BUREAU INTERNATIONAL DES POIDS ET MESURES

BIPM Annual Report on Time Activities

Rapport annuel du BIPM sur les activités du temps

Volume 2

2007

Pavillon de Breteuil
F-92312 SÈVRES Cedex, France

ISBN 92-822-2227-6
ISSN 1994-9405

Contents

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

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

Practical information about the BIPM Time, Frequency and Gravimetry Section

The Time, Frequency and Gravimetry Section of the BIPM issues two periodic publications. These are the monthly *Circular T* and the *BIPM Annual Report on Time Activities*. 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 temps, fréquences et gravimétrie du BIPM produit deux publications périodiques : la Circulaire T, *mensuelle, et le* Rapport annuel du BIPM sur les activités du temps. *Les circulaires et la plupart des tableaux de ce rapport annuel sont disponibles par utilisation du site internet du BIPM, http://www.bipm.org.*

Address:	Time, Frequency and Gravimetry Section Bureau International des Poids et Mesures Pavillon de Breteuil F-92312 Sèvres Cedex, France	
Telephone:	BIPM Switchboard:	+ 33 1 45 07 70 70
Telefax:	BIPM Time, Frequency and Gravimetry Section:	+ 33 1 45 07 70 59
	BIPM General:	+ 33 1 45 34 20 21
Internet:	http://www.bipm.org or anonymous ftp to 62.161.69.5 (subdirectory TAI)	
E-mail:	tai@bipm.org	

Staff dedicated to Time Activities as of January 2008 :

Dr Elisa Felicitas ARIAS, Head, Principal Research Physicist	+ 33 1 45 07 70 76	farias@bipm.org
Dr Zhiheng JIANG, Principal Physicist	+ 33 1 45 07 70 34	jiang@bipm.org
Dr Włodzimierz LEWANDOWSKI, Principal Physicist	+ 33 1 45 07 70 63	wlewandowski@bipm.org
Dr Gianna PANFILO, Physicist	+ 33 1 45 07 70 75	gpanfilo@bipm.org
Dr Gérard PETIT, Principal Physicist	+ 33 1 45 07 70 67	gpetit@bipm.org
Miss Hawaï KONATÉ, Technician	+ 33 1 45 07 70 72	hkonate@bipm.org
Mr Laurent TISSERAND, Technician	+ 33 1 45 07 70 45	ltisserand@bipm.org

Electronic access to the files on BIPM time activities

A large number of files related to the BIPM Time Activities are available from the website. (http://www.bipm.org/en/scientific/tai/time_ftp.html)

The files are found in the four subdirectories **data, publications, scales and links**.
Data, **publications** and **scales** 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- Reports of evaluation of primary frequency standards and all clock and time transfer data files used for the computation of TAI, arranged in yearly directories, starting January 2005. See readme.txt for details.

Publication- the latest issues on time activities

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.

publications	**filename**
Acronyms of laboratories	acronyms.pdf
Leap seconds	leaptab.txt
Circular T	cirt.XXX
Fractional frequency of EAL from primary frequency standards	etXY.ZT
Weights of clocks participating in the computation of TAI	wXY.ZT
Rates relative to TAI of clocks participating in the computation of TAI	rXY.ZT
Values of the differences between TAI and the local atomic scale of the given laboratory, including relevant notes	TAI - lab
Values of the differences between UTC and its local representation by the given laboratory, including relevant notes	UTC - lab
Values of the differences between TAI and UTC and the respective local scales, evaluated for two-month periods until the end of 1997	TAIXYZ
[*UTC*(*lab1*) - *UTC*(*lab2*)] obtained by the TWSTFT link	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	schgps.XX
GLONASS satellites	schglo.XX

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

Scale- time scales data

Content	**filename**
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
Starting 1993:	
Difference between the normalized frequencies of EAL and TAI	EALTAIXY.ar
TAI frequency	FTAIXY.ar (for 1993,1994)
Measurements of the duration of the TAI scale interval	UTAIXY.ar (starting 1995)
Mean duration of TAI scale interval	SITAIXY.ar (1993-1999)
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)
Until 1992:	
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

Leap seconds

Secondes intercalaires

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

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

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

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

IERS Earth Orientation Product 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 400 atomic clocks kept by 65 laboratories spread worldwide. The data are regularly reported to the BIPM by about 60 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 0 h UTC for Modified Julian Dates (MJD) ending in 4 and 9, at 0 h 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 (Échelle Atomique Libre), defined as a weighted average of clock readings. The processing is carried out and, subsequently, treats one month blocks of data [1] and [2]. 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 to compare local realizations of UTC in contributing laboratories and uses them in the formation of TAI. The network of time links used by the BIPM is non-redundant and relies on observation of GPS satellites and on two-way satellite time and frequency transfer (TWSTFT).

Most time links are based on GPS satellite observations. 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 satellite ephemeredes.

GPS links are computed with the method called "GPS all in view" [3], with a network of time links that uses the PTB as a unique pivot laboratory for all the GPS links. The network of time links is shown on page 11 of this volume.

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 [4, 5]. 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

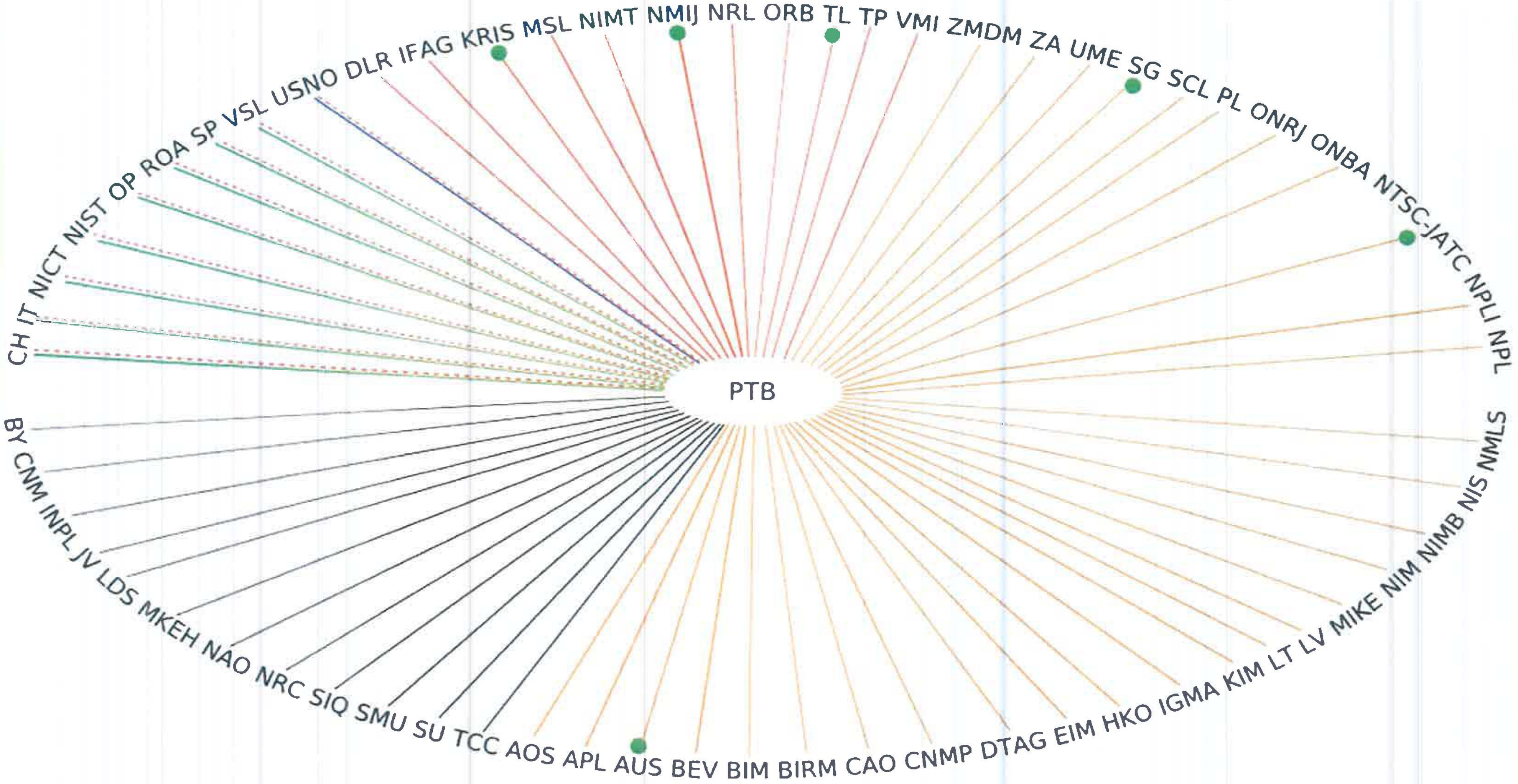
Tables 8 and 9 of this report give the rates relative to TAI and the weights of the clocks contributing to TAI in 2007.

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

The report on the scientific work of the BIPM on time activities for the period July 2006-June 2007, published in the *Director's Report on the Activity and Management of the BIPM*, 2007, **8** is reproduced after the yellow pages. All the publications mentioned in this report are available on request from the BIPM.

References

[1] Thomas C. and Azoubib J., TAI computation: study of an alternative choice for implementing an upper limit of clock weights, *Metrologia*, 1996, **33**, 227-240.
[2] Azoubib J., 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] Petit G., Jiang Z., GPS All in View time transfer for TAI computation, *Metrologia*, 2008, **45** (1), 35-45.
[4] Guinot B., Atomic time scales for pulsar studies and other demanding applications, *Astron. Astrophys.*, 1988, **192**, 370-373.
[5] Petit G., A new realization of Terrestrial Time, Proc. 35th PTTI, 2003, 307-317.



ORGANIZATION OF THE ALL-IN-VIEW INTERNATIONAL TIME LINKS

March 2008

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

BIPM

Etablissement du Temps atomique international et du Temps universel coordonné

1. Données et mode de calcul

Le Temps atomique international (TAI) et le Temps universel coordonné (UTC) sont obtenus par une combinaison de données provenant de quelque 400 horloges atomiques conservées par 65 laboratoires répartis dans le monde entier, et fournies régulièrement au BIPM par une soixantaine de laboratoires de temps qui maintiennent un UTC local, UTC(k) (liste donnée dans le tableau 3). Ces données prennent la forme de différences de temps [UTC(k) - Horloge] *enregistrées de 5 jours en 5 jours pour les dates juliennes modifiées (MJD) se terminant par 4 et 9, à 0 h UTC, « dates normales ». L'équipement maintenu par ces laboratoires de temps est décrit dans le tableau 4.*

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

2. Exactitude

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

3. Disponibilité

Le TAI et l'UTC sont disponibles sous forme de différences de temps avec les échelles locales de temps UTC(k), approximation de l'UTC, et TA(k), temps atomique local indépendant. Ces différences, [TAI - TA(k)] *et* [UTC - UTC(k)], *calculées pour les dates normales sont disponibles sur le site internet du BIPM (voir p. 5 de ce volume).*

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 liaisons horaires dans le but de comparer des réalisations locales de l'UTC dans les laboratoires participants. Le système des liaisons horaires utilisé par le BIPM est non-redondant et repose sur l'observation des satellites du GPS et sur la technique d'aller et retour sur satellite de télécommunications (TWSTFT).

La plupart des liaisons se font par observation 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 plus de celles avec des récepteurs mono-fréquence traditionnels (mono et multi-canaux). Dans les cas où plusieurs techniques participent à une liaison horaire, une d'entre elles est considérée comme 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 des satellites produites par l'IGS.

Les comparaisons horaires par GPS se font par la méthode dite « GPS all in view » [3], dont le réseau a un seul laboratoire central (PTB) pour toutes les comparaisons horaires. Le schéma des comparaisons horaires se trouve à la page 11 de ce volume.

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 site web du BIPM.*

Le BIPM publie régulièrement une évaluation de [UTC - temps du GLONASS], *accessible sur le site web du BIPM et déduite des observations habituelles du système GLONASS, réalisées à l' Astrogeo-dynamical 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 site web (voir p. 5 de ce volume).

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 [4, 5]. 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 (voir p. 5 de ce volume).

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 2007.
Les pages jaunes, à la fin de ce volume, concernent les émissions de signaux horaires et les services de dissémination du temps.

Le rapport (juillet 2006 - juin 2007) du travail scientifique du BIPM sur les activités du temps publié dans le Rapport du directeur sur l'activité et la gestion du Bureau international des poids et mesures (BIPM), 2007, ***8****, 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 2008

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

Table 2. Relationship between TAI and UTC, up to 31 December 2008

Limits of validity (at 0 h UTC)	[*TAI* - *UTC*] / s
1961 Jan. 1 - 1961 Aug. 1	1.422 8180 + (MJD - 37300) x 0.001 296
1961 Aug. 1 - 1962 Jan. 1	1.372 8180 + " "
1962 Jan. 1 - 1963 Nov. 1	1.845 8580 + (MJD - 37665) x 0.001 1232
1963 Nov. 1 - 1964 Jan. 1	1.945 8580 + " "
1964 Jan. 1 - 1964 Apr. 1	3.240 1300 + (MJD - 38761) x 0.001 296
1964 Apr. 1 - 1964 Sep. 1	3.340 1300 + " "
1964 Sep. 1 - 1965 Jan. 1	3.440 1300 + " "
1965 Jan. 1 - 1965 Mar. 1	3.540 1300 + " "
1965 Mar. 1 - 1965 Jul. 1	3.640 1300 + " "
1965 Jul. 1 - 1965 Sep. 1	3.740 1300 + " "
1965 Sep. 1 - 1966 Jan. 1	3.840 1300 + " "
1966 Jan. 1 - 1968 Feb. 1	4.313 1700 + (MJD - 39126) x 0.002 592
1968 Feb. 1 - 1972 Jan. 1	4.213 1700 + " "
1972 Jan. 1 - 1972 Jul. 1	10 (integral number of seconds)
1972 Jul. 1 - 1973 Jan. 1	11
1973 Jan. 1 - 1974 Jan. 1	12
1974 Jan. 1 - 1975 Jan. 1	13
1975 Jan. 1 - 1976 Jan. 1	14
1976 Jan. 1 - 1977 Jan. 1	15
1977 Jan. 1 - 1978 Jan. 1	16
1978 Jan. 1 - 1979 Jan. 1	17
1979 Jan. 1 - 1980 Jan. 1	18
1980 Jan. 1 - 1981 Jul. 1	19
1981 Jul. 1 - 1982 Jul. 1	20
1982 Jul. 1 - 1983 Jul. 1	21
1983 Jul. 1 - 1985 Jul. 1	22
1985 Jul. 1 - 1988 Jan. 1	23
1988 Jan. 1 - 1990 Jan. 1	24
1990 Jan. 1 - 1991 Jan. 1	25
1991 Jan. 1 - 1992 Jul. 1	26
1992 Jul. 1 - 1993 Jul. 1	27
1993 Jul. 1 - 1994 Jul. 1	28
1994 Jul. 1 - 1996 Jan. 1	29
1996 Jan. 1 - 1997 Jul. 1	30
1997 Jul. 1 - 1999 Jan. 1	31
1999 Jan. 1 - 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) (updated to April 2008)

AMC	Alternate Master Clock station, Colorado Springs, Colo., USA
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
BIM	Bulgarian Institute of Metrology, Sofiya, Bulgary
BIRM	Beijing Institute of Radio Metrology and Measurement, Beijing, P. R. China
BY	Belarussian State Institute of Metrology, Minsk, Belarus
CAO	Stazione Astronomica di Cagliari (Cagliari Astronomical Observatory), Cagliari, Italy
CH	Federal Office of Metrology, Switzerland (METAS)
CNM	Centro Nacional de Metrología, Querétaro, Mexico (CENAM)
CNMP	Centro Nacional de Metrología de Panamá, Panamá
DLR	Deutsche Zentrum für Luft- und Raumfahrt (German Aerospace Centre) Oberpfaffenhofen, Germany
DTAG	Deutsche Telekom AG, Frankfurt/Main, Germany
EIM	Hellenic Institute of Metrology, Thessaloniki, Greece
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
IFAG	Bundesamt für Kartographie und Geodäsie (Federal Agency for Cartography and Geodesy), Fundamental station, Wettzell, Kötzting, Germany
IGMA	Instituto Geográfico Militar, Buenos Aires, Argentina
INPL	National Physical Laboratory, Jerusalem, Israel
IPQ	Instituto Português da Qualidade, Monte de Caparica, Portugal
IT	Istituto Nazionale di Ricerca Metrologica (I.N.RI.M.), Italy
JATC	Joint Atomic Time Commission, Lintong, P.R. China
JV	Justervesenet, Norwegian Metrology and Accreditation Service, Kjeller, Norway
KIM	Research Centre for Calibration, Instrumentation and Metrology The Indonesian Institute of Sciences, Serpong-Tangerang - Indonesia
KRIS	Korea Research Institute of Standards and Science, Daejeon, Rep. of Korea
MIKE	Center for Metrology and Accreditation, Finland
MKEH	Hungarian Trade Licensing Office, Hungary
LDS	University of Leeds, Leeds, United Kingdom
LT	Lithuanian National Metrology Institute, Vilnius, Lithuania
LV	SA Latvian National Metrology Centre, Riga, Latvia
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
NMIA	National Measurement Institute of Australia, Sydney, Australia, formerly NML
NMIJ	National Metrology Institute of Japan, Tsukuba, Japan

Table 3. Acronyms and locations of the timing centres which maintain a local approximation of UTC, UTC(k), and/or an independent local time scale, TA(k) (Cont.) (updated to April 2008)

NMLS	National Metrology Laboratory of SIRIM Berhad, Shah Alam, Malaysia
NPL	National Physical Laboratory, Teddington, United Kingdom
NPLI	National Physical Laboratory, New Delhi, India
NRC	National Research Council of Canada, Ottawa, Canada
NRL	U.S. Naval Research Laboratory, Washington D.C., USA
NTSC	National Time Service Center of China, Lintong, P.R. China
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)
SIQ	Slovenian Institute of Quality and Metrology, Ljubljana, Slovenia
SMU	Slovenský metrologićký ústav (Slovak Institute of Metrology), Bratislava, Slovakia
SP	Sveriges Provnings- och Forskningsinstitut (Swedish National Testing and Research Institute), Borås, Sweden
SU	Institute of Metrology for Time and Space (IMVP), NPO "VNIIFTRI" Mendeleevo, Moscow Region, Russia
TCC	TIGO Concepción Chile, Chile
TL	Telecommunication Laboratories, Chung-Li, Taiwan
TP	Institute of Photonics and Electronics, Czech Academy of Sciences, Praha, Czech Republic
UME	Ulusai Metroloji Enstitüsü, Marmara Research Center, (National Metrology Institute), Gebze Kocaeli, Turkey
USNO	U.S. Naval Observatory, Washington D.C., USA
VMI	Vietnam Metrology Institute, Ha Noi - Vietnam
VSL	NMi Van Swinden Laboratorium, Delft, the Nederlands
ZA	Council for Scientific and Industrial Research, South Africa
ZMDM	Bureau of Measures and Precious Metals, Belgrade, Serbia

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 2007

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	2 Ind. Cs 1 H-maser	1 H-maser + microphase-stepper		*		*	*
APL	3 Ind. Cs 3 H-masers	1 Cs + microphase-stepper		*			
AUS	5 Ind. Cs 4 H-masers (2)	1 Cs		*	*		*
BEV	3 Ind. Cs 1 H-maser	1 Cs		*			
BIM	1 Ind. Cs	1 Cs		*			
BIRM	2 Ind. Cs 6 H-masers	1 Cs		*	*		
BY	6 H-masers	3-4 H-masers		*			
CAO (a)	2 Ind. Cs	1 Cs		*			
CH	4 Ind. Cs (3) 1 H-maser	all the Cs 1 H-maser	*		*		*
CNM (a)	3 Ind. Cs 1 H-maser	1 Cs		*			
CNMP	1 Ind. Cs	1 Cs		*			
DLR	3 Ind. Cs 5 H-masers	1 Cs			*		
DTAG	3 Ind. Cs	1 Cs		*			
EIM	4 Ind. Cs	1 Cs		*			
HKO	2 Ind. Cs	1 Cs		*			
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		*			
IT	5 Ind. Cs 2 H-masers 1 Lab. Cs	1 H-maser + microphase-stepper	*	*	*	*	*
JATC	9 Ind. Cs (4) 4 H-masers	1 H-maser + microphase-stepper	*	*	*		*
JV (a)	4 Ind. Cs	1 Cs		*			

Table 4. Equipment and source of UTC(k) of the laboratories contributing to TAI in 2007 (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 4 H-masers	1 H-maser + microphase-stepper	*	*	*	*	*
LDS (a)	1 Ind. Cs	1 Cs		*		*	
LT	2 Ind. Cs	1 Cs		*			
LV	2 Ind. Cs	1 Cs		*			
MIKE	2 Ind. Cs 2 H-masers	1 H-maser + microphase-stepper		*	*	*	
MKEH (5)	1 Ind. Cs	1 Cs		*			
MSL	3 Ind. Cs	1 Cs		*	*		
NAO	4 Ind. Cs 1 H-maser	1 Cs + microphase-stepper		*			
NICT	27 Ind. Cs 7 H-masers (6) 1 Lab. Cs	18 Cs	*	*	*		*
NIM	3 Ind. Cs 2 H-masers	1 Cs + microphase-stepper		*			
NIMB	2 Ind. Cs	1 Cs		*			
NIMT	3 Ind. Cs	1 Cs		*	*		
NIS (a)	3 Ind. Cs	1 Cs		*	*	*	
NIST	8 Ind. Cs 1 Lab. Cs 6 H-masers	4 Cs 5 H-masers	*	*	*	*	*
NMIJ	5 Ind. Cs 1 Lab. Cs 3 H-masers	1 H-maser + microphase-stepper		*	*		*
NMLS	5 Ind. Cs	1 Cs			*		
NPL	2 Ind. Cs 3 H-masers	1 H-maser		*	*		*
NPLI (a)	3 Ind. Cs	1 Cs		*		*	
NRC	2 Ind. Cs 2 Lab. Cs 3 H-masers	1 Ind. Cs + microphase-stepper	*	*	*		
NTSC	14 Ind. Cs 4 H-masers	1 H-maser + microphase-stepper	*	*	*		*
ONBA	1 Ind. Cs	1 Cs		*			

Table 4. Equipment and source of UTC(k) of the laboratories contributing to TAI in 2007 (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		
ONRJ	5 Ind. Cs	1 Cs + microphase-stepper	* (7)	*			
OP	7 Ind. Cs 3 Lab. Cs 4 H-masers	1 Cs + microphase-stepper	* (8)	*	*		*
ORB	3 Ind. Cs 3 H-masers	1 H-maser			*		
PL	9 Ind. Cs 3 H-masers	1 Cs + microphase-stepper (10)	* (9)	*			
PTB	3 Ind. Cs 3 Lab. Cs (11) 3 H-masers	1 Lab. Cs	* (12)	*	*	*	*
ROA	6 Ind. Cs 1 H-maser	all the Cs		*	*		*
SCL	2 Ind. Cs	1 Cs + microphase-stepper		*			
SG	3 Ind. Cs (13)	1 Cs + microphase-stepper		*			
SIQ	1 Ind. Cs	1 Cs		*			
SMU	1 Ind. Cs	1 Cs + output frequency steering		*			
SP	11 Ind. Cs (14) 6 H-masers	1 Cs + microphase-stepper			*		*
SU	1 Lab. Cs 8 H-masers	3-4 H-masers	* (15)	*	*	*	
TCC (a)	3 Ind. Cs 2 H-masers	1 Cs + microphase-stepper		*	*		
TL	10 Ind. Cs 2 H-masers	1 H-maser + microphase-stepper	* (16)		*		*
TP	4 Ind. Cs	1 Cs + output frequency steering		*	*		
UME	3 Ind. Cs	1 Cs		*	*	*	
USNO	72 Ind. Cs 24 H-masers	1 H-maser + frequency synthesizer steered to UTC(USNO) (17)	(17) *	*	*	*	*
VSL	4 Ind. Cs	1 Cs + microphase-stepper		*	*	*	*
ZA (18)	4 Ind. Cs	1 Cs		*		*	
ZMDM	1 Ind. Cs	1 Cs + microphase-stepper		*			

Notes

(1)		When several clocks are indicated as source of UTC(k), laboratory k computes a software clock, steered to UTC. Often a physical realization of UTC(k) is obtained using a Cs clock and a micro-phase-stepper.	
(2)	AUS	Some of the standards are located as follows (at the end of 2007):	
		* National Measurement Institute (NMIA, Sydney)	4 Cs, 2 H-masers
		Australian laboratories intercompared by GPS are:	
		* Canberra Deep Space Communication Complex (CDSCC, Canberra)	1 Cs, 2 H-masers
(3)	CH	All the standards are located in Bern at METAS (Federal Office of Metrology). Since November 2007, UTC(CH) is defined in real time by a hydrogen maser steered to the paper time scale UTC(CH.P).	
(4)	JATC	The standards are located at National Time Service Centre (NTSC). The link between UTC(JATC) and UTC(NTSC) is obtained by internal connection.	
(5)	MKEH	Since 1 January 2007 the National Office of Measures of Hungary (OMH) has merged into the Hungarian Trade Licensing Office (MKEH).	
(6)	NICT	The standards are located as follows (at the end of 2007):	
		* Koganei Headquarters	20 Cs, 7 H-masers
		* Ohtakadoya-yama LF station	3 Cs
		* Hagane-yama LF station	3 Cs
		* Kobe Advanced ICT Research Center	2 Cs
(7)	ONRJ	The Brazilian atomic time scale TA(ONRJ) is computed by the National Observatory in Rio de Janeiro with data from 5 industrial caesium clocks.	
(8)	OP	The French atomic time scale TA(F) is computed by the LNE-SYRTE with data from 23 industrial caesium clocks located as follows (at the end of 2007) :	
		* Centre Electronique de l'Armement (CELAR, Rennes)	1 Cs
		* Centre National d'Etudes Spatiales (CNES, Toulouse)	4 Cs
		* France Telecom Recherche et Developpement (Lannion)	2 Cs
		* Agilent Technologies France (Massy)	2 Cs
		* Observatoire de la Côte d'Azur (OCA, Grasse)	2 Cs
		* Observatoire de Paris (LNE-SYRTE, Paris)	7 Cs
		* Observatoire de Besançon (OB, Besançon)	3 Cs
		* Direction des Constructions Navales (DCN, Brest)	2 Cs
		All laboratories are linked via GPS receivers.	
(9)	PL	The Polish official scale UTC(PL) is maintained by the GUM.	

