

**BUREAU INTERNATIONAL DES POIDS ET MESURES**

**Annual Report of the BIPM Time Section**

**Rapport annuel de la Section du temps du BIPM**

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

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

### Practical information about the BIPM Time Section

The Time Section of the BIPM issues two periodic publications. These are the monthly *Circular T* and the *Annual Report of the BIPM Time Section*. The complete texts of *Circular T* and most tables of the present Annual Report are available from BIPM website, <http://www.bipm.org>.

*La Section du temps du BIPM produit deux publications périodiques : la Circulaire T, mensuelle, et le Rapport annuel de la Section du temps du BIPM. Les circulaires et la plupart des tableaux de ce rapport annuel sont disponibles par utilisation du site internet du BIPM, <http://www.bipm.org>.*

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### Electronic access to the BIPM Time Section files

A large number of files from the BIPM Time Section are available from the website.  
[\(http://www.bipm.org/en/scientific/tai/time\\_ftp.html\)](http://www.bipm.org/en/scientific/tai/time_ftp.html)

The files are found in the four subdirectories **data**, **publication**, **scale** and **links**.

**Data**, **publication** and **scale** are available by ftp (62.161.69.5 or ftp2.bipm.org, user anonymous, e-mail address as password, cd pub/tai).

**Links** is available by ftp (62.161.69.131 or tai.bipm.org, user anonymous, e-mail address as password, cd TimeLink/LkC).

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

#### **Publication**- the latest issues of the Time Section

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

<b>publications</b>	<b>filename</b>
Acronyms of laboratories	acronyms.pdf
Leap seconds	leaptab.txt
Circular T	cirt.XXX
Fractional frequency of EAL from primary frequency standards	etXY.ZT
Weights of clocks participating in the computation of TAI	wXY.ZT
Rates relative to TAI of clocks participating in the computation of TAI	rXY.ZT
Values of the differences between TAI and the local atomic scale of the given laboratory, including relevant notes	TAI - lab
Values of the differences between UTC and its local representation by the given laboratory, including relevant notes	UTC - lab
Values of the differences between TAI and UTC and the respective local scales, evaluated for two-month periods until the end of 1997	TAIXYZ
[UTC(lab1) - UTC(lab2)] obtained by the TWSTFT link, as published in the BIPM TWSTFT reports	lab1 - lab2.tw
BIPM Two-Way Satellite Time and Frequency Transfer Reports (until February 2003)	twstftXX.pdf
Most recent schedules for common-view observations of GPS and GLONASS satellites	schgps.XX schglo.XX

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

**Scale- time scales data**

<b>Content</b>	<b>filename</b>
Time Dissemination Services	TIMESERVICES.DOC
Time Signals	TIMESIGNALS.DOC
Rates of clocks contributing to TAI	RTAIXY.ar
Weights of clocks contributing to TAI	WTAIXY.ar
TT(BIPMXY) computed in the year 19XY or 20XY	TTBIPM.XY
<b>Starting 1993:</b>	
Difference between the normalized frequencies of EAL and TAI	EALTAIXY.ar
TAI frequency	FTAIXY.ar (for 1993,1994)
Measurements of the duration of the TAI scale interval	UTAIXY.ar (starting 1995)
Mean duration of TAI scale interval	SITAIXY.ar (1993-1999)
Mean fractional deviation of the TAI scale interval from that of TT duration of TAI scale interval	SITAIXY.ar (starting 2000)
[TAI - GPS time] and [UTC - GPS time] (until March 2003)	UTCGPSXY.ar
[TAI - GLONASS time] and [UTC - GLONASS time] (until March 2003)	UTCGLOXY.ar
[TAI - GPS time] and [UTC - GPS time], [TAI - GLONASS time] and [UTC - GLONASS time] (starting April 2003)	UTCGPSGLOXY.ar
Local representations of UTC: Values of [UTC - UTC(lab)]	UTCXY.ar (1993-1998)
Independent local atomic time scales: values of [TAI - TA(lab)]	TAIXY.ar (1993-1998)
<b>Until 1992:</b>	
Local representations of UTC: Values of [UTC - UTC(lab)]	UTC.XY
Local values of [TAI - TA(lab)]	TA.XY

**Links** – Results of link comparison, arranged in yearly directories, starting January 2005.  
See *readme.txt* for details.

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

For any comment or query send a message to: [tai@bipm.org](mailto:tai@bipm.org)

## Leap seconds

### *Secondes intercalaires*

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

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

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

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

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

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

## Establishment of International Atomic Time and of Coordinated Universal Time

### **1. Data and computation**

International Atomic Time (TAI) and Coordinated Universal Time (UTC) are obtained from a combination of data from some 300 atomic clocks kept by about 65 laboratories spread worldwide. The data are regularly reported to the BIPM by about 55 timing centres which maintain a local UTC, UTC(k) (see Table 3). The data are in the form of time differences [UTC(k) - Clock] taken at 5 day intervals at 0h UTC for Modified Julian Dates (MJD) ending in 4 and 9, at 0h UTC ; these dates are referred here as 'standard dates'. The equipment maintained by the timing centres is detailed in Table 4.

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

### **2. Accuracy**

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

### **3. Availability**

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

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

### **4. Time links**

The BIPM organizes the international network of time links, which takes the form of local stars within a continent, joined by long-distance links (see Figure).

In 2005, the network of time links used by the BIPM was non-redundant and relied on observation of GPS satellites in common views and on two way satellite time and frequency transfer (TWSTFT). Most time links are based on GPS satellite common views. Data from multi-channel dual-frequency GPS

geodetic type receivers is regularly used in the calculation of time links, in addition to that acquired by the traditional single-frequency (single or multi-channel) GPS time receivers. For those links performed with more than one technique, one of them is considered as official for TAI and the others are calculated as a back-up. GPS links in TAI with single-frequency receivers are corrected using the ionospheric maps produced by the International GNSS Service (IGS); all GPS links are corrected using the IGS precise operational satellite ephemerides. The uncertainty of  $[UTC(k_1) - UTC(k_2)]$ , obtained at the BIPM with these procedures is given in *Circular T*, section 6. The BIPM also publishes an evaluation of  $[UTC - GPS\ time]$  which is accessible via the BIPM website.

The BIPM regularly publishes an evaluation of  $[UTC - GLONASS\ time]$ , also available from the BIPM website, using current observations of the GLONASS system at the Astrogeodynamical Observatory (AOS), Poland.

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

## **5. Time scales established in retrospect**

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

### **Notes**

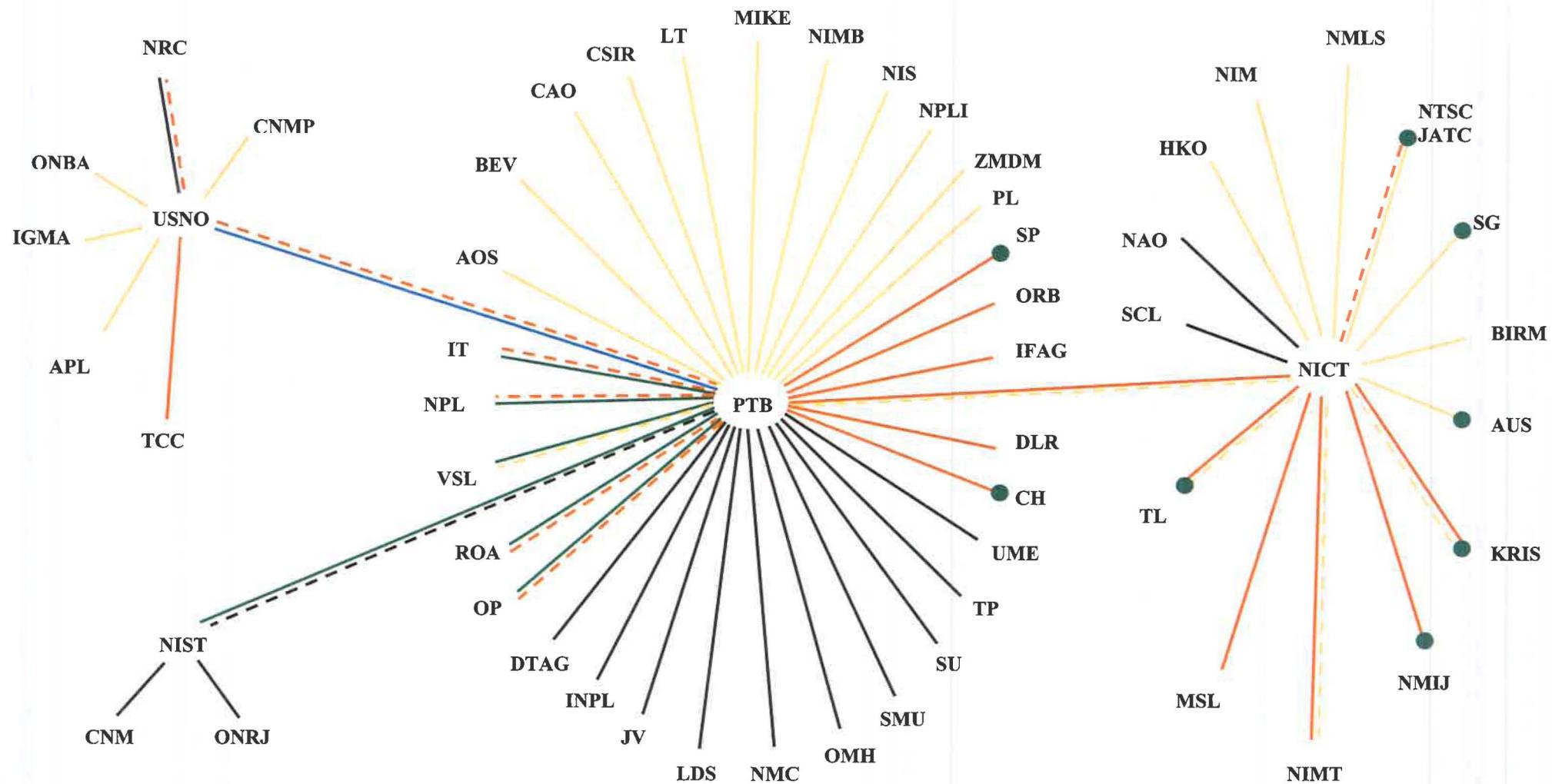
Tables 8 and 9 of this report give the rates relative to TAI and the weights of the clocks contributing to TAI in 2005.

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

The report of the BIPM Time Section for the period July 2004-June 2005, published in the *Director's Report on the Activity and Management of the BIPM*, 2005, 6 is reproduced after the yellow pages. All the publications mentioned in this report are available on request from the BIPM.

### **References**

- [1] C. Thomas and J. Azoubib, TAI computation: study of an alternative choice for implementing an upper limit of clock weights, *Metrologia*, 1996, **33**, 227-240.
- [2] J. Azoubib, A revised way of fixing an upper limit to clock weights in TAI computation, *Report to the 15th meeting of the CCTF*, available on request.
- [3] B. Guinot, Atomic time scales for pulsar studies and other demanding applications, *Astron. Astrophys.*, 1988, **192**, 370-373.



## ORGANIZATION OF THE INTERNATIONAL TIME LINKS

April 2006

- Laboratory equipped with TWSTFT (not yet used)
- TWSTFT by Ku band with X band back-up
- TWSTFT link
- GPS CV single-channel link
- - - GPS CV single-channel back-up link
- GPS CV multi-channel link
- GPS CV multi-channel back-up link
- GPS CV dual frequency link
- GPS CV dual frequency back-up link



## *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 300 horloges atomiques conservées par environ 65 laboratoires répartis dans le monde entier, et fournies régulièrement au BIPM par environ 55 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 juliannes 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], [2] produit une échelle atomique libre, EAL, définie comme étant une moyenne pondérée de lectures d'horloges (jusqu'en 1997 des blocs de deux mois étaient utilisés). Le choix de la pondération et du mode de prédiction de fréquence optimise la stabilité de l'EAL à long terme. Il n'est pas tenté d'assurer la conformité de l'intervalle unitaire de l'EAL avec la seconde du Système international d'unités.

### **2. Exactitude**

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

### **3. Disponibilité**

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

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

### **4. Liaisons horaires**

Le BIPM organise le réseau international de comparaisons horaires selon un schéma en étoile au niveau des continents, et en liaisons à longue distance. En 2005, le système des liaisons horaires utilisé par le BIPM était non-redondant et reposait sur l'observation des satellites du GPS en vues simultanées et sur la technique d'aller et retour sur satellite de télécommunications (TWSTFT).

*La plupart des liaisons se fait par vues simultanées des satellites du GPS. Des données acquises avec des récepteurs GPS de type géodésique, multi-canaux et bi-fréquence sont utilisées régulièrement dans le calcul des liaisons horaires, en addition à celles avec des récepteurs monofréquence traditionnels (mono et multi-canaux). Dans les cas où plusieurs techniques participent à une liaison horaire, une d'entre elles est considérée comme étant officielle, et les autres sont calculées pour sauvegarde. Les liaisons par GPS mono-fréquence sont corrigées à l'aide des cartes ionosphériques produites par l'IGS ; toutes les liaisons par GPS sont corrigées en utilisant des éphémérides précises et opérationnelles des satellites produites par l'IGS . L'incertitude de [UTC( $k_1$ ) - UTC( $k_2$ )] est publiée dans la Circulaire T, section 6. 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 Astrogeodynamical Observatory (AOS), Pologne.*

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

## **5. Echelles de temps établies rétrospectivement**

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

### **Notes**

*Les tableaux 8 et 9 de ce rapport donnent les fréquences relatives au TAI et les poids des horloges qui ont contribué au calcul en 2005.*

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

*Le rapport (juillet 2004 - juin 2005) de la section du temps du BIPM publié dans le Rapport du directeur sur l'activité et la gestion du Bureau international des poids et mesures (BIPM), 2005, 6, est reproduit après les pages jaunes. Toutes les publications qui y sont mentionnées sont disponibles sur demande au BIPM.*

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

**Table 1. Relative frequency offsets and step adjustments of UTC,  
up to 31 December 2006**

	Date (at 0h UTC)	Offsets	Steps/s
1961	Jan. 1	$-150 \times 10^{-10}$	
1961	Aug. 1	"	+0.050
1962	Jan. 1	$-130 \times 10^{-10}$	
1963	Nov. 1	"	-0.100
1964	Jan. 1	$-150 \times 10^{-10}$	
1964	Apr. 1	"	-0.100
1964	Sep. 1	"	-0.100
1965	Jan. 1	"	-0.100
1965	Mar. 1	"	-0.100
1965	Jul. 1	"	-0.100
1965	Sep. 1	"	-0.100
1966	Jan. 1	$-300 \times 10^{-10}$	
1968	Feb. 1	"	+0.100
1972	Jan. 1	0	-0.107 7580
1972	Jul. 1	"	-1
1973	Jan. 1	"	-1
1974	Jan. 1	"	-1
1975	Jan. 1	"	-1
1976	Jan. 1	"	-1
1977	Jan. 1	"	-1
1978	Jan. 1	"	-1
1979	Jan. 1	"	-1
1980	Jan. 1	"	-1
1981	Jul. 1	"	-1
1982	Jul. 1	"	-1
1983	Jul. 1	"	-1
1985	Jul. 1	"	-1
1988	Jan. 1	"	-1
1990	Jan. 1	"	-1
1991	Jan. 1	"	-1
1992	Jul. 1	"	-1
1993	Jul. 1	"	-1
1994	Jul. 1	"	-1
1996	Jan. 1	"	-1
1997	Jul. 1	"	-1
1999	Jan. 1	"	-1
2006	Jan. 1	"	-1



**Table 2. Relationship between TAI and UTC, up to 31 December 2006**

Limits of validity (at 0h UTC)	[TAI - UTC] / s
1961 Jan. 1 - 1961 Aug. 1	1.422 8180 + (MJD - 37300) × 0.001 296
1961 Aug. 1 - 1962 Jan. 1	1.372 8180 + " "
1962 Jan. 1 - 1963 Nov. 1	1.845 8580 + (MJD - 37665) × 0.001 1232
1963 Nov. 1 - 1964 Jan. 1	1.945 8580 + " "
1964 Jan. 1 - 1964 Apr. 1	3.240 1300 + (MJD - 38761) × 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) × 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 - 2006 Jan. 1	32
2006 Jan. 1 -	33



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

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

(1) Change to INRIM (Istituto Nazionale di Ricerca Metrologica) with acronym IT.

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

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

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

**Table 4. Equipment and source of UTC(k) of the laboratories contributing to TAI in 2005**

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

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links			
				GPS		GLONASS	Two-Way
				SF	DF		
AOS	1 Ind. Cs	1 Cs + microphase-stepper		*		*	
APL	3 Ind. Cs 3 H-masers	1 Cs + microphase-stepper		*			
AUS	11 Ind. Cs 4 H-masers 1 Linear Ion Trap Standard (2)	1 Cs		*	*		*
BEV	3 Ind. Cs 2 Ind. Rb	1 Cs		*			
BIRM (a)	2 Ind. Cs 3 H-masers	1 Cs		*		*	
CAO (a)	2 Ind. Cs	1 Cs		*	(3)		
CH	4 Ind. Cs (4) 1 H-maser	all the Cs 1 H-maser	*		*		*
CNM	3 Ind. Cs 1 H-maser	1 Cs		*			
CNMP	2 Ind. Cs	1 Cs		*			
CSIR	2 Ind. Cs	1 Cs		*		*	
DLR	2 Ind. Cs 4 H-masers	1 Cs				*	
DTAG	3 Ind. Cs	1 Cs		*			
HKO	2 Ind. Cs	1 Cs		*			
IEN	4 Ind. Cs 2 H-masers 1 Lab.Cs	1 Cs + microphase-stepper		*	*	*	*
IFAG	5 Ind. Cs 3 H-masers	1 Cs + microphase-stepper		*	*		
IGMA (a)	3 Ind. Cs	1 Cs + microphase-stepper		*			
INPL	2 Ind. Cs	1 Cs		*			
JATC	9 Ind. Cs (5) 4 H-masers	1 H-maser + microphase-stepper	*	*	*	*	*
JV (a)	4 Ind. Cs	1 Cs		*	(6)		

**Table 4. Equipment and source of UTC(k) of the laboratories contributing to TAI in 2005. (Cont.)**

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

Lab k	Equipment	Source of UTC(k) (1)	TA(k)	Time Links			
				GPS		GLONASS	Two-Way
				SF	DF		
KRIS	5 Ind. Cs 3 H-masers	1 H-maser + microphase-stepper	*	*	*	*	*
LDS	1 Ind. Cs	1 Cs		*		*	
LT	1 Ind. Cs	1 Cs		*			
MIKE	2 Ind. Cs 2 H-masers	1 H-maser + microphase-stepper		*	*	*	
MSL	3 Ind. Cs	1 Cs		*	*	*	
NAO	4 Ind. Cs 1 H-maser	1 Cs + microphase-stepper		*			
NICT	24 Ind. Cs 4 H-masers 1 Lab. Cs	18 Cs		*	*	*	*
NIM	3 Ind. Cs	1 Cs + microphase-stepper		*			
NIMB	2 Ind. Cs	1 Cs		*			
NIMT	1 Ind. Cs	1 Cs		*	*		
NIS	3 Ind. Cs	1 Cs		*	*	*	
NIST	5 Ind. Cs 1 Lab. Cs 6 H-masers	4 Cs 5 H-masers		*	*	*	*
NMC	1 Ind. Cs	1 Cs		*			
NMIJ	4 Ind. Cs 1 Lab. Cs 2 H-masers	1 Cs + microphase-stepper		*	*		*
NMLS	5 Ind. Cs	1 Cs			*	*	
NPL	2 Ind. Cs 3 H-masers	1 H-maser		*	*		*
NPLI	3 Ind. Cs	1 Cs		*		*	
NRC	2 Ind. Cs 2 Lab. Cs 3 H-masers	1 Lab. Cs + microphase-stepper		*	*		*
NTSC	14 Ind. Cs 4 H-masers	1 H-maser + microphase-stepper		*	*	*	*

**Table 4. Equipment and source of UTC(k) of the laboratories contributing to TAI in 2005 (Cont.)**

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

**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 2005):
- |   |                  |
|---|------------------|
| <ul style="list-style-type: none"> <li>* National Measurement Institute (NMIA, Sydney)</li> </ul> | 4 Cs, 2 H-masers |
|---|------------------|
- Australian laboratories intercompared by GPS are:
- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>* National Measurement Institute, Melbourne branch (NMIA, Melbourne)</li> <li>* Telstra Corporation Ltd (Melbourne)</li> <li>* Geoscience Australia, Yarragadee Observatory (Yarragadee, Western Australia)</li> <li>* Canberra Deep Space Communication Complex (CDSCC, Canberra)</li> </ul> | 1 Cs<br>3 Cs<br>1 Cs<br>1 Cs, 2 H-masers<br>1 Linear Ion Trap Standard (LITS) |
|--|---|
- (3) CAO From Feb 2005 the gps receiver used is a multichannel TTS-2.
- (4) CH All the standards are located in Bern at METAS (METrology and Accreditation Switzerland, situation at the end of 2005).
- (5) JATC The standards are located at National Time Service Center, (NTSC).  
The link between UTC(JATC) and UTC(NTSC) is obtained by internal connection.
- (6) JV GPS single frequency reception, all satellites in view.
- (7) OP The French atomic time scale TA(F) is computed by the LNE-SYRTE with data from 25 industrial caesium clocks located as follows (at the end of 2005) :
- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>* Centre Electronique de l'Armement (CELR, Rennes)</li> <li>* Centre National d'Etudes Spatiales (CNES, Toulouse)</li> <li>* France Telecom Recherche et Developpement (Lannion)</li> <li>* Agilent Technologies France (Massy)</li> <li>* Observatoire de la Côte d'Azur (OCA, Grasse)</li> <li>* Observatoire de Paris (LNE-SYRTE, Paris)</li> <li>* Observatoire de Besançon (OB, Besançon)</li> <li>* Direction des Constructions Navales (DCN, Brest)</li> <li>* Tekelec (Les Ulis)</li> </ul> | 1 Cs<br>3 Cs<br>3 Cs<br>2 Cs<br>2 Cs<br>7 Cs<br>3 Cs<br>3 Cs<br>1 Cs |
|--|--|
- All laboratories are linked via GPS receivers.
- (8) PL The Polish official scale UTC(PL) is maintained by the GUM.
- (9) PL The Polish atomic time scale TA(PL) is computed by the AOS and GUM with data from 10 caesium clocks and 2 hydrogen masers located as follows:
- |   |                         |
|---|-------------------------|
| <ul style="list-style-type: none"> <li>* Central Office of Measures (GUM, Warsaw)</li> <li>* Astrogeodynamical Observatory, Space Research Center P.A.S. (AOS, Borowiec)</li> </ul> | 3 Cs, 1 H-maser<br>1 Cs |
|---|-------------------------|

**Notes (Cont.)**

* National Institute of Telecommunications (IŁ, Warsaw)	2 Cs
* Research & Development Centre of the Polish Telecom (CBR, Warsaw)	2 Cs
* 1st Specialized Metrology Center of Polish Air Forces (1\$OM, Warsaw)	1 H-maser
* Military Primary Standards Laboratory (COMW, Zielonka)	1 Cs
* Time and Frequency Standard Laboratory of the Semiconductor Physics Institute, a guest laboratory from Lithuania (LT, Vilnius, Lithuania)	1 Cs

All laboratories are linked via MC GPS-CV receivers.

- (10) PTB The laboratory Cs, PTB CS1, PTB CS2 and PTB CS3, are operated continuously as clocks. The uncertainty of PTB CS3 is no longer evaluated, so that PTB CS3 is no longer a primary clock. PTB CSF1 is a fountain frequency standard using laser cooled caesium atoms. It is intermittently operated as a frequency standard. Contributions to TAI are made through comparisons with one of PTB's hydrogen masers.  
Until further notice, TA(PTB) and UTC(PTB) are derived from PTB CS2, TA(PTB) directly, UTC(PTB) including steering.
- (11) PTB TA(PTB)-UTC(PTB) and the frequency steering applied to UTC(PTB) are published in PTB Time Service Bulletin.
- (12) SP The standards are located as follows (at the end of 2005):
- |   |                  |
|---|------------------|
| * Swedish National Testing and Research Institute (SP, Borås) | 4 Cs, 1 H-maser  |
| * STUPI AB (Stockholm)  | 4 Cs, 2 H-masers |
| * Pendulum Instruments AB (Stockholm)                         | 1 Cs             |
| * Onsala Space Observatory (Onsala)                           | 1 H-maser        |
- (13) SU  $TA(SU)-UTC(SU) = 29.172\ 759\ 000\ s$  from MJD 53004 to 53368,  
 $TA(SU)-UTC(SU) = 29.172\ 758\ 840\ s$  from MJD 53369.
- (14) USNO The time scales A.1(MEAN) and UTC(USNO) are computed by USNO. They are determined by a weighted average of Cs clocks and H-masers located at the USNO. A.1(MEAN) is a free atomic time scale, while UTC(USNO) is steered to UTC. Included in the total number of USNO atomic standards are the clocks located at the USNO Alternate Master Clock in Colorado Springs, CO.
- (15) VSL GPS dual frequency results from geodetic Topcon 40 channel receiver, but not in CGGTTS format.
- (a) Information based on the Annual Report for 2004, not confirmed by the laboratory.

