581	0.468	0.545	0.700	0.700	0.700
NIM	12 614	*****	*****	*****	*****	*****	*****
NIM	35 479	*****	*****	0.000	0.000	0.000	0.000
NIM	35 1238	*****	*****	0.000	0.000	0.000	0.000

TABLE 9A. (CONT.)

LAB.	CLOCK		51209	51234	51264	51294	51329	51359
NIM	35	1239	0.000	0.000	0.000	*****	*****	*****
NIST	35	132	0.700	*****	*****	*****	*****	*****
NIST	35	182	0.700	0.700	0.700	0.700	0.700	0.700
NIST	35	408	0.700	0.700	0.700	0.700	0.700	0.700
NIST	35	1074	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	201	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	203	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	204	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	205	*****	*****	0.000	0.000	0.000	0.000
NIST	40	222	0.700	0.700	0.700	0.700	0.700	0.700
NIST	50	2008	0.000	0.028	0.034	0.046	0.036	0.031
NPL	35	123	0.700	0.700	0.700	0.700	0.700	0.700
NPL	35	784	0.700	0.700	0.700	0.700	0.700	0.700
NPL	35	1275	0.000	0.000	0.000	0.700	0.700	0.000
NPL	36	404	0.648	0.483	0.436	0.397	0.345	0.245
NPL	40	1701	0.700	0.700	0.700	0.700	0.700	0.700
NPL	40	1708	0.000	0.700	0.700	0.700	0.700	0.700
NRC	35	234	*****	0.000	0.000	0.000	0.000	*****
NRC	35	372	0.033	0.028	0.357	0.700	0.700	0.700
NRC	40	303	*****	*****	*****	*****	*****	*****
NRC	40	304	*****	*****	0.000	0.000	0.000	0.000
NRC	90	61	*****	0.000	0.000	0.000	0.000	0.191
NRC	90	63	0.700	0.700	0.700	*****	*****	*****
NRLM	35	224	0.700	0.700	0.700	0.700	0.700	0.700
NRLM	35	459	0.700	0.700	0.700	0.700	0.700	0.700
NRLM	35	523	0.700	0.700	0.700	0.700	0.700	0.700
OMH	36	849	0.700	0.700	0.700	0.700	0.700	0.700
ONRJ	35	903	0.700	0.700	0.700	0.700	0.700	0.700
ORB	35	201	0.620	0.503	0.459	0.473	0.541	0.533
ORB	35	202	0.700	0.642	0.634	0.700	0.684	0.565
ORB	35	593	0.700	0.700	0.700	0.700	0.700	0.700
ORB	40	2601	0.031	0.034	0.022	0.019	0.016	0.016
PSB	35	267	0.000	0.000	*****	0.000	0.000	0.000
PSB	35	277	0.000	0.000	*****	0.000	0.000	0.000
PTB	35	128	0.105	0.108	0.124	0.163	0.195	0.224
PTB	35	271	0.700	0.700	0.700	0.700	0.700	0.700
PTB	35	415	0.700	0.700	0.700	0.700	0.700	0.700
PTB	35	1072	0.700	0.700	0.700	0.700	0.700	*****
PTB	40	502	*****	*****	0.000	0.000	0.000	*****
PTB	40	505	0.278	0.245	0.257	0.362	0.421	0.442
PTB	40	537	0.137	0.090	0.080	0.081	0.059	0.043
PTB	92	1	0.700	0.700	0.700	0.700	0.700	0.700
PTB	92	2	0.700	0.700	0.700	0.700	0.700	0.700
PTB	92	3	0.700	0.700	0.602	0.700	0.700	0.700
ROA	14	896	0.023	0.041	0.043	0.049	0.049	0.043

TABLE 9A. (CONT.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
NIM	35	1239	*****	*****	0.000	0.000	0.000	0.000
NIST	35	132	*****	*****	*****	*****	*****	*****
NIST	35	182	0.700	0.700	*****	*****	*****	*****
NIST	35	408	0.700	0.700	0.700	0.700	0.700	0.700
NIST	35	1074	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	201	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	203	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	204	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	205	0.700	0.700	0.700	0.700	0.700	0.700
NIST	40	222	0.700	0.700	0.700	0.700	0.700	0.700
NIST	50	2008	0.035	0.037	0.040	0.058	0.072	0.079
NPL	35	123	*****	*****	*****	*****	*****	*****
NPL	35	784	0.700	0.700	0.700	0.700	0.700	0.700
NPL	35	1275	0.288	0.445	0.581	0.700	0.700	0.700
NPL	36	404	0.282	0.339	0.661	0.700	0.700	*****
NPL	40	1701	0.700	0.700	0.700	0.700	0.700	0.700
NPL	40	1708	0.700	0.700	0.700	0.700	0.700	0.700
NRC	35	234	*****	*****	*****	*****	*****	0.000
NRC	35	372	*****	*****	0.000	0.000	0.000	0.000
NRC	40	303	*****	*****	0.000	0.000	0.000	0.000
NRC	40	304	*****	*****	0.000	0.000	0.000	0.000
NRC	90	61	*****	*****	0.000	0.000	0.000	0.000
NRC	90	63	*****	*****	*****	*****	*****	*****
NRLM	35	224	0.700	0.700	0.700	0.700	0.700	0.700
NRLM	35	459	0.700	0.700	0.700	0.700	0.700	0.700
NRLM	35	523	0.700	0.700	0.700	0.700	0.700	0.700
OMH	36	849	0.700	0.700	0.700	0.700	0.700	*****
ONRJ	35	903	0.700	*****	*****	0.000	0.000	*****
ORB	35	201	0.651	*****	*****	0.000	0.000	0.000
ORB	35	202	0.700	*****	*****	0.000	0.000	0.000
ORB	35	593	0.700	*****	*****	0.000	0.000	*****
ORB	40	2601	0.025	*****	*****	0.000	0.000	0.000
PSB	35	267	0.000	*****	*****	0.000	0.000	0.000
PSB	35	277	0.000	*****	*****	0.000	0.000	0.000
PTB	35	128	0.358	0.481	0.700	0.700	*****	*****
PTB	35	271	0.700	0.700	0.700	0.700	0.700	0.700
PTB	35	415	0.700	0.700	0.700	0.700	0.700	0.700
PTB	35	1072	*****	*****	*****	*****	*****	*****
PTB	40	502	*****	*****	0.000	0.000	*****	*****
PTB	40	505	0.476	0.471	0.557	0.700	0.700	0.700
PTB	40	537	0.035	0.034	0.034	0.029	0.025	0.016
PTB	92	1	0.700	0.700	0.700	0.700	0.700	0.700
PTB	92	2	0.700	0.700	0.700	0.700	0.700	0.700
PTB	92	3	0.700	0.700	0.700	0.700	0.700	*****
ROA	14	896	0.051	0.053	0.048	0.045	0.047	0.050