Notes (Cont.)

(10) PL

The Polish atomic time scale TA(PL) is computed by the AOS and GUM with data from 11 caesium clocks and 3 hydrogen masers located as follows:

* Central Office of Measures (GUM, Warsaw)	3 Cs, 1 H-maser
* Astrogeodynamical Observatory, Space Research Center P.A.S. (AOS, Borowiec)	1 Cs, 1 H-maser
* National Institute of Telecommunications (IŁ, Warsaw)	2 Cs
* Research & Development Centre of the Polish Telecom (CBR, Warsaw)	1 Cs
* Military Primary Standards Laboratory (CWOM, Warsaw)	1 Cs, 1 H-maser
* Tele & Radio Research Institute (ITR, Warsaw)	1 Cs

and additionally

* Time and Frequency Standard Laboratory of the Semiconductor Physics Institute, a guest laboratory from Lithuania (LT, Vilnius, Lithuania)	2 Cs

All laboratories are linked via MC GPS-CV receivers.

(11) PTB

The laboratory Cs, PTB CS1 and PTB CS2 are operated continuously as clocks. PTB CSF1 is a fountain frequency standard using laser cooled caesium atoms. It is intermittently operated as a frequency standard. Contributions to TAI are made through comparisons with one of PTB's hydrogen masers.
Until further notice, TA(PTB) and UTC(PTB) are derived from PTB CS2, TA(PTB) directly, UTC(PTB) including frequency steering.

(12) PTB

TA(PTB)-UTC(PTB) and the frequency steering applied to UTC(PTB) are published in PTB Time Service Bulletin.

(13) SG

4 Ind. Cs till MJD=54320. Reference clock was changed starting MJD=54320 as 1 Ind. Cs failed.

(14) SP

The standards are located as follows (at the end of 2007):

* Swedish National Testing and Research Institute (SP, Borås)	4 Cs, 2 H-masers
* STUPI AB (Stockholm)	6 Cs, 3 H-masers
* Pendulum Instruments AB (Stockholm)	1 Cs
* Onsala Space Observatory (Onsala)	1 H-maser

(15) SU

Starting MJD=53369 time units in TA(SU) and UTC(SU) are different.
TA(SU) is a free atomic time scale, while UTC(SU) is steered to UTC.

(16) TL

TA(TL) is generated from a 9-caesium-clock ensemble.

(17) 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.

(18) ZA

National Metrology Institute of South Africa, formerly CSIR.

(a)

Information based on the Annual Report for 2006, not confirmed by the laboratory.

Table 5. Differences between the normalized frequencies of EAL and TAI, up to May 2008

(File available on http://www.bipm.org under the name EALTAI07.AR, which contains values since the beginning of the steering)

Date	MJD	[f(EAL) - f(TAI)] x 10^{-13}
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
2006 May 29 - 2006 Jun 28	53884 - 53914	6.823
2006 Jun 28 - 2006 Jul 28	53914 - 53944	6.823
2006 Jul 28 - 2006 Aug 27	53944 - 53974	6.820
2006 Aug 27 - 2006 Sep 26	53974 - 54004	6.820
2006 Sep 26 - 2006 Oct 31	54004 - 54039	6.817
2006 Oct 31 - 2006 Nov 30	54039 - 54069	6.817
2006 Nov 30 - 2006 Dec 30	54069 - 54099	6.812
2006 Dec 30 - 2007 Jan 29	54099 - 54129	6.806
2007 Jan 29 - 2007 Feb 28	54129 - 54159	6.802
2007 Feb 28 - 2007 Mar 30	54159 - 54189	6.802
2007 Mar 30 - 2007 Apr 29	54189 - 54219	6.802
2007 Apr 29 - 2007 May 29	54219 - 54249	6.802
2007 May 29 - 2007 Jun 28	54249 - 54279	6.799
2007 Jun 28 - 2007 Jul 28	54279 - 54309	6.796
2007 Jul 28 - 2007 Aug 27	54309 - 54339	6.793
2007 Aug 27 - 2007 Sep 26	54339 - 54369	6.790
2007 Sep 26 - 2007 Oct 31	54369 - 54404	6.787
2007 Oct 31 - 2007 Nov 30	54404 - 54434	6.784
2007 Nov 30 - 2007 Dec 30	54434 - 54464	6.779
2007 Dec 30 - 2008 Jan 29	54464 - 54494	6.776
2008 Jan 29 - 2008 Feb 28	54494 - 54524	6.772
2008 Feb 28 - 2008 Mar 29	54524 - 54554	6.769
2008 Mar 29 - 2008 Apr 28	54554 - 54584	6.766
2008 Apr 28 - 2008 May 28	54584 - 54614	6.763

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 UTAI07.AR)

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

In this table, *d* is obtained on the given periods of estimation by comparison of the TAI frequency with that of the individual primary frequency standards (PFS) IT-CSF1, NICT-CSF1, NIST-F1, NMIJ-F1, NPL-CSF1, PTB-CS1, PTB-CS2, PTB-CSF1, SYRTE-FO1, SYRTE-FO2, SYRTE-FOM and SYRTE-JPO for the year 2007.
Previous calibrations are available in the successive annual reports of the BIPM Time section volumes 1 to 18 and in the BIPM Annual Report on Time Activities, volume 1.

Each comparison is provided with the following information:
u_A is the uncertainty originating in the instability of the PFS,
u_B is the combined uncertainty from systematic effects,
Ref(u_B) is a reference giving information on the stated value of u_B,
$u_{link/lab}$ is the uncertainty in the link between the PFS and the clock participating to TAI, including the uncertainty due to dead-time,
$u_{link/TAI}$ is the uncertainty in the link to TAI (For evaluations published since September 2006, this value is computed using the standard uncertainty of [*UTC-UTC*(*k*)], following a recommendation of the CCTF Working Group on PFS),
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 2007 are indicated below.

Primary Standard	Type /selection	Type B std. Uncertainty	Operation	Comparison with	Number/typical duration of comp.
IT-CSF1	Fountain	0.5×10^{-15}	Discontinuous	H maser	1 / 20 d
NICT-CSF1	Fountain	$(1.6 \text{ to } 2.8)\times10^{-15}$	Discontinuous	UTC(NICT)	5 / 10 to 15 d
NIST-F1	Fountain	0.3×10^{-15}	Discontinuous	H maser	6 / 10 to 25 d
NMIJ-F1	Fountain	3.9×10^{-15}	Discontinuous	H maser	1 / 15 d
NPL-CSF1	Fountain	1.8×10^{-15}	Discontinuous	H maser	4 / 25 to 35 d
PTB-CS1	Beam /Mag.	8×10^{-15}	Continuous	TAI	12 / 30 d
PTB-CS2	Beam /Mag.	12×10^{-15}	Continuous	TAI	12 / 30 d
PTB-CSF1	Fountain	1.0×10^{-15}	Discontinuous	H maser	1 / 15 d
SYRTE-FO1	Fountain	0.4×10^{-15}	Discontinuous	H maser	1 / 30 d
SYRTE-FO2	Fountain	$0.4\text{-}0.5\times10^{-15}$	Discontinuous	H maser	6 / 15 to 30 d
SYRTE-FOM	Fountain	$(0.9 \text{ to } 1.2)\times10^{-15}$	Discontinuous	H maser	8 / 10 to 30 d
SYRTE-JPO	Beam /Opt.	6.3×10^{-15}	Discontinuous	H maser	12 / 15 to 35 d

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

Table 6. (Cont.)

Standard	Period of estimation		d (10^{-15})	u_A (10^{-15})	u_B (10^{-15})	Ref(u_B)	$u_{link/lab}$ (10^{-15})	$u_{link/TAI}$ (10^{-15})	u (10^{-15})	Notes
IT-CSF1	54204	54224	4.6	0.8	0.5	[1]	0.3	0.5	1.1	
NICT-CSF1	54014	54029	1.7	1.0	2.5	[2]	0.3	0.9	2.9	
NICT-CSF1	54029	54039	3.1	1.0	2.8		0.3	1.2	3.2	
NICT-CSF1	54039	54049	0.3	1.0	1.6		0.3	1.2	2.3	
NICT-CSF1	54079	54094	4.2	1.0	1.9		0.3	0.9	2.3	
NICT-CSF1	54369	54384	4.5	1.0	1.8		0.3	0.6	2.2	
NIST-F1	54134	54154	0.6	0.4	0.3	[3]	0.2	0.5	0.7	
NIST-F1	54204	54219	2.8	0.5	0.3		0.3	0.6	0.9	
NIST-F1	54219	54234	3.1	0.4	0.3		0.2	0.6	0.8	
NIST-F1	54314	54339	3.4	0.3	0.3		0.1	0.4	0.6	
NIST-F1	54384	54399	4.1	0.3	0.3		0.3	0.6	0.8	
NIST-F1	54409	54419	3.7	0.4	0.3		0.6	0.9	1.2	
NMIJ-F1	54339	54354	1.4	0.9	3.9	[4]	0.4	0.9	4.1	
NPL-CSF1	54284	54319	2.0	0.5	1.8	[5]	0.2	0.4	1.9	
NPL-CSF1	54319	54344	4.3	0.6	1.8		0.1	0.5	2.0	
NPL-CSF1	54344	54369	5.6	0.7	1.8		0.2	0.5	2.0	
NPL-CSF1	54369	54399	8.2	0.7	1.8		0.2	0.5	2.0	
PTB-CS1	54099	54129	-3.1	5.0	8.0	[6]	0.0	0.2	9.4	(1)
PTB-CS1	54129	54159	-3.1	5.0	8.0		0.0	0.2	9.4	
PTB-CS1	54159	54189	-10.2	5.0	8.0		0.0	0.2	9.4	
PTB-CS1	54189	54219	0.4	5.0	8.0		0.0	0.1	9.4	
PTB-CS1	54219	54249	3.3	5.0	8.0		0.0	0.2	9.4	
PTB-CS1	54249	54279	7.6	5.0	8.0		0.0	0.2	9.4	
PTB-CS1	54279	54309	2.1	5.0	8.0		0.0	0.1	9.4	
PTB-CS1	54309	54339	-5.9	5.0	8.0		0.0	0.1	9.4	
PTB-CS1	54339	54369	-6.9	5.0	8.0		0.0	0.1	9.4	
PTB-CS1	54369	54404	-15.0	5.0	8.0		0.0	0.1	9.4	
PTB-CS1	54404	54434	-10.8	5.0	8.0		0.0	0.1	9.4	
PTB-CS1	54434	54464	-8.8	5.0	8.0		0.0	0.1	9.4	
PTB-CS2	54099	54129	0.6	3.0	12.0	[7]	0.0	0.2	12.4	(1)
PTB-CS2	54129	54159	-4.9	3.0	12.0		0.0	0.2	12.4	
PTB-CS2	54159	54189	-4.3	3.0	12.0		0.0	0.2	12.4	
PTB-CS2	54189	54219	2.4	3.0	12.0		0.0	0.1	12.4	
PTB-CS2	54219	54249	0.7	3.0	12.0		0.0	0.2	12.4	
PTB-CS2	54249	54279	2.8	3.0	12.0		0.0	0.2	12.4	
PTB-CS2	54279	54309	3.0	3.0	12.0		0.0	0.1	12.4	
PTB-CS2	54309	54339	5.6	3.0	12.0		0.0	0.1	12.4	
PTB-CS2	54339	54369	4.8	3.0	12.0		0.0	0.1	12.4	
PTB-CS2	54369	54404	0.2	3.0	12.0		0.0	0.1	12.4	
PTB-CS2	54404	54434	-0.7	3.0	12.0		0.0	0.1	12.4	
PTB-CS2	54434	54464	0.8	3.0	12.0		0.0	0.1	12.4	
PTB-CSF1	54369	54384	1.2	1.0	1.0	[8]	0.1	0.2	1.4	

Table 6. (Cont.)

Standard	Period of estimation	d (10^{-15})	u_A (10^{-15})	u_B (10^{-15})	Ref(u_B)	$u_{link/lab}$ (10^{-15})	$u_{link/TAI}$ (10^{-15})	u (10^{-15})	Notes
SYRTE-FO1	54189 54219	2.5	0.3	0.4	[9]	0.1	0.3	0.6	
SYRTE-FO2	54194 54219	2.8	0.2	0.4	[9]	0.1	0.4	0.6	
SYRTE-FO2	54224 54249	4.2	0.3	0.5		0.5	0.4	0.8	
SYRTE-FO2	54249 54279	2.2	0.3	0.5		0.1	0.3	0.6	
SYRTE-FO2	54279 54309	2.4	0.4	0.5		0.1	0.3	0.7	
SYRTE-FO2	54309 54329	3.7	0.3	0.5		0.3	0.5	0.8	
SYRTE-FO2	54334 54349	7.1	0.3	0.5		0.1	0.6	0.8	
SYRTE-FOM	54189 54219	2.6	0.2	1.2	[10]	0.1	0.3	1.3	
SYRTE-FOM	54224 54234	3.1	0.4	0.9		0.1	0.9	1.3	
SYRTE-FOM	54249 54269	2.1	0.4	0.9		0.1	0.5	1.1	
SYRTE-FOM	54344 54374	2.1	0.1	0.9		0.1	0.3	1.0	
SYRTE-FOM	54374 54384	3.8	0.2	0.9		0.1	0.9	1.3	
SYRTE-FOM	54389 54404	1.0	0.2	0.9		0.1	0.6	1.1	
SYRTE-FOM	54404 54434	2.8	0.2	0.9		0.1	0.3	1.0	
SYRTE-FOM	54434 54464	5.4	0.2	0.9		0.2	0.4	1.0	
SYRTE-JPO	54099 54129	15.0	0.7	6.3	[11]	0.3	0.3	6.4	
SYRTE-JPO	54129 54159	12.1	0.6	6.3		0.3	0.3	6.3	
SYRTE-JPO	54159 54189	11.9	0.7	6.3		0.3	0.3	6.4	
SYRTE-JPO	54189 54219	10.4	0.7	6.3		0.3	0.3	6.4	
SYRTE-JPO	54219 54239	10.3	0.8	6.3		0.3	0.5	6.4	
SYRTE-JPO	54249 54279	9.9	0.7	6.3		0.3	0.3	6.4	
SYRTE-JPO	54284 54309	1.4	0.9	6.3		0.3	0.4	6.4	
SYRTE-JPO	54309 54339	1.8	0.7	6.3		0.3	0.3	6.4	
SYRTE-JPO	54339 54369	3.1	0.7	6.3		0.3	0.3	6.4	
SYRTE-JPO	54369 54404	3.8	0.8	6.3		0.3	0.3	6.4	
SYRTE-JPO	54404 54429	0.8	0.9	6.3		0.3	0.4	6.4	
SYRTE-JPO	54449 54464	4.1	1.0	6.3		0.3	0.9	6.4	

Notes:

(1) Continuously operating as a clock participating to TAI.

References:

[1] Levi F. et al., *Metrologia* **43**-6, 545, 2006.
[2] Kumagai M., et al., *Metrologia* **45**-2, 139-148, 2008.
[3] Heavner T.P. et al., *Metrologia* **42**, 411, 2005. Parker T.E. et al., *Metrologia* **42**, 423, 2005.
[4] Kurosu T. et al., *IEEE Trans. IM*-**53**, 466, 2004.
[5] Szymaniec K. et al., *Metrologia*, **42**, 49, 2005; Szymaniec K. et al., *Metrologia*, **43**, L18, 2006.
[6] Bauch A. et al., *Metrologia* **35**, 829, 1998; Bauch A., *Metrologia* **42**, S43, 2005.
[7] Bauch A. et al., *IEEE Trans. IM*-**36**, 613, 1987; Bauch A., *Metrologia* **42**, S43, 2005.
[8] Weyers S. et al., *Metrologia* **38**-4, 343, 2001; Weyers S. et al., Proceedings of the 6th Symposium on Frequency Standards and Metrology, University of St Andrews, World Scientific pub., 64–71, 2001.
[9] Vian C. et al., *IEEE Trans. IM*-**54**, 833, 2005 ; Vian C. et al., *Proc 19th EFTF*, 53, 2005.
[10] Marion H. et al. *Phys. Rev. Lett.*, **90**, 150801, 2003.
[11] Makdissi A. and de Clercq E., *Metrologia* **38**-5, 409, 2001.

Report on the activity of IT-CsF1 Primary Frequency Standard during 2007

Filippo Levi, Davide Calonico, Luca Lorini and Aldo Godone
Istituto Nazionale Ricerca Metrologica (INRIM), Str. delle Cacce 91 -10135 Torino - Italy

During 2007, IT-CsF1 reported one frequency evaluation to the BIPM. In the tables below, a summary of the report and a typical accuracy budget is shown.

CircT	Period (MJD)	Dur.	Local Osc.	yITCsF1-yTAI	uA	uB	ulab	uTAI	u
233	54204-54224	20	1401102	4.6	0.8	0.5	0.3	0.5	1.1

Effect	Correction ($x10^{-15}$)	Uncertainty ($x10^{-15}$)
Quadratic Zeeman (field map)	-45.8	0.1
Blackbody Radiation	29.7	0.2
Collisional (average shift $1.1x10^{-15}$) (*)	-	0.1
Gravitational Potential	-26.10	0.01
Microwave related	-	0.3
Total	-41.8	0.5

(*) collisional shift is continuously corrected; here is taken into account just the type B uncertainty [1].

The reference papers for IT-CsF1 evaluations procedure are [1,2]. Some details are reported here.
Quadratic Zeeman shift: before each fountain evaluation, the magnetic field is mapped along the atom flight path, with low frequency spectroscopy ($\Delta F=0$, $\Delta m=\pm1$); the field map is then used to calculate the DC Zeeman shift experienced by the atoms .The AC quadratic Zeeman shift due to the RF cavity heater was measured lower than $4x10^{-17}$. As in previous evaluations, the C-field map showed a long term stability for the Zeeman shift of few parts in 10^{16} .
Atomic density shift: IT-CsF1 is still operated alternating a low-density state (~20000 s) and a high-density state (~5000 s), then the measured 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; the type B uncertainty due to the signal stability and to the linearity assumption between density and signal is ≤10% of the weighted averaged density shift [1].
Blackbody radiation shift: as in previous evaluations, the blackbody radiation shift is corrected using the accepted value β = $-1.711(.003)x10^{-14}$; IT-CsF1 is operated around 343 K and the uncertainty on this correction is typically $2\text{-}3\times10^{-16}$.
Microwave related shifts: before and after each TAI evaluation, the presence of unwanted microwave related shifts (such as microwave leakages, spurious spectrum components, distributed phase shifts) is tested as described in [3]. The measured shift is compatible with zero at 4×10^{-16} level.
Gravitational shift: At the end of 2007, IT-CsF1 orthometric height has been evaluated to be (239.43±0.03) m over the Geoid [4]. The frequency shift for IT-CsF1 is $(26.10\pm0.01)\times10^{-15}$.
Other tests: Some null-shift tests are performed before each BIPM evaluation. Tipically, they include a light shift test, e.g. a check of the mechanical shutters, sometimes a test on synchronous effects.
Type A uncertainty: IT-CsF1 is generally operated by comparing its frequency to an H-maser (BIPM code 1401102). The short term stability is limited at $3x10^{-13}\tau^{-1/2}$ by the BVA filter noise.
Laboratory link uncertainty: long term stability measurements show that the H Maser stability (drift removed) is better than fountain stability up to 10^6 seconds.
During the evaluation in 2007, IT-CsF1 was operated with a dead time uncertainty lower than $3x10^{-16}$; a detailed description of its evaluation procedure is reported in [1].

[1] F. Levi, D. Calonico, L. Lorini, A. Godone, "IEN-CsF1 primary frequency standard at INRIM: accuracy evaluation and TAI calibrations", Metrologia 43, 6, 545-555, 2006.
[2] F. Levi, L. Lorini, D. Calonico, A. Godone, "IEN-CsF1 Accuracy Evaluation and Two-Way Frequency Comparison", IEEE Trans. On UFFC, Vol. 51, No. 10, 2004.
[3] J.H. Shirley,F. Levi, T.P. Heavner, D. Calonico, Yu Dai-Hyuk, S.R. Jefferts, "Microwave leakage-induced frequency shifts in the primary frequency Standards NIST-F1 and IEN-CSF1", IEEE Trans. On UFFC 53, 12, 2376–2385, 2006.
[4] D. Calonico, A Cina, I H Bendea, F Levi, L Lorini and A Godone, "Gravitational redshift at INRIM", Metrologia 44, L44–L48, 2007.

Operation of Cs atomic fountain NICT-CsF1 in 2007

In 2006, we started the operation of a new atomic fountain named "NICT-CsF1" as a primary frequency standard. Details of NICT-CsF1 are summarized in Ref [1]. According to CCTF Recommendation CCTF/06-08, we had checked the long-term frequency stability of NICT-CsF1 over about 3 months. The result was analyzed and the first evaluation report was submitted in July 2007. This report was reviewed by the working group on primary frequency standard (CCTF-WGPFS) and received a recommendation that the reported numbers be used in the calculation of TAI. Finally, the report was accepted by the BIPM and the value was appeared in the circular T [2].

In September – October 2007, we carried out 15 days accuracy evaluation using NICT-CsF1, and the result has been sent to BIPM to contribute to TAI. In this period, the type B uncertainty of NICT-CsF1 was estimated as 1.8×10^{-15}. The total uncertainty including the uncertainty of the link was estimated as 2.2×10^{-15} [3].

Physical Effect	Bias	Uncertainty
2nd Zeeman	73.8	<0.1
Collision (averaged)	-8.3	1.7
Blackbody Radiation	-16.9	0.4
Gravity Potential	8.4	0.1
MW-PW dependence	-2.1	0.3
Cavity Pulling	0.0	<0.1
Rabi Pulling	0.0	<0.1
Ramsey Pulling	0.0	<0.1
Spectral impurities	0.0	<0.1
Light Shift	0.0	<0.1
Distributed cavity phase	0.0	0.3
Majorana	0.0	<0.1
Background Gas	0.0	0.3
Total (Type B)		1.8

units are fractional frequency in 10^{-15}

Table 1. Frequency shifts and their uncertainties in 2007 measurement (MJD54369-54384)

For remote comparisons, NICT-CsF1 was operated with PTB fountain clock PTB-CSF1 simultaneously twice in December 2006 and in September 2007. The hydrogen masers linked to the fountains at both sites were compared directly by TWSTFT link between NICT and PTB. The results showed good agreements with each other. These are the first series of the Europe - Asia long baseline remote comparisons of the primary frequency standards [2, 3, 4].

References

[1] M. Kumagai, H. Ito, M. Kajita and M. Hosokawa; *Metrologia* 45 (2008) 139-148.
[2] *Circular T* 236
[3] *Circular T* 238
[4] M. Fujieda, T. Gotoh, D. Piester, M. Kumagai, S. Weyers, A. Bauch, R. Wynands and M. Hosokawa, 2007 *Proc. Eur. Freq. Time Forum (Geneva)* pp 937– 941.

Operation of NIST-F1 in 2007

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 recent 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 a range of atom densities is used 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 on the order of 3×10^{-16}. Each formal evaluation also includes mapping the magnetic field, and measuring possible biases due to such things as microwave amplitude and light leaks.

Six formal evaluations were carried out in 2007, in February, April, May, August, October and November. There continues to be considerable theoretical and experimental work carried out with an emphasis this year on work related to searches for possible drifts in fundamental constants [4,5].

The Type B uncertainties for the six runs in 2007 are substantially the same as those given in Table 1 of [2], and are dominated by the blackbody and microwave amplitude shifts. For the February run the total Type B uncertainty was 3.3×10^{-16}, dominated by the Blackbody shift with an uncertainty of 2.8×10^{-16}. The Type B uncertainty for the October run was 3.4×10^{-16}. The Type A uncertainties ranged from 2.6×10^{-16} to 4.5×10^{-16} for the six runs. The components of the Type A uncertainty from to the spin exchange shift ranged from 2.0×10^{-16} to 3.7×10^{-16}. Total uncertainties, including frequency transfer and dead time uncertainties, ranged from 0.56×10^{-15} to 1.19×10^{-15}.

REFERENCES

1 S.R. Jefferts, J. Shirley, T.E. Parker, T.P. Heavner, D.M. Meekhof, C. Nelson, F. Levi, G. Costanzo, A. De Marchi, R. Drullinger, L. Hollberg, W.D. Lee, and F.L. Walls, "Accuracy Evaluation of NIST-F1," *Metrologia*, vol. 39, pp 321-336, 2002.

2 T.P. Heavner, S.R. Jefferts, E.A. Donley, J.H. Shirley, and T.E. Parker, "NIST-F1: Recent Improvements and Accuracy Evaluations," *Metrologia*, vol. 42, pp 411-422, 2005.

3 T.E. Parker, S.R. Jefferts, T.P. Heavner, and E.A. Donley, "Operation of the NIST-F1 Caesium Fountain Primary Frequency Standard with a Maser Ensemble, Including the Impact of Frequency Transfer Noise," *Metrologia*, vol. 42, pp 423-430, 2005.

4 N. Ashby, T.P. Heavner, S.R. Jefferts, T.E. Parker, A.G. Radnaev, and Y.O. Dudin, "Testing Local Position Invariance with Four Cesium- Fountain Primary Frequency Standards and Four NIST Hydrogen Masers" , Phys. Rev. Lett. 98 16 Feb 2007.

5 T. Fortier, N. Ashby, J.C. Bergquist, M.J. Delaney, S.A. Diddams, T.P. Heavner, L. Hollberg, W.M. Itano, S.R. Jefferts, K. Kim, F. Levi, L. Lorini, W.H. Oskay, T.E. Parker, J.H. Shirley, and J.E. Stalnaker, "Precision Atomic Spectroscopy for Improved Limits on Variation of the Fine Structure Constant and Local Position Invariance" Phys. Rev. Lett. 98 16 Feb 2007.

Operation of NMIJ-F1 Primary Frequency Standard in 2007

In 2007, we have operated NMIJ-F1 for 15 days of one campaign to calibrate TAI as the Cs fountain primary frequency standard at the National Metrology Institute of Japan (NMIJ). The uncertainty evaluation was the same as the one we have ever used [1,2], which is shown in Table 1.

