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A Bernard Guinot

Since the 1st of January 1988, the establishment of International Atomic Time, TAI, and of Coordinated Universal Time, UTC (with the exception of the determination and the announcement of leap seconds of UTC) has been the responsibility of the Bureau International des Poids et Mesures (BIPM) under the authority of the Comité International des Poids et Mesures (CIPM).

The determination and announcement of the dates of leap seconds of UTC are among the tasks of the International Earth Rotation Service (IERS), which is responsible for Earth rotation determination and maintainance of the related celestial and terrestrial reference systems.

Information on IERS can be obtained from

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The periodic publications on Time of the BIPM are the monthly Circulars T and the Annual Report of the BIPM Time Section. Some information on Time is also available by telephone line, either through the General Electric Mark 3 system or through the BIPM data service.

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Mrs Patrizia Tavella (April and November 1990), from the Instituto Elettrotecnico Nazionale Galileo Ferraris, Torino, Italy.

Dr Marc A. Weiss (March, April, May 1990), from the National Institute of Standards and Technology, Boulder, Colorado (U.S.A.).

Note : Prof. Bernard Guinot was Head of the Time Section until his retirement on 1990 October 1st.

From left to right:

W. Lewandowski, M. Thomas, H. Konaté, M.A. Weiss, G. Petit, C. Thomas, B. Guinot, T.J. Quinn, J. Azoubib, P. Tavella.

(April 1990)

Depuis le 1er janvier 1988, l'établissement du Temps atomique international, TAI, et du Temps universel coordonné, UTC, (à l'exception de l'annonce des secondes intercalaires de l'UTC) est placé sous la responsabilité du Bureau international des poids et mesures (BIPM) et du Comité international des poids et mesures (CIPM).

Le choix des dates et l'annonce des secondes intercalaires de l'UTC constituent quelques-unes des missions du Service international de la rotation terrestre (IERS), qui est responsable de la détermination de la rotation terrestre et de la conservation des systèmes de référence terrestre et céleste associés.

Les renseignements sur l'IERS et ses publications peuvent être obtenus à l'adresse suivante :

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Renseignements pratiques sur la Section du temps du BIPM

Les publications périodiques du BIPM concernant le temps sont la Circulaire T, mensuelle, et le Rapport annuel de la Section du temps du BIPM. Certaines autres informations sur le temps sont aussi disponibles par ligne téléphonique, soit par le système informatique General Electric Mark 3, soit par le service de données propre à la Section du temps du BIPM.

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* Mr PETIT a été engagé au BIPM le 1er mars 1990.

<u>Stagiaires en 1990</u> :

Mme Patrizia Tavella (avril et novembre 1990) de l'Instituto Elettrotecnico Nazionale Galileo Ferraris, Turin, Italie.

M. Marc Weiss (mars, avril, mai 1990), du National Institute of Standards and Technology, Boulder, Colorado, Etats-Unis d'Amérique.

<u>Note</u> : M. Bernard Guinot a été responsable de la Section du temps du BIPM jusqu'au moment de sa retraite le 1er octobre 1990.

CONTENTS

TABLE DES MATIERES

Part C - Time signals
Signaux horaires

PART A

ATOMIC TIME SCALES ESTABLISHED

BY THE BIPM

PARTIE A

ECHELLES DE TEMPS ATOMIQUE ETABLIES

PAR LE BIPM

1 - ESTABLISHMENT OF INTERNATIONAL ATOMIC TIME AND COORDINATED UNIVERSAL TIME IN 1990

International Atomic Time (TAI) and Coordinated Universal Time (UTC) are obtained from a combination of the readings of atomic clocks and frequency standards spread worldwide.

An iterative algorithm produces a free atomic time scale, EAL (Echelle atomique libre) defined as a weighted average of clock readings. The processing is done in deferred-time and treats two-month blocks of data [1] [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 unitary scale interval with the second of the International System of Units: this interval may diverge progressively from the second.

The duration of the unitary scale interval of EAL is evaluated by comparison with the data of primary cesium standards. TAI is then derived from EAL by adding a linear function of time with a convenient slope to ensure the accuracy of the TAI unitary 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 "steering" of TAI.

TAI and UTC are made available in the form of time differences with respect to time scales kept by national laboratories "k": UTC(k), approximation to UTC, and TA(k), independent local atomic time.

These differences UTC - UTC(k), TAI - TA(k), are computed at 10-day intervals for Modified Julian Dates (MJD) ending in 9, at 0h UTC, and designated here as "standard dates".

The computation of TAI has a basic periodicity of two months. However a provisional computation is made every other month (January, March, etc.) with the data which is available. The following month, TAI is recomputed for the whole span of two months. The deviations between the provisional one-month and complete two-month solutions are usually smaller than 10 ns. This organization allows the monthly publication of results in the BIPM Circular T.

When preparing the Annual Report, the results of Circular T are revised taking into account some improvement in the data made known after the publication of Circular T. The computation is then strictly made for the six two-month intervals of the year.

[illegible] the following, and everywhere in this Report, the laboratories are [illegible]ted by the acronyms explained in Table 1 of Part B.

2 - Time links used by the BIPM in 1990

The network of time links used by the BIPM in 1990 is non-redundant.

2.1 LORAN-C links

The laboratories where only LORAN-C is received are preferably linked to laboratories where both LORAN-C and GPS are received. Simultaneous receptions of the LORAN-C signals have been organized.

The time differences of the UTC(k)'s of the laboratories are computed daily, then the values at the standard dates are evaluated by linear fit over 10 days (5 before and 5 after the standard date), except when time or frequency steps of the UTC(k)'s are reported or found.

The following LORAN-C time comparisons are evaluated by the BIPM and used in TAI computation (end 1990):

FTZ - PTB
TP - PTB
BEV - OP
PKNM - OP
CAO - IEN
YUZM - IEN
CSAO - TAO
JATC - TAO
NIM - TAO
SO - TAO
RC - USNO

2.2 GPS links

Time comparisons can be made by simultaneous tracking of satellites ("common-view method") according to a schedule established and proposed to contributing laboratories by the BIPM.

However, in the BIPM evaluation of time comparisons, a "clock transportation mode" is generally applied. In this mode UTC(j) - GPS time and UTC(k) - GPS time are evaluated separately from the data of satellites which can be observed from these sites at their maximum of elevation, without requiring the simultaneity of the observations. By filtering and interpolating, daily values of these quantities are obtained at 0h UTC. Then UTC(j) - UTC(k) is obtained by differences at the standard dates. The reasons for using this method are that it may give better results than the common-view approach over very long distances, and that it allows a local treatment inside the participating laboratories and thus reduces the amount of data to be transmitted (cases of DPT and ONRJ).

In TAI computation, the following GPS links are used (end 1990):

Link	Computed by
IEN - OP	computed by BIPM
IFAG - OP	
INPL - OP	
LDS - OP	
NPL - OP	
NPLI - OP	
ORB - OP	
PTB - OP	
ROA - OP	
STA - OP	
TAO - OP	
TUG - OP	
USNO - OP	
VSL - OP	
CRL - TAO	
KSRI - TAO	
NAOM - TAO	
NRLM - TAO	
PEL - TAO	
TL - TAO	
NRC - NIST	computed by NIST
USNO - NIST	
APL - USNO	computed by APL
AUS - USNO	computed by ORR
CH - PTB	computed by CH
DPT - OP	computed by DPT and BIPM
IGMA - USNO	computed by IGMA
ONRJ - USNO	computed by ONRJ and BIPM

Measurements of ionospheric delays obtained from dual-frequency GPS receivers are now available. Current measurements performed at the CRL and the BIPM with realtime TECmeters, developed by the CRL in early 1989, allow the correction of time comparison TAO - OP for the whole year 1990. Some other ionospheric measurements, obtained at OP and NIST from prototypes of the Ionospheric Measurement System, developed in 1990 by the NIST, are used for experimental purposes, but are not yet introduced on a regular basis into the TAI computation.

The quality of GPS time links is greatly improved by the use of accurate antenna coordinates. On 1990 June 12 at 0h00 UTC, the BIPM proposed the introduction of new coordinates (see Table A) into the GPS time receivers. There were obtained by a combination of two techniques: geodetic methods which give the relative position of the antenna with respect to the nearest IERS site, and the BIPM method of differential positioning [3] between GPS antennas. This action has ensured the worldwide homogeneity in the IERS Terrestrial Reference Frame (ITRF) of the coordinates of all national laboratories equipped with GPS receivers.

TABLE A. CORRECTIONS TO BE ADDED TO THE COORDINATES INTRODUCED INTO THE GPS RECEIVERS IN ORDER TO OBTAIN THE COORDINATES IN THE ITRF88 (THE INTRODUCTION OF THESE CORRECTIONS WAS SUGGESTED FOR 1990 JUNE 12 0H UTC)

Lab.	DX m	DY m	DZ m	Dlat "	Dlong "	Dh m	Uncert. m (1)	Method
EUROPE								
CH	-1.09	-0.79	-0.58	0.015	-0.030	-1.23	0.50	(2)
IEN	0.04	1.29	0.98	0.018	0.059	0.84	0.50	(3)
IFAG	0.70	-0.50	0.16	-0.011	-0.032	-0.49	0.10	(4)
NPL	2.40	0.16	1.57	-0.029	0.009	2.72	0.50	(3)
OCA	0.01	-0.41	0.32	0.008	-0.018	0.19	0.10	(5)
OB	2.63	-0.29	1.17	-0.036	-0.027	2.61	0.50	(16)
OP	-0.43	2.33	1.29	0.036	0.115	0.75	0.50	(3)
ORB	2.26	0.37	2.45	-0.007	0.010	3.34	0.50	(3)
PTB	0.20	-1.42	2.13	0.044	-0.076	1.65	0.50	(3)
ROA	-2.58	3.67	-8.24	-0.157	0.136	-7.29	0.70	(3)
STA	3.71	3.07	-0.07	-0.126	0.112	2.22	0.70	(6)
TUG	-0.53	0.62	0.15	0.011	0.035	-0.12	0.10	(7)
VSL	-2.71	4.93	3.57	0.131	0.269	1.38	0.50	(3)
NORTH AMERICA								
APL	2.08	-2.34	-5.02	-0.182	0.062	-1.05	1.00	(8)
NIST	-0.99	1.02	-0.23	0.009	-0.052	-0.70	0.30	(9)
NRC	10.42	-6.45	6.36	-0.059	0.394	10.72	1.00	(8)
USNO	1.41	-3.12	2.72	0.000	0.028	4.32	0.10	(10)
EAST ASIA								
CRL	-1.80	1.43	-0.64	-0.060	0.003	1.49	0.10	(11)
KSRI	-0.95	-10.61	0.98	0.176	0.289	-5.75	0.50	(12)
NAOM	12.83	-2.62	-12.65	-0.079	-0.252	-17.00	1.00	(13)
NRLM	6.78	-6.93	-10.63	-0.094	0.039	-14.05	2.00	(14)
TAO	2.04	-1.30	1.16	0.076	-0.013	-1.27	0.50	(12)
TL	0.00	0.00	0.00	0.000	0.000	0.00	2.00	(15)
MIDDLE EAST								
INPL	-4.98	2.47	-4.91	-0.090	0.187	-4.84	1.00	(3)

NOTES

(1) Estimated uncertainty of the corrected coordinates in the ITRF88.

(2) BIPM differential positioning with respect to Grasse ITRF SLR site (data from 27 June 1989 to 13 December 1989).

(3) BIPM differential positioning with respect to Grasse ITRF SLR site (data from 15 December 1987 to 21 June 1988).

(4) Local survey to Wettzell ITRF VLBI site (January 1990).

(5) Local survey to Grasse ITRF SLR site (January 1989).

(6) BIPM differential positioning with respect to Grasse ITRF SLR site (data from 19 December 1988 to 26 June 1989).

(7) Local survey to Graz ITRF SLR site.

(8) BIPM differential positioning with respect to Maryland Point ITRF VLBI site (data from 15 December 1987 to 21 June 1988).

(9) GPS geodetic differential positioning with respect to Platteville ITRF VLBI site (July 1989).

(10) GPS geodetic differential positioning with respect to Maryland Point ITRF VLBI site (November 1989).

(11) Local survey to Kashima ITRF VLBI site (March 1989).

(12) BIPM differential positioning with respect to Kashima ITRF VLBI site (data from 20 December 1988 to 26 June 1989).

(13) BIPM differential positioning with respect to Kashima ITRF VLBI site (data from 18 May 1989 to 26 June 1989)

(14) GPS geodetic differential positioning with respect to a WGS 84 Doppler site (28 August 1989).

(15) WGS 84 Doppler positioning (23 May 1989).

(16) BIPM differential positioning with respect to Grasse ITRF SLR site (data from 22 june 1988 to 26 june 1989).

Precise ephemerides of GPS satellites, computed by the US Defense Mapping Agency, have been received at the BIPM since early 1990. They are used experimentally to correct time comparisons for the satellites position. In 1990, the delay of access (2 months) to precise ephemerides was too long to introduce this correction in current TAI computation.

2.3 GLONASS links

From his current observations of both the GPS and GLONASS satellite systems Prof. P. Daly, University of Leeds, establishes and reports GPS time - GLONASS time, as well as UTC(USNO) - UTC(SU) at ten-day intervals.

In TAI computation, the only available GLONASS link is (end 1990):

USNO - SU (from 1990 June 27).

2.4 Television links

The simultaneous reception of public television signals provides the links

PTB - ASMW ASMW - ZIPE ZIPE - AOS	till 1990 September 25
TP - OMH	
PTB - ZIPE PKNM - AOS	from 1990 October 5

2.5 Two-way time transfer via geostationary satellites

For experimental purposes, two-way time transfers via geostationary satellites have been carried out since early 1990, on the one hand between NIST, NRC and USNO in North America, and on the other hand between TUG and OCA in Europe. These experimental results were not used for TAI computation in 1990.

3. ACCURACY OF THE TAI SCALE INTERVAL

Table B gives the normalized frequency offsets between EAL and TAI. The relationship TAI-EAL was modified five times in 1990, by frequency offsets of 0.5×10^{-14} in order to compensate a frequency drift of EAL with respect to the primary standards of the PTB.

TABLE B - DIFFERENCES BETWEEN THE NORMALIZED FREQUENCIES OF EAL AND TAI
(until January 1991)

Date	MJD	f(EAL) - f(TAI) in 10^{-13}
until 1977 Jan 1	until 43144	0
1977 Jan 1 - 1977 Apr 26	43144 - 43259	10,0
1977 Apr 26 - 1977 Jun 25	43259 - 43319	9,8
1977 Jun 25 - 1977 Aug 24	43319 - 43379	9,6
1977 Aug 24 - 1977 Oct 23	43379 - 43439	9,4
1977 Oct 23 - 1978 Oct 28	43439 - 43809	9,2
1978 Oct 28 - 1979 Jun 25	43809 - 44049	9,0
1979 Jun 25 - 1979 Aug 24	44049 - 44109	8,8
1979 Aug 24 - 1979 Oct 23	44109 - 44169	8,6
1979 Oct 23 - 1982 Apr 30	44169 - 45089	8,4
1982 Apr 30 - 1982 Jun 29	45089 - 45149	8,2
1982 Jun 29 - 1982 Aug 28	45149 - 45209	8,0
1982 Aug 28 - 1984 Feb 29	45209 - 45759	7,8
1984 Feb 29 - 1987 Apr 24	45759 - 46909	8,0
1987 Apr 24 - 1987 Dec 30	46909 - 47159	8,0125
1987 Dec 30 - 1989 Jun 22	47159 - 47699	8,0
1989 Jun 22 - 1989 Dec 29	47699 - 47889	7,95
1989 Dec 29 - 1990 Feb 27	47889 - 47949	7,90
1990 Feb 27 - 1990 Apr 28	47949 - 48009	7,85
1990 Apr 28 - 1990 Jun 27	48009 - 48069	7,80
1990 Jun 27 - 1990 Aug 26	48069 - 48129	7,75
1990 Aug 26	48129	7,70

As the time scales UTC and TAI differ by an integral number of seconds (see Tables 2 and 3 of Part B), UTC is necessarily subject to the same intentional frequency adjustement as TAI.

4. TIME SCALES ESTABLISHED IN RETROSPECT

For the most demanding applications, such as millisecond pulsar timing, the BIPM issues atomic time scales in retrospect designated as TT(BIPMxx) where 1900 + xx is the year of computation [4]. 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.

REFERENCES

[1] B. Guinot and C. Thomas, 'Establishment of the International Atomic Time', Annual Report of the BIPM Time Section, 1988, pp. D3-D22.

[2] P. Tavella and C. Thomas, 'Comparative study of time scale algorithms", 1991, Metrologia, in press.

[3] B. Guinot and W. Lewandowski, 'Improvement of the GPS time comparisons by simultaneous relative positioning of the antennas, Bull. Géod. 63, 1989, pp. 371-386.

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

1. ETABLISSEMENT DU TEMPS ATOMIQUE INTERNATIONAL ET DU TEMPS UNIVERSEL COORDONNE EN 1990

Le Temps atomique international (TAI) et le Temps universel coordonné (UTC) sont obtenus par une combinaison des lectures de données d'horloges atomiques et d'étalons primaires de fréquence répartis dans le monde entier.

Un algorithme itératif qui traite en temps différé des blocs de 2 mois de données [1] [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, elle peut en diverger lentement, mais indéfiniment.

La durée de l'intervalle unitaire de l'EAL est évaluée par comparaison aux données d'étalons de fréquence à césium primaires. 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 TAI et l'UTC sont disponibles sous forme de différences de temps avec les échelles de temps conservées par des laboratoires horaires nationaux "k" : UTC(k), approximation de UTC, et TA(k), temps atomique local indépendant.

Les différences UTC - UTC(k), TAI - TA(k), sont calculées de 10 jours en 10 jours pour les dates juliennes modifiées (MJD) se terminant par 9, à 0h UTC, "dates normales".

Le calcul du TAI doit être fait, en principe, tous les deux mois. Mais un calcul provisoire est fait un mois sur deux (pour janvier, mars, ...) avec les données disponibles. Le mois suivant, le calcul du TAI est repris pour une durée de deux mois. L'écart entre les résultats des calculs provisoire et complet est ordinairement inférieur à 10 ns. Cette organisation permet la publication mensuelle des résultats dans la Circulaire T du BIPM.

Quand le Rapport annuel est préparé, les résultats de la circulaire T sont révisés, compte-tenu des améliorations de données, connues après la publication de la Circulaire T. Les calculs sont alors strictement faits par période de deux mois.

Dans la suite et dans tout ce rapport, les laboratoires sont désignés par les sigles explicités dans la table 1 de la partie B.

2. LIAISONS HORAIRES UTILISEES PAR LE BIPM EN 1990

Le système non-redondant des liaisons entre les UTC(k) des laboratoires participants est établi pour les dates normales

- par le LORAN-C,
- par le GPS,
- par le GLONASS,
- par la réception d'impulsions de la télévision publique.

Dans toutes ces méthodes on fait appel généralement à la réception simultanée des signaux et l'on recherche la meilleure estimation des différences des UTC(k) aux dates normales.

L'ensemble des liaisons utilisées est donné dans le texte anglais qui précède.

On dispose maintenant de mesures du retard ionosphérique obtenues à partir de récepteurs GPS double-fréquence. Des mesures régulières au CRL et au BIPM, réalisées avec l'équipement développé par le CRL, ont été utilisées pour corriger la liaison TAO-OP en 1990. Les systèmes de mesures ionosphériques, développés par le NIST, et en fonctionnement à l'OP et au NIST, ne sont utilisés qu'à but expérimental. Les mesures qu'ils délivrent ne sont pas encore introduites dans les calculs courants du TAI.

La qualité des comparaisons horaires par GPS est largement améliorée si les coordonnées d'antenne sont connues avec précision. Le BIPM a suggéré de corriger les coordonnées d'antennes introduites dans les récepteurs GPS (voir le tableau A) le 12 juin 1990, à 0h00 UTC. Ces coordonnées plus exactes avaient été obtenues grâce à deux techniques : des méthodes géodésiques qui donnent la position de l'antenne par rapport au site IERS le plus proche, et la méthode de positionnement différentiel développée par le BIPM [3]. L'homogénéisation mondiale des coordonnées d'antennes de tous les laboratoires nationaux équipés de récepteurs GPS a donc été réalisée dans le système de référence terrestre de l'IERS.

Le BIPM reçoit les éphémérides précises des satellites GPS, produites par la DMA, depuis le début de 1990. Elles permettent d'améliorer les comparaisons horaires par correction de la position du satellite. A cause du délai d'accès (2 mois), ce travail reste à un niveau expérimental et les données d'éphémérides précises ne sont pas introduites dans les calculs courants du TAI.

Des comparaisons de temps par la méthode des deux voies utilisant un satellite géostationnaire ont été réalisées à titre expérimental, d'une part entre le NIST, le NRC et l'USNO en Amérique du Nord, d'autre part entre le TUG et l'OCA en Europe. Les résultats de ces expériences n'ont pas été utilisés pour le calcul du TAI en 1990.

3. Exactitude de l'intervalle unitaire du TAI

Le tableau B (texte anglais) donne le décalage de fréquence entre le TAI et l'EAL. La relation entre le TAI et l'EAL a été modifée cinq fois en 1990, par des décalages de fréquence de $0,5 \times 10^{-14}$, afin de compenser une dérive de fréquence de l'EAL par rapport aux étalons primaires de la PTB.

4. Echelles de temps etablies retrospectivement

Pour les applications les plus exigeantes, comme le chronométrage des pulsars milliseconde, le BIPM produit des échelles de temps rétrospectivement, désignées par TT(BIPMxx), 1900 + xx étant l'année du calcul [4]. 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.

Les références sont données dans le texte anglais.