TABLE 9A. (CONT.)

LAB.	CLOCK	51209	51234	51264	51294	51329	51359
ROA	14 1569	0.044	0.027	0.025	0.029	0.025	0.014
ROA	31 422	0.371	0.298	0.267	0.307	0.546	0.476
ROA	35 583	0.525	0.443	0.482	0.700	0.700	0.700
ROA	35 718	0.700	0.700	0.700	0.700	0.700	0.700
SCL	14 2127	0.000	0.006	0.008	0.014	0.015	0.019
SCL	35 764	0.000	0.461	0.632	0.700	0.700	0.700
SMU	36 1063	0.448	0.548	0.651	0.700	0.700	0.700
SO	40 5102	0.000	0.000	0.076	0.106	0.127	0.160
SP	16 137	0.017	0.013	0.011	0.013	0.012	0.012
SP	35 641	0.700	0.700	0.700	0.700	0.700	0.700
SP	35 1188	0.000	0.000	0.000	0.000	0.700	0.700
SU	40 3802	*****	0.000	0.000	0.000	0.000	0.700
SU	40 3805	*****	*****	*****	0.000	0.000	0.000
SU	40 3806	*****	0.000	0.000	0.000	0.000	0.700
SU	40 3808	*****	0.000	0.000	0.000	0.000	0.700
SU	40 3809	*****	0.000	0.000	0.000	0.000	0.700
SU	40 3811	*****	*****	*****	*****	*****	*****
SU	40 3812	*****	0.000	0.000	0.000	0.000	0.700
TL	34 438	0.003	0.002	0.002	0.003	0.006	0.000
TL	35 160	*****	*****	*****	*****	0.000	0.000
TL	35 300	0.700	0.700	0.700	0.700	0.700	0.700
TL	35 474	0.700	0.700	0.700	0.700	0.700	0.700
TL	35 809	0.700	0.700	0.700	0.700	0.700	0.700
TL	35 1012	0.662	0.421	0.272	0.299	0.270	0.288
TL	40 3052	*****	*****	*****	*****	*****	*****
TL	40 3053	*****	*****	*****	*****	*****	*****
TP	35 1227	0.700	0.700	0.700	0.700	0.700	0.700
TP	36 154	0.700	0.700	0.700	0.700	0.700	0.700
TP	36 163	0.361	0.266	0.267	0.284	0.248	0.250
TP	36 326	0.000	0.000	0.647	0.700	0.700	0.700
TUG	14 1654	0.238	0.204	0.188	0.236	0.220	0.234
TUG	35 247	0.508	0.405	0.416	0.510	0.534	0.457
UME	35 251	0.700	0.700	0.700	0.700	0.700	0.700
UME	35 252	0.700	0.700	0.700	0.700	0.700	0.700
UME	35 872	*****	*****	*****	*****	*****	*****
USNO	35 101	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 104	0.700	*****	*****	0.000	0.000	0.000
USNO	35 106	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 108	0.700	0.635	0.622	*****	0.000	0.000
USNO	35 114	0.145	*****	*****	0.000	0.000	0.000
USNO	35 120	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 142	0.700	0.700	*****	*****	0.000	0.000
USNO	35 146	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 148	0.700	0.700	*****	*****	0.000	0.000
USNO	35 150	0.700	0.700	0.700	0.700	*****	*****