Source of uncertainty	Bias ($x10^{-15}$)	Uncertainty ($x10^{-15}$)
2nd order Zeeman	185.0	0.5
Blackbody radiation	-18.0	1.4
Gravitation	1.6	0.1
Cold collisions	0.0	3.3
Distributed cavity phase	0.0	1.2
Microwave power dependence	0.0	0.7
Total	168.6	3.9

Table 1: Typical uncertainty budget used in 2007

During 2007, most of the effort was spent for modification of optical system including trap laser (tuned to F=4-F'=5) and optical shutters. The reliability of the entire system has improved when considering the modification of the electrical system (microwave, sequential control) that continues since 2005. In 2008, we plan to make more frequent operation of NMIJ-F1 than the last two years.

[1] T. Kurosu, Y. Fukuyama, Y. Koga and K. Abe, "Preliminary evaluation of the Cs atomic fountain frequency standard at NMIJ/AIST." IEEE Trans. Instrum. Meas., vol. 53, pp. 466-471, 2004.

[2] S. Yanagimachi, K. Watabe, K. Hagimoto, A. Kubota, T. Ikegami, and S. Ohshima, "Recent status of an atomic fountain frequency standard NMIJ-F1", CPEM2006 Digest, Trino, pp. 588-589.

Evaluations of the frequency of TAI by the primary frequency standard NPL-CsF1 in 2007

National Physical Laboratory, UK

In 2007 the primary frequency standard NPL-CsF1 was used to measure the frequency of the H-maser HM2 (BIPM clock code: 1401708) during four campaigns, 115 days in total. A detailed description of the standard as well as the evaluation procedures of the systematic frequency biases can be found in ref. [1].

Uncertainties of systematic frequency biases

The biases and uncertainties used to calculate the total contribution to the frequency of NPL-CsF1 are as follows:

Effect	Bias ($\times 10^{-15}$)	Uncertainty ($\times 10^{-15}$)
2nd ord. Zeeman	143.0	0.1
black-body rad.	-16.2	0.4
collisions	(-0.9)	0.2
μ-w leakage	0.0	1.7
cavity pulling	0.0	0.1
μ-w spectrum	0.0	<0.1
cavity phase	0.0	0.3
Rabi pulling	0.0	0.1
AC Stark	0.0	0.1
gravity	1.3	0.1
total (1σ), u_B		1.8

Notes:

1) The procedure for estimation of the microwave leakage frequency shift and its uncertainty in NPL-CsF1 has been revised since the publication in [1] and previous evaluations reported to BIPM (see ref. [2]).

2) The physics package of the NPL-CsF1 frequency standard has not been modified since the previous evaluations.

3) The value of frequency bias due to cold collisions is given for example only. The actual value was computed continuously and standard's frequency was extrapolated to zero atomic density.

4) The NPL-CsF1 standard was operated with reduced collisional frequency shift by adjusting the clock state fractional populations (ref. [3]). The type B uncertainty of the collisional shift is conservatively estimated at 20% of the shift itself allowing for possible discrepancy between the density ratios and the detected atom number ratios, which may affect the extrapolation results.

5) Corrections due to effects other than collisions were sufficiently stable over a campaign period, so that a single correction value could be applied.

Uncertainties of the frequency measurement

1) The type A uncertainty of the complete measurement u_A was obtained by assuming white FM noise over the effective period of integration.

2) The uncertainty of the link with the local time scale $u_{l/lab}$ is a quadratic sum of two contributions:

$$(u_{l/lab})^2 = (u_{link})^2 + (u_{dt})^2$$

where u_{link} is the uncertainty associated with the frequency transfer between CsF1 and HM1, and u_{dt} is an additional uncertainty of the measured maser frequency due to gaps (dead time) in the operation of the fountain standard.

3) The fractional frequency uncertainty, u_{dt}, arising from the dead time was approximated by the square root of the sum of the time variances, normalised by the length of the measurement campaign, thus:

$$u_{dt} = \frac{1}{T}\sqrt{\sum_{i=1}^{N}[\sigma_x(\tau_i)]^2}$$

where $\sigma_x(\tau_i$ is the time deviation (TDEV) of the maser over a duration τ_i; and T is the duration of the campaign.

References

[1] K. Szymaniec, W. Chalupczak, P.B. Whibberley, S.N. Lea, D. Henderson, *Metrologia*, **42**, pp. 49-57, (2005).

[2] K. Szymaniec, W. Chalupczak, P.B. Whibberley, S.N. Lea, D. Henderson, *Metrologia*, **43**, pp. L18-L19, (2006).

[3] K. Szymaniec, W. Chalupczak, E. Tiesinga, C.J. Williams, S. Weyers, R. Wynands, *Phys. Rev. Lett.* **98**, 153002, (2007).

Operation of the PTB primary clocks in 2007

PTB's primary clocks with a thermal beam

During 2007 PTB CS1 and CS2 [1] were in continuous clock operation without any modification or (major) disturbance. The relative frequency instability of the 5 MHz output signals of the two clocks has been repeatedly analyzed with reference to one of PTB's active hydrogen masers. For CS1 values $\sigma_y(\tau = 1\text{h, CS1})$ between 93×10^{-15} and 104×10^{-15} were recorded. For $\sigma_y(\tau = 1\text{h, CS2})$ values of slightly above 60×10^{-15} were found. This data confirms the findings of previous years and justifies the estimate of the uncertainty contributions u_A as $u_A(\tau = 30\text{d, CS1}) = 5\times10^{-15}$, and $u_A(\tau = 30\text{d, CS2}) = 3\times10^{-15}$.

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. During 2007, 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 findings call for a modification of the previously stated relative frequency uncertainties, u_B, which are 8×10^{-15} and 12×10^{-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 to BIPM so that $u_{l/lab}$ is zero.

PTB's caesium fountain clock CSF1

A detailed description of the PTB fountain CSF1 is given in Refs. [3] and [4]. The statistical uncertainty $u_A(\tau = 15\text{d})$ is conservatively estimated as $1.0\cdot10^{-15}$. The fractional dead time during the measurement of the TAI scale unit in 2007 was less than 0.3%, so that $u_{l/lab}$ was below $0.1\cdot10^{-15}$. Below we report some type B uncertainty contributions, which are treated in a different way or were newly addressed for the measurement of the TAI scale unit in 2007. The last evaluation of CSF1 is the first one which was performed with a pure optical molasses for atom trapping, without utilisation of a magneto-optical trap.

1) Black body radiation shift

Recently the frequency shifting effect due to the electric field of the ambient temperature radiation has been reevaluated [5]. We use this most up-to-date result for the correction of the black body radiation shift. Without utilisation of a magneto-optical trap the observed temperature gradients along the vacuum tube of CSF1 are lower, so that we now assume an uncertainty contribution of $< 0.1\cdot10^{-15}$, corresponding to an uncertainty of the temperature of 0.2 K.

2) Cold collisions

The collisional frequency shift of CSF1 in the pure molasses operation mode was evaluated before and after the TAI scale unit measurement. The number of atoms contributing to the signal – and in this way the density – was changed by varying the loading time of the molasses. The results of these evaluations are slope factors which give – multiplied with the actual number of atoms – the collisional frequency shift correction [3], [4]. For the correction of the TAI scale unit measurement the weighted average slope value obtained from both collisional shift evaluations was taken.
As described in Refs. [3] and [4] the uncertainty of the collisional shift correction is composed of the statistical uncertainty and a 10% systematic uncertainty because of a potentially imperfect proportionality between the measured actual number of atoms and the effective density.

3) Microwave power dependence: $1\pi/2$-pulses, $3\pi/2$-pulses

In the case of pure molasses operation, the currently observed remaining frequency difference for operation at $1\pi/2$ pulse area and $3\pi/2$-pulse area is $(1.3 \pm 0.4)\cdot10^{-15}$. In order to take this difference of unknown origin into account we have added a conservative uncertainty contribution of half of the measured frequency difference (i.e., $0.7 \cdot 10^{-15}$) to the uncertainty budget for the normal mode of operation at $1\pi/2$ pulse area.

Below we compile the corrected biases and the uncertainty budget of CSF1, valid for the 2007 TAI scale unit measurement.

Physical effect	Bias / 10^{-15}	Type B uncertainty / 10^{-15}
Second order Zeeman shift	46.6	0.1
Black body radiation shift	- 16.5	0.1
Cold collisions	- 0.25	0.3
Gravitational red shift	8.6	0.1
Cavity phase		0.5
Majorana transitions		0.1
Rabi and Ramsey pulling		0.1
Microwave leakage		0.1
Electronics		0.2
Light shift		0.1
Background gas collisions		0.1
Microwave power dependence		0.7
Total type B uncertainty		1.0

Table 1: Frequency biases and type B uncertainties of PTB-CSF1 in 2007

References

[1] A. Bauch, Metrologia, 2005, 42, S43 – S54.

[2] T. Heindorff, A. Bauch, P. Hetzel, G. Petit, S. Weyers, Metrologia, 2001, 38, 497-502.

[3] S. Weyers, U. Hübner, R. Schröder, Chr. Tamm, A. Bauch, Metrologia, 2001, 38, 343–352.

[4] S. Weyers, A. Bauch, R. Schröder, Chr. Tamm, in: Proceedings of the 6th Symposium on Frequency Standards and Metrology 2001, University of St Andrews, Fife, Scotland, pp. 64–71, ISBN 981-02-4911-X (World Scientific).

[5] P. Rosenbusch, S. Zhang, and A. Clairon, 21th European Frequency and Time Forum (EFTF), Geneva, pp. 1060–1063 (June 2007).

Operation of the LNE-SYRTE primary clocks in 2007

LNE-SYRTE-JPO Thermal Beam

During 2007 SYRTE-JPO was in continuous clock operation except for disturbances. 12 calibrations were transmitted to TAI. The operational parameters are measured periodically and taken into account for each calibration. They are the Zeeman frequency, the microwave power, the amplitude and the symmetry of the neighbouring lines, the cavity detuning, and the optical power. The atomic velocity distribution was measured two times in 2007, one time for each beam direction. The beam was reversed one time at the end of June, the measured end-to-end phase difference was found unchanged. The last complete accuracy evaluation was performed in 2005 and gave the same value as in [1] : $u_B = 6.3\text{x}10^{-15}$. The "jump" ($8\text{x}10^{-15}$) of the mean frequency compared to TAI between the month of June and July coincides with the beam reversal. No direct explanation was found, and an effect of light shift due to spurious laser light and/or an effect of microwave leakage are suspected. The u_A uncertainty is computed for each calibration from the dispersion of the frequency measurements compared to the reference maser.

LNE-SYRTE Fountain clocks

In 2007 the 3 LNE-SYRTE fountains FO1, FO2 and FOM have transmitted respectively 1, 6 and 8 calibrations to TAI.

Several modifications have been realized on the three SYRTE fountains to improve their accuracy and their stability. The microwave synthesizers are now referenced to the same 1 GHz signal provided by a cryogenic sapphire oscillator (CSO) phase locked to a hydrogen Maser, to take the benefit of the ultra-low phase noise of the CSO.

Further measurements have been performed to test the effect of microwave leaks and synchronous perturbations on the phase of the interrogation signal. FO1 and FO2 are now equipped by pulsed microwave synthesizers with very low phase transient that have been tested with a home-made heterodyne analyser with a resolution of 1 µrad [2, 3].

A new measurement of the blackbody radiation interaction (BBR) has been undertaken with the FO1 fountain [4]. Two series of measurement, on the DC Stark shift, and when surrounding the atoms by a heating graphite tube, confirmed the previous evaluation of the BBR shift. In normal operation, the fountains are at ambient temperature. They are equipped by several calibrated thermistors. The overall uncertainty on the absolute temperature is better than of 0.2 °C which gives an uncertainty on the BBR at 6×10^{-17}.

The operation of FOM has been also tested in an autonomous mode: the microwave signal is generated from a BVA quartz oscillator frequency locked on the atomic transition. A 100 MHz signal is produced for external use. A phase comparator measured this 100 MHz signal against the reference Maser that was tracked at the same time by the other fountains.

The following table gives the uncertainty budget for the three SYRTE fountains over 2007. The values are given in units of 10^{-16}.

<table>
<tr><td>Fountain</td><td colspan="2">FO1</td><td colspan="2">FO2</td><td colspan="2">FOM</td></tr>
<tr><td>Physical origin</td><td>Correction</td><td>Uncertainty</td><td>Correction</td><td>Uncertainty</td><td>Correction</td><td>Uncertainty</td></tr>
<tr><td>2nd order Zeeman</td><td>-1242.8</td><td>0.3</td><td>-1919.2</td><td>0.2</td><td>-304.6</td><td>1.1</td></tr>
<tr><td>Blackbody Radiation</td><td>+165.2</td><td>0.6</td><td>+167.5</td><td>0.6</td><td>+161.8</td><td>0.6</td></tr>
<tr><td>Cold Collisions + cavity pulling</td><td>+201.4</td><td>2.4</td><td>+220</td><td>2.9</td><td>+33</td><td>6.6</td></tr>
<tr><td>First Doppler</td><td>0</td><td><3.2</td><td rowspan="2">0</td><td rowspan="2">3</td><td rowspan="3">0</td><td rowspan="3">6</td></tr>
<tr><td>Synchronous phase fluctuations</td><td>0</td><td><0.6</td></tr>
<tr><td>Microwave Leaks, spectral purity</td><td>0</td><td><0.7</td><td>0</td><td>0.5</td></tr>
<tr><td>Background gas collisions</td><td>0</td><td><0.3</td><td>0</td><td><1</td><td>0</td><td><1</td></tr>
<tr><td>Microwave recoil</td><td>0</td><td><1.4</td><td>0</td><td><1.4</td><td>0</td><td><1.4</td></tr>
<tr><td>Ramsey & Rabi pulling</td><td>0</td><td><1</td><td>0</td><td><1</td><td>0</td><td><1</td></tr>
<tr><td>Second order Doppler</td><td>0</td><td><0.1</td><td>0</td><td><0.1</td><td>0</td><td><0.1</td></tr>
<tr><td>Red shift</td><td>-69.3</td><td>1</td><td>-65.4</td><td>1</td><td>-68.7</td><td>1</td></tr>
<tr><td>Total (1σ) uncertainty u_B</td><td></td><td>4.7</td><td></td><td>4.8</td><td></td><td>9.3</td></tr>
</table>

Table 1 : Accuracy budget of the 3 LNE-SYRTE atomic Clock

The short-term frequency instability of the fountain clocks were evaluated by comparison to a cryogenic oscillator phase locked on an active H maser. The typical relative frequency stabilities are respectively $\sigma_y(\tau)=5 \times 10^{-14} \tau^{-1/2}$ for FO1, $\sigma_y(\tau)=4 \times 10^{-14} \tau^{-1/2}$ for FO2, and $\sigma_y(\tau)=8 \times 10^{-14} \tau^{-1/2}$ for FOM.

The comparisons between the PFS and TAI showed a disagreement at the level of $2\ 10^{-15}$ for some of the calibrations published in 2007. No such frequency jumps were observed by direct comparisons between the fountains. This is probably due to an underestimation of the uncertainty of the link. Indeed, some noise may be added by the extrapolation of UTC(OP) to BIPM dates or by the fact that the time transfer and the fountains are not referenced to the same H-Maser. We are working to reduce this source of uncertainty.

References

[1] A. Makdissi and E. de Clercq, "Evaluation of the accuracy of the optically pumped caesium beam primary frequency standard of BNM-LPTF", Metrologia Vol. 38 n° 5, 2001, pp. 409 – 425.

[2] D. Chambon et al., "Design and Metrological Features of Microwave Synthesizers for Atomic Fountain Frequency Standard." IEEE Trans. Ultrason. Ferroelect. Freq. Contr. Vol 54, Issue 4, April 2007, pp. 729 – 735.

[3] G. Santarelli et al., "Phase Transient Measurement at the Micro radian level for Atomic Fountain Clocks", Proceedings of the 20th EFTF, 2006, pp. 166-172.

[4] P. Rosenbusch et al., "Blackbody radiation shift in primary frequency standards", Proc. of FCS 2007 Joint with the 21st EFTF May 29 2007-June 1 2007, pp. 1060 – 1063.

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

(File available on http://www.bipm.org under the name SITAI07.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 (PFS) IT-CSF1, NICT-CSF1, NICT-O1, NIST-F1, NMIJ-F1, NPL-CSF1, PTB-CS1, PTB-CS2, PTB-CSF1, SYRTE-FO1, SYRTE-FO2, SYRTE-FOM and SYRTE-JPO consistently corrected for the black-body radiation shift.
In this computation, for the PFS evaluations carried out after Jan. 2005, the uncertainty of the link to TAI has been computed using the standard uncertainty of [UTC-UTC(k)], following the recommendation of the CCTF working group on PFS. The model for the instability of EAL has been expressed as the quadratic sum of three components: a white frequency noise $2.0\times10^{-15}/\sqrt{\tau}$, a flicker frequency noise 0.4×10^{-15} and a random walk frequency noise $1.0\times10^{-16}\times\sqrt{\tau}$, with τ in days. The relation between EAL and TAI is given in Table 5.

Month	Interval	$d/10^{-15}$	uncertainty/10^{-15}
Jan. 2005	53369-53399	+4.8	0.5
Feb. 2005	53399-53429	+5.9	0.9
Mar. 2005	53429-53459	+5.9	1.1
Apr. 2005	53459-53489	+6.1	1.0
May 2005	53489-53519	+6.5	0.8
Jun. 2005	53519-53549	+6.4	0.7
Jul. 2005	53549-53579	+6.1	0.7
Aug. 2005	53579-53609	+6.0	0.8
Sep. 2005	53609-53639	+5.1	0.8
Oct. 2005	53639-53674	+5.0	0.5
Nov. 2005	53674-53704	+4.5	1.0
Dec. 2005	53704-53734	+4.1	0.9
Jan. 2006	53734-53764	+3.4	0.6
Feb. 2006	53764-53794	+2.7	0.5
Mar. 2006	53794-53824	+2.6	0.6
Apr. 2006	53824-53854	+2.6	1.0
May 2006	53854-53884	+2.6	1.1
Jun. 2006	53884-53914	+2.8	1.1
Jul. 2006	53914-53944	+3.2	0.8
Aug. 2006	53944-53974	+2.8	1.0
Sep. 2006	53974-54004	+2.9	1.0
Oct. 2006	54004-54039	+2.7	0.5
Nov. 2006	54039-54069	+1.5	0.5
Dec. 2006	54069-54099	+1.5	0.5
Jan. 2007	54099-54129	+1.3	0.9
Feb. 2007	54129-54159	+1.0	0.6
Mar. 2007	54159-54189	+1.9	0.9
Apr. 2007	54189-54219	+2.7	0.3
May 2007	54219-54249	+3.4	0.5
Jun. 2007	54249-54279	+2.5	0.5
Jul. 2007	54279-54309	+2.6	0.5
Aug. 2007	54309-54339	+3.7	0.4
Sep. 2007	54339-54369	+4.0	0.6
Oct. 2007	54369-54404	+3.3	0.4
Nov. 2007	54404-54434	+3.4	0.6
Dec. 2007	54434-54464	+4.1	0.8

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 48 File SCHGPS.48	implemented on MJD = 54222 (2007 May 2) at 0 h UTC	Reference date MJD = 50722 (1997 October 1)
GPS Schedule no 49 File SCHGPS.49	implemented on MJD = 54406 (2007 November 2) at 0 h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 23 File SCHGLO.23	implemented on MJD = 54222 (2007 May 2) at 0 h UTC	Reference date MJD = 50722 (1997 October 1)
GLONASS Schedule no 24 File SCHGLO.24	implemented on MJD = 54406 (2007 November 2) at 0 h 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 UTCGPSGLO07.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

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

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

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

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

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

Here C_0 is given at 0 h 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 0 h UTC. Daily values of C_0 are then derived by linear interpolation of [*UTC* - *UTC*(*OP*)].

The standard deviation σ_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 UTCGPSGLO07.AR)

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

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

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

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, 0 h UTC, until further notice:

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

Here C_1 is given at 0 h 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 time*] at 0 h 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 σ_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 8. Rates relative to TAI of contributing clocks in 2007

(File available on http://www.bipm.org under the name RTAI07.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 8 gives homogeneous rates for the whole year 2007. 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 available from the TFG section under request. 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
13 EBAUCHES, OSCILLATOM B5000
14 HEWLETT-PACKARD 5061A OPT. 4
16 OSCILLOQUARTZ 3200
17 OSCILLOQUARTZ 3000
15 DATUM/SYMMETRICOM Cs III
4x HYDROGEN MASERS
9x PRIMARY CLOCKS AND PROTOTYPES
21 OSCILLOQUARTZ 3210
23 OSCILLOQUARTZ EUDICS 3020
30 HEWLETT-PACKARD 5061B
31 HEWLETT-PACKARD 5061B OPT. 4
34 H-P 5061A/B with 5071A tube
35 H-P/AGILENT/SYMMETRICOM 5071A High perf.
36 H-P/AGILENT/SYMMETRICOM 5071A Low perf.
50 FREQ. AND TIME SYSTEMS INC. 4065A
51 DATUM/SYMMETRICOM 4065 B
52 DATUM/SYMMETRICOM 4065 C

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
APL	35 904	4.16	5.41	4.12	5.53	-	3.83	3.98	4.68	4.85	4.67	4.47	3.79
APL	35 1264	23.24	22.33	20.52	21.90	-	21.41	20.68	17.17	21.53	21.08	21.06	21.40
APL	35 1791	-4.37	-3.49	-3.79	-4.27	-	-3.68	-3.91	-4.30	-4.05	-3.83	-3.97	-4.32
APL	40 3107	22.30	21.87	21.51	21.03	-	20.44	20.18	18.38	19.87	19.59	19.30	19.15
APL	40 3108	97.36	102.87	108.29	113.83	-	124.86	130.31	136.03	141.47	147.21	152.88	157.96
APL	40 3109	-25.90	-25.67	-25.46	-25.34	-	-25.01	-24.65	-23.31	-23.31	-22.66	-22.15	-21.45
AUS	35 2269	-	-	-	-	-	-	-	-	-1.25	-1.41	-2.11	-2.41
AUS	36 249	-4.99	-6.09	-4.71	-7.84	-4.48	-	-8.40	-6.79	-6.72	-6.30	-6.65	-6.06
AUS	36 340	3.02	2.75	1.70	0.43	-0.13	1.46	-0.39	-0.65	-1.46	0.98	0.24	0.21
AUS	36 654	-15.79	-15.82	-16.52	-16.07	-15.44	-15.43	-16.07	-16.73	-	-	-	-

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
AUS	36 1141	6.44	5.44	4.86	7.85	7.15	5.24	5.58	4.67	5.30	4.64	4.32	4.84
AUS	40 5401	-	-	-	-	-	48.65	-	-	-	-	-	-
AUS	40 5402	-	-	6.83	11.88	11.57	11.09	-	-	0.62	-9.72	-8.23	-
AUS	40 5403	-8.51	-16.78	3.20	29.78	30.77	-	-0.64	-3.28	-8.79	-17.04	-11.83	-8.89
BEV	35 1065	-1.03	-0.48	-0.61	0.32	-1.11	-1.06	-0.32	-1.28	-1.72	-1.69	-0.99	0.44
BEV	35 1793	-0.16	0.21	-0.42	0.26	-0.60	-0.52	0.10	-0.22	-0.80	-0.40	-1.15	-0.41
BIM	35 1501	-3.12	-4.42	-2.92	-3.47	-1.42	-2.66	-0.39	-2.78	-2.45	-2.06	-3.73	-4.54
BY	40 4209	-	-	-	14.56*	8.46*	10.48*	13.19*	3.77*	8.96*	10.85	2.92	7.23
BY	40 4260	-	-	-	-67.85*	-70.52*	-61.97*	-60.16*	-61.39*	-59.19*	-59.45*	-53.97*	82.01
BY	40 4263	-	-	-	135.76*	129.56*	131.96*	21.50*	6.20*	0.02*	-3.24*	0.49	-
BY	40 4278	-	-	-	3.64*	24.64*	13.81*	13.25*	11.36*	7.30*	1.75*	-15.23*	-17.02
CAO	35 939	1.43	0.15	0.14	-1.12	-0.13	-1.61	-1.69	-3.51	-4.22	-4.04	-2.70	-0.96
CAO	35 1270	-	-	-	-	5.42	4.97	3.45	3.77	2.88	2.52	1.82	1.90
CH	35 771	9.35	9.60	8.62	8.94	9.84	8.38	8.73	7.86	9.47	8.77	9.39	9.15
CH	35 2117	1.37	2.14	1.71	1.40	1.69	0.78	2.77	1.38	1.58	1.20	1.54	1.65
CH	36 354	44.61	44.89	45.32	43.30	43.94	43.72	42.14	43.14	43.42	43.41	43.37	43.18
CH	36 413	-8.64	-8.63	-8.19	-8.36	-9.22	-7.73	-8.32	-8.63	-7.54	-9.17	-9.37	-8.99
CH	40 5701	-122.80	-122.86	-123.51	-122.90	-123.86	-125.16	-126.10	-127.07	-128.06	-129.40	-130.53	-132.51
CNM	35 1705	0.28	0.40	0.32	-3.04	-3.44	-2.86	-1.66	-0.71	-1.02	-1.09	-0.19	0.57
CNM	35 1815	1.59*	1.09*	1.53*	1.73*	1.46*	-0.34*	-0.16*	-0.58*	0.01*	-2.62*	-1.73*	-0.69
CNM	36 1537	-15.19	-16.49	-15.34	-13.72	-14.79	-15.58	-15.64	-12.67	-14.12	-15.22	-13.64	-14.84
CNM	40 7301	-51.35	-51.80	-74.89	-64.84	-75.49	-81.50	-69.79	-63.51	-55.05	-55.33	-56.02	-62.50
CNMP	36 1752	-1.29	0.41	0.29	0.61	3.09	1.77	0.87	1.06	0.60	0.27	-	-
CNMP	36 1806	-	-	-	-	-	-	-	-	-	-	-2.75	1.35
DLR	35 1714	-	-	-	-	-0.23	0.46	-0.47	-0.69	-0.63	-0.52	0.45	-1.36
DTAG	36 136	-	-	-	-	9.65	15.91	8.98	0.35	-8.96	-11.81	-29.14	0.43
DTAG	36 345	-	-	-	-1.60	-1.36	-0.61	-1.26	-0.92	-2.37	-1.81	-2.73	-1.22
DTAG	36 465	-	-	-	0.85	0.08	-0.16	-0.19	0.23	-1.79	-0.82	-1.03	-3.71
EIM	35 716	-	-	-	-	-	-	-	-	13.38	13.32	12.87	-
EIM	35 1431	-	-	-	-	-	-	-	-	9.55	9.24	10.07	-
EIM	35 2060	-	-	-	-	-	-	-	-	0.02	0.03	-0.12	-
F	35 122	27.05	26.74	26.64	26.56	26.29	26.48	26.57	26.68	26.30	26.72	25.89	26.28
F	35 124	9.55	9.03	9.21	10.02	9.61	9.84	10.81	10.27	9.83	10.40	10.23	10.43
F	35 131	11.04	11.39	12.00	11.18	10.57	10.32	10.30	11.08	10.45	11.09	11.47	11.64
F	35 158	10.26	10.41	10.14	10.70	11.18	11.73	11.29	11.35	11.01	12.02	12.51	12.05