PART B

TABLE OF RESULTS

PARTIE B

TABLEAUX DE RESULTATS

TABLE 1. ACRONYMS AND LOCATIONS OF THE COLLABORATING LABORATORIES TO TAI

AOS	Astronomical Latitude Observatory, Borowiec, Polska
APL	Applied Physics Laboratory, Laurel, USA
ASMW(1)	Amt für Standardisierung, Messwesen und Warenprüfung, Berlin, Deutschland
ATC	Australian Telecommunications Commission, Melbourne, Australia
AUS	Consortium of laboratories in Australia
BEV	Bundesamt für Eich - und Vermessungswesen, Wien, Oesterreich
BAO	Beijing Observatory, Beijing, P.R. China
CAO	Astronomical Observatory of Cagliari University, Cagliari, Italia
CH	Consortium of laboratories in Switzerland
CRL	Communications Research Laboratory, Tokyo, Japan
CSAO	Shaanxi Astronomical Observatory, Lintong, P.R. China
DDR(1)	Consortium of laboratories in East Germany
DPT	Division of Production Technology, CSIR, Pretoria, South Africa
F	Commission Nationale de l'Heure, Paris, France
FTZ	Fernmeldetechnisches Zentralamt, Darmstadt, Deutschland
IEN	Istituto Elettrotecnico Nazionale Galileo Ferraris, Torino, Italia
IFAG	Institut für Angewandte Geodäsie, Frankfurt am Main, Deutschland
IGMA	Instituto Geografico Militar, Buenos-Aires, Argentina
INPL	National Physical Laboratory, Jerusalem, Israel
INTI	Instituto Nacional de Tecnologia Industrial, Buenos-Aires, Argentina
JATC	Joint Atomic Time Commission, Lintong, P.R. China
KSRI	Korea Standards Research Institute, Taejon, Rep. of Korea
LDS	The University of Leeds, Leeds, United Kingdom
NAOM	National Astronomical Observatory, Misuzawa, Japan
NIM	National Institute of Metrology, Beijing, P.R. China
NIST	National Institute of Standards and Technology, Boulder, USA
NML	National Measurement Laboratory, CSIRO, Sydney, Australia
NPL	National Physical Laboratory, Teddington, United Kingdom
NPLI	National Physical Laboratory, New-Delhi, India
NRC	National Research Council of Canada, Ottawa, Canada
NRLM	National Research Laboratory of Metrology, Tsukuba, Japan
OMH	Orszagos Mérésügyi Hivatal, Budapest, Hungary
ONBA	Observatorio Naval, Buenos-Aires, Argentina
ONRJ	Observatorio Nacional, Rio de Janeiro, Brazil
OP	Observatoire de Paris, Paris, France
ORB	Observatoire Royal de Belgique, Bruxelles, Belgique
ORR	Orroral Observatory, Belconnen, Australia
PEL	Physics and Engineering Laboratory, Lower Hutt, New Zealand
PKNM	Polski Komitet Normalizacji Miar I Jakosci, Warszawa, Polska

TABLE 1. ACRONYMS AND LOCATIONS OF THE COLLABORATING LABORATORIES TO TAI (CONT.)

PTB	Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland
RAO	Radio Astronomical Observatory, Johannesburg, South Africa
RC	Comité Estatal de Normalizacion, Habana, Cuba
RGO	Royal Greenwich Observatory, Cambridge, United Kingdom
ROA	Real Instituto y Observatorio de la Armada, San Fernando, Espana
RSA	Consortium of laboratories in South Africa
SAAO	South African Astronomical Observatory, Cape Town, South Africa
SO	Shanghai Observatory, Shanghai, P.R. China
STA	Swedish Telecommunications Administration, Stockholm, Sweden
SU	Laboratoire d'état de l'étalon de temps et de fréquences, Moskva, URSS
TAO	Tokyo Astronomical Observatory, Tokyo, Japan
TID	Deep Space Communications Center, Tidbinbilla, Australia
TL	Telecommunication Laboratories, Chung-Li, Taiwan, China
TP	Ústav Radiotechniky a Elektroniky ČSAV, Praha, Československo Astronomický ústav ČSAV, Praha, Československo
TUG	Technische Universität, Graz, Oesterreich
USNO	U.S. Naval Observatory, Washington D.C., USA
VSL	Van Swinden Laboratorium, Delft, Nederland
YUZM	Bureau Fédéral des Mesures et Métaux Précieux, Beograd, Yougoslavia
ZIPE	Zentralinstitut Physik der Erde, Potsdam, Deutschland

(1) As a consequence of the unification of Germany, the ASMW became a part of the PTB on 1990 October 3rd. This Report refers to the acronyms ASMW and DDR only until 1990 October 3rd.

TABLE 2. FREQUENCY OFFSETS AND STEP ADJUSTEMENTS OF UTC, UNTIL 1991 JUNE 30

DATE (AT 0HUTC)	OFFSETS	STEPS	DATE (AT 0HUTC)	OFFSETS	STEPS
1961 Jan. 1	-150×10^{-10}		1972 Jan. 1	0	-0.107 7580 s
1961 Aug. 1	"	+0.050 s	1972 Jul. 1	"	-1 s
			1973 Jan. 1	"	-1 s
1962 Jan. 1	-130×10^{-10}		1974 Jan. 1	"	-1 s
1963 Nov. 1	"	-0.100 s	1975 Jan. 1	"	-1 s
			1976 Jan. 1	"	-1 s
1964 Jan. 1	-150×10^{-10}		1977 Jan. 1	"	-1 s
1964 Apr. 1	"	-0.100 s	1978 Jan. 1	"	-1 s
1964 Sep. 1	"	-0.100 s	1979 Jan. 1	"	-1 s
1965 Jan. 1	"	-0.100 s	1980 Jan. 1	"	-1 s
1965 Mar. 1	"	-0.100 s	1981 Jul. 1	"	-1 s
1965 Jul. 1	"	-0.100 s	1982 Jul. 1	"	-1 s
1965 Sep. 1	"	-0.100 s	1983 Jul. 1	"	-1 s
			1985 Jul. 1	"	-1 s
1966 Jan. 1	-300×10^{-10}		1988 Jan. 1	"	-1 s
1968 Feb. 1	"	+0.100 s	1990 Jan. 1	"	-1 s
			1991 Jan. 1	"	-1 s

TABLE 3. RELATIONSHIP BETWEEN TAI AND UTC, UNTIL 1991 JUNE 30

LIMITS OF VALIDITY (AT 0HUTC)	TAI - UTC (IN SECONDS)	
1961 Jan. 1 - 1961 Aug. 1	1.422 8180 +	(MJD - 37300) x 0.001 296
1961 Aug. 1 - 1962 Jan. 1	1.372 8180 +	" "
1962 Jan. 1 - 1963 Nov. 1	1.845 8580 +	(MJD - 37665) x 0.001 1232
1963 Nov. 1 - 1964 Jan. 1	1.945 8580 +	" "
1964 Jan. 1 - 1964 Apr. 1	3.240 1300 +	(MJD - 38761) x 0.001 296
1964 Apr. 1 - 1964 Sep. 1	3.340 1300 +	" "
1964 Sep. 1 - 1965 Jan. 1	3.440 1300 +	" "
1965 Jan. 1 - 1965 Mar. 1	3.540 1300 +	" "
1965 Mar. 1 - 1965 Jul. 1	3.640 1300 +	" "
1965 Jul. 1 - 1965 Sep. 1	3.740 1300 +	" "
1965 Sep. 1 - 1966 Jan. 1	3.840 1300 +	" "
1966 Jan. 1 - 1968 Feb. 1	4.313 1700 +	(MJD - 39126) x 0.002 592
1968 Feb. 1 - 1972 Jan. 1	4.213 1700 +	" "
1972 Jan. 1 - 1972 Jul. 1	10	(integral number of seconds)
1972 Jul. 1 - 1973 Jan. 1	11	
1973 Jan. 1 - 1974 Jan. 1	12	
1974 Jan. 1 - 1975 Jan. 1	13	
1975 Jan. 1 - 1976 Jan. 1	14	
1976 Jan. 1 - 1977 Jan. 1	15	
1977 Jan. 1 - 1978 Jan. 1	16	
1978 Jan. 1 - 1979 Jan. 1	17	
1979 Jan. 1 - 1980 Jan. 1	18	
1980 Jan. 1 - 1981 Jul. 1	19	
1981 Jul. 1 - 1982 Jul. 1	20	
1982 Jul. 1 - 1983 Jul. 1	21	
1983 Jul. 1 - 1985 Jul. 1	22	
1985 Jul. 1 - 1988 Jan. 1	23	
1988 Jan. 1 - 1990 Jan. 1	24	
1990 Jan. 1 - 1991 Jan. 1	25	
1991 Jan. 1 -	26	

TABLE 4. LABORATORIES CONTRIBUTING TO TAI IN 1990 : INDEPENDENT LOCAL TIME SCALE,

(Ind. Cs : industrial Cs Standard, Lab. Cs : laboratory Cs standard,

Laboratory (k)	Equipment in atomic standards	Information on TA(k) - UTC(k)	
		Interval of validity (in MJD at 0hUTC)	TA(k) - UTC(k) in s
AOS	1 Ind. Cs	47927-48103 48104-48233 48234-	25.000 000 000 25.000 020 000 25.000 040 000
APL	2 Ind. Cs 4 H-Masers	47799-47889 47899-48010 48011-	24.000 001 338 25.000 001 338 25.000 000 507
ASMW(2)	2 Ind. Cs		
ATC	7 Ind. Cs		
AUS	(3)	year 1990	TA(AUS)-UTC(AUS) is sent to the BIPM by ORR
BEV	1 Ind. Cs		
CAO	2 Ind. Cs		
CH	13 Ind. Cs (4)	year 1990	TA(CH)-UTC(CH) is sent to the BIPM
CRL	1 Lab. Cs 11 Ind. Cs 3 H-Masers	year 1990	TA(CRL)-UTC(CRL) published in CRL Standard Frequency and Time Bulletin
CSAO	5 Ind. Cs 3 H-Masers	year 1990	TA(CSAO)-UTC(CSAO) is published in the CSAO Time and Frequency Services Bulletin

EQUIPMENT, SOURCE OF UTC AND RECEPTION OF TIME SIGNALS

H-Maser : Hydrogen Maser)

	Source of of UTC(k)	Information on time links				
		GPS reception	GLONASS reception	LORAN-C reception (1)	Television link with	Two-way satellite time transfer
	1 Cs				PKNM, ZIPE	
	1 H-Maser	*				
	1 Cs + microstepper			7970-W	ZIPE, TP, PTB	
	1 Cs + microstepper	*			other lab. in Australia	
	all the Cs	*				
	1 Cs			7970-W 7990-M 7990-X 7990-Y	OMH, TUG, SU other lab. in Czechoslovakia	
	1 Cs			7990-M 7990-X 7990-Z	IEN, other lab. in Italy	
	all the Cs	*		7970-W 7990-Z	PTT	
	6 Cs	*		9970-M	NRLM, TAO	
	all the Cs			9970-Y	other lab. in China	

TABLE 4. LABORATORIES CONTRIBUTING TO TAI IN 1990 : INDEPENDENT LOCAL TIME SCALE,

(Ind. Cs : industrial Cs Standard, Lab. Cs : laboratory Cs standard,

Laboratory (k)	Equipment in atomic standards	Information on TA(k) - UTC(k)	
		Interval of validity (in MJD at 0hUTC)	TA(k) - UTC(k) in s
DDR(5)	3 Ind. Cs (6)	year 1990 until 48167	TA(DDR)-UTC(ASMW) is sent to the BIPM
DPT	1 Ind. Cs		
F	22 Ind. Cs (7)	year 1990	TA(F)-UTC(OP) is published in bulletin H by OP (LPTF)
FTZ	7 Ind. Cs		
IEN	5 Ind. Cs		
IFAG	4 Ind. Cs 2 H-Masers		
IGMA	4 Ind. Cs		
INPL	5 Ind. Cs		
JATC	1 Lab. Cs 14 Ind. Cs 6 H-Masers (8)	year 1990	TA(JATC)-UTC(JATC) is sent to the BIPM
KSRI	4 Ind. Cs		
LDS	2 Ind. Cs		
NAOM	4 Ind. Cs		

EQUIPMENT, SOURCE OF UTC AND RECEPTION OF TIME SIGNALS (CONT.)

H-Maser : Hydrogen Maser)

Source of of UTC(k)	Information on time links				
	GPS reception	GLONASS reception	LORAN-C reception (1)	Television link with	Two-way satellite time transfer
1 Cs	*			other lab. in S.A.	
see OP					
1 Cs			7970-W		
1 Cs + microstepper	*		7990-Z	CAO, other lab. in Italy	
1 Cs + microstepper	*		7970-W		
1 Cs + microstepper	*			ONBA, other lab. in Argentina	
4 Cs	*				
1 Cs + microstepper			9970-Y		
1 Cs	*		9970-Y		
1 Cs	* (9)	* (9)			
1 Cs + microstepper	*		9970-M 9970-X		

TABLE 4. LABORATORIES CONTRIBUTING TO TAI IN 1990 : INDEPENDENT LOCAL TIME SCALE,

(Ind. Cs : industrial Cs Standard, Lab. Cs : laboratory Cs standard,

Laboratory (k)	Equipment in atomic standards	Information on TA(k) - UTC(k)	
		Interval of validity (in MJD at 0hUTC)	TA(k) - UTC(k) in s
NIM	3 Ind. Cs	year 1990	TA(NIM)-UTC(NIM) is sent to the BIPM
NIST	1 Lab. Cs 19 Ind. Cs 1 H-Maser(pas.) 1 H-Maser(act.) (10)	year 1990	TA(NIST)-UTC(NIST) is published in the NIST T and F Bulletins
NML	3 Ind. Cs 2 H-Masers		
NPL	7 Ind. Cs		
NPLI	5 Ind. Cs		
NRC	3 Lab. Cs 1 Ind. Cs	year 1990	24.999 983 931
NRLM	5 Ind. Cs 2 Lab. Cs		
OMH	1 Ind. Cs		
ONBA	2 Ind. Cs		
ONRJ	5 Ind. Cs		

EQUIPMENT, SOURCE OF UTC AND RECEPTION OF TIME SIGNALS (CONT.)

H-Maser : Hydrogen Maser)

	Source of of UTC(k)	Information on time links				
		GPS reception	GLONASS reception	LORAN-C reception (1)	Television link with	Two-way satellite time transfer
	1 Cs + microstepper	*		9970-Y	other lab. in China	
	11 Cs 1 Lab. Cs 1 H-Maser	*		9940-M 8970-M		* (11)
	all the Cs	*			other lab. in Sydney region	
	1 Cs + microstepper	*		7970-W	transmitting station at Rugby	
	1 Cs	*				
	1 lab. Cs (12)	*		9960-M		* (11)
	1 Cs	*		9970-M 9970-X	CRL, TAO	
	1 Cs				BEV, SU, TP	
	2 Cs				IGMA other lab. in Argentina	
	5 Cs	*			other lab. in Brasil	

TABLE 4. LABORATORIES CONTRIBUTING TO TAI IN 1990 : INDEPENDENT LOCAL TIME SCALE,

(Ind. Cs : industrial Cs Standard, Lab. Cs : laboratory Cs standard,

Laboratory (k)	Equipment in atomic standards	Information on TA(k) - UTC(k)	
		Interval of validity (in MJD at 0hUTC)	TA(k) - UTC(k) in s
OP	5 Ind. Cs		see F
ORB	3 Ind. Cs		
ORR	5 Ind. Cs		
PEL	3 Ind. Cs		
PKNM	4 Ind. Cs		
PTB (14)	2 Lab. Cs 7 Ind. Cs	year 1990	25.000 363 400
RAO	1 H-Maser		
RC	6 H-Masers	year 1990	TA(RC)-UTC(RC) is sent to the BIPM
ROA	6 Ind. Cs		
SAAO	1 Ind. Cs		

EQUIPMENT, SOURCE OF UTC AND RECEPTION OF TIME SIGNALS (CONT.)

H-Maser : Hydrogen Maser)

	Source of of UTC(k)	Information on time links				
		GPS reception	GLONASS reception	LORAN-C reception (1)	Television link with	Two-way satellite time transfer
	1 Cs	*		7970-W 7990-Z 8940-M	18 lab. in France.	
	1 Cs	*		7970-W		
	all the Cs	*			other lab. in Australia	
	1 Cs	*			other lab. in New Zealand	
	1 Cs + microstepper			7970-W (13)	AOS	
	Ind. Cs + microstepper steered by PTB primary st.	*		7970-W	ASMW, TP, ZIPE and other lab.	
		*				
	3 H-Masers			7980-M 7980-Y		
	all the Cs	*		7990-Z		
	1 Cs	*				

TABLE 4. LABORATORIES CONTRIBUTING TO TAI IN 1990 : INDEPENDENT LOCAL TIME SCALE,

(Ind. Cs : industrial Cs Standard, Lab. Cs : laboratory Cs standard,

Laboratory (k)	Equipment in atomic standards	Information on TA(k) - UTC(k)	
		Interval of validity (in MJD at 0hUTC)	TA(k) - UTC(k) in s
SO	1 Lab. Cs 3 Ind. Cs 3 H-Masers	year 1990	TA(SO)-UTC(SO) is published in the SO Atomic Time Bulletin
STA	3 Ind. Cs		
SU	2 Lab. Cs 6 H-Masers	year 1990	22.172 750 000
TAO	7 Ind. Cs		
TL	5 Ind. Cs		
TP	2 Ind. Cs		
TUG	3 Ind. Cs		
USNO	45 Ind. Cs 10 H-Masers 3 Prototype Mercury Ion freq. Std (16)	year 1990	A.1(MEAN)-UTC(USNO,MC) is sent to the BIPM (17)

EQUIPMENT, SOURCE OF UTC AND RECEPTION OF TIME SIGNALS (CONT.)

H-Maser : Hydrogen Maser)

Source of of UTC(k)	Information on time links				
	GPS reception	GLONASS reception	LORAN-C reception (1)	Television link with	Two-way satellite time transfer
1 Cs + microstepper	*		9970-Y	other lab in China	
1 Cs	*		7970-W	other lab. in Sweden	
2 Lab. Cs 6 H-Masers		*	7970-W 9970-X	TP, OMH	
1 Cs + microstepper	*		9970-M 9970-Y	CRL, NAOM NRLM	
1 Cs + microstepper	*		9970-Y		
1 Cs + microstepper			7970-W	PTB, SU, ZIPE, ASMW, OMH	
1 Cs	*		7970-W 7990-M	BEV	* (15)
UTC(USNO,MC) is an H-Maser + Freq. synthe-sizer steered to UTC(USNO)	* (18)		(18)	(18)	* (11)

TABLE 4. LABORATORIES CONTRIBUTING TO TAI IN 1990 : INDEPENDENT LOCAL TIME SCALE,

(Ind. Cs : industrial Cs Standard, Lab. Cs : laboratory Cs standard,

Laboratory (k)	Equipment in atomic standards	Information on TA(k) - UTC(k)	
		Interval of validity (in MJD at 0hUTC)	TA(k) - UTC(k) in s
VSL	4 Ind. Cs		
YUZM	1 Ind. Cs		
ZIPE	1 Ind. Cs		

EQUIPMENT, SOURCE OF UTC AND RECEPTION OF TIME SIGNALS (CONT.)

H-Maser : Hydrogen Maser)

	Source of of UTC(k)	Information on time links				
		GPS reception	GLONASS reception	LORAN-C reception (1)	Television link with	Two-way satellite time transfer
	1 Cs + microstepper	*		7970-M 7970-W 9980-X	13 Lab. in Netherlands	
	1 Cs			7990-M		
	1 Cs + microstepper			7970-W	AOS, ASMW, TP, PTB	

NOTES

(1) LORAN-C stations :

7970-M	Norwegian Sea chain,	Ejde, Denmark
7970-W	" "	Sylt, Germany
7980-M	Southeast USA chain	Malone, Florida, USA
7980-Y	" "	Jupiter,Florida, USA
7990-M	Mediterranean chain,	Sellia Marina, Italy
7990-X	" "	Lampedusa, Italy
7990-Y	" "	Kargabarun, Turkey
7990-Z	" "	Estartit, Espagne
8940-M	French chain,	Lessay, France
8970-M	Great Lakes chain,	Dana, Indiana, USA
9940-M	West Coast chain,	Fallon, Nevada, USA
9960-M	Northeast Coast chain,	Seneca, New york, USA
9970-M	Northwest Pacific chain,	Iwo Jima, Japan
9970-X	" "	Hokkaido, Japan
9970-Y	" "	Gesashi, Japan
9980-X	North Atlantic chain	Ejde, Denmark.

(2) As a consequence of the unification of Germany the ASMW became a part of the PTB on 1990 October 3rd. The clocks kept by the former ASMW are now compared to UTC(PTB).

(3) Industrial Cs clocks and H-Masers kept by different laboratories in Australia.

(4) The standards are located as follows (at the end of 1990) :

Office Fédéral de Métrologie (Bern)	(OFM)	7 Cs
Observatoire de Neuchâtel (Neuchâtel)	(ON)	4 Cs
Direction Générale des PTT (Bern)	(PTT)	2 Cs.

They are intercompared by LORAN-C (OFM-ON) and TV method (OFM-PTT) and linked to the foreign laboratories through the Swiss Federal Office of Metrology.

(5) As a consequence of the unification of Germany the ASMW became a part of the PTB on 1990 October 3rd. The computation of TA(DDR) was simultaneously stopped.

(6) The standards are located as follows : ASMW, 2 Cs ; ZIPE, 1 Cs.

NOTES (CONT.)

(7) The standards are located as follows (at the end of 1990) :

Centre Electronique de l'Armement (Rennes)	2 Cs
Centre National d'Etudes Spatiales (CNES)	2 Cs
Centre National d'Etudes des Télécommunications	3 Cs
Observatoire de la Côte d'Azur (OCA, formerly CERGA)	3 Cs
Electronique Serge Dassault (Trappes)	1 Cs
Hewlett-Packard (Orsay)	1 Cs
Observatoire de Paris : Laboratoire Primaire du Temps et des Fréquences (LPTF)	5 Cs
Observatoire de Besançon (OB)	2 Cs
Laboratoire de Physique et de Métrologie des Oscillateurs (Besançon) (LPMO)	1 Cs
Ecole Nationale Supérieure de Mécanique et des Microtechniques (Besançon) (ENSMM)	1 Cs
Société d'Etudes, Recherches et Constructions Electroniques (Carquefou) (SERCEL).	1 Cs

Links by GPS : OP-OB, OP-SERCEL, OP-OCA, OP-CNES.
Cable links : OB-LPMO, OB-ENSMM.
Other national links by the TV method.
Link to foreign laboratories through OP(LPTF) by GPS.

(8) The standards are located as follows :
Shaanxi Astronomical Observatory (CSAO)
Shanghai Astronomical Observatory (SO)
Beijing Astronomical Observatory
Wuhan Time Observatory
Beijing Institute of Radio Metrology and Measurement.

(9) Reception of GPS and GLONASS signals on a common receiver.