TABLE 9A. (CONT.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
ROA	14	1569	0.010	0.008	0.007	0.008	0.010	0.012
ROA	31	422	0.000	0.112	0.136	0.194	0.249	0.235
ROA	35	583	0.700	0.700	0.700	0.700	0.700	0.700
ROA	35	718	0.700	0.700	0.700	0.700	0.700	0.700
SCL	14	2127	0.029	0.000	0.009	0.010	*****	*****
SCL	35	764	0.700	0.700	0.700	0.700	0.700	0.700
SMU	36	1063	0.700	*****	*****	*****	*****	*****
SO	40	5102	0.258	0.377	*****	*****	*****	*****
SP	16	137	0.016	0.023	0.034	0.033	0.039	0.041
SP	35	641	0.700	0.700	0.700	0.700	0.700	0.700
SP	35	1188	0.700	0.700	0.700	0.700	0.700	0.700
SU	40	3802	0.700	0.700	0.700	*****	*****	*****
SU	40	3805	0.000	0.700	0.700	*****	*****	*****
SU	40	3806	0.700	0.700	0.700	*****	*****	*****
SU	40	3808	0.700	0.700	0.700	*****	*****	*****
SU	40	3809	0.700	0.700	0.700	*****	*****	*****
SU	40	3811	*****	0.000	0.000	*****	*****	*****
SU	40	3812	0.700	0.700	0.700	*****	*****	*****
TL	34	438	0.002	0.002	0.002	0.002	0.003	0.003
TL	35	160	0.000	0.000	0.700	0.356	0.599	0.700
TL	35	300	0.700	0.700	0.700	0.700	0.700	0.700
TL	35	474	0.700	0.700	0.700	0.700	0.700	0.700
TL	35	809	0.700	0.700	0.700	0.700	0.700	0.700
TL	35	1012	0.378	0.466	0.633	0.687	0.700	0.700
TL	40	3052	*****	0.000	0.000	0.000	0.000	0.366
TL	40	3053	*****	0.000	*****	*****	0.000	0.000
TP	35	1227	0.700	0.700	0.700	0.700	0.700	0.700
TP	36	154	0.700	0.700	0.700	0.700	0.700	0.700
TP	36	163	0.452	0.647	0.700	0.700	0.700	0.700
TP	36	326	0.700	0.700	0.700	0.700	0.700	0.700
TUG	14	1654	0.363	0.459	0.607	0.000	0.000	0.127
TUG	35	247	0.640	0.700	0.700	0.700	0.700	0.700
UME	35	251	0.000	*****	*****	*****	*****	*****
UME	35	252	0.700	*****	*****	0.000	0.000	0.000
UME	35	872	*****	*****	*****	0.000	0.000	0.000
USNO	35	101	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	104	0.000	0.593	0.700	0.700	0.700	0.700
USNO	35	106	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	108	0.000	0.000	0.700	0.700	0.700	0.700
USNO	35	114	0.000	0.700	0.700	0.700	0.700	0.700
USNO	35	120	0.700	0.700	0.700	0.700	0.700	*****
USNO	35	142	0.000	0.000	0.700	0.700	*****	*****
USNO	35	146	0.700	0.700	*****	*****	*****	*****
USNO	35	148	0.000	*****	*****	0.000	0.000	0.000
USNO	35	150	*****	*****	*****	*****	*****	0.000

TABLE 9A. (CONT.)

LAB.	CLOCK	51209	51234	51264	51294	51329	51359
USNO	35 152	*****	0.000	0.000	0.000	0.000	0.700
USNO	35 153	0.700	0.700	0.700	0.700	0.609	0.448
USNO	35 156	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 161	0.000	0.000	0.631	0.578	0.640	0.626
USNO	35 164	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 165	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 166	0.700	*****	*****	0.000	0.000	0.000
USNO	35 167	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 169	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 171	0.700	0.700	0.700	0.700	0.700	*****
USNO	35 213	*****	0.000	0.000	0.000	0.000	*****
USNO	35 217	0.000	0.000	0.700	*****	*****	*****
USNO	35 225	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 226	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 227	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 229	0.700	0.700	0.700	0.700	*****	*****
USNO	35 233	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 242	0.700	*****	*****	*****	*****	*****
USNO	35 244	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 249	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 253	0.700	0.700	0.700	0.700	0.700	*****
USNO	35 254	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 255	0.000	0.700	0.700	0.700	0.700	0.700
USNO	35 256	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 260	0.700	0.700	0.700	*****	*****	*****
USNO	35 270	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 279	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 392	0.235	0.170	0.127	0.136	0.124	*****
USNO	35 394	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 417	*****	0.000	0.000	0.000	0.000	0.700
USNO	35 1096	0.000	0.000	0.000	0.000	0.214	0.218
USNO	35 1097	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35 1125	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40 701	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40 702	*****	*****	0.000	0.000	0.000	*****
USNO	40 703	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40 704	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40 705	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40 708	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40 709	0.700	0.700	0.611	0.576	0.445	0.371
USNO	40 710	0.177	0.505	0.573	0.700	0.700	0.700
USNO	40 711	0.053	0.042	0.039	0.046	0.043	0.041
USNO	40 712	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40 715	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40 718	0.081	0.064	0.057	0.087	0.094	0.083

TABLE 9A. (CONT.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
USNO	35	152	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	153	0.495	0.572	0.663	0.700	0.700	0.700
USNO	35	156	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	161	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	164	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	165	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	166	0.000	0.700	0.700	0.700	0.700	0.700
USNO	35	167	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	169	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	171	*****	*****	*****	*****	*****	*****
USNO	35	213	*****	*****	0.000	0.000	0.000	0.000
USNO	35	217	*****	0.000	0.000	0.000	0.000	0.700
USNO	35	225	0.700	0.700	*****	*****	*****	*****
USNO	35	226	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	227	0.700	0.700	*****	*****	0.000	0.000
USNO	35	229	*****	*****	*****	*****	*****	0.000
USNO	35	233	*****	*****	*****	*****	*****	*****
USNO	35	242	*****	*****	*****	*****	*****	0.000
USNO	35	244	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	249	0.700	*****	*****	0.000	0.000	0.000
USNO	35	253	*****	0.000	*****	*****	*****	*****
USNO	35	254	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	255	0.700	0.700	*****	*****	*****	0.000
USNO	35	256	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	260	*****	0.000	0.000	0.000	0.000	0.700
USNO	35	270	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	279	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	392	*****	*****	*****	*****	0.000	0.000
USNO	35	394	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	417	0.507	0.481	0.698	0.700	0.700	0.700
USNO	35	1096	0.210	0.227	0.306	0.408	0.480	0.547
USNO	35	1097	0.700	0.700	0.700	0.700	0.700	0.700
USNO	35	1125	0.700	0.700	*****	*****	0.000	0.000
USNO	40	701	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40	702	*****	0.000	0.000	0.000	0.000	0.192
USNO	40	703	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40	704	0.700	0.700	0.000	0.410	0.379	0.356
USNO	40	705	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40	708	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40	709	0.384	0.417	0.501	0.666	0.700	0.700
USNO	40	710	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40	711	0.053	0.063	0.078	0.105	0.128	0.141
USNO	40	712	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40	715	0.700	0.700	0.700	0.700	0.700	0.700
USNO	40	718	0.107	*****	*****	*****	*****	*****

TABLE 9A. (CONT.)