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
F	35 172	-	6.95	7.27	7.16	7.21	7.45	6.63	6.79	6.37	6.65	7.20	6.24
F	35 198	4.76	5.39	4.40	5.12	5.33	5.01	4.58	-	-	-	5.62	-
F	35 385	22.68	22.84	21.69	21.12	21.32	20.85	21.36	21.98	21.33	21.66	21.70	21.05
F	35 396	5.69	7.03	5.94	5.62	6.01	5.01	4.70	5.03	5.61	-	-	-
F	35 520	14.46	12.78	14.26	10.96	13.36	14.33	12.91	12.07	-	-	-	-
F	35 609	-10.67	-11.63	-11.47	-11.65	-	-	-	-	-	-	-10.10	-10.52
F	35 770	-	-	-	-	-	-	-	-	-8.98	-9.81	-9.66	-9.80
F	35 774	-19.09	-18.99	-	-	-	-	-	-	-	-	-	-
F	35 781	10.60	8.83	8.96	9.97	9.44	7.71	7.31	-	-	-	8.33	-
F	35 819	10.48	11.34	11.05	13.00	11.54	10.56	10.73	11.13	10.92	11.63	10.23	10.62
F	35 859	2.02	2.07	0.87	1.46	2.41	2.42	3.60	2.26	2.18	-	-	-
F	35 1029	11.49	11.76	11.57	12.11	11.29	11.48	11.20	11.14	11.60	11.81	11.46	11.96
F	35 1178	27.07	29.34	28.09	28.10	27.66	28.04	26.66	28.11	28.27	-	-	28.08
F	35 1222	12.52	12.49	12.38	12.22	12.83	12.10	12.36	-	-	-	12.19	-
F	35 1258	2.13	1.13	2.04	1.89	2.50	2.11	2.71	3.42	3.18	4.64	4.25	4.30
F	35 1321	-	-	2.54	2.89	3.05	2.88	2.98	2.80	3.19	2.51	2.89	2.63
F	35 1556	-20.72	-21.06	-20.77	-21.42	-	-	-	-	-20.01	-20.67	-21.22	-21.30
F	35 2027	2.50	2.05	1.56	2.06	1.65	1.52	2.19	1.78	1.02	0.99	0.46	0.36
F	40 805	-29.19	-26.47	-25.31	-21.82	-20.78	-22.91	-25.57	-26.45	-26.40	-25.92	-23.03	-20.11
F	40 816	-41.13	-40.51	-39.95	-39.66	-41.30	-41.99	-42.60	-43.22	-43.68	-43.62	-43.97	-44.70
F	40 889	88.97	92.83	96.11	99.80	103.18	106.67	110.16	113.67	117.17	121.09	124.83	128.10
F	40 890	31.46	31.84	32.11	32.88	33.61	34.34	35.33	36.27	37.23	38.58	39.94	40.76
F	53 6385	-	-	-	-	-	-	-	-	-	-	-21.96	-21.44
HKO	35 1893	-	1.17	0.60	1.15	1.72	-1.17	-3.69	2.52	2.15	0.05	-1.33	-0.93
IFAG	36 1167	-1.71	-2.90	-3.04	-2.55	-1.20	1.46	-0.01	0.06	0.11	0.67	-2.34	-3.83
IFAG	36 1173	-8.17	-8.88	-8.60	-8.11	-5.59	-3.76	-3.67	-4.04	-2.79	-5.37	-7.97	-8.81
IFAG	36 1629	7.70	7.45	7.38	7.55	8.81	6.52	6.33	6.39	7.21	7.23	7.33	6.69
IFAG	36 1732	-	11.71	11.51	11.11	10.92	11.17	11.21	11.68	12.01	11.69	12.18	12.83
IFAG	36 1798	0.80	0.39	0.00	-	-	-	-	-	-1.74	-3.03	-4.48	-4.82
IFAG	40 4413	-	24.00	30.64	55.80	70.95	16.95	38.73	-	-	-	-	-
IFAG	40 4418	19.27	4.99	2.12	3.09	4.03	4.13	5.28	5.83	6.81	8.00	9.68	5.79
IFAG	40 4439	-	2.23	-2.28	-4.06	-6.23	-8.55	-	-12.42	-12.51	0.04	-1.58	-2.92
IGMA	16 112	0.35	13.45	4.72	-3.54	2.09	-4.99	4.69	1.14	-	-	-	-
IGMA	35 674	-0.13	-0.05	13.98	-16.91	-0.88	-0.59	-1.18	-1.38	-	-	-	-
IGMA	35 676	-0.13	0.57	1.12	0.56	0.86	-0.08	1.03	-	-	-	-	-

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
INPL	35 1653	0.87	2.58	-9.66	-2.35	-	-	-	-	-	-	-	-
IT	35 219	9.88	10.20	10.45	9.90	9.85	9.37	9.54	9.68	8.95	9.11	8.07	9.01
IT	35 505	-8.34	-9.32	-8.04	-7.74	-8.31	-8.20	-7.86	-9.01	-7.12	-8.34	-7.88	-8.31
IT	35 1115	14.05	13.47	14.63	13.40	14.04	16.27	15.63	17.02	17.50	17.12	16.18	17.39
IT	35 1373	-10.56	-10.14	-9.91	-9.70	-9.99	-10.37	-9.86	-10.00	-9.29	-8.71	-9.51	-8.47
IT	35 2118	-	-	-	-	-	7.84	7.41	8.40	8.29	8.63	8.23	8.70
IT	40 1101	155.09	154.47	156.40	161.50	182.23	203.44	217.69	223.29	251.12	267.08	-	-
IT	40 1102	13.59	4.27	3.25	4.59	6.37	7.74	8.75	10.57	12.29	14.03	15.62	16.52
JV	21 216	14.36	14.66	10.83	15.28	18.69	18.80	17.23	19.68	21.08	19.28	19.56	22.54
JV	21 387	-42.93	4.94	29.44	46.85	95.50	26.52	-39.69	135.60	167.75	-38.32	-64.48	-192.24
JV	36 1277	-17.22	-19.25	-17.84	-17.04	-18.87	-17.46	-16.00	-18.84	-18.39	-18.65	-18.75	-17.80
KRIS	35 321	11.19	11.85	13.10	13.16	13.42	15.26	16.01	16.17	16.27	15.61	16.17	15.67
KRIS	35 1693	-	8.03	7.41	8.30	7.92	7.43	7.63	7.34	7.69	7.19	7.16	7.34
KRIS	35 1783	16.44	16.18	-	-	17.59	17.22	17.38	17.22	17.45	17.97	17.37	19.11
KRIS	36 1135	35.86	33.59	36.27	33.23	32.41	38.50	35.93	37.38	35.85	36.26	36.79	34.28
KRIS	40 5623	111.88	112.41	112.59	113.28	114.22	115.02	115.72	115.72	116.13	116.15	115.46	116.27
KRIS	40 5625	61.59	65.48	68.72	72.10	-	-	-	-	-	-	-	-
LDS	35 289	5.34	7.63	8.94	8.18	9.48	8.09	8.67	9.27	10.32	8.87	7.14	7.68
LT	35 1362	-0.42	1.29	1.06	0.62	-0.07	-0.07	0.02	0.26	1.85	0.51	-0.47	1.32
LT	35 1868	7.94	8.40	7.61	7.62	8.18	7.56	7.53	6.98	7.52	6.44	6.09	5.93
LV	35 2335	-	-	-	-	-	-	-	-	-	-	-	11.04
LV	36 1953	-	-	-	-	-	-	-	-	8.99	9.49	-	-
MIKE	35 1171	13.56	15.02	16.66	18.19	15.50	17.30	15.45	17.95	17.07	16.74	15.56	17.07
MIKE	36 986	-3.08	-0.11	2.12	0.90	-0.45	0.65	-0.24	2.56	1.27	1.55	0.88	-0.40
MIKE	40 4113	17.51	21.25	23.18	24.42	25.59	27.79	29.57	31.64	33.04	34.53	34.98	37.95
MIKE	40 4180	-0.29*	0.14*	-0.24*	-0.34*	0.27*	-0.32*	-0.05*	-0.06*	-0.11*	-0.05*	-0.07	0.13
MKEH	36 849	1.52	3.32	1.48	3.34	1.08	2.35	3.61	5.21	4.58	3.20	2.30	-
MSL	12 933	-	6.77	2.46	-6.26	-8.17	-1.91	-4.90	9.92	6.17	11.06	13.15	8.06
MSL	36 274	-	8.35	4.30	3.83	6.92	4.58	8.05	5.86	4.71	4.29	6.28	5.95
MSL	36 1025	-	-13.07*	-11.71*	-11.21*	-40.67*	-39.30*	-39.02*	-28.01*	-30.01*	-0.04	-3.35	-1.01
NAO	35 779	-6.10	-5.35	-5.96	-5.12	-6.23	-6.33	-	-	-	-	-	0.66
NAO	35 1206	15.41	15.69	15.75	15.20	15.00	14.69	14.94	15.13	15.97	14.13	14.75	14.24
NAO	35 1214	5.67	6.42	7.31	6.63	6.52	6.05	9.55	7.15	7.60	6.26	6.37	5.74
NAO	35 1689	7.05	7.27	7.36	5.51	3.93	3.21	8.24	4.60	2.35	-2.92	2.05	-0.91
NICT	35 12	1.30	1.61	3.04	3.36	3.43	3.24	3.66	2.63	3.07	2.76	-	-

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
NICT	35 144	-12.75	-13.80	-12.55	-13.48	-13.46	-12.55	-13.04	-12.08	-12.71	-12.33	-12.69	-12.79
NICT	35 332	-	-	-	15.26	13.60	12.76	11.48	10.94	10.10	9.88	9.83	9.52
NICT	35 342	-	-	-	37.67	39.81	40.12	41.04	41.89	41.09	40.78	40.39	41.32
NICT	35 343	-	-	-	4.68	5.00	4.28	4.29	4.07	3.75	3.85	4.89	4.85
NICT	35 715	-14.18	-13.80	-13.69	-13.37	-13.91	-13.56	-13.40	-13.20	-12.84	-12.67	-12.51	-12.47
NICT	35 732	4.46	4.25	4.20	3.64	4.25	3.95	3.33	3.88	4.28	4.81	5.00	5.93
NICT	35 907	-10.57	-10.79	-6.77	-7.29	-6.82	-6.96	-7.85	-7.50	-8.14	-7.90	-7.35	-8.22
NICT	35 908	3.41	3.40	3.20	3.03	2.82	2.06	3.37	3.04	2.38	2.89	2.61	2.85
NICT	35 916	-	-	-	-	-	-	-	-	-	-	-	-10.99
NICT	35 1225	-	-	-	-	-	-3.12	-2.99	-2.72	-3.59	-2.67	-3.17	-2.63
NICT	35 1778	13.96	14.11	13.92	14.09	14.59	13.68	13.64	14.11	13.66	13.90	14.69	13.57
NICT	35 1789	8.37	7.34	7.50	7.09	7.36	6.40	6.47	8.31	7.82	7.72	7.26	6.11
NICT	35 1790	-3.03	-2.67	-3.30	-2.22	-2.78	-2.81	-3.11	-2.90	-2.80	-2.75	-2.66	-3.12
NICT	35 1866	-	-	-	-	-	12.78	13.57	12.93	13.63	12.98	12.53	13.03
NICT	35 1882	65.18	66.75	66.88	66.99	66.87	66.95	67.50	67.15	67.03	67.00	67.06	67.04
NICT	35 1887	30.84	30.44	27.49	25.70	26.99	26.57	30.79	31.73	29.80	28.93	26.54	28.23
NICT	35 1944	3.29	3.12	3.32	3.42	3.77	4.36	4.07	3.56	3.62	3.35	3.49	3.26
NICT	35 2010	-	5.67	5.63	4.97	4.92	5.06	5.67	5.39	4.92	4.41	4.59	5.48
NICT	35 2011	-	4.48	4.04	4.10	5.58	4.48	4.60	4.62	5.31	5.30	4.74	4.78
NICT	35 2056	10.53	11.34	12.56	12.24	11.67	11.78	12.48	12.73	12.45	12.87	12.65	12.34
NICT	35 2113	-22.05	-21.73	-22.59	-23.35	-23.76	-23.39	-23.91	-23.03	-24.49	-24.38	-27.41	-28.00
NICT	35 2116	10.26	10.68	10.63	10.68	11.11	11.29	11.59	11.38	12.34	12.42	12.52	13.37
NICT	36 1217	-	-	-	-	-	2.26	3.81	3.68	3.74	4.33	5.31	4.46
NICT	36 1226	-	-	-	-	-	27.21	25.19	26.39	26.01	25.91	26.00	26.80
NICT	36 1611	-	-	-	-	-	6.88	7.54	9.83	11.01	8.81	9.93	7.24
NICT	40 2002	4.67	5.42	6.12	6.77	7.52	8.29	9.03	9.40	9.64	9.95	10.36	11.06
NICT	40 2003	12.18	13.18	13.84	14.25	14.03	14.07	14.26	15.02	15.71	17.58	18.45	18.83
NIM	35 479	1.42	2.46	2.46	2.94	4.84	5.16	4.66	4.88	4.45	3.98	3.92	4.71
NIM	35 1235	-	-3.35	-3.77	-3.93	-4.24	-4.22	-2.91	-3.98	-4.55	-4.55	-4.14	-4.43
NIM	35 1239	2.32	2.76	3.58	4.58	5.00	5.26	4.40	4.18	2.48	3.50	4.10	4.42
NIM	40 4814	-5.18	-3.07	-3.92	-7.27	-	-	-	-	-	-	-	-
NIM	40 4832	21.25	21.24	20.88	20.95	21.23	20.89	22.72	21.06	20.91	20.79	20.92	20.85
NIM	40 4835	2.51	2.63	3.39	4.88	5.60	6.04	5.79	5.17	4.80	5.74	6.07	5.70
NIMB	35 600	-	-	-	-4.71	-2.26	-0.93	-0.49	-2.45	-1.44	-1.29	-3.16	-0.11
NIS	35 1126	-0.16	0.02	0.06	0.56	0.63	-0.28	-0.11	2.24	2.76	-1.91	-1.12	-0.32

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
NIST	15 9866	-45.22	-46.06	-48.39	-45.71	-47.52	-	-	-	-	-	-	-
NIST	35 132	-3.86	-4.18	-3.75	-4.14	-4.30	-4.11	-3.95	-4.23	-4.48	-4.11	-4.40	-5.18
NIST	35 182	-10.45	-11.51	-10.86	-11.50	-10.37	-11.80	-10.57	-10.29	-30.66	-	-	-
NIST	35 282	7.28	6.95	7.18	6.09	-	-1.36	5.81	5.60	6.09	5.49	6.36	7.46
NIST	35 408	-0.88	-1.15	-0.46	-1.01	-1.02	0.09	-0.82	-1.36	-0.33	-0.50	-0.02	-0.17
NIST	35 1074	-15.26	-14.14	-15.13	-14.79	-14.41	-15.15	-15.17	-14.83	-14.88	-14.14	-14.66	-14.62
NIST	35 2031	-2.39	-2.22	-2.96	-2.82	-	8.80	-3.46	-3.76	-6.05	-6.33	-6.31	-6.61
NIST	35 2032	-1.48	-1.08	-1.48	-4.15	-	2.24	-4.30	-4.45	-3.51	-3.50	-3.13	-2.91
NIST	35 2034	-21.12	-21.11	-21.16	-20.45	-	-1.69	-19.78	-20.67	-	-	-	-9.17
NIST	40 203	92.02	93.41	94.35	95.55	96.54	97.73	98.79	99.85	101.38	102.76	104.20	105.45
NIST	40 204	19.99	20.35	20.54	20.79	20.74	21.18	21.37	21.39	21.78	21.92	22.15	22.05
NIST	40 205	-26.20	-25.98	-26.14	-26.10	-26.32	-26.33	-26.66	-26.70	-26.62	-26.64	-26.60	-26.60
NIST	40 206	-66.56	-66.81	-67.40	-67.61	-67.92	-68.11	-68.15	-68.16	-68.24	-68.37	-68.32	-68.34
NIST	40 222	12.39	13.47	14.04	14.80	15.45	16.31	16.82	17.47	18.14	18.60	19.20	19.70
NMIJ	35 224	12.67	-	-14.93	-14.39	-13.35	-13.04	-13.82	-13.69	-13.81	-13.78	-13.06	-14.06
NMIJ	35 523	10.98	12.07	12.66	11.76	12.18	12.37	12.83	11.92	11.98	11.33	11.59	11.97
NMIJ	35 1466	15.88	16.29	15.91	16.24	16.28	16.13	16.98	17.11	18.12	21.61	-	-
NMIJ	40 5002	-4.31	-5.45	-4.41	-5.67	-5.45	-7.19	-5.64	-6.72	-7.72	-8.78	-7.39	-8.48
NMIJ	40 5003	-4.72	-5.59	-5.88	-6.33	-7.08	-	-	-	-	-	-	-
NMIJ	40 5014	0.55	0.51	-0.65	-0.71	-0.73	-0.78	-0.71	-0.69	-0.80	-1.21	-0.62	-1.55
NMLS	35 1659	-0.75	-0.26	-0.52	0.08	1.26	1.75	2.57	1.97	2.67	1.85	2.41	1.36
NPL	35 1275	8.98	8.34	9.53	11.13	11.95	11.26	8.13	7.37	7.09	7.49	8.87	-
NPL	36 784	5.42	5.69	5.13	5.70	5.98	5.07	5.72	6.50	5.32	5.47	6.83	-
NPL	40 1701	1.70	2.08	2.21	2.42	3.08	2.93	3.18	3.83	3.58	3.75	4.24	-
NPL	40 1708	-2.77*	-2.92*	-2.62*	-2.20*	-1.92*	-1.88*	-1.48*	0.26*	0.13*	0.22*	0.72	-
NPLI	35 2257	-	-	-	6.16	4.84	2.54	2.63	-0.03	-0.17	-	-	-0.74
NRC	35 234	1.52	1.91	1.35	0.79	0.33	-0.22	-0.15	-0.03	0.17	0.30	0.14	0.29
NRC	35 372	1.08	0.07	0.33	0.82	0.53	0.49	1.23	0.66	1.10	1.25	0.97	0.90
NTSC	35 1007	12.09	13.33	12.91	8.39	8.02	7.21	7.38	10.10	16.37	17.73	18.32	9.65
NTSC	35 1008	4.38	4.17	4.45	3.82	3.86	3.00	2.82	3.17	3.62	3.62	3.56	3.12
NTSC	35 1011	-0.64	-0.04	-0.15	-0.69	-0.75	-0.67	-1.32	-0.87	-0.98	-1.84	-1.30	-1.83
NTSC	35 1016	15.40	15.05	14.58	15.52	15.30	14.92	15.51	14.67	14.38	14.16	13.50	14.58
NTSC	35 1017	-0.42	-1.15	-0.56	0.05	1.00	0.47	0.94	0.07	-1.95	-0.97	-1.58	0.33
NTSC	35 1818	-27.36	-27.32	-26.66	-27.00	-25.93	-25.94	-24.70	-24.74	-23.30	-22.80	-22.13	-22.39
NTSC	35 1820	-3.55	-4.08	-3.38	-3.20	-3.31	-3.15	-3.01	-2.52	-2.12	-2.56	-2.58	-2.24

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
NTSC	35 1823	34.75	34.03	34.44	36.15	37.52	36.68	34.98	22.92	20.98	18.50	15.20	12.25
NTSC	35 2096	-6.18	-6.35	-6.38	-6.42	-6.73	-6.15	-6.20	-6.20	-7.06	-5.89	-6.79	-5.86
NTSC	35 2098	3.93	4.53	4.63	4.39	4.48	4.72	4.73	5.13	5.57	6.11	6.17	6.79
NTSC	35 2131	5.76	5.13	5.17	5.11	4.11	4.62	3.48	4.20	2.71	2.66	2.52	1.90
NTSC	35 2141	30.62	32.67	29.84	28.18	35.68	36.47	33.30	32.16	39.53	40.22	38.05	40.54
NTSC	35 2142	-13.21	-12.36	-12.62	-12.85	-12.49	-12.01	-12.44	-11.87	-11.95	-12.01	-11.76	-11.65
NTSC	35 2143	2.33	2.10	1.89	1.67	1.82	1.89	1.90	1.60	1.79	1.70	2.24	2.71
NTSC	35 2144	-4.02	-4.19	-4.13	-4.49	-4.13	-4.25	-3.84	-4.84	-4.19	-4.73	-4.40	-3.68
NTSC	35 2145	1.44	1.55	1.69	1.15	1.35	0.77	0.80	1.41	1.04	0.90	1.83	0.92
NTSC	35 2146	-0.59	0.48	0.33	1.35	0.97	1.12	1.33	2.36	2.42	3.06	2.64	2.63
NTSC	35 2147	1.05	2.25	2.35	2.82	2.66	2.79	3.78	4.79	4.72	5.12	4.78	5.40
NTSC	40 4926	27.99	35.41	43.47	52.03	60.60	69.46	78.76	87.96	97.15	107.06	116.76	137.15
NTSC	40 4927	138.01	142.62	147.13	152.06	157.02	161.94	167.40	172.93	178.65	184.75	190.87	196.42
NTSC	40 4933	-	-	-	-	-	-	-	-	-10.27	-17.38	-32.76	-38.55
NTSC	40 4945	-35.76	-38.20	-30.17	-19.38	-22.78	-30.62	-39.62	-54.47	-62.21	-77.52	-101.38	-139.35
NTSC	40 4946	-	-	-	-	-	-	-	-	-	12.22	13.41	14.94
ONBA	12 1371	18.14	-2.00	-	-	-	-	-	-	-	-	-	-
ONBA	36 2228	-	-	-	-3.35	-3.55	-2.59	-2.70	-1.04	-1.27	-1.57	-2.30	-1.56
ONRJ	35 103	8.45	8.77	8.97	8.31	8.91	8.66	8.54	9.37	8.54	8.91	8.08	8.41
ONRJ	35 123	30.97	31.21	30.58	30.89	30.50	32.61	30.95	29.71	31.34	30.93	30.73	30.55
ONRJ	35 129	1.12	0.94	0.44	-0.04	0.93	-0.21	-0.02	0.50	0.45	0.92	0.62	0.32
ONRJ	35 1942	9.68	9.86	9.56	8.46	7.87	8.97	8.67	8.25	8.31	8.26	8.72	7.98
ONRJ	52 125	-	-	-	-	-	-	2.47	-	-	-6.85	-9.80	-11.43
ORB	35 201	-0.09	0.98	1.30	2.69	-0.97	1.32	1.50	2.15	1.12	1.16	0.23	2.21
ORB	35 202	6.94	7.70	9.17	7.74	8.94	8.95	5.59	8.48	9.50	9.28	8.12	4.96
ORB	35 593	77.02	77.13	78.04	75.62	77.24	75.47	78.21	76.53	77.65	77.62	77.85	78.06
ORB	40 2601	-0.25	-0.48	1.22	1.98	1.67	-0.48	0.16	0.17	-0.53	-0.38	-1.17	-1.67
PL	25 124	-	-	-	-	-	-	4.92	4.66	11.90	17.26	18.97	21.45
PL	35 441	2.47	2.09	3.26	1.94	2.54	2.91	3.69	3.59	3.68	3.83	3.95	3.59
PL	35 502	1.63	1.94	1.20	0.53	0.29	1.98	1.25	1.39	-0.28	1.35	0.30	0.20
PL	35 745	-0.76	-1.05	-1.38	-1.52	-1.55	-1.25	-1.40	-1.23	-1.17	-1.36	-1.63	-0.80
PL	35 1120	0.15*	-0.33*	-0.40*	0.10*	-0.26*	0.21	0.05	-0.09	-0.44	0.41	0.91	0.77
PL	35 1660	-0.95	-2.39	2.48	2.07	3.15	9.26	16.87	13.83	14.18	13.38	13.55	13.58
PL	35 1709	0.89	0.74	0.91	0.96	1.03	0.60	0.53	0.54	0.07	-0.36	-0.95	-0.28
PL	35 1746	1.05	1.11	0.96	1.10	0.96	1.46	0.95	0.53	0.74	0.78	0.78	1.61