(10) The laboratory primary standard controls TA(NIST) via an accuracy algorithm. Six of the commercial standards provide the reference for WWV and WWVB and two for GOES satellite time but do not contribute directly to TA(NIST); they are available for NIST time scales back-up and are compared to TA(NIST) to within 0.01 μs. An other independent local time is evaluated by a different algorithm. It is designated as AT1, and appears in the BIPM publications as TA(NISA).

(11) For experimental purposes, two-way satellite time transfer operates between NIST and NRC, and between NIST and USNO.

(12) NRC Cs VIA was the source of UTC(NRC) until 1990 June 2, 19hUTC. UTC(NRC) was then provided by NRC Cs V. The relations between UTC(NRC) and these primary clocks, with PT designating proper time, are in microseconds :
from 1990 January 1, 0hUTC to 1990 January 28, 19hUTC,

UTC(NRC) = PT(NRC Cs VIA) - 0.017387 x (MJD-47892) + 16.541,

from 1990 February 7, 0hUTC to 1990 May 18, 0hUTC,

UTC(NRC) = PT(NRC Cs VIA) - 0.017387 x (MJD-47892) + 16.742,

from 1990 June 7, 0hUTC to 1991 January 1, 0hUTC,

UTC(NRC) = PT(NRC Cs V) - 0.00097 x (MJD-48043) + 26.854.

NOTES (CONT.)

(13) Reception of Soviet Union LORAN chain 8000.

(14) The two Lab. Cs are functionning continuously (primary clocks). TA(PTB) and UTC(PTB) are derived directly from a local oscillator monitored by the primary clock CS1.
MEZ(D) = UTC(PTB) + 1 h or MESZ(D) = UTC(PTB) + 2 h (summer time) is the legal time of the Federal Republic of Germany, which is disseminated by DCF77.
Two Ind. Cs are located at the transmitter station Mainflingen and provide the DCF77 steering signal.

(15) For experimental purposes two-way satellite time transfer operates between TUG and OCA (Observatoire de la côte d'Azur, Grasse, France)

(16) The time scales UTC(USNO) and A.1(MEAN), both computed by USNO, depend on nominally 20 Cs clocks, selected on the basis of observed 5-day stability.

(17) The time scale A.1(MEAN) computed by USNO is designated as TA(USNO) in the BIPM publications.

(18) The daily time differences (published weekly, Series 4 of USNO) gives the values of UTC(USNO MC) - transmitting station for :
- the LORAN-C chains,
- the Washington D.C. TV Station WTTG,
- the GPS satellite system.

These data are also available via the Automated Data Service (ADS) and the General Electric Mark 3 international computer network (RC28 catalog).
The ADS may be accessed on :
202-653-0155 and 202-653-0068,
1200/2400/9600 baud, 8 bits, 1 stop, no parity
modem password : CESIUM133.
Instructions for Internet access :
Telnet to tsts14.usno.navy.mil (192.41.40). Login as ads.

TABLE 5. ABSOLUTE TIME COMPARISONS BETWEEN LABORATORIES

The time comparison experiment was carried out by the first mentioned laboratory.

5A. CLOCK TRANSPORTATION

DATE 1990	MJD	TIME COMPARISON (1 microsecond)	UNCERT.	SOURCE OF REPORT
Feb 1	47923.02	UTC(SU) - UTC(RC) = -13.188	0.025	SU
May 22	48033.05	UTC(TAO) - UTC(CRL) = 3.493	0.005	TAO
May 25	48036.05	UTC(TAO) - UTC(NRLM) = -23.853	0.008	TAO
May 29	48040.01	UTC(TAO) - UTC(NAOM) = -0.914	0.010	TAO
Jun 13	48055.42	UTC(ASMW) - UTC(PTB) = 3.858	0.010	ASMW
Jun 13	48055.42	UTC(ASMW) - UTC(SU) = 10.318	0.010	ASMW
Sep 10	48144.54	UTC(OMH) - UTC(SU) = 7.89	0.05	OMH
Sep 27	48161.29	UTC(PKNM) - UTC(SU) = 8.714	0.030	PKNM
Nov 1	48196.22	UTC(CRL) - UTC(TAO) = -1.212	0.005	CRL
Dec 6	48231.06	UTC(CRL) - UTC(TAO) = -0.759	0.005	CRL

5B. GPS TIME RECEIVER TRANSPORTATION

DATE 1990	MJD	TIME COMPARISON (1 microsecond)	UNCERT.	SOURCE OF REPORT
Jun 22	48064.00	UTC(OP) - UTC(SU) = 10.661	0.019	OP

TABLE 6. INDEPENDENT LOCAL ATOMIC TIME SCALES

The following table gives the values of TAI-TA(k), where TA(k) denotes the independent atomic time scale established by laboratory k. The values are rounded to 10 ns for the laboratories linked via LORAN-C or television.

Unit is one microsecond.

DATE 1990 0hUTC	MJD	TAI - TA(k)				
		AOS	APL	AUS	CH	CRL
Jan 8	47899	-	-1.234	-25.677	-62.680	-1.967
Jan 18	47909	-	-1.218	-25.883	-62.920	-1.901
Jan 28	47919	-	-1.068	-25.961	-63.143	-1.845
Feb 7	47929	-	-0.956	-26.128	-63.319	-1.808
Feb 17	47939	1.11	-0.869	-26.262	-63.486	-1.779
Feb 27	47949	1.07	-0.793	-26.401	-63.660	-1.738
Mar 9	47959	0.46	-0.657	-26.558	-63.835	-1.685
Mar 19	47969	-0.41	-0.539	-26.736	-64.002	-1.640
Mar 29	47979	-0.94	-0.383	-26.929	-64.169	-1.597
Apr 8	47989	-1.56	-0.240	-27.088	-64.360	-1.538
Apr 18	47999	-2.14	-0.094	-27.192	-64.533	-1.483
Apr 28	48009	-2.67	-0.041	-27.351	-64.723	-1.428
May 8	48019	-3.34	-0.049	-27.517	-64.912	-1.349
May 18	48029	-3.94	-0.031	-27.774	-65.091	-1.258
May 28	48039	-4.59	-0.013	-28.017	-65.270	-1.174
Jun 7	48049	-6.01	-0.003	-28.134	-65.453	-1.089
Jun 17	48059	-7.08	-0.109	-28.173	-65.623	-0.987
Jun 27	48069	-8.47	-0.153	-28.480	-65.807	-0.907
Jul 7	48079	-10.02	-0.026	-28.794	-65.979	-0.836
Jul 17	48089	-11.41	-0.192	-28.970	-66.162	-0.748
Jul 27	48099	-12.72	-0.338	-29.244	-66.330	-0.652
Aug 6	48109	-14.44	-0.325	-29.548	-66.512	-0.543
Aug 16	48119	-16.22	-0.541	-29.783	-66.677	-0.448
Aug 26	48129	-18.03	-0.635	-30.022	-66.833	-0.356
Sep 5	48139	-18.90	-0.729	-30.239	-66.993	-0.235
Sep 15	48149	-19.95	-0.796	-30.389	-67.146	-0.126
Sep 25	48159	-21.36	-0.821	-30.623	-67.288	-0.020
Oct 5	48169	-22.80	-0.858	-30.780	-67.448	0.097
Oct 15	48179	-24.31	-0.907	-30.943	-67.633	0.232
Oct 25	48189	-25.80	-0.947	-31.145	-67.783	0.390
Nov 4	48199	-27.30	-0.973	-31.297	-67.951	0.538
Nov 14	48209	-28.92	-0.998	-31.473	-68.131	0.689
Nov 24	48219	-31.04	-1.045	-31.696	-68.294	0.846
Dec 4	48229	-32.34	-1.051	-31.834	-68.431	0.994
Dec 14	48239	-33.84	-1.122	-32.018	-68.565	1.120
Dec 24	48249	-35.34	-1.164	-32.161	-68.680	1.291

TABLE 6. (CONT.)

Unit is one microsecond.

DATE 1990 0hUTC	MJD	TAI - TA(k)				
		CSAO	DDR *	F	JATC	NIM
Jan 8	47899	34.91	-27.61	76.865	-1.48	-10.58
Jan 18	47909	34.69	-27.43	77.199	-1.47	-10.65
Jan 28	47919	34.41	-27.31	77.512	-1.45	-10.81
Feb 7	47929	33.84	-27.15	77.811	-1.44	-10.89
Feb 17	47939	33.38	-26.97	78.091	-1.54	-11.02
Feb 27	47949	33.05	-26.84	78.375	-1.59	-11.23
Mar 9	47959	32.68	-26.77	78.674	-1.55	-11.22
Mar 19	47969	32.25	-26.65	78.978	-1.50	-11.24
Mar 29	47979	31.86	-26.48	79.292	-1.50	-11.24
Apr 8	47989	31.43	-26.32	79.600	-1.44	-11.16
Apr 18	47999	31.17	-26.13	79.920	-1.48	-11.08
Apr 28	48009	30.81	-26.02	80.237	-1.32	-11.07
May 8	48019	30.45	-25.91	80.538	-1.32	-11.12
May 18	48029	30.32	-25.90	80.831	-1.28	-11.05
May 28	48039	30.02	-26.02	81.128	-1.26	-10.71
Jun 7	48049	29.71	-26.23	81.412	-1.25	-10.45
Jun 17	48059	29.34	-26.39	81.718	-1.35	-10.37
Jun 27	48069	29.11	-26.46	81.991	-1.35	-10.31
Jul 7	48079	28.83	-26.88	82.282	-1.20	-10.26
Jul 17	48089	28.57	-27.18	82.594	-1.17	-10.19
Jul 27	48099	28.29	-27.41	82.899	-1.16	-10.13
Aug 6	48109	27.91	-27.64	83.211	-1.04	-9.91
Aug 16	48119	27.61	-27.88	83.516	-0.96	-9.87
Aug 26	48129	27.53	-28.16	83.830	-0.84	-9.95
Sep 5	48139	27.16	-28.43	84.122	-0.88	-10.23
Sep 15	48149	27.16	-28.75	84.402	-0.71	-10.23
Sep 25	48159	27.21	-29.04	84.690	-0.25	-10.09
Oct 5	48169	27.29	-	84.960	-0.40	-10.30
Oct 15	48179	27.24	-	85.244	-0.40	-10.53
Oct 25	48189	27.11	-	85.534	-0.28	-10.71
Nov 4	48199	27.12	-	85.823	-0.23	-10.51
Nov 14	48209	27.13	-	86.114	-0.15	-10.56
Nov 24	48219	27.14	-	86.413	-0.12	-11.01
Dec 4	48229	27.04	-	86.721	-0.26	-11.30
Dec 14	48239	26.92	-	87.007	-0.25	-11.13
Dec 24	48249	26.80	-	87.299	-0.41	-11.38

* As a consequence of the unification of Germany, the computation of TA(DDR) stopped on 1990 October 3rd.

TABLE 6. (CONT.)

Unit is one microsecond.

DATE 1990 0hUTC	MJD	TAI - TA(k)			
		NISA *	NIST	NRC	PTB
Jan 8	47899	-45061.837	-45135.872	15.280	-359.611
Jan 18	47909	-45062.032	-45136.359	15.307	-359.615
Jan 28	47919	-45062.221	-45136.856	15.358	-359.668
Feb 7	47929	-45062.423	-45137.358	15.392	-359.634
Feb 17	47939	-45062.647	-45137.889	15.426	-359.626
Feb 27	47949	-45062.855	-45138.407	15.470	-359.648
Mar 9	47959	-45063.048	-45138.909	15.514	-359.663
Mar 19	47969	-45063.232	-45139.416	15.603	-359.667
Mar 29	47979	-45063.431	-45139.936	15.731	-359.687
Apr 8	47989	-45063.633	-45140.480	15.847	-359.701
Apr 18	47999	-45063.812	-45141.015	16.028	-359.688
Apr 28	48009	-45064.016	-45141.567	16.215	-359.700
May 8	48019	-45064.226	-45142.129	16.422	-359.705
May 18	48029	-45064.436	-45142.684	16.714	-359.696
May 28	48039	-45064.662	-45143.260	16.910	-359.686
Jun 7	48049	-45064.882	-45143.831	17.006	-359.692
Jun 17	48059	-45065.099	-45144.401	17.086	-359.685
Jun 27	48069	-45065.345	-45145.005	17.219	-359.699
Jul 7	48079	-45065.577	-45145.615	17.337	-359.689
Jul 17	48089	-45065.823	-45146.246	17.401	-359.689
Jul 27	48099	-45066.075	-45146.881	17.480	-359.681
Aug 6	48109	-45066.333	-45147.527	17.564	-359.676
Aug 16	48119	-45066.592	-45148.175	17.421	-359.671
Aug 26	48129	-45066.853	-45148.828	17.270	-359.652
Sep 5	48139	-45067.105	-45149.468	17.129	-359.660
Sep 15	48149	-45067.366	-45150.123	16.999	-359.657
Sep 25	48159	-45067.611	-45150.749	16.914	-359.668
Oct 5	48169	-45067.853	-45151.378	16.852	-359.669
Oct 15	48179	-45068.086	-45152.003	16.769	-359.676
Oct 25	48189	-45068.317	-45152.630	16.728	-359.647
Nov 4	48199	-45068.575	-45153.277	16.690	-359.669
Nov 14	48209	-45068.841	-45153.922	16.660	-359.684
Nov 24	48219	-45069.118	-45154.581	16.559	-359.701
Dec 4	48229	-45069.375	-45155.220	16.591	-359.715
Dec 14	48239	-45069.655	-45155.881	16.680	-359.747
Dec 24	48249	-45069.923	-45156.526	16.715	-359.742

* TA(NISA) designates the scale AT1 of NIST.

TABLE 6. (CONT.)

Unit is one microsecond.

DATE 1990 OhUTC	MJD	TAI - TA(k) RC	SO	SU *	USNO
Jan 8	47899	17998740.44	-43.77	2827261.31	-34592.632
Jan 18	47909	17998739.85	-43.69	2827261.19	-34593.306
Jan 28	47919	17998739.22	-43.63	2827261.14	-34594.005
Feb 7	47929	17998738.49	-43.52	2827261.00	-34594.686
Feb 17	47939	17998738.40	-43.61	2827260.79	-34595.348
Feb 27	47949	17998738.12	-43.77	2827260.81	-34596.100
Mar 9	47959	17998738.05	-43.74	2827260.83	-34596.769
Mar 19	47969	17998737.94	-43.68	2827260.68	-34597.413
Mar 29	47979	17998737.60	-43.71	2827260.70	-34598.055
Apr 8	47989	17998737.37	-43.70	2827260.73	-34598.724
Apr 18	47999	17998737.16	-43.75	2827260.70	-34599.378
Apr 28	48009	17998737.00	-43.73	2827260.39	-34600.068
May 8	48019	17998736.62	-43.76	2827260.16	-34600.715
May 18	48029	17998736.39	-43.88	2827260.07	-34601.361
May 28	48039	17998735.96	-43.79	2827260.11	-34602.017
Jun 7	48049	17998735.79	-43.84	2827260.11	-34602.693
Jun 17	48059	17998735.52	-44.00	2827260.11	-34603.343
Jun 27	48069	17998735.17	-44.12	2827259.93	-34604.006
Jul 7	48079	17998734.92	-44.03	2827260.01	-34604.643
Jul 17	48089	17998734.36	-44.06	2827260.02	-34605.260
Jul 27	48099	17998733.95	-44.05	2827259.86	-34605.909
Aug 6	48109	17998733.47	-44.05	2827259.75	-34606.559
Aug 16	48119	17998733.00	-43.95	2827259.67	-34607.209
Aug 26	48129	17998732.53	-43.96	2827259.52	-34607.849
Sep 5	48139	17998732.00	-44.18	2827259.16	-34608.500
Sep 15	48149	17998731.36	-44.16	2827259.20	-34609.136
Sep 25	48159	17998731.00	-44.31	2827259.02	-34609.750
Oct 5	48169	17998730.46	-44.41	2827259.01	-34610.370
Oct 15	48179	17998729.81	-44.62	2827259.00	-34611.009
Oct 25	48189	17998729.11	-44.59	2827258.90	-34611.648
Nov 4	48199	17998728.53	-44.75	2827258.76	-34612.283
Nov 14	48209	17998727.78	-44.77	2827258.71	-34612.901
Nov 24	48219	17998727.21	-44.79	2827258.54	-34613.543
Dec 4	48229	17998726.47	-45.01	2827258.26	-34614.195
Dec 14	48239	17998725.93	-45.06	2827258.20	-34614.860
Dec 24	48249	17998725.38	-45.25	2827258.15	-34615.515

* From MJD = 48069 time transfer data obtained from GLONASS satellite trackings at the University of Leeds (U.K.).

TABLE 7. PRIMARY FREQUENCY STANDARDS USED AS CLOCKS

Five primary frequency standards were used as clocks in 1990: NRC CsV, NRC CsVI A and C, and PTB CS1 and CS2. The following table gives the time differences in microseconds, between TAI and these laboratory standards.

TAI-LAB.STD.

DATE 1990 0hUTC	MJD	PTB (1)		NRC (2)		
		CS1	CS2	CsV	CsVI A	CsVI C
Jan 8	47899	3.773	0.877	28.091	15.624	23.611
Jan 18	47909	3.769	0.853	27.827	15.485	23.701
Jan 28	47919	3.778	0.817	27.600	15.362	23.702
Feb 7	47929	3.787	0.810	27.359	15.422	23.679
Feb 17	47939	3.756	0.768	27.081	15.282	23.640
Feb 27	47949	3.739	0.699	26.848	15.152	23.600
Mar 9	47959	3.735	0.665	26.601	15.022	23.614
Mar 19	47969	3.734	0.638	26.670	14.937	23.612
Mar 29	47979	3.720	0.625	26.562	14.891	23.502
Apr 8	47989	3.722	0.586	26.649	14.834	23.641
Apr 18	47999	3.707	0.559	26.852	14.841	23.712
Apr 28	48009	3.698	0.495	27.077	14.854	23.737
May 8	48019	3.693	0.434	27.291	14.887	23.743
May 18	48029	3.703	0.384	27.478	15.005	23.651
May 28	48039	3.712	0.394	27.666	19.154	23.541
Jun 7	48049	3.706	0.385	27.785	19.093	22.298
Jun 17	48059	3.713	0.368	27.855	19.009	19.374
Jun 27	48069	3.699	0.319	27.978	18.922	19.037
Jul 7	48079	3.709	0.275	28.086	18.896	18.143
Jul 17	48089	3.709	0.250	28.141	18.877	17.884
Jul 27	48099	3.717	0.247	28.210	18.854	17.833
Aug 6	48109	3.722	0.270	28.285	18.813	17.765
Aug 16	48119	3.727	0.256	28.132	18.797	17.724
Aug 26	48129	3.746	0.223	27.971	18.723	17.648
Sep 5	48139	3.739	0.175	27.820	18.666	17.591
Sep 15	48149	3.741	0.113	27.680	18.586	17.524
Sep 25	48159	3.730	0.063	27.586	18.545	17.490
Oct 5	48169	3.729	0.018	27.514	18.564	17.446
Oct 15	48179	3.722	-0.007	27.420	18.620	17.455
Oct 25	48189	3.751	-0.015	27.371	18.669	17.421
Nov 4	48199	3.728	-0.030	27.323	18.699	17.356
Nov 14	48209	3.714	-0.044	27.283	18.751	17.314
Nov 24	48219	3.697	-0.049	27.173	18.811	17.280
Dec 4	48229	3.684	-0.039	27.195	18.883	17.254
Dec 14	48239	3.651	-0.065	27.275	18.954	17.155
Dec 24	48249	3.657	-0.072	27.300	19.006	16.998

TABLE 7. (CONT.)

NOTES

(1) The time scales under the headings PTB CS1, CS2 are coordinate time scales at sea level derived from the scales of proper time produced by standards CS1 and CS2 of PTB. The gravitational correction is -0.00066µs/d .

(2) The time scales under the headings NRC Cs V, Cs VI A, Cs VI C, are the scales of proper time PT(NRC Cs V), PT(NRC Cs VI A), PT(NRC Cs VI C), produced directly by primary frequency standards Cs V, Cs VI A, Cs VI C, of NRC used as clocks. The gravitational frequency correction to these time scales of proper time to obtain coordinate times at sea level is -0.00097µs/d .

TABLE 8A. UTC - UTC(k)

The following table gives the values of UTC-UTC(k), where UTC(k) denotes the approximation to UTC kept by laboratory k. The values are rounded to 10 ns for laboratories linked via LORAN-C or television.

Unit is one microsecond.

DATE 1990 0hUTC	MJD	UTC - UTC(k) AOS (1)	APL (2)	ASMW (3)	AUS	BEV (4)	CAO
Jan 8	47899	-2.10	0.104	0.27	-1.107	-	12.95
Jan 18	47909	-0.88	0.120	0.14	-1.212	-	13.18
Jan 28	47919	0.67	0.270	-0.07	-1.275	-	13.51
Feb 7	47929	1.55	0.382	-0.25	-1.309	-	-
Feb 17	47939	1.11	0.469	-0.32	-1.348	-	10.44
Feb 27	47949	1.07	0.545	-0.31	-1.343	-10.11	11.93
Mar 9	47959	0.46	0.681	-0.27	-1.315	-10.31	12.15
Mar 19	47969	-0.41	0.799	-0.21	-1.276	-10.64	10.59
Mar 29	47979	-0.94	0.955	-0.10	-1.217	8.60	9.63
Apr 8	47989	-1.56	1.098	0.02	-1.162	8.19	8.90
Apr 18	47999	-2.14	1.244	0.20	-1.063	7.58	-
Apr 28	48009	-2.67	1.297	0.28	-1.010	7.10	8.54
May 8	48019	-3.34	0.458	0.27	-0.936	6.43	8.29
May 18	48029	-3.94	0.476	0.04	-0.853	6.18	8.80
May 28	48039	-4.59	0.494	-0.15	-0.778	5.75	8.61
Jun 7	48049	-6.01	0.504	-0.18	-0.707	4.39	8.23
Jun 17	48059	-7.08	0.398	-0.14	-0.655	3.78	8.01
Jun 27	48069	-8.47	0.354	-0.14	-0.620	3.16	7.69
Jul 7	48079	-10.02	0.481	-0.38	-0.572	2.52	7.36
Jul 17	48089	-11.41	0.315	-0.43	-0.536	2.64	7.06
Jul 27	48099	-12.72	0.169	-0.28	-0.505	-	6.77
Aug 6	48109	5.56	0.182	-0.16	-0.468	-	6.52
Aug 16	48119	3.78	-0.034	-0.01	-0.423	-	6.25
Aug 26	48129	1.97	-0.128	0.03	-0.382	-	5.68
Sep 5	48139	1.10	-0.222	0.04	-0.336	-	5.29
Sep 15	48149	0.05	-0.289	-0.02	-0.302	-	4.76
Sep 25	48159	-1.36	-0.314	-0.09	-0.258	3.80	4.20
Oct 5	48169	-2.80	-0.351	-	-0.233	3.01	3.93
Oct 15	48179	-4.31	-0.400	-	-0.181	2.26	3.50
Oct 25	48189	-5.80	-0.440	-	-0.121	1.49	3.16
Nov 4	48199	-7.30	-0.466	-	-0.076	0.77	2.81
Nov 14	48209	-8.92	-0.491	-	-0.021	0.10	2.46
Nov 24	48219	-11.04	-0.538	-	0.024	-0.44	2.27
Dec 4	48229	-12.35	-0.544	-	0.068	-1.08	1.98
Dec 14	48239	6.16	-0.615	-	0.090	-1.55	1.77
Dec 24	48249	4.66	-0.657	-	0.108	-2.38	-

TABLE 8A. (CONT.)