LAB.	CLOCK		51209	51234	51264	51294	51329	51359
USNO	40	722	0.018	0.013	0.011	0.012	0.010	0.009
VSL	35	179	0.700	0.700	0.700	0.700	0.700	0.000
VSL	35	456	0.700	0.700	0.700	0.700	0.700	0.700
VSL	35	548	0.700	0.700	0.700	0.700	0.700	0.700
VSL	35	731	0.700	0.700	0.700	0.700	0.700	0.700

TABLE 9A. (CONT.)

LAB.	CLOCK		51389	51419	51449	51479	51509	51539
USNO	40	722	0.013	*****	*****	0.000	0.000	*****
VSL	35	179	0.080	*****	*****	*****	*****	0.000
VSL	35	456	0.700	0.700	0.700	0.700	0.700	0.700
VSL	35	548	0.700	0.700	0.700	0.700	0.700	0.700
VSL	35	731	0.700	0.700	0.700	0.700	0.700	0.700

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	21 OSCILLOQUARTZ 3210
13 EBAUCHES, OSCILLATOM B5000	23 OSCILLOQUARTZ EUDICS 3020
14 HEWLETT-PACKARD 5061A OPT. 4	30 HEWLETT-PACKARD 5061B
16 OSCILLOQUARTZ 3200	31 HEWLETT-PACKARD 5061B OPT. 4
17 OSCILLOQUARTZ 3000	34 H-P 5061A/B with 5071A tube
18 FREQ. AND TIME SYSTEMS INC. 4000	35 HEWLETT-PACKARD 5071A High perf.
4x HYDROGEN MASERS	36 HEWLETT-PACKARD 5071A Low perf.
9x PRIMARY CLOCKS AND PROTOTYPES	50 FREQ. AND TIME SYSTEMS INC. 4065A

TABLE 9B. STATISTICAL DATA ON THE WEIGHTS ATTRIBUTED TO THE CLOCKS IN 1999

Interval	Number of clocks			Number of clock with a given weight								
				0* weight			0** weight			maximum weight		
1999	HM	5071A	total	HM	5071A	total	HM	5071A	total	HM	5071A	total
Jan.	29	140	218	4	21	33	0	0	1	16	95	122
Feb.	35	140	226	9	18	35	0	1	4	17	90	118
Mar.	41	136	230	14	15	37	0	0	2	15	90	114
Apr.	40	135	225	14	19	41	0	0	2	16	91	119
May	39	138	224	13	20	37	0	0	2	16	89	118
June	37	132	214	6	19	27	0	3	4	21	86	121
July	39	131	214	5	22	29	1	2	4	22	86	122
Aug.	40	126	209	9	21	33	1	2	4	23	87	124
Sep.	41	120	206	9	19	34	1	0	3	22	88	126
Oct.	35	130	210	9	26	42	1	0	3	17	97	131
Nov.	37	129	209	10	25	41	2	0	3	18	100	135
Dec.	37	132	205	8	26	37	1	1	2	19	102	136

* 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 January and February 2000.

AUTHORITIES RESPONSIBLE FOR THE TIME SIGNAL EMISSIONS

Signal	Authority
ATA	National Physical Laboratory Dr. K.S. Krishnan Road New Delhi - 110012, India
BPM	Shaanxi Astronomical Observatory Chinese Academy of Sciences P.O. Box 18 - Lintong Shaanxi, 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 - 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 Sección de Hora 11.110 San Fernando Cádiz, Spain
HBG	Service horaire HBG Observatoire Cantonal CH - 2000 Neuchâtel, Suisse
HLA	Time and Frequency Laboratory Korea Research Institute of Standards and Science Yusong P.O. Box 102, Taejon 305-600 Republic of Korea

Signal	Authority
IAM	Istituto Superiore delle Comunicazioni e delle Tecnologie dell'Informazione Viale America, 201 00144 - Roma, Italia
JG2AS, JJY	Standards and Measurements Division Communications Research Laboratory 2-1, Nukui-kitamachi 4-chome Koganei-shi, Tokyo 184-8795 Japan
LOL	Servicio de Hidrografia 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
PPR	Departamento Serviço da hora Observatorio Nacional (CNPq) Rua General Bruce, 586, Sao Cristovao 20921-030 - Rio de Janeiro, Brasil
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	France Telecom Centre National d'Etudes des Télécommunications DTD/EDT Synchronisation Temps Fréquence 2, avenue Pierre Marzin 22307 - Lannion Cedex, France

Signal	Authority
VNG	National Standards Commission P.O. Box 282 North Ryde NSW 2113 Australia
WWV, WWVB, WWVH	Time and Frequency Division, 847.00 National Institute of Standards and Technology - 325 Broadway Boulder, Colorado 80303, U.S.A.
YVTO	Direccion de Hidrografia y Navegacion 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). Second marker No 15 is prolonged to 0.2 s if the reserve antenna is in use. 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	Interruption of the carrier at the beginning of each second during 100 ms or 200 ms. The minutes are identified by a double pulse (from sec 0.0 to 0.1 and 0.2 to 0.3). Coded transmission of year, month, day, hour, minute and day of week from sec n° 21 to n° 58 (similar to DCF 77). During summer time (UTC +2), sec n° 17 interruption is 200 ms long while during winter time (UTC +1) sec n° 18 is 200 ms long.
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.
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.