**Table 5. Differences between the normalized frequencies of EAL and TAI, up to May 2006**

(File available on <http://www.bipm.org> under the name EALTAI05.AR, which contains values since the beginning of the steering)

Date	MJD	[f(EAL) - f(TAI)] × 10 <sup>-13</sup>
1996 Apr 26 - 1996 Jun 30	50199 - 50264	7.32
1996 Jun 30 - 1996 Aug 29	50264 - 50324	7.31
1996 Aug 29 - 1996 Oct 28	50324 - 50384	7.295
1996 Oct 28 - 1996 Dec 27	50384 - 50444	7.280
1996 Dec 27 - 1997 Feb 25	50444 - 50504	7.265
1997 Feb 25 - 1997 Apr 26	50504 - 50564	7.250
1997 Apr 26 - 1997 Jun 30	50564 - 50629	7.230
1997 Jun 30 - 1997 Aug 29	50629 - 50689	7.210
1997 Aug 29 - 1997 Oct 28	50689 - 50749	7.190
1997 Oct 28 - 1997 Dec 27	50749 - 50809	7.170
1997 Dec 27 - 1998 Jan 31	50809 - 50844	7.160
1998 Jan 31 - 1998 Feb 25	50844 - 50869	7.150
1998 Feb 25 - 1998 Mar 27	50869 - 50899	7.140
1998 Mar 27 - 1999 Feb 25	50899 - 51234	7.130
1999 Feb 25 - 1999 Dec 27	51234 - 51539	7.140
1999 Dec 27 - 2000 May 30	51539 - 51694	7.130
2000 May 30 - 2000 Sep 27	51694 - 51814	7.120
2000 Sep 27 - 2000 Nov 26	51814 - 51874	7.110
2000 Nov 26 - 2001 Jan 30	51874 - 51939	7.100
2001 Jan 30 - 2001 Apr 30	51939 - 52029	7.090
2001 Apr 30 - 2001 Jul 29	52029 - 52119	7.080
2001 Jul 29 - 2001 Sep 27	52119 - 52179	7.070
2001 Sep 27 - 2001 Nov 26	52179 - 52239	7.060
2001 Nov 26 - 2002 Jan 30	52239 - 52304	7.050
2002 Jan 30 - 2002 Mar 31	52304 - 52364	7.040
2002 Mar 31 - 2002 Jun 30	52364 - 52424	7.030
2002 Jun 30 - 2002 Jul 29	52424 - 52484	7.020
2002 Jul 29 - 2002 Sep 27	52484 - 52544	7.010
2002 Sep 27 - 2002 Nov 26	52544 - 52604	7.000
2002 Nov 26 - 2003 Jan 30	52604 - 52669	6.990
2003 Jan 30 - 2003 Mar 31	52669 - 52729	6.980
2003 Mar 31 - 2003 May 30	52729 - 52789	6.970
2003 May 30 - 2003 Aug 28	52789 - 52909	6.960
2003 Sep 27 - 2003 Nov 26	52909 - 52969	6.950
2003 Nov 26 - 2004 Jan 30	52969 - 53034	6.940
2004 Jan 30 - 2004 Mar 30	53034 - 53094	6.930
2004 Mar 30 - 2004 May 29	53094 - 53154	6.920
2004 May 29 - 2004 Jun 28	53154 - 53184	6.910
2004 Jun 28 - 2004 Jul 28	53184 - 53214	6.904
2004 Jul 28 - 2004 Dec 30	53214 - 53369	6.899
2004 Dec 30 - 2005 Feb 28	53369 - 53429	6.895
2005 Feb 28 - 2005 Mar 30	53429 - 53459	6.891
2005 Mar 30 - 2005 Apr 29	53459 - 53489	6.888
2005 Apr 29 - 2005 May 29	53489 - 53519	6.886
2005 May 29 - 2005 Jun 28	53519 - 53549	6.884
2005 Jun 28 - 2005 Jul 28	53549 - 53579	6.878
2005 Jul 28 - 2005 Aug 27	53579 - 53609	6.876
2005 Aug 27 - 2005 Sep 26	53609 - 53639	6.870
2005 Sep 26 - 2005 Oct 31	53639 - 53674	6.868
2005 Oct 31 - 2005 Nov 30	53674 - 53704	6.862
2005 Nov 30 - 2005 Dec 30	53704 - 53734	6.856
2005 Dec 30 - 2006 Jan 29	53734 - 53764	6.850
2006 Jan 29 - 2006 Feb 28	53764 - 53794	6.844
2006 Feb 28 - 2006 Mar 30	53794 - 53824	6.838
2006 Mar 30 - 2006 Apr 29	53824 - 53854	6.832
2006 Apr 29 - 2006 May 29	53854 - 53884	6.826

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

**Table 6. Measurements of the duration of the TAI scale interval**(File available on <http://www.bipm.org> under the name UTAI05.AR)

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

In this table,  $d$  is obtained on the given periods of estimation by comparison of the TAI frequency with that of the individual primary frequency standards (PFS) IEN-CSF1, NICT-O1, NIST-F1, NMIJ-F1, PTB-CS1, PTB-CS2, SYRTE-FO2, and SYRTE-JPO for the year 2005.

Previous calibrations are available in the successive annual reports of the BIPM Time Section volumes 1 to 17.

Each comparison is provided with the following information:

$u_A$  is the uncertainty originating in the instability of the PFS,

$u_B$  is the combined uncertainty from systematic effects,

Ref( $u_B$ ) is a reference giving information on the stated value of  $u_B$ ,

$u_{\text{link/lab}}$  is the uncertainty in the link between the PFS and the clock participating to TAI, including the uncertainty due to dead-time,

$u_{\text{link/TAI}}$  is the uncertainty in the link to TAI,

$u$  is the quadratic sum of all four uncertainty values.

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

The typical characteristics of the calibrations of the TAI frequency provided by the different primary standards over 2005 are indicated below.

Primary Standard	Type /selection	Type B std. Uncertainty	Operation	Comparison with	Number/typical duration of comp.
IEN-CSF1	Fountain	$(0.6 \text{ to } 1.1) \times 10^{-15}$	Discontinuous	H maser	4 / 10 to 40 d
NICT-01	Beam /Opt.	$6 \times 10^{-15}$	Discontinuous	UTC(NICT)	2 / 10 d
NIST-F1	Fountain	$0.3 \times 10^{-15}$	Discontinuous	H maser	3 / 30 to 40 d
NMIJ-F1	Fountain	$4 \times 10^{-15}$	Discontinuous	H maser	3 / 10 d
PTB-CS1	Beam /Mag.	$8 \times 10^{-15}$	Continuous	TAI	12 / 30 d
PTB-CS2	Beam /Mag.	$12 \times 10^{-15}$	Continuous	TAI	12 / 30 d
SYRTE-FO2	Fountain	$(0.6 \text{ to } 0.8) \times 10^{-15}$	Discontinuous	H maser	3 / 15 to 25 d
SYRTE-JPO	Beam /Opt.	$6 \times 10^{-15}$	Discontinuous	H maser	11 / 10 to 25 d

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

**Table 6. (Cont.)**

Standard	Period of estimation	$d$ ( $10^{-15}$ )	$u_A$ ( $10^{-15}$ )	$u_B$ ( $10^{-15}$ )	Ref( $u_B$ )	$u_{\text{link/lab}}$ ( $10^{-15}$ )	$u_{\text{link/TAI}}$ ( $10^{-15}$ )	$u$ ( $10^{-15}$ )	Notes
IEN-CSF1	53404 53414	7.9	0.4	1.1	[1]	0.4	3.0	3.2	
IEN-CSF1	53559 53584	6.4	0.4	0.9		0.3	1.2	1.6	
IEN-CSF1	53584 53624	8.0	0.3	0.9		0.5	0.8	1.3	
IEN-CSF1	53639 53664	6.8	0.6	0.6		0.4	1.2	1.5	
NICT-01	53424 53434	10.4	5.7	5.5	[2]	0.0	3.0	8.5	
NICT-01	53469 53479	0.0	5.7	5.5		0.8	3.0	8.5	
NIST-F1	53359 53399	4.9	0.4	0.3	[3]	0.3	0.8	1.0	
NIST-F1	53529 53559	6.3	0.4	0.3		0.2	1.0	1.1	
NIST-F1	53629 53669	4.3	0.3	0.3	[4]	0.3	0.8	0.9	
NMIJ-F1	53549 53559	5.8	1.1	3.8	[5]	0.5	3.0	5.0	(1)
NMIJ-F1	53589 53599	-9.2	1.1	4.0		0.5	3.0	5.1	
NMIJ-F1	53629 53639	-7.2	1.1	4.2		0.5	3.0	5.3	
PTB-CS1	53369 53399	-2.6	5.0	8.0	[6]	0.0	1.0	9.5	(2)
PTB-CS1	53399 53429	-1.3	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53429 53459	3.6	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53459 53489	1.1	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53489 53519	-2.8	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53519 53549	2.8	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53549 53579	3.3	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53579 53609	-4.8	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53609 53639	-1.9	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53639 53674	7.1	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53674 53704	-9.9	5.0	8.0		0.0	1.0	9.5	
PTB-CS1	53704 53734	-1.6	5.0	8.0		0.0	1.0	9.5	
PTB-CS2	53369 53399	3.4	3.0	12.0	[7]	0.0	1.0	12.4	(2)
PTB-CS2	53399 53429	3.7	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53429 53459	3.2	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53459 53489	0.4	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53489 53519	2.1	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53519 53549	2.7	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53549 53579	5.9	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53579 53609	-3.0	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53609 53639	2.2	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53639 53674	2.7	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53674 53704	-0.7	3.0	12.0		0.0	1.0	12.4	
PTB-CS2	53704 53734	4.6	3.0	12.0		0.0	1.0	12.4	
SYRTE-F02	53379 53399	4.6	0.04	0.8	[8,9]	0.1	1.5	1.7	
SYRTE-F02	53489 53504	7.1	0.0	0.7		0.1	2.0	2.1	
SYRTE-F02	53639 53664	4.9	0.1	0.6		0.1	1.2	1.3	
SYRTE-JPO	53479 53489	9.7	0.6	6.3	[10]	0.3	3.0	7.0	
SYRTE-JPO	53489 53509	10.9	0.5	6.3		0.3	1.5	6.5	
SYRTE-JPO	53514 53534	7.6	0.5	6.3		0.3	1.5	6.5	
SYRTE-JPO	53554 53569	5.1	0.8	6.3		0.3	2.0	6.7	
SYRTE-JPO	53579 53589	0.8	1.0	6.3		0.3	3.0	7.1	
SYRTE-JPO	53594 53609	3.7	0.6	6.3		0.3	2.0	6.6	

**Table 6. (Cont.)**

Standard	Period of estimation	$d$ ( $10^{-15}$ )	$u_A$ ( $10^{-15}$ )	$u_B$ ( $10^{-15}$ )	Ref( $u_B$ )	$u_{\text{link/lab}}$ ( $10^{-15}$ )	$u_{\text{link/TAI}}$ ( $10^{-15}$ )	$u$ ( $10^{-15}$ )	Notes
SYRTE-JPO	53614	53629	5.5	0.6	6.3	0.3	2.0	6.6	
SYRTE-JPO	53644	53654	9.2	0.6	6.3	0.3	3.0	7.0	
SYRTE-JPO	53659	53674	5.5	0.6	6.3	0.3	2.0	6.6	
SYRTE-JPO	53679	53704	11.4	0.9	6.3	0.3	1.2	6.5	
SYRTE-JPO	53709	53724	12.3	1.2	6.3	0.3	2.0	6.7	

**Table 6. (Cont.)****Notes:**

- (1) NMIJ Cs atomic fountain.  
 (2) Continuously operating as a clock participating to TAI.

**References:**

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## Report on the activity of IEN-CsF1 Primary Frequency Standard during 2005

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During 2005, three IEN-CsF1 frequency evaluations were reported to the BIPM. In the table below, a summary of those reports is shown.

CircT	Period (MJD)	Dur.	Local Osc.	yIENCsF1-yTAI	uA	uB	ulab	uTAI
213	53559-53584	25dd	1401102	6.4	0.4	0.9	0.3	1.2
213	53584-53624	40dd	1401102	8.0	0.3	0.9	0.5	0.8
214	53639-53664	25dd	1401102	6.8	0.6	0.6	0.4	1.2

The reference paper for IEN-CsF1 accuracy evaluation procedure is [1]. Further details are reported here.

Quadratic Zeeman shift: before each fountain evaluation run the magnetic field is mapped along the atom flight path, with low frequency ( $\Delta F=0$ ,  $\Delta m=\pm 1$ ) spectroscopy; the field map is then used to estimate the DC Zeeman shift experienced by the atoms. The AC quadratic Zeeman shift generated by the cavity heater was measured to be lower than  $4 \times 10^{-17}$ .

Atomic density shift: IENCsF1 is continuously run alternating a low density state (~9000 s) and an high density state (~1000 s), then the local oscillator frequency is extrapolated to the zero density condition. The collisional shift uncertainty, mainly of type A, is included in the uncertainty of the final linear fit of the measured frequencies; there is an additional type B uncertainty due to the signal stability and to the assumed linearity between density and signal: it is evaluated to be ~15% of the weighted averaged density shift.

Blackbody radiation shift: during 2003, we have recalculated the BBR shift [3] and measured it on the IEN-CsF1 fountain [2]; in 2005 we have measured the DC Stark shift coefficient for the Cs clock transition with a vapour cell frequency standard [5]: our results are in agreement among them, but they do not agree with the value used by other laboratories participating to TAI calibration [4]. Our theoretical and experimental values for  $\beta$  are:

$$\beta_{\text{Exp}} = -1.43(.09) \times 10^{-14} \quad [2]$$

$$\beta_{\text{Theo}} = -1.49(.07) \times 10^{-14} \quad ;[3]$$

$$\beta_{\text{Exp2}} = -1.54(.03) \times 10^{-14} \quad [5]$$

Waiting for a general discussion on these results, and to allow comparison with other frequency standards, the value used during the 2005 evaluations is  $\beta = -1.711(.003) \times 10^{-14}$  [4].

Gravitational shift: the elevation of IEN-CsF1 on the Geoid is measured to be 242.5(.5) m, with the IEN geodetic GPS receiver (which is part of the IGS station network) and with the local Geoid height tabulated by NIMA (EGM96) [6].

Type A uncertainty IEN-CSF1 is generally operated by comparing its frequency with a BVA quartz oscillator phase locked to an H-maser (BIPM code 1401102). The short term stability is limited by the quartz noise at  $3 \times 10^{-13} \tau^{-1/2}$ .

Laboratory link uncertainty: long term stability measurements show that the H Maser (code 1401102) stability is better than fountain stability up to  $10^5$  seconds. During the evaluations performed in 2005, IEN-CSF1 operated with dead time intervals shorter than  $10^5$  seconds and then with negligible added uncertainty. The local link uncertainty is then limited by the H maser to UTC(IEN) transfer measurements in the IEN laboratory. A typical accuracy budget (evaluation period MJD 53154-53174) is reported in the table below:

Effect	Bias ( $\times 10^{-15}$ )	Uncertainty ( $\times 10^{-15}$ )
Quadratic Zeeman (field map)	-46.1	0.1
Blackbody Radiation	29.8	0.1
Collisional (average shift $1.2 \times 10^{-15}$ ) (*)	-	0.2
Gravitational Potential	-26.4	0.1
Others Effects (**)	-	0.5
<b>Total</b>	<b>-42.7</b>	<b>0.6</b>

(\*) collisional shift is continuously corrected; here is taken into account just the type B uncertainty

(\*\*) Including quadratic Zeeman shift from the heater, microwave leakage and other effects.

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### Operation of the LNE-SYRTE primary clocks in 2005

#### Uncertainty budget for uB

In 2005 the fountain clock FO2 has transmitted three calibrations to TAI and caesium beam clock JPO was operational in an almost continuous way since April and have transmitted eleven calibrations to TAI. Evaluations of relative frequency uncertainties  $u_B$  were measured. Particularly the estimation of the quadratic Zeeman, the Blackbody radiations and the Microwave spectrum & leakage effects in FO2 clock were appreciably improved. For quadratic Zeeman effect the phase gradient is minimized at the top of atoms trajectory, for the Blackbody effect the temperature gradient is well controlled inside 0,2K thank to homogeneisation of temperature room, for the Microwave spurious effect the microwave leakage were limited and for the first Doppler effect the minimisation of phase gradient is object of study. Frequency stability of FO2 fountain has shown an appreciable behavior, reaches a stability of  $2,2 \times 10^{-16}$  at 40000s. That results have well consolidated the accuracy budget of FO2 see ref [1] & [2]. Systematic effects shifting the frequency of the primary clocks are listed in Table I for the three published FO2 calibrations over 2005 and see ref [5] for JPO.

Month	January		May		September October	
	Correction	Uncertainty	Correction	Uncertainty	Correction	Uncertainty
Physical origin						
2 <sup>nd</sup> order Zeeman	-1908,66	+/- 0,14	-1908,96	+/- 0,1	-1909,46	+/- 0,07
Blackbody Radiation	168,2	+/- 2,5	170,7	+/- 2,5	168,4	+/- 0,6
Cold Collisions + cavity pulling	347,8	+/- 3,5	289,3	+/- 2,9	9,3	+/- 0,9
Microwave Spurious	0,0	+/- 4,5	0,0	+/- 4,5	0,0	+/- 4,4
First Doppler	0,0	+/- 3,8	0,0	+/- 3,8	0,0	+/- 3,0
others	0,0	+/- 2,0	0,0	+/- 2,0	0,0	+/- 2,0
Total ( $1\sigma$ ) uncertainty $u_B$	7,6		7,3		5,8	

Table I: Accuracy budget of the FO2-CS fountain involved in the 2005 measurements in units  $10^{-16}$ .

#### Evaluation of uA

The short-term frequency instability of the fountain clocks were evaluated throughout 2005 by comparison with an active H maser locked by a BVA quartz oscillator and also by a cryogenic oscillator. Experimentally the relative frequency stability for FO2 was measured to  $\sigma_y(\tau) = 1,1 \cdot 10^{-13} \tau^{-1/2}$  with BVA quartz oscillator and  $\sigma_y(\tau) = 1,6 \cdot 10^{-14} \tau^{-1/2}$  with cryogenic oscillator.

#### Evaluation of ul/lab

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

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### Operation of the NICT primary clocks in 2005

In the first half of 2005, we operated our optically pumped primary frequency standard NICT-O1 and sent the accuracy evaluation report to BIPM twice. In the latter half, its operation had been stopped for a few months because of a renewal of its laser system and a replacement of run out Cs ovens. After the above maintenance, trial run was conducted from October. As a result, we confirmed that there is no observable change in the light shift with the renewal of the laser system. Therefore, we do not change the Type B uncertainty budget shown below [1].

Physical Effect	Bias ( $10^{-15}$ )	Uncertainty ( $10^{-15}$ )
Second-order Doppler	$\delta v_D \sim -260$	2
Second-order Zeeman	$\delta v_{QZ} \sim 1.5 \times 10^5$	0.2
Cavity pulling	$\delta v_C \sim 0$	0.6
Cavity phase	$\delta v_E \sim \pm 160$	3.6
Blackbody	$\delta v_B \sim -20$	0.5
Gravitation	$\delta v_G \sim 8.2$	0.1
Uncorrected biases	0	3.6
Combined Type B Uncertainty		5.5

Table 1: Uncertainty budget for  $\mu\text{B}$

Effect	Uncertainty( $10^{-15}$ )
Magnetic Field Inhomogeneity	0.03
Rabi Pulling	0.02
Ramsey Pulling	0.002
Bloch-Siegert Shift	0.3
Fluorescent Light Shift	0.5
Majorana Transitions	1.3
Collisions	1.7
Beam Flux Variation	0.1
Microwave Leakage	1.0
DC Stark Shift	0.01
Spectral Purity	0.1
Modulation Synchronous Effects	
Detector/ Demodulator	1.5
AM on Laser	1.0
Switching Transients	2.0
Combined Type B Uncertainty	3.6

Table 2: Details on the uncertainty of uncorrected biases

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## Operation of NIST-F1 in 2005

NIST-F1, the Cs fountain primary frequency standard at the National Institute of Standards and Technology (NIST), has been in operation since November 1998, and the first formal report to the BIPM was made in November 1999 [1]. Two new papers updating the operation of NIST-F1 were published in 2005 [2, 3]. During a formal evaluation the average frequency of one of the hydrogen masers at NIST is measured by NIST-F1 and the results, along with all relevant biases and uncertainties, are reported to the BIPM. NIST-F1 is not operated as a clock and is run only intermittently. The standard is constantly evolving, and both hardware and software improvements are continually being made. In most formal evaluations we have used a range of atom densities along with a weighted linear least squares fit to determine the frequency at zero density. The typical frequency shift from the lowest measured density to zero density is now on the order of  $2 \times 10^{-16}$ . Each formal evaluation also includes mapping the magnetic field, and measuring possible biases due to such things as microwave leakage and light leaks.

NIST operates a clock ensemble comprised of five active, cavity tuned hydrogen masers, and four commercial caesium standards. This provides a very stable frequency reference, which allows us to accurately characterize the performance of the reference maser. Since the masers are quite stable, we can tolerate a relatively large amount of fountain dead time [3]. This allows us to use a significantly longer report interval for a given fountain run time in order to reduce the frequency uncertainty introduced by the noise in transferring the result to TAI. Frequency noise in the NIST internal measurement system has an uncertainty well under  $1 \times 10^{-16}$ , and therefore the uncertainty introduced by the dead time dominates the value of  $u_{\text{link/lab}}$ , which ranged from  $1.8 \times 10^{-16}$  to  $3 \times 10^{-16}$  in 2005.

Two formal evaluations were carried out in 2005, one 30 day report interval in July 2005, and a 40 day interval starting in September 2005. Only relatively minor changes have been made to the standard in 2005. These include improvements to the optical detection electronics and low noise quartz local oscillator that resulted in a further improvement in the frequency stability of NIST-F1. This allowed a lower atom density to be used for the same fountain frequency stability. A magnetic field monitor was also added to the software and this has verified that there are no significant changes in the magnetic field during the runs. No change was necessary in the uncertainty of the magnetic field bias. There has also been considerable theoretical and experimental work carried out on biases caused by distributed cavity phase shift, microwave leakage, and spurs [4, 5, 6].

The Type B uncertainties for the two runs in 2005 are given in Table 1 of [2], except that the uncertainty for microwave leakage was reduced from  $2 \times 10^{-16}$  to  $1.4 \times 10^{-16}$  by additional measurements. For both runs the total Type B uncertainty was  $3.1 \times 10^{-16}$ . The Type A uncertainties were  $4.3 \times 10^{-16}$  and  $3.4 \times 10^{-16}$  respectively for the July and September runs (note that the uncertainty for the spin exchange shift is included in the Type A uncertainty). Total uncertainties, including frequency transfer and dead time uncertainties, were  $1.15 \times 10^{-15}$  and  $0.93 \times 10^{-15}$  for the two runs.

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## Operation of NMIJ-F1 Primary Frequency standard in 2005

In 2005, NMIJ started the operation of NMIJ-F1 as a primary frequency standard. The design, the basic performance and the preliminary evaluation of NMIJ-F1 are described in Ref. 1. After this evaluation, some modification was made to NMIJ-F1. The improvement of the microwave synthesizer for the Ramsey interrogation was executed, and also the microwave synthesizer for the state selection was introduced. The resulting uncertainties are larger than the preliminary evaluation [1], because the operational conditions are slightly different from those days. The conditions will be improved and will approach to the best one in the future.

Three measurements were reported and their measurements periods were ten days each. The evaluated uncertainties  $u_A$ ,  $u_{link/lab}$ ,  $u_B$  are described in the following briefly.

### Type A uncertainty $u_A$

The NMIJ-F1 uses an optical molasses to load the atoms, and its frequency stability,  $\sigma_y(\tau)$ , is about  $1 \times 10^{-12} \tau^{1/2}$ . Assuming white FM noise over the comparison period, 10 days, the measurement uncertainty based on the frequency instability is  $1.1 \times 10^{-15}$ .

### Uncertainty of the link in the laboratory $u_{link/lab}$

The uncertainty of the link in the laboratory,  $u_{link/lab}$ , consists of two factors as written in the following equation

$$u_{link/lab} = \sqrt{u_{dead\ time}^2 + u_{link/maser}^2}$$

where  $u_{link/maser}$  is the uncertainty due to the noise of the phase comparator between the fountain and HM,  $u_{dead\ time}$  is the uncertainty due to the operational dead time of the fountain.  $u_{link/maser}$  was  $0.5 \times 10^{-16}$  for 10 days. NMIJ-F1 was operated almost continuously and those efficiencies were over 90 %. The operation was only interrupted sometimes due to earthquakes, electric power failures and so on.  $u_{dead\ time}$  was low level of  $10^{-16}$  for three frequency comparisons of TAI and NMIJ-F1.

### Type B uncertainty $u_B$

The following table shows uncertainty budgets that were used for the frequency comparison during MJD 53589-53599. Type B uncertainty contributed by the 5 factors [1-3] is  $4.0 \times 10^{-15}$ , which is mainly limited by the cold collisional frequency shift.

Source of uncertainty	Bias	Uncertainty
2 <sup>nd</sup> order Zeeman	181.7	2.0
Blackbody radiation	-17.2	0.9
Gravitation	1.6	0.1
Cold collisions	0.0	3.3
Distributed cavity phase	-	1.2
Total	166.1	4.0

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## Operation of the PTB primary clocks in 2005

### PTB's primary clocks with a thermal beam

During 2005, PTB CS1 and CS2 were in continuous clock operation without any modification or (major) disturbance. In the CS1, the beam signal stayed at a lower level than in previous years after the caesium oven nozzle had clogged in April 2005. This explains that  $\sigma_y(\tau=1\text{h}, \text{CS1}) = (90 - 100) \times 10^{-15}$  was measured in the second half of 2005. For PTB CS2, however,  $\sigma_y(\tau=1\text{h}, \text{CS2}) = 65 \times 10^{-15}$  was measured as usual. The frequency instability of the clock signals was checked with an active hydrogen maser as the reference. A long-term analysis of the frequency instability between CS1 and CS2 over 2500 days revealed white frequency noise as the dominant noise source for averaging times up to 300 days [1], which justifies the estimate of the uncertainty contributions  $u_A$  as  $u_A(\tau=30\text{d}, \text{CS1}) = 5 \times 10^{-15}$ , and  $u_A(\tau=30\text{d}, \text{CS2}) = 3 \times 10^{-15}$ .