Unit is one microsecond.

DATE 1990 0hUTC	MJD	UTC - UTC(k) CH	CRL	CSAO	DPT	FTZ	IEN
Jan 8	47899	-1.098	-0.764	-3.39	-17.922	16.44	-0.356
Jan 18	47909	-1.153	-0.704	-3.51	-18.246	16.44	-0.446
Jan 28	47919	-1.195	-0.662	-3.69	-18.563	16.42	-0.551
Feb 7	47929	-1.146	-0.635	-4.16	-18.895	16.36	-0.676
Feb 17	47939	-1.054	-0.611	-4.52	-19.193	16.31	-0.825
Feb 27	47949	-0.967	-0.585	-4.76	-19.456	16.34	-0.962
Mar 9	47959	-0.882	-0.533	-5.02	-19.750	16.49	-0.955
Mar 19	47969	-0.790	-0.502	-5.35	-19.972	16.47	-0.926
Mar 29	47979	-0.697	-0.461	-5.64	-20.184	16.41	-0.905
Apr 8	47989	-0.621	-0.416	-5.97	-20.447	16.45	-0.896
Apr 18	47999	-0.524	-0.363	-6.13	-20.671	16.43	-0.905
Apr 28	48009	-0.449	-0.323	-6.39	-20.834	16.46	-0.905
May 8	48019	-0.373	-0.254	-6.65	-20.982	16.44	-0.905
May 18	48029	-0.286	-0.173	-6.68	-21.066	16.38	-0.908
May 28	48039	-0.198	-0.099	-6.88	-21.173	16.43	-0.918
Jun 7	48049	-0.116	-0.027	-7.09	-21.183	16.46	-0.904
Jun 17	48059	-0.015	0.046	-7.36	-21.223	16.43	-0.863
Jun 27	48069	0.024	0.099	-7.49	-21.271	16.56	-0.857
Jul 7	48079	0.044	0.147	-7.62	-21.279	16.57	-0.833
Jul 17	48089	0.052	0.208	-7.67	-21.336	16.59	-0.822
Jul 27	48099	0.076	0.284	-7.76	-21.362	16.56	-0.775
Aug 6	48109	0.082	0.364	-7.93	-21.456	16.57	-0.687
Aug 16	48119	0.105	0.435	-8.03	-21.531	16.61	-0.529
Aug 26	48129	0.137	0.465	-7.92	-21.581	16.61	-0.360
Sep 5	48139	0.166	0.506	-8.08	-21.597	16.58	-0.225
Sep 15	48149	0.200	0.542	-7.89	-21.745	16.68	-0.087
Sep 25	48159	0.241	0.606	-7.63	-21.837	16.69	0.055
Oct 5	48169	0.270	0.677	-7.35	-	16.86	0.198
Oct 15	48179	0.284	0.762	-7.20	-	17.05	0.345
Oct 25	48189	0.336	0.856	-7.13	-22.142	17.20	0.496
Nov 4	48199	0.369	0.938	-6.92	-22.318	17.38	0.625
Nov 14	48209	0.386	1.030	-6.71	-22.490	17.53	0.744
Nov 24	48219	0.426	1.130	-6.51	-22.655	17.74	0.856
Dec 4	48229	0.484	1.219	-6.40	-22.835	17.93	0.788
Dec 14	48239	0.539	1.292	-6.32	-23.069	18.12	0.669
Dec 24	48249	0.616	1.365	-6.25	-23.291	18.33	0.555

TABLE 8A. (CONT.)

Unit is one microsecond.

DATE 1990 0hUTC	MJD	UTC - UTC(k) IFAG (5)	IGMA (6)	INPL	INTI (7)	JATC	KSRI (8)
Jan 8	47899	0.816	9.304	149.095	-	-10.61	-8.091
Jan 18	47909	0.608	9.362	150.702	-	-10.93	-7.857
Jan 28	47919	0.473	9.501	152.285	-	-11.21	-7.817
Feb 7	47929	0.467	9.423	153.837	-	-11.58	-7.641
Feb 17	47939	0.374	9.397	155.677	-	-12.03	-52.859
Feb 27	47949	0.329	9.404	157.348	-	-12.40	-53.877
Mar 9	47959	-1.672	9.352	159.096	-	-12.85	-54.790
Mar 19	47969	-1.678	9.460	161.040	-	-13.32	-55.645
Mar 29	47979	-1.544	9.412	163.093	-	-13.79	-56.506
Apr 8	47989	-1.431	9.404	165.194	-	-14.38	-57.326
Apr 18	47999	-1.324	9.436	167.348	-	-14.99	-58.203
Apr 28	48009	-1.196	9.453	169.555	-	-15.47	-59.045
May 8	48019	-1.104	9.491	171.637	-	-16.07	-59.887
May 18	48029	-1.081	9.512	173.731	-	-16.56	-60.637
May 28	48039	-0.977	9.467	175.756	-	-17.24	-61.381
Jun 7	48049	-0.966	9.444	177.804	-	-17.85	-62.272
Jun 17	48059	-0.933	9.489	179.878	-	-18.50	-63.147
Jun 27	48069	-0.735	9.495	182.187	-	-19.05	-64.057
Jul 7	48079	-0.602	9.393	-	-	-19.26	-64.961
Jul 17	48089	-0.312	9.307	-	-	-19.30	-65.804
Jul 27	48099	0.034	9.334	-	-	-19.36	-66.664
Aug 6	48109	0.506	9.410	5.322	-	-19.37	-67.488
Aug 16	48119	0.762	9.415	4.167	-	-19.38	-68.346
Aug 26	48129	0.960	9.414	3.018	-	-19.25	-69.200
Sep 5	48139	1.071	9.414	1.863	-	-19.26	-70.048
Sep 15	48149	1.144	9.399	0.695	-	-18.96	-70.900
Sep 25	48159	1.392	9.392	-0.463	-	-18.30	-71.783
Oct 5	48169	1.547	9.419	-1.188	-	-18.34	-72.497
Oct 15	48179	1.848	9.442	-1.929	-	-18.23	-73.384
Oct 25	48189	1.960	9.530	-2.674	-	-18.23	-74.280
Nov 4	48199	2.168	9.658	-3.481	-	-18.20	-75.194
Nov 14	48209	2.253	9.827	-4.291	-	-18.24	-76.114
Nov 24	48219	2.293	9.968	-4.535	-	-18.35	-76.996
Dec 4	48229	2.525	10.160	-5.510	-	-18.64	-77.906
Dec 14	48239	2.561	10.179	-	-	-18.82	-78.833
Dec 24	48249	2.612	10.312	-	-	-19.15	-79.771

TABLE 8A. (CONT.)

Unit is one microsecond.

DATE 1990 0hUTC	MJD	UTC - UTC(k) LDS	NAOM (9)	NIM	NIST	NPL	NPLI (10)
Jan 8	47899	-	-0.711	9.33	0.218	-2.185	-20.086
Jan 18	47909	-	-0.911	9.36	0.263	-2.199	-20.611
Jan 28	47919	-	-1.174	9.31	0.314	-2.250	-21.154
Feb 7	47929	-	-1.951	9.27	0.346	-2.298	-21.660
Feb 17	47939	-	-2.186	9.19	0.352	-2.307	-22.218
Feb 27	47949	-	-2.413	9.01	0.374	-2.295	-22.794
Mar 9	47959	-	-2.588	9.04	0.403	-2.325	-23.338
Mar 19	47969	-	-2.794	9.02	0.439	-2.285	-23.944
Mar 29	47979	-	-3.020	8.98	0.460	-2.294	-24.469
Apr 8	47989	-	-3.282	9.00	0.471	-2.345	-24.981
Apr 18	47999	-	-3.528	9.02	0.502	-2.356	-25.459
Apr 28	48009	-	-3.763	8.98	0.508	-2.342	-26.040
May 8	48019	-	-3.970	8.87	0.501	-2.362	-
May 18	48029	-	-4.093	8.90	0.491	-2.407	-28.802
May 28	48039	-	-4.229	9.19	0.465	-2.482	-29.246
Jun 7	48049	-	-4.283	9.40	0.439	-2.501	-29.405
Jun 17	48059	-	-4.274	9.43	0.412	-2.455	-29.572
Jun 27	48069	-	-4.337	9.44	0.356	-2.333	-29.552
Jul 7	48079	-	-4.427	9.44	0.311	-2.146	-29.470
Jul 17	48089	-	-4.497	9.46	0.250	-1.942	-29.354
Jul 27	48099	-	-4.520	9.47	0.183	-1.755	-29.014
Aug 6	48109	-	-4.555	9.63	0.110	-1.516	-28.805
Aug 16	48119	-8.430	-4.591	9.61	0.036	-1.379	-28.522
Aug 26	48129	-9.796	-4.684	9.48	-0.040	-1.213	-
Sep 5	48139	-11.167	-4.779	9.14	-0.101	-1.020	-29.028
Sep 15	48149	-12.553	-4.917	9.09	-0.167	-0.930	-29.857
Sep 25	48159	-13.987	-4.996	9.17	-0.217	-0.925	-30.424
Oct 5	48169	-15.407	-5.110	8.91	-0.260	-0.946	-31.954
Oct 15	48179	-16.875	-5.261	8.62	-0.288	-0.885	-31.807
Oct 25	48189	-18.278	-5.427	8.39	-0.314	-0.732	-31.737
Nov 4	48199	-19.821	-5.543	8.55	-0.363	-0.716	-31.727
Nov 14	48209	-21.346	-5.632	8.46	-0.409	-0.763	-31.698
Nov 24	48219	-22.840	-5.626	7.98	-0.466	-0.725	-31.506
Dec 4	48229	-24.364	-5.716	7.66	-0.498	-0.789	-31.233
Dec 14	48239	-25.866	-5.826	7.79	-0.543	-0.899	-30.983
Dec 24	48249	-27.370	-5.907	7.51	-0.576	-1.008	-30.569

TABLE 8A. (CONT.)

Unit is one microsecond.

DATE 1990 0hUTC	MJD	UTC - UTC(k) NRC (11)	NRLM	OMH (12)	ONRJ	ONBA (13)	OP
Jan 8	47899	-0.789	-35.517	1.11	11.135	-	-0.218
Jan 18	47909	-0.762	-34.711	0.50	11.364	-	-0.243
Jan 28	47919	-0.711	-33.929	-0.71	11.702	-	-0.295
Feb 7	47929	-0.677	-33.232	-	11.892	-	-0.326
Feb 17	47939	-0.643	-32.531	-	11.998	-	-0.390
Feb 27	47949	-0.599	-31.990	-	11.954	-	-0.467
Mar 9	47959	-0.555	-31.507	1.13	12.008	-	-0.526
Mar 19	47969	-0.466	-30.960	1.22	11.955	-	-0.581
Mar 29	47979	-0.338	-30.490	1.19	11.853	-	-0.654
Apr 8	47989	-0.222	-30.050	1.32	11.634	-	-0.683
Apr 18	47999	-0.041	-29.466	1.39	-	-	-0.666
Apr 28	48009	0.146	-28.795	1.62	11.702	-	-0.650
May 8	48019	0.353	-28.215	1.28	11.654	-	-0.655
May 18	48029	0.645	-27.680	1.33	11.804	-	-0.642
May 28	48039	0.841	-27.181	1.47	12.005	-	-0.581
Jun 7	48049	0.937	-26.671	1.90	12.242	-	-0.540
Jun 17	48059	1.017	-25.974	1.71	12.368	-	-0.496
Jun 27	48069	1.150	-25.365	1.84	12.313	-	-0.479
Jul 7	48079	1.268	-24.758	1.37	12.323	-	-0.419
Jul 17	48089	1.332	-24.183	1.20	12.395	-	-0.386
Jul 27	48099	1.411	-23.696	1.27	12.268	-	-0.394
Aug 6	48109	1.495	-23.242	1.35	11.794	-	-0.408
Aug 16	48119	1.352	-22.863	1.46	11.484	-	-0.427
Aug 26	48129	1.201	-22.471	1.59	11.215	-	-0.415
Sep 5	48139	1.060	-22.188	1.61	10.893	-	-0.428
Sep 15	48149	0.930	-22.049	1.42	10.635	-	-0.431
Sep 25	48159	0.845	-21.914	1.47	10.207	-	-0.406
Oct 5	48169	0.783	-21.828	-	9.825	-	-0.407
Oct 15	48179	0.700	-21.766	1.24	9.784	-	-0.364
Oct 25	48189	0.659	-21.648	-	9.839	-	-0.302
Nov 4	48199	0.621	-21.632	0.94	9.865	-	-0.263
Nov 14	48209	0.591	-21.713	1.53	9.985	-	-0.228
Nov 24	48219	0.490	-21.711	1.69	9.991	-	-0.204
Dec 4	48229	0.522	-21.775	2.08	9.765	-	-0.194
Dec 14	48239	0.611	-21.902	2.33	9.611	-	-0.230
Dec 24	48249	0.646	-22.287	2.27	-	-	-0.257

TABLE 8A. (CONT.)

Unit is one microsecond.

DATE 1990 OhUTC	MJD	UTC - UTC(k) ORB	PEL	PKNM	PTB	RC	ROA
Jan 8	47899	5.046	-	-1.92	3.789	-2.09	9.875
Jan 18	47909	5.086	-	-2.59	3.785	-1.93	9.827
Jan 28	47919	5.122	1.719	-2.90	3.732	-1.80	9.779
Feb 7	47929	5.167	-	-3.25	3.766	-1.82	9.656
Feb 17	47939	5.227	-	-3.25	3.774	-1.91	9.619
Feb 27	47949	5.332	-	-3.51	3.752	-2.17	9.586
Mar 9	47959	5.452	-	-3.97	3.737	-2.22	9.557
Mar 19	47969	5.607	-	-4.65	3.733	-2.31	9.453
Mar 29	47979	5.739	-	-5.30	3.713	-2.62	9.280
Apr 8	47989	5.945	-	-5.79	3.699	-2.83	9.237
Apr 18	47999	6.175	-	-6.38	3.712	-3.00	9.100
Apr 28	48009	6.370	-	-6.84	3.700	-3.11	9.048
May 8	48019	6.565	-	-7.32	3.695	-3.41	8.921
May 18	48029	6.749	-	-6.98	3.704	-3.52	8.888
May 28	48039	6.975	-	-6.59	3.714	-3.62	8.861
Jun 7	48049	7.257	-	-6.23	3.708	-3.44	8.779
Jun 17	48059	7.477	-	-5.72	3.715	-3.36	8.707
Jun 27	48069	7.685	-	-5.49	3.701	-3.37	8.600
Jul 7	48079	7.897	-	-5.19	3.711	-3.25	8.506
Jul 17	48089	8.106	-	-4.74	3.711	-3.45	8.388
Jul 27	48099	8.350	-	-4.10	3.719	-3.42	8.292
Aug 6	48109	8.629	-	-3.53	3.724	-3.43	8.195
Aug 16	48119	8.858	-	-3.15	3.729	-3.42	8.075
Aug 26	48129	9.097	-	-2.61	3.748	-3.47	7.963
Sep 5	48139	9.339	-	-1.72	3.740	-3.35	7.845
Sep 15	48149	9.549	-	-0.95	3.743	-3.35	7.759
Sep 25	48159	9.807	-	-0.28	3.732	-3.09	7.728
Oct 5	48169	10.096	-	0.45	3.731	-3.12	7.771
Oct 15	48179	10.353	-	1.24	3.724	-3.25	7.854
Oct 25	48189	10.646	-	2.09	3.753	-3.44	7.911
Nov 4	48199	10.952	-	2.71	3.731	-3.45	7.933
Nov 14	48209	11.264	-	3.25	3.716	-3.55	7.952
Nov 24	48219	11.543	-	3.87	3.699	-3.41	7.985
Dec 4	48229	11.838	-	4.38	3.685	-3.44	7.997
Dec 14	48239	12.153	-	4.79	3.653	-3.28	7.963
Dec 24	48249	12.574	-	5.41	3.658	-3.13	7.912

TABLE 8A. (CONT.)

Unit is one microsecond.

DATE 1990 0hUTC	MJD MJD	UTC - UTC(k) SO	STA	SU (14)	TAO	TL (15)	TP
Jan 8	47899	3.87	0.334	11.31	-4.866	1.161	1.66
Jan 18	47909	3.96	0.335	11.19	-4.922	0.902	1.54
Jan 28	47919	4.01	0.316	11.14	-4.950	0.826	1.45
Feb 7	47929	4.10	0.291	11.00	-4.979	1.021	1.33
Feb 17	47939	4.02	0.282	10.79	-5.011	1.269	0.97
Feb 27	47949	3.85	0.304	10.81	-5.063	1.531	0.98
Mar 9	47959	3.86	0.288	10.83	-4.910	1.727	0.71
Mar 19	47969	3.90	0.236	10.68	-4.741	1.902	0.70
Mar 29	47979	3.83	0.204	10.70	-4.551	2.099	0.79
Apr 8	47989	3.83	0.134	10.73	-4.345	2.313	0.76
Apr 18	47999	3.75	0.041	10.70	-4.194	2.181	0.56
Apr 28	48009	3.77	-0.017	10.39	-4.013	2.362	0.73
May 8	48019	3.73	-0.060	10.16	-3.831	2.511	-0.04
May 18	48029	3.61	-0.108	10.07	-3.625	2.698	-0.23
May 28	48039	3.69	-0.538	10.11	-3.401	2.890	0.26
Jun 7	48049	3.64	-0.569	10.11	-3.162	3.075	0.52
Jun 17	48059	3.46	-0.486	10.11	-2.960	3.274	0.14
Jun 27	48069	3.34	-0.412	9.93	-2.774	3.485	-0.30
Jul 7	48079	3.40	-0.299	10.01	-2.579	3.722	-0.98
Jul 17	48089	3.36	-0.187	10.02	-2.378	4.000	-0.70
Jul 27	48099	3.34	0.077	9.86	-2.152	4.298	-0.22
Aug 6	48109	3.31	0.268	9.75	-1.937	4.506	-0.04
Aug 16	48119	3.42	0.462	9.67	-1.723	4.606	0.24
Aug 26	48129	3.42	0.559	9.52	-1.563	4.476	0.23
Sep 5	48139	3.19	0.537	9.16	-1.354	4.318	0.09
Sep 15	48149	3.21	0.298	9.20	-1.180	4.135	0.04
Sep 25	48159	3.06	0.107	9.02	-0.993	3.964	0.28
Oct 5	48169	2.98	-0.117	9.01	-0.814	3.798	0.40
Oct 15	48179	2.78	-0.374	9.00	-0.603	3.632	0.64
Oct 25	48189	2.82	-0.579	8.90	-0.400	3.499	0.99
Nov 4	48199	2.65	-0.709	8.76	-0.190	3.264	1.39
Nov 14	48209	2.64	-0.635	8.71	0.029	2.927	1.53
Nov 24	48219	2.60	-0.546	8.54	0.268	2.681	1.47
Dec 4	48229	2.35	-0.464	8.26	0.504	2.488	1.39
Dec 14	48239	2.30	-0.388	8.20	0.728	2.244	1.40
Dec 24	48249	2.08	-0.306	8.15	0.751	2.016	1.34

TABLE 8A. (CONT.)

Unit is one microsecond.

DATE 1990 0hUTC	MJD	UTC - UTC(k) TUG (16)	USNO (17)	VSL	YUZM (18)	ZIPE
Jan 8	47899	4.699	-1.107	2.300	18.39	0.26
Jan 18	47909	-4.035	-1.212	2.369	17.83	0.15
Jan 28	47919	-3.772	-1.275	2.417	17.58	0.02
Feb 7	47929	-3.517	-1.309	2.458	17.62	-0.03
Feb 17	47939	-3.318	-1.348	2.436	17.18	-0.07
Feb 27	47949	-3.138	-1.343	2.492	17.16	-0.20
Mar 9	47959	-2.918	-1.315	2.526	17.11	-0.37
Mar 19	47969	-2.669	-1.276	2.602	16.91	-0.38
Mar 29	47979	-2.392	-1.217	2.669	17.07	-0.24
Apr 8	47989	-2.117	-1.162	2.693	17.13	-0.08
Apr 18	47999	-1.854	-1.063	2.726	16.41	0.05
Apr 28	48009	-1.599	-1.010	2.722	16.19	0.03
May 8	48019	-1.323	-0.936	2.748	15.80	0.04
May 18	48029	-1.085	-0.853	2.741	15.97	-0.01
May 28	48039	-0.840	-0.778	2.764	16.42	-0.13
Jun 7	48049	-0.556	-0.707	2.803	16.63	-0.17
Jun 17	48059	-0.272	-0.655	2.833	17.18	-0.28
Jun 27	48069	0.004	-0.620	2.874	17.85	-0.27
Jul 7	48079	0.282	-0.572	2.901	18.54	-0.29
Jul 17	48089	0.482	-0.536	2.977	19.34	-0.18
Jul 27	48099	0.739	-0.505	3.125	20.06	0.02
Aug 6	48109	0.998	-0.468	3.304	25.92	0.15
Aug 16	48119	1.244	-0.423	3.425	26.77	0.30
Aug 26	48129	1.505	-0.382	3.528	27.23	0.32
Sep 5	48139	1.756	-0.336	3.645	27.79	0.34
Sep 15	48149	1.971	-0.302	3.713	27.97	0.27
Sep 25	48159	2.214	-0.258	3.721	28.11	0.01
Oct 5	48169	2.462	-0.233	3.779	28.46	0.06
Oct 15	48179	2.709	-0.181	3.797	28.65	0.10
Oct 25	48189	2.962	-0.121	3.838	28.64	0.08
Nov 4	48199	3.240	-0.076	3.801	28.69	0.09
Nov 14	48209	3.484	-0.021	3.899	28.69	0.09
Nov 24	48219	3.763	0.024	3.911	28.33	-0.10
Dec 4	48229	4.029	0.068	3.945	28.22	-0.03
Dec 14	48239	4.275	0.090	3.985	27.82	0.02
Dec 24	48249	-4.442	0.108	4.056	27.59	0.03

TABLE 8A. (CONT.)