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
JG2AS (1)	Sanwa Ibaraki Japan 36° 11'N 139° 51'E	40	Continuous, except interruption during communications.	During experimental coded transmission of the total day, hour, minute and DUT1, second pulses are 0.2 s, 0.5 s and 0.8 s long. In case of no coded transmission, A1A type second pulses of 0.5 s duration.
JJY	Sanwa Ibaraki Japan 36° 11'N 139° 51'E	5 000 8 000 10 000	Continuous, except interruption between minutes 35 and 39.	Second pulses of 8 cycles of 1 600 Hz modulation. Minute pulses are preceded by a 600 Hz modulation. DUT1: ITU-R code by lengthening.
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 annoucement of hour, minute, day of the year, year, day of the week and leap second. Fully operational since 10 June 1999.
LOL (2)	Buenos Aires Argentina 34° 37'S 58° 21'E	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.
PPR	Rio de Janeiro Brazil 22° 59'S 43° 11'W	435 4 244 8 634 13 105 17 194.4	1 h 30 m, 14 h 30 m, 21 h 30 m.	Second ticks, of A1 type, during the five minutes preceding the indicated times. The minute ticks are longer.
RAB-99	Khabarovsk Russia 48° 30'N 134° 50'E	25	Winter schedule 02 h 06 m to 02 h 22 m 06 h 06 m to 06 h 22 m Summer schedule 01 h 06 m to 01 h 22 m 05 h 06 m to 05 h 22 m	A1N type signals are transmitted between 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 duration and minute pulses of 10 s duration are transmitted between minutes 13 and 22.

(1) JG2AS. The signal has been stopped since 4 June, 1999. The station was abolished on 30 June 1999.

(2) LOL. * Irregular ** discontented for maintenance

Station	Location Latitude Longitude	Frequency (KHz)	Schedule (UTC)	Form of the signal
RBU	Moscow Russia 55° 30'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 59 th 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 (3)	Irkutzk Russia 52° 32'N 103° 52'E	50	0 h to 21 h 05 m 23 h to 23 h 05 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 59 th minute. The pulses at the beginning of the second are prolonged to 40 ms and of the minute to 0.5 s. DUT1+dUT1: by double pulse.
RWM (3)	Moscow Russia 55° 44'N 38° 12'E	4 996 9 996 14 996	The station operates simultaneously on the three frequencies.	A1X type second pulses od 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.
ULA-4 (3)	Tashkent Uzbekistan 41° 19'N 69° 15'E	2 500 5 000 10 000	0 h to 3 h 50 m 5 h to 23 h 50 m 0 h to 3 h 50 m 14 h to 23 h 50 m 5 h to 13 h 20 m	A1X type second pulses of 0.1 s duration are transmitted between minutes 0 and 10, 30 and 40. The pulses at the beginning of the minute are prolonged to 0.5 s. A1N type 0.1 second pulses of 0.02 s duration are transmitted between minutes 10 and 20, 40 and 50. 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.
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.

(3) RTZ, RMW, ULA-4. CIS radiostation 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 = +px0.02 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 = -qx0.02 s.

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
VNG	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. 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 59 th 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.

ACCURACY OF THE CARRIER FREQUENCY

Station	Relative uncertainty of the carrier frequency in 10^{-10}
ATA	0.1
BPM	0.1
BSF	0.1
CHU	0.05
DCF77	0.01
EBC	0.1
HBG	0.1
HLA	0.1
IAM	0.5
JG2AS, JJY	0.1
JJY(40)	0.01
LOL	0.1
MSF	0.02
RAB-99, RBU	0.05
RWM, ULA-4	0.5
RJH-63, RTZ	0.05
RJH-69, RJH-77	0.05
RJH-86, RJH-90	0.05
TDF	0.02
VNG	0.1
WWV	0.01
WWVB	0.01
WWVH	0.01

TIME DISSEMINATION SERVICES

The following tables are based on information received at the BIPM in January and February 2000.

AUTHORITIES RESPONSIBLE FOR THE TIME DISSEMINATION SERVICES

AOS	Astrogeodynamical Observatory Borowiec near Poznan Space Research Centre P.A.S. PL 62-035 Kornik Poland
GUM	Time and Frequency Laboratory Główny Urzad Miar Ul. Elektoralna 2 P.O. Box P-10 PL 00-950 Warszawa - Poland
NIST	National Institute of Standards and Technology Time and Frequency Division, 847.00 325 Broadway Boulder, Colorado 80303, USA
NRC	National Research Council of Canada Institute for National Measurement Standards - Time Standards Ottawa, Ontario, K1A OR6, Canada
ONRJ	Observatorio Nacional (CNPq) Departamento Serviço da Hora Rua General Bruce, 586, Sao Cristovao 20291- 030 - Rio de Janeiro, Brasil
ROA	Real Instituto y Observatorio de la Armada 11100 San Fernando Cádiz, Spain
PTB	Physikalisch-Technische Bundesanstalt Lab. Zeit-und Frequenzuebertragung Bundesallee 100 D-38116 Braunschweig Germany
USNO	U.S. Naval Observatory 3450 and Massachusetts Ave., N.W. Washington, D.C. 20392-5420 USA

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

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.
Acces phone number : +48 22 654 88 72

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/.

NRC Telephone Code

Provides digital time code by telephone modem for setting time in computers.
Access phone number : +1 613 645 3900

Network Time Protocol

Operates two time servers using the « National 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.

ONRJ

Internet Time Service

Available from Monday to Friday, between 9 :00 and 19 :00 UTC at the address 200.20.186.75

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.

Time Stamping

URL : http://ntp0.roa.es
Service policy : free
Note : Pilot Time stamping under development

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 ».
Acess 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

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 +1 202 762-1602
Web site for time and for data files: http://www.usno.navy.mil
Network Time Protocal (NTP) see http://www.usno.navy.mil/ntp.html
for software and site closest to you.

Comité International des Poids et Mesures

Report of the 88th Meeting, 1999, Tome 67

(BIPM Publication)

Director's report on the scientific work of the BIPM

(October 1998 - September 1999)

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

Reference time scales TAI and UTC have been computed regularly and have been published in the monthly *Circular T*. Definitive results for 1998 have been available, in the form of computer-readable files in the BIPM home-page, since 5 March 1999 and printed volumes of the *Annual Report of the BIPM Time Section for 1998* (Volume 11) were distributed in April 1999.