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
PL	35 1934	-1.28	-1.20	-1.31	-0.49	-1.90	-0.73	-0.79	-1.09	-0.20	-0.17	-0.79	-0.95
PL	36 1395	-8.30	-6.28	-5.04	-6.54	-6.77	-5.11	-6.67	-5.65	-5.54	-6.14	-9.12	-7.38
PL	40 4002	12.18	17.89	8.57	-	6.35	-0.29	0.77	16.18	28.30	35.34	45.51	47.33
PL	40 4004	10.68*	6.93*	3.42*	-0.52*	0.33*	-0.27	-2.45	-5.23	11.88	12.83	12.91	5.48
PTB	35 128	-	-	-	-	-	-3.25	-2.52	-2.87	-2.56	-2.67	-1.82	-2.03
PTB	35 415	2.80	4.04	3.83	4.65	4.30	4.37	4.39	4.65	4.23	4.12	3.94	4.75
PTB	35 1072	11.22	10.83	11.42	11.32	11.38	11.56	10.64	10.39	10.81	11.39	9.83	10.74
PTB	40 506	-	-	-	-	-	12.72	16.79	21.21	24.75	28.95	33.70	38.26
PTB	40 510	5.33	5.38	5.33	5.63	5.95	7.13	7.82	7.89	7.16	6.83	5.89	5.66
PTB	40 590	-10.37*	-9.28*	-8.35*	-7.09*	-6.03*	-4.93*	-3.98*	-21.68*	-1.83	-1.10	-0.16	0.81
PTB	92 1	1.60	1.89	2.34	1.26	1.18	0.68	1.26	2.00	2.28	2.85	2.40	2.30
PTB	92 2	1.42	1.88	1.86	1.24	1.40	1.15	1.21	1.03	1.08	1.37	1.55	1.45
PTB	92 3	2.42	0.59	-	-	-	-	-	-	-	-	-	-
ROA	31 422	44.41	5.74	-6.81	-14.82	-3.90	-8.81	-12.34	-1.01	-17.42	-14.80	-	-
ROA	35 583	0.41*	0.63*	0.18*	-0.35*	0.21*	0.30	0.29	-0.05	0.48	-0.14	0.34	-0.37
ROA	35 718	-8.13	-7.29	-7.10	-7.12	-7.24	-6.69	-6.03	-6.47	-6.52	-6.86	-6.77	-7.12
ROA	35 1699	-	-	1.72	1.35	1.50	1.52	1.64	1.09	1.90	1.92	2.55	1.93
ROA	36 1488	9.65	9.88	8.03	7.98	8.18	8.28	7.68	8.44	8.91	8.35	8.43	7.97
ROA	36 1490	7.44	6.98	7.36	6.04	6.43	5.50	7.11	7.24	7.37	6.92	7.17	6.84
ROA	40 1436	-74.99	-74.75	-74.27	-73.75	-73.03	-71.92	-70.65	-68.98	-68.32	-65.58	-63.54	-61.74
SCL	35 621	-3.79	-2.99	-3.97	-4.00	-4.13	-4.16	-	-	-	-	-	-
SCL	35 1745	-0.35	-0.55	-0.90	-0.30	-0.06	0.01	-	-0.71	-0.42	-0.57	-1.05	0.13
SCL	35 2178	-	-	-	-	-	-	-	-	-	-	1.54	2.07
SG	35 1035	5.01	4.07	3.99	3.61	3.64	3.99	3.76	-	-	-	-	-
SG	35 1127	1.51	0.65	1.26	1.58	1.31	1.46	0.69	1.50	0.53	-	-0.07	0.83
SG	35 1889	18.76	19.25	18.42	17.84	18.04	18.13	18.15	17.56	15.06	-	14.48	14.97
SG	36 522	-3.07	-0.90	-1.54	-1.62	-2.52	-1.09	532.45	-533.04	1.62	-	2.50	2.90
SIQ	36 1268	-	-	-	-	-	-	-	-	21.91	-18.68	24.89	24.56
SMU	36 1193	-0.46	-1.45	0.11	-0.17	-0.25	0.26	0.36	-0.42	0.08	-0.71	-0.82	-1.05
SP	19 197	-59.36	-62.82	-65.22	-64.45	-64.23	-65.03	-70.63	-71.93	-71.06	-69.65	-67.89	-69.03
SP	35 572	18.07	17.71	17.02	17.39	18.33	18.70	17.89	17.88	16.75	16.03	17.98	17.48
SP	35 641	6.70	7.76	6.43	6.69	5.84	6.51	5.99	5.86	5.98	6.08	6.45	6.84
SP	35 1188	28.46	28.66	29.03	29.09	29.22	29.50	28.72	29.24	28.93	28.94	29.23	29.33
SP	35 1531	20.35	20.33	19.82	19.47	20.81	21.41	21.30	20.70	21.27	20.20	20.72	19.38
SP	35 1642	13.30	12.77	12.04	11.68	11.60	11.95	12.62	12.82	11.59	11.42	11.89	11.85

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
SP	35 2166	0.15	0.41	0.43	0.66	0.19	1.14	0.83	0.86	1.00	1.27	0.85	0.99
SP	36 1175	3.19	2.94	2.30	3.10	1.85	3.01	1.88	2.19	3.23	1.92	3.36	1.73
SP	36 2068	1.58	1.70	1.64	2.48	0.73	3.05	3.46	0.50	-0.07	-0.42	3.18	2.25
SP	36 2218	27.85	27.30	27.26	27.78	27.08	27.17	26.64	27.53	26.88	27.60	27.30	26.31
SP	36 2297	-	-	-	-	-6.82	-7.06	-6.60	-6.48	-7.05	-6.28	-6.76	-6.40
SP	40 7201	4.44	7.38	9.72	11.50	13.74	16.12	18.79	20.61	22.33	24.65	27.68	29.73
SP	40 7203	-	-	-	3.10	3.96	4.58	5.35	6.00	6.62	7.43	8.42	9.19
SP	40 7210	96.45	101.70	106.27	111.30	-	-52.65	-48.06	-43.46	-39.05	-34.14	-28.29	-26.90
SP	40 7211	45.75	47.63	49.09	50.73	51.86	53.40	54.91	-	-	-	-	-
SP	40 7218	93.74	90.24	88.89	-	62.60	60.17	-	-	-	-	-	-
SU	40 3802	-3.13*	-0.42	-0.50	0.10	0.64	0.81	1.24	1.70	2.31	2.66	3.02	3.53
SU	40 3805	86.31*	89.78*	90.36*	90.98*	91.47*	91.37*	91.65*	94.06	94.40	94.87	95.08	96.66
SU	40 3810	63.48	64.00	64.24	64.50	64.79	65.07	65.39	65.79	66.24	66.98	67.71	68.34
SU	40 3822	56.74*	58.35*	59.93*	61.41*	63.24*	64.67*	66.34	67.93	69.52	71.28	72.76	74.27
SU	40 3825	51.46*	53.41*	53.49*	54.07*	54.36*	54.90*	55.72*	55.87*	57.09*	57.56	-	-
SU	40 3831	43.94*	44.52*	45.28*	45.72*	46.30*	47.37*	47.52*	48.47*	48.76*	47.90*	48.56*	48.80
SU	40 3837	51.76*	51.71*	51.97*	52.15*	52.64*	51.94	51.81	52.60	52.75	53.15	52.69	52.61
TCC	35 768	-4.76	-4.33	-1.77	-4.90	-4.36	-5.41	-4.39	-28.27	-5.73	-	-5.51	-6.96
TCC	35 1028	-7.31	-6.56	-8.24	-9.00	-7.37	-7.89	-5.91	-31.91	-8.62	-	-	-
TCC	35 1881	-20.32*	-19.24*	-19.54*	-18.89*	-17.98*	-18.35*	-16.07*	-41.57*	-17.38*	-	-1.73	14.41
TCC	40 8620	-10.95	-11.22	-12.23	-12.94	-13.30	-13.89	-12.71	-16.94	-15.85	-	-16.86	-
TCC	40 8624	-14.80	-15.09	-15.99	-16.49	-16.81	-17.19	-16.03	-27.12	-18.49	-	-19.67	-16.27
TL	35 160	-4.99	-4.93	-4.53	-5.95	-6.11	-5.38	-4.64	-5.72	-5.12	-5.35	-5.52	-4.90
TL	35 300	7.67	7.27	6.81	7.17	6.81	11.29	8.55	11.30	12.31	11.31	7.77	7.03
TL	35 474	20.24	19.25	16.58	18.43	17.17	17.79	16.00	15.86	15.95	15.81	14.60	14.28
TL	35 809	2.86	4.30	2.86	2.81	-0.08	1.12	0.20	-1.20	-1.23	1.96	2.46	1.10
TL	35 1012	6.66	6.08	6.98	6.14	6.04	5.84	6.40	6.11	6.45	4.90	6.62	-2.45
TL	35 1104	-	-	-	12.14	9.98	10.25	9.99	10.67	10.77	11.41	10.70	10.11
TL	35 1132	-3.18	-3.53	-4.29	-3.60	-3.64	-4.69	-4.37	-4.57	-5.97	-5.37	-2.86	-5.18
TL	35 1498	15.76	16.13	15.66	15.49	14.66	15.18	15.44	14.42	15.11	15.79	16.55	15.37
TL	35 1500	12.99	13.85	13.89	13.54	14.16	14.54	14.53	15.39	16.06	16.41	15.28	16.72
TL	35 1712	1.41	1.97	1.94	1.32	1.10	1.17	1.39	1.23	1.03	0.92	1.05	0.70
TL	40 3052	54.65	55.58	56.55	57.42	58.28	59.14	60.43	61.23	62.18	63.36	64.40	63.68
TL	40 3053	6.63	7.35	7.40	7.85	8.06	8.12	8.39	8.78	9.44	9.82	9.85	10.16
TP	35 163	18.94	19.10	18.70	19.14	17.18	18.51	18.56	19.67	19.25	18.98	18.54	18.84

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
TP	35 326	-5.09	-5.34	-5.47	-7.19	-9.98	-27.67	-41.48	-47.70	-49.83	-49.30	-50.14	-50.33
TP	35 1227	8.43	8.75	9.57	8.38	8.22	8.47	8.05	8.16	7.42	8.84	8.84	9.41
TP	36 154	12.59	10.92	10.61	11.85	12.38	12.70	12.85	13.35	11.10	11.15	9.50	11.67
UME	35 252	-	3.41	2.33	4.16	4.37	3.97	4.32	-43.62	1.01	0.96	0.87	-1.21
UME	35 872	-	0.23	0.60	-0.32	0.19	-0.78	-0.21	-0.63	-1.70	-1.47	-1.72	-1.54
USNO	35 101	-5.74	-6.04	-6.29	-5.78	-6.09	-6.57	-5.27	-4.53	-3.70	-3.92	-3.02	-3.88
USNO	35 104	14.77	13.86	14.17	14.47	12.79	13.52	17.01	17.45	15.98	15.57	16.92	17.18
USNO	35 106	16.34	16.41	16.16	16.79	16.27	16.21	16.60	16.10	16.16	15.92	15.70	15.71
USNO	35 108	4.61	4.41	4.78	4.53	4.24	4.52	4.29	4.62	5.04	5.44	5.06	6.99
USNO	35 114	-6.29	-6.28	-6.04	-6.15	-6.09	-5.92	-6.44	-5.85	-6.06	-5.31	-5.16	-5.44
USNO	35 120	1.45	1.13	1.51	1.64	1.43	1.53	2.43	1.80	0.85	1.27	1.39	0.98
USNO	35 142	5.45	6.25	-	-	-	-	-	-	-	-	-	-11.39
USNO	35 145	-	-	-	-	-	-	11.72	13.53	14.82	14.75	15.68	17.86
USNO	35 146	-	-	-	-	-	-	-	-	0.66	0.71	0.41	0.66
USNO	35 148	11.41	10.89	10.05	10.32	10.07	9.44	9.85	10.07	9.61	8.58	8.76	8.70
USNO	35 150	-	-	-	-0.61	-1.41	-0.98	-0.11	-0.14	-0.29	-0.70	-0.34	-0.07
USNO	35 152	7.84	7.90	8.13	8.29	10.11	9.72	6.87	4.78	-	-	-	-
USNO	35 153	8.98	9.49	9.97	10.35	10.56	10.61	10.83	10.52	11.78	12.30	12.43	14.36
USNO	35 156	10.17	10.65	10.17	10.35	11.03	11.08	10.63	11.62	12.56	12.25	12.04	11.33
USNO	35 161	6.16	5.63	6.33	6.29	7.58	6.51	5.99	8.16	7.86	9.02	8.62	9.11
USNO	35 164	-4.74	-4.79	-4.61	-4.74	-4.24	-5.84	-4.44	1.17	1.59	4.09	5.25	2.26
USNO	35 165	14.02	13.46	13.81	13.83	13.36	13.06	12.81	13.03	13.82	12.73	13.31	12.88
USNO	35 166	1.17	1.45	1.74	1.26	1.39	1.23	0.50	-1.43	-0.47	-0.75	-1.46	-0.63
USNO	35 167	3.93	2.97	2.89	2.82	2.46	3.33	2.82	2.16	1.83	1.08	0.88	0.18
USNO	35 169	-6.86	-6.12	-5.70	-6.21	-6.25	-4.13	-4.89	-5.23	-5.58	-4.70	-4.51	-
USNO	35 173	-9.71	-10.20	-9.74	-9.57	-10.21	-9.88	-10.04	-	-	-	-	-4.56
USNO	35 213	2.89	3.73	4.23	3.83	4.27	3.85	3.62	3.54	3.82	3.46	3.71	3.42
USNO	35 226	25.12	24.78	24.13	24.58	24.01	-	-	-	-1.29	-	-	-
USNO	35 227	10.81	10.55	10.82	11.06	10.60	10.64	10.60	11.34	-	-	-	10.92
USNO	35 229	12.45	13.36	13.16	14.05	-	-	-	-	-	-	-	-
USNO	35 231	-	-	-	-	-	-	-	-	-	-13.23	-13.69	-14.41
USNO	35 233	4.16	4.58	-	-	-	-	-	-	-	17.12	17.37	17.51
USNO	35 242	12.92	12.45	13.18	12.60	12.75	13.29	12.90	12.97	12.76	12.83	12.51	13.05
USNO	35 244	-	-	-	4.79	4.21	4.44	4.47	4.95	4.27	5.28	5.08	5.56
USNO	35 249	5.01	4.66	4.90	4.30	2.93	2.23	1.85	4.12	1.97	2.26	2.75	3.65

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
USNO	35 253	-	-	-	-	-	-	-	-	-	-	-36.49	-34.05
USNO	35 254	15.59	14.16	15.76	14.97	15.48	13.93	13.56	14.48	14.88	-	-	-
USNO	35 255	8.73	7.45	7.55	7.65	7.99	8.20	7.65	8.62	7.95	7.61	8.11	7.39
USNO	35 256	13.58	14.73	14.94	13.83	-	-	-	-	-	-	-	11.49
USNO	35 260	3.25	3.01	3.12	3.61	5.98	8.06	6.60	3.40	3.42	1.83	2.92	4.63
USNO	35 268	1.60	2.73	1.73	3.16	3.68	3.71	2.87	3.61	2.81	2.15	3.07	3.72
USNO	35 270	-11.64	-12.21	-	-	-	-	-	-	-	-	-	19.38
USNO	35 279	4.28	3.19	2.77	3.27	2.68	3.01	3.66	2.59	3.09	3.11	3.07	3.35
USNO	35 389	-17.15	-17.54	-17.65	-17.77	-18.56	-17.79	-17.23	-17.78	-17.60	-17.95	-17.95	-17.70
USNO	35 392	11.61	11.85	-	-	-	-	-	-	26.04	26.58	26.95	27.85
USNO	35 394	27.67	27.41	27.16	26.51	27.10	27.36	26.57	27.15	27.42	27.81	33.74	-
USNO	35 416	-	-	-	-	-	-	-	-	-	-10.23	-11.03	-11.00
USNO	35 417	16.51	16.51	16.51	16.60	16.09	16.13	13.94	15.17	16.76	-	-	-
USNO	35 703	-0.39	-0.99	-1.57	-1.65	-0.95	-1.45	-0.16	-1.15	0.12	0.03	-0.11	0.33
USNO	35 717	-14.16	-13.52	-13.91	-14.18	-14.49	-13.66	-12.85	-13.79	-12.99	-12.69	-13.18	-12.87
USNO	35 762	-4.51	-4.56	-3.92	-5.12	-4.46	-4.56	-	-	-	-	-	-3.43
USNO	35 763	-19.21	-19.22	-19.16	-18.74	-18.99	-18.98	-18.90	-18.84	-18.43	-18.68	-18.30	-17.99
USNO	35 765	-6.77	-7.35	-8.27	-7.09	-8.60	-7.82	-	-	-9.06	-9.46	-9.73	-9.83
USNO	35 1096	29.16	28.31	28.03	28.20	28.73	29.07	29.96	29.15	29.22	29.10	28.85	29.47
USNO	35 1097	14.19	15.75	14.99	13.97	14.08	13.79	13.38	12.97	13.18	13.55	13.27	13.15
USNO	35 1125	18.26	18.00	17.69	18.61	-	-	-	-	-	-	-	-
USNO	35 1327	-7.55	-7.07	-7.35	-6.43	-6.62	-6.02	-6.46	-6.75	-7.05	-5.98	-5.99	-6.05
USNO	35 1328	1.23	1.17	1.54	1.86	2.62	2.75	2.97	2.88	5.61	5.67	5.59	5.39
USNO	35 1331	-39.66	-39.60	-39.76	-39.12	-39.47	-39.07	-39.04	-38.82	-38.27	-37.43	-37.85	-38.56
USNO	35 1438	-	-	-	-6.18	-6.10	-5.66	-4.55	-4.70	-4.92	-4.60	-4.14	-4.32
USNO	35 1459	-4.32	-3.93	-4.77	-5.08	-4.38	-4.22	-4.12	-4.49	-5.23	-	-	-
USNO	35 1462	10.05	-	-	-	-	-	-	-	-	-	-	-4.90
USNO	35 1463	10.86	11.19	10.67	10.83	10.94	10.55	10.93	10.69	10.90	11.72	11.06	11.22
USNO	35 1468	2.83	3.12	3.70	3.38	3.40	3.76	2.89	2.67	3.76	3.43	3.25	3.82
USNO	35 1481	7.10	6.84	7.39	-	-	-	-	-	-	-	-	-
USNO	35 1543	10.46	10.22	10.31	9.99	10.63	10.73	9.59	9.21	9.33	10.09	-	-
USNO	35 1573	0.79	-0.14	0.74	-0.03	0.61	1.04	1.57	1.71	-	-	-	-
USNO	35 1575	-3.45	-3.36	-3.77	-3.78	-3.76	-3.47	-3.70	-3.39	-4.52	-4.36	-4.54	-4.69
USNO	35 1655	-10.05	-10.36	-10.29	-10.46	-10.24	-10.92	-11.30	-10.22	-10.41	-10.58	-10.88	-10.01
USNO	35 1692	3.19	2.58	2.51	3.23	3.67	3.71	2.63	3.63	3.23	2.95	4.01	3.41

Table 8. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
USNO	35 1694	-2.98	-2.75	-2.58	-3.21	-3.34	-3.39	-3.35	-3.10	-3.50	-3.07	-3.74	-3.16
USNO	35 1696	4.81	5.64	6.10	4.82	4.42	4.99	5.16	4.69	5.13	5.53	4.14	5.14
USNO	35 1697	2.09	1.91	1.98	1.96	2.18	2.04	1.90	1.66	1.95	1.45	2.32	2.01
USNO	40 701	-21.27	-20.96	-20.87	-20.59	-20.34	-20.14	-19.25	-15.52	-12.44	-10.63	-8.23	-9.57
USNO	40 702	-10.67	-10.21	-10.38	-10.35	-10.48	-10.58	-10.62	-10.35	-10.38	-10.31	-10.50	-10.50
USNO	40 704	14.87	15.06	15.19	15.38	15.31	15.51	15.80	16.21	16.43	16.68	16.70	16.82
USNO	40 705	-48.46	-48.44	-48.69	-48.63	-48.82	-48.83	-48.76	-47.31	-46.20	-46.36	-45.99	-48.36
USNO	40 708	-	-	-	-	-	-	-	-	63.42	63.39	63.51	63.70
USNO	40 710	63.09	-	-	-	-561.69	-560.95	-560.54	-560.39	-559.99	-559.54	-559.07	-558.64
USNO	40 711	223.49	225.36	227.10	228.92	230.65	232.46	234.34	236.00	237.85	239.79	241.79	243.63
USNO	40 712	47.71	47.74	47.72	47.82	47.57	47.55	47.54	47.43	47.41	47.41	47.46	47.52
USNO	40 713	3.44	3.73	3.84	4.40	4.53	4.93	5.28	5.51	5.86	6.30	6.58	6.96
USNO	40 714	-25.59	-25.31	-25.13	-24.57	-24.26	-23.92	-23.69	-23.70	-23.61	-23.52	-23.55	-23.30
USNO	40 715	69.13	69.66	70.09	70.61	70.84	71.07	71.51	72.02	72.48	73.02	73.57	74.02
USNO	40 716	208.15	208.13	208.03	208.34	208.28	208.40	208.43	208.47	208.17	208.05	208.17	208.24
USNO	40 718	122.32	122.66	123.09	123.33	123.25	124.29	124.93	125.29	125.76	126.54	127.60	128.18
USNO	40 719	-5.02	-3.61	-2.35	-1.00	0.42	2.14	3.75	5.22	6.86	8.61	10.31	11.96
USNO	40 720	1.60	3.59	5.46	7.28	9.33	11.23	13.21	16.09	-	-	22.71	24.78
USNO	40 722	185.91	191.11	196.10	200.89	205.80	210.51	215.33	220.08	224.97	230.03	235.01	239.76
USNO	40 723	-69.89	-69.99	-70.09	-70.40	-70.71	-70.42	-70.24	-69.75	-69.82	-69.87	-69.89	-69.94
USNO	40 724	-100.62	-100.33	-100.32	-100.23	-100.12	-99.95	-100.04	-99.97	-100.01	-100.09	-100.17	-100.22
USNO	40 725	-34.40	-34.34	-34.72	-34.64	-34.96	-35.21	-35.21	-34.46	-33.24	-33.20	-33.05	-32.78
USNO	40 726	118.82	124.40	129.95	135.47	140.85	146.26	151.68	157.05	162.34	168.09	173.73	180.27
USNO	40 728	34.89	38.89	42.55	46.42	50.18	54.28	58.30	62.71	67.13	71.98	77.00	-
USNO	40 729	-	-	32.19	38.69	45.12	51.87	58.58	65.50	71.99	78.83	85.80	92.44
USNO	40 730	-55.62	-52.75	-50.04	-46.93	-43.83	-40.44	-37.08	-33.32	-30.09	-26.52	-22.87	-19.50
USNO	40 731	-	-154.72	-154.08	-153.32	-152.57	-151.62	-150.41	-149.46	-148.24	-147.05	-146.04	-145.23
VSL	35 179	6.69	7.49	7.31	7.76	6.94	7.05	7.21	7.96	8.58	8.17	8.25	9.53
VSL	35 456	22.47	21.80	20.47	20.29	19.58	19.41	19.08	19.52	20.41	20.95	20.84	19.67
VSL	35 548	12.49	12.66	12.37	12.69	12.21	12.14	12.95	12.29	12.17	11.82	11.59	12.24
VSL	35 731	20.15	20.63	20.70	20.69	20.64	21.56	20.27	20.89	20.63	20.13	20.25	19.97
ZA	36 1034	-	-12.11	-12.04	-12.81	-13.02	-16.91	-15.36	-14.34	-	-	-13.63	-
ZMDM	36 2033	6.41	6.07	5.85	6.64	5.69	6.37	5.01	5.93	5.79	5.38	6.06	6.42

Table 9A. Relative weights (in percent) of contributing clocks in 2007

(File available on http://www.bipm.org under the name WTAI07.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
13 EBAUCHES, OSCILLATOM B5000
14 HEWLETT-PACKARD 5061A OPT. 4
16 OSCILLOQUARTZ 3200
17 OSCILLOQUARTZ 3000
15 DATUM/SYMMETRICOM Cs III
4x HYDROGEN MASERS
9x PRIMARY CLOCKS AND PROTOTYPES
21 OSCILLOQUARTZ 3210
23 OSCILLOQUARTZ EUDICS 3020
30 HEWLETT-PACKARD 5061B
31 HEWLETT-PACKARD 5061B OPT. 4
34 H-P 5061A/B with 5071A tube
35 H-P/AGILENT/SYMMETRICOM 5071A High perf.
36 H-P/AGILENT/SYMMETRICOM 5071A Low perf.
50 FREQ. AND TIME SYSTEMS INC. 4065A
51 DATUM/SYMMETRICOM 4065 B
52 DATUM/SYMMETRICOM 4065 C

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
APL	35 904	0.351	0.293	0.324	0.274	-	0.000	0.000	0.000	0.000	0.400	0.581	0.500
APL	35 1264	0.748	0.671	0.000	0.228	-	0.000	0.000	0.000	0.000	0.022	0.031	0.042
APL	35 1791	0.899	0.850	0.859	0.836	-	0.000	0.000	0.000	0.000	0.820	0.828	0.847
APL	40 3107	0.015	0.016	0.021	0.024	-	0.000	0.000	0.000	0.000	0.108	0.147	0.189
APL	40 3108	0.000	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.001	0.001	0.001
APL	40 3109	0.204	0.216	0.268	0.336	-	0.000	0.000	0.000	0.000	0.080	0.074	0.067
AUS	35 2269	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
AUS	36 249	0.000	0.123	0.186	0.000	0.074	-	0.000	0.000	0.000	0.000	0.113	0.140
AUS	36 340	0.115	0.202	0.235	0.147	0.126	0.132	0.107	0.085	0.083	0.083	0.086	0.088
AUS	36 654	0.131	0.135	0.175	0.225	0.324	0.311	0.364	0.527	-	-	-	-