The clocks' operational parameters were checked periodically and validated to estimate the clock uncertainty. These parameters are the Zeeman frequency, the temperature of the beam tube (vacuum enclosure), the line width of the clock transition as a measure of the mean atomic velocity, the microwave power level, the spectral purity of the microwave excitation signal, and some characteristic signals of the electronics. Reversals of the beam direction were performed on each clock three times, and the end-to-end phase difference determined thereafter exhibited the normal scatter around the long term mean value. No indications were found calling for a modification of the previously stated relative frequency uncertainties,  $u_B$ , which are  $8 \times 10^{-15}$  and  $12 \times 10^{-15}$  for CS1 and CS2, respectively [2]. The clocks have been operated continuously, and time differences UTC(PTB) – clock in the standard ALGOS format have been reported so that  $u_{t/\text{lab}}$  is zero.

### PTB's caesium fountain clock CSF1

Routine operation of CSF1 has not been resumed in 2005. During a joint measurement campaign in October/November 2004 a sudden relative frequency excursion of PTB's CSF1 with respect to FO2 (BNM-SYRTE), CSF1 (IEN), and CsF1 (NPL) of 2 parts in  $10^{14}$  occurred. This could be traced back to a faulty cable in the 5-MHz circuitry. In the course of such studies, the clarification of other open questions seemed more important than resuming routine operation. Therefore, CSF1 was not used as primary frequency standard except for a short period in August 2005 when it served as the primary reference for an optical frequency measurement. For this period  $u_B(\text{CSF1}) = 2.6 \times 10^{-15}$  was estimated which is larger by about a factor 3 than the value reported in previous years, because not all evaluations of systematic effects had been completed.

Several investigations of potential causes of frequency bias in fountain clocks have been completed now and results will be presented during EFTF2006. It is planned that routine operation will be resumed during 2006.

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**Table 7. Mean fractional deviation of the TAI scale interval from that of TT**(File available on <http://www.bipm.org> under the name SITAI05.AR)

The fractional deviation  $d$  of the scale interval of TAI from that of TT (in practice the SI second on the geoid), and its relative uncertainty, are computed by the BIPM for all the intervals of computation of TAI, according to the method described in 'Azoubib J., Granveaud M., Guinot B., *Metrologia* 1977, **13**, pp. 87-93', using all available measurements from the most accurate primary frequency standards IEN-CSF1, NICT-O1, NIST-F1, NMJJ-F1, NPL-CSF1, PTB-CS1, PTB-CS2, PTB-CSF1, SYRTE-FO2, SYRTE-FOM and SYRTE-JPO consistently corrected for the black-body radiation shift.

In this computation, the model for the instability of EAL has been expressed as the quadratic sum of three components: a white frequency noise  $3.0 \times 10^{-15} / \sqrt{\tau}$ , a flicker frequency noise  $0.5 \times 10^{-15}$  and a random walk frequency noise  $1.0 \times 10^{-16} \times \sqrt{\tau}$ , with  $\tau$  in days. The relation between EAL and TAI is given in Table 5.

Month	Interval	$d/10^{-15}$	uncertainty/ $10^{-15}$
Jan. 2003	52639-52669	+9.8	1.3
Feb. 2003	52669-52694	+9.0	1.2
Mar. 2003	52694-52729	+9.0	0.9
Apr. 2003	52729-52759	+9.0	1.1
May 2003	52759-52789	+7.6	1.1
Jun. 2003	52789-52819	+7.0	1.1
Jul. 2003	52819-52849	+8.3	1.2
Aug. 2003	52849-52879	+9.7	1.2
Sep. 2003	52879-52909	+10.2	0.8
Oct. 2003	52909-52939	+9.5	1.1
Nov. 2003	52939-52969	+10.0	1.1
Dec. 2003	52969-53004	+9.4	0.8
Jan. 2004	53004-53034	+8.6	0.9
Feb. 2004	53034-53064	+6.4	0.9
Mar. 2004	53064-53094	+5.5	1.0
Apr. 2004	53094-53124	+4.5	0.8
May 2004	53124-53154	+5.2	0.7
Jun. 2004	53154-53184	+5.7	1.0
Jul. 2004	53184-53214	+3.9	1.1
Aug. 2004	53214-53244	+3.3	1.2
Sep. 2004	53244-53274	+3.4	1.3
Oct. 2004	53274-53309	+3.5	1.2
Nov. 2004	53309-53339	+3.9	0.8
Dec. 2004	53339-53369	+4.5	1.1
Jan. 2005	53369-53399	+4.7	0.8
Feb. 2005	53399-53429	+5.4	1.2
Mar. 2005	53429-53459	+5.4	1.3
Apr. 2005	53459-53489	+5.5	1.3
May 2005	53489-53519	+5.9	1.1
Jun. 2005	53519-53549	+6.0	1.0
Jul. 2005	53549-53579	+5.2	0.8
Aug. 2005	53579-53609	+5.4	0.9
Sep. 2005	53609-53639	+5.0	0.9
Oct. 2005	53639-53674	+5.0	0.7
Nov. 2005	53674-53704	+4.4	1.4
Dec. 2005	53704-53734	+4.0	1.7

### **Independent local atomic time scales**

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

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

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

### **Local representations of UTC**

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

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

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

**International GPS and GLONASS Tracking Schedules**(Files available on <http://www.bipm.org>)

GPS Schedule no 44 File SCHGPS.44	implemented on MJD = 53461 (2005 April 1) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GPS Schedule no 45 File SCHGPS.45	implemented on MJD = 53642 (2005 September 29) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 19 File SCHGLO.19	implemented on MJD = 53461 (2005 April 1) at 0h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 20 File SCHGLO.20	implemented on MJD = 53642 (2005 September 29) at 0h UTC	Reference date MJD = 50722 (1997 October 1)

## Relations of UTC and TAI with GPS time and GLONASS time

(File available on <http://www.bipm.org> under the name UTCGPSGLO05.AR)

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

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

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

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

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

From 2006 January 1, 0h UTC until further notice:

$$[UTC - GPS\ time] = -14\ s + C_0.$$

Here  $C_0$  is given at 0h UTC every day.

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

The standard deviation  $\sigma_0$  characterizes the dispersion of individual measurements for a month. The actual uncertainty of user's access to GPS time may differ from these values.  $N_0$  is the number of measurements.

## **Relations of UTC and TAI with GPS time and GLONASS time (Cont.)**

(File available on <http://www.bipm.org> under the name UTCGPSGLO05AR)

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

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

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

where the time difference 0 s is kept constant by the application of leap seconds so that GLONASS time follows the UTC system, and  $C_1$  is a quantity of the order of several tens 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 2006 January 1, 0h UTC, until further notice:

$$[TAI - GLONASS \text{ time}] = 33 \text{ s} + C_1.$$

Here  $C_1$  is given at 0h UTC every day.

$C_1$  is computed as follows. The GLONASS data recorded at the Astrogeodynamical Observatory, Borowiec, Poland for the highest-elevation satellites are smoothed to obtain daily values of  $[UTC(AOS) - GLONASS \text{ time}]$  at 0h UTC. Daily values of  $C_1$  are then derived by linear interpolation of  $[UTC - UTC(AOS)]$ .

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 standard deviation  $\sigma_1$  characterizes the dispersion of individual measurements for a month. The actual uncertainty of user's access to GLONASS time may differ from these values.  $N_1$  is the number of measurements.

**Table 8A. Rates relative to TAI of contributing clocks in 2005**

(File available on <http://www.bipm.org> under the name RTAI05.AR)

Mean clock rates relative to TAI are computed for one-month intervals ending at the MJD dates given in the table. When an intentional frequency adjustment has been applied to a clock, the data prior to this adjustment are corrected, so that Table 8A gives homogeneous rates for the whole year 2005. For studies including the clock rates of previous years, corrections must be brought to the data published in the Annual Report for the previous years. These corrections are given in Table 8B. Unit is ns/day, " -" denotes that the clock was not used, "\*" denotes that the related rate was influenced by a frequency jump.

The 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	51 DATUM/SYMMETRICOM 4065 B
13 EBAUCHES, OSCILLATOM B5000	23 OSCILLOQUARTZ EUDICS 3020	52 DATUM/SYMMETRICOM 4065 C
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	
15 DATUM/SYMMETRICOM Cs III	35 H-P/AGILENT 5071A High perf.	
4x HYDROGEN MASERS	36 H-P/AGILENT 5071A Low perf.	
9x PRIMARY CLOCKS AND PROTOTYPES	50 FREQ. AND TIME SYSTEMS INC. 4065A	

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
APL	35 904	3.95	4.10	4.85	5.88	4.46	3.86	-	-	4.91	-	4.88	-
APL	35 1264	10.37	10.70	9.53	11.66	9.66	10.31	-	-	-	-	-	-
APL	35 1791	-6.55	-6.70	-6.69	-4.83	-6.72	-5.89	-	-	-4.54	-	-4.68	-
APL	40 3107	-0.90	7.79	14.93	22.04	25.40	28.84	-	-	36.59	-	38.34	-
APL	40 3108	-49.19	-44.61	-39.51	-32.70	-28.32	-22.17	-	-	-1.82	-	12.52	-
APL	40 3109	-	-	-	-	-	-	-	-	-	-	-28.31	-
AUS	36 249	-2.49	-5.42	-6.61	-	-7.19	-4.98	-6.20	-	-	-	-1.74	-5.59
AUS	36 299	19.48	19.20	18.93	19.22	18.89	19.02	17.99	-	-	-	-	-
AUS	36 340	-1.25	-1.73	-1.82	-2.17	-0.28	-0.50	-0.30	-	0.11	-0.69	-2.38	-0.26
AUS	36 654	-18.97	-19.58	-19.47	-19.42	-19.81	-17.55	-17.82	-	-20.17	-18.72	-20.32	-18.53

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
AUS	36 1035	5.42	4.10	4.63	4.60	5.69	2.00	8.06	-	6.66	4.77	25.57	-13.29
AUS	40 5401	29.59	31.15	34.18	28.39	33.31	36.06	34.88	-	36.63	36.96	33.72	-
AUS	40 5402	-	-	-	-	-	8.42	11.48	-	4.49	-0.86	9.00	12.40
AUS	40 5403	1.48	9.50	14.84	-	23.03	21.78	-21.21	-	-	-	-10.09	-21.36
AUS	99 1	19.08	18.99	-	-	39.09	39.34	36.28	-	-	--	8805.37	-6.44
BEV	16 71	87.56	141.38	143.03	101.00	105.18	-	-	-	-	-	-	-
BEV	35 1065	0.13	0.83	-0.67	-0.11	-0.58	-0.34	0.74	0.47	1.54	1.49	2.56	2.72
BEV	35 1793	-1.84*	-1.53*	0.54*	-0.02*	2.27*	1.71*	0.12	-0.61	-0.57	0.19	-0.12	0.11
CAO	35 939	5.49	2.79	3.22	3.19	5.70	2.86	2.84	1.87	2.83	3.14	5.60	3.13
CAO	35 1270	-2.49	-3.47	-4.48	-2.40	-3.88	-4.30	-4.32	-4.78	-3.85	-3.68	-3.26	-3.73
CH	35 771	9.03	8.40	8.53	8.88	8.41	9.43	8.73	8.95	8.64	9.00	8.49	9.39
CH	35 2117	-	-	-	-	0.07	-0.13	1.92	1.03	1.50	1.31	0.37	1.77
CH	36 354	45.96	46.65	45.44	46.46	46.05	44.12	46.16	44.32	45.31	44.86	44.93	43.17
CH	36 413	-	-	-11.15	-14.18	-12.68	-12.74	-11.63	-9.60	-11.80	-13.72	-11.86	-10.27
CH	40 5701	-83.99	-86.04	-87.91	-89.58	-90.92	-92.72	-94.39	-96.05	-97.60	-99.14	-100.31	-101.79
CNM	35 1705	0.03	-0.97	-0.15	0.63	-0.23	-0.81	-0.66	0.29	0.49	0.20	-0.19	0.95
CNM	35 1815	1.42*	0.88*	1.39*	1.16	-0.23	-0.32	0.18	0.08	-0.43	-0.64	-0.46	-0.69
CNM	36 1537	-19.50	-16.30	-17.75	-17.29	-18.00	-17.41	-19.57	-18.74	-19.18	-17.49	-16.57	-17.19
CNM	40 7301	-33.80	-33.89	-36.21	-53.36	-49.47	-53.09	-61.03	-65.22	-61.89	-60.74	-40.95	-41.49
CNMP	36 1752	-4.86	-6.38	-6.92	-7.05	-6.03	-7.48	-5.18	-6.02	-7.00	-5.23	-5.95	-3.91
DLR	35 1714	-1.07	-0.06	-0.35	-1.02	-0.27	0.19	0.06	-0.14	0.83	1.01	-	-
DTAG	36 136	-1.06	-1.96	-3.20	-3.64	-0.30	-4.13	0.44	3.84	3.32	1.14	9.01	4.33
DTAG	36 345	-0.06	-0.42	0.11	-1.95	-2.05	-2.39	-1.91	-1.48	-2.78	-1.24	-0.59	0.11
DTAG	36 465	1.04	1.99	1.62	0.24	-1.89	0.02	-0.52	-1.85	-1.63	-1.56	-1.00	-1.34
F	35 122	13.54	16.24	14.71	14.03	15.39	13.59	14.09	13.82	13.09	-	-	27.58
F	35 124	6.27	6.15	6.74	5.79	6.47	6.22	-	-	-	-	8.77	8.91
F	35 131	15.38	15.48	16.00	15.65	16.04	12.34	12.47	12.15	12.34	12.57	11.96	12.13
F	35 158	16.93	17.08	16.69	16.68	16.03	16.17	17.04	17.53	-	-	-	5.87
F	35 172	8.58	8.23	7.69	8.75	8.55	8.10	7.92	7.48	7.75	7.64	7.70	7.40
F	35 198	5.35	5.30	5.28	5.46	4.31	4.90	5.01	4.27	4.99	3.19	4.98	5.51
F	35 355	-	-	2.51	2.55	3.06	2.56	2.46	2.73	-	-	-	-
F	35 385	21.59	22.69	23.06	23.92	23.23	23.55	23.56	24.13	23.50	23.37	22.55	23.68
F	35 396	-	6.04	4.54	5.46	4.72	5.12	4.45	2.92	4.18	4.31	4.48	4.25
F	35 520	13.59	15.13	14.25	-	-	12.95	14.49	12.26	14.67	14.94	14.81	14.21
F	35 536	7.66	7.89	8.48	7.17	8.25	7.98	7.83	7.74	8.49	8.44	8.33	8.60

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
F	35 609	-7.39	-8.68	-7.79	-6.43	-5.48	-8.46	-9.10	-8.57	-8.32	-6.45	-	-
F	35 770	17.84	18.26	18.04	18.21	15.77	16.03	15.85	15.19	14.53	14.96	14.80	14.86
F	35 774	-15.84	-16.38	-	-	-17.69	-17.00	-17.42	-16.88	-16.58	-17.09	-16.91	-16.21
F	35 781	-	9.35	9.67	9.81	10.24	10.18	11.06	9.35	11.26	8.09	10.27	9.70
F	35 819	6.62	7.13	7.48	8.13	9.44	8.93	8.01	-	-	9.92	9.52	9.40
F	35 859	-	-	3.13	2.84	3.34	4.04	3.76	3.21	3.27	3.43	-	-
F	35 1029	14.00	13.35	12.81	-	-	13.99	14.21	13.75	13.55	13.57	13.54	13.26
F	35 1177	-	-	-14.70	-14.52	-14.25	-13.67	-14.45	-14.52	-15.06	-	-	-
F	35 1178	-	-	-	-	-	-	-	-	28.00	27.35	-	-
F	35 1222	6.35	6.82	5.99	5.57	6.37	7.82	6.14	5.64	-	-	-	-
F	35 1321	11.48	11.26	11.82	11.69	12.43	12.19	12.59	12.40	12.72	11.74	12.97	13.89
F	35 1556	-18.29	-18.96	-17.74	-17.23	-16.02	-20.69	-20.12	-20.81	-20.77	-17.87	-17.18	-18.11
F	35 2027	6.13	6.05	6.00	5.83	6.23	6.46	5.63	5.66	5.96	5.53	6.02	5.89
F	40 805	-55.92	-53.79	-51.51	-50.17	-50.06	-	-	-57.68	-58.63	-57.69	-55.07	-48.24
F	40 816	-27.10	-25.97	-25.54	-27.72	-28.72	-	-	-	-31.69	-32.18	-31.34	-29.58
F	40 889	-	-	-	-	-	-	-	-	-	37.66	41.06	43.84
F	40 890	-	-	-	-	-	-	-	-	10.08	11.34	13.02	14.46
HKO	35 1893	5.48	4.79	-3.36	-1.45	-0.51	-0.49	-0.01	-0.10	0.38	-0.44	0.18	0.94
IEN	35 219	15.65	15.38	14.56	13.13	12.14	12.05	11.79	10.75	9.90	10.72	10.61	10.59
IEN	35 505	-7.01	-7.78	-7.03	-9.46	-10.16	-11.01	-10.34	-10.00	-9.70	-10.00	-9.93	-10.17
IEN	35 1115	5.21	5.23	4.95	2.42	-7.63	9.33	16.04	15.40	17.12	13.04	13.70	15.52
IEN	35 1373	-0.85	0.22	-1.29	0.68	-0.71	0.19	0.54	1.85	-1.52	-0.68	13.64	-
IEN	35 2118	-	-	-	-	-	-	11.74	11.37	11.83	12.46	12.88	12.91
IEN	40 1102	-24.87*	-24.04*	-25.47*	-22.09*	-20.61*	-19.50*	-18.31*	-17.07*	-16.19*	-15.13*	-13.64*	-12.80
IFAG	36 1167	-5.43	-3.81	-2.77	-2.08	-3.94	-0.87	0.14	0.40	-0.09	-2.50	-4.57	-1.94
IFAG	36 1173	-7.76	-7.10	-6.48	-6.17	-4.88	-2.10	-0.37	-0.46	-0.84	-3.75	-3.98	-5.15
IFAG	36 1629	5.38	4.06	4.70	7.20	6.84	7.89	7.55	7.64	8.09	7.78	6.69	6.22
IFAG	36 1732	-0.32	-0.23	-0.05	0.69	0.37	-	-	-	-	0.80	0.42	1.22
IFAG	36 1798	-1.86	-0.96	-1.05	-0.28	-0.41	-0.39	-0.20	0.08	0.45	0.60	0.17	0.04
IFAG	40 4401	-	-	-	-	-	-	51.21	58.08	73.33	97.27	97.57	14.57
IFAG	40 4403	-	-	-	-	-	-	-	22.22	41.72	58.97	-	-
IFAG	40 4413	-	-	5.01	11.13	17.42	3.46	-	-	-	-	-	-
IFAG	40 4418	0.35	0.44	0.45	1.36	2.25	1.93	2.04	3.09	3.62	4.38	5.69	7.76
IGMA	16 112	40.31	46.22	41.98	29.02	27.45	-29.45	-	-	-	6.15	-13.86	-0.83
IGMA	35 674	1.13	0.80	1.07	0.65	0.05	0.51	-	1.32	-	-0.98	-0.85	0.15

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
IGMA	35 676	-2.96	-3.06	-2.20	-3.13	-2.73	-4.60	-	-2.75	-	-2.10	-0.72	-1.69
INPL	35 1652	-7.27	-6.91	-7.06	-8.53	-7.06	-2.88	-3.53	-3.43	-2.35	1.85	3.57	4.75
JV	21 216	7.43	9.66	10.53	5.18	1.40	3.83	5.40	4.50	4.30	0.60	1.72	4.61
JV	21 387	6.87	-2.69	-106.18	-369.34	-359.03	-327.77	-302.90	-313.37	-333.50	-384.37	73.06	167.81
JV	36 1277	-19.60	-17.02	-18.62	-19.40	-19.27	-18.72	-18.28	-19.42	-17.90	-19.97	-18.77	-18.97
JV	51 2040	-	-	-	-	-	-	-	-	-	-	-	48.04
KRIS	35 321	-	-	-	-	-	-	-	-	-	-	12.57	11.43
KRIS	35 1693	10.08	9.82	9.61	9.57	9.74	9.14	9.14	8.47	9.12	8.88	9.25	9.23
KRIS	35 1783	-	-	-	-	10.56	11.98	10.35	11.51	12.05	12.58	13.21	13.41
KRIS	36 321	4.51	3.90	-	-	-	-	-	-	-	-	-	-
KRIS	36 739	-11.00	-11.30	-13.20	-14.50	-14.67	-13.51	-13.49	-13.56	-12.50	-12.84	-11.73	-10.36
KRIS	36 1135	31.78	33.38	34.30	34.74	37.26	36.05	37.73	36.79	37.58	34.75	35.97	34.12
KRIS	40 5623	40.39	40.57	40.37	39.76	39.89	39.83	39.79	39.96	40.14	40.26	57.16	69.69
KRIS	40 5624	108.88	114.39	1238.28	111.73	117.92	121.98	127.28	132.25	136.99	141.34	146.27	150.64
KRIS	40 5625	-	-	-	-	-	-	-	-	-	-	18.91	21.65
LDS	35 289	5.69	4.94	7.18	6.49	4.49	6.82	6.50	7.61	6.98	5.51	7.19	5.45
LT	35 1362	28.05*	29.83*	30.67*	28.69*	28.83*	31.98*	33.89*	33.18*	30.84*	30.27	19.79	12.22
MIKE	35 1171	-	-	-	-	95.91	25.54	-	-	-	-	-	-
MIKE	36 986	-	-	-	-	101.80	-4.60	-4.46	-13.02	-18.60	-	-	-
MIKE	40 4113	-	-	-	-	96.26	-	-	-	-	-	-	-
MIKE	40 4180	-	-	-	-	103.58	-0.47	-0.04	0.10	-0.38	-	-	-
MSL	12 933	11.90	0.39	2.89	-4.29	-2.03	-1.18	-3.91	2.59	-11.25	-7.03	-9.16	-4.79
MSL	36 274	7.35	-61.54	5.00	7.47	5.20	6.55	4.96	2.35	6.23	7.28	4.79	5.98
MSL	36 1025	3.43	7.08	5.30	6.11	4.53	-0.31	2.04	5.99	7.02	5.52	5.63	6.08
NAO	35 779	3.29	3.20	3.34	3.53	4.29	4.12	4.22	4.39	4.28	3.98	5.54	4.50
NAO	35 1206	18.15	17.39	16.75	16.94	17.02	16.85	16.28	17.03	16.28	16.86	17.11	16.74
NAO	35 1214	1.44	2.58	2.19	1.71	2.47	1.91	1.97	2.83	2.49	2.56	2.57	2.86
NAO	35 1689	0.02	-0.61	-0.43	-0.48	0.08	-0.18	-0.39	-0.23	-	9.32	-	-
NICT	35 112	1.39	1.33	1.19	0.95	0.32	1.77	0.90	0.97	1.42	1.08	1.19	1.10
NICT	35 144	-19.23	-19.44	-20.75	-18.17	-16.42	-16.71	-16.78	-16.58	-16.42	-15.93	-15.61	-15.65
NICT	35 332	14.67	14.33	13.98	13.81	14.73	15.30	14.84	14.73	16.12	16.85	17.08	15.79
NICT	35 342	7.51	8.40	8.94	8.60	8.20	9.54	8.90	9.06	9.44	9.30	9.36	9.51
NICT	35 343	15.29	15.34	14.92	14.49	14.02	14.36	14.60	14.46	13.74	13.48	12.99	13.51
NICT	35 715	8.61	8.52	8.67	8.56	8.90	8.91	8.87	9.78	10.79	12.14	12.71	14.39
NICT	35 732	2.67	4.31	5.02	4.26	2.73	3.35	2.40	4.05	3.30	3.41	2.98	2.64