NOTES

(1) AOS . Time steps of UTC(AOS) of -20 μs on MJD = 48104 and MJD = 48233.57

(2) APL . Time step of UTC(APL) of 0.831 μs on MJD = 48011.

(3) ASMW. As a consequence of the unification of Germany the ASMW became a part of the PTB on 1990 October 3rd.

(4) BEV . Time step of UTC(BEV) of -20 μs on MJD = 47972.59

(5) IFAG. Time step of UTC(IFAG) of 2 μs on MJD = 47949.37

(6) IGMA. The following table gives UTC-UTC(IGMA) for 1989. Changes of master clock on MJD = 47610 and MJD = 47840.

MJD	UTC-UTC(IGMA)	MJD	UTC-UTC(IGMA)	MJD	UTC-UTC(IGMA)
47529	5.702	47659	10.248	47779	8.484
47539	6.362	47669	10.010	47789	8.301
47549	7.063	47679	9.976	47799	8.178
47559	7.826	47689	9.850	47809	8.125
47569	8.506	47699	9.716	47819	8.026
47579	9.124	47709	9.559	47829	7.873
47589	9.703	47719	9.399	47839	7.756
47599	10.314	47729	9.197	47849	8.199
47609	10.921	47739	9.046	47859	8.194
47619	10.819	47749	8.858	47869	8.425
47629	10.730	47759	8.715	47879	8.706
47639	10.590	47769	8.610	47889	9.051
47649	10.443				

(7) INTI. The following table gives UTC-UTC(INTI) for 1989.

MJD	UTC-UTC(INTI)	MJD	UTC-UTC(INTI)	MJD	UTC-UTC(INTI)
47529	18.22	47659	19.68	47779	-
47539	18.54	47669	19.98	47789	-
47549	18.97	47679	19.67	47799	-
47559	19.51	47689	19.70	47809	-
47569	19.48	47699	19.85	47819	-
47579	19.17	47709	-	47829	-
47589	19.30	47719	-	47839	-
47599	19.18	47729	-	47849	-
47609	19.37	47739	-	47859	-
47619	19.68	47749	-	47869	-
47629	19.64	47759	-	47879	-
47639	19.68	47769	-	47889	-
47649	19.66				

TABLE 8A. (CONT.)

(8) KSRI. Change of master clock on MJD = 47934.1

(9) NAOM. Time step of UTC(NAOM) of -35 μs on MJD = 47891.99
The apparent time step of UTC(NAOM) of about 0.500 μs between MJD = 47919 and MJD = 47929 results from a change of GPS receiver at NAOM on MJD = 47923.
Change of master clock on MJD = 48195.

(10) NPLI. Time step of UTC(NPLI) of 1.3 μs on MJD = 48166.5

(11) NRC . Time step of UTC(NRC) of -15 μs on MJD = 47892.

(12) OMH . Time step of UTC(OMH) of -10 μs on MJD = 47893.625

(13) ONBA. The following table gives UTC-UTC(ONBA) for 1989.

MJD	UTC-UTC(ONBA)	MJD	UTC-UTC(ONBA)	MJD	UTC-UTC(ONBA)
47529	-19.20	47659	-34.03	47779	-40.60
47539	-20.65	47669	-35.69	47789	-41.85
47549	-21.82	47679	-36.56	47799	-43.16
47559	-22.94	47689	-36.96	47809	-44.11
47569	-23.16	47699	-37.13	47819	-44.48
47579	-23.20	47709	-38.16	47829	-45.12
47589	-24.12	47719	-38.84	47839	-46.42
47599	-24.34	47729	-39.48	47849	-47.59
47609	-26.53	47739	-	47859	-48.73
47619	-29.40	47749	-	47869	-49.78
47629	-30.33	47759	-38.29	47879	-51.07
47639	-31.17	47769	-39.61	47889	-52.23
47649	-32.38				

(14) SU . From MJD = 48069 time transfer data obtained from GLONASS satellite trackings at the University of Leeds (U.K.).

(15) TL . Change of master clock on MJD = 47894.083

(16) TUG . Time steps of UTC(TUG) of 9 μs on MJD = 47903.508 and MJD = 48244.326

(17) USNO. UTC(USNO) designates the scale UTC(USNO MC) of USNO.

(18) YUZM. Time step of UTC(YUZM) of -5 μs on MJD = 48103.5

TABLE 8B. TAI - GPS TIME AND UTC - GPS TIME

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

TAI - GPS time = 19s + C0,

where the time difference of 19 seconds is kept constant and C0 is a quantity of the order of a few hundreds 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:

until 1990 January 1, 0hUTC:

UTC - GPS time = -5s + C0,

from 1990 January 1, 0hUTC, until 1991 January 1, 0hUTC :

UTC - GPS time = -6s + C0,

from 1991 January 1, 0hUTC:

UTC - GPS time = -7s + C0.

Here C0 is given at 0hUTC every day.

C0 is computed as follows: the GPS data taken at OP are first corrected for the measured ionospheric delays. Then they are smoothed to obtain daily values of UTC(OP) - GPS time at 0hUTC. UTC - GPS time is derived from them using linear interpolation of UTC - UTC(OP) from Table 8A. The r values, also reported here, are the residuals to the smoothed data for the middle of the 13-minute tracking period. They show the quality of the synchronization.

UTC may be derived at any site from observation of any listed satellite, by interpolating C0 to the tracking time. The quality of access to UTC mainly depends upon local conditions of observation.

Note:

The reference times reported in the following tables are given for the first date of the table only. They correspond to mid-points of 13-minute trackings.

* corresponds to data rejected in the smoothing.
\- corresponds to missing data.

TABLE 8B. (CONT.)

Date 1989/90 0hUTC	MJD	C0 (ns)	r(ns) PRN11 NAV 8 11h48m	PRN14 NAV14 14h12m	PRN 6 NAV 3 18h28m	PRN 9 NAV 6 21h24m	PRN12 NAV10 22h12m	PRN13 NAV 9 23h12m	PRN 3 NAV11 0h36m
Dec 31	47891	-496	0	-	8	-6	2	2	5
Jan 1	47892	-506	-1	-	4	-16	19*	8	2
Jan 2	47893	-515	4	-	4	-14	-5	2	5
Jan 3	47894	-529	1	-	0	-12	5	16*	4
Jan 4	47895	-543	-3	-	1	-5	-1	-10	10
Jan 5	47896	-560	2	-	7	0	-9	1	4
Jan 6	47897	-575	8	-	-3	-10	9	-9	5
Jan 7	47898	-592	1	26*	13	-3	-8	11	-8
Jan 8	47899	-609	7	-2	-1	0	24*	5	-
Jan 9	47900	-623	-3	8	2	-2	1	-3	0
Jan 10	47901	-635	-3	26*	3	-11	-15	-6	4
Jan 11	47902	-644	3	16	19*	1	-3	5	0
Jan 12	47903	-656	-1	-4	1	-14	-3	-7	2
Jan 13	47904	-674	0	8	0	-17	-3	0	3
Jan 14	47905	-685	15	-	5	-6	-13	-1	2
Jan 15	47906	-687	18	-	-1	0	-1	-5	1
Jan 16	47907	-687	-2	-	1	-8	1	-5	-5
Jan 17	47908	-684	8	-	7	-1	-8	-4	-1
Jan 18	47909	-681	12	-	-2	-11	6	-17	0
Jan 19	47910	-682	13	-	1	-11	-6	1	1
Jan 20	47911	-684	13	-	-	-9	-8	-8	-5
Jan 21	47912	-687	11	9	3	-7	-3	-3	-3
Jan 22	47913	-694	10	10	3	-12	-3	-9	-2
Jan 23	47914	-705	10	0	16	-16	-4	-8	-4
Jan 24	47915	-719	10	19	-4	-11	-5	6	-5
Jan 25	47916	-735	12	230*	0	-1	7	-12	-2
Jan 26	47917	-752	14	-105*	-1	-15	-7	-16	-4
Jan 27	47918	-763	5	38*	10	0	4	5	7
Jan 28	47919	-763	-14*	-	1	14*	-1	11	-1
Jan 29	47920	-770	-11	-	4	7	-1	0	-5
Jan 30	47921	-786	-10	-	10	1	-15	-2	4
Jan 31	47922	-799	-9	-	-	-	-	-	-
Feb 1	47923	-805	7	-	15	23*	4	-11	-8

TABLE 8B. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN11 NAV 8 9h44m	PRN14 NAV14 12h 8m	PRN 6 NAV 3 16h24m	PRN 9 NAV 6 19h20m	PRN12 NAV10 20h 8m	PRN13 NAV 9 21h 8m	PRN 3 NAV11 22h28m
Jan 31	47922	-799	-9	-	-	-	-	-	-
Feb 1	47923	-805	7	-	15	23*	4	-11	-8
Feb 2	47924	-807	3	-	19	16*	11	7	-1
Feb 3	47925	-815	1	-	-3	-5	-14	-7	-14
Feb 4	47926	-833	8	27	7	1	35*	-1	-3
Feb 5	47927	-855	13	-2	-7	-19	25*	-9	-1
Feb 6	47928	-871	0	9	11	-12	15	11	7
Feb 7	47929	-881	4	-74*	-	-13	11	-16	0
Feb 8	47930	-900	-2	29	-3	-23	-9	-6	-4
Feb 9	47931	-924	11	-81*	2	-11	29*	-1	7
Feb 10	47932	-947	7	25	2	-15	-11	-1	-3
Feb 11	47933	-971	-1	-	2	-12	-9	-1	-2
Feb 12	47934	-991	1	-	6	-30*	10	-6	-3
Feb 13	47935	-1011	15	-	0	-6	6	-5	1
Feb 14	47936	-1036	9	-	2	-23	-18	0	-11
Feb 15	47937	-1059	21	-	11	-20	1	0	-8
Feb 16	47938	-1077	18	-	15	-22	-8	13	1
Feb 17	47939	-1094	12	-	4	-20	-10	-10	1
Feb 18	47940	-1117	19	-	1	-13	-10	-5	-5
Feb 19	47941	-1138	25	-	12	-9	3	-22	-6
Feb 20	47942	-1161	20	-	12	-2	-9	-18	-1
Feb 21	47943	-1186	23	-	8	-11	-5	-13	-9
Feb 22	47944	-1213	-	-	5	-	-1	-	-1
Feb 23	47945	-1236	15	-	0	-11	1	-15	-7
Feb 24	47946	-1257	11	-	6	-7	-4	-11	-4
Feb 25	47947	-1277	18	11	5	-12	6	2	-2
Feb 26	47948	-1304	10	11	-1	-3	-10	-4	-6
Feb 27	47949	-1339	6	22	-4	-11	-8	-5	-8
Feb 28	47950	-1371	12	21	0	-5	-3	3	3
Mar 1	47951	-1399	1	1	7	-16	26*	-3	7

TABLE 8B. (CONT.)

r(ns)

Date 1990 0hUTC	MJD	C0 (ns)	PRN11 NAV 8 7h52m	PRN14 NAV14 10h16m	PRN 6 NAV 3 14h32m	PRN 9 NAV 6 17h28m	PRN12 NAV10 18h16m	PRN13 NAV 9 19h16m	PRN 3 NAV11 20h36m
Feb 28	47950	-1371	11	20	-1	-6	-4	2	2
Mar 1	47951	-1399	1	1	7	-16	26*	-3	7
Mar 2	47952	-1422	8	-6	7	-4	-21	-2	-7
Mar 3	47953	-1436	2	16	5	1	0	-6	1
Mar 4	47954	-1449	-2	-	18	1	-7	7	-6
Mar 5	47955	-1463	-3	-	15	3	-17	-6	-3
Mar 6	47956	-1477	7	-	5	-11	3	-21	1
Mar 7	47957	-1484	2	-	19	-10	16	2	-9
Mar 8	47958	-1485	-2	-	10	-13	3	-10	-1
Mar 9	47959	-1485	-2	-	11	1	16	9	-7
Mar 10	47960	-1484	3	-	11	-6	-25	-27*	-4
Mar 11	47961	-1479	3	-13	9	0	6	12	-3
Mar 12	47962	-1470	1	-15	22	5	20	-13	3
Mar 13	47963	-1463	-5	15	-15	-4	7	3	-5
Mar 14	47964	-1460	-6	-13	8	-1	-14	13	3
Mar 15	47965	-1450	-	6	-19	12	1	25	2
Mar 16	47966	-1437	-5	-5	-24	-8	19	3	-1
Mar 17	47967	-1425	0	10	-15	9	23*	-5	2
Mar 18	47968	-1419	-3	-	-12	2	8	0	7
Mar 19	47969	-1413	-2	-	-6	4	-22	-4	-6
Mar 20	47970	-1404	8	-	-4	7	-22	20	21
Mar 21	47971	-1395	1	-	-6	2	19	-7	-3
Mar 22	47972	-1391	-6	-	-15	7	-26	0	-3
Mar 23	47973	-1386	-4	-	-3	5	3	23	3
Mar 24	47974	-1378	-6	-	0	7	1	11	-4
Mar 25	47975	-1372	-4	-117*	-10	7	-20	-5	10
Mar 26	47976	-1366	17	-138*	-4	-6	0	5	2
Mar 27	47977	-1361	-9	-222*	-7	-7	10	-1	16
Mar 28	47978	-1360	2	-26*	-26*	-	-12	17	3
Mar 29	47979	-1359	6	-84*	6	48*	0	-10	-1
Mar 30	47980	-1354	1	-132*	2	-43*	-12	24*	5
Mar 31	47981	-1345	-2	39*	-8	0	20	-5	10
Apr 1	47982	-1330	-5	-	1	3	-18	2	-2

TABLE 8B. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	PRN11 NAV 8 5h48m	PRN14 NAV14 8h12m	PRN 6 NAV 3 12h28m	PRN 9 NAV 6 15h24m	PRN12 NAV10 16h12m	PRN13 NAV 9 17h12m	PRN 3 NAV11 18h32m
			r(ns)						
Mar 31	47981	-1345	-2	39*	-8	0	20	-5	10
Apr 1	47982	-1330	-5	-	1	3	-18	2	-2
Apr 2	47983	-1316	5	-	-11	7	15	-4	6
Apr 3	47984	-1307	-3	-	-3	2	17	8	2
Apr 4	47985	-1305	-10	-	-31*	-5	12	-13	2
Apr 5	47986	-1304	-9	-	0	10	1	5	-2
Apr 6	47987	-1298	-5	-	5	9	-27*	8	-4
Apr 7	47988	-1292	10	-	-8	2	-34*	-14	-16
Apr 8	47989	-1287	5	85*	-8	14	20	-8	-29*
Apr 9	47990	-1275	8	296*	-3	4	-13	-6	-4
Apr 10	47991	-1265	5	-80*	-13	11	-6	7	33*
Apr 11	47992	-1253	1	217*	9	-2	0	-11	-1
Apr 12	47993	-1240	2	102*	6	7	-10	-6	4
Apr 13	47994	-1231	7	-25	0	6	-2	16	5
Apr 14	47995	-1226	4	-18	-4	-12	-2	-11	-3
Apr 15	47996	-1218	8	45*	4	0	6	-14	8
Apr 16	47997	-1205	15	186*	-9	-10	21	0	1
Apr 17	47998	-1195	-2	-35	7	-8	7	-17	8
Apr 18	47999	-1186	3	109*	-10	-3	1	4	-6
Apr 19	48000	-1177	-	102*	1	25*	-1	-10	7
Apr 20	48001	-1171	7	-116*	-11	-5	-2	0	5
Apr 21	48002	-1168	-2	-27	-7	179*	13	-38*	10
Apr 22	48003	-1162	-6	-	6	16	-12	10	8
Apr 23	48004	-1155	-3	-	-8	0	-12	-19	10
Apr 24	48005	-1147	-	-	-9	9	8	12	7
Apr 25	48006	-1142	-	-	12	-3	-15	-12	3
Apr 26	48007	-1140	-1	-	-1	-1	4	-8	5
Apr 27	48008	-1130	-2	-	3	7	8	-14	7
Apr 28	48009	-1118	3	-	1	-1	-10	-19	3
Apr 29	48010	-1111	5	36*	5	24	2	-16	2
Apr 30	48011	-1107	1	84*	1	1	7	23*	2
May 1	48012	-1107	-11	227*	3	-6	4	-12	8

TABLE 8B. (CONT.)

r(ns)

Date 1990 0hUTC	MJD	C0 (ns)	PRN11 NAV 8 3h 0m	PRN14 NAV14 6h12m	PRN 6 NAV 3 10h28m	PRN 9 NAV 6 13h24m	PRN12 NAV10 14h12m	PRN13 NAV 9 15h12m	PRN 3 NAV11 16h32m
Apr 30	48011	-1107	1	84*	1	1	7	23*	2
May 1	48012	-1107	-11	227*	3	-6	4	-12	8
May 2	48013	-1099	0	94*	-4	2	14*	-12	7
May 3	48014	-1091	-	-127*	4	9	4	-10	-3
May 4	48015	-1086	-11	-19	5	18	-18	-8	4
May 5	48016	-1082	-12	-52*	16	18	20*	-12	3
May 6	48017	-1076	-16	-	2	6	6	-14	6
May 7	48018	-1073	-4	-	12	10	8	4	-5
May 8	48019	-1073	-12	-	2	12	-3	-12	0
May 9	48020	-1071	-4	-	-1	6	33*	-17	1
May 10	48021	-1063	9	-	9	8	-24	-15	8
May 11	48022	-1051	5	-	4	7	3	0	3
May 12	48023	-1042	-2	-	3	14	-13	-22	1
May 13	48024	-1031	5	-85*	3	17	-6	-19	-1
May 14	48025	-1016	9	-1184*	3	13	-22	-3	5
May 15	48026	-1002	3	236*	-2	10	3	-10	-11
May 16	48027	-991	5	154*	14	6	-11	-17	5
May 17	48028	-981	2	-132*	3	1	-15	-15	4
May 18	48029	-971	4	171*	-4	7	-2	1	-2
May 19	48030	-955	-	-109*	8	2	-17	-11	10
May 20	48031	-942	-5	-	3	7	8	-8	1
May 21	48032	-929	-5	-	4	10	-2	-15	-2
May 22	48033	-914	7	-	18	30*	-21	-14	2
May 23	48034	-901	14	-	1	2	-12	-6	-4
May 24	48035	-890	-	50*	5	-1	2	-9	7
May 25	48036	-877	-	256*	-2	25	-20	-8	5
May 26	48037	-867	-	-91*	-3	7	-4	-17	-3
May 27	48038	-851	-	242*	5	20	-7	-	-
May 28	48039	-832	-	-2	0	7	-1	-41	-3
May 29	48040	-818	-	76*	2	12	-4	-	-
May 30	48041	-804	-	-35*	1	-2	25*	-33*	-
May 31	48042	-788	-	-70*	7	9	10	19*	-2
Jun 1	48043	-776	0	20	1	7	-7	-13	-3

TABLE 8B. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN11 NAV 8 0h56m	PRN14 NAV14 4h 8m	PRN 6 NAV 3 8h24m	PRN 9 NAV 6 11h20m	PRN12 NAV10 12h 8m	PRN13 NAV 9 13h 8m	PRN 3 NAV11 14h28m
May 31	48042	-788	-	-70*	7	9	10	19*	-2
Jun 1	48043	-776	0	20	1	7	-7	-13	-3
Jun 2	48044	-765	6	157*	0	10	-24*	-7	-9
Jun 3	48045	-749	-1	-128*	1	21	2	-23	0
Jun 4	48046	-730	1	-207*	9	21	-38*	-23	-8
Jun 5	48047	-714	2	38*	-4	18	3	-15	-7
Jun 6	48048	-700	-7	-48*	-2	11	-4	5	-1
Jun 7	48049	-686	8	89*	-8	15	-11	-15	-1
Jun 8	48050	-675	-1	-124*	0	13	15*	-4	-8
Jun 9	48051	-666	0	106*	-3	19	-13	-20	-3
Jun 10	48052	-653	2	69*	-4	6	2	-12	-2
Jun 11	48053	-632	1	-125*	-4	12	0	-2	-13

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN 6 NAV 3 7h36m	PRN 9 NAV 6 10h32m	PRN13 NAV 9 11h 4m	PRN12 NAV10 11h20m	PRN 3 NAV11 14h32m
Jun 12	48054	-624	0	26	-7	-8	-8
Jun 13	48055	-605	2	25	-9	24*	-18
Jun 14	48056	-584	-11	20	2	24*	-7
Jun 15	48057	-563	5	-11*	-20	14	-10
Jun 16	48058	-543	7	21	1	-10	-20
Jun 17	48059	-525	1	28	-14	8	-10
Jun 18	48060	-509	-3	14	-2	-8	-5
Jun 19	48061	-495	5	6	5	-6	-9
Jun 20	48062	-480	-4	18	-15	9	0
Jun 21	48063	-462	-9	13	-6	11	-9
Jun 22	48064	-444	1	15	6	-10	0
Jun 23	48065	-430	-2	9	-18	-3	-1
Jun 24	48066	-418	6	22	2	-12	-14
Jun 25	48067	-407	1	8	-5	-3	-4
Jun 26	48068	-394	-4	13	4	-8	-3
Jun 27	48069	-380	2	10	-5	8	-7
Jun 28	48070	-365	4	14	-2	-10	-6
Jun 29	48071	-351	4	16	1	-13	-64*
Jun 30	48072	-336	-2	29	-19	-26*	-4
Jul 1	48073	-320	-5	23	-9	-7	-6

TABLE 8B . (CONT.)

r(ns)