Following the meeting of representatives of laboratories contributing to TAI and the 14th CCTF meeting held at the BIPM in April 1999, changes are being implemented to render the data used in TAI, as well as the results, more accessible to the users and to make the procedures of calculation even more transparent and traceable.

2 Algorithms for time scales

Research concerning time scale algorithms includes studies which aim to improve the long-term stability of the free atomic time scale EAL and the accuracy of TAI.

2.1 EAL stability

The replacement of clocks of older design by new ones of type HP 5071A continues. Some 75 % of the clocks are now either commercial caesium clocks of the new type or active, auto-tuned active hydrogen masers, and together they contribute 89 % of the total weight with consequent improvement in the stability of EAL, the first step in the calculation of TAI. To improve the stability of EAL further, the algorithm which produces it has been revised. Since 1 January 1998, the weighting method in the ALGOS algorithm has been changed adopting a relative maximum weight of a clock, a value initially set to 0.7 %. The calculation interval of TAI has also been reduced from two months to one month so that each monthly *Circular T* gives definitive results for access to the reference time scales TAI and UTC.

The medium-term stability of EAL, expressed in terms of the Allan deviation, σy, is estimated to be 0.6×10^{-15} for averaging duration of 20 and 40 days over the period January 1997 to February 1999. This improves the predictability of UTC for averaging times of between one and two months, a scale attribute of fundamental importance for institutions charged with the dissemination of real-time time scales.

At the meeting of representatives of laboratories contributing to TAI, held at the BIPM on 19 April 1999, the Working group on TAI decided to create a study group on algorithms to study, develop and compare time scales algorithms. Although the aim of this group is not to propose changes in the current procedures of production of TAI, the time section will be closely involved with the work of this study group.

2.2 TAI accuracy

To characterize the accuracy of TAI, estimates are made of the relative departure, and its uncertainty, of the duration of the TAI scale interval from the SI second as produced on the rotating geoid by primary frequency standards. Since October 1998, individual measurements of the TAI frequency have been provided by six primary frequency standards:

- NIST-7, which is the optically pumped primary frequency standard developed at the NIST, Boulder (Colorado, United States). In the period covered by this report, it provided three measurements covering 30-day periods centred in October and December 1998 and in February 1999. The type B uncertainty of NIST-7 is stated by the NIST as 1×10^{-14} ($1\ \sigma$).
- NRLM-4, which is the newly optically pumped primary frequency standard developed at the NRLM, Tsukuba (Japan). In the period overed by this report, it provided four measurements covering 10-day periods in November and December 1998 and in January and February 1999. The type B uncertainty of NRLM-4 is stated by the NRLM as 2.9×10^{-14} ($1\ \sigma$).
- PTB CS1, CS2 and CS3 are classical primary frequency standards operating continuously as clocks at the PTB, Braunschweig (Germany). Frequency measurements have been taken continuously, over one-month periods, in the period covered by this report (until July 1999 for CS1). The published evaluation of their type B uncertainties ($1\ \sigma$) are 0.7×10^{-14}, 1.5×10^{-14} and 1.4×10^{-14}, respectively.
- LPTF-JPO, which is the optically pumped primary frequency standard developed at the BNM-LPTF, Paris (France). In the period covered by this report, it provided two measurements covering a 20-day period in June 1999 and a 10-day period in July 1999. The type B uncertainty of LPTF-JPO is stated by the BNM-LPTF as 6.3×10^{-15} ($1\ \sigma$).

The global treatment of individual measurements led to a relative departure of the duration of the TAI scale unit from the SI second on the geoid ranging since October 1998 from -0.4×10^{-14} to $+0.4 \times 10^{-14}$, with an uncertainty of 0.4×10^{-14}. The procedure for compensating the discrepancy consecutive to uniform application of the correction for the black-body radiation frequency shift in 1995 has now been abandoned and the relationship between the frequencies of EAL and TAI has been fixed since March 1998, except for a 1×10^{-15} frequency step in March 1999.

The CCTF working group on the expression of uncertainties in primary frequency standards continued its work. A final report was presented at the CCTF 14th meeting in April 1999, leading to the adoption by the CCTF of two Recommendations. The Time section is particularly concerned by Recommendation S 3 (1999) for its use of primary frequency standards to ensure the accuracy of TAI, and steps to implement new procedures are being taken.

3 Time links

Since many years, the sole means of time transfer used for TAI computation (for the time links computed at the BIPM) has been the 'classical' GPS common-view technique based on C/A-code measurements obtained from one-channel receivers. The combined standard uncertainty of one 13-minute comparison between remote clocks is about 3 ns for continental distances and 5 ns for intercontinental distances, provided that the GPS receivers involved are differentially calibrated. The commercial availability of newly developed receivers has stimulated interest in extending the 'classical' common-view technique for use of multichannel dual-code dual-system (GPS and GLONASS) observations, with the aim of improving the accuracy of time transfer. In addition, the BIPM Time section is interested in other time and frequency comparison methods, among them phase measurements and two-way time transfer via geostationary satellites.

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

i) Current work

The BIPM issues, twice a year, GPS and GLONASS international common-view schedules. GPS Schedule No. 31 and GLONASS Schedule No. 6 were implemented in time receivers on 1 October 1998; GPS Schedule No. 32 and GLONASS Schedule No. 7 on 30 March 1999.

The GPS data are collected and treated regularly following well-known procedures. Only strict common-views are used in order to overcome effects related to the implementation of Selective Availability on satellite signals. The international network of GPS time links used by the BIPM is organized to follow a pattern of local stars within a continent, together with two long-distance links, NIST-OP and CRL-OP, for which data are corrected to take account of ionospheric measurements and post-processed precise satellite ephemerides. Multi-channel GPS and GLONASS data taken by about ten time laboratories are also collected and studied at the BIPM, but are not currently used in the TAI computation.