Table 9A. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
AUS	36 1141	0.613	0.340	0.228	0.196	0.205	0.174	0.163	0.140	0.143	0.133	0.137	0.133
AUS	40 5401	-	-	-	-	-	0.000	-	-	-	-	-	-
AUS	40 5402	-	-	0.000	0.000	0.000	0.000	-	-	0.000	0.000	0.000	-
AUS	40 5403	0.000	0.001	0.001	0.000	0.000	-	0.000	0.000	0.000	0.000	0.002	0.002
BEV	35 1065	0.289	0.287	0.376	0.346	0.450	0.748	0.776	0.696	0.538	0.441	0.454	0.349
BEV	35 1793	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.721	0.816
BIM	35 1501	0.116	0.065	0.092	0.109	0.117	0.149	0.119	0.143	0.157	0.159	0.152	0.118
BY	40 4209	-	-	-	0.000	0.000	0.000	0.000	0.023	0.010	0.007	0.009	0.011
BY	40 4260	-	-	-	0.000	0.000	0.000	0.000	0.003	0.004	0.005	0.004	0.000
BY	40 4263	-	-	-	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	-
BY	40 4278	-	-	-	0.000	0.000	0.000	0.000	0.002	0.002	0.002	0.001	0.001
CAO	35 939	0.000	0.000	0.000	0.053	0.084	0.084	0.090	0.060	0.047	0.045	0.049	0.050
CAO	35 1270	-	-	-	-	0.000	0.000	0.000	0.000	0.060	0.061	0.054	0.058
CH	35 771	0.341	0.344	0.306	0.289	0.301	0.290	0.378	0.317	0.364	0.350	0.344	0.509
CH	35 2117	0.253	0.338	0.498	0.465	0.641	0.552	0.530	0.593	0.650	0.578	0.650	0.671
CH	36 354	0.137	0.121	0.120	0.112	0.168	0.169	0.125	0.124	0.148	0.142	0.212	0.203
CH	36 413	0.143	0.138	0.169	0.234	0.280	0.237	0.317	0.338	0.595	0.506	0.508	0.467
CH	40 5701	0.005	0.004	0.005	0.005	0.006	0.007	0.008	0.010	0.012	0.015	0.017	0.015
CNM	35 1705	0.899	0.850	0.859	0.000	0.000	0.050	0.050	0.053	0.058	0.072	0.076	0.085
CNM	35 1815	0.139	0.131	0.116	0.109	0.121	0.091	0.084	0.075	0.097	0.144	0.163	0.208
CNM	36 1537	0.132	0.121	0.122	0.087	0.105	0.113	0.162	0.106	0.119	0.119	0.107	0.159
CNM	40 7301	0.005	0.008	0.000	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.002
CNMP	36 1752	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-
CNMP	36 1806	-	-	-	-	-	-	-	-	-	-	0.000	0.000
DLR	35 1714	-	-	-	-	0.000	0.000	0.000	0.000	0.298	0.415	0.399	0.280
DTAG	36 136	-	-	-	-	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001
DTAG	36 345	-	-	-	0.000	0.000	0.000	0.000	0.505	0.226	0.277	0.200	0.256
DTAG	36 465	-	-	-	0.000	0.000	0.000	0.000	0.365	0.105	0.131	0.148	0.000
EIM	35 716	-	-	-	-	-	-	-	-	0.000	0.000	0.000	-
EIM	35 1431	-	-	-	-	-	-	-	-	0.000	0.000	0.000	-
EIM	35 2060	-	-	-	-	-	-	-	-	0.000	0.000	0.000	-
F	35 122	0.763	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
F	35 124	0.899	0.850	0.859	0.836	0.871	0.839	0.769	0.681	0.738	0.784	0.758	0.729
F	35 131	0.801	0.728	0.769	0.735	0.610	0.496	0.408	0.545	0.499	0.519	0.590	0.593
F	35 158	0.064	0.062	0.082	0.102	0.120	0.123	0.142	0.200	0.250	0.307	0.292	0.348

Table 9A. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
F	35 172	-	0.000	0.000	0.000	0.000	0.839	0.845	0.820	0.744	0.820	0.828	0.791
F	35 198	0.000	0.000	0.380	0.531	0.695	0.839	0.845	-	-	-	0.000	-
F	35 385	0.567	0.462	0.277	0.175	0.152	0.143	0.136	0.139	0.198	0.207	0.249	0.409
F	35 396	0.555	0.463	0.489	0.476	0.552	0.442	0.356	0.322	0.446	-	-	-
F	35 520	0.146	0.118	0.183	0.000	0.104	0.105	0.111	0.105	-	-	-	-
F	35 609	0.162	0.263	0.272	0.276	-	-	-	-	-	-	0.000	0.000
F	35 770	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
F	35 774	0.000	0.172	-	-	-	-	-	-	-	-	-	-
F	35 781	0.000	0.000	0.036	0.045	0.066	0.074	0.077	-	-	-	0.000	-
F	35 819	0.000	0.000	0.000	0.057	0.089	0.114	0.146	0.191	0.246	0.290	0.284	0.291
F	35 859	0.000	0.000	0.000	0.000	0.182	0.227	0.139	0.187	0.250	-	-	-
F	35 1029	0.414	0.500	0.542	0.836	0.871	0.839	0.750	0.820	0.825	0.820	0.828	0.847
F	35 1178	0.000	0.000	0.000	0.000	0.099	0.151	0.127	0.174	0.229	-	-	0.000
F	35 1222	0.000	0.000	0.859	0.836	0.871	0.839	0.845	-	-	-	0.000	-
F	35 1258	0.000	0.000	0.181	0.256	0.335	0.453	0.506	0.387	0.417	0.000	0.178	0.157
F	35 1321	-	-	0.000	0.000	0.000	0.000	0.845	0.820	0.825	0.820	0.828	0.847
F	35 1556	0.568	0.755	0.859	0.836	-	-	-	-	0.000	0.000	0.000	0.000
F	35 2027	0.138	0.121	0.119	0.115	0.138	0.168	0.249	0.449	0.618	0.542	0.371	0.307
F	40 805	0.028	0.018	0.012	0.007	0.005	0.005	0.005	0.007	0.010	0.013	0.018	0.023
F	40 816	0.009	0.011	0.018	0.037	0.054	0.069	0.077	0.082	0.076	0.068	0.063	0.056
F	40 889	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
F	40 890	0.005	0.004	0.004	0.005	0.005	0.007	0.009	0.013	0.024	0.032	0.023	0.017
F	53 6385	-	-	-	-	-	-	-	-	-	-	0.000	0.000
HKO	35 1893	-	0.000	0.000	0.000	0.000	0.054	0.019	0.022	0.028	0.035	0.038	0.045
IFAG	36 1167	0.041	0.038	0.041	0.041	0.044	0.043	0.043	0.057	0.074	0.074	0.071	0.059
IFAG	36 1173	0.054	0.040	0.037	0.034	0.036	0.032	0.034	0.034	0.034	0.034	0.033	0.031
IFAG	36 1629	0.262	0.357	0.587	0.558	0.568	0.461	0.344	0.283	0.319	0.341	0.330	0.326
IFAG	36 1732	-	0.000	0.000	0.000	0.000	0.652	0.845	0.820	0.825	0.820	0.828	0.635
IFAG	36 1798	0.510	0.475	0.432	-	-	-	-	-	0.000	0.000	0.000	0.000
IFAG	40 4413	-	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-
IFAG	40 4418	0.022	0.000	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.008
IFAG	40 4439	-	0.000	0.000	0.000	0.000	0.004	-	0.000	0.000	0.000	0.000	0.002
IGMA	16 112	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	-	-	-	-
IGMA	35 674	0.000	0.406	0.000	0.001	0.002	0.002	0.003	0.003	-	-	-	-
IGMA	35 676	0.000	0.763	0.490	0.653	0.809	0.752	0.817	-	-	-	-	-

Table 9A. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
INPL	35 1653	0.330	0.218	0.000	0.015	-	-	-	-	-	-	-	-
IT	35 219	0.511	0.593	0.754	0.836	0.871	0.839	0.845	0.820	0.825	0.782	0.000	0.338
IT	35 505	0.657	0.778	0.811	0.730	0.870	0.839	0.845	0.729	0.548	0.540	0.519	0.536
IT	35 1115	0.108	0.262	0.475	0.660	0.686	0.000	0.187	0.117	0.086	0.074	0.076	0.075
IT	35 1373	0.217	0.222	0.520	0.705	0.871	0.839	0.845	0.820	0.825	0.697	0.707	0.531
IT	35 2118	-	-	-	-	-	0.000	0.000	0.000	0.000	0.349	0.506	0.585
IT	40 1101	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-
IT	40 1102	0.000	0.003	0.004	0.004	0.004	0.005	0.006	0.006	0.007	0.008	0.008	0.008
JV	21 216	0.040	0.047	0.046	0.058	0.000	0.023	0.024	0.020	0.018	0.018	0.018	0.016
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	0.139	0.130	0.180	0.140	0.147	0.140	0.111	0.113	0.122	0.123	0.153	0.179
KRIS	35 321	0.068	0.061	0.063	0.061	0.065	0.059	0.054	0.046	0.039	0.036	0.039	0.054
KRIS	35 1693	-	0.000	0.000	0.000	0.000	0.436	0.607	0.657	0.825	0.820	0.794	0.847
KRIS	35 1783	0.183	0.155	-	-	0.000	0.000	0.000	0.000	0.825	0.820	0.828	0.000
KRIS	36 1135	0.156	0.118	0.126	0.119	0.085	0.059	0.059	0.056	0.059	0.058	0.055	0.053
KRIS	40 5623	0.002	0.002	0.004	0.006	0.010	0.016	0.023	0.033	0.044	0.052	0.061	0.069
KRIS	40 5625	0.002	0.001	0.001	0.001	-	-	-	-	-	-	-	-
LDS	35 289	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.091	0.091	0.086	0.104
LT	35 1362	0.134	0.118	0.130	0.165	0.181	0.191	0.192	0.331	0.270	0.398	0.335	0.312
LT	35 1868	0.000	0.000	0.000	0.613	0.849	0.839	0.845	0.649	0.797	0.468	0.315	0.228
LV	35 2335	-	-	-	-	-	-	-	-	-	-	-	0.000
LV	36 1953	-	-	-	-	-	-	-	-	0.000	0.000	-	-
MIKE	35 1171	0.012	0.012	0.012	0.027	0.069	0.068	0.077	0.077	0.079	0.105	0.098	0.098
MIKE	36 986	0.013	0.012	0.024	0.038	0.079	0.082	0.083	0.080	0.084	0.084	0.082	0.079
MIKE	40 4113	0.010	0.009	0.008	0.007	0.006	0.006	0.007	0.006	0.006	0.005	0.005	0.004
MIKE	40 4180	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
MKEH	36 849	0.074	0.066	0.072	0.083	0.079	0.088	0.094	0.095	0.102	0.101	0.112	-
MSL	12 933	-	0.000	0.000	0.000	0.000	0.002	0.003	0.002	0.003	0.003	0.002	0.003
MSL	36 274	-	0.000	0.000	0.000	0.000	0.018	0.021	0.029	0.038	0.044	0.052	0.064
MSL	36 1025	-	0.000	0.000	0.000	0.000	0.082	0.086	0.000	0.001	0.001	0.001	0.001
NAO	35 779	0.000	0.000	0.000	0.385	0.403	0.416	-	-	-	-	-	0.000
NAO	35 1206	0.000	0.247	0.378	0.428	0.480	0.440	0.491	0.594	0.678	0.577	0.512	0.442
NAO	35 1214	0.000	0.085	0.066	0.079	0.105	0.137	0.000	0.081	0.096	0.123	0.159	0.150
NAO	35 1689	0.000	0.850	0.859	0.000	0.000	0.045	0.049	0.054	0.044	0.000	0.016	0.014
NICT	35 112	0.475	0.448	0.405	0.318	0.305	0.333	0.317	0.330	0.342	0.340	-	-

Table 9A. (Cont.)

Lab.	Clock		54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
NICT	35	144	0.122	0.128	0.143	0.213	0.369	0.450	0.803	0.574	0.626	0.581	0.733	0.742
NICT	35	332	-	-	-	0.000	0.000	0.000	0.000	0.023	0.023	0.025	0.027	0.030
NICT	35	342	-	-	-	0.000	0.000	0.000	0.000	0.029	0.042	0.058	0.075	0.091
NICT	35	343	-	-	-	0.000	0.000	0.000	0.000	0.437	0.379	0.422	0.469	0.567
NICT	35	715	0.839	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.703	0.682
NICT	35	732	0.647	0.612	0.629	0.716	0.769	0.753	0.845	0.820	0.825	0.820	0.828	0.000
NICT	35	907	0.040	0.034	0.039	0.040	0.043	0.044	0.046	0.047	0.055	0.061	0.069	0.097
NICT	35	908	0.045	0.048	0.059	0.063	0.114	0.132	0.163	0.244	0.401	0.474	0.529	0.838
NICT	35	916	-	-	-	-	-	-	-	-	-	-	-	0.000
NICT	35	1225	-	-	-	-	-	0.000	0.000	0.000	0.000	0.535	0.717	0.847
NICT	35	1778	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
NICT	35	1789	0.415	0.324	0.305	0.252	0.295	0.239	0.202	0.260	0.332	0.447	0.437	0.311
NICT	35	1790	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
NICT	35	1866	-	-	-	-	-	0.000	0.000	0.000	0.000	0.480	0.403	0.559
NICT	35	1882	0.018	0.018	0.023	0.033	0.055	0.202	0.265	0.259	0.267	0.261	0.260	0.605
NICT	35	1887	0.000	0.022	0.022	0.022	0.024	0.025	0.023	0.022	0.027	0.037	0.040	0.041
NICT	35	1944	0.191	0.175	0.221	0.235	0.309	0.412	0.576	0.768	0.825	0.820	0.828	0.847
NICT	35	2010	-	0.000	0.000	0.000	0.000	0.490	0.625	0.820	0.825	0.613	0.588	0.711
NICT	35	2011	-	0.000	0.000	0.000	0.000	0.178	0.270	0.385	0.426	0.478	0.576	0.707
NICT	35	2056	0.651	0.481	0.000	0.176	0.193	0.237	0.228	0.211	0.240	0.235	0.338	0.414
NICT	35	2113	0.612	0.744	0.859	0.836	0.487	0.411	0.294	0.297	0.212	0.195	0.000	0.043
NICT	35	2116	0.197	0.188	0.212	0.238	0.284	0.289	0.291	0.401	0.311	0.247	0.242	0.220
NICT	36	1217	-	-	-	-	-	0.000	0.000	0.000	0.000	0.132	0.093	0.126
NICT	36	1226	-	-	-	-	-	0.000	0.000	0.000	0.000	0.128	0.182	0.229
NICT	36	1611	-	-	-	-	-	0.000	0.000	0.000	0.000	0.027	0.036	0.040
NICT	40	2002	0.000	0.068	0.056	0.046	0.042	0.037	0.033	0.032	0.033	0.035	0.038	0.042
NICT	40	2003	0.008	0.007	0.007	0.007	0.008	0.009	0.013	0.019	0.031	0.040	0.044	0.041
NIM	35	479	0.121	0.142	0.173	0.165	0.000	0.071	0.076	0.095	0.098	0.104	0.117	0.123
NIM	35	1235	-	0.000	0.000	0.000	0.000	0.488	0.325	0.426	0.406	0.408	0.478	0.521
NIM	35	1239	0.080	0.079	0.078	0.065	0.060	0.052	0.051	0.053	0.063	0.063	0.081	0.185
NIM	40	4814	0.003	0.003	0.003	0.003	-	-	-	-	-	-	-	-
NIM	40	4832	0.899	0.850	0.859	0.836	0.871	0.839	0.000	0.565	0.558	0.517	0.577	0.574
NIM	40	4835	0.079	0.074	0.090	0.100	0.107	0.092	0.088	0.088	0.091	0.099	0.094	0.108
NIMB	35	600	-	-	0.000	0.000	0.000	0.000	0.000	0.026	0.040	0.053	0.061	0.064
NIS	35	1126	0.000	0.010	0.015	0.019	0.026	0.034	0.043	0.045	0.046	0.047	0.047	0.102

Table 9A. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
NIST	15 9866	0.001	0.001	0.002	0.003	0.004	-	-	-	-	-	-	-
NIST	35 132	0.494	0.391	0.520	0.836	0.770	0.839	0.845	0.820	0.825	0.820	0.828	0.847
NIST	35 182	0.798	0.534	0.674	0.626	0.871	0.672	0.671	0.662	0.000	-	-	-
NIST	35 282	0.467	0.480	0.514	0.337	-	0.000	0.000	0.000	0.000	0.007	0.010	0.012
NIST	35 408	0.573	0.553	0.647	0.602	0.620	0.551	0.627	0.637	0.652	0.820	0.828	0.847
NIST	35 1074	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
NIST	35 2031	0.380	0.404	0.357	0.470	-	0.000	0.000	0.000	0.000	0.002	0.002	0.003
NIST	35 2032	0.026	0.021	0.022	0.023	-	0.000	0.000	0.000	0.000	0.009	0.013	0.019
NIST	35 2034	0.725	0.654	0.672	0.626	-	0.000	0.000	0.000	-	-	-	0.000
NIST	40 203	0.010	0.010	0.011	0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.010	0.009
NIST	40 204	0.557	0.421	0.363	0.293	0.302	0.274	0.252	0.255	0.283	0.309	0.344	0.414
NIST	40 205	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
NIST	40 206	0.054	0.051	0.051	0.049	0.053	0.071	0.094	0.125	0.155	0.168	0.238	0.377
NIST	40 222	0.021	0.018	0.019	0.018	0.020	0.020	0.021	0.023	0.026	0.028	0.029	0.032
NMIJ	35 224	0.040	-	0.000	0.000	0.000	0.000	0.120	0.181	0.265	0.351	0.370	0.439
NMIJ	35 523	0.350	0.296	0.218	0.207	0.201	0.181	0.278	0.286	0.358	0.438	0.426	0.589
NMIJ	35 1466	0.129	0.112	0.139	0.146	0.172	0.202	0.197	0.284	0.000	0.000	-	-
NMIJ	40 5002	0.039	0.025	0.027	0.025	0.027	0.024	0.028	0.027	0.025	0.026	0.030	0.070
NMIJ	40 5003	0.182	0.135	0.126	0.106	0.091	-	-	-	-	-	-	-
NMIJ	40 5014	0.000	0.089	0.087	0.080	0.082	0.082	0.082	0.094	0.117	0.179	0.507	0.399
NMLS	35 1659	0.242	0.245	0.305	0.241	0.157	0.104	0.069	0.068	0.060	0.063	0.069	0.119
NPL	35 1275	0.000	0.000	0.000	0.056	0.045	0.056	0.054	0.049	0.049	0.053	0.061	-
NPL	36 784	0.056	0.043	0.042	0.038	0.044	0.056	0.067	0.071	0.119	0.674	0.633	-
NPL	40 1701	0.154	0.124	0.115	0.110	0.111	0.118	0.130	0.138	0.193	0.378	0.286	-
NPL	40 1708	0.334	0.552	0.721	0.787	0.833	0.805	0.664	0.451	0.492	0.423	0.315	-
NPLI	35 2257	-	-	0.000	0.000	0.000	0.000	0.000	0.012	0.013	-	0.000	0.000
NRC	35 234	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.078	0.308
NRC	35 372	0.296	0.216	0.231	0.220	0.238	0.229	0.238	0.270	0.675	0.820	0.828	0.847
NTSC	35 1007	0.000	0.000	0.000	0.015	0.015	0.015	0.017	0.022	0.016	0.013	0.011	0.011
NTSC	35 1008	0.000	0.850	0.859	0.836	0.871	0.519	0.354	0.375	0.457	0.454	0.490	0.509
NTSC	35 1011	0.000	0.000	0.000	0.000	0.629	0.839	0.491	0.634	0.751	0.458	0.482	0.425
NTSC	35 1016	0.379	0.312	0.317	0.396	0.642	0.839	0.845	0.820	0.825	0.757	0.000	0.384
NTSC	35 1017	0.081	0.055	0.055	0.055	0.076	0.085	0.110	0.159	0.160	0.226	0.176	0.177
NTSC	35 1818	0.361	0.301	0.205	0.219	0.163	0.153	0.108	0.098	0.072	0.055	0.045	0.048
NTSC	35 1820	0.269	0.338	0.553	0.530	0.590	0.819	0.767	0.820	0.597	0.617	0.566	0.630

Table 9A. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
NTSC	35 1823	0.000	0.000	0.000	0.000	0.033	0.043	0.058	0.000	0.003	0.003	0.002	0.002
NTSC	35 2096	0.360	0.399	0.505	0.595	0.786	0.839	0.845	0.820	0.825	0.820	0.828	0.847
NTSC	35 2098	0.899	0.744	0.561	0.635	0.637	0.567	0.583	0.543	0.480	0.363	0.404	0.267
NTSC	35 2131	0.526	0.380	0.379	0.360	0.259	0.252	0.171	0.179	0.133	0.124	0.104	0.095
NTSC	35 2141	0.003	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.004	0.011	0.010
NTSC	35 2142	0.899	0.850	0.859	0.836	0.871	0.661	0.628	0.653	0.612	0.639	0.789	0.847
NTSC	35 2143	0.200	0.227	0.304	0.374	0.492	0.602	0.723	0.820	0.825	0.820	0.828	0.847
NTSC	35 2144	0.289	0.239	0.237	0.268	0.310	0.449	0.845	0.820	0.825	0.820	0.828	0.847
NTSC	35 2145	0.506	0.548	0.617	0.752	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
NTSC	35 2146	0.146	0.101	0.109	0.083	0.093	0.099	0.105	0.106	0.125	0.125	0.120	0.152
NTSC	35 2147	0.526	0.216	0.185	0.144	0.156	0.163	0.137	0.106	0.096	0.087	0.094	0.096
NTSC	40 4926	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NTSC	40 4927	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
NTSC	40 4933	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
NTSC	40 4945	0.002	0.001	0.002	0.002	0.002	0.003	0.002	0.000	0.001	0.001	0.000	0.000
NTSC	40 4946	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
ONBA	12 1371	0.000	0.000	-	-	-	-	-	-	-	-	-	-
ONBA	36 2228	-	-	-	0.000	0.000	0.000	0.000	0.077	0.087	0.110	0.141	0.173
ONRJ	35 103	0.013	0.015	0.019	0.023	0.029	0.035	0.035	0.035	0.036	0.036	0.828	0.847
ONRJ	35 123	0.010	0.012	0.016	0.019	0.025	0.028	0.028	0.029	0.031	0.031	0.348	0.351
ONRJ	35 129	0.021	0.025	0.033	0.039	0.051	0.061	0.063	0.068	0.073	0.080	0.819	0.847
ONRJ	35 1942	0.031	0.030	0.033	0.032	0.034	0.036	0.037	0.040	0.045	0.049	0.266	0.333
ONRJ	52 125	-	-	-	-	-	-	0.000	-	-	0.000	0.000	0.000
ORB	35 201	0.127	0.110	0.114	0.104	0.081	0.102	0.144	0.141	0.194	0.192	0.168	0.167
ORB	35 202	0.053	0.070	0.069	0.068	0.070	0.133	0.113	0.114	0.106	0.134	0.137	0.077
ORB	35 593	0.077	0.061	0.060	0.062	0.066	0.079	0.093	0.166	0.252	0.244	0.227	0.215
ORB	40 2601	0.580	0.514	0.414	0.224	0.191	0.180	0.186	0.191	0.190	0.182	0.159	0.128
PL	25 124	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.002	0.002
PL	35 441	0.742	0.689	0.859	0.836	0.871	0.839	0.627	0.485	0.455	0.422	0.394	0.397
PL	35 502	0.626	0.565	0.630	0.526	0.367	0.365	0.402	0.412	0.255	0.345	0.288	0.278
PL	35 745	0.591	0.660	0.676	0.688	0.734	0.741	0.820	0.820	0.825	0.820	0.828	0.847
PL	35 1120	0.426	0.387	0.442	0.393	0.443	0.460	0.581	0.784	0.825	0.820	0.828	0.847
PL	35 1660	0.218	0.155	0.091	0.069	0.053	0.000	0.000	0.004	0.004	0.003	0.003	0.004
PL	35 1709	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.797	0.000	0.348
PL	35 1746	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847

Table 9A. (Cont.)