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
NICT	35 907	-11.43	-10.84	-10.58	-11.36	-11.38	-11.40	-10.66	-10.87	-10.07	-10.30	-10.45	-11.08
NICT	35 908	12.14	-	-	-	9.37	9.19	8.34	9.06	10.46	10.28	10.84	10.42
NICT	35 1778	11.91	11.95	13.27	13.46	14.42	13.73	13.37	13.74	13.85	14.05	14.16	13.64
NICT	35 1789	8.86	9.18	9.30	9.41	10.03	10.28	10.76	10.13	10.08	9.76	9.97	9.36
NICT	35 1790	-4.11	-3.79	-4.07	-4.26	-5.05	-4.51	-4.12	-3.73	-3.68	-3.97	-3.68	-3.59
NICT	35 1882	54.06	54.33	54.78	55.05	55.02	55.34	55.21	55.65	55.75	57.04	57.70	57.93
NICT	35 1887	25.20	24.25	24.91	25.02	24.28	25.12	24.75	24.89	24.35	24.86	24.99	24.72
NICT	35 1944	-	-	7.22	7.23	7.92	7.49	6.76	7.00	6.61	6.71	6.59	6.24
NICT	35 2056	-	-	-	9.43	8.85	8.99	9.12	9.48	9.17	8.85	9.26	8.82
NICT	35 2113	-	-	-	-22.92	-25.07	-25.21	-24.86	-25.10	-24.94	-24.69	-24.48	-23.72
NICT	35 2116	-	-	-	11.81	9.74	8.19	6.81	6.89	6.60	6.57	6.77	7.13
NIM	35 479	4.41	4.69	4.32	3.29	3.63	3.71	1.47	4.15	2.39	1.98	3.27	4.31
NIM	35 1238	3.97	3.45	4.26	3.95	3.97	4.29	3.80	4.86	5.40	3.40	5.57	4.06
NIM	35 1239	4.33	4.11	3.93	3.52	3.32	2.98	1.45	3.85	2.55	2.67	7.30	3.83
NIM	40 4814	-	-	-	-	-	-	-	-	-	-0.05	7.23	6.16
NIM	40 4832	-	-	-	-	-	-	-	-	-	20.59	20.66	20.55
NIMB	35 600	-	-	-	-19038.71	-0.03	-3.64	-0.86	-0.75	-0.96	-2.24	-1.62	-1.44
NIS	35 1126	-	-	-	-	-	-	-	-	-2.78	-0.23	0.43	0.37
NIST	15 9866	-54.39	-	-56.50	-	-	-	-	20.68	28.36	31.95	30.53	23.24
NIST	35 132	-1.72	-1.55	-1.52	-2.04	-2.42	-1.70	-2.06	-2.10	-1.38	-2.65	-3.16	-2.83
NIST	35 182	-10.14	-10.57	-9.90	-10.30	-10.23	-10.48	-10.23	-10.41	-10.46	-10.03	-10.88	-9.96
NIST	35 282	-	-	-	-	-	-	-	-	1.94	1.32	1.98	6.54
NIST	35 408	-0.54	-0.78	-1.48	-0.35	-0.75	-1.40	-1.51	-1.70	-0.91	-1.29	-0.75	-0.88
NIST	35 1074	-16.08	-15.59	-16.22	-16.42	-16.79	-16.57	-16.64	-16.74	-16.29	-16.14	-15.46	-14.87
NIST	35 2031	-	-	-	-	-	-	-	-	-2.14	-1.48	-0.61	-2.63
NIST	35 2032	-	-	-	-	-	-	-	-	-10.99	-10.41	-9.64	-9.69
NIST	35 2034	-	-	-	-	-	-	-	-	-21.27	-20.82	-21.16	-21.90
NIST	40 201	21.93	23.00	23.79	7.66	25.79	26.74	27.71	29.11	30.14	31.17	32.11	32.94
NIST	40 203	61.87	62.27	63.67	65.16	66.84	68.29	69.71	71.05	72.32	73.75	75.26	76.56
NIST	40 204	14.86	15.13	15.28	15.39	15.78	15.87	15.85	15.98	16.16	16.77	17.07	17.33
NIST	40 205	-25.68	-25.41	-25.58	-25.56	-25.51	-25.63	-25.80	-25.92	-26.03	-25.97	-25.98	-25.93
NIST	40 222	-4.41	-3.89	-3.53	-2.99	-2.40	-1.93	-1.37	-0.71	-0.20	0.48	1.29	2.10
NMC	35 1501	-2.34	-0.70	-2.53	-3.62	-3.55	-2.77	-1.59	-3.00	-2.73	-0.48	-	-3.60
NMIJ	35 224	-16.54	-16.53	-16.98	-16.56	-17.14	-17.39	-17.71	-	-11.91	-12.42	-12.54	-
NMIJ	35 459	-0.14	0.43	-0.16	0.10	0.08	0.44	-0.47	-0.14	0.34	0.70	0.05	-

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
NMIJ	35 523	-	-	-	-	3.95	10.18	6.91	7.43	7.31	8.26	8.18	-
NMIJ	35 1273	-10.00	-10.28	-11.90	-	-	-	-	-	-	-	-	-
NMIJ	35 1466	9.56	9.30	8.85	8.94	9.09	9.11	10.49	11.88	10.62	10.98	12.66	-
NMIJ	40 5014	1.68	2.08	2.74	2.00	2.37	2.81	3.90	8.56	3.77	2.28	-	-
NMLS	35 165919052.40	-0.82	0.43	-2.22	-2.60	-1.69	-0.37	-0.38	-0.07	-0.62	0.21	-0.53	-
NPL	35 1275	-2.14	-2.38	-2.28	-3.03	-2.83	-3.65	-3.33	-3.59	-4.00	-	-	-
NPL	36 784	-	5.93	-1.42	-1.41	-1.14	-1.23	-2.57	0.01	-0.99	0.69	0.38	0.71
NPL	40 1701	-2.15*	-1.82*	-2.46*	-2.41*	-2.24*	-2.04*	-1.94*	-1.73*	-1.58*	-1.23*	-0.98	-0.76
NPL	40 1708	6.07	6.07	6.35	6.39	6.90	7.10	7.26	6.70	6.96	7.11	7.18	7.06
NPLI	35 725	14.12*	15.63*	15.57	7.16	1.07	0.92	0.98	2.12	2.73	1.72	-3.63	1.20
NRC	35 234	16.78	16.81	16.33	16.30	16.59	17.27	16.66	16.14	17.33	16.49	16.46	17.17
NRC	35 372	21.27	21.95	22.23	20.80	21.34	21.92	21.62	23.06	21.41	21.79	3.13	-
NRC	90 61	0.32	-0.12	-0.56	-0.36	-0.25	-0.38	-0.71	0.21	1.05	0.77	-0.99	0.21
NTSC	35 1007	19.48	18.69	19.74	18.28	19.07	19.70	19.42	19.10	19.06	19.86	18.92	18.75
NTSC	35 1008	-	10.11	10.78	10.28	10.15	8.49	9.13	9.70	11.42	11.28	9.49	9.25
NTSC	35 1011	2.09	2.64	2.07	2.46	3.37	3.29	4.46	3.72	2.77	2.69	3.71	3.98
NTSC	35 1016	14.13	14.48	15.04	15.83	15.37	16.32	16.77	15.95	15.52	15.13	15.10	15.61
NTSC	35 1017	1.53	2.01	2.05	-	2.26	2.56	3.24	2.75	2.53	2.43	2.48	1.57
NTSC	35 1018	12.86	11.50	11.61	11.39	11.80	11.28	10.56	11.48	11.23	11.56	11.98	11.87
NTSC	35 1818	-	-	-32.93	-34.19	-32.28	-32.94	-31.22	-30.70	-29.85	-29.88	-29.77	-29.24
NTSC	35 1820	-7.48	-7.30	-7.46	-7.57	-7.35	-7.48	-7.28	-6.66	-5.79	-6.61	-5.70	-5.96
NTSC	35 1823	2.01	1.80	2.77	2.82	6.03	6.32	11.81	7.90	3.17	2.84	3.45	3.40
NTSC	35 2098	-	-	-	-	-	-	-	-	-	-	-	3.18
NTSC	35 2131	-	-	-	-	-	-	-	-	-	-	-	7.63
NTSC	35 2141	-	-	-	-	-	-	-	-	-	-	-	13.83
NTSC	35 2142	-	-	-	-	-	-	-	-	-	-	-	-13.44
NTSC	35 2144	-	-	-	-	-	-	-	-	-	-	-	-6.53
NTSC	40 226	-75.07	-73.91	-72.49	-70.44	-67.71	-64.82	-61.65	-58.47	-54.80	-	-	-
NTSC	40 227	4.53	11.65	19.35	28.32	38.83	49.46	60.19	69.92	78.09	-	-	-
NTSC	40 4926	-	-	-	-	-	-	-	-	-	-50.84	-46.67	-42.81
NTSC	40 4927	-	-	-	-	-	-	-	-	-	85.49	91.57	96.18
NTSC	40 4945	-	-	-	-	-	-	-	-7.42	-13.80	-32.77	-34.25	-29.77
NTSC	40 4946	-	-	-	-	-	-	-	-9.71	-2.62	2.23	-3.33	2.46
OMH	36 849	1.22	3.74	3.57	1.54	0.68	2.57	3.83	3.15	2.72	3.86	2.62	3.45
ONBA	12 1091	-91.27	19.94	27.26	-4.24	-9.94	0.59	3.27	-6.22	-4.41	-8.51	-17.46	7.81

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
ONRJ	35 1942	-	-	-	-	-	-	-	-	11.17	10.55	10.86	10.79
ORB	35 201	4.74	-	-	-	2.49	0.07	1.13	3.13	-0.03	-0.70	3.95	1.91
ORB	35 202	10.94	5.81	6.62	10.21	8.51	6.68	7.66	7.10	5.40	7.98	8.14	6.41
ORB	35 593	71.01	69.33	73.49	73.12	71.23	72.14	70.81	73.19	73.11	71.72	71.50	76.14
ORB	40 2601	0.33	0.43	0.21	0.57	1.49	0.13	-0.29	-1.03	-1.45	-1.24	0.21	0.10
PL	35 441	1.61	1.88	1.36	1.44	1.77	1.38	1.66	2.64	1.18	1.58	2.04	0.99
PL	35 502	-	-0.30*	-0.66*	-0.01*	0.25*	0.04*	0.23	0.00	-0.22	-0.23	-0.78	-0.09
PL	35 745	-	-	-	-	-	-	-	-0.53	0.26	-0.25	-0.19	-0.48
PL	35 761	-3.26	-4.50	-2.65	-2.69	-3.12	-5.01	-1.58	-2.20	-	-	-	-
PL	35 1120	-	-	-	-	-	3.23	3.21	3.16	3.21	2.86	3.40	3.14
PL	35 1660	0.08	0.02	-0.61	-0.22	-1.40	-0.31	0.89	0.98	0.49	0.68	-0.49	0.40
PL	35 1709	-	-	1.46	1.47	1.30	0.88	1.07	1.03	0.97	1.73	1.08	0.68
PL	35 1746	-0.39	-0.81	0.79	-0.29	0.47	0.28	1.15	0.65	0.65	0.57	0.88	0.29
PL	35 1934	-1.62	-2.01	-1.54	-1.87	-2.10	-2.00	-1.66	-1.94	-1.74	-1.80	-1.74	-1.83
PL	36 1395	-	-	-	-	-	-	-7.30	-	-	-	-	-
PL	40 4002	19.66	-	-	21.63	14.60	-1.87	-0.22	2.72	1.91	-	5.93	8.50
PL	40 4004	0.21*	0.34	1.99	8.96	20.66	12.88	15.15	17.70	32.87	29.23	-	-
PTB	35 128	-2.38	-1.96	-2.71	-2.01	-1.61	-2.57	-2.85	-1.68	-2.33	-1.71	-1.53	-1.79
PTB	35 415	1.37	1.67	3.55	3.45	3.00	4.09	4.31	4.14	3.60	3.29	2.63	2.53
PTB	35 1072	13.71	14.09	13.88	14.09	14.79	14.67	14.90	15.33	14.95	15.22	15.26	14.90
PTB	40 505	1.29	2.06	3.05	-	-	-	-	-	-	-	-	-
PTB	40 510	0.84	0.77	1.59	2.62	2.97	2.40	2.11	3.20	3.37	5.05	-	-
PTB	40 590	24.27	26.43	28.29	30.09	32.11	33.81	35.48	37.08	38.62	40.18	6.16	2.38
PTB	92 1	1.66	1.50	0.99	1.23	1.70	1.14	1.26	2.06	1.80	0.91	2.29	1.59
PTB	92 2	1.18	1.23	1.14	1.38	1.25	1.15	0.88	1.73	1.27	1.25	1.44	0.95
PTB	92 3	-	-	-	-	-	-	-	-	-	3.50	4.04	3.82
ROA	14 1569	33.27	28.36	-	-	-	-	-	-	-	-	-	-
ROA	31 422	-	-	-	-	-44.81	24.26	60.11	57.47	58.90	42.29	9.22	28.67
ROA	35 583	0.80*	1.54*	0.96*	1.39*	2.47*	-1.67*	0.83*	0.64*	0.45*	0.37*	0.37*	1.42
ROA	35 718	-12.29	-11.58	-12.37	-11.21	-12.29	-11.64	-11.87	-12.19	-12.07	-10.06	-9.58	-10.42
ROA	36 1488	8.73	7.68	8.60	8.44	10.14	7.91	8.03	8.21	9.59	8.47	8.72	8.06
ROA	36 1490	8.36	8.20	7.77	8.25	7.48	7.45	9.41	8.42	8.93	7.48	8.27	8.91
ROA	40 1436	-	-	-	-	-	-	-	-	-	-	14.78	-0.96
SCL	35 621	-2.66	-2.46	-2.32	-2.79	-2.99	-2.68	-3.15	-2.95	-2.36	-3.03	-2.48	-3.35
SCL	35 745	-1.64	-1.52	-1.63	-1.38	-1.01	-	-	-	-	-	-	-

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
SCL	35 1745	-	-	-	-	-	-	-1.54	-1.30	-1.63	-1.02	-1.01	-1.43
SG	35 1035	7.18	6.29	5.03	4.31	3.85	4.43	4.87	5.49	4.70	-	5.08	5.02
SG	35 1127	0.79	0.98	1.56	0.29	0.11	1.26	0.74	0.39	0.42	-	1.25	0.71
SG	36 522	-6.30	-6.40	-6.01	-5.38	-4.06	-5.49	-6.18	-6.72	-5.69	-	-4.12	-5.14
SMU	36 1193	1.81	-0.84	-0.31	0.12	0.66	0.46	-0.45	-0.49	0.26	-0.48	-0.13	-
SP	19 197	-	-	-	-	-62.14	-52.12	-57.31	-60.91	-69.00	-66.64	-67.85	-71.22
SP	35 572	23.42	23.47	23.52	23.01	23.03	22.97	23.29	27.78	-	-	-	-
SP	35 641	7.70	7.56	7.57	7.58	7.79	6.76	7.54	7.27	6.82	7.28	7.00	6.96
SP	35 1188	28.17	29.33	29.02	29.22	29.02	29.35	29.94	29.17	28.90	29.49	26.93	28.27
SP	35 1531	-	-	-	-	-	22.02	21.15	20.24	19.72	20.64	20.37	21.03
SP	35 1642	14.52	15.30	14.82	14.16	14.42	15.13	13.95	14.75	14.84	14.22	14.49	14.67
SP	35 2166	-	-	-	-	-	-	1.05	-0.43	-0.35	-0.71	-0.52	-0.34
SP	36 1175	1.52	1.17	1.26	1.66	2.60	1.79	0.78	2.03	3.07	1.86	1.37	1.91
SP	36 2068	-	-	1.46	1.05	1.42	1.27	1.46	1.19	1.02	1.10	0.94	0.62
SP	40 7201	94.54	97.74	100.57	103.28	106.49	109.52	112.71	116.36	120.07	123.68	127.81	131.62
SP	40 7210	-19.61	-13.93	-9.37	-6.72	-5.16	-2.55	1.98	15.48	12.39	17.82	22.84	27.89
SP	40 7211	-	-	4.10	7.22	9.87	11.78	13.26	15.75	17.69	19.58	21.63	23.57
SP	40 7218	-72.21	-	-	-	-	-	-	-90.74	-92.65	-99.67	-104.52	-109.31
SU	40 3802	1.16	1.77	2.18	2.93	3.43	3.71	4.14	4.62	5.12	5.75	6.15	7.02
SU	40 3803	-40.98*	-40.95*	-41.08*	-41.33*	-41.84*	-41.89*	-42.11	-40.72	-40.52	-40.49	-40.62	-39.33
SU	40 3805	76.55	77.54	78.04	78.77	79.11	79.58	80.04	80.47	80.98	81.59	82.00	82.87
SU	40 3807	-0.71	0.37	0.28	0.28	0.44	1.59	2.43	3.01	3.40	4.54	-	-
SU	40 3810	60.00*	60.47*	60.62*	60.83*	61.07*	61.13*	61.19*	61.27*	61.34*	61.83*	61.68*	62.10
SU	40 3822	17.13	18.71	20.49	22.26	24.33	25.74	27.94	29.84	31.27	33.43	34.84	36.79
SU	40 3825	24.41	26.95	26.46	26.70	27.38	28.12	28.80	29.57	30.81	32.95	34.66	36.25
SU	40 3827	62.26*	64.34	62.16	63.64	66.01	68.82	-	-	66.57	66.65	67.42	66.88
SU	40 3831	32.76*	33.32*	34.27*	34.77*	35.69*	36.24*	39.02*	33.40	33.58	34.20	34.28	35.47
SU	40 3837	45.57	45.50	45.64	46.22	46.63	47.00	47.19	47.60	47.71	48.36	48.44	48.66
TCC	35 768	-0.15	-1.13	-2.58	0.63	-2.29	-3.50	-2.52	-3.30	1.01	-3.21	-5.17	-4.42
TCC	35 1028	-7.15	-6.94	-6.96	-6.13	-5.69	-6.80	-7.28	-7.89	-5.87	-	-8.81	-7.79
TCC	35 1881	-3.51	-3.72	-2.53	-3.19	-3.17	-3.56	-3.12	-3.17	-2.22	-2.58	-0.93	-2.63
TCC	40 8620	-0.95	-0.92	-0.83	-1.17	-1.36	-2.04	-1.73	-2.76	-3.09	-3.72	-4.42	-4.49
TCC	40 8624	0.03	-2.56	-2.92	-3.54	-3.82	-4.67	-4.58	-5.68	-5.91	-6.71	-6.93	-7.70
TL	35 160	-7.14	-6.60	-6.21	-5.59	-5.41	-7.50	-6.40	-5.56	-5.30	-6.33	-6.78	-6.10
TL	35 300	7.69	6.39	6.83	5.63	6.52	4.23	5.81	5.72	6.63	7.05	7.38	7.20

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
TL	35 474	21.50	21.55	21.76	23.18	22.64	21.37	22.54	23.36	22.50	22.51	23.14	22.89
TL	35 809	2.03	2.89	1.24	1.77	1.92	1.54	3.24	3.27	3.33	3.50	3.17	3.32
TL	35 1012	7.91	7.35	8.97	7.72	8.06	4.58	7.10	7.30	6.64	7.78	7.11	6.62
TL	35 1132	-3.24	-2.40	-3.27	-4.02	-2.91	-3.94	-2.33	-2.99	-2.16	-1.51	-3.62	-2.73
TL	35 1498	13.86	14.98	14.46	14.46	14.45	14.48	14.70	14.34	14.67	15.18	15.46	15.41
TL	35 1500	-	-	-	-	-	-	-	-	-	9.38	9.68	9.72
TL	35 1712	1.02	0.97	0.65	0.62	0.89	0.68	1.95	1.38	1.56	1.54	1.35	1.75
TL	40 3052	24.85	26.64	27.80	28.75	30.71	30.55	33.05	34.34	35.65	36.83	38.33	39.45
TL	40 3053	-0.34	0.28	0.25	0.21	0.94	0.04	1.11	1.62	-	-	2.44	2.76
TP	35 163	19.28	18.19	18.93	-	18.82	18.02	17.29	18.34	18.18	17.24	17.71	17.41
TP	35 326	-20.90	-20.50	-21.22	-	-	-	-	-21.71	-21.69	-21.88	-2.71	8.28
TP	35 1227	4.15	3.78	2.30	-	3.55	4.11	5.90	4.20	3.68	-	-	-
TP	36 154	12.21	11.77	11.20	-	13.07	12.52	12.13	11.04	14.09	12.02	13.48	14.04
USNO	15 5561	33.01	32.38	31.40	29.69	28.86	28.60	28.88	28.03	25.26	23.86	21.26	-
USNO	15 5564	-16.74	-15.91	-14.83	-16.14	-16.92	-17.79	-15.14	-15.12	-12.57	-12.87	-12.63	-12.58
USNO	35 101	-6.14	-6.67	-5.53	-5.16	-6.29	-6.13	-7.20	-6.83	-6.05	-5.91	-5.50	-5.61
USNO	35 104	19.31	18.63	19.24	19.05	-	-	-	-	-	-	15.19	15.18
USNO	35 106	-11.09	-10.56	-8.26	-8.86	-5.33	-4.03	-	-	-	-	-	-
USNO	35 108	10.49	10.49	11.71	11.17	9.95	10.71	10.43	11.44	11.25	11.01	10.13	10.94
USNO	35 114	-114.05	-112.91	-109.92	-	-	-	-	-	-	-	-	-
USNO	35 120	1.05	1.77	0.67	1.43	0.73	1.39	1.02	1.87	2.32	2.21	3.07	2.43
USNO	35 142	4.45	4.85	5.13	5.36	6.85	6.53	6.93	5.68	4.66	5.28	5.99	5.79
USNO	35 146	0.99	1.56	0.86	2.13	1.85	1.93	1.95	2.17	0.44	1.15	2.19	1.45
USNO	35 148	15.91	16.19	14.22	16.87	16.97	16.53	14.78	15.72	11.82	11.53	10.54	13.29
USNO	35 150	7.40	8.12	7.16	8.22	8.41	8.63	7.78	9.31	8.52	7.33	8.77	7.97
USNO	35 152	1.26	2.59	1.81	1.94	3.53	-	-	-	4.84	4.20	4.68	5.37
USNO	35 153	-	-	9.41	8.18	7.57	-	-	-	6.99	7.16	7.49	8.95
USNO	35 156	-	-	11.26	10.78	11.49	11.46	11.03	11.44	11.48	11.47	11.59	10.51
USNO	35 161	6.60	7.38	6.98	8.32	8.04	8.37	8.05	8.10	8.70	8.08	-	-
USNO	35 164	4.03	4.52	4.72	5.90	4.86	5.65	6.50	7.92	9.43	9.55	9.83	9.90
USNO	35 165	16.20	16.03	15.59	15.38	15.82	15.69	16.12	15.95	15.43	15.05	15.61	15.16
USNO	35 166	-	-	1.41	0.89	0.44	1.34	0.88	0.44	-0.42	0.89	0.85	1.28
USNO	35 167	5.52	4.70	4.89	4.76	4.95	4.88	4.89	4.57	3.62	3.78	3.63	4.44
USNO	35 169	-7.62	-8.06	-8.44	-7.57	-7.26	-6.96	-7.45	-7.46	-5.78	-5.53	-5.94	-5.82
USNO	35 173	-12.18	-11.78	-11.70	-11.14	-12.03	-12.50	-11.62	-11.63	-11.39	-11.93	-11.30	-11.37

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
USNO	35 213	-	-	-	-	-	0.86	1.09	1.41	2.08	1.93	2.44	1.48
USNO	35 217	-0.64	-	-	-	-	-9.02	-9.75	-11.10	-12.27	-11.78	-12.23	-10.36
USNO	35 225	-1.08	-1.44	-0.64	-0.48	-1.09	-0.80	-0.86	-1.38	-0.89	-0.99	-0.85	-0.67
USNO	35 226	21.85	22.56	21.88	21.96	21.40	21.61	22.01	22.20	21.23	22.75	22.20	21.80
USNO	35 227	7.86	7.71	8.07	8.20	7.93	8.08	8.30	8.22	9.08	8.76	9.16	8.96
USNO	35 229	-	-	-	-	-	-	-	-	10.78	9.94	10.08	10.98
USNO	35 231	-5.28	-6.55	-6.19	-6.28	-6.36	-5.64	-7.87	-6.20	-6.89	-5.82	-5.86	-6.53
USNO	35 233	2.24	2.80	2.19	2.44	2.67	3.42	3.68	3.56	2.79	2.94	2.53	3.43
USNO	35 242	21.16	20.60	21.20	21.45	21.50	21.12	20.04	21.09	20.98	21.12	20.95	22.29
USNO	35 244	19.76	19.39	19.70	18.99	18.88	19.35	20.01	18.77	18.58	19.38	19.38	18.51
USNO	35 249	4.35	4.61	4.91	4.67	5.00	5.13	5.48	4.78	5.00	4.70	4.48	4.95
USNO	35 253	13.38	13.04	13.10	13.15	13.11	12.56	13.81	13.18	13.43	13.80	-	-
USNO	35 254	-	-	-	-	-	11.19	10.87	11.15	11.64	11.80	12.50	12.41
USNO	35 255	5.54	5.16	5.57	6.20	6.09	6.55	6.45	7.08	6.76	8.38	7.09	7.73
USNO	35 256	13.07	13.56	13.38	14.05	13.87	13.65	13.45	13.55	13.74	13.82	13.52	13.90
USNO	35 260	1.28	1.99	2.13	2.26	2.33	2.31	2.68	3.02	3.06	2.93	2.12	3.21
USNO	35 268	1.98	1.29	2.47	2.96	3.88	3.79	3.51	3.01	0.80	2.69	2.09	2.27
USNO	35 270	-11.16	-11.61	-11.49	-11.98	-11.40	-11.15	-11.33	-11.77	-11.38	-11.10	-11.53	-10.87
USNO	35 279	2.49	3.39	2.56	2.90	2.79	3.55	2.23	2.10	3.20	3.18	3.19	3.67
USNO	35 389	-21.34	-21.29	-21.06	-20.17	-20.28	-19.42	-20.32	-18.96	-19.35	-18.92	-19.33	-18.05
USNO	35 392	9.65	9.64	10.12	9.31	9.91	9.51	10.11	9.54	10.13	10.05	10.44	10.46
USNO	35 394	27.05	26.62	26.86	27.47	27.14	27.53	26.93	26.46	26.46	27.25	26.66	26.85
USNO	35 416	-24.52	-25.77	-25.14	-25.56	-25.14	-25.07	-24.69	-26.26	-25.59	-26.49	-25.77	-26.24
USNO	35 417	9.78	9.44	8.70	9.79	9.59	-	-	-	15.98	15.59	15.61	15.18
USNO	35 703	-2.92	-1.43	-1.85	-0.42	-	-	-24.87	-1.21	-0.23	23.11	-3.51	-1.59
USNO	35 717	-14.90	-15.29	-15.42	-15.14	-14.56	-14.83	-14.64	-15.79	-15.36	-14.85	-15.46	-14.76
USNO	35 762	-4.94	-4.57	-4.45	-4.18	-5.44	-4.89	-4.84	-4.60	-4.33	-3.96	-4.55	-4.18
USNO	35 763	-14.89	-15.35	-14.34	-	-	-	-	-	-	-	-	-17.56
USNO	35 765	-6.19	-6.02	-6.21	-5.47	-5.92	-5.95	-6.58	-6.47	-6.77	-6.06	-6.01	-6.42
USNO	35 1096	26.21	26.04	26.09	25.64	26.03	25.89	25.57	25.90	25.80	25.47	25.62	25.94
USNO	35 1125	18.27	18.57	18.17	18.65	18.50	18.74	18.72	19.47	17.91	18.77	19.40	18.37
USNO	35 1327	7.95	6.69	8.31	8.32	8.27	6.98	7.76	6.69	7.40	7.94	7.08	-
USNO	35 1328	5.50	4.90	5.37	5.66	4.89	5.69	6.05	4.93	5.31	5.38	4.77	5.57
USNO	35 1331	-3.33	-3.80	-3.75	-4.14	-	-	-	-	-	-	-	-40.88
USNO	35 1438	2.18	1.35	1.67	0.96	1.55	1.06	1.91	1.50	1.17	1.06	0.92	1.45