The BIPM publishes an evaluation of the daily time differences [*UTC – GPS time*] and [*UTC - GLONASS time*] in its monthly *Circular T*. These differences are obtained by smoothing GPS data, taken at the OP, and GLONASS data, taken at the NMi-VSL, from a selection of satellites at high elevation. The standard deviations characteristic of daily GPS and GLONASS results are respectively about 8 ns and 3 ns, the poorer performance of the GPS resulting from intentional degradation of the signal by Selective Availability of GPS. The combined standard uncertainty of the daily GLONASS values is, however, not better than several hundred nanoseconds, compared to 10 ns for GPS, because no absolutely calibrated GLONASS time receivers are available.

ii) Determination of differential delays of GPS and GLONASS receivers

An important 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 OP and European time laboratories equipped with two-way time transfer stations began in June 1997. Recently the 4th trip was terminated and preparation for the 5th are underway [3]. The results of these successive calibration trips are consistent with the stated uncertainties (a few nanoseconds) for most of the laboratories visited. In some cases, however, larger discrepancies were observed.

Another series of differential calibration of GPS/GLONASS multichannel dual-code receivers began in December 1998. This involves six laboratories in Europe, three in the United States and one in South Africa, Australia and Japan.

iii) Standards for GPS and GLONASS receivers

The staff of the BIPM Time section is actively involved in the work of the CCTF sub-group on GPS and GLONASS time transfer standards, and several decisions made by the sub-group have their origins in studies initiated at the BIPM.

The *Technical Directives*, agreed by the sub-group in 1993 for the standardization of 'classical' GPS time receiver software, are now widely implemented (CGGTTS Version 1). The BIPM played a key role in the adaptation of the standard GPS data format for use in dual-system, dual-frequency, dual-code observation. This format (CGGTTS Version 2) is now used in commercially available receivers.

The BIPM has continued studies aiming at reducing the sensitivity to outside temperature of some types of GPS and GLONASS receivers currently in operation, and has bought for this purpose three commercial temperature-stabilized antennas, model TSA 100 from 3S Navigation. Their use with

3S Navigation and Ashtech Z12T receivers clearly demonstrates a reduction of systematic effects in experiments of time and frequency transfer. Cables with a low temperature sensitivity have also been experimented successfully [9, 10].

The BIPM has also been concerned with the problem of the so-called 'GPS week roll-over' which has occurred on 22 August 1999 when the GPS week number passed from 1023 to 1024. New EPROMS to remedy this software problem have been available from the makers of the 'classical' time receivers. All receivers belonging to the BIPM have been updated, thanks partly to units supplied by the NIST. Some problems have been observed on some receivers, at the BIPM and in time laboratories, but have been cured within a few weeks. The year 2000 problem is also taken into account in new software releases.

iv) Multi-channel multi-code multi-system receivers

Several studies have been carried out with a view to extending the 'classical' GPS common-view time transfer technique to multichannel dual-system (GPS and GLONASS) observations. The idea is to take advantage of 'all-in-view' observations from each site for computing as many common views as possible between two sites [4, 5, 7]. The number of GPS and GLONASS satellites now in orbit is such that for short-distance links (<1000 km) 5 GPS and 3 GLONASS common views may be obtained simultaneously for each 16-minute interval. This increases the number of daily common views by a factor 20 relative to the 'classical case', and thus to a possible gain of about 4.5 in the precision of daily clock comparisons.

The BIPM is currently equipped with four GPS/GLONASS or GLONASS-only time receivers from the 3S Navigation Company:

- one two-channel P-code single-frequency GLONASS unit;
- one multichannel dual-code GPS/GLONASS receiver with twelve channels for C/A-code single-frequency GPS or GLONASS observation, and two P-code channels for double-frequency GLONASS observation (receivers of the same type are in operation in some timing centres, in particular at the NMi-VSL);
- two multichannel dual-code GPS/GLONASS receiver with twelve channels for C/A-code single-frequency GPS or GLONASS observation, and eight P-code channels for double-frequency GLONASS observation.

These two multichannel receivers are equipped with temperature-stabilized antennas.

A on-site study with GLONASS P-code single-channel data shows a noise reduction by a factor 5 relative to GPS C/A-code single-channel data performance [1, 4, 6]. Further improvement is expected when using GLONASS P code in a multi-channel mode [8].

The BIPM is also conducting studies involving cheap pocket-sized multichannel GPS C/A-code receivers: software which fulfils all standards agreed for accurate time transfer is being developed for one of these, the Motorola Oncore 8-channel receiver [7].

Finally the time section has participated, under a contract by the CNES, to the technical evaluation of a set of receivers (EURIDIS) designed by the CNES for the future European project of GPS augmentation system.

v) IGS estimated ionospheric corrections

Studies have been carried out to investigate the use of IGS (International GPS Service) estimates of ionospheric parameters to correct for the ionospheric delays of single frequency receivers like the ones operated by most time laboratories. These studies have shown that the IGS estimates present significant advantages with respect to the standard ionospheric model used in terms of stability and accuracy for medium and long distance links. Such estimations have been introduced since July 1999 in regular TAI calculation for a number of medium and long distance links that previously used only the standard ionospheric model. They are also used for the two intercontinental links that dispose of dual frequency ionospheric measurements (NIST-OP and CRL-OP) because IGS estimates, although slightly less precise, are more accurate and regularly available. Ionospheric measurements are kept as a backup.