Lab.	Clock		54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
PL	35	1934	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.778	0.673	0.759	0.787
PL	36	1395	0.090	0.083	0.085	0.104	0.111	0.098	0.099	0.130	0.152	0.183	0.000	0.107
PL	40	4002	0.015	0.005	0.007	-	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
PL	40	4004	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.004	0.004	0.004	0.004
PTB	35	128	-	-	-	-	-	0.000	0.000	0.000	0.000	0.820	0.445	0.521
PTB	35	415	0.636	0.533	0.555	0.432	0.429	0.446	0.417	0.375	0.385	0.407	0.587	0.701
PTB	35	1072	0.899	0.683	0.656	0.681	0.744	0.839	0.727	0.509	0.537	0.559	0.399	0.546
PTB	40	506	-	-	-	-	-	0.000	0.000	0.000	0.000	0.002	0.001	0.001
PTB	40	510	0.000	0.000	0.000	0.836	0.871	0.000	0.131	0.114	0.138	0.165	0.186	0.186
PTB	40	590	0.010	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.012	0.012	0.012	0.013
PTB	92	1	0.899	0.850	0.859	0.836	0.789	0.532	0.636	0.663	0.689	0.514	0.473	0.471
PTB	92	2	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
PTB	92	3	0.097	0.062	-	-	-	-	-	-	-	-	-	-
ROA	31	422	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-
ROA	35	583	0.167	0.144	0.133	0.128	0.151	0.198	0.280	0.820	0.825	0.820	0.828	0.847
ROA	35	718	0.899	0.850	0.859	0.740	0.781	0.648	0.407	0.359	0.414	0.630	0.653	0.679
ROA	35	1699	-	-	0.000	0.000	0.000	0.000	0.845	0.820	0.825	0.820	0.828	0.847
ROA	36	1488	0.190	0.262	0.261	0.278	0.377	0.413	0.335	0.358	0.375	0.388	0.371	0.344
ROA	36	1490	0.236	0.236	0.239	0.172	0.175	0.160	0.222	0.241	0.358	0.458	0.496	0.497
ROA	40	1436	0.002	0.002	0.002	0.003	0.007	0.015	0.035	0.046	0.036	0.020	0.012	0.009
SCL	35	621	0.496	0.467	0.460	0.516	0.546	0.548	-	-	-	-	-	-
SCL	35	1745	0.899	0.850	0.859	0.836	0.871	0.839	-	0.000	0.000	0.000	0.000	0.411
SCL	35	2178	-	-	-	-	-	-	-	-	-	-	0.000	0.000
SG	35	1035	0.000	0.383	0.431	0.350	0.390	0.491	0.551	-	-	-	-	-
SG	35	1127	0.000	0.261	0.395	0.450	0.631	0.792	0.781	0.820	0.825	-	0.000	0.000
SG	35	1889	0.000	0.049	0.075	0.098	0.138	0.180	0.226	0.263	0.000	-	0.000	0.000
SG	36	522	0.000	0.036	0.049	0.062	0.087	0.098	0.000	0.000	0.000	-	0.000	0.000
SIQ	36	1268	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
SMU	36	1193	0.156	0.119	0.128	0.139	0.154	0.211	0.324	0.442	0.445	0.434	0.585	0.504
SP	19	197	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.011
SP	35	572	0.160	0.173	0.201	0.342	0.424	0.457	0.487	0.546	0.387	0.221	0.242	0.295
SP	35	641	0.688	0.784	0.518	0.415	0.272	0.251	0.218	0.222	0.274	0.302	0.439	0.535
SP	35	1188	0.843	0.669	0.743	0.758	0.804	0.781	0.764	0.820	0.825	0.820	0.828	0.847
SP	35	1531	0.899	0.850	0.859	0.836	0.871	0.556	0.450	0.461	0.415	0.438	0.471	0.351
SP	35	1642	0.703	0.622	0.353	0.232	0.214	0.198	0.197	0.208	0.252	0.239	0.295	0.423

Table 9A. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
SP	35 2166	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
SP	36 1175	0.403	0.431	0.428	0.409	0.413	0.402	0.457	0.504	0.477	0.434	0.501	0.398
SP	36 2068	0.255	0.310	0.326	0.367	0.387	0.258	0.203	0.204	0.157	0.119	0.101	0.103
SP	36 2218	0.172	0.181	0.216	0.188	0.325	0.466	0.539	0.789	0.825	0.820	0.828	0.692
SP	36 2297	-	-	-	-	0.000	0.000	0.000	0.000	0.825	0.820	0.828	0.847
SP	40 7201	0.000	0.000	0.000	0.000	0.005	0.005	0.004	0.004	0.004	0.003	0.003	0.003
SP	40 7203	-	-	-	0.000	0.000	0.000	0.000	0.057	0.054	0.047	0.037	0.033
SP	40 7210	0.000	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.001	0.001	0.001
SP	40 7211	0.005	0.004	0.005	0.004	0.005	0.005	0.005	-	-	-	-	-
SP	40 7218	0.000	0.000	0.002	-	0.000	0.000	-	-	-	-	-	-
SU	40 3802	0.093	0.000	0.047	0.039	0.037	0.035	0.035	0.037	0.040	0.045	0.047	0.053
SU	40 3805	0.090	0.000	0.031	0.023	0.021	0.020	0.020	0.018	0.019	0.019	0.020	0.022
SU	40 3810	0.634	0.353	0.276	0.210	0.188	0.166	0.156	0.152	0.145	0.128	0.099	0.081
SU	40 3822	0.005	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.005	0.005	0.005
SU	40 3825	0.013	0.009	0.008	0.008	0.009	0.011	0.013	0.019	0.023	0.027	-	-
SU	40 3831	0.028	0.027	0.030	0.030	0.033	0.035	0.039	0.042	0.054	0.062	0.061	0.063
SU	40 3837	0.210	0.237	0.347	0.604	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
TCC	35 768	0.030	0.034	0.039	0.043	0.054	0.052	0.070	0.000	0.003	-	0.000	0.000
TCC	35 1028	0.229	0.177	0.220	0.212	0.257	0.264	0.181	0.000	0.004	-	-	-
TCC	35 1881	0.204	0.230	0.296	0.316	0.274	0.251	0.000	0.000	0.004	-	0.000	0.000
TCC	40 8620	0.016	0.015	0.015	0.015	0.016	0.014	0.015	0.012	0.012	-	0.000	-
TCC	40 8624	0.067	0.056	0.050	0.042	0.042	0.042	0.055	0.000	0.013	-	0.000	0.000
TL	35 160	0.751	0.686	0.691	0.455	0.391	0.399	0.415	0.394	0.413	0.468	0.582	0.671
TL	35 300	0.394	0.356	0.373	0.356	0.781	0.000	0.106	0.064	0.043	0.039	0.039	0.038
TL	35 474	0.062	0.043	0.027	0.025	0.024	0.025	0.023	0.029	0.035	0.038	0.055	0.048
TL	35 809	0.144	0.131	0.127	0.121	0.000	0.077	0.070	0.056	0.052	0.051	0.050	0.054
TL	35 1012	0.127	0.425	0.416	0.453	0.514	0.489	0.503	0.597	0.677	0.000	0.506	0.000
TL	35 1104	-	-	-	0.000	0.000	0.000	0.000	0.084	0.131	0.163	0.209	0.238
TL	35 1132	0.340	0.212	0.144	0.139	0.141	0.126	0.148	0.179	0.134	0.149	0.171	0.177
TL	35 1498	0.566	0.744	0.754	0.701	0.481	0.465	0.539	0.479	0.553	0.580	0.500	0.497
TL	35 1500	0.178	0.113	0.095	0.090	0.091	0.099	0.118	0.141	0.129	0.112	0.145	0.135
TL	35 1712	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.730	0.828	0.847
TL	40 3052	0.010	0.009	0.010	0.010	0.011	0.012	0.013	0.013	0.015	0.015	0.014	0.016
TL	40 3053	0.188	0.153	0.160	0.149	0.150	0.146	0.164	0.173	0.171	0.148	0.140	0.151
TP	35 163	0.000	0.363	0.560	0.602	0.000	0.319	0.402	0.380	0.450	0.501	0.469	0.474

Table 9A. (Cont.)

Lab.	Clock		54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
TP	35	326	0.006	0.006	0.008	0.011	0.021	0.000	0.000	0.001	0.001	0.000	0.000	0.000
TP	35	1227	0.096	0.092	0.095	0.103	0.178	0.573	0.570	0.587	0.508	0.571	0.539	0.502
TP	36	154	0.000	0.061	0.061	0.081	0.112	0.139	0.165	0.179	0.191	0.169	0.102	0.131
UME	35	252	-	0.000	0.000	0.000	0.000	0.102	0.139	0.000	0.000	0.001	0.001	0.001
UME	35	872	-	0.000	0.000	0.000	0.000	0.227	0.328	0.366	0.205	0.195	0.179	0.191
USNO	35	101	0.568	0.494	0.523	0.808	0.763	0.547	0.611	0.527	0.000	0.223	0.141	0.132
USNO	35	104	0.192	0.147	0.146	0.154	0.128	0.135	0.105	0.086	0.091	0.091	0.077	0.071
USNO	35	106	0.000	0.000	0.000	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	35	108	0.015	0.011	0.011	0.011	0.012	0.012	0.015	0.019	0.034	0.820	0.828	0.000
USNO	35	114	0.000	0.000	0.000	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	35	120	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	35	142	0.784	0.712	-	-	-	-	-	-	-	-	-	0.000
USNO	35	145	-	-	-	-	-	-	0.000	0.000	0.000	0.000	0.031	0.021
USNO	35	146	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
USNO	35	148	0.244	0.202	0.217	0.183	0.224	0.227	0.285	0.298	0.448	0.283	0.229	0.197
USNO	35	150	-	-	-	0.000	0.000	0.000	0.000	0.249	0.367	0.497	0.630	0.742
USNO	35	152	0.225	0.209	0.360	0.402	0.000	0.140	0.142	0.082	-	-	-	-
USNO	35	153	0.899	0.850	0.859	0.725	0.596	0.538	0.425	0.423	0.307	0.215	0.161	0.000
USNO	35	156	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.000	0.307	0.266	0.292
USNO	35	161	0.571	0.408	0.556	0.633	0.656	0.665	0.655	0.000	0.298	0.173	0.143	0.119
USNO	35	164	0.000	0.000	0.000	0.000	0.871	0.272	0.364	0.000	0.018	0.012	0.009	0.010
USNO	35	165	0.400	0.635	0.859	0.836	0.871	0.839	0.758	0.773	0.807	0.631	0.608	0.694
USNO	35	166	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.000	0.184	0.153	0.111	0.107
USNO	35	167	0.769	0.558	0.633	0.619	0.458	0.512	0.564	0.485	0.387	0.252	0.175	0.124
USNO	35	169	0.000	0.269	0.279	0.255	0.257	0.208	0.214	0.218	0.237	0.224	0.269	-
USNO	35	173	0.893	0.788	0.684	0.836	0.871	0.839	0.845	-	-	-	-	0.000
USNO	35	213	0.321	0.264	0.232	0.327	0.378	0.436	0.571	0.820	0.825	0.820	0.828	0.847
USNO	35	226	0.191	0.175	0.228	0.358	0.460	-	-	-	0.000	-	-	-
USNO	35	227	0.518	0.479	0.505	0.492	0.871	0.839	0.845	0.820	-	-	-	0.000
USNO	35	229	0.525	0.455	0.544	0.000	-	-	-	-	-	-	-	-
USNO	35	231	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
USNO	35	233	0.899	0.850	-	-	-	-	-	-	-	0.000	0.000	0.000
USNO	35	242	0.075	0.084	0.097	0.111	0.137	0.200	0.808	0.820	0.825	0.820	0.828	0.847
USNO	35	244	-	-	-	0.000	0.000	0.000	0.000	0.820	0.825	0.751	0.828	0.721
USNO	35	249	0.602	0.487	0.675	0.563	0.000	0.000	0.092	0.107	0.101	0.100	0.102	0.113

Table 9A. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
USNO	35 253	-	-	-	-	-	-	-	-	-	-	0.000	0.000
USNO	35 254	0.000	0.420	0.311	0.319	0.353	0.344	0.286	0.343	0.365	-	-	-
USNO	35 255	0.899	0.740	0.577	0.459	0.480	0.486	0.512	0.642	0.820	0.815	0.828	0.785
USNO	35 256	0.650	0.632	0.611	0.573	-	-	-	-	-	-	-	0.000
USNO	35 260	0.502	0.428	0.456	0.498	0.000	0.000	0.057	0.057	0.059	0.052	0.049	0.051
USNO	35 268	0.540	0.604	0.502	0.464	0.368	0.328	0.332	0.312	0.356	0.343	0.330	0.319
USNO	35 270	0.899	0.784	-	-	-	-	-	-	-	-	-	0.000
USNO	35 279	0.899	0.850	0.742	0.797	0.687	0.749	0.771	0.608	0.645	0.633	0.735	0.759
USNO	35 389	0.755	0.829	0.746	0.529	0.318	0.306	0.312	0.324	0.334	0.350	0.447	0.847
USNO	35 392	0.743	0.738	-	-	-	-	-	-	0.000	0.000	0.000	0.000
USNO	35 394	0.899	0.850	0.859	0.624	0.620	0.635	0.486	0.654	0.825	0.820	0.000	-
USNO	35 416	-	-	-	-	-	-	-	-	-	0.000	0.000	0.000
USNO	35 417	0.894	0.822	0.849	0.818	0.871	0.839	0.000	0.234	0.246	-	-	-
USNO	35 703	0.591	0.746	0.766	0.739	0.871	0.839	0.829	0.820	0.586	0.491	0.464	0.390
USNO	35 717	0.710	0.761	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.656	0.616	0.567
USNO	35 762	0.208	0.358	0.243	0.238	0.234	0.232	-	-	-	-	-	0.000
USNO	35 763	0.246	0.329	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	35 765	0.334	0.451	0.387	0.479	0.381	0.421	-	-	0.000	0.000	0.000	0.000
USNO	35 1096	0.214	0.202	0.220	0.288	0.307	0.410	0.321	0.585	0.634	0.634	0.651	0.622
USNO	35 1097	0.000	0.000	0.000	0.128	0.176	0.200	0.190	0.173	0.191	0.220	0.233	0.223
USNO	35 1125	0.899	0.850	0.859	0.836	-	-	-	-	-	-	-	-
USNO	35 1327	0.000	0.000	0.000	0.320	0.389	0.294	0.369	0.480	0.606	0.584	0.587	0.660
USNO	35 1328	0.168	0.149	0.177	0.203	0.252	0.268	0.259	0.286	0.000	0.078	0.060	0.057
USNO	35 1331	0.290	0.360	0.387	0.450	0.572	0.632	0.845	0.820	0.825	0.000	0.349	0.369
USNO	35 1438	-	-	-	0.000	0.000	0.000	0.000	0.129	0.187	0.224	0.218	0.256
USNO	35 1459	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	-	-	-
USNO	35 1462	0.653	-	-	-	-	-	-	-	-	-	-	0.000
USNO	35 1463	0.000	0.000	0.000	0.105	0.163	0.201	0.265	0.328	0.422	0.463	0.535	0.847
USNO	35 1468	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	35 1481	0.899	0.850	0.859	-	-	-	-	-	-	-	-	-
USNO	35 1543	0.725	0.790	0.793	0.639	0.871	0.839	0.678	0.470	0.415	0.545	-	-
USNO	35 1573	0.899	0.850	0.859	0.792	0.854	0.839	0.797	0.585	-	-	-	-
USNO	35 1575	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.714	0.551
USNO	35 1655	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	35 1692	0.899	0.850	0.859	0.836	0.699	0.576	0.629	0.618	0.726	0.820	0.775	0.781

Table 9A. (Cont.)

Lab.	Clock	54129	54159	54189	54219	54249	54279	54309	54339	54369	54404	54434	54464
USNO	35 1694	0.899	0.816	0.859	0.836	0.699	0.689	0.845	0.820	0.825	0.820	0.828	0.847
USNO	35 1696	0.600	0.545	0.563	0.446	0.521	0.514	0.549	0.499	0.703	0.696	0.503	0.553
USNO	35 1697	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	40 701	0.395	0.342	0.375	0.365	0.376	0.383	0.284	0.000	0.000	0.013	0.008	0.007
USNO	40 702	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	40 704	0.169	0.156	0.164	0.161	0.181	0.189	0.191	0.820	0.825	0.680	0.511	0.424
USNO	40 705	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.000	0.215	0.149	0.149
USNO	40 708	-	-	-	-	-	-	-	-	0.000	0.000	0.000	0.000
USNO	40 710	0.067	-	-	-	0.000	0.000	0.000	0.000	0.200	0.177	0.146	0.129
USNO	40 711	0.004	0.004	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
USNO	40 712	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	40 713	0.125	0.112	0.119	0.112	0.122	0.125	0.128	0.136	0.148	0.148	0.145	0.142
USNO	40 714	0.118	0.107	0.118	0.119	0.130	0.126	0.125	0.132	0.149	0.234	0.266	0.324
USNO	40 715	0.071	0.064	0.064	0.058	0.061	0.063	0.063	0.080	0.088	0.086	0.077	0.077
USNO	40 716	0.899	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	40 718	0.517	0.342	0.259	0.205	0.211	0.163	0.123	0.103	0.092	0.076	0.057	0.048
USNO	40 719	0.008	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.006
USNO	40 720	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	-	-	0.000	0.000
USNO	40 722	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001
USNO	40 723	0.763	0.850	0.859	0.836	0.871	0.839	0.845	0.820	0.825	0.820	0.828	0.847
USNO	40 724	0.312	0.255	0.260	0.251	0.274	0.307	0.401	0.583	0.825	0.820	0.828	0.847
USNO	40 725	0.344	0.329	0.318	0.314	0.453	0.459	0.469	0.611	0.514	0.414	0.328	0.255
USNO	40 726	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
USNO	40 728	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	-
USNO	40 729	-	-	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000
USNO	40 730	0.000	0.000	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001
USNO	40 731	-	0.000	0.000	0.000	0.000	0.046	0.033	0.027	0.023	0.019	0.016	0.015
VSL	35 179	0.077	0.084	0.108	0.117	0.134	0.137	0.156	0.174	0.195	0.333	0.370	0.000
VSL	35 456	0.518	0.553	0.343	0.260	0.183	0.133	0.107	0.113	0.136	0.137	0.135	0.156
VSL	35 548	0.222	0.240	0.286	0.284	0.349	0.514	0.540	0.820	0.825	0.820	0.828	0.847
VSL	35 731	0.000	0.480	0.500	0.464	0.508	0.524	0.435	0.562	0.703	0.820	0.828	0.785
ZA	36 1034	-	0.000	0.000	0.000	0.000	0.000	0.021	0.029	-	-	0.000	-
ZMDM	36 2033	0.256	0.289	0.362	0.378	0.394	0.414	0.489	0.500	0.545	0.466	0.673	0.725

Table 9B: Statistical data on the weights attributed to the clocks in 2007

Interval		Number of Clocks			Number of clocks with a given weight: Weight = 0*			Weight = 0**			Max weight			Max relative weight
		HM	5071A	Total	HM	5071A	Total	HM	5071A	Total	HM	5071A	Total	
2007	Jan.	77	207	321	6	32	43	8	6	17	7	37	46	0.899
2007	Feb.	79	213	334	7	28	41	9	1	14	8	36	46	0.850
2007	Mar.	81	212	333	9	29	43	5	5	14	8	42	52	0.859
2007	Apr.	84	218	344	12	25	45	6	5	16	9	41	52	0.836
2007	May	81	208	333	13	23	46	5	9	19	10	42	53	0.871
2007	June	85	218	348	16	26	50	6	7	18	9	47	57	0.839
2007	July	82	214	344	13	24	48	6	6	16	8	42	52	0.845
2007	Aug.	81	209	337	9	16	32	6	8	19	9	49	60	0.820
2007	Sep.	83	213	343	10	22	40	6	7	17	9	48	61	0.825
2007	Oct.	82	202	331	6	14	26	6	6	15	8	45	57	0.820
2007	Nov.	83	210	341	8	24	38	6	6	16	8	42	54	0.828
2007	Dec.	77	213	335	6	29	41	6	7	15	8	41	51	0.847

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

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

** Null weight resulting from the statistics.

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

Clocks with missing data during an 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 April 2008.

AUTHORITIES RESPONSIBLE FOR THE TIME SIGNAL EMISSIONS

Signal	Authority
BPM	Time and Frequency Division National Time Service Center, NTSC 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 Swiss Federal Office of Metrology Time and Frequency Laboratory Length, Optics and Time Section Lindenweg 50 CH-3003 Bern-Wabern Switzerland
HLA	Length and Time Metrology Center Division of Physical Metrology Korea Research Institute of Standards and Science P.O. Box 102, Yuseong Daejeon 305-340 Republic of Korea
JJY	Space-Time Standards 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
MIKES	Centre for Metrology and Accreditation Tekniikantie 1 FI-02150 Espoo Finland
MSF	National Physical Laboratory Industry and Innovation Division Hampton Road Teddington, Middlesex TW11 0LW United Kingdom
RAB-99, RBU, RJH-63, RJH-69, RJH-77, RJH-86, RJH-90,RTZ,RWM	All-Russian Scientific Research Institute for Physical Technical and Radiotechnical Measurements Institute of Metrology for Time and Space Meendeleevo, Moscow Region 141570 Russia
STFS	National Physical Laboratory Dr. K.S. Krishnan Road New Delhi - 110012, India
TDF	CFHM Chambre française de l'horlogerie et des microtechniques 22 avenue Franklin Roosevelt 75008 Paris, France and LNE Laboratoire national de métrologie et d'essais 1 rue Gaston Boissier 75724 Paris Cedex 15, 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 Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
BPM(1)	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	The DCF77 time signals are generated by PTB and are in accordance with the legal time of Germany which is UTC(PTB)+1 h or UTC(PTB)+2 h. At the beginning of each second (except in the last second of each minute) the carrier amplitude is reduced to 25% for a duration of 0.1 or 0.2 s corresponding to "binary 0" or "binary 1", respectively, referred to as second marks 0 to 59 in the following. The number of the minute, hour, day of the month, day of the week, month and year are transmitted in BCD code using second marks 20 to the 58, including overhead. Information emitted during minute n is valid for minute n+1. The information transmitted during the second marks 1 to the 14 is provided by third parties. Information on that additional service can be obtained from PTB. To achieve a more accurate time transfer and a better use of the frequency spectrum available an additional pseudo-random phase shift keying of the carrier is superimposed on 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.

(1) Information based on the Annual Report 2006, not confirmed by the Laboratory

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
HBG	Prangins Switzerland 46° 24'N 6° 15'E	75	continuous	At the beginning of each second (except the 59th second), the carrier is interrupted for a duration of 0.1 s or 0.2 s corresponding to "binary 0" or "binary 1", respectively, double pulse each minute. The number of the minute, hour, day of the month, day of the week, month and year are transmitted in BCD code from the 21st to the 58th second. The HBG time signal is generated in accordance with the legal time of Switzerland which is UTC + 1 h (Central European Time CET) or UTC + 2 h (Central European Summer Time CEST). In addition, CET and CEST are indicated by a binary 1 at the 18th or 17th second, respectively.
HLA	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 52nd second pulse. BCD time code given on 100 Hz subcarrier. DUT1: ITU-R code by double pulse.
JJY	Tamura-shi 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	Saga-shi 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(1)	Leeds United Kingdom 53 ° 48'N 1° 33'W	5 000	Continuous	Second pulse amplitude = 2.4 V (50 ohm), 5 ns rise time and 20 μs width. Initial clock synchronization: 50 ns of UTC.
LOL(1)	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.
MIKES	Espoo Finland 60° 11'N 24° 50'E	25 000	Continuous	Modulation as in DCF77, time code in UTC.

(1) Information based on the Annual Report 2006, not confirmed by the Laboratory

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
MSF	Until 2007 March 31 23 :00 UTC : Rugby United Kingdom 52° 22'N 1° 11'W From 2007 March 31 23 :00 UTC : Anthorn United Kingdom 54° 54'N 3° 16'W	60	Continuous, except for interruptions for maintenance from 10 h 0 m to 14 h 0 m on the second Thursday of December and March, and from 09 h 0 m to 13 h 0 m on the second Thursday of June 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 during second 00 of each minute. The beginning of the interruption marks the start of the second. BCD 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 Russia 55° 44'N 38° 12'E	200/3	Continuous	DXXXW type 0.1 s signals. The numbers of the minute, hour, day of the month, day of the week, month, year of the century, difference between the universal time and the local time, TJD and DUT1+dUT1 are transmitted each minute from the 1st to the 59th second. DUT1+dUT1 : by double pulse.
RJH-63	Krasnodar Russia 44° 46'N 39° 34'E	25.0 25.1 25.5 23.0 20.5	11 h 06 m to 11 h 40 m	A1N type signals are transmitted between minutes 9 and 20 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 9 and 11 ; 0.1 second pulses of 25 ms duration, 10 second pulses of 1 s duration and minute pulses of 10 s duration are transmitted between minutes 11 and 20.
RJH-69	Molodechno Belarus 54° 28'N 26° 47'E	25.0 25.1 25.5 23.0 20.5	07 h 06 m to 07 h 47 m	A1N type signals are transmitted between minutes 10 and 22 : 0.025 second pulses of 12.5 ms duration are transmitted between minutes 10 and 13; second pulses of 0.1 s duration, 10 second pulses of 1 s duration, 0.1 second pulses of 25 ms and minute pulses of 10 s duration are transmitted between minutes 13 and 22.

Station	Location Latitude Longitude	Frequency (KHz)	Schedule (UTC)	Form of the signal
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 1st to the 59th second. DUT1+dUT1: by double pulse.
RWM (2)	Moscow Russia 55° 44'N 38° 12'E	4 996 9 996 14 996	The station operates simultaneously on the three frequencies.	A1X type second pulses of 0.1 s duration are transmitted between minutes 10 and 20, 40 and 50. The pulses at the beginning of the minute are prolonged to 0.5 s. A1N type 0.1 s second pulses of 0.02 s duration are transmitted between minutes 20 and 30. The pulses at the beginning of the second are prolonged to 40 ms and of the minute to 0.5 ms. DUT1+dUT1: by double pulse.

(2) 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 21st and 24th 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 31st and 34th second, so that dUT1 = $-q \times 0.02$ s.

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
STFS(1)	Sikandrabad India 28° 28'N 77° 13'E	2 599 675	continuous	Pulse width modulated binary coded 5 kHz pulses carrying information on Indian Standard Time – IST (UTC+ 5 h 30 m), Time of Day and current position coordinates of the satellite. Pulse repetition rate is 100 pps. The above format is frequency modulated on the carrier.
TDF	Allouis France 47° 10'N 2° 12'E	162	continuous, except every Tuesday from 1 h to 5 h	Phase modulation of the carrier by +1 and -1 rd in 0.1 s every second except the 59th second of each minute. This modulation is doubled to indicate binary 1. The numbers of the minute, hour, day of the month, day of the week, month and year are transmitted each minute from the 21st to the 58th second, in accordance with the French legal time scale. In addition, a binary 1 at the 17th second indicates that the local time is 2 hours ahead of UTC (summer time); a binary 1 at the 18th second indicates that the local time is 1 hour ahead of UTC (winter time); a binary 1 at the 14th second indicates that the current day is a public holiday (Christmas, 14 July, etc...); a binary 1 at the 13th second indicates that the current day is a day before a public holiday.
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.

(1) Information based on the Annual Report 2006, not confirmed by the Laboratory

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
MIKES	0.01
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 April 2008.