Table 8A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
USNO	35 1459	-3.80	-4.81	-4.85	-4.86	-4.18	-5.07	-4.32	-4.09	-4.50	-4.15	-4.98	-4.17
USNO	35 1462	9.57	9.38	10.05	9.88	10.36	10.63	9.89	9.23	9.00	8.92	9.03	8.44
USNO	35 1463	9.73	9.95	10.16	10.33	9.67	9.85	10.25	8.12	6.48	10.03	9.88	8.82
USNO	35 1468	1.57	1.27	0.90	1.86	1.62	1.99	2.18	2.36	2.21	1.49	2.28	3.19
USNO	35 1481	4.55	6.17	5.89	5.93	6.55	6.02	6.01	5.72	6.16	7.34	6.23	5.85
USNO	35 1543	11.97	11.30	10.88	11.31	11.34	10.41	11.53	10.92	11.12	11.06	11.35	11.50
USNO	35 1573	2.60	1.85	2.57	2.05	1.21	2.32	1.17	1.26	1.23	0.75	1.28	1.18
USNO	35 1575	-1.93	-2.32	-2.43	-2.29	-2.51	-2.60	-2.32	-2.57	-3.17	-2.84	-2.56	-3.27
USNO	35 1655	-13.44	-12.91	-13.05	-12.38	-12.69	-12.44	-12.16	-12.45	-11.63	-11.22	-11.78	-11.06
USNO	35 1692	2.99	3.34	2.02	2.43	2.22	1.76	2.05	1.81	2.21	2.01	1.98	1.75
USNO	35 1694	-0.58	-1.23	-0.92	-1.43	-1.29	-0.93	-1.66	-1.39	-1.31	-1.78	-1.93	-2.90
USNO	35 1696	4.26	4.04	4.64	4.67	4.59	4.77	4.71	5.78	4.61	4.62	5.33	5.43
USNO	35 1697	1.95	1.13	1.10	1.74	1.97	1.21	1.86	1.75	1.36	2.24	1.64	2.50
USNO	35 1698	11.71	11.95	12.42	11.32	-	-	-	-	-	-	-	-
USNO	40 701	-26.08	-24.37	-24.38	-24.32	-24.16	-24.16	-24.18	-23.99	-23.90	-23.62	-23.74	-23.54
USNO	40 702	-10.93	-10.88	-10.93	-	-	-10.30	-10.35	-10.37	-10.37	-10.32	-10.75	-11.14
USNO	40 704	10.53	10.67	10.74	10.94	11.09	11.15	11.28	11.56	11.68	11.90	12.13	12.40
USNO	40 705	-46.62	-46.75	-46.92	-46.98	-46.97	-47.17	-47.28	-47.35	-47.32	-47.39	-47.62	-47.63
USNO	40 708	25.46	25.57	26.29	26.69	26.77	27.32	27.34	28.21	28.62	29.18	29.47	30.10
USNO	40 710	50.94	51.25	51.83	-	-	53.24	53.75	54.27	54.74	55.33	56.62	57.36
USNO	40 711	178.62	180.31	182.06	183.98	185.99	187.79	189.59	191.61	193.41	195.43	197.38	199.21
USNO	40 712	-133.11	-131.17	-	-	-	-	-	-	-	-	-	-
USNO	40 713	-2.93	-5.02	-4.75	-4.42	-4.03	-3.71	-3.30	-2.88	-2.58	-2.15	-1.76	-1.37
USNO	40 714	-34.62	-34.07	-33.72	-33.46	-32.91	-32.55	-32.18	-31.92	-31.49	-30.94	-30.55	-30.03
USNO	40 716	206.44	206.15	206.08	206.13	206.35	206.37	206.35	206.38	206.46	206.58	206.64	206.74
USNO	40 718	118.42	118.55	118.56	118.64	118.83	118.87	118.95	119.10	119.18	119.34	119.44	119.67
USNO	40 719	-33.18	-32.44	-31.70	-30.89	-29.73	-28.88	-27.84	-26.78	-25.72	-24.55	-23.36	-21.98
USNO	40 720	-39.26	-37.72	-36.39	-34.97	-33.26	-31.75	-30.37	-28.73	-27.11	-25.34	-23.51	-21.92
USNO	40 721	284.13	295.29	306.13	-	-	-	-	-	398.29	406.74	409.91	416.44
USNO	40 722	-	51.41	57.73	64.15	70.74	77.03	83.31	89.68	95.82	102.24	108.61	114.30
USNO	40 723	-66.05	-66.23	-66.50	-	-	-68.45	-68.47	-68.57	-68.74	-68.84	-68.95	-68.99
USNO	40 726	-	-	-	-	-	-	-	-	-	-	40.34	45.36
VSL	35 179	10.10	-	-	-	12.10	11.78	11.39	-	-	-	7.43	6.58
VSL	35 456	18.94	-	-	-	20.21	20.38	20.40	20.94	19.88	20.72	21.44	22.43
VSL	35 548	12.48	-	-	-	10.78	10.74	11.87	11.86	11.74	11.01	12.76	12.43
VSL	35 731	20.58	-	-	-	20.44	20.91	21.34	21.71	20.26	20.39	20.01	21.65

**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.

		2004	2003	2002	2001	
	clock n°	corr. (ns/d)	corr. (ns/d)	corr. (ns/d)	corr. (ns/d)	
AUS	36 340					(1)
BEV	35 1065	+5.44	+5.44 (2)			
BEV	35 1793	+1.12	-0.52 (3)			
CNM	35 1815	+1.12	-1.04			
IT	40 1102	-34.55	-34.55			
IGMA	16 112				-0.50	(4)
LT	35 1362				+3.28	(5)
NPL	40 1701	-3.00	-4.00	-7.00	-8.00	(6)
NPLI	35 0725	+7.60				
ORB	40 2601			-1.73	-6.03	(7)
PL	35 441			+2.16		
PL	35 761					(8)
PL	35 1660	+0.52	+0.52	+1.10	+0.08	(9)
PL	35 1746			+4.40		
PTB	40 510	-0.61	-0.61	-3.11		
ROA	35 583	+3.83	+3.83	+2.19		
SU	40 3802		-17.30	-17.30	-43.30	(10)
SU	40 3803	+5.62	+4.82	-1.68 (11)		
SU	40 3807		-89.00			
SU	40 3810	+0.78	+0.78	-2.22	-0.22	(12)
SU	40 3825		-66.30	-66.30 (13)		
SU	40 3831	+2.59	+1.99	+1.99		
SU	40 3827	-7.78 (14)				
TCC	35 0768	+10.00	+10.00			
TCC	40 8620	-23.80	-23.80	-23.80		
TCC	40 8624	+23.20				

- (1) A correction of +3.28 ns/d has to be applied in 1999.
- (2) A correction of +5.44 ns/d has to be applied for the last 4 months of 2003.
- (3) A correction of -0.52 ns/d has to be applied for the last 7 months of 2003.
- (4) A correction of -0.50 ns/d has to be applied in 2000, 1990, 1998, 1997, and for the last 5 two-month intervals of 1996.
- (5) A correction of +3.28 ns/d has to be applied for the last 5 months of 2001.
- (6) A correction of -8.80 ns/d has to be applied in 2000, -10.60 ns/d in 1999, -12.20 ns/d in 1998, -15.00 ns/d in 1997, -16.2 ns/d in 1996, -12.55 ns/d in 1995, 1994, 1993 and 1992, and +14.45 ns/d in 1991.
- (7) A correction of -6.03 ns/d has to be applied for the last four months of 2001.
- (8) A correction of -4.32 ns/d has to be applied in 2001 and for the last two months of 2000.
- (9) A correction of +0.08 ns/d has to be applied for the last four months of 2001.
- (10) A correction of -43.30 ns/d has to be applied for the last four months of 2001.
- (11) A correction of -1.68 ns/d has to be applied for the last month of 2002.
- (12) A correction of -0.22 ns/d has to be applied for the last four months of 2001.
- (13) A correction of -66.30 ns/d has to be applied for the last six months of 2002.
- (14) A correction of -7.78 ns/d has to be applied for the last seven months of 2004.

**Table 9A. Relative weights (in percent) of contributing clocks in 2005**

(File available on <http://www.bipm.org> under the name WTAI05.AR)

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

The 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	51 DATUM/SYMMETRICOM 4065 B
13 EBAUCHES, OSCILLATOM B5000	23 OSCILLOQUARTZ EUDICS 3020	52 DATUM/SYMMETRICOM 4065 C
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	
15 DATUM/SYMMETRICOM Cs III	35 H-P/AGILENT 5071A High perf.	
4x HYDROGEN MASERS	36 H-P/AGILENT 5071A Low perf.	
9x PRIMARY CLOCKS AND PROTOTYPES	50 FREQ. AND TIME SYSTEMS INC. 4065A	

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
APL	35 904	0.000	0.000	0.000	0.127	0.190	0.224	-	-	0.000	-	0.000	-
APL	35 1264	0.000	0.000	0.000	0.129	0.150	0.215	-	-	-	-	-	-
APL	35 1791	0.000	0.000	0.000	0.086	0.114	0.163	-	-	0.000	-	0.000	-
APL	40 3107	0.000	0.000	0.000	0.001	0.001	0.001	-	-	0.000	-	0.000	-
APL	40 3108	0.000	0.000	0.000	0.001	0.001	0.001	-	-	0.000	-	0.000	-
APL	40 3109	-	-	-	-	-	-	-	-	-	-	0.000	-
AUS	36 249	0.033	0.043	0.048	-	0.000	0.000	0.000	-	-	-	0.000	0.000
AUS	36 299	0.362	0.446	0.442	0.502	0.795	0.902	0.776	-	-	-	-	-
AUS	36 340	0.155	0.129	0.123	0.101	0.105	0.119	0.114	-	0.166	0.202	0.205	0.259
AUS	36 654	0.000	0.230	0.216	0.255	0.283	0.000	0.124	-	0.149	0.146	0.159	0.187
AUS	36 1035	0.044	0.091	0.091	0.089	0.084	0.072	0.047	-	0.054	0.051	0.000	0.002
AUS	40 5401	0.000	0.000	0.022	0.017	0.022	0.020	0.022	-	0.027	0.025	0.026	-
AUS	40 5402	-	-	-	-	-	0.000	0.000	-	0.000	0.003	0.005	0.005
AUS	40 5403	0.003	0.003	0.003	-	0.000	0.000	0.000	-	-	-	0.000	0.000
AUS	99 1	0.000	0.003	-	-	0.000	0.000	0.000	-	-	-	0.000	0.000

**Table 9A. (Cont.)**

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
BEV	16 71	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-	-
BEV	35 1065	0.228	0.227	0.167	0.148	0.129	0.133	0.141	0.138	0.205	0.376	0.221	0.159
BEV	35 1793	0.980	0.996	0.739	0.779	0.904	0.902	0.000	0.000	0.123	0.106	0.097	0.097
CAO	35 939	0.095	0.097	0.099	0.097	0.072	0.076	0.076	0.069	0.078	0.132	0.109	0.106
CAO	35 1270	0.000	0.053	0.048	0.037	0.038	0.041	0.040	0.046	0.057	0.071	0.125	0.302
CH	35 771	0.980	0.914	0.844	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
CH	35 2117	-	-	-	-	0.000	0.000	0.000	0.000	0.109	0.147	0.185	0.213
CH	36 354	0.455	0.497	0.463	0.672	0.805	0.000	0.331	0.228	0.243	0.219	0.213	0.138
CH	36 413	-	-	0.000	0.000	0.000	0.000	0.055	0.036	0.055	0.054	0.071	0.075
CH	40 5701	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005
CNM	35 1705	0.980	0.996	0.977	0.932	0.980	0.902	0.889	0.750	0.707	0.665	0.752	0.610
CNM	35 1815	0.460	0.562	0.614	0.958	0.737	0.671	0.627	0.562	0.453	0.373	0.350	0.333
CNM	36 1537	0.197	0.121	0.116	0.129	0.140	0.138	0.124	0.119	0.125	0.116	0.119	0.148
CNM	40 7301	0.004	0.005	0.004	0.000	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
CNMP	36 1752	0.000	0.000	0.000	0.000	0.033	0.053	0.086	0.236	0.251	0.221	0.228	0.173
DLR	35 1714	0.000	0.000	0.111	0.136	0.193	0.249	0.302	0.368	0.399	0.367	-	-
DTAG	36 136	0.027	0.033	0.033	0.038	0.031	0.042	0.038	0.000	0.025	0.023	0.000	0.012
DTAG	36 345	0.266	0.266	0.238	0.223	0.196	0.167	0.164	0.179	0.162	0.154	0.165	0.166
DTAG	36 465	0.194	0.140	0.124	0.127	0.104	0.108	0.112	0.093	0.096	0.086	0.089	0.083
F	35 122	0.363	0.233	0.249	0.236	0.247	0.227	0.216	0.207	0.180	-	-	0.000
F	35 124	0.754	0.747	0.800	0.872	0.941	0.992	-	-	-	-	0.000	0.000
F	35 131	0.980	0.996	0.977	1.012	0.992	0.000	0.108	0.073	0.066	0.056	0.053	0.050
F	35 158	0.196	0.149	0.142	0.145	0.157	0.166	0.153	0.160	-	-	-	0.000
F	35 172	0.420	0.484	0.458	0.726	0.737	0.747	0.708	0.578	0.859	0.680	0.623	0.604
F	35 198	0.094	0.098	0.119	0.138	0.162	0.191	0.251	0.285	0.342	0.000	0.328	0.359
F	35 355	-	-	0.000	0.000	0.000	0.000	0.992	1.004	-	-	-	-
F	35 385	0.070	0.074	0.076	0.068	0.077	0.085	0.080	0.088	0.190	0.387	0.367	0.407
F	35 396	-	0.000	0.000	0.000	0.000	0.202	0.213	0.096	0.129	0.149	0.189	0.219
F	35 520	0.113	0.137	0.157	-	-	0.000	0.000	0.000	0.000	0.055	0.077	0.106
F	35 536	0.878	0.795	0.646	0.821	0.853	0.992	0.992	1.004	0.951	0.951	0.969	0.969
F	35 609	0.123	0.107	0.106	0.102	0.098	0.097	0.078	0.079	0.084	0.093	-	-
F	35 770	0.106	0.081	0.073	0.071	0.074	0.080	0.084	0.077	0.076	0.067	0.063	0.072
F	35 774	0.086	0.084	-	-	0.000	0.000	0.000	0.000	0.482	0.667	0.958	0.758
F	35 781	-	0.000	0.000	0.000	0.000	0.692	0.298	0.298	0.271	0.141	0.181	0.214
F	35 819	0.145	0.201	0.250	0.240	0.150	0.154	0.174	-	-	0.000	0.000	0.000

**Table 9A. (Cont.)**

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
F	35 859	-	-	0.000	0.000	0.000	0.000	0.365	0.490	0.705	0.870	-	-
F	35 1029	0.062	0.058	0.054	-	-	0.000	0.000	0.000	0.000	0.671	0.806	0.667
F	35 1177	-	-	0.000	0.000	0.000	0.000	0.500	0.654	0.521	-	-	-
F	35 1178	-	-	-	-	-	-	-	-	0.000	0.000	-	-
F	35 1222	0.427	0.514	0.556	0.505	0.554	0.380	0.491	0.400	-	-	-	-
F	35 1321	0.283	0.435	0.354	0.326	0.265	0.363	0.503	0.509	0.539	0.692	0.778	0.000
F	35 1556	0.079	0.086	0.091	0.089	0.084	0.065	0.055	0.045	0.041	0.043	0.061	0.067
F	35 2027	0.842	0.954	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
F	40 805	0.011	0.009	0.007	0.005	0.004	-	-	0.000	0.000	0.000	0.000	0.000
F	40 816	0.000	0.000	0.000	0.000	0.043	-	-	-	0.000	0.000	0.000	0.000
F	40 889	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
F	40 890	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
HKO	35 1893	0.000	0.001	0.001	0.001	0.002	0.004	0.012	0.012	0.013	0.014	0.028	0.029
IEN	35 219	0.319	0.420	0.504	0.316	0.170	0.124	0.090	0.060	0.045	0.038	0.041	0.041
IEN	35 505	0.131	0.165	0.161	0.153	0.137	0.110	0.097	0.091	0.099	0.091	0.090	0.089
IEN	35 1115	0.114	0.131	0.163	0.147	0.000	0.012	0.006	0.005	0.004	0.004	0.003	0.003
IEN	35 1373	0.194	0.200	0.197	0.222	0.243	0.409	0.352	0.203	0.185	0.179	0.000	-
IEN	35 2118	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.243	0.265
IEN	40 1102	0.062	0.056	0.065	0.047	0.034	0.026	0.019	0.015	0.014	0.012	0.011	0.010
IFAG	36 1167	0.034	0.055	0.068	0.083	0.098	0.092	0.067	0.054	0.055	0.051	0.046	0.050
IFAG	36 1173	0.016	0.018	0.021	0.025	0.030	0.029	0.023	0.023	0.025	0.024	0.025	0.027
IFAG	36 1629	0.140	0.123	0.112	0.109	0.111	0.117	0.108	0.106	0.115	0.107	0.110	0.109
IFAG	36 1732	0.296	0.426	0.722	1.012	0.992	-	-	-	-	0.000	0.000	0.000
IFAG	36 1798	0.370	0.483	0.720	0.825	0.750	0.733	0.682	0.552	0.467	0.354	0.370	0.475
IFAG	40 4401	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.000	0.000
IFAG	40 4403	-	-	-	-	-	-	-	0.000	0.000	0.000	-	-
IFAG	40 4413	-	-	0.000	0.000	0.000	0.000	-	-	-	-	-	-
IFAG	40 4418	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.068	0.000
IGMA	16 112	0.009	0.010	0.010	0.000	0.003	0.000	-	-	-	0.000	0.000	0.000
IGMA	35 674	0.577	0.612	0.639	0.839	0.758	0.766	-	0.000	-	0.000	0.000	0.080
IGMA	35 676	0.000	0.250	0.150	0.160	0.155	0.174	-	0.000	-	0.000	0.000	0.141
INPL	35 1652	0.029	0.030	0.039	0.058	0.058	0.034	0.025	0.021	0.025	0.000	0.013	0.009
JV	21 216	0.037	0.050	0.055	0.033	0.000	0.016	0.018	0.020	0.021	0.017	0.015	0.018
JV	21 387	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
JV	36 1277	0.000	0.000	0.000	0.069	0.096	0.138	0.173	0.190	0.238	0.203	0.251	0.251

Table 9A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
JV	51 2040	-	-	-	-	-	-	-	-	-	-	-	0.000
KRIS	35 321	-	-	-	-	-	-	-	-	-	-	-	0.000 0.000
KRIS	35 1693	0.000	0.463	0.576	0.669	0.872	0.730	0.654	0.423	0.499	0.399	0.525	0.641
KRIS	35 1783	-	-	-	-	0.000	0.000	0.000	0.000	0.130	0.121	0.110	0.108
KRIS	36 321	0.194	0.213	-	-	-	-	-	-	-	-	-	-
KRIS	36 739	0.099	0.154	0.144	0.115	0.096	0.099	0.092	0.092	0.100	0.122	0.123	0.098
KRIS	36 1135	0.057	0.107	0.086	0.079	0.050	0.058	0.039	0.034	0.034	0.033	0.037	0.054
KRIS	40 5623	0.251	0.326	0.428	0.498	0.754	0.809	0.697	0.690	0.951	0.951	0.000	0.000
KRIS	40 5624	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
KRIS	40 5625	-	-	-	-	-	-	-	-	-	-	0.000	0.000
LDS	35 289	0.181	0.198	0.198	0.228	0.220	0.215	0.206	0.176	0.201	0.213	0.207	0.184
LT	35 1362	0.185	0.155	0.113	0.120	0.144	0.090	0.000	0.047	0.052	0.055	0.000	0.000
MIKE	35 1171	-	-	-	-	0.000	0.000	-	-	-	-	-	-
MIKE	36 986	-	-	-	-	0.000	0.000	0.000	0.000	0.002	-	-	-
MIKE	40 4113	-	-	-	-	0.000	-	-	-	-	-	-	-
MIKE	40 4180	-	-	-	-	0.000	0.000	0.000	0.000	0.951	-	-	-
MSL	12 933	0.007	0.007	0.007	0.005	0.005	0.007	0.007	0.007	0.005	0.004	0.004	0.004
MSL	36 274	0.044	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MSL	36 1025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.040	0.038
NAO	35 779	0.285	0.341	0.436	0.581	0.448	0.409	0.411	0.395	0.616	0.951	0.000	0.542
NAO	35 1206	0.000	0.000	0.031	0.039	0.051	0.065	0.068	0.081	0.096	0.104	0.398	0.574
NAO	35 1214	0.065	0.245	0.554	0.840	0.867	0.894	0.992	0.841	0.951	0.951	0.969	0.969
NAO	35 1689	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	-	0.000	-	-
NICT	35 112	0.907	0.885	0.950	1.012	0.992	0.860	0.978	1.004	0.951	0.951	0.969	0.969
NICT	35 144	0.023	0.026	0.031	0.030	0.026	0.024	0.024	0.026	0.038	0.069	0.070	0.070
NICT	35 332	0.368	0.278	0.207	0.171	0.220	0.291	0.370	0.522	0.580	0.000	0.191	0.186
NICT	35 342	0.416	0.494	0.519	0.504	0.449	0.433	0.414	0.434	0.489	0.468	0.625	0.602
NICT	35 343	0.126	0.106	0.099	0.096	0.107	0.141	0.214	0.308	0.352	0.373	0.283	0.251
NICT	35 715	0.482	0.571	0.560	0.655	0.743	0.816	0.992	1.004	0.000	0.000	0.095	0.000
NICT	35 732	0.126	0.124	0.131	0.126	0.109	0.106	0.099	0.110	0.208	0.280	0.270	0.233
NICT	35 907	0.260	0.236	0.221	0.231	0.430	0.901	0.992	1.004	0.944	0.949	0.969	0.968
NICT	35 908	0.264	-	-	-	0.000	0.000	0.000	0.000	0.142	0.152	0.149	0.182
NICT	35 1778	0.731	0.730	0.000	0.332	0.000	0.170	0.169	0.178	0.198	0.220	0.255	0.338
NICT	35 1789	0.980	0.974	0.866	1.012	0.673	0.482	0.343	0.339	0.461	0.475	0.540	0.661
NICT	35 1790	0.136	0.167	0.230	0.366	0.448	0.608	0.836	1.004	0.951	0.969	0.969	0.969