3.2 Phase measurements

GPS and GLONASS time and frequency transfer may also be carried out using dual-frequency carrier-phase measurements rather than code measurements. This technique, already in common use for GPS in the geodetic community, can be adapted to the needs of time transfer: it is expected that an uncertainty of one part in 10^{15} in frequency transfer may be obtained over a period of one day. An Ashtech Z12T receiver has been acquired for this purpose and has been in operation at the BIPM since December 1997. In close collaboration with the BNM-LPTF, which owns a similar receiver, a detailed study of the two receivers placed side by side has been carried out. Results of the first experiments are the following:

- In the short-baseline configuration (comparison of two receivers linked to the same local clock, their antennas distant by several metres) the observed noise is characterized by a standard deviation of 3.4 ps for averaging times of 30 s. When using temperature stabilized antennas, low-temperature coefficient cables and high-quality connectors, the measurement noise averages out to reach a modified Allan deviation of 4×10^{-17} for an averaging time of 60 000 s [9, 10, 11].
- Frequency comparisons have been carried out over baselines ranging from tens to thousands of kilometres. It has been shown [12] that two distant H-masers may be compared with a frequency uncertainty between 1.5×10^{-15} and 2×10^{-15} for an averaging duration of one day, which is a promising step for confirming the capability of this technique to compare new primary frequency standards.
- Experiments are starting to perform the calibration of the Z12T hardware delays by comparison with other receivers at the BIPM.

These studies are being conducted in the framework of the IGS/BIPM Pilot Project to study accurate time and frequency comparisons using GPS phase and code measurements, which (after its first general meeting at the BIPM in June 1998) held a short meeting in Reston (Virginia, United States) during the 30th PTTI.

The 3S Navigation receivers in operation at the BIPM have the capability to provide GLONASS phase measurements and software has been installed to allow automatic data retrieval. With this set-up, one 3S receiver has been collecting data for the International GLONASS Experiment, IGEX'98, organized by the IAG, the IGS and the ION, since its inception in October 1998. The objective of this project is, among others, to produce post-processed precise GLONASS satellite ephemerides as has been done for several years for GPS satellites.

3.3 Two-way time transfer

The CCTF working group on two-way satellite time transfer met for the sixth time in San Fernando (Spain) on 29-30 October 1998. More technical meetings of representatives of the participating two-way stations were held on 3 December 1998 in Reston (Virginia, United States), during the 30th PTTI, and on 14 April 1999 in Besançon (France) during the Joint Meeting FCS/EFTF. At these meetings the main topics discussed were the comparisons of two-way and GPS common-view time transfer and preparations for routine operation. Since May 1998, the BIPM has embarked on the collection of two-way data from seven operational stations and undertaken treatment of some two-way links. A staff member of the BIPM is in charge of the secretariat of the working group and the BIPM is also involved in the calibration of two-way time transfer links by comparison with GPS [2, 3]. Following discussions at the 14th CCTF meeting, the BIPM Time Section introduced the TUG/PTB TWSTT link into the computation of TAI, starting with the *Circular T* issue covering July 1999.

4 Pulsars

Millisecond pulsars can be used as stable clocks to realize a time scale by means of a stability algorithm. Collaboration is maintained with a number of radio-astronomy groups observing pulsars and analysing pulsar data. The Time section provided these groups with the latest version of its post-processed realization of Terrestrial Time TT (BIPM99) in March 1999.

A new technique to obtain pulsar data for use at radio observatories has been developed with the collaboration of the CNES. The implementation of this technique to search for new pulsars in a sky survey has been the subject of the doctoral work [14] conducted by B. Rougeaux at the BIPM, in collaboration with the CNES, the Observatoire Midi-Pyrénées, Toulouse (France), and the OP. The complete chain of hardware and software has been validated by observations of known pulsars and a programme of survey observations, covering a small area on the sky, has been started at Nançay (France). The processing of these observations, started at the BIPM, will be pursued at the OMP, which is taking over the continuation of this project.

5 Space-time references

The BIPM/IAU Joint Committee on general relativity for space-time reference systems and metrology (G. Petit chairman), created in 1997 continued its work. A Web site has been established (http://www.bipm.fr/WG/CCTF/JCR) that provides general information on the Joint Committee and outlines the main features of its work.

Two studies have been undertaken at the BIPM. One concerns the extension of the relativistic framework for the realization of barycentric coordinate time. In 1991 the IAU defined a number of coordinate time scales (including barycentric coordinate time, TCB) together with transformations and parameters relating them to each other. These definitions are valid up to terms of order c^{-2} in the post-Newtonian expansions used, but could lead to ambiguities when used at the next order of the expansion c^{-4}. Terms of this order describe effects that may amount to parts in 10^{16} in relative frequency for a clock in the solar system, so future studies will have to take them into account. This implies the need to adopt new conventions, for example concerning the gauge used. The second study concerns the realization of geocentric coordinate times. In this case no extension of the metric is needed but practical problems linked to the Earth need to be addressed. They mainly concern the treatment of tidal effects when combining data (e.g. geopotential model, geometric coordinates) from different origins for determining the relation between proper time of a clock and coordinate time. In addition it would be desirable to change the definition of Terrestrial Time to remove the reference to the geoid, so the uncertainty associated to this surface.

6 Other studies

Scientists of the time-section are involved, in collaboration with the BNM-LPTF, in the evaluation of the possible use for international time keeping, and in particular TAI, 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 accuracies 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. Within this work an important part concerns the calculation, at the required accuracy, of relativistic corrections affecting the clocks themselves as well as the time transfer between the space and ground clocks.

Another area of research, in collaboration with the university Paris VI (Pierre et Marie Curie), involves atomic interferometers, in particular the study of some systematic effects when using them gravimetric measurements [15]. Such instruments are based on the hyperfine transition in laser-cooled Cs atoms that are launched in a fountain geometry, which is identical to the technique used in atomic fountain clocks. Hence advances in the two fields are closely related.

7 Publications

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3. Kirchner D., Ressler H., Hetzel P., Soering A., Lewandowski W., Calibration of three European TWSTFT stations using a portable station and comparison of TWSTF and GPS common-view measurements results, *Proc. 30th PTTI*, 1998, 365-376.
4. Lewandowski W., Azoubib J., GPS+GLONASS: Toward sub-nanosecond time transfer, *GPS World*, 1998, **9**, No. 11, 30-39.
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