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	Length, Time and Optical Standards Section National Measurement Institute PO Box 264 Lindfield NSW 2070 - Australia
BelGIM	Belarusian State Institute of Metrology National Standard for Time, Frequency and Time-scale of the Republic of Belarus Minsk, Minsk Region – 220053 Belarus
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
EIM	Hellenic Institute of Metrology Electrical Measurements Department Block 45, Industrial Area of Thessaloniki PO 57022, Sindos Thessaloniki, Greece
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
INPL	National Physical Laboratory Danciger A bldg Givat - Ram, The Hebrew university 91904 Jerusalem, Israel
INRIM	Istituto Nazionale di Ricerca Metrologica Strada delle Cacce, 91 I – 10135 Torino, Italy
KRISS	Length and Time Metrology Group Division of Physical 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	Federal Office of Metrology Length, Optics 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	Space-Time Standards 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
NIMB	Time and Frequency Laboratory National Institute of Metrology Sos. Vitan - Barzesti, 11 042122 Bucharest Romania
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
NMIJ	Time and Frequency Division National Metrology Institute of Japan(NMIJ), AIST Umezono 1-1-1, Tsukuba, Ibaraki 305-8563, Japan
NMISA	Time and Frequency Laboratory National Metrology Institute of South Africa Private Bag X34 Lynnwood Ridge 0040 - South Africa

NMLS	Time and Frequency Laboratory National Metrology Laboratory SIRIM Berhad, Lot PT 4803, Bandar Baru Salak Tinggi, 43900 Sepang - Malaysia
NPL	National Physical Laboratory Industry and Innovation Division 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 20921-400 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 Technical Research Institute of Sweden 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 Photonics and Electronics Czech Academy of Sciences Chaberská 57 182 51 Praha 8 Czech Republic
UME	Ulusal Metroloji Enstitüsü TUBITAK Gebze Yerleskesi, National Metrology Institute Gebze Kocaeli, Turkey
USNO	U.S. Naval Observatory 3450 Massachusetts Ave., N.W. Washington, D.C. 20392-5420 USA
VNIIFTRI	All-Russian Scientific Research Institute for Physical Technical and Radiotechnical Measurements Institute of Metrology for Time and Space Mendeleevo, Moscow Region 141570 Russia
VSL	NMi Van Swinden Laboratorium Postbus 654 2600 AR Delft Netherlands

TIME DISSEMINATION SERVICES

AOS	AOS Computer Time Service: vega.cbk.poznan.pl (150.254.183.15) Synchronization: NTP V3 primary (Caesium clock), PC Pentium, RedHat Linux Service Area: Poland/Europe Access Policy: open access Contact: Jerzy Nawrocki (nawrocki@cbk.poznan.pl) Robert Diak (kondor@cbk.poznan.pl) Full list of time dissemination services is available on: http://www.eecis.udel.edu/~mills/ntp/clock1.htm
AUS	Network Time Service Computers connected to the Internet can be synchronized to UTC(AUS) using the NTP protocol. The NTP servers are referenced to UTC(AUS) either directly or via a GPS common view link. Please see www.measurement.gov.au/time for information on access or contact time@measurement.gov.au Dial-up Computer Time Service Computers can also obtain time via a modem connection to our dialup timeserver. For further information, please see our web pages as above.
BelGIM(1)	Internet Time Service: BelGIM operates one time server Stratum 1 using the "Network Time Protocol" (NTP). The server host name is: http://www.belgim.by (Stratum 1)
BEV	3 NTP servers are available; addresses: bevtime1.metrologie.at bevtime2.metrologie.at time.metrologie.at more information on http://www.metrologie.at Provides a time dissemination service via phone and modem to synchronize PC clocks. Uses the Time Distribution System from TUG. It has a baud rate of 1200 and everyone can use it with no cost. Access phone number is +43 (0) 1 211106381 The system will be updated periodically (DUT1, Leap Second…).
CENAM	CENAM operates a voice automatic system that provides the local time for three different time zones for México; Central Time, Pacific Time and Northwest Time as well the UTC(CNM). The access numbers are: +52 442 211 0506: Central Time +52 442 211 0507: Pacific Time +52 442 211 0508: Northwest Time +52 442 215 3902: UTC(CNM) Telephone Code CENAM provides a telephone code for setting time in computers. More information about this service please contact J. Mauricio López at jlopez@cenam.mx

(1) Information based on the Annual Report 2006, not confirmed by the Laboratory

	Network Time Protocol Operates one time server using the "Network Time Protocol", it is located at the Centro Nacional de Metrología, Querétaro, México. Further information at http://www.cenam.mx/hora_oficial/ Web-based time-of-day clock that displays local time for México time zones. Referenced to CENAM Internet Time Service. Available at http://www.cenam.mx/hora_oficial/ Transmission of voice by radio in Mexico City to more than 20 million inhabitants. The voice messages are transmitted every minute, 24 hours a day, every day of the year, by the radio station XEQK, whose signal is at 1350 kHz amplitude modulated (AM).
EIM	Internet Time Service EIM operates a stratum-1 time server using the "Network Time Protocol" (NTP). The DNS electronic address is ntp.eim.gr (IP 194.30.249.20). A second NTP server with electronic address time.eim.gr will be operating soon.
GUM	Telephone Time Service providing the European time code by telephone modem for setting time in computers. Includes provision for compensation of propagation time delay. Access phone number : +48 22 654 88 72 Network Time Service Two NTP servers are available: tempus1.gum.gov.pl tempus2.gum.gov.pl with an open access policy. It provides synchronization to UTC(PL). Contact: timegum@gum.gov.pl
HKO	Speaking Clock Service HKO operates an automatic "Dial-a-weather System" that provides voice announcement of the Hong Kong Standard Time. (=UTC(HKO) + 8 h). Access phone number: + 852 1878200 Network Time Service HKO operates two Internet time servers using Network Time Protocol. Host name of the server: stdtime.gov.hk Further information at http://www.hko.gov.hk/nts/ntime.htm
INPL	INPL is providing two electronic time dissemination services: 1. via telephone. The user must download a program from INPL ftp site (vms.huji.ac.il) 2. NTS via optic fiber to the Hebrew University which provides time on the internet. For details email clock@vms.huji.ac.il
INRIM	CTD Telephone Time Code 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(IT) for computer clocks without compensation for the propagation time. Software for the synchronization of computer clocks is available on INRIM home page (www.inrim.it). Internet Time Service INRIM operates two time servers using the "Network Time Protocol" (NTP); host names of the servers are ntp1.inrim.it and ntp2.inrim.it. More information on this service can be found on the web pages: www.inrim.it/ntp/index_i.shtml.

KRISS	Telephone Time Service Provides digital time code to synchronize computer clocks to Korea Standard Time (=UTC(KRIS) + 9 h) via modem. Access phone numbers: + 82 42 863 7117, + 82 42 868 5116 Network Time Service KRISS operates three time servers using the NTP to synchronize computer clocks to Korea Standard Time via the Internet. Host name of the server : time.kriss.re.kr (210.98.16.100) Software for the synchronization of computer clocks is available at http://www.kriss.re.kr
LNE-SYRTE	LNE-SYRTE operates one primary time server using the "Network Time Protocol" (NTP) : Hostname: ntp-p1.obspm.fr Futher information at: http://lne-syrte.obspm.fr/gen/ntp_infos.html
LT	Network Time Service via NTP protocol NTP 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 http://www.pfi.lt/metrology/
METAS	Telephone Time Service The coded time information is referenced to UTC(CH) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". Access phone numbers: +41 31 323 32 25, +41 31 323 47 00. Network Time Protocol METAS operates public NTP servers in free access. Host names: ntp.metas.ch ntp11.metas.ch ntp12.metas.ch More information at http://www.metas.ch and http://www.ntp.org
MSL	Network Time Service Computers connected to the Internet can be synchonized to UTC(MSL) using the NTP protocol. Access is available for users within New Zealand. Two servers are available at msltime1.irl.cri.nz and msltime2.irl.cri.nz Telephone Time Service A dial up computer time setting service for linking computers to UTC(MSL). The service uses a time code specific to New Zealand. Because it is a pay service, access is restricted to callers within New Zealand. Speaking Clock A speaking clock gives New Zealand time. Because it is a pay service, access is restricted to callers within New Zealand. Further information about these services can be found at http://www.irl.cri.nz/msl/services/time/index.html

NICT	Telephone Time Service (TTS) Provides digital time code accessible by computer at 300/1200/2400 bps, 8 bits, no parity. Access phone numbers: + 81 42 327 7592. Network Time Service (NTS) NICT operates a Stratum 1 time server linked to UTC(NICT) using the "Network Time Protocol" (NTP). Internet Time Service (ITS) NICT operates four time servers by using NTP. Host name of these servers: ntp.nict.jp (Round robin). GPS common view data NICT provides the GPS common view data based on UTC(NICT) to the time business service in Japan.
NIM	Television Time Service The coded time information generated by one time code generator is inserted into the TV signal. It can be obtained by using a decode TV receiver. The time reference is UTC(NIM). Access TV channels of CCTV. Telephone Time Service The coded time information generated by NIM time code generator, referenced to UTC(NIM). Telephone Code provides digital time code at 1200 to 9600 bauds, 8 bits, no parity, 1 stop bit. Access phone number: 8610 6422 9086. Network Time Service Provides digital time code across the Internet using NTP.
NIMB	2 NTP servers are available: Addresses: ntp.oraoficiala.ro (STRATUM 2) with an open access policy ntp.inm.ro (STRATUM 1) with restricted access policy. Both NTP servers are referenced to UTC (NIMB)
NIMT	3 NTP servers are available: Addresses: time1.nimt.or.th time2.nimt.or.th time3.nimt.or.th The NTP servers are referenced to UTC(NIMT)
NIST	Automated Computer Time Service (ACTS) Provides digital time code by telephone modem for setting time in computers. Free software and source code available for download from NIST. Includes provision for calibration of telephone time delay. Access phone numbers : +1 303 494 4774 (24 phone lines) and +1 808 335 4721 (4 phone lines). Further information at http://tf.nist.gov/service/acts.htm Internet Time Service (ITS) Provides digital time code across the Internet using three different protocols: Network Time Protocol, Daytime Protocol, and Time Protocol. Geographically distributed set of 17 time servers at 14 locations within the United States of America. Free software and source code available for download from NIST. Further information at http://tf.nist.gov/service/its.htm

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 http://www.time.gov (in cooperation with the United States Naval Observatory), and at http://nist.time.gov

Telephone voice announcement: Audio portions of radio broadcasts from time and frequency stations WWV and WWVH can be heard by telephone:
+1 303 499 7111 for WWV
+1 808 335 4363 for WWVH

NMIJ

GPS common-view data
GPS common-view data using CGGTTS format referred to UTC(NMIJ) are available through the NMIJ's web site for the remote frequency calibration service.

NMISA

Telephone Time Service (TTS)
Provides digital time code accessible by computer for setting time in computers. Measurement of telephone transmission delay is included. Access phone numbers: + 27 12 349 1576, + 27 12 349 1577.

Network Time Service
One open access NTP server is available at address time.nmisa.org.

More information is available at http://www.nmisa.org/time.html

NMLS

Telephone Time Service
The coded time information is referenced to UTC(NMLS) and generated by a TUG type telephone time code generator using an ASCII-character code. The time protocols are sent in the "European Telephone Time Code" format. The service phone number is +60 3 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.

Network Time Protocol (NTP) Service
The NTP time information is referenced to UTC(NMLS) and is currently generated by two Stratum-1 NTP servers, made available for public freely. The NTP server host names are ntp1.sirim.my and ntp2.sirim.my.

NPL

Telephone Time Service
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 www.npl.co.uk/time.
The service telephone number is 0906 851 6333.
Note: this is a premium rate number and can only be accessed from within the UK.

Internet Time Service
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 www.npl.co.uk/time.
The server host names are:
ntp1.npl.co.uk
ntp2.npl.co.uk

NPLI

Telephone Time Service
The coded time information generated by time code generator of NPLI, referenced to UTC(NPLI). Telephone Code provides digital time code (for the current time of Indian standard Time) at 1200 bauds, 8 bits, no parity, 1 stop bit. This service is known as TELECLOCK Service.
Accessible by :

a. an NPLI-developed Teleclock Receiver already available in the market.
b. a Computer through Telephone Modem and NPLI-developed software.

One-way Geostationary Satellite Time Service.

NRC

Telephone Code
Provides digital time code by telephone modem for setting time in computers. Access phone number : +1 613 745 3900.
http://inms-ienm.nrc-cnrc.gc.ca/time_services/computer_timedate_e.html

Talking Clock Service
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: http://inms-ienm.nrc-cnrc.gc.ca/time_services/cbc_broadcasts_e.html

Web Clock Service
The Web Clock shows dynamic clocks in each Canadian Time zone, for both Standard time and daylight saving time. The web page is at: http://time5.nrc.ca/webclock_e.shtml.

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

Further information at http://inms-ienm.nrc-cnrc.gc.ca/time_services/network_time_protocol_e.html

NTSC(1)

Network Time Service (NTS)
Provides a synchronization to UTC(NTSC) computer clocks within China.
Software for the synchronization of computer clocks is available on the NTSC Time and Frequency home page : http://time.ntsc.ac.cn
Access Policy: free
Contact: Shaowu DONG (dongsw@ntsc.ac.cn).

ONBA

Speaking clock access phone number 113 (only accessible in Argentina).
Hourly and half hourly radio-broadcast time signal.
Internet time service at web site www.hidro.gov.ar/hora/hora.asp

ONRJ

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)

Internet Time Service at the address : 200.20.186.75 and 200.20.186.94
SNTP at port 123
Time/UDP at port 37
Time/TCP at port 37
Daytime/TCP at port 13

(1) Information based on the Annual Report 2006, not confirmed by the Laboratory

WEB-based Time Services:
1) A real-time clock aligned to UTC(ONRJ) and corrected for internet transmission delay.
Further information at: http://200.20.186.71/asp/relogio/horainicial.asp
2) Voice Announcer, in Portuguese, each ten seconds, after download of the Web page at: http://200.20.186.71.

ORB

Network Time Service via NTP protocol
Hostname : ntp1.oma.be and ntp2.oma.be
Access policy : free
Synchronization to UTC(ORB)
Contact : f.roosbeek@oma.be
Information on the web pages
http://www.observatoire.be/D1/TIME/ntp_en.htm

ORB provides a time dissemination via phone and modem to synchronize PC clocks on UTC(ORB). The system used is the Time Distribution System from TUG, which produces the telephone time code mostly used in Europe.
The baud rate used is 1200. The access phone number is 32 (0) 2 373 03 20. The system is updated periodically with DUT1 and leap seconds

PTB

Telephone Time Service
The coded time information is referenced to UTC(PTB) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the " European Telephone Time Code ". Access phone number : +49 531 51 20 38 .

Internet Time Service
The PTB operates two time servers using the " Network Time Protocol " (NTP). Software for the synchronization of computer clocks is available on the web pages of the PTB
http://www.ptb.de/en/org/q/q4/q42/_index.htm).
Host names of the servers: ptbtime1.ptb.de
ptbtime2.ptb.de

ROA

Telephone Code
The coded time information is referenced to UTC(ROA) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". Access phone number : +34 956 599 429

Network Time Protocol
Server : hora.roa.es
Synchronized to UTC(ROA) better than 10 microseconds
Service policy : free

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.

SG

Website: http://www.SingaporeStandardTime.org.sg.

Automated Computer Time Service (ACTS)
Transmits digital time code (NIST format) via telephone modem for setting time in computers. The coded time information is referenced to UTC(SG). Includes provision for correcting telephone time delay. Free software available for downloading from the website.
Access phone number : +65 67799978.

Network Time Service (NeTS)
Transmits digital time code via the Internet using three protocols – Time Protocol, Daytime Protocol and Network Time Protocol.
Free software available for downloading from the website. Operates two time servers at addresses nets.org.sg and 203.117.180.35.

Web-based time service:
Displays a real time clock referenced to NeTS. User-selectable display of local time (adjusted for daylight saving) of any major city worldwide and time difference information between any two cities.

Further information is available at the website.

SP

Telephone Time Service
The coded time information is referenced to UTC(SP) and generated by two TUG type time code generators using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code".
Access phone number: +46 33 41 57 83

Internet Time Service
The coded time information is referenced to UTC(SP) and generated by two NTP servers using the Network Time Protocol (NTP).
Access host names : ntp1.sp.se and ntp2.sp.se

Speaking Clock
The speaking clock service is operated by Telia AB in Sweden. The time announcement is referenced to UTC(SP) and disseminated from a computer based system operated and maintained at SP.
Access phone number : 90510 (only accessible in Sweden).
Access phone number : +4633 90510 (from outside Sweden).

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

TL

Speaking Clock Service
Traceable to UTC(TL). Broadcast through PSTN (Public Switching Telephone Network) automatically and provides accurate voice time signal to public users.

The Computer Time Service
Provides digital time code by telephone modem for setting time in computers.
Access phone number : +886 3 4245117.

IRIG-B time code service
Provides IRIG-B Modulated time code via a dial-up phone connection. No need of any kind of modem.
Access phone number: +886 3 4203090

NTP Service
TL operates a time server using the "Network Time Protocol" (NTP).
Host name of the server : time.stdtime.gov.tw
Further information at http://www.stdtime.gov.tw/english/e-home.htm

TP

Internet Time Service
IPE operates a time server directly referenced to UTC(TP).
Time information is accessible through Network Time Protocol (NTP).

Server host name: time.ufe.cz
More information at http://www.ufe.cz/time

UME	Telephone Time Service Providing the European time code that is referenced to UTC(UME) by telephone modem for setting computer time. Includes compensation of propagation time delay. More information for this service please contact to eml@ume.tubitak.gov.tr. Access phone number : +90 262 679 50 24 Network Time Service UME operates an NTP server referenced to UTC(UME). Host server name : time.ume.tubitak.gov.tr
USNO	Telephone Voice Announcer +1 202 762-1401 Backup voice announcer: +1 719 567-6742 Telephone Code +1 202 762-1594 provides digital time code at 1200 baud, 8 bits, no parity Automated data service for downloading files +1 202 762-1503 Web site for time and for data files: http://tycho.usno.navy.mil Network Time Protocol (NTP) see http://tycho.usno.navy.mil/ntp.html for software and site closest to you.
VNIIFTRI	Internet Time Service VNIIFTRI operates three time servers Stratum 1and one time server Stratum 2 using the "Network Time Protocol" (NTP). The server host names are: ntp1.imvp.ru (Stratum 1) ntp2.imvp.ru (Stratum 1) ntp3.imvp.ru (Stratum 1) ntp21.imvp.ru (Stratum 2).
VSL	Telephone Time Service The coded time information is referenced to UTC(VSL) and generated by a TUG type time code generator using an ASCII-character code. The time protocols are sent in a common format, the "European Telephone Time Code". The access phone number is 0900 6171819. This is a toll number and therefore can only be accessed in the Netherlands. VSL operates a time server directly referenced to UTC(VSL). Time information is accessible through Network Time Protocol (NTP). Server host name: ntp.nmi.nl (Stratum 1)

Director's Report on the Activity and Management of the BIPM, 2007, T. 8

(July 2006 – June 2007)

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*. Consequently, with the new structure of the section, the traditional *Annual Report of the BIPM Time Section* has changed its name to *BIPM Annual Report on Time Activities*, but the contents remain the same. The *BIPM Annual Report on Time Activities for 2006*, volume **1**, complemented by computer-readable files on the BIPM website (http://www.bipm.org), provides the definitive results for 2006.

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* or EAL) from which TAI and UTC are 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 86 % of the clocks used in the calculation of time scales are either commercial cæsium clocks of the HP/Agilent 5071A type or active, auto-tuned hydrogen masers. To improve the stability of EAL, a weighting procedure is applied to clocks where the maximum relative weight each month depends on the number of participating clocks. About 14 % of the participating clocks have, on average, been at the maximum weight, during 2006. This procedure generates a time scale which relies upon the best clocks.

Since 2003, it is estimated that the stability of EAL, expressed in terms of an Allan deviation, has been at or below 0.4×10^{-15} for averaging times of one month. Slowly varying long-term drifts limit the stability to around 2×10^{-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 2006, individual measurements of the TAI frequency have been provided by eleven primary frequency standards, including seven cæsium fountains (IT CSF1, LNE-SYRTE FO1, LNE-SYRTE FO2, LNE-SYRTE FOM, NIST F1, NMIJ F1 and PTB CSF1). Reports on the operation of the primary frequency standards are regularly published in the *BIPM Annual Report on Time Activities* and on the BIPM website.

Starting in July 2004, a monthly steering correction of, a maximum, 0.7×10^{-15} is applied as deemed necessary. Since July 2006, the global treatment of individual measurements has led to a relative departure of the duration of the TAI scale unit from the SI second on the geoid ranging from $+0.7 \times 10^{-15}$ to $+3.7 \times 10^{-15}$, with a standard uncertainty of about 1×10^{-15}. Since September 2006, we have used for this treatment the standard uncertainties of $[UTC - UTC(k)]$ to estimate the uncertainty in linking the primary standards to TAI. Over the year, six steering corrections have been applied for a total correction of $[f(EAL) - f(TAI)]$ of -2.4×10^{-15}.

2.3 Independent atomic time scales

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 the TAI frequency by the primary frequency standards. We have provided an updated computation of TT(BIPM), named TT(BIPM06), valid until December 2006. Here, we have used all recently available data from the new cæsium fountains and a revised estimation of the stability of the free atomic time scale EAL on which TAI is based.

3 Primary frequency standards and secondary representations of the second

Members of the BIPM Time, Frequency and Gravimetry section are actively participating in the work of the CCTF Working Group on Primary Frequency Standards (PFS), seeking to encourage the creation of better documentation, comparisons, and the use of high accuracy PFS (Cs fountains) for TAI.

Other microwave and optical atomic transitions are being proposed as secondary representations of the second by the CCL/CCTF Joint Working Group on Standard Frequencies (until October 2006, CCL/CCTF Joint Working Group on Secondary Representations of the Second). A list containing frequency values and uncertainties for Rb, Hg^+, Yb^+, Sr^+ and Sr has been proposed by the Joint Working Group and recommended by the Consultative Committee for Time and Frequency (CCTF): Recommendation CCTF 2 (2006) and by the CIPM: Recommendation 1 (CI-2006). An extensive comparison of measurements from all Cs PFS, including eight fountains, spanning seven years has been carried out. BIPM staff continues to participate in the rapidly evolving field of optical frequency standards, addressing, for example, the issue of their comparison at the 10^{-17} uncertainty level or below.

4 Time links

Clock comparisons can presently be made by three independent techniques: satellite common-view based on C/A code measurements from GPS single frequency receivers; satellite common-view obtained with dual-frequency, multi-channel GPS geodetic type receivers (P3); and two-way satellite time and frequency transfer through geostationary telecommunications satellites (TWSTFT). Significant improvement is being made with the growing number of time links with P3 receivers (twelve official links in June 2006, and several more computed as additional links), and with the increasing number of TWSTFT observations (up to twelve per day for links in Europe and with North America). The classical GPS single-channel single-frequency receivers that today represent only 25 % of the time transfer equipment are being replaced to allow multi-channel, single or dual frequency observations. As a result, there has been an improvement in the accuracy for time transfer, and the whole system of time links has become more reliable.

Testing continues on other time and frequency comparison methods and techniques. Exhaustive analysis has proved that further improvement should be possible, in particular, for clock comparison over long distances by calculating GPS all-in-view solutions instead of the current GPS common-views. The CCTF Working Group on TAI has established two study groups to analyze the benefits of this change, and which reported to the CCTF at their meeting in September 2006. The new method has been implemented in TAI computation in October 2006, and a complete description has been published.

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

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.

4.2 Phase and code measurements from geodetic-type receivers

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 Section is a member.

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. Since 2006, calibration results have also been issued for the new type of receiver Septentrio PolaRx2, and other types of receivers are being investigated in collaboration with laboratories equipped with such receivers. From July 2006 to June 2007, 12 such calibrations have taken place concerning receivers in six laboratories. The travelling Z12-T had to be repaired at the end of 2006 and a Septentrio receiver has been used as a travelling receiver since that time. At least two receivers remain at the BIPM to serve as a local reference with which the travelling receiver is compared between calibration trips.

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 2007, 23 laboratories regularly provide such P3 data. Time links computed using these data are systematically compared to those generated by other available techniques, notably for two-way time transfer. Geodetic-type receivers also provide raw phase measurements which may be used, along with the code measurements, to compute time links. This is routinely done by the IGS for some time laboratories which are also part of the IGS network. In addition, new Precise Point Positioning (PPP) software, obtained in collaboration with geodetic institutes, allows the BIPM to compute its own solutions for such time links. Comparisons between PPP, IGS, P3 and two-way links have led to insightful results on the stability of each technique. A procedure to regularly compute PPP time links for TAI computation is being installed.

4.3 Two-way time transfer

Three meetings related to TWSTFT activities have been held since July 2006. The BIPM collects two-way data from 16 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 the computation of TAI. The BIPM is also involved in the calibration of two-way time-transfer links by comparison with GPS.

4.4 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.

4.5 Calibration of TAI time links

The BIPM is conducting a series of calibrations of GPS time equipment in time laboratories which contribute to TAI. From July 2006 to June 2007, GPS/GLONASS time equipment in three laboratories and GPS P3 equipment in seven laboratories have been calibrated. The BIPM is also taking part in the organization of TWSTFT calibration trips.

5 Key comparisons

Monthly updates of key comparison in time CCTF-K001.UTC are published 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 this key comparison.

6 Pulsars

Collaboration continues with the Observatoire Midi-Pyrénées (OMP), Toulouse, and other radio-astronomy groups observing pulsars and analyzing pulsar data to study the potential capability of millisecond pulsars as a means of sensing the very long-term stability of atomic time. The Time, Frequency and Gravimetry section provides these groups with its post-processed realization of Terrestrial Time.

7 Space-time references

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 created (http://tai.bipm.org/iers/forum/) for users to offer comments related to the future updates of the *IERS Conventions*. Updates to the *Conventions* (2003) have been posted on the website (http://tai.bipm.org/iers/convupdt). These updates consider several new models for effects that affect the positions of Earth's points at the mm level, which is now significant. These modifications are studied with the help of the Advisory Board for the *IERS Conventions* updates, including representatives of all groups involved in the IERS.

Activities related to the realization of reference frames for astronomy and geodesy are developed in cooperation with the IERS. In these domains, improvements in accuracy will enhance the need for a full relativistic treatment and it is essential to continue participating in international working groups on these matters; e.g. through the new IAU Commission "Relativity in Fundamental Astronomy". Cooperation continued for the maintenance of the international celestial reference system and work started in the framework of the IAU, IVS and IERS for the construction of a new conventional reference frame.

8 Publications, lecture, travel: Time, Frequency and Gravimetry section

8.1 External publications

1. Arias E.F, Time scales and relativity, Proc. International School of Physics "Enrico Fermi", Course CLXVI, Metrology and Fundamental Constants, Societa Italiana di Fisica, 2007, 367-392
2. Jiang Z., Dach R., Petit G., Schildknecht T., Hugentobler U., Comparison and combination of TAI time links with continuous GPS carrier phase results, *Proc. EFTF-IFCS 2006*, 2007, 440-447.
3. Jiang Z., Petit G., Redundancy in the TAI TWSTFT time transfer network, *Proc. EFTF-IFCS 2006*, 2007, 468-475.

4. Matsakis D., Lee M., Dach R., Hugentobler U., Jiang Z., GPS Carrier Phase Analysis Noise on the USNO-PTB Baselines, *Proc. FCS 2006*, 631-636.
5. Matsakis D., Arias E.F., Bauch A., Davis J., Gotoh T., Hosokawa M., Piester D., On optimizing the configuration of time-transfer links used to generate TAI, *Proc. 20th EFTF*, 2006, 448-454.
6. Nawrocki J., Rau Z., Lewandowski W., Małkowski M., Marszalec M., Nerkowski D., Steering UTC(AOS) and UTC(PL) by TA(PL), *Proc. 38th PTTI - Applications and Planning Meeting,* 2006, Reston, VA, 2007, 379-388.
7. Petit G., Defraigne P., Warrington B., Uhrich P., Calibration of dual frequency GPS receivers for TAI, *Proc. 20th EFTF*, 2006, 455-459.
8. Petit G., Jiang Z., Using a redundant time link system in TAI computation, *Proc. 20th EFTF*, 2006, 436-439.

8.2 BIPM publications

9. BIPM Annual Report on Time Activities for 2006, 2007, **1,** 100 pp.
10. *Circular T* (monthly), 7 pp.

OFF'7 Diffusion
23, rue des Alouettes
95600 EAUBONNE
Tél. : 01 39 59 16 16
Dépôt légal : juin 2008