Date 1990 0hUTC	MJD	C0 (ns)	PRN 6 NAV 3 6h24m	PRN 9 NAV 6 9h20m	PRN13 NAV 9 9h52m	PRN12 NAV10 10h 8m	PRN 3 NAV11 13h20m
Jun 30	48072	-336	-2	29	-19	-26*	-4
Jul 1	48073	-320	-5	23	-9	-7	-6
Jul 2	48074	-309	2	19	-11	4	-6
Jul 3	48075	-305	-9	19	-11	-10	-2
Jul 4	48076	-305	-1	27	6	29*	-8
Jul 5	48077	-309	-2	10	-9	-11	-3
Jul 6	48078	-311	-6	14	3	34*	-6
Jul 7	48079	-310	-22*	18	-6	25*	-10
Jul 8	48080	-316	3	21	-14	-33*	2
Jul 9	48081	-327	-8	2	2	22*	-6
Jul 10	48082	-340	-1	-	-	-	-1
Jul 11	48083	-351	-4	22	-	-4	-10
Jul 12	48084	-359	-	9	-5	-25*	-12
Jul 13	48085	-364	-12	22	-1	16	-8
Jul 14	48086	-375	-3	13	-17	-31*	-2
Jul 15	48087	-389	-1	18	1	4	-6
Jul 16	48088	-405	-2	7	-3	-13	1
Jul 17	48089	-419	-10	-1	3	3	2
Jul 18	48090	-432	3	7	1	25*	-11
Jul 19	48091	-442	14	14	-7	-13	-8
Jul 20	48092	-453	4	15	1	3	-10
Jul 21	48093	-470	3	15	-11	2	-13
Jul 22	48094	-486	1	16	-15	-20*	-13
Jul 23	48095	-497	3	17	0	-39*	-6
Jul 24	48096	-508	-4	21	4	-8	-8
Jul 25	48097	-521	4	-29*	-4	-9	-12
Jul 26	48098	-534	-2	10	-3	21*	-3
Jul 27	48099	-542	12	6	-2	-21*	0
Jul 28	48100	-549	-2	24	-4	-	-13
Jul 29	48101	-554	-1	13	-14	-23*	0
Jul 30	48102	-555	0	57*	2	22*	3
Jul 31	48103	-557	7	-6	-5	9	-13
Aug 1	48104	-558	-3	21	2	-16	2

TABLE 8B . (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN 6 NAV 3 4h20m	PRN 9 NAV 6 7h16m	PRN13 NAV 9 7h48m	PRN12 NAV10 8h 4m	PRN 3 NAV11 11h16m
Jul 31	48103	-557	7	-6	-5	9	-13
Aug 1	48104	-558	-3	21	2	-16	2
Aug 2	48105	-562	-10	21	-3	3	-7
Aug 3	48106	-573	-4	20	3	-1	-19
Aug 4	48107	-583	-	15	-6	4	-14
Aug 5	48108	-589	-	22	6	-9	-5
Aug 6	48109	-590	-	35*	-3	32*	0
Aug 7	48110	-590	-	11	-2	-4	-2
Aug 8	48111	-585	-	6	1	3	-4
Aug 9	48112	-579	614*	19	-23*	3	-10
Aug 10	48113	-573	-21	13	16	-3	-1
Aug 11	48114	-568	-9	21	2	-25*	-8
Aug 12	48115	-565	-7	11	4	6	-2
Aug 13	48116	-562	-21	1	-1	0	8
Aug 14	48117	-553	-1	5	-24*	-4	-7
Aug 15	48118	-541	-7	4	19	-1	0
Aug 16	48119	-531	-7	4	9	-12	-10
Aug 17	48120	-519	-5	4	4	0	2
Aug 18	48121	-503	1	6	-8	0	-2
Aug 19	48122	-487	2	-1	7	-2	0
Aug 20	48123	-472	-7	-1	7	1	-8
Aug 21	48124	-458	-12	-17*	2	4	-1
Aug 22	48125	-445	9	-3	0	-2	0
Aug 23	48126	-438	-5	-4	0	1	5
Aug 24	48127	-429	5	5	-9	-14	-5
Aug 25	48128	-417	-1	-22*	12	-3	-4
Aug 26	48129	-401	1	-16*	25*	-1	4
Aug 27	48130	-386	-17	-9	3	14	4
Aug 28	48131	-367	-6	3	3	8	0
Aug 29	48132	-342	-12	0	14	8	-7
Aug 30	48133	-315	-7	8	3	1	-8
Aug 31	48134	-283	9	-1	2	5	3
Sep 1	48135	-252	3	-6	-9	16	-11

TABLE 8B . (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN 6 NAV 3 2h16m	PRN 9 NAV 6 5h12m	PRN13 NAV 9 5h44m	PRN12 NAV10 6h 0m	PRN 3 NAV11 9h12m
Aug 31	48134	-283	9	-1	2	5	3
Sep 1	48135	-252	3	-6	-9	16	-11
Sep 2	48136	-224	-7	-13	6	18	-9
Sep 3	48137	-194	-14	6	18	8	-5
Sep 4	48138	-167	-17	5	3	32*	-5
Sep 5	48139	-141	1	16	1	-15	0
Sep 6	48140	-117	-8	11	11	-2	-2
Sep 7	48141	-98	4	2	-2	-10	2
Sep 8	48142	-80	-6	-4	5	-22*	-4
Sep 9	48143	-62	-6	-2	-10	10	5
Sep 10	48144	-47	1	9	6	18	-9
Sep 11	48145	-33	-13	-2	-5	2	-1
Sep 12	48146	-17	4	-5	2	-6	2
Sep 13	48147	-8	-6	3	15	14	1
Sep 14	48148	-15	-15	-6	14	-12	-1
Sep 15	48149	-28	4	-3	-2	2	0
Sep 16	48150	-38	-3	-5	3	8	-3
Sep 17	48151	-47	-6	-9	1	23	2
Sep 18	48152	-60	-12	-2	11	-1	-1
Sep 19	48153	-73	-30*	-5	-4	12	-5
Sep 20	48154	-86	3	3	3	8	-2
Sep 21	48155	-99	-2	-6	-31*	-14	0
Sep 22	48156	-113	8	9	10	-6	7
Sep 23	48157	-129	1	-13	-16	13	3
Sep 24	48158	-139	5	6	5	-11	2
Sep 25	48159	-138	-13	-3	-15	20	2
Sep 26	48160	-137	-2	-1	-11	-	6
Sep 27	48161	-140	-2	-3	-3	32*	5
Sep 28	48162	-148	-7	-3	6	5	-5
Sep 29	48163	-159	9	-16	16	-6	0
Sep 30	48164	-171	-6	6	4	-6	9
Oct 1	48165	-181	1	-8	-4	26*	0

TABLE 8B. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	PRN 6 NAV 3 0h16m	PRN 9 NAV 6 3h12m	PRN13 NAV 9 3h44m	PRN12 NAV10 4h 0m	PRN 3 NAV11 7h12m
			r(ns)				
Sep 30	48164	-171	-6	6	4	-6	9
Oct 1	48165	-181	1	-8	-4	26*	0
Oct 2	48166	-191	1	4	-4	6	-1
Oct 3	48167	-209	-	-5	8	0	6
Oct 4	48168	-230	-8	-15	-14	3	3
Oct 5	48169	-244	-5	0	11	1	3
Oct 6	48170	-251	-13	-8	4	8	5
Oct 7	48171	-256	-6	-2	-8	-2	6
Oct 8	48172	-260	-1	2	15	6	4
Oct 9	48173	-268	4	-12	-5	7	1
Oct 10	48174	-276	-3	-5	-11	57*	-1
Oct 11	48175	-280	-	-7	-9	17	6
Oct 12	48176	-284	-6	-3	4	-27*	0
Oct 13	48177	-291	-2	-4	3	7	-
Oct 14	48178	-295	2	-14	3	1	2
Oct 15	48179	-296	-1	-14	-11	20	4
Oct 16	48180	-298	-9	2	-1	-44*	-
Oct 17	48181	-304	-2	-5	-16	15	3
Oct 18	48182	-302	8	-6	-14	19	2
Oct 19	48183	-296	-1	-1	-10	17	-1
Oct 20	48184	-290	-2	3	-3	-8	10
Oct 21	48185	-282	-9	-9	-6	-4	12
Oct 22	48186	-270	-7	-13	-24*	11	6
Oct 23	48187	-257	3	-10	11	-31*	7
Oct 24	48188	-253	3	-5	-8	3	1
Oct 25	48189	-250	-	4	-16	1	3
Oct 26	48190	-240	0	-1	-5	-4	14
Oct 27	48191	-226	4	-14	13	-12	4
Oct 28	48192	-220	0	-3	-27*	24*	10
Oct 29	48193	-218	-3	12	-5	-17	8
Oct 30	48194	-211	0	6	-12	-1	11
Oct 31	48195	-197	-10	-4	-1	-21*	1
Nov 1	48196	-184	-11	-8	12	14	6

TABLE 8B. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN 6 NAV 3 22h 8m	PRN 9 NAV 6 1h 8m	PRN13 NAV 9 1h40m	PRN12 NAV10 1h56m	PRN 3 NAV11 5h 8m
Oct 31	48195	-197	-10	-4	-1	-21*	1
Nov 1	48196	-184	-11	-8	12	14	6
Nov 2	48197	-179	-8	-5	-5	4	9
Nov 3	48198	-176	5	-2	-37*	-9	10
Nov 4	48199	-171	-2	-1	11	-11	0
Nov 5	48200	-168	6	4	-14	-14	15
Nov 6	48201	-164	1	-5	-20	13	4
Nov 7	48202	-160	-	5	-9	-2	9
Nov 8	48203	-150	0	-3	3	-1	-10
Nov 9	48204	-140	-7	-1	11	10	2
Nov 10	48205	-135	-1	-10	2	-5	7
Nov 11	48206	-135	-10	-2	-11	-27*	19
Nov 12	48207	-134	12	7	1	0	5
Nov 13	48208	-134	-1	-4	-16	-6	-4
Nov 14	48209	-130	-2	2	-3	7	2
Nov 15	48210	-128	2	-3	0	-1	13
Nov 16	48211	-128	1	-	-7	-31*	3
Nov 17	48212	-128	0	-5	-13	9	1
Nov 18	48213	-121	-9	-4	6	-27*	11
Nov 19	48214	-111	-4	3	4	-10	16
Nov 20	48215	-101	7	5	-6	-	6
Nov 21	48216	-95	7	-2	-16	5	0
Nov 22	48217	-95	0	-3	-8	-17	4
Nov 23	48218	-91	0	-11	3	-1	0
Nov 24	48219	-84	7	-10	-	31*	15
Nov 25	48220	-81	-4	1	3	-29*	-1
Nov 26	48221	-81	3	-14	-1	-4	2
Nov 27	48222	-85	1	4	-13	23	-8
Nov 28	48223	-87	7	-10	1	-	-7
Nov 29	48224	-83	-	-	-	-	-
Nov 30	48225	-76	11	-15	4	7	-10
Dec 1	48226	-74	-9	-2	-20	-8	8

TABLE 8B. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN 6 NAV 3 20h 8m	PRN 9 NAV 6 23h 4m	PRN13 NAV 9 23h36m	PRN12 NAV10 23h52m	PRN 3 NAV11 3h 8m
Nov 30	48225	-76	11	-15	4	7	-10
Dec 1	48226	-74	-9	-2	-20	-8	8
Dec 2	48227	-73	4	-9	-1	18	12
Dec 3	48228	-68	0	-5	-5	-1	-3
Dec 4	48229	-59	9	-12	11	8	-4
Dec 5	48230	-53	-7	-29	-4	18	10
Dec 6	48231	-45	-3	5	-9	12	-1
Dec 7	48232	-34	20	-8	-21	-13	6
Dec 8	48233	-24	4	-6	7	-11	16
Dec 9	48234	-18	-5	-4	4	-14	7
Dec 10	48235	-10	10	-21	6	-10	13
Dec 11	48236	5	4	-12	15	22	1
Dec 12	48237	19	-2	16	-25	-5	-3
Dec 13	48238	30	-12	53*	-12	2	-3
Dec 14	48239	45	7	-46*	-4	17	8
Dec 15	48240	59	-23	-43*	-17	-14	20
Dec 16	48241	69	20	-39*	-13	9	5
Dec 17	48242	80	-16	16	-11	-2	9
Dec 18	48243	84	1	-135*	-20	-	11

Date 1990/91 0hUTC	MJD	C0 (ns)	r(ns) PRN 3 NAV11 1h44m	PRN11 NAV 8 6h32m	PRN 6 NAV 3 18h 0m	PRN12 NAV10 22h 0m	PRN13 NAV 9 22h16m
Dec 19	48244	90	5	-7	10	19*	-7
Dec 20	48245	88	0	-2	-2	-5	-4
Dec 21	48246	90	4	1	0	8	-4
Dec 22	48247	91	14	1	-10	2	-8
Dec 23	48248	89	-3	5	-4	-15	-13
Dec 24	48249	91	15	3	-2	10	9
Dec 25	48250	96	7	-16	7	-15	26*
Dec 26	48251	98	3	-4	9	-11	-26*
Dec 27	48252	100	-1	-4	0	5	-1
Dec 28	48253	106	8	-1	-2	25*	-12
Dec 29	48254	116	4	-2	-5	-8	12
Dec 30	48255	122	10	7	0	-14	-2
Dec 31	48256	124	-6	-11	7	11	4
Jan 1	48257	129	0	-1	4	-10	-32

TABLE 8C. COMPLEMENT TO TABLE 8B

The following tables give the residuals r computed from the observation of a selection of Block II satellites, with respect to the smoothed data UTC - GPS time obtained from Block I satellites only. The C0 values reported here, from 1990 June 12 to 1991 January 1, are already given in Table 8B.

The following tables give the evidence of the turning on or off of Selective Availability on Block II satellites.

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN14 NAV14 2h 0m	PRN20 NAV20 11h36m	PRN16 NAV16 15h52m	PRN17 NAV17 19h20m	PRN 2 NAV13 21h12m
Jun 12	48054	-624	58	55	-398	13	-
Jun 13	48055	-605	41	-182	-143	-207	-
Jun 14	48056	-584	-42	-155	41	-	-82
Jun 15	48057	-563	-171	-5	-108	4	234
Jun 16	48058	-543	130	48	-5	51	66
Jun 17	48059	-525	96	25	25	-71	-34
Jun 18	48060	-509	370	6	85	28	17
Jun 19	48061	-495	105	-173	106	45	-220
Jun 20	48062	-480	87	-9	-7	-104	-32
Jun 21	48063	-462	0	-90	-36	23	258
Jun 22	48064	-444	189	-215	119	120	-11
Jun 23	48065	-430	-86	-49	-202	-58	-2
Jun 24	48066	-418	9	0	14	-1	3
Jun 25	48067	-407	3	4	3	3	9
Jun 26	48068	-394	-1	3	13	12	8
Jun 27	48069	-380	11	6	1	-8	-2
Jun 28	48070	-365	-7	-18	-1	9	6
Jun 29	48071	-351	-5	6	7	2	4
Jun 30	48072	-336	-2	16	13	35	14
Jul 1	48073	-320	-19	221	189	-265	66

TABLE 8C. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN14 NAV14 0h48m	PRN20 NAV20 10h24m	PRN16 NAV16 14h40m	PRN17 NAV17 18h 8m	PRN 2 NAV13 20h 0m
Jun 30	48072	-336	-2	16	13	35	14
Jul 1	48073	-320	-19	221	189	-265	66
Jul 2	48074	-309	111	258	256	9	-181
Jul 3	48075	-305	61	-40	4	137	-47
Jul 4	48076	-305	121	-143	-164	28	-90
Jul 5	48077	-309	-65	151	14	205	81
Jul 6	48078	-311	-	226	-64	-21	213
Jul 7	48079	-310	-12	64	18	165	-44
Jul 8	48080	-316	85	-5	4	7	6
Jul 9	48081	-327	5	6	-8	37	-3
Jul 10	48082	-340	-	-4	9	-3	-7
Jul 11	48083	-351	-	-	9	31	9
Jul 12	48084	-359	-2	4	34	23	15
Jul 13	48085	-364	0	-2	18	26	8
Jul 14	48086	-375	4	-19	8	14	11
Jul 15	48087	-389	105	-178	142	-87	-215
Jul 16	48088	-405	-102	83	-	-	-
Jul 17	48089	-419	-115	142	45	-96	22
Jul 18	48090	-432	-142	38	-17	127	-111
Jul 19	48091	-442	-7	-32	109	242	-109
Jul 20	48092	-453	-18	9	-187	106	136
Jul 21	48093	-470	67	-28	107	-65	104
Jul 22	48094	-486	-108	74	94	179	-170
Jul 23	48095	-497	47	-143	16	-22	44
Jul 24	48096	-508	-195	-7	-109	76	-125
Jul 25	48097	-521	-126	337	-226	35	-188
Jul 26	48098	-534	31	-143	104	73	85
Jul 27	48099	-542	-196	60	-86	-90	-123
Jul 28	48100	-549	224	-	63	173	95
Jul 29	48101	-554	-259	-133	0	-16	103
Jul 30	48102	-555	114	38	-154	-64	122
Jul 31	48103	-557	2	188	-143	32	-68
Aug 1	48104	-558	327	-166	1	159	209

TABLE 8C. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN14 NAV14 22h40m	PRN20 NAV20 8h20m	PRN16 NAV16 12h36m	PRN17 NAV17 16h 4m	PRN 2 NAV13 17h56m
Jul 31	48103	-557	2	188	-143	32	-68
Aug 1	48104	-558	327	-166	1	159	209
Aug 2	48105	-562	137	-77	-93	75	-155
Aug 3	48106	-573	162	84	-147	112	-60
Aug 4	48107	-583	-66	62	28	129	131
Aug 5	48108	-589	93	-5	134	425	-140
Aug 6	48109	-590	-311	176	-61	-74	-
Aug 7	48110	-590	-37	37	-130	223	-92
Aug 8	48111	-585	-129	-193	-5	157	-1
Aug 9	48112	-579	108	18	-38	21	335
Aug 10	48113	-573	5	-26	-2	0	-7
Aug 11	48114	-568	-18	-2	2	13	2
Aug 12	48115	-565	-5	-3	1	19	-13
Aug 13	48116	-562	8	-5	0	-4	-3
Aug 14	48117	-553	4	-11	-2	10	1
Aug 15	48118	-541	5	11	1	15	-6
Aug 16	48119	-531	3	-2	4	5	-14
Aug 17	48120	-519	11	-1	-2	3	-12
Aug 18	48121	-503	1	11	-4	-10	-13
Aug 19	48122	-487	-4	0	-5	10	-8
Aug 20	48123	-472	1	-9	5	6	5
Aug 21	48124	-458	0	-5	33	-1	-8
Aug 22	48125	-445	5	1	11	4	-13
Aug 23	48126	-438	5	-3	-2	7	-
Aug 24	48127	-429	17	2	-13	25	-6
Aug 25	48128	-417	-6	13	-28	-12	-17
Aug 26	48129	-401	0	8	-31	-20	-20
Aug 27	48130	-386	4	17	-13	16	-30
Aug 28	48131	-367	-10	3	-84	-4	-18
Aug 29	48132	-342	-21	-4	-48	-7	-32
Aug 30	48133	-315	-29	1	-10	-7	-26
Aug 31	48134	-283	-5	18	0	5	-6
Sep 1	48135	-252	5	4	24	-7	-3

TABLE 8C. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN14 NAV14 20h36m	PRN20 NAV20 6h16m	PRN16 NAV16 10h32m	PRN17 NAV17 14h 0m	PRN 2 NAV13 15h52m
Aug 31	48134	-283	-5	18	0	5	-6
Sep 1	48135	-252	5	4	24	-7	-3
Sep 2	48136	-224	12	0	15	31	-1
Sep 3	48137	-194	5	17	20	5	-1
Sep 4	48138	-167	-10	-1	14	3	-9
Sep 5	48139	-141	11	4	16	-1	-10
Sep 6	48140	-117	-11	6	-37	-6	-7
Sep 7	48141	-98	-2	12	7	1	-5
Sep 8	48142	-80	9	-13	17	14	-10
Sep 9	48143	-62	1	18	4	20	-13
Sep 10	48144	-47	5	16	7	7	-15
Sep 11	48145	-33	-3	12	22	1	0
Sep 12	48146	-17	-6	-8	9	10	-9
Sep 13	48147	-8	19	-13	2	3	-17
Sep 14	48148	-15	-4	13	9	9	-4
Sep 15	48149	-28	-10	7	8	-17	-8
Sep 16	48150	-38	16	-14	29	-7	-11
Sep 17	48151	-47	-1	14	6	19	0
Sep 18	48152	-60	-8	7	13	16	3
Sep 19	48153	-73	1	12	16	18	-1
Sep 20	48154	-86	5	12	30	-7	-10
Sep 21	48155	-99	-6	8	-8	-	-10
Sep 22	48156	-113	-12	-3	24	8	-17
Sep 23	48157	-129	-12	13	25	5	-2
Sep 24	48158	-139	1	6	0	-7	-17
Sep 25	48159	-138	-2	13	28	0	-11
Sep 26	48160	-137	3	0	55	7	-15
Sep 27	48161	-140	8	4	44	23	-18
Sep 28	48162	-148	7	-3	42	-4	-9
Sep 29	48163	-159	-6	-2	42	-12	-8
Sep 30	48164	-171	10	10	33	5	-9
Oct 1	48165	-181	3	9	19	-3	-14

TABLE 8C. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN14 NAV14 18h36m	PRN20 NAV20 4h16m	PRN16 NAV16 8h32m	PRN17 NAV17 12h 0m	PRN 2 NAV13 13h42m
Sep 30	48164	-171	10	10	33	5	-9
Oct 1	48165	-181	3	9	19	-3	-14
Oct 2	48166	-191	3	14	18	-10	-2
Oct 3	48167	-209	13	-1	26	5	6
Oct 4	48168	-230	-8	6	28	-4	-8
Oct 5	48169	-244	18	5	27	-12	-14
Oct 6	48170	-251	5	11	9	-4	-5
Oct 7	48171	-256	8	-4	-7	-2	-7
Oct 8	48172	-260	-13	3	5	20	-7
Oct 9	48173	-268	9	-2	3	-3	1
Oct 10	48174	-276	19	10	12	-8	0
Oct 11	48175	-280	-2	-4	9	1	-17
Oct 12	48176	-284	7	11	16	-3	-10
Oct 13	48177	-291	8	3	11	-3	-16
Oct 14	48178	-295	-6	5	40	-11	-10
Oct 15	48179	-296	16	9	52	-4	-5
Oct 16	48180	-298	-9	6	43	-2	-9
Oct 17	48181	-304	9	14	26	-12	-14
Oct 18	48182	-302	11	5	4	-1	-20
Oct 19	48183	-296	24	-1	31	-51	-10
Oct 20	48184	-290	-5	11	38	-2	-4
Oct 21	48185	-282	0	-11	15	3	-10
Oct 22	48186	-270	14	16	-3	4	0
Oct 23	48187	-257	13	2	0	-6	-6
Oct 24	48188	-253	-6	7	-13	15	-15
Oct 25	48189	-250	-1	1	-1	-15	-7
Oct 26	48190	-240	-3	-5	-4	-15	-12
Oct 27	48191	-226	6	-2	-23	14	-7
Oct 28	48192	-220	-20	-1	-8	-2	-2
Oct 29	48193	-218	11	3	-10	-17	-13
Oct 30	48194	-211	6	-11	-8	12	-20
Oct 31	48195	-197	17	1	-1	21	2
Nov 1	48196	-184	20	8	7	24	6

TABLE 8C. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN14 NAV14 16h32m	PRN20 NAV20 2h12m	PRN16 NAV16 6h28m	PRN17 NAV17 9h56m	PRN 2 NAV13 11h48m
Oct 31	48195	-197	17	1	-1	21	2
Nov 1	48196	-184	20	8	7	24	6
Nov 2	48197	-179	3	3	9	-12	2
Nov 3	48198	-176	0	4	4	1	-8
Nov 4	48199	-171	12	5	9	-1	-15
Nov 5	48200	-168	3	7	-1	15	-5
Nov 6	48201	-164	-1	10	5	-15	1
Nov 7	48202	-160	-1	4	-2	10	-9
Nov 8	48203	-150	15	-3	6	7	-4
Nov 9	48204	-140	-2	14	18	-16	0
Nov 10	48205	-135	9	7	18	-3	5
Nov 11	48206	-135	-13	17	-3	-11	-1
Nov 12	48207	-134	-2	1	12	-3	-9
Nov 13	48208	-134	9	-6	7	-22	3
Nov 14	48209	-130	21	12	25	5	-6
Nov 15	48210	-128	5	5	16	-3	7
Nov 16	48211	-128	8	4	1	-6	-8
Nov 17	48212	-128	14	8	39	8	-1
Nov 18	48213	-121	4	1	-11	-6	2
Nov 19	48214	-111	-3	6	14	17	6
Nov 20	48215	-101	17	6	19	9	9
Nov 21	48216	-95	0	13	20	-3	3
Nov 22	48217	-95	-1	7	25	3	-2
Nov 23	48218	-91	-8	3	7	-9	3
Nov 24	48219	-84	-14	6	30	-9	-1
Nov 25	48220	-81	0	-1	41	0	6
Nov 26	48221	-81	2	14	-9	0	-5
Nov 27	48222	-85	0	17	26	-1	5
Nov 28	48223	-87	10	-7	-4	7	0
Nov 29	48224	-83	-	-	-	-	-
Nov 30	48225	-76	21	10	30	22	-6
Dec 1	48226	-74	-12	14	19	-9	2

TABLE 8C. (CONT.)