**Table 9A. (Cont.)**

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
NICT	35 1882	0.135	0.149	0.145	0.138	0.142	0.150	0.217	0.759	0.775	0.000	0.000	0.133
NICT	35 1887	0.427	0.515	0.489	0.456	0.462	0.452	0.446	0.505	0.576	0.951	0.969	0.969
NICT	35 1944	-	-	0.000	0.000	0.000	0.000	0.380	0.473	0.455	0.465	0.499	0.433
NICT	35 2056	-	-	-	0.000	0.000	0.000	0.000	1.004	0.951	0.951	0.969	0.969
NICT	35 2113	-	-	-	0.000	0.000	0.000	0.000	0.073	0.115	0.149	0.205	0.231
NICT	35 2116	-	-	-	0.000	0.000	0.000	0.000	0.016	0.021	0.024	0.030	0.038
NIM	35 479	0.980	0.996	0.977	0.813	0.728	0.759	0.000	0.202	0.172	0.125	0.136	0.151
NIM	35 1238	0.634	0.655	0.599	0.586	0.611	0.608	0.992	0.882	0.629	0.524	0.415	0.415
NIM	35 1239	0.980	0.996	0.977	1.012	0.962	0.668	0.000	0.212	0.196	0.168	0.000	0.091
NIM	40 4814	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
NIM	40 4832	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
NIMB	35 600	-	-	-	0.000	0.000	0.000	0.000	0.000	0.041	0.051	0.072	0.095
NIS	35 1126	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
NIST	15 9866	0.037	-	0.000	-	-	-	-	0.000	0.000	0.000	0.000	0.003
NIST	35 132	0.415	0.459	0.545	0.516	0.506	0.666	0.766	0.857	0.951	0.921	0.000	0.420
NIST	35 182	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
NIST	35 282	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
NIST	35 408	0.909	0.840	0.816	0.654	0.680	0.706	0.636	0.560	0.604	0.686	0.705	0.834
NIST	35 1074	0.319	0.361	0.466	0.669	0.743	0.765	0.667	0.700	0.837	0.778	0.712	0.614
NIST	35 2031	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
NIST	35 2032	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
NIST	35 2034	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
NIST	40 201	0.024	0.021	0.019	0.000	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.004
NIST	40 203	0.011	0.011	0.011	0.011	0.010	0.010	0.009	0.008	0.009	0.008	0.008	0.007
NIST	40 204	0.232	0.241	0.259	0.282	0.296	0.335	0.418	0.530	0.707	0.570	0.469	0.403
NIST	40 205	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
NIST	40 222	0.102	0.096	0.092	0.085	0.079	0.077	0.070	0.063	0.065	0.056	0.051	0.045
NMC	35 1501	0.144	0.100	0.099	0.097	0.121	0.192	0.181	0.184	0.199	0.134	-	0.000
NMIJ	35 224	0.000	0.004	0.003	0.003	0.003	0.002	-	0.000	0.000	0.000	-	-
NMIJ	35 459	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	-
NMIJ	35 523	-	-	-	-	0.000	0.000	0.000	0.000	0.016	0.021	0.030	-
NMIJ	35 1273	0.887	0.704	0.000	-	-	-	-	-	-	-	-	-
NMIJ	35 1466	0.228	0.309	0.322	0.332	0.353	0.384	0.283	0.000	0.157	0.154	0.131	-
NMIJ	40 5014	0.311	0.236	0.163	0.154	0.216	0.228	0.176	0.000	0.046	0.047	-	-
NMLS	35 1659	0.000	0.000	0.000	0.000	0.000	0.050	0.065	0.083	0.110	0.130	0.152	0.183

**Table 9A. (Cont.)**

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
NPL	35 1275	0.405	0.406	0.502	0.430	0.516	0.336	0.356	0.286	0.258	-	-	-
NPL	36 784	-	0.000	0.000	0.000	0.000	0.007	0.009	0.012	0.017	0.021	0.026	0.032
NPL	40 1701	0.444	0.415	0.502	0.578	0.633	0.843	0.941	1.004	0.951	0.951	0.969	0.865
NPL	40 1708	0.980	0.996	0.977	1.012	0.992	0.951	0.750	0.810	0.909	0.951	0.969	0.969
NPLI	35 725	0.096	0.097	0.097	0.000	0.000	0.005	0.004	0.004	0.004	0.004	0.003	0.004
NRC	35 234	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
NRC	35 372	0.118	0.173	0.186	0.209	0.315	0.337	0.381	0.380	0.388	0.451	0.000	-
NRC	90 61	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.900	0.700	0.508	0.504
NTSC	35 1007	0.041	0.071	0.146	0.157	0.161	0.154	0.152	0.215	0.435	0.417	0.704	0.705
NTSC	35 1008	-	0.000	0.000	0.000	0.000	0.000	0.115	0.155	0.150	0.150	0.177	0.190
NTSC	35 1011	0.117	0.143	0.158	0.181	0.228	0.270	0.240	0.231	0.257	0.253	0.394	0.354
NTSC	35 1016	0.980	0.996	0.977	0.000	0.526	0.316	0.196	0.186	0.211	0.221	0.286	0.349
NTSC	35 1017	0.068	0.067	0.070	-	0.068	0.078	0.081	0.115	0.132	0.325	0.804	0.554
NTSC	35 1018	0.434	0.419	0.538	0.529	0.742	0.778	0.508	0.527	0.544	0.508	0.531	0.550
NTSC	35 1818	-	-	0.000	0.000	0.000	0.000	0.067	0.057	0.052	0.050	0.056	0.058
NTSC	35 1820	0.000	0.000	0.363	0.419	0.568	0.710	0.859	0.906	0.611	0.663	0.517	0.461
NTSC	35 1823	0.811	0.930	0.977	1.012	0.000	0.082	0.000	0.018	0.020	0.019	0.020	0.020
NTSC	35 2098	-	-	-	-	-	-	-	-	-	-	-	0.000
NTSC	35 2131	-	-	-	-	-	-	-	-	-	-	-	0.000
NTSC	35 2141	-	-	-	-	-	-	-	-	-	-	-	0.000
NTSC	35 2142	-	-	-	-	-	-	-	-	-	-	-	0.000
NTSC	35 2144	-	-	-	-	-	-	-	-	-	-	-	0.000
NTSC	40 226	0.000	0.000	0.044	0.022	0.012	0.008	0.005	0.004	0.003	-	-	-
NTSC	40 227	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	-	-	-
NTSC	40 4926	-	-	-	-	-	-	-	-	-	0.002	0.002	0.001
NTSC	40 4927	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
NTSC	40 4945	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.000
NTSC	40 4946	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.003
OMH	36 849	0.181	0.171	0.165	0.146	0.117	0.123	0.124	0.133	0.159	0.142	0.154	0.162
ONBA	12 1091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ONRJ	35 1942	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
ORB	35 201	0.217	-	-	-	0.000	0.000	0.000	0.000	0.038	0.036	0.033	0.044
ORB	35 202	0.059	0.057	0.070	0.060	0.063	0.061	0.062	0.064	0.058	0.057	0.062	0.061
ORB	35 593	0.138	0.113	0.089	0.091	0.092	0.094	0.089	0.097	0.115	0.108	0.123	0.000
ORB	40 2601	0.980	0.996	0.977	1.012	0.000	0.827	0.756	0.444	0.281	0.206	0.212	0.222

**Table 9A. (Cont.)**

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
PL	35 441	0.761	0.562	0.594	0.571	0.534	0.550	0.571	0.389	0.564	0.951	0.969	0.835
PL	35 502	-	0.000	0.000	0.000	0.000	0.722	0.910	1.004	0.951	0.951	0.969	0.969
PL	35 745	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.684
PL	35 761	0.103	0.090	0.092	0.108	0.143	0.119	0.104	0.105	-	-	-	-
PL	35 1120	-	-	-	-	-	0.000	0.000	0.000	0.000	0.951	0.969	0.969
PL	35 1660	0.169	0.165	0.187	0.175	0.131	0.129	0.132	0.192	0.222	0.226	0.320	0.403
PL	35 1709	-	-	0.000	0.000	0.000	0.000	0.880	1.004	0.951	0.951	0.969	0.969
PL	35 1746	0.980	0.842	0.848	0.799	0.774	0.822	0.592	0.563	0.695	0.645	0.651	0.639
PL	35 1934	0.372	0.469	0.581	0.692	0.793	0.808	0.808	0.885	0.951	0.951	0.969	0.969
PL	36 1395	-	-	-	-	-	-	-	0.000	-	-	-	-
PL	40 4002	0.005	-	-	0.000	0.000	0.000	0.000	0.001	0.001	-	0.000	0.000
PL	40 4004	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.001	0.001	-	-
PTB	35 128	0.971	0.832	0.871	0.772	0.614	0.656	0.583	0.654	0.702	0.836	0.877	0.969
PTB	35 415	0.150	0.143	0.202	0.301	0.333	0.314	0.233	0.199	0.214	0.199	0.212	0.207
PTB	35 1072	0.179	0.226	0.297	0.357	0.342	0.375	0.370	0.286	0.665	0.703	0.753	0.769
PTB	40 505	0.033	0.034	0.035	-	-	-	-	-	-	-	-	-
PTB	40 510	0.065	0.056	0.054	0.053	0.055	0.056	0.054	0.053	0.060	0.062	-	-
PTB	40 590	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.000	0.001
PTB	92 1	0.975	0.996	0.977	1.012	0.992	0.992	0.956	1.004	0.951	0.876	0.856	0.969
PTB	92 2	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
PTB	92 3	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
ROA	14 1569	0.002	0.002	-	-	-	-	-	-	-	-	-	-
ROA	31 422	-	-	-	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ROA	35 583	0.331	0.311	0.327	0.315	0.289	0.277	0.171	0.162	0.192	0.241	0.388	0.388
ROA	35 718	0.235	0.215	0.243	0.250	0.310	0.305	0.285	0.428	0.505	0.000	0.241	0.230
ROA	36 1488	0.110	0.113	0.113	0.111	0.095	0.101	0.097	0.120	0.198	0.197	0.313	0.349
ROA	36 1490	0.165	0.169	0.172	0.175	0.391	0.388	0.295	0.331	0.470	0.408	0.423	0.489
ROA	40 1436	-	-	-	-	-	-	-	-	-	-	0.000	0.000
SCL	35 621	0.257	0.204	0.184	0.163	0.152	0.186	0.173	0.233	0.399	0.648	0.969	0.969
SCL	35 745	0.271	0.334	0.431	0.547	0.567	-	-	-	-	-	-	-
SCL	35 1745	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.969	0.969
SG	35 1035	0.000	0.360	0.400	0.296	0.214	0.201	0.198	0.194	0.200	-	0.000	0.000
SG	35 1127	0.752	0.996	0.944	0.972	0.732	0.871	0.879	0.884	0.890	-	0.000	0.000
SG	36 522	0.179	0.178	0.282	0.279	0.223	0.250	0.262	0.221	0.275	-	0.000	0.000
SMU	36 1193	0.019	0.026	0.035	0.044	0.054	0.067	0.077	0.094	0.164	0.195	0.231	-

**Table 9A. (Cont.)**

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
SP	19 197	-	-	-	-	0.000	0.000	0.000	0.000	0.002	0.002	0.003	0.003
SP	35 572	0.000	0.091	0.137	0.178	0.231	0.292	0.349	0.000	-	-	-	-
SP	35 641	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.871	0.826	0.916
SP	35 1188	0.077	0.072	0.079	0.083	0.095	0.177	0.242	0.340	0.460	0.569	0.000	0.253
SP	35 1531	-	-	-	-	-	0.000	0.000	0.000	0.000	0.085	0.124	0.170
SP	35 1642	0.726	0.799	0.789	0.569	0.546	0.588	0.548	0.579	0.659	0.725	0.713	0.938
SP	35 2166	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.134	0.194
SP	36 1175	0.089	0.095	0.117	0.458	0.728	0.757	0.544	0.528	0.463	0.490	0.467	0.483
SP	36 2068	-	-	0.000	0.000	0.000	0.000	0.992	1.004	0.951	0.951	0.969	0.969
SP	40 7201	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
SP	40 7210	0.000	0.000	0.000	0.000	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
SP	40 7211	-	-	0.000	0.000	0.000	0.000	0.006	0.005	0.005	0.004	0.004	0.004
SP	40 7218	0.002	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.001
SU	40 3802	0.112	0.122	0.130	0.124	0.117	0.109	0.097	0.089	0.092	0.073	0.068	0.061
SU	40 3803	0.113	0.157	0.188	0.215	0.231	0.263	0.243	0.226	0.264	0.270	0.386	0.368
SU	40 3805	0.022	0.020	0.019	0.017	0.017	0.018	0.018	0.021	0.029	0.036	0.055	0.055
SU	40 3807	0.102	0.086	0.085	0.091	0.111	0.115	0.096	0.080	0.074	0.055	-	-
SU	40 3810	0.692	0.518	0.419	0.336	0.293	0.270	0.264	0.279	0.417	0.448	0.764	0.737
SU	40 3822	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.004	0.004	0.004
SU	40 3825	0.015	0.012	0.012	0.012	0.014	0.018	0.023	0.037	0.037	0.023	0.018	0.015
SU	40 3827	0.164	0.144	0.170	0.191	0.000	0.000	-	-	0.000	0.000	0.000	0.000
SU	40 3831	0.038	0.048	0.054	0.053	0.048	0.042	0.026	0.027	0.035	0.041	0.056	0.062
SU	40 3837	0.146	0.182	0.244	0.294	0.348	0.327	0.295	0.266	0.271	0.191	0.178	0.164
TCC	35 768	0.055	0.056	0.064	0.054	0.064	0.062	0.059	0.080	0.080	0.065	0.047	0.044
TCC	35 1028	0.108	0.131	0.155	0.182	0.182	0.193	0.201	0.192	0.207	-	0.000	0.000
TCC	35 1881	0.107	0.159	0.247	0.359	0.364	0.427	0.483	0.482	0.594	0.687	0.000	0.370
TCC	40 8620	0.307	0.392	0.407	0.411	0.383	0.294	0.305	0.213	0.200	0.121	0.084	0.081
TCC	40 8624	0.046	0.040	0.046	0.044	0.043	0.041	0.040	0.035	0.039	0.031	0.032	0.034
TL	35 160	0.385	0.410	0.391	0.341	0.270	0.266	0.256	0.218	0.204	0.208	0.223	0.377
TL	35 300	0.145	0.150	0.154	0.145	0.167	0.133	0.137	0.133	0.201	0.204	0.198	0.202
TL	35 474	0.303	0.334	0.349	0.313	0.304	0.307	0.288	0.236	0.252	0.234	0.227	0.432
TL	35 809	0.696	0.647	0.493	0.514	0.516	0.507	0.389	0.313	0.296	0.243	0.319	0.311
TL	35 1012	0.000	0.162	0.105	0.144	0.188	0.000	0.102	0.121	0.150	0.139	0.152	0.145
TL	35 1132	0.071	0.074	0.078	0.072	0.079	0.076	0.073	0.072	0.078	0.074	0.072	0.336
TL	35 1498	0.883	0.826	0.845	0.933	0.987	0.992	0.992	1.004	0.951	0.951	0.969	0.969

Table 9A. (Cont.)

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
TL	35 1500	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
TL	35 1712	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
TL	40 3052	0.008	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.008	0.008	0.008
TL	40 3053	0.462	0.322	0.280	0.276	0.260	0.306	0.283	0.265	-	-	0.000	0.000
TP	35 163	0.577	0.000	0.222	-	0.000	0.000	0.000	0.000	0.235	0.203	0.275	0.306
TP	35 326	0.980	0.996	0.916	-	-	-	-	0.000	0.000	0.000	0.000	0.000
TP	35 1227	0.650	0.774	0.000	-	0.000	0.000	0.000	0.000	0.088	-	-	-
TP	36 154	0.108	0.105	0.091	-	0.000	0.000	0.000	0.000	0.062	0.081	0.104	0.112
USNO	15 5561	0.093	0.098	0.082	0.051	0.039	0.035	0.034	0.030	0.026	0.018	0.013	-
USNO	15 5564	0.052	0.069	0.082	0.100	0.115	0.116	0.219	0.199	0.000	0.067	0.062	0.056
USNO	35 101	0.168	0.183	0.179	0.175	0.160	0.155	0.118	0.111	0.128	0.199	0.505	0.517
USNO	35 104	0.980	0.996	0.977	1.012	-	-	-	-	-	-	0.000	0.000
USNO	35 106	0.000	0.000	0.000	0.000	0.015	0.012	-	-	-	-	-	-
USNO	35 108	0.680	0.996	0.000	0.298	0.316	0.345	0.367	0.358	0.392	0.405	0.423	0.601
USNO	35 114	0.004	0.004	0.004	-	-	-	-	-	-	-	-	-
USNO	35 120	0.579	0.614	0.665	0.773	0.720	0.825	0.912	0.793	0.728	0.562	0.370	0.404
USNO	35 142	0.518	0.517	0.525	0.660	0.000	0.330	0.242	0.245	0.290	0.264	0.271	0.269
USNO	35 146	0.187	0.230	0.224	0.153	0.140	0.134	0.129	0.129	0.152	0.310	0.488	0.516
USNO	35 148	0.488	0.602	0.000	0.143	0.176	0.227	0.185	0.207	0.000	0.045	0.032	0.033
USNO	35 150	0.400	0.407	0.333	0.414	0.450	0.442	0.512	0.373	0.400	0.317	0.364	0.456
USNO	35 152	0.019	0.024	0.029	0.034	0.141	-	-	0.000	0.000	0.000	0.000	0.000
USNO	35 153	-	-	0.000	0.000	0.000	-	-	-	0.000	0.000	0.000	0.000
USNO	35 156	-	-	0.000	0.000	0.000	0.000	0.795	1.004	0.951	0.951	0.969	0.969
USNO	35 161	0.000	0.000	0.000	0.000	0.159	0.186	0.241	0.302	0.342	0.396	-	-
USNO	35 164	0.634	0.996	0.977	0.000	0.630	0.498	0.316	0.000	0.000	0.047	0.040	0.037
USNO	35 165	0.000	0.000	0.000	0.000	0.607	0.894	0.992	1.004	0.951	0.828	0.969	0.886
USNO	35 166	-	-	0.000	0.000	0.000	0.000	0.444	0.435	0.237	0.293	0.389	0.462
USNO	35 167	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.000	0.452	0.374	0.386
USNO	35 169	0.341	0.350	0.384	0.346	0.303	0.313	0.495	1.004	0.000	0.261	0.234	0.227
USNO	35 173	0.980	0.996	0.977	1.012	0.992	0.942	0.961	0.995	0.951	0.951	0.969	0.969
USNO	35 213	-	-	-	-	-	0.000	0.000	0.000	0.000	0.327	0.300	0.394
USNO	35 217	0.545	-	-	-	-	0.000	0.000	0.000	0.000	0.036	0.044	0.060
USNO	35 225	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	35 226	0.980	0.850	0.886	1.012	0.992	0.992	0.992	1.004	0.951	0.777	0.931	0.877
USNO	35 227	0.910	0.832	0.809	0.642	0.672	0.639	0.677	0.903	0.951	0.951	0.883	0.969

**Table 9A. (Cont.)**

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
USNO	35 229	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
USNO	35 231	0.096	0.099	0.107	0.112	0.189	0.537	0.000	0.322	0.321	0.378	0.388	0.370
USNO	35 233	0.876	0.585	0.937	0.995	0.992	0.639	0.457	0.446	0.636	0.727	0.732	0.764
USNO	35 242	0.201	0.195	0.246	0.242	0.246	0.279	0.200	0.193	0.202	0.626	0.792	0.684
USNO	35 244	0.736	0.743	0.872	0.880	0.992	0.992	0.992	1.004	0.833	0.782	0.809	0.608
USNO	35 249	0.848	0.928	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	35 253	0.000	0.000	0.000	0.000	0.992	0.992	0.759	0.978	0.951	0.951	-	-
USNO	35 254	-	-	-	-	-	0.000	0.000	0.000	0.000	0.630	0.322	0.334
USNO	35 255	0.980	0.996	0.966	1.012	0.992	0.992	0.974	0.770	0.801	0.000	0.295	0.252
USNO	35 256	0.883	0.906	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	35 260	0.980	0.996	0.977	1.012	0.992	0.906	0.682	0.492	0.457	0.558	0.604	0.757
USNO	35 268	0.654	0.393	0.393	0.449	0.387	0.377	0.336	0.330	0.212	0.197	0.195	0.189
USNO	35 270	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	35 279	0.840	0.879	0.893	0.881	0.977	0.992	0.992	0.854	0.894	0.836	0.856	0.760
USNO	35 389	0.422	0.394	0.602	0.000	0.516	0.303	0.305	0.230	0.235	0.201	0.213	0.201
USNO	35 392	0.879	0.801	0.708	1.012	0.940	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	35 394	0.032	0.037	0.044	0.079	0.179	0.363	0.659	0.738	0.740	0.682	0.856	0.969
USNO	35 416	0.980	0.000	0.508	0.465	0.470	0.486	0.532	0.432	0.492	0.352	0.348	0.361
USNO	35 417	0.767	0.816	0.799	0.708	0.677	-	-	-	0.000	0.000	0.000	0.000
USNO	35 703	0.000	0.000	0.000	0.000	-	-	0.000	0.000	0.000	0.000	0.000	0.000
USNO	35 717	0.581	0.858	0.709	0.792	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	35 762	0.980	0.996	0.977	1.012	0.741	0.691	0.609	0.896	0.951	0.951	0.969	0.969
USNO	35 763	0.944	0.996	0.898	-	-	-	-	-	-	-	-	0.000
USNO	35 765	0.980	0.996	0.977	1.012	0.992	0.992	0.878	0.797	0.949	0.951	0.969	0.969
USNO	35 1096	0.594	0.913	0.906	0.868	0.889	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	35 1125	0.000	0.384	0.307	0.351	0.368	0.378	0.372	0.405	0.493	0.530	0.649	0.915
USNO	35 1327	0.499	0.337	0.346	0.340	0.346	0.299	0.292	0.264	0.277	0.303	0.423	-
USNO	35 1328	0.502	0.574	0.776	0.740	0.992	0.992	0.992	1.004	0.951	0.951	0.965	0.969
USNO	35 1331	0.980	0.996	0.977	1.012	-	-	-	-	-	-	-	0.000
USNO	35 1438	0.674	0.640	0.613	0.568	0.602	0.625	0.734	1.004	0.951	0.951	0.804	0.882
USNO	35 1459	0.980	0.723	0.728	0.644	0.672	0.569	0.564	0.562	0.654	0.693	0.939	0.969
USNO	35 1462	0.980	0.996	0.977	1.012	0.992	0.992	0.992	0.967	0.684	0.484	0.454	0.331
USNO	35 1463	0.474	0.486	0.489	0.483	0.478	0.499	0.705	0.000	0.000	0.130	0.135	0.128
USNO	35 1468	0.642	0.907	0.977	1.012	0.992	0.992	0.992	0.810	0.823	0.799	0.969	0.655
USNO	35 1481	0.000	0.427	0.461	0.529	0.657	0.678	0.709	0.762	0.820	0.474	0.509	0.493

**Table 9A. (Cont.)**

Lab.	Clock	53399	53429	53459	53489	53519	53549	53579	53609	53639	53674	53704	53734
USNO	35 1543	0.402	0.533	0.735	0.734	0.758	0.517	0.767	0.656	0.883	0.797	0.865	0.969
USNO	35 1573	0.330	0.276	0.365	0.309	0.263	0.352	0.296	0.263	0.281	0.256	0.372	0.348
USNO	35 1575	0.670	0.546	0.813	0.716	0.891	0.808	0.783	0.846	0.620	0.734	0.935	0.799
USNO	35 1655	0.966	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.623	0.612	0.451
USNO	35 1692	0.000	0.000	0.216	0.264	0.298	0.275	0.295	0.300	0.380	0.391	0.531	0.542
USNO	35 1694	0.980	0.996	0.977	1.002	0.992	0.992	0.945	0.894	0.951	0.835	0.782	0.000
USNO	35 1696	0.658	0.584	0.591	0.619	0.992	0.992	0.992	0.815	0.876	0.951	0.942	0.969
USNO	35 1697	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	35 1698	0.499	0.471	0.503	0.440	-	-	-	-	-	-	-	-
USNO	40 701	0.709	0.401	0.315	0.274	0.235	0.233	0.241	0.277	0.402	0.339	0.340	0.526
USNO	40 702	0.557	0.488	0.457	-	-	0.000	0.000	0.000	0.000	0.951	0.969	0.683
USNO	40 704	0.564	0.623	0.770	0.791	0.837	0.968	0.949	0.978	0.951	0.951	0.906	0.739
USNO	40 705	0.515	0.420	0.376	0.365	0.406	0.420	0.424	0.430	0.458	0.554	0.746	0.949
USNO	40 708	0.112	0.109	0.099	0.091	0.093	0.101	0.104	0.101	0.110	0.093	0.098	0.088
USNO	40 710	0.049	0.054	0.061	-	-	0.000	0.000	0.000	0.000	0.125	0.069	0.051
USNO	40 711	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
USNO	40 712	0.000	0.000	-	-	-	-	-	-	-	-	-	-
USNO	40 713	0.000	0.000	0.060	0.081	0.113	0.155	0.187	0.208	0.243	0.225	0.191	0.152
USNO	40 714	0.000	0.000	0.248	0.283	0.246	0.219	0.185	0.166	0.162	0.130	0.127	0.098
USNO	40 716	0.812	0.834	0.856	0.875	0.912	0.988	0.992	1.004	0.951	0.951	0.969	0.969
USNO	40 718	0.980	0.996	0.977	1.012	0.992	0.992	0.992	1.004	0.951	0.951	0.969	0.969
USNO	40 719	0.016	0.021	0.025	0.027	0.027	0.027	0.024	0.021	0.021	0.017	0.016	0.014
USNO	40 720	0.014	0.012	0.011	0.009	0.009	0.008	0.007	0.007	0.007	0.006	0.006	0.006
USNO	40 721	0.000	0.000	0.000	-	-	-	-	-	0.000	0.000	0.000	0.000
USNO	40 722	-	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.000
USNO	40 723	0.000	0.000	0.000	-	-	0.000	0.000	0.000	0.000	0.951	0.969	0.969
USNO	40 726	-	-	-	-	-	-	-	-	-	-	0.000	0.000
VSL	35 179	0.226	-	-	-	0.000	0.000	0.000	-	-	-	0.000	0.000
VSL	35 456	0.291	-	-	-	0.000	0.000	0.000	0.000	0.488	0.622	0.456	0.212
VSL	35 548	0.769	-	-	-	0.000	0.000	0.000	0.000	0.268	0.320	0.225	0.254
VSL	35 731	0.447	-	-	-	0.000	0.000	0.000	0.000	0.212	0.239	0.241	0.266

**Table 9B. Statistical data on the weights attributed to the clocks in 2005**

Interval		Number of Clocks			Number of clocks with a given weight						Max relative weight %			
		Weight = 0*			Weight = 0**			Max weight		HM	5071A	Total		
		HM	5071A	Total	HM	5071A	Total	HM	5071A	Total				
2005	Jan.	61	184	288	13	16	33	0	7	11	4	32	38	0.980
2005	Feb.	60	181	284	14	17	33	0	2	8	4	31	38	0.996
2005	Mar.	61	189	293	10	22	37	1	5	12	4	30	37	0.977
2005	Apr.	56	184	280	7	23	33	3	4	14	4	31	39	1.012
2005	May	59	194	299	7	31	48	4	5	14	3	31	38	0.992
2005	June	60	197	301	10	32	50	2	3	12	2	32	37	0.992
2005	July	57	193	293	8	27	41	2	6	12	3	33	39	0.992
2005	Aug.	59	194	292	11	27	44	2	5	12	4	35	43	1.004
2005	Sep.	66	200	307	16	27	44	2	6	14	7	36	46	0.951
2005	Oct.	65	196	303	13	23	40	3	7	14	9	36	47	0.951
2005	Nov.	69	197	311	20	26	53	6	10	22	7	35	44	0.969
2005	Dec.	65	198	307	13	29	49	8	7	19	5	37	45	0.969

$W_{max}=A/N$ , here  $N$  is the number of clocks, excluding those with a priori null weight,  $A=2.50$ .