Date 1990 0hUTC	MJD	C0 (ns)	r(ns) PRN14 NAV14 14h32m	PRN20 NAV20 0h12m	PRN16 NAV16 4h28m	PRN17 NAV17 7h56m	PRN 2 NAV13 9h48m
Nov 30	48225	-76	21	10	30	22	-6
Dec 1	48226	-74	-12	14	19	-9	2
Dec 2	48227	-73	11	-	0	-3	3
Dec 3	48228	-68	13	3	16	-10	-8
Dec 4	48229	-59	-21	-3	7	2	1
Dec 5	48230	-53	5	19	20	-8	1
Dec 6	48231	-45	2	3	-4	4	1
Dec 7	48232	-34	6	9	35	-19	2
Dec 8	48233	-24	1	-7	22	-12	7
Dec 9	48234	-18	-20	-3	-2	-7	-1
Dec 10	48235	-10	-18	-10	26	-21	-8
Dec 11	48236	5	-6	2	38	-27	-6
Dec 12	48237	19	-8	-8	-5	-11	2
Dec 13	48238	30	-	1	37	-20	10
Dec 14	48239	45	4	-2	47	-22	1
Dec 15	48240	59	0	-13	-3	-18	8
Dec 16	48241	69	-3	-4	24	-17	9
Dec 17	48242	80	-3	6	5	0	2
Dec 18	48243	84	-17	-	27	-4	-10

Date 1990/91 0hUTC	MJD	C0 (ns)	r(ns) PRN14 NAV14 10h32m	PRN18 NAV18 12h40m	PRN16 NAV16 16h24m	PRN 2 NAV13 19h36m	PRN20 NAV20 23h 4m
Dec 19	48244	90	-6	-14	1	-5	11
Dec 20	48245	88	5	16	4	22	0
Dec 21	48246	90	-18	0	11	25	-1
Dec 22	48247	91	-3	-16	-25	2	11
Dec 23	48248	89	3	-10	-5	9	-7
Dec 24	48249	91	-14	0	12	7	-18
Dec 25	48250	96	-13	-10	-12	4	-1
Dec 26	48251	98	-7	-2	3	6	2
Dec 27	48252	100	-12	-17	-5	9	-1
Dec 28	48253	106	-16	-5	5	19	-12
Dec 29	48254	116	-9	-4	-6	6	1
Dec 30	48255	122	2	-8	-7	2	0
Dec 31	48256	124	12	13	6	13	-1
Jan 1	48257	129	-15	-10	7	2	9

TABLE 8D. UTC - GLONASS TIME

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

$$\text{UTC - GLONASS time} = \text{C1 (modulo 1s)}.$$

From his current observation of both the GPS and GLONASS satellite systems Prof. P. Daly, University of Leeds, establishes and reports GPS time - GLONASS time at ten-day intervals, together with the standard deviation SD of his daily GLONASS data. C1 is then derived using UTC - GPS time of Table 8B.

DATE 1990 0hUTC	MJD	C1 (μs)	SD (μs)
Jan 8	47899	43.23	0.09
Jan 18	47909	43.64	0.12
Jan 28	47919	44.09	0.13
Feb 7	47929	44.58	0.11
Feb 17	47939	45.01	0.10
Feb 27	47949	45.43	0.12
Mar 9	47959	45.85	0.10
Mar 19	47969	46.27	0.14
Mar 29	47979	46.45	0.09
Apr 8	47989	46.59	0.09
Apr 18	47999	46.76	0.07
Apr 28	48009	46.94	0.11
May 8	48019	47.12	0.07
May 18	48029	47.31	0.09
May 28	48039	47.55	0.06
Jun 7	48049	47.77	0.07
Jun 17	48059	48.03	0.07
Jun 27	48069	9.90 (1)	0.06
Jul 7	48079	9.85	0.06
Jul 17	48089	9.68	0.06
Jul 27	48099	9.50	0.08
Aug 6	48109	9.29	0.06
Aug 16	48119	9.06	0.05
Aug 26	48129	8.75	0.06
Sep 5	48139	8.27	0.09
Sep 15	48149	7.88	0.06
Sep 25	48159	7.28	0.06
Oct 5	48169	6.69	0.08
Oct 15	48179	6.05	0.06
Oct 25	48189	5.49	0.06
Nov 4	48199	4.97	0.11
Nov 14	48209	4.33	0.08
Nov 24	48219	3.85	0.05
Dec 4	48229	3.41	0.07
Dec 14	48239	2.96	0.06
Dec 24	48249	2.58 (2)	0.06

TABLE 8D. (CONT.)

NOTES

(1) On 1990 June 22 at approximately 15h30 UTC, GLONASS time was synchronized with UTC(SU). (Communication from Prof. P. Daly)

(2) Interpolated value.

TABLE 9. COMPARISON BETWEEN ABSOLUTE TIME COMPARISONS AND THE BIPM RESULTS

The following tables give the differences between absolute time comparison values of Table 5 and the BIPM data deduced from Table 8A (before rounding-off).

9A. CLOCK TRANSPORTATION

DATE 1990	MJD	TIME COMPARISON	DIFFERENCE CLOCK TR. - BIPM (1 microsecond)
Feb 1	47923.02	UTC(SU) - UTC(RC)	-0.299
May 22	48033.05	UTC(TAO) - UTC(CRL)	+0.102
May 25	48036.05	UTC(TAO) - UTC(NRLM)	+0.008
May 29	48040.01	UTC(TAO) - UTC(NAOM)	-0.056
Jun 13	48055.42	UTC(ASMW) - UTC(PTB)	-0.006
Jun 13	48055.42	UTC(ASMW) - UTC(SU)	+0.055
Sep 10	48144.54	UTC(OMH) - UTC(SU)	+0.22
Sep 27	48161.29	UTC(PKNM) - UTC(SU)	-0.418
Nov 1	48196.22	UTC(CRL) - UTC(TAO)	-0.049
Dec 6	48231.06	UTC(CRL) - UTC(TAO)	-0.075

9B. GPS TIME RECEIVER TRANSPORTATION

DATE 1990	MJD	TIME COMPARISON	DIFFERENCE GPS COMP. - BIPM (1 microsecond)
Jun 22	48064.00	UTC(OP) - UTC(SU)	+0.153

TABLE 10A. RATES RELATIVE TO TAI OF THE CONTRIBUTING CLOCKS

Mean clock rates relative to TAI are computed for two-month intervals ending at the dates given in the table.
When an intentional frequency adjustment has been applied to a clock, the data prior to this adjustment are corrected, so that Table 10A gives homogeneous rates for the whole year 1990. For studies including the clock rates of previous years, corrections must be brought to the data published in the Annual Reports for 1988 and 1989 and in the BIH Annual Reports for the previous years. These corrections are given in Table 10B.
Unit in ns/day, *** denotes that the clock was not used.

LAB.	CLOCK		47949	48009	48069	48129	48189	48249	
AOS	19	7	74.96	-62.65	-96.29	-157.54	-132.06	-161.19	
APL	14	793	-3.78	-3.26	-2.93	***	***	***	
APL	31	571	33.37	30.17	4.60	25.97	0.04	4.40	
APL	40	3101	8.53	13.15	-1.52	-9.32	-4.84	-3.58	
APL	40	3102	***	***	***	-9.33	-3.73	-3.42	
APL	40	3103	***	***	***	***	***	-3.49	
APL	40	3106	6.34	10.14	-2.30	-10.37	-3.73	-3.26	
ASMW	16	76	129.24	134.47	125.93	105.67	***	***	(1)
AUS	12	590	***	***	***	***	***	261.22	
AUS	12	1823	-7.66	-5.83	-8.63	-27.43	***	***	
AUS	14	870	-14.52	-26.11	-18.82	-10.50	-7.62	0.02	
AUS	14	902	-82.99	-77.09	-94.97	-102.57	-92.99	-56.29	
AUS	14	1363	***	-1.92	-5.98	-7.87	-14.43	***	
AUS	14	1443	-20.26	-25.97	-17.36	-49.73	-30.17	***	
AUS	14	1694	-8.92	-10.69	-14.79	-14.04	-9.64	-1.26	
AUS	14	1777	-138.27	-135.42	-138.46	-150.52	-136.85	-139.83	
AUS	14	1844	98.52	97.45	90.15	78.34	90.91	88.82	
AUS	14	2019	***	***	***	-120.84	-110.46	-112.90	
AUS	14	2020	***	-10.27	1.79	4.25	27.22	***	
AUS	40	5401	***	***	***	***	12.25	13.97	
AUS	44	1	14.86	2.94	***	***	***	***	
AUS	44	2	42.45	44.38	46.56	47.34	47.50	48.89	
BEV	16	71	***	-49.15	-67.55	***	***	-62.19	
CAO	30	384	***	***	-13.17	-31.48	-42.78	***	
CH	12	285	34.40	37.32	39.01	36.23	38.19	40.99	
CH	12	863	-33.25	-39.68	-49.99	-64.38	-53.20	-19.86	
CH	16	64	6.77	9.65	-1.18	-4.57	-6.15	29.09	
CH	16	69	-127.33	-129.33	-129.28	-120.87	-120.92	-117.13	
CH	16	77	-2.71	-3.43	-2.41	-0.63	-3.47	-2.63	
CH	16	114	-9.85	-8.61	-18.75	-29.92	2.15	***	
CH	16	140	1.49	-1.39	***	***	-22.08	15.92	
CH	17	206	***	-66.23	-59.53	-60.07	-58.59	-63.62	
CH	21	179	-33.35	-24.57	-20.64	-18.84	-3.81	***	
CH	21	194	89.35	98.80	96.81	98.55	98.32	96.57	
CH	21	217	***	***	***	***	***	12.80	

TABLE 10A. (CONT.)

LAB.	CLOCK		47949	48009	48069	48129	48189	48249	
CH	21	243	18.72	12.64	9.47	-12.42	16.97	21.03	
CH	21	265	-36.84	-38.56	-31.26	-34.29	-35.62	-48.23	
CH	31	403	-0.17	1.21	-3.38	-4.78	-7.59	-14.15	
CRL	14	764	-47.75	-47.69	-45.23	-44.98	-46.95	-46.49	
CRL	14	865	-83.11	-80.51	-78.76	-76.31	-73.45	-71.39	
CRL	14	932	***	***	-298.78	-299.76	-294.56	-294.18	
CRL	14	1729	-107.19	-108.25	-101.86	-98.94	-93.99	-93.60	
CRL	14	2456	***	***	***	***	***	0.25	
CRL	31	131	-63.06	-70.25	-87.69	-95.22	***	***	
CRL	31	305	144.73	156.24	184.75	191.66	185.59	194.68	
CRL	45	3	114.58	118.04	115.22	116.93	119.61	***	
CSAO	12	1646	-23.95	-33.54	-43.12	-44.58	-23.79	-59.01	
CSAO	12	1648	52.38	51.13	62.11	61.97	85.68	84.73	
CSAO	12	2068	124.25	140.97	113.47	131.45	131.15	144.62	
CSAO	30	151	194.64	214.18	200.81	208.50	203.05	206.55	
CSAO	40	4902	***	***	-6.81	4.75	***	***	
F	12	206	-267.81	-270.59	-260.51	-246.79	-254.93	-271.65	
F	12	439	-208.83	-206.21	-197.99	-196.47	-198.61	-207.67	
F	12	2405	14.50	14.27	11.68	10.80	8.50	24.62	
F	14	134	-13.83	-10.62	-13.12	-19.65	-10.81	-16.65	
F	14	158	68.91	71.20	70.43	69.78	64.11	67.55	
F	14	195	-117.12	-118.73	-117.49	-120.28	-119.09	-119.99	
F	14	347	-82.65	-78.06	-83.76	-88.45	-92.13	-85.80	(2)
F	14	405	-9.50	10.79	5.04	-11.34	-27.25	-21.21	
F	14	475	***	-100.17	-117.04	-115.05	***	***	
F	14	500	***	-10.12	-12.12	5.21	0.97	-1.85	
F	14	560	-94.08	-99.96	-94.61	-93.44	-95.27	-90.21	
F	14	594	-87.29	-84.07	-88.14	-86.03	-88.99	-83.28	
F	14	753	-25.59	-25.49	-34.25	-36.86	-36.10	-30.32	
F	14	1120	-59.18	-58.64	-56.61	-57.25	-59.21	-59.77	
F	14	1407	***	***	***	-63.84	-65.77	-66.20	
F	14	1645	-3.99	-7.57	-8.94	***	***	2.92	
F	14	1712	-108.46	-110.35	-105.02	***	***	-106.32	
F	16	106	***	5.32	-2.68	0.38	-7.17	-4.68	
F	16	178	14.87	5.37	-0.89	8.92	2.38	13.13	
F	16	187	-32.07	-31.69	-33.82	-29.90	-27.38	-14.97	
F	17	489	11.21	16.08	12.79	7.05	12.37	9.16	
FTZ	14	312	-5.98	-3.16	-4.11	-19.75	28.96	21.50	
FTZ	14	895	24.15	42.78	48.14	***	***	***	
FTZ	14	1217	-1.99	0.84	1.32	0.86	10.24	18.87	
FTZ	14	1482	18.40	19.11	17.42	19.95	20.62	22.90	
FTZ	14	1656	8.32	-3.49	-3.58	-8.15	18.04	40.92	
FTZ	14	1674	***	***	***	***	***	23.50	
FTZ	16	130	-0.91	-6.65	-7.00	-5.34	18.13	***	
IEN	14	469	-209.08	-208.78	-212.50	-209.23	-210.13	-214.76	

TABLE 10A. (CONT.)

LAB.	CLOCK		47949	48009	48069	48129	48189	48249
IEN	14	893	-57.94	-61.83	-62.21	-55.10	-48.77	-51.94
IEN	14	1230	-98.03	-71.10	-39.68	-8.38	-7.34	-62.12
IFAG	14	1105	-111.09	-127.32	-129.18	-108.80	-119.76	-128.61
IFAG	16	131	-29.48	-38.94	-37.60	-33.46	-34.95	-35.38
IFAG	16	138	74.75	73.15	56.14	27.33	43.56	74.84
IFAG	16	274	187.72	191.77	200.24	205.39	204.21	199.31
IGMA	14	2407	***	***	***	-98.09	-100.80	-99.28
IGMA	16	112	***	***	***	1.37	3.26	15.08
IGMA	17	127	***	***	***	-44.30	-11.94	44.16
INPL	14	2308	***	-5.80	-4.69	***	-198.41	***
INPL	31	145	***	-127.60	-124.09	***	-117.88	***
KSRI	12	1406	281.90	301.53	336.64	353.55	356.53	***
KSRI	12	1902	***	***	280.75	274.63	217.96	186.45
KSRI	12	1903	-164.06	-141.47	-148.14	-151.77	-151.40	-169.08
KSRI	14	1516	-102.60	-85.75	-82.82	-85.30	-83.97	-91.22
LDS	14	868	***	***	***	***	-75.31	-84.85
NAOM	14	614	***	***	138.74	180.46	250.01	***
NAOM	14	885	-12.40	***	***	***	***	***
NAOM	14	1315	-109.06	-107.56	-93.60	-89.73	-96.89	-102.08
NAOM	14	2146	-91.09	-87.50	-84.06	-86.93	-95.60	-97.75
NIM	12	1615	-2053.87	-2015.72	-1771.94	-1551.95	-492.66	-509.98
NIM	12	1633	17.09	20.94	31.67	23.02	5.53	-7.16
NIM	12	1640	-2.67	28.46	8.99	-0.01	-18.44	-19.00
NIST	11	167	-43.17	13.93	11.46	1.03	10.77	-9.68
NIST	13	61	-116.19	-113.26	-112.43	-111.43	-111.43	-107.02
NIST	14	323	***	***	***	***	***	-51.30
NIST	14	324	***	***	***	***	-51.87	-55.16
NIST	14	601	-24.42	-24.97	-26.03	-29.43	-30.17	-31.28
NIST	14	1316	-89.89	-90.77	-91.99	-93.80	-93.10	-93.39
NIST	14	2165	-7.74	***	-304.89	-307.85	-298.94	-304.73
NIST	16	217	-42.11	-37.04	-44.41	-41.71	-41.78	-41.40
NIST	18	113	-505.03	***	-192.43	-210.54	-240.38	-266.72
NIST	31	569	-113.15	-105.52	-100.86	-103.24	-102.55	-104.62
NIST	90	204	***	-1707.13	***	***	***	***
NPL	12	316	-104.02	-101.35	-103.44	-104.08	-103.59	-104.08
NPL	12	418	***	***	-219.58	-188.90	-210.30	***
NPL	12	832	-294.47	-298.61	-294.87	-291.72	-306.64	-308.39
NPL	14	1334	-110.49	-108.52	-117.14	-115.54	-117.13	-124.00
NPL	14	1813	-2.31	-5.92	-9.25	4.01	-4.60	-14.42
NPL	14	2064	-9.20	***	***	-18.45	-18.41	-22.49
NPL	31	328	-13.85	-12.88	-15.33	-3.78	-13.48	-30.31
NRC	14	267	-82.31	-86.25	-66.86	-45.29	-53.17	-74.35
NRC	90	5	-25.48	4.17	14.79	0.76	-9.89	-1.42
NRC	90	61	-9.65	-4.85	0.32	-3.07	-0.99	5.91
NRC	90	63	0.46	2.27	-86.39	-18.30	-3.69	-6.18

TABLE 10A. (CONT.)

LAB.	CLOCK		47949	48009	48069	48129	48189	48249	
NRLM	12	363	75.63	52.06	56.37	47.90	12.61	-8.99	
NRLM	14	906	341.70	292.18	313.61	326.58	226.01	182.33	
NRLM	31	312	71.67	89.42	127.25	126.35	150.86	211.66	
OMH	12	1067	***	***	7.43	-1.45	***	***	
ORB	12	205	***	-25.42	-40.19	-18.26	-7.80	-15.90	
ORB	12	804	-6.47	-6.62	-10.21	-1.27	3.20	2.57	
ORB	21	312	***	17.89	22.43	23.86	25.78	31.29	
PKNM	14	1144	***	***	-79.65	-79.74	-82.34	-88.05	
PKNM	16	124	11.21	24.74	2.85	0.68	25.69	40.91	
PKNM	30	652	***	***	***	***	***	-47.34	
PKNM	30	664	***	***	***	***	***	-153.48	
PTB	12	320	-57.86	-55.55	***	***	***	***	
PTB	14	394	-21.88	-28.36	-23.46	-25.45	-25.34	-34.55	
PTB	14	867	-182.56	-180.87	-173.63	-169.52	-169.83	-174.90	
PTB	14	1103	-65.48	-66.39	-60.18	-56.43	-60.18	-66.75	
PTB	14	2379	-48.06	-47.94	-44.04	-46.21	-44.07	-46.77	
PTB	16	76	***	***	***	***	118.89	135.67	(1)
PTB	21	178	***	***	***	***	***	0.24	
PTB	92	1	-0.69	-0.68	0.17	0.67	-0.12	-1.66	
PTB	92	2	-3.06	-3.13	-2.34	-1.10	-4.20	-0.84	
ROA	14	896	13.89	10.20	13.29	9.38	15.20	15.39	
ROA	14	1569	3.41	-0.29	13.68	9.05	7.13	12.68	
ROA	16	113	***	***	-10.85	-4.55	-4.23	0.98	
ROA	16	121	54.47	51.30	46.49	56.22	55.65	61.79	
ROA	16	177	-17.80	-16.72	-20.57	-24.54	-20.94	***	
SO	12	997	-65.62	-56.92	-66.39	-79.29	-85.98	***	
SO	14	574	-6.11	-0.75	6.25	28.51	-3.86	-10.41	
SO	16	180	71.34	71.21	66.75	72.82	59.32	54.10	
STA	14	900	-31.41	-35.89	-35.42	-43.94	-41.97	-38.13	
STA	14	1376	-95.82	-100.57	***	***	***	-136.54	
STA	16	137	-94.43	-100.43	-99.06	-87.54	-92.26	-39.00	
SU	40	3801	-9.69	-5.28	-5.19	***	***	-13.54	(3)
SU	40	3802	-9.59	-5.57	-5.06	***	***	-13.58	(3)
TAO	14	1075	-35.36	-35.14	-35.19	-34.65	-34.51	-32.65	
TAO	14	1498	-139.49	-136.87	-135.56	-136.37	-132.47	-130.43	
TAO	14	2494	-10.16	-9.27	-6.50	-6.95	-8.52	***	
TAO	31	283	-47.02	-50.04	-49.45	-58.63	-70.49	-75.94	
TAO	31	284	-172.00	-175.05	-176.06	-174.98	-167.35	-162.29	
TAO	31	285	-50.58	-43.53	-40.80	-37.45	-55.57	-38.49	
TAO	31	286	-147.17	-148.38	-150.28	-150.56	-149.67	-145.37	
TL	12	477	-228.00	-241.41	-72.88	-141.75	-147.00	-152.37	
TL	12	1145	150.54	151.63	145.86	154.06	155.65	136.65	
TL	12	2276	-50.68	-54.36	-54.18	-51.92	-53.22	-57.14	
TL	16	283	-117.95	-65.98	-175.19	-171.75	-139.30	-144.82	
TL	31	317	-53.34	-42.71	-37.34	-34.54	-46.95	-55.08	

TABLE 10A. (CONT.)