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

\*\* Null weight resulting from the statistics.

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

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



## TIME SIGNALS

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

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

The following tables are based on information received at the BIPM in February and May 2006.



## AUTHORITIES RESPONSIBLE FOR THE TIME SIGNAL EMISSIONS

Signal	Authority
BPM	Time and Frequency Division National Time Service Center, NTSC (Formerly Shaanxi Astronomical Observatory, CSAO) Chinese Academy of Sciences P.O. Box 18 - Lintong Shaanxi 710600, China
CHU	National Research Council of Canada Institute for National Measurement Standards – Frequency and Time Standards Bldg M-36, 1200 Montreal Road Ottawa, Ontario, K1A 0R6, Canada
DCF77	Physikalisch-Technische Bundesanstalt Time and Frequency Department, WG 4.42 Bundesallee 100 D-38116 Braunschweig Germany
EBC	Real Instituto y Observatorio de la Armada Cecilio Pujazón s/n 11.110 San Fernando Cádiz, Spain
HBG	METAS METrology and Accreditation Switzerland Electricity, Acoustic and Time Section Lindenweg 50 CH-3003 Bern-Wabern Switzerland
HLA	Time and Frequency Group Korea Research Institute of Standards and Science P.O. Box 102, Yuseong Daejeon 305-340 Republic of Korea
JJY	Japan Standard Time Group National Institute of Information and Communications Technology 4-2-1, Nukui-kitamachi Koganei, Tokyo 184-8795 Japan

Signal	Authority
LDS	School of Electronic and Electrical Engineering Leeds University Leeds LS2 9JT United Kingdom
LOL	Servicio de Hidrografía Naval Observatorio Naval Buenos Aires Av. España 2099 C1107AMA – Buenos Aires, Argentina
MSF	National Physical Laboratory Division for Enabling Metrology Hampton Road Teddington, Middlesex TW11 0LW United Kingdom
RAB-99, RBU, RJH-63, RJH-69, RJH-77, RJH-86, RJH-90, RTZ, RWM	Institute of Metrology for Time and Space (IMVP), FGUP "VNIIFTRI" Mendeleev, Moscow Region 141570 Russia
STFS	National Physical Laboratory Dr. K.S. Krishnan Road New Delhi - 110012, India
TDF	FT R et D France Telecom Recherche et Développement Laboratoire RTA/D2M Technopole ANTICIPA 2, avenue Pierre Marzin 22307 - Lannion Cedex, France
WWV, WWVB, WWVH	Time and Frequency Division, 847.00 National Institute of Standards and Technology - 325 Broadway Boulder, Colorado 80305, U.S.A.
YVTO	Dirección de Hidrografía y Navegación Observatorio Naval Cagigal Apartado Postal No 6745 Caracas, Venezuela

### TIME SIGNALS EMITTED IN THE UTC SYSTEM

Station	Location			Form of the signal
	Latitude	Frequency	Schedule (UTC)	
	Longitude	(kHz)		
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.
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 9th 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.
DCF77	Mainflingen Germany 50° 1'N 9° 0'E	77.5	continuous	At the beginning of each second (except the 59th second) the carrier amplitude is reduced to about 25 % for a duration of 0.1 s or 0.2 s. Coded transmission of year, month, day, hour, minute and day of the week in a BCD code from second marker No 21 to No 58 (The second marker durations of 0.1 s or 0.2 s correspond to a binary 0 or a binary 1 respectively). The coded time information is related to legal time of Germany and second markers 17 and 18 indicate if the transmitted time refers to UTC(PTB) + 2 h (summer time) or UTC(PTB) + 1 h (winter time). To achieve a more accurate time transfer and better use of the frequency spectrum available, an additional pseudo-random phase-shift keying of the carrier is superimposed to the AM second markers. No transmission of DUT1.
EBC	San Fernando Spain 36° 28'N 6° 12'W	15006 4998	10 h 00 m to 10 h 25 m 10 h 30 m to 10 h 55 m except Saturday, Sunday and national holidays.	Second pulses of 0.1 s duration of a 1 kHz modulation. Minute pulses of 0.5 s duration of 1 250 Hz modulation. DUT1: ITU-R code by double pulse.

Station	Location	Frequency (kHz)	Schedule (UTC)	Form of the signal
	Latitude			
	Longitude			
HBG	Prangins Switzerland 46° 24'N 6° 15'E	75	continuous	At the beginning of each second (except the 59 <sup>th</sup> second), the carrier is interrupted for a duration of 0.1 s or 0.2 s corresponding to "binary 0" or "binary 1", respectively, double pulse each minute. The number of the minute, hour, day of the month, day of the week, month and year are transmitted in BCD code from the 21 <sup>st</sup> to the 58 <sup>th</sup> second. The time signals are generated by the Swiss Federal Office of Metrology and Accreditation and in accordance with the legal time of Switzerland which is UTC(CH) + 1 h (Central European Time CET) or UTC(CH) + 2 h (Central European Summer Time CEST). In addition, CET and CEST are indicated by a binary 1 at the 18 <sup>th</sup> or 17 <sup>th</sup> second, respectively.
HLA	Daejeon 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 52 <sup>nd</sup> second pulse. BCD time code given on 100 Hz subcarrier. DUT1: ITU-R code by double pulse.
JJY	Miyakoji Fukushima Japan 37° 22'N 140° 51'E	40	Continuous	A1B type 0.2 s, 0.5 s and 0.8 s second pulses, spacings are given by the reduction of the amplitude of the carrier. Coded announcement of hour, minute, day of the year, year, day of the week and leap second. Transmitted time refers to UTC(NICT) + 9 h.
JJY	Fuji Saga Japan 33° 28'N 130° 11'E	60	Continuous	A1B type 0.2 s, 0.5 s and 0.8 s second pulses, spacings are given by the reduction of the amplitude of the carrier. Coded announcement of hour, minute, day of the year, year, day of the week and leap second same as JJY(40). Transmitted time refers to UTC(NICT) + 9 h.
LDS	Leeds United Kingdom 53 ° 48'N 1° 33'W	5 000	Continuous	Second pulse amplitude = 2.4 V (50 ohm), 5 ns rise time and 20 µs width. Initial clock synchronization: 50 ns of UTC.

Station	Location		Frequency (kHz)	Schedule (UTC)	Form of the signal
	Latitude	Longitude			
LOL	Buenos Aires Argentina 34° 37'S 58° 21'W	10 000	14 h to 15 h except Saturday, Sunday and national holidays.		Second pulses of 5 cycles of 1000 Hz modulation. Second 59 is omitted. Announcement 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, May and September. A longer period of maintenance during the summer is announced annually.		Interruptions of the carrier of 100 ms for the second pulses and of 500 ms for the minute pulses. The signal is given by the beginning of the interruption. BCD NRZ code, 1 bit/s (year, month, day of the month, day of the week, hour, minute) from second 17 to 59 in each minute, following the seconds interruption. DUT1: ITU-R code by double pulse.
RAB-99	Khabarovsk Russia 48° 30'N 134° 50'E	25.0 25.1 25.5 23.0 20.5	02 h 06 m to 02 h 40 m 06 h 06 m to 06 h 40 m		A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.
RBU	Moscow 55° 44'N 38° 12'E	200/3	Continuous		DXXXW type 0.1 s signals. The numbers of the minute, hour, day of the month, day of the week, month, year of the century, difference between the universal time and the local time, TJD and DUT1+dUT1 are transmitted each minute from the 1 <sup>st</sup> to the 59 <sup>th</sup> second. DUT1+dUT1 : by double pulse.
RJH-63	Krasnodar Russia 44° 46'N 39° 34'E	25.0 25.1 25.5 23.0 20.5	11 h 06 m to 11 h 40 m		A1N type signals are transmitted between minutes 9 and 20 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 9 and 11 ; 0.1 second pulses of 25 ms duration, 10 second pulses of 1 s duration and minute pulses of 10 s duration are transmitted between minutes 11 and 20.
RJH-69	Molodechno Belarus 54° 28'N 26° 47'E	25.0 25.1 25.5 23.0 20.5	07 h 06 m to 07 h 47 m		A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.

Station	Location	Frequency (KHz)	Schedule (UTC)	Form of the signal
	Latitude Longitude			
RJH-77	Arkhangelsk Russia 64° 22'N 41° 35'E	25.0 25.1 25.5 23.0 20.5	09 h 06 m to 09 h 47 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.
RJH-86	Bishkek Kirgizstan 43° 03'N 73° 37'E	25.0 25.1 25.5 23.0 20.5	04 h 06 m to 04 h 47 m 10 h 06 m to 10 h 47 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.
RJH-90	Nizhni Novgorod Russia 56° 11'N 43° 57'E	25.0 25.1 25.5 23.0 20.5	05 h 06 m to 05 h 47 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.
RTZ	Irkutsk Russia 52° 26'N 103° 41'E	50	Winter schedule 22 h 00 m to 24 h 00 m 00 h 00 m to 21 h 00 m Summer schedule 21 h 00 m to 24 h 00 m 00 h 00 m to 20 h 00 m	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 1 <sup>st</sup> to the 59 <sup>th</sup> second. DUT1+dUT1: by double pulse.
RWM (1)	Moscow Russia 55° 44'N 38° 12'E	4 996 9 996 14 996	The station operates simultaneously on the three frequencies.	A1X type second pulses of 0.1 s duration are transmitted between minutes 10 and 20, 40 and 50. The pulses at the beginning of the minute are prolonged to 0.5 s. A1N type 0.1 s second pulses of 0.02 s duration are transmitted between minutes 20 and 30. The pulses at the beginning of the second are prolonged to 40 ms and of the minute to 0.5 ms. DUT1+dUT1: by double pulse.

- (1) RMW is the 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 21<sup>st</sup> and 24<sup>th</sup> second so that  $dUT1 = +p \times 0.02$  s.  
Negative values of dUT1 are transmitted by the marking of  $q$  second markers within the range between the 31<sup>st</sup> and 34<sup>th</sup> second, so that  $dUT1 = -q \times 0.02$  s.

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
STFS	Sikandabad India 28° 28'N 77° 13'E	2 599 675	continuous	Pulse width modulated binary coded 5 kHz pulses carrying information on Indian Standard Time – IST (UTC+ 5 h 30 m). Time of Day and current position coordinates of the satellite. Pulse repetition rate is 100 pps. The above format is frequency modulated on the carrier.
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 59 <sup>th</sup> 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 21 <sup>st</sup> to the 58 <sup>th</sup> second, in accordance with the French legal time scale. In addition, a binary 1 at the 17 <sup>th</sup> second indicates that the local time is 2 hours ahead of UTC (summer time); a binary 1 at the 18 <sup>th</sup> second indicates that the local time is 1 hour ahead of UTC (winter time); a binary 1 at the 14 <sup>th</sup> second indicates that the current day is a public holiday (Christmas, 14 July, etc.); a binary 1 at the 13 <sup>th</sup> second indicates that the current day is a day before a public holiday.
WWV	Fort-Collins CO, USA 40° 41'N 105° 2'W	2 500 5 000 10 000 15 000 20 000	continuous	Pulses of 5 cycles of 1 kHz modulation. 29th and 59th second pulses omitted. Hour is identified by 0.8 second long 1 500 Hz tone. Beginning of each minute identified by 0.8 second long 1 000 Hz tone. DUT1: ITU-R code by double pulse. BCD time code given on 100 Hz subcarrier, includes DUT1 correction.
WWVB	Fort-Collins CO, USA 40° 40'N 105° 3'W	60	continuous	Second pulses given by reduction of the amplitude of the carrier, coded announcement of the date, time, DUT1 correction, daylight saving time in effect, leap year and leap second.
WWVH	Kauai HI, USA 21° 59'N 159° 46'W	2 500 5 000 10 000 15 000	continuous	Pulses of 6 cycles of 1 200 Hz modulation. 29th and 59th second pulses omitted. Hour is identified by 0.8 second long 1 500 Hz tone. Beginning of each minute identified by 0.8 second long 1 200 Hz tone. DUT1: ITU-R code by double pulse. BCD time code given on 100 Hz subcarrier, includes DUT1 correction.
YVTO	Caracas Venezuela 10° 30'N 66° 55'W	5 000	continuous	Second pulses of 1 kHz modulation with 0.1 s duration. The minute is identified by a 800 Hz tone and a 0.5 s duration. Second 30 is omitted. Between seconds 40 and 50 of each minute, voice announcement of the identification of the station. Between seconds 52 and 57 of each minute, voice announcement of hour, minute and second.

## ACCURACY OF THE CARRIER FREQUENCY

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

## TIME DISSEMINATION SERVICES

The following tables are based on information received at the BIPM in February and May 2006.



## AUTHORITIES RESPONSIBLE FOR THE TIME DISSEMINATION SERVICES

AOS	Astrogeodynamical Observatory Borowiec near Poznań Space Research Centre P.A.S. PL 62-035 Kórnik - Poland
AUS	Standards for Time and Frequency Project National Measurement Institute PO Box 264 Lindfield NSW 2070 - AUSTRALIA
BEV	Bundesamt für Eich- und Vermessungswesen Arltgasse 35 A-1160 Wien , Vienna - Austria
CENAM	Centro Nacional de Metrología km. 4.5 Carretera a Los Cués El Marqués, Querétaro, C.P. 76241 - México
CSIR	Time and Frequency Laboratory CSIR – National Metrology Laboratory P.O. Box 395 Pretoria 0001 - South Africa
GUM	Time and Frequency Laboratory Electrical Metrology Division Główny Urząd Miar – Central Office of Measures ul. Elektoralna 2 PL 00 – 950 Warszawa P-10, Poland
HKO	Hong Kong Observatory 134A, Nathan Road Kowloon, Hong Kong
IEN	Istituto Elettrotecnico Nazionale Galileo Ferraris Strada delle Cacce, 91 I – 10135 Torino Italia
INPL	National Physical Laboratory Danciger A bldg Givat - Ram, The Hebrew university 91904 Jerusalem ISRAEL
KRISS	Time and Frequency Group Division of Optical Metrology Korea Research Institute of Standards and Science P.O. Box 102, Yuseong Daejeon 305-340 Republic of Korea
LNE-SYRTE	Laboratoire National de Métrologie et d'Essais Systèmes de Référence Temps-Espace Observatoire de Paris 61, avenue de l'Observatoire, 75014 Paris – France
LT	Time and Frequency Standard Laboratory Semiconductor Physics Institute – State Metrology Service A. Goštauto 11 Vilnius LT01108, Lithuania

METAS	METrology and Accreditation Switzerland Electricity, Acoustic and Time Section Lindenweg 50 CH-3003 Bern-Wabern Switzerland
MSL	Measurement Standards Laboratory Industrial Research Gracefield Road PO Box 31-310 Lower Hutt – New Zealand
NICT	Japan Standard Time Group National Institute of Information and Communications Technology 4 -2 -1, Nukui-kitamachi Koganei, Tokyo 184-8795 Japan
NIM	Time & Frequency Laboratory National Institute of Metrology No. 18, Bei San Huan Dong Lu Beijing 100013 - People's Republic of China
NIMT	Time & Frequency Laboratory National Institute of Metrology (Thailand) 3/5 Moo 3, Klong 5, Klong Luang, Pathumthani 12120, Thailand
NIST	National Institute of Standards and Technology Time and Frequency Division, 847.00 325 Broadway Boulder, Colorado 80305, USA
NMLS	Time and Frequency Laboratory National Metrology Laboratory SIRIM Berhad, Lot PT 4803, Bandar Baru Salak Tinggi, 43900 Sepang - Malaysia
NPL	National Physical Laboratory Division for Enabling Metrology Hampton Road Teddington, Middlesex TW11 0LW United Kingdom
NPLI	Time and Frequency Section National Physical Laboratory Dr.K.S.Krishnan Road New Delhi 110012 - India
NRC	National Research Council of Canada Institute for National Measurement Standards Frequency and Time Standards Bldg M-36, 1200 Montreal Rd. Ottawa, Ontario, K1A OR6, Canada
NTSC	National Time Service Center Chinese Academy of Sciences P.O. Box 18, Lintong Shaanxi 710600, China

ONBA	Servicio de Hidrografía Naval Observatorio Naval Buenos Aires Servicio de Hora Av. España 2099 C1107AMA – Buenos Aires, Argentina
ONRJ	Observatorio Nacional (MCT) Divisão Serviço da Hora Rua General José Cristino, 77 São Cristovão 20291- 400 Rio de Janeiro, Brasil
ORB	Royal Observatory of Belgium Avenue Circulaire, 3 B-1180 Brussels Belgium
PTB	Physikalisch-Technische Bundesanstalt Time and Frequency Department, WG 4. 42 Bundesallee 100 D-38116 Braunschweig Germany
ROA	Real Instituto y Observatorio de la Armada Cecilio Pujazón s/n 11.100 San Fernando Cádiz, Spain
SG	National Metrology Centre Standards, Productivity and Innovation Board (SPRING Singapore) 1 Science Park Drive, Singapore 118221 Singapore
SP	SP Swedish National Testing and Research Institute Box 857 S-501 15 BORAS Sweden
TL	National Standard Time and Frequency Laboratory Telecommunication Laboratories Chunghwa Telecom. Co., Ltd. No. 12, Ln.551, Ming-Tsu Road Sec. 5 Yang-Mei, Taoyuan, 326 Taiwan, Rep. of China
TP	Institute of Radio Engineering and Electronics Czech Academy of Sciences Chaberská 57 182 51 Praha 8 Czech Republic
USNO	U.S. Naval Observatory 3450 Massachusetts Ave., N.W. Washington, D.C. 20392-5420 USA
VSL	NMi Van Swinden Laboratorium Postbus 654 2600 AR Delft Netherlands

## TIME DISSEMINATION SERVICES

AOS	<p><b>AOS Computer Time Service:</b>          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 (<a href="mailto:nawrocki@cbk.poznan.pl">nawrocki@cbk.poznan.pl</a>)          Robert Diak (<a href="mailto:kondor@cbk.poznan.pl">kondor@cbk.poznan.pl</a>)</p> <p>Full list of time dissemination services is available on:  <a href="http://www.eecis.udel.edu/~mills/ntp/clock1.htm">http://www.eecis.udel.edu/~mills/ntp/clock1.htm</a></p>
AUS	<p><b>Network Time Service</b>          Computers connected to the Internet can be synchronized to UTC(AUS) using the NTP protocol. The NTP servers are referenced to UTC(AUS) either directly or via a GPS common view link.          Please see <a href="http://www.measurement.gov.au/time">www.measurement.gov.au/time</a> for information on access or contact <a href="mailto:time@measurement.gov.au">time@measurement.gov.au</a></p> <p><b>Dial-up Computer Time Service</b>          Computers can also obtain time via a modem connection to our dialup timeserver. For further information, please see our web pages as above.</p>
BEV	<p>3 NTP servers are available; addresses:          time.metrology.at          217.19.37.26          217.19.37.27          more information on <a href="http://www.metrology.at">http://www.metrology.at</a></p> <p>Provides a time dissemination service via phone and modem to synchronize PC clocks.          Uses the Time Distribution System from TUG. It has a baud rate of 1200 and everyone can use it with no cost.          Access phone number is +43 (0) 1 49110381          The system will be updated periodically (DUT1, Leap Second...).</p>
CENAM	<p>CENAM operates a voice automatic system that provides the local time for three different time zones for North America; Central Time, Mountain Time and Pacific Time as well the UTC(CNM). The access numbers are:</p> <p>+52 442 211 0506: Central Time  +52 442 211 0507: Mountain Time  +52 442 211 0508: Pacific Time  +52 442 215 3902: UTC(CNM)</p> <p><b>Telephone Code</b>          CENAM provides a telephone code for setting time in computers. More information about this service please contact J. Mauricio López at <a href="mailto:jlopez@cenam.mx">jlopez@cenam.mx</a></p> <p><b>Network Time Protocol</b>          Operates one time server using the "Network Time Protocol", it is located at the Centro Nacional de Metrología, Querétaro, México. Further information at <a href="http://www.cenam.mx/HoraExacta.asp">http://www.cenam.mx/HoraExacta.asp</a></p>

CSIR	<p><b>Telephone Time Service (TTS)</b>  Provides digital time code accessible by computer for setting time in computers. Measurement of telephone transmission delay is included.  Access phone numbers: + 27 12 349 1576, + 27 12 349 1577.  More information and software for accessing the service is available at <a href="http://www.nml.csir.co.za/">http://www.nml.csir.co.za/</a></p> <p><b>Network Time Service</b>  Two NTP servers are available, tick.nml.csir.co.za with restricted access policy and tock.nml.csir.co.za with an open access policy.  More information is available at <a href="http://www.nml.csir.co.za/time.htm">http://www.nml.csir.co.za/time.htm</a></p>
GUM	<p><b>Telephone Time Service</b> providing the European time code by telephone modem for setting time in computers. Includes provision for compensation of propagation time delay.  Access phone number : +48 22 654 88 72</p> <p><b>Network Time Service</b>  Two NTP servers are available:  tempus1.gum.gov.pl  tempus2.gum.gov.pl  with an open access policy. It provides synchronization to UTC(PL).  Contact: <a href="mailto:timegum@gum.gov.pl">timegum@gum.gov.pl</a></p>
HKO	<p><b>Speaking Clock Service</b>  HKO operates an automatic Telephone Information Enquiry System that provides voice announcement of the Hong Kong Standard Time. (=UTC(HKO) + 8 h). Access phone number: + 852 1878200</p> <p><b>Network Time Service</b>  HKO operates two Internet time servers using Network Time Protocol.  Host name of the server: stdtime.gov.hk  Further information at <a href="http://www.hko.gov.hk/nts/ntime.htm">http://www.hko.gov.hk/nts/ntime.htm</a></p>
IEN (1)	<p><b>CTD Telephone Time Code</b>  Time signals dissemination, according to the European Time code format, available via modem on regular dial-up connection.  Access phone numbers : 0039 011 3919 263 and 0039 011 3919 264.  Provides a synchronization to UTC(IEN) for computer clocks without compensation for the propagation time.  Software for the synchronization of computer clocks is available on IEN home page (<a href="http://www.ien.it">www.ien.it</a>).</p> <p><b>Internet Time Service</b>  The IEN operates two time servers using the "Network Time Protocol" (NTP); host names of the servers are npt1.ien.it and ntp2.it.  More information on this service can be found on the web pages: <a href="http://www.ien.it/ntp/index_i.shtml">www.ien.it/ntp/index_i.shtml</a>.</p>
INPL	<p>INPL is providing two electronic time dissemination services:</p> <ol style="list-style-type: none"> <li>1. via telephone. The user must download a program from INPL ftp site (<a href="http://vms.huji.ac.il">vms.huji.ac.il</a>)</li> <li>2. NTS via optic fiber to the Hebrew University which provides time on the internet. For details email <a href="mailto:clock@vms.huji.ac.il">clock@vms.huji.ac.il</a></li> </ol>

KRISS	<p><b>Telephone Time Service</b>  Provides digital time code to synchronize computer clocks to Korea Standard Time (=UTC(KRIS) + 9 h) via modem.  Access phone numbers: + 82 42 863 7117, + 82 42 868 5116</p> <p><b>Network Time Service</b>  KRISS operates three time servers using the NTP to synchronize computer clocks to Korea Standard Time via the Internet.  Host name of the server : time.kriss.re.kr (203.254.163.74)</p> <p>Software for the synchronization of computer clocks is available at  <a href="http://www.kriss.re.kr/time">http://www.kriss.re.kr/time</a></p>
LNE-SYRTE	<p>LNE-SYRTE operates one primary time server using the "Network Time Protocol" (NTP) :  Hostname: ntp-p1.obspm.fr</p> <p>Futher information at: <a href="http://lne-syrite.obspm.fr/gen/ntp_infos.html">http://lne-syrite.obspm.fr/gen/ntp_infos.html</a></p>
LT	<p><b>Network Time Service via NTP protocol</b>  NPT v3  DNS: laikas.pfi.lt  Port 123  Synchronization from Caesium clock (1pps)  System: Datum TymeServe 2100 NTP server  Access policy: free  Contact: Rimantas Miškinis  Mail: Laikas@pfi.lt  <a href="http://www.pfi.lt/metrology/">http://www.pfi.lt/metrology/</a></p>
METAS	<p><b>Telephone Time Service</b>  The coded time information is referenced to UTC(CH) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code".  Access phone numbers: +41 31 323 32 25, +41 31 323 47 00.</p> <p><b>Network Time Protocol</b>  METAS operates a time server using the "Network Time Protocol"(NTP).  Host name of the server : ntp.metas.ch  Further information available at <a href="http://www.metas.ch">http://www.metas.ch</a></p>
MSL	<p><b>Network Time Service</b>  Computers connected to the Internet can be synchonized to UTC(MSL) using the NTP protocol. Access is available for users within New Zealand. Two servers are available at msftime1.irl.cri.nz and msftime2.irl.cri.nz</p> <p><b>Telephone Time Service</b>  A dial up computer time setting service for linking computers to UTC(MSL). The service uses a time code specific to New Zealand. Because it is a pay service, access is restricted to callers within New Zealand.</p> <p><b>Speaking Clock</b>  A speaking clock gives New Zealand time. Because it is a pay service, access is restricted to callers within New Zealand.  Further information about these services can be found at <a href="http://www.irl.cri.nz/msl/services/time/index.html">http://www.irl.cri.nz/msl/services/time/index.html</a></p>

NICT	<p><b>Telephone Time Service (TTS)</b>  Provides digital time code accessible by computer at 300/1200/2400 bps, 8 bits, no parity.  Access phone numbers: + 81 42 327 7592.</p> <p><b>Network Time Service (NTS)</b>  NICT operates time server of UTC(NICT) using the "Network Time Protocol" to NTP service companies in Japan as Stratum 1 server.  GPS common view data  NICT provides the GPS common view data based on UTC(NICT) to the time business service in Japan.</p>
NIM	<p><b>Television Time Service</b>  The coded time information generated by one time code generator is inserted into the TV signal. It can be obtained by using a decode TV receiver.  The time reference is UTC(NIM). Access TV channels of CCTV.</p> <p><b>Telephone Time Service</b>  The coded time information generated by NIM time code generator, referenced to UTC(NIM). Telephone Code provides digital time code at 1200 to 9600 bauds, 8 bits, no parity, 1 stop bit.  Access phone number: 8610 6422 9086.</p> <p><b>Network Time Service</b>  Provides digital time code across the Internet using NTP.</p>
NIMT	<p>2 NTP servers are available:  Addresses: 203.158.69.60  203.158.69.61  Both NTP servers are referenced to UTC(NIMT)</p>
NIST	<p><b>Automated Computer Time Service (ACTS)</b>  Provides digital time code by telephone modem for setting time in computers. Free software and source code available for download from NIST.  Includes provision for calibration of telephone time delay.  Access phone numbers : +1 303 494 4774 (24 phone lines) and +1 808 335 4721 (4 phone lines).  Further information at <a href="http://tf.nist.gov/service/acts.htm">http://tf.nist.gov/service/acts.htm</a></p> <p><b>Internet Time Service (ITS)</b>  Provides digital time code across the Internet using three different protocols: Network Time Protocol, Daytime Protocol, and Time Protocol.  Geographically distributed set of 15 time servers at 12 locations within the United States of America. Free software and source code available for download from NIST.  Further information at <a href="http://tf.nist.gov/service/its.htm">http://tf.nist.gov/service/its.htm</a></p> <p>Web-based time-of-day clock that displays UTC or local time for United States time zones. Referenced to NIST Internet Time Service. Provides snapshot of time with any web browser, but continuously running time display requires web browser with Java plug-in installed. Available at <a href="http://www.time.gov">http://www.time.gov</a> (in cooperation with the United States Naval Observatory), and at <a href="http://nist.time.gov">http://nist.time.gov</a></p>

NMLS	<p><b>Telephone Time Service</b>  The coded time information is referenced to UTC(NMLS) and generated by a TUG type telephone time code generator using an ASCII-character code. The time protocols are sent in the "European Telephone Time Code" format. The service phone number is +60 3 8778 1674. Current service status is free of charge. Fees are made only on the provision of the software for accessing the service via modem dial-up.</p> <p><b>Network Time Protocol Version 3</b>  The NTP time information is referenced to UTC(NMLS) and is currently generated by two Stratum-1 and Stratum-2 NTP servers, made available for public freely. The addresses for the servers are mst.sirim.my, 202.190.27.9 and 202.190.27.10.</p>
NPL	<p><b>Telephone Time Service</b>  A TUG time code generator provides the European Telephone Time Code, referenced to UTC(NPL), by telephone modem.  Software for synchronising computers is available from the NPL web site at <a href="http://www.npl.co.uk/time">www.npl.co.uk/time</a>.  The service telephone number is 0906 851 6333.  Note: this is a premium rate number and can only be accessed from within the UK.</p> <p><b>Internet Time Service</b>  Two servers referenced to UTC(NPL) provide Network Time Protocol (NTP) time code across the internet.  More information is available from the NPL web site at <a href="http://www.npl.co.uk/time">www.npl.co.uk/time</a>.  The server host names are:  ntp1.npl.co.uk  ntp2.npl.co.uk</p>
NPLI	<p><b>Telephone Time Service</b>  The coded time information generated by time code generator of NPLI, referenced to UTC(NPLI). Telephone Code provides digital time code (for the current time of Indian standard Time) at 1200 bauds, 8 bits, no parity, 1 stop bit. This service is known as TELECLOCK Service.  Accessible by :  a. an NPLI-developed Teleclock Receiver already available in the market.  b. a Computer through Telephone Modem and NPLI-developed software.  One-way Geostationary Satellite Time Service.</p>
NRC	<p><b>Telephone Code</b>  Provides digital time code by telephone modem for setting time in computers. Access phone number : +1 613 745 3900.  <a href="http://inms-ienm.nrc-cnrc.gc.ca/en/time_services/computer_timedate_e.php">http://inms-ienm.nrc-cnrc.gc.ca/en/time_services/computer_timedate_e.php</a></p> <p><b>Talking Clock Service</b>  Voice announcements of Eastern Time are at ten-second interval followed by a tone to indicate the exact time.  The service is available to the public in English at +1 613 745 1576 and in French at +1 613 745 9426. For more information see: <a href="http://inms-ienm.nrc-cnrc.gc.ca/en/time_services/telephone_clock_e.php">http://inms-ienm.nrc-cnrc.gc.ca/en/time_services/telephone_clock_e.php</a></p> <p><b>Web Clock Service</b>  The Web Clock shows dynamic clocks in each Canadian Time zone, for both Standard time and daylight saving time. The web page is at: <a href="http://time5.nrc.ca/webclock_e.shtml">http://time5.nrc.ca/webclock_e.shtml</a>.</p>

	<p>Network Time Protocol          Operates two time servers using the " Network Time Protocol ",          each one being on different location and network.          Host names : time.nrc.ca and time.chu.nrc.ca</p> <p>Further information at <a href="http://inms-ienm.nrc-cnrc.gc.ca/en/time_services/network_time_protocol_e.php">http://inms-ienm.nrc-cnrc.gc.ca/en/time_services/network_time_protocol_e.php</a></p>
NTSC	<p>Network Time Service (NTS)          Provides a synchronization to UTC(NTSC) computer clocks within China.          Software for the synchronization of computer clocks is available on the NTSC Time and Frequency home page : <a href="http://time.ntsc.ac.cn">http://time.ntsc.ac.cn</a>          Access Policy: free          Contact: Shaowu DONG (<a href="mailto:dongsw@ntsc.ac.cn">dongsw@ntsc.ac.cn</a>).</p>
ONBA	<p>Speaking clock access phone number 113 (only accessible in Argentina).          Hourly and half hourly radio-broadcast time signal.          Internet time service at web site <a href="http://www.hidro.gov.ar/hora/hora.asp">www.hidro.gov.ar/hora/hora.asp</a></p>
ONRJ	<p>Telephone Voice Announcer (55) 21 25806037.          Telephone Code (55) 21 25800677 provides digital time code at 300 bauds, 8 bits, no parity, 1 stop bit (Leitch CSD5300)</p> <p>Internet Time Service at the address : 200.20.186.75          SNTP at port 123          Time/UDP at port 37          Time/TCP at port 37          Daytime/TCP at port 13</p> <p>WEB-based Time Services:          1) A real-time clock aligned to UTC(ONRJ) and corrected for internet transmission delay.          Further information at: <a href="http://200.20.186.71/asp/relogio/horainicial.asp">http://200.20.186.71/asp/relogio/horainicial.asp</a>          2) Voice Announcer, in Portuguese, each ten seconds, after download of the Web page at: <a href="http://200.20.186.71">http://200.20.186.71</a>.</p>
ORB	<p>Network Time Service via NTP protocol          Hostname : <a href="http://ntp.oma.be">ntp.oma.be</a>          Access policy : free          Synchronization to UTC(ORB)          Contact : <a href="mailto:f.roosbeek@oma.be">f.roosbeek@oma.be</a>          Information on the web pages  <a href="http://www.observatoire.be/D1/TIME/ntp_en.htm">http://www.observatoire.be/D1/TIME/ntp_en.htm</a></p> <p>ORB provides a time dissemination via phone and modem to synchronize PC clocks on UTC(ORB). The system used is the Time Distribution System from TUG, which produces the telephone time code mostly used in Europe.          The baud rate used is 1200. The access phone number is 32 (0) 2 373 03 20. The system is updated periodically with DUT1 and leap seconds</p>
PTB	<p>Telephone Time Service          The coded time information is referenced to UTC(PTB) and generated by a TUG type time code generator using an ASCII-character code.          The time protocols are sent in a common format, the " European Telephone Time Code ". Access phone number : +49 531 51 20 38 .</p> <p>Internet Time Service          The PTB operates two time servers using the " Network Time Protocol " (NTP). Software for the synchronization of computer clocks is available on the web pages of the PTB  <a href="http://www.ptb.de/en/org/q/q4/q42_index.htm">http://www.ptb.de/en/org/q/q4/q42_index.htm</a>.          Host names of the servers: <a href="http://ptbtime1.ptb.de">ptbtime1.ptb.de</a>  <a href="http://ptbtime2.ptb.de">ptbtime2.ptb.de</a></p>

ROA	<p><b>Telephone Code</b>  The coded time information is referenced to UTC(ROA) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". Access phone number : +34 956 599 429</p> <p><b>Network Time Protocol</b>  Server : hora.roa.es  Synchronized to UTC(ROA) better than 10 microseconds  Service policy : free</p> <p>Server : ntp0.roa.es  Synchronized to UTC(ROA) better than 10 microseconds  Service policy : restricted  Note : server used as prototype to check new software, hardware, etc.</p>
SG	<p><b>Web-based time service:</b>  Displays a real-time clock referenced to UTC(SG) at web-site <a href="http://www.SingaporeStandardTime.org.sg">http://www.SingaporeStandardTime.org.sg</a>. User-selectable displays of local time (adjusted for daylight savings) of major cities worldwide and time differences between any two cities are also available at the web-site.</p> <p><b>Automated Computer Time Service (ACTS)</b>  Transmits digital time code (NIST format) via telephone &amp; modem for setting time in computers. The coded time information is referenced to UTC(SG). Includes provision for correcting telephone time delays.  Access phone number : +65 67799978.  Information is available at <a href="http://www.SingaporeStandardTime.org.sg">http://www.SingaporeStandardTime.org.sg</a>.</p> <p><b>Network Time Service (NeTS)</b>  Transmits digital time code via the Internet using three different protocols – Time, Daytime and NTP. Operates two time servers.  Host names : NeTS.org.sg  203.117.180.35  Information available at <a href="http://www.SingaporeStandardTime.org.sg">http://www.SingaporeStandardTime.org.sg</a>.</p>
SP	<p><b>Telephone Time Service</b>  The coded time information is referenced to UTC(SP) and generated by two TUG type time code generators using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code".  Access phone number: +46 33 41 57 83</p> <p><b>Internet Time Service</b>  The coded time information is referenced to UTC(SP) and generated by two NTP servers using the Network Time Protocol (NTP).  Access host names : ntp1.sp.se and ntp2.sp.se</p> <p><b>Speaking Clock</b>  The speaking clock service is operated by Telia AB in Sweden. The time announcement is referenced to UTC(SP) and disseminated from a computer based system operated and maintained at SP.  Access phone number : 90510 (only accessible in Sweden).  Access phone number : +4633 90510 (from outside Sweden).</p> <p>More information about these services are found at the web site <a href="http://www.sp.se">www.sp.se</a></p>

TL	<p><b>Speaking Clock Service</b>          Traceable to UTC(TL). Broadcast through PSTN (Public Switching Telephone Network) automatically and provides accurate voice time signal to public users.</p> <p><b>The Computer Time Service</b>          Provides digital time code by telephone modem for setting time in computers.          Access phone number : +886 3 4245117.</p> <p><b>NTP Service</b>          TL operates a time server using the "Network Time Protocol (NTP)".          Host name of the server : time.stdtime.gov.tw          Further information at <a href="http://www.stdtime.gov.tw/english/e-home.htm">http://www.stdtime.gov.tw/english/e-home.htm</a></p>
TP	<p><b>Internet Time Service</b>          IREE operates a time server directly referenced to UTC(TP).          Time information is accessible through Network Time Protocol (NTP).</p> <p>Server host name: time.ure.cas.cz          More information at <a href="http://www.ure.cas.cz/time">http://www.ure.cas.cz/time</a></p>
USNO	<p><b>Telephone Voice Announcer</b> +1 202 762-1401          Backup voice announcer: (719) 567-6742  <b>Telephone Code</b> +1 202 762-1594          provides digital time code at 1200 baud, 8 bits, no parity          Automated data service for downloading files +1 202 762-1503          Web site for time and for data files: <a href="http://tycho.usno.navy.mil">http://tycho.usno.navy.mil</a>          Network Time Protocol (NTP) see  <a href="http://tycho.usno.navy.mil/ntp.html">http://tycho.usno.navy.mil/ntp.html</a>          for software and site closest to you.</p>
VSL	<p><b>Telephone Time Service</b>          The coded time information is referenced to UTC(VSL) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". The access phone number is 0900 6171819. This is a toll number and therefore can only be accessed in the Netherlands.</p>



# Director's Report on the Activity and Management of the BIPM, 2005, T. 6

(July 2004 – June 2005)

BIPM Publication

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

The reference time scales, International Atomic Time (TAI) and Coordinated Universal Time (UTC), are computed from data reported regularly to the BIPM by the various timing centres that maintain a local UTC; monthly results are published in *Circular T. The Annual Report of the BIPM Time Section for 2004* (Volume 17), complemented by computer-readable files on the BIPM website ([www.bipm.org](http://www.bipm.org)), provides the definitive results for 2004.

## 2 Algorithms for time scales

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

### 2.1 EAL stability

Some 85 % of the clocks used in the calculation of the time scales are now either commercial caesium clocks of the HP/Agilent 5071A type or active, auto-tuned hydrogen masers. To improve the stability of EAL, the weighting procedure applied to clocks sets the maximum relative weight each month to  $2.5/N$ , where  $N$  is the total number of participating clocks. A clock reaches the maximum weight when its variance computed from 12 consecutive 30 day samples is, at most, about  $6 \times 10^{-15}$ . About 13 % of the participating clocks have been at the maximum weight, on average, during 2004. This procedure generates a time scale which relies upon the best clocks.

A new estimation of the medium-term and long-term stability of EAL has been completed. Expressed in terms of an Allan deviation, it is estimated to be  $0.4 \times 10^{-15}$  for averaging times of one month since 2003. Slowly varying long-term drifts limit its stability to  $2 \times 10^{-15}$  for averaging times of six months.

### 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 July 2004, individual measurements of the TAI frequency have been provided by eight primary frequency standards including four caesium fountains (IEN CSF1, LNE-SYRTE FO2, NIST F1, and NPL CSF). Reports on the operation of the primary frequency standards are regularly published in the *Annual Report of the BIPM Time section*.

Following Recommendation CCTF 3 (2004), the procedure for the frequency steering of TAI has been revised. Starting in July 2004, a monthly steering correction of order  $0.7 \times 10^{-15}$  is applied as deemed necessary. Since July 2004, the global treatment of individual measurements has led to a relative departure of the duration of the TAI scale unit from the SI second on the geoid ranging from  $+2.1 \times 10^{-15}$  to  $+5.8 \times 10^{-15}$ , with a standard uncertainty of about  $2 \times 10^{-15}$ . Over the year, six steering corrections have been applied for a total correction of  $[f(EAL) - f(TAI)]$  of  $-2 \times 10^{-15}$ .

### 2.3 Determination of uncertainties in $[UTC - UTC(k)]$

Since January 2005, the values of the uncertainties of  $[UTC - UTC(k)]$  have been published in the BIPM publication *Circular T*. This has been recommended by the CCTF, and is required by the CIPM MRA for publication of the key comparison in time in the KCDB. The BIPM Time section addressed this issue in cooperation with the IEN and the USNO. An analytical solution was derived from the law of the propagation of uncertainty, taking into account that leap seconds and deterministic frequency steering of EAL do not affect these uncertainties. The analytical results were verified through Monte Carlo simulations using the software that generates UTC, and good agreement was found, giving confidence in the analytical estimation. A more detailed analysis is in progress, using full inclusion of all available calibration information, more details for the correlation between the links, methods for optimizing the link structure, given uncertainty information, non-Gaussian behavior and different correlation properties of uncertainties due to calibration or due to random noise.

### 2.4 Independent atomic time scales

The BIPM staff is involved in the organization and elaboration of the Polish independent atomic time scale TA(PL). Specially devised software for a limited number of clocks has been developed, and is being improved. For an averaging time of about one month, the stability of TA(PL) is approximately  $2.5 \times 10^{-15}$ .

#### TT(BIPM)

Because TAI is computed in “real-time” and has operational constraints, it does not provide an optimal realization of Terrestrial Time TT, the time coordinate of the geocentric reference system. The BIPM therefore computes an additional realization TT(BIPM) in post-processing, which is based on a weighted average of the evaluation of TAI frequency by the primary frequency standard. We have provided an updated computation of TT(BIPM), named TT(BIPM2004), valid until August 2004. In this, we used all recently available data from the new caesium fountains and a revised estimation of the stability of the free atomic time scale EAL on which TAI is based.

## 3 Time links

The BIPM Time section organizes the international network of time links. In 2004, significant improvement was made on time transfer for TAI. Ten time links obtained with dual-frequency GPS geodetic-type receivers (P3) have been introduced into TAI since 2003, and this process continues. This allows the use of three techniques for clock comparison in TAI. At present, 30 % of the links are performed with the classical GPS common-view technique based on C/A-code measurements obtained from single-channel single-frequency receivers; about 36 % of the links are obtained from observations with multichannel receivers, some of them being GPS and GLONASS dual-code dual-system ones; 10 % are calculated from observations of dual frequency GPS receivers; and 13 % are links performed with the TWSTFT technique. As a result, there has been an improvement in the accuracy for time transfer, and the whole system of time links becomes more reliable. In addition, the BIPM Time section continues to test other time and frequency comparison methods and techniques. Results of these comparisons are available on the BIPM website.

With the aim of supporting some contributing laboratories in the improvement of their contributions to TAI, GPS receivers have been sent to three time laboratories under a loan agreement.

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

*i) Current work*

The BIPM publishes an evaluation of the daily time differences [ $UTC - GPS\ time$ ] and [ $UTC - GLONASS\ time$ ] in its monthly publication *Circular T*, and routinely issues GPS and GLONASS international common-view schedules. The international network of GPS common-view links used by the BIPM follows a pattern of local stars within a continent. All GPS links are corrected for satellite positions using IGS (International GNSS Service) post-processed precise satellite ephemerides, and those performed with single-frequency receivers are corrected for ionospheric delays using IGS maps.

*ii) Standards for GPS and GLONASS receivers*

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

*iii) Multichannel GPS time links*

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

*iv) IGS estimated ionospheric corrections*

Ionospheric parameters estimated by the IGS are routinely used to correct all GPS links performed with single channel receivers for ionospheric delays in regular TAI calculations.

3.2 Phase and code measurements from geodetic-type receivers

It will be recalled that GPS and GLONASS time and frequency transfer may also be carried out using dual-frequency carrier-phase measurements in addition to code measurements. This technique, already in common use in the geodetic community, can be adapted to the needs of time and frequency transfer. These studies are conducted in the framework of the IGS working group on clock products, of which a physicist of the staff is a member. Studies continue at the BIPM using two Ashtech Z12-T GPS receivers, one Javad Legacy GPS/GLONASS receiver, one Septentrio PolarX receiver, and one TTS-3 GPS/GLONASS receiver (acquired in December 2004).

The method developed to perform the absolute calibration of the Ashtech Z12-T hardware delays allows us to use this receiver for differential calibrations of similar receivers worldwide. Calibration trips began in January 2001 and have continued ever since. From July 2004 to June 2005, 12 such calibrations have taken place concerning receivers in nine laboratories. The new Ashtech Z12-T serves as a local reference with which the traveling Ashtech Z12-T is compared while at the BIPM. Collaboration has been started with CNES to perform new measurements for absolute calibration of the receiver at the CNES facilities in Toulouse. Calibration of the new type of receiver Septentrio PolaRx2 is being investigated in collaboration with laboratories equipped with such receivers.

Data from geodetic-type receivers worldwide are collected for TAI computation, using procedures and software developed in collaboration with the Observatoire Royal de Belgique (ORB). As of June 2005, 17 laboratories regularly provide such P3 data. Time links computed using these data are systematically compared to other available techniques, notably for two-way time transfer. Because several time laboratories participate both to TAI with P3 data and to the IGS network, we have also compared the P3 links with time links computed by the IGS using phase and code measurements. We have shown that the long-term stability of the P3 links is typically well below 1 ns. These time links

have also been used for a dedicated exercise of comparison of caesium fountains carried out in October-November 2004.

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

### 3.3 Two-way time transfer

Two meetings related to TWSTFT activities have been held since October 2004. The BIPM collects two-way data from 12 operational stations and undertakes treatment of some two-way links. About ten TWSTFT links are routinely used in the computation of TAI; some others are in preparation for their introduction into TAI. The BIPM is also involved in the calibration of two-way time-transfer links by comparison with GPS. The Time section interrupted the elaboration of TWSTFT reports; instead, multi-technique comparisons are performed and published on the internet. A staff member of the BIPM provides the secretariat for the CCTF Working Group on TWSTFT.

### 3.4 Uncertainties of TAI time links

The values of the Type A and Type B uncertainties of TAI time links are published in the *Circular T*, together with the information on the time links used in each monthly calculation. Mainly because of lack of calibration, the Type B uncertainties of GPS links can reach 30 ns. This underlines the need to complete the calibration of all TAI time links.

### 3.5 Calibration of TAI time links

The BIPM is conducting a series of calibrations of GPS time equipment located in time laboratories contributing to TAI. From July 2004 to June 2005, GPS time equipment in 17 laboratories and GPS P3 equipment in nine laboratories have been calibrated. In addition, the Time section staff is developing methods for calibration of GPS/GLONASS time receivers. The BIPM is also taking part in the organization of TWSTFT calibration trips.

## 4 Key comparisons

The key comparison in time CCTF-K2001.UTC was published for the first time in January 2005. Monthly updates are performed after the publication of *Circular T*. Timing centres in laboratories who are participants to the CIPM MRA, from Member States and Associates of the CGPM, take part in the key comparison.

## 5 Pulsars

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

## 6 Space-time references

Uniformity in the definition of space reference systems plays an increasingly important role in basic metrology, particularly for astro-geodetic techniques that contribute to the International Earth Rotation and Reference Systems Service (IERS). Since 1 January 2001, a collaborative effort between the BIPM and the U.S. Naval Observatory (USNO) provides the Conventions of the IERS. The new edition of the *IERS Conventions* (2003), finalized in 2003, has been published in paper version. This document summarizes the models, constants and procedures used for data analysis in the IERS, and for the astrometry-geodesy community at large.

A web and ftp site for the IERS Conventions has been established at the BIPM (<http://tai.bipm.org/iers/>) and a user discussion forum has been set-up (<http://tai.bipm.org/iers/forum/>) for users to offer comments related to the future updates of the IERS Conventions. First updates of the Conventions (2003) have been posted on the website <http://tai.bipm.org/iers/convupdt>. They are mostly editorial corrections and small modifications of the text. Larger modifications are currently studied with the help of an Advisory Board for the IERS Conventions updates, chaired by Jim Ray, and including representatives of all groups involved in the IERS. A special session on the IERS Conventions updates has been convened at the General Assembly of the European Geophysical Union in April 2005 to discuss these topics. The 39th meeting of the Directing Board of the IERS was held at the BIPM on 23 September 2004.

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

## 7 Other studies

Peter Wolf is presently on secondment at the Paris Observatory (OP) and we are reporting here his contribution to their programmes.

Final results of the test of Lorentz invariance using the cryogenic sapphire oscillator at the LNE-SYRTE (OP) have been published. They improve the best previous results by about an order of magnitude. First results of the rotating Michelson-Morley experiment at the university of Western Australia were obtained, with another factor of 7 improvement. Other possibilities for testing the Lorentz invariance in the photon sector have been investigated. We have recently carried out a test of Lorentz invariance in the matter sector using Zeeman transitions in a caesium atomic fountain clock at the LNE-SYRTE, with first results published.

Optical lattice clocks are being constructed and operated at several laboratories. They use a large number of neutral atoms (Sr, Yb, Hg, Ca) trapped in an optical potential, and are the most promising candidates for reaching  $10^{-17}$  to  $10^{-18}$  accuracies as they combine the advantages of single trapped ion, and freely falling neutral atom standards. We have studied methods to circumvent limitations of such clocks imposed by the intensity of the trapping laser. We show that gravity can be effectively used to reduce the intensity requirement by more than an order of magnitude. The proposed scheme is being implemented in the Sr standard of LNE-SYRTE.

## 8 Publications

### 8.1 External publications

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## 8.2 BIPM publications

16. *Annual Report of the BIPM Time Section (2004)*, 2005, **17**, 94 pp.
17. *Circular T* (monthly), 7 pp.

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