LAB.	CLOCK	47949	48009	48069	48129	48189	48249
TP	17 101	-51.66	-28.38	-61.30	-81.54	-58.98	-16.89
TUG	12 524	47.40	55.86	59.01	55.61	53.86	47.99
TUG	14 1654	23.91	26.06	26.58	24.79	24.16	26.44
TUG	18 108	592.09	607.57	639.03	630.77	644.26	675.64
USNO	14 116	-102.22	***	***	***	***	***
USNO	14 527	***	***	-142.04	***	-153.19	-163.87
USNO	14 583	26.83	27.69	27.24	22.22	24.53	21.15
USNO	14 651	***	***	***	***	***	-116.04
USNO	14 653	***	***	***	***	-33.67	-40.63
USNO	14 654	-110.20	-108.15	-110.04	-110.69	-109.67	-112.03
USNO	14 656	63.54	73.86	64.66	76.44	78.57	73.78
USNO	14 752	31.66	32.38	33.93	36.91	39.03	37.68
USNO	14 761	***	***	-91.91	***	***	***
USNO	14 787	-2.11	-0.87	-2.44	-0.74	-6.84	3.74
USNO	14 833	-64.71	-86.09	-87.08	-94.31	-91.94	-82.59
USNO	14 837	-84.47	-75.76	-75.55	***	***	***
USNO	14 1028	36.93	***	***	***	***	***
USNO	14 1035	-96.06	-92.60	-91.16	-69.40	-82.60	-67.53
USNO	14 1094	-123.91	-119.60	-116.88	-117.15	-117.73	-120.76
USNO	14 1255	-60.88	-59.43	-58.53	-58.92	-55.38	-57.40
USNO	14 1264	23.57	26.59	37.06	35.25	35.89	29.49
USNO	14 1300	***	***	-32.66	***	***	***
USNO	14 1301	***	***	***	***	-111.58	-113.51
USNO	14 1305	-94.33	-92.62	-89.99	-86.82	-83.50	-78.33
USNO	14 1343	1481.27	***	***	***	***	***
USNO	14 1362	3.67	-2.96	1.15	***	***	***
USNO	14 1490	-145.50	-138.23	-135.88	-149.66	-143.21	-153.45
USNO	14 1586	***	***	***	***	-76.28	-76.49
USNO	14 1605	43.71	49.72	55.07	46.11	43.25	44.48
USNO	14 1710	-58.35	-59.11	-58.26	-61.59	-36.19	-36.70
USNO	14 1809	-85.96	-75.58	-69.53	-71.47	-69.22	-77.71
USNO	14 1846	-62.44	-60.21	-59.87	-56.60	-55.30	-55.59
USNO	14 2098	***	***	***	***	-51.70	-50.52
USNO	14 2312	-32.65	-38.37	-20.25	-18.85	-16.14	2.43
USNO	14 2313	***	***	***	***	-49.55	-65.89
USNO	14 2314	1.78	-2.75	7.60	7.94	4.82	***
USNO	14 2315	923.44	926.43	924.23	924.37	927.82	926.04
USNO	14 2450	***	***	-67.84	***	***	***
USNO	14 2481	-13.02	-8.06	-5.30	3.72	6.93	-14.07
USNO	14 2482	13.24	-11.36	82.35	***	***	***
USNO	14 2483	-42.55	-37.93	-38.44	-34.66	-34.14	-30.53
USNO	14 2485	***	***	-81.00	-79.14	-79.03	-80.91
USNO	14 2486	-32.83	-43.88	-42.41	-45.64	-49.62	-60.18
USNO	14 2488	-132.65	-105.17	-105.95	-110.44	-110.35	-111.12
USNO	31 335	-46.31	-38.17	-39.15	-49.06	-34.15	-40.03

TABLE 10A. (CONT.)

LAB.	CLOCK	47949	48009	48069	48129	48189	48249
USNO	31 336	***	***	***	***	-152.01	-150.53
USNO	31 338	-19.44	-21.16	-3.51	***	***	***
USNO	31 339	53.91	***	***	***	***	***
USNO	31 340	-10.09	-5.02	-7.03	***	2.42	-0.41
USNO	40 1	-42.94	***	***	***	***	***
USNO	40 22	-118.55	-129.56	-108.54	-82.68	-100.69	-116.07
USNO	40 23	-15.61	-0.53	2.64	14.46	8.05	0.75
USNO	40 702	115.45	109.64	101.78	97.09	94.86	***
USNO	40 703	121.79	116.55	***	***	***	101.14
USNO	40 704	-26.62	-32.31	-39.78	-45.62	-46.84	-49.36
USNO	40 705	***	***	-5.48	-13.69	-17.49	-21.77
USNO	40 706	***	***	-21.59	***	***	***
USNO	40 724	-630.08	-648.75	-667.39	-682.92	-695.04	-707.85
USNO	40 725	***	-46.58	***	***	-79.84	-101.63
USNO	40 6201	***	***	***	***	25.10	22.50
USNO	40 6208	***	10.72	17.89	***	***	8.43
VSL	12 349	8.10	10.31	14.44	6.34	0.96	10.39
VSL	12 1489	***	-168.62	-156.44	-156.55	-150.03	-142.56
VSL	14 1034	-76.82	-76.66	-71.82	-62.35	-69.73	-70.50
YUZM	12 1189	-30.94	-14.70	30.07	75.52	23.01	-19.09
ZIPE	12 979	-132.99	-137.04	***	***	***	***

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

11 HEWLETT-PACKARD 5060A
12 HEWLETT-PACKARD 5061A
13 EBAUCHES, OSCILLATOM B5000
14 HEWLETT-PACKARD 5061A OPT.4
16 OSCILLOQUARTZ 3200
17 OSCILLOQUARTZ 3000
18 FREQ. AND TIME SYSTEMS INC. 4000
19 RHODE AND SCHARZ XSC
21 OSCILLOQUARZ 3210
30 HEWLETT-PACKARD 5061B
31 HEWLETT-PACKARD 5061B OPT. 4
4x HYDROGEN MASERS
9x PRIMARY CLOCKS AND PROTOTYPES

Notes:

(1) As a consequence of the unification of Germany, the ASMW became a part of the PTB on 1990 October 3rd. It follows that clock ASMW 16 76, which continuously operated in 1990, is designated as PTB 16 76 for the last four months of the year.

(2) Clock F 14 347 was designated as F 12 347 in the previous Annual Report.

(3) Hydrogen masers SU 403801 and 403802 were designated as SU 40 381 and 40 382 in previous Annual Reports.

TABLE 10B. CORRECTIONS FOR HOMOGENEOUS USE OF THE CLOCK RATES PUBLISHED IN THE CURRENT AND PREVIOUS ANNUAL REPORTS.

Each line refers to the same clock working without interruption.

	1990	1989		1988		1987	
	clock n°	clock n°	corr. (ns/d)	clock n°	corr. (ns/d)	clock n°	corr. (ns/d)
AUS	14 1694	14 1694	-43.20				
CSAO	12 1646	12 1646		12 1646		12 1646[(1)]	+41.60
	12 1648	12 1648		12 1648		12 1648[(2)]	
NIST	14 601	14 601		14 601	+18.75		
	14 1316	14 1316	+16.93	14 1316	+16.93	14 1316[(3)]	+16.93
	16 217	16 217	-6.13	16 217	-6.13		
ROA	14 1569	14 1569		14 1569		14 1569[(4)]	-13.00
	16 177	16 177		16 177		16 177[(5)]	+46.00
USNO	14 2314	14 2314		14 2314		14 2314	+31.00

(1) A correction of +41.60 ns/d has to be applied for the last three two-month intervals of 1986.

(2) A correction of +98.60 ns/d has to be applied in 1986 and 1985.

(3) A correction of +16.93 ns/d has to be applied in 1986, 1985 and for the last three two-month intervals of 1984.

(4) A correction of -13.00 ns/d has to be applied in 1986.

(5) A correction of +46.00 ns/d has to be applied in 1986, 1985 and for the last two-month interval of 1984.

TABLE 11A. WEIGHTS OF THE CONTRIBUTING CLOCKS

Clock weights are computed for two-month intervals ending at the dates given in the table.
Since 1988 January 1st, the absolute weight of a given clock cannot exceed the value 100. For the year 1990, it corresponds to a maximum relative weight of about 1.7%.

*** denotes that the clock was not used.

LAB.	CLOCK		47949	48009	48069	48129	48189	48249	
AOS	19	7	1	0	0	0	0	0	
APL	14	793	0	0	100	***	***	***	
APL	31	571	0	0	0	4	3	4	
APL	40	3101	0	23	16	10	12	12	
APL	40	3102	***	***	***	0	0	53	
APL	40	3103	***	***	***	***	***	0	
APL	40	3106	0	38	22	12	16	16	
ASMW	16	76	0	0	0	0	***	***	(1)
AUS	12	590	***	***	***	***	***	0	
AUS	12	1823	0	0	100	0	***	***	
AUS	14	870	5	20	19	21	26	14	
AUS	14	902	0	6	4	4	5	4	
AUS	14	1363	***	0	0	42	20	***	
AUS	14	1443	79	100	68	0	7	***	
AUS	14	1694	21	41	55	75	100	46	
AUS	14	1777	25	20	18	16	24	31	
AUS	14	1844	3	4	6	9	11	17	
AUS	14	2019	***	***	***	0	0	19	
AUS	14	2020	***	0	0	9	3	***	
AUS	40	5401	***	***	***	***	0	0	
AUS	44	1	3	3	***	***	***	***	
AUS	44	2	21	20	18	18	17	100	
BEV	16	71	***	0	0	***	***	0	
CAO	30	384	***	***	0	0	2	***	
CH	12	285	5	5	5	11	100	100	
CH	12	863	13	23	17	0	6	4	
CH	16	64	12	10	10	24	21	0	
CH	16	69	41	56	100	63	84	47	
CH	16	77	100	100	100	100	100	100	
CH	16	114	2	2	2	2	2	***	
CH	16	140	4	4	***	***	0	0	
CH	17	206	***	0	0	44	73	94	
CH	21	179	15	8	9	8	7	***	
CH	21	194	100	0	36	33	55	98	
CH	21	217	***	***	***	***	***	0	

TABLE 11A. (CONT.)

LAB.	CLOCK		47949	48009	48069	48129	48189	48249	
CH	21	243	25	30	30	0	7	7	
CH	21	265	6	5	9	12	46	0	
CH	31	403	100	100	100	100	71	26	
CRL	14	764	100	100	100	100	100	100	
CRL	14	865	37	100	100	100	100	73	
CRL	14	932	***	***	0	0	82	100	
CRL	14	1729	100	100	99	73	33	32	
CRL	14	2456	***	***	***	***	***	0	
CRL	31	131	6	4	3	2	***	***	
CRL	31	305	17	22	0	2	2	3	
CRL	45	3	0	26	27	36	100	***	
CSAO	12	1646	2	1	1	2	5	5	
CSAO	12	1648	8	6	9	12	0	5	
CSAO	12	2068	1	1	1	1	7	8	
CSAO	30	151	3	2	4	5	5	23	
CSAO	40	4902	***	***	0	0	***	***	
F	12	206	3	4	4	7	15	11	
F	12	439	12	10	14	45	47	36	
F	12	2405	11	16	28	100	100	0	
F	14	134	0	0	100	38	57	71	
F	14	158	100	100	100	100	95	100	
F	14	195	62	62	58	49	100	100	
F	14	347	36	31	31	41	30	34	(2)
F	14	405	25	0	6	6	5	4	
F	14	475	***	0	0	5	***	***	
F	14	500	***	0	0	0	10	17	
F	14	560	78	81	66	70	100	100	
F	14	594	52	65	94	100	100	100	
F	14	753	0	0	17	16	21	32	
F	14	1120	100	100	100	100	100	100	
F	14	1407	***	***	***	0	0	100	
F	14	1645	51	37	29	***	***	0	
F	14	1712	12	11	11	***	***	0	
F	16	106	***	0	0	27	20	29	
F	16	178	0	0	7	14	20	25	
F	16	187	47	73	100	100	100	0	
F	17	489	0	0	88	40	67	82	
FTZ	14	312	9	13	33	0	0	3	
FTZ	14	895	58	0	5	***	***	***	
FTZ	14	1217	100	100	100	100	64	0	
FTZ	14	1482	100	86	87	80	90	100	
FTZ	14	1656	28	15	14	18	10	0	
FTZ	14	1674	***	***	***	***	***	0	
FTZ	16	130	8	5	5	5	9	***	
IEN	14	469	73	52	31	41	100	100	

TABLE 11A. (CONT.)

LAB.	CLOCK		47949	48009	48069	48129	48189	48249
IEN	14	893	28	31	41	41	42	42
IEN	14	1230	1	1	1	1	1	1
IFAG	14	1105	10	12	12	14	15	12
IFAG	16	131	11	16	16	20	81	79
IFAG	16	138	2	1	2	2	2	2
IFAG	16	274	80	86	0	15	14	24
IGMA	14	2407	***	***	***	0	0	100
IGMA	16	112	***	***	***	0	0	0
IGMA	17	127	***	***	***	0	0	0
INPL	14	2308	***	0	0	***	0	***
INPL	31	145	***	0	0	***	0	***
KSRI	12	1406	1	4	2	1	1	***
KSRI	12	1902	***	***	0	0	0	0
KSRI	12	1903	0	13	16	17	19	9
KSRI	14	1516	19	18	17	16	15	20
LDS	14	868	***	***	***	***	0	0
NAOM	14	614	***	***	0	0	0	***
NAOM	14	885	21	***	***	***	***	***
NAOM	14	1315	0	5	6	9	14	19
NAOM	14	2146	49	52	49	89	35	30
NIM	12	1615	0	0	0	0	0	0
NIM	12	1633	0	0	10	19	9	5
NIM	12	1640	0	0	2	3	3	3
NIST	11	167	3	2	2	2	1	2
NIST	13	61	4	13	12	100	100	100
NIST	14	323	***	***	***	***	***	0
NIST	14	324	***	***	***	***	0	0
NIST	14	601	100	100	100	86	61	76
NIST	14	1316	100	100	100	100	100	100
NIST	14	2165	45	***	0	0	27	53
NIST	16	217	4	32	22	27	66	100
NIST	18	113	1	***	0	0	1	1
NIST	31	569	0	0	15	28	45	67
NIST	90	204	***	0	***	***	***	***
NPL	12	316	4	4	5	100	100	100
NPL	12	418	***	***	0	0	2	***
NPL	12	832	0	53	100	100	0	18
NPL	14	1334	5	6	5	11	16	27
NPL	14	1813	32	23	14	16	19	24
NPL	14	2064	0	***	***	0	0	81
NPL	31	328	26	21	22	46	63	0
NRC	14	267	8	6	6	5	4	4
NRC	90	5	7	5	2	3	3	5
NRC	90	61	18	10	6	8	20	46
NRC	90	63	8	13	0	1	1	1

TABLE 11A. (CONT.)

LAB.	CLOCK		47949	48009	48069	48129	48189	48249	
NRLM	12	363	0	1	0	0	1	1	
NRLM	14	906	0	0	0	0	0	0	
NRLM	31	312	0	0	0	1	1	0	
OMH	12	1067	***	***	0	0	***	***	
ORB	12	205	***	0	0	4	4	6	
ORB	12	804	1	1	1	7	8	41	
ORB	21	312	***	0	0	68	83	43	
PKNM	14	1144	***	***	0	0	100	37	
PKNM	16	124	4	3	4	5	8	4	
PKNM	30	652	***	***	***	***	***	0	
PKNM	30	664	***	***	***	***	***	0	
PTB	12	320	100	100	***	***	***	***	
PTB	14	394	100	100	100	100	100	0	
PTB	14	867	18	31	48	40	31	42	
PTB	14	1103	9	7	9	20	93	61	
PTB	14	2379	100	100	100	100	100	100	
PTB	16	76	***	***	***	***	1	8	(1)
PTB	21	178	***	***	***	***	***	0	
PTB	92	1	100	100	100	100	100	100	
PTB	92	2	100	100	100	100	100	100	
ROA	14	896	21	61	100	100	100	100	
ROA	14	1569	13	13	13	31	41	40	
ROA	16	113	***	***	0	0	44	33	
ROA	16	121	0	18	20	22	39	44	
ROA	16	177	7	7	18	27	67	***	
SO	12	997	8	0	21	16	8	***	
SO	14	574	3	3	15	0	5	5	
SO	16	180	12	14	44	100	0	15	
STA	14	900	14	16	15	28	34	37	
STA	14	1376	54	89	***	***	***	0	
STA	16	137	100	62	83	47	50	0	
SU	40	3801	0	0	0	***	***	0	(3)
SU	40	3802	0	0	0	***	***	0	(3)
TAO	14	1075	100	100	100	100	100	100	
TAO	14	1498	31	42	63	100	100	100	
TAO	14	2494	100	100	100	100	100	***	
TAO	31	283	0	72	100	0	0	6	
TAO	31	284	67	41	49	89	93	40	
TAO	31	285	100	52	38	41	22	20	
TAO	31	286	27	27	32	44	42	100	
TL	12	477	1	1	0	0	0	0	
TL	12	1145	4	3	3	3	9	0	
TL	12	2276	11	15	27	25	32	100	
TL	16	283	0	0	0	0	0	1	
TL	31	317	15	10	6	4	6	14	

TABLE 11A. (CONT.)

LAB.	CLOCK		47949	48009	48069	48129	48189	48249
TP	17	101	0	0	0	1	3	2
TUG	12	524	11	12	23	47	47	46
TUG	14	1654	100	100	100	100	100	100
TUG	18	108	1	1	1	1	1	1
USNO	14	116	11	***	***	***	***	***
USNO	14	527	***	***	0	***	0	0
USNO	14	583	1	1	1	2	12	89
USNO	14	651	***	***	***	***	***	0
USNO	14	653	***	***	***	***	0	0
USNO	14	654	0	0	100	100	100	100
USNO	14	656	67	0	42	28	24	30
USNO	14	752	40	58	91	100	100	100
USNO	14	761	***	***	0	***	***	***
USNO	14	787	3	2	2	4	17	84
USNO	14	833	0	0	3	4	5	8
USNO	14	837	0	0	0	***	***	***
USNO	14	1028	2	***	***	***	***	***
USNO	14	1035	3	5	8	8	12	7
USNO	14	1094	11	22	36	54	100	100
USNO	14	1255	100	100	100	100	100	100
USNO	14	1264	0	0	0	18	27	38
USNO	14	1300	***	***	0	***	***	***
USNO	14	1301	***	***	***	***	0	0
USNO	14	1305	28	43	60	62	69	35
USNO	14	1343	5	***	***	***	***	***
USNO	14	1362	0	6	5	***	***	***
USNO	14	1490	0	0	0	0	0	20
USNO	14	1586	***	***	***	***	0	0
USNO	14	1605	49	85	59	50	49	43
USNO	14	1710	0	17	15	20	0	8
USNO	14	1809	10	10	11	18	29	28
USNO	14	1846	84	100	100	100	100	100
USNO	14	2098	***	***	***	***	0	0
USNO	14	2312	12	17	8	11	10	5
USNO	14	2313	***	***	***	***	0	0
USNO	14	2314	5	8	21	23	73	***
USNO	14	2315	0	0	100	100	100	100
USNO	14	2450	***	***	0	***	***	***
USNO	14	2481	43	66	67	34	21	14
USNO	14	2482	3	4	0	***	***	***
USNO	14	2483	35	72	100	100	100	81
USNO	14	2485	***	***	0	0	100	100
USNO	14	2486	9	10	33	27	17	11
USNO	14	2488	66	0	4	4	5	10
USNO	31	335	24	36	61	28	30	35

TABLE 11A. (CONT.)

LAB.	CLOCK	47949	48009	48069	48129	48189	48249
USNO	31 336	***	***	***	***	0	0
USNO	31 338	0	0	0	***	***	***
USNO	31 339	8	***	***	***	***	***
USNO	31 340	100	100	100	***	0	0
USNO	40 1	0	***	***	***	***	***
USNO	40 22	0	0	0	0	0	0
USNO	40 23	0	0	0	0	0	0
USNO	40 702	0	0	0	0	0	***
USNO	40 703	0	0	***	***	***	0
USNO	40 704	0	0	0	0	0	0
USNO	40 705	***	***	0	0	0	0
USNO	40 706	***	***	0	***	***	***
USNO	40 724	0	0	0	0	0	0
USNO	40 725	***	0	***	***	0	0
USNO	40 6201	***	***	***	***	0	0
USNO	40 6208	***	0	0	***	***	0
VSL	12 349	100	100	79	94	42	42
VSL	12 1489	***	0	0	11	13	10
VSL	14 1034	100	100	100	0	36	42
YUZM	12 1189	0	0	0	0	1	1
ZIPE	12 979	23	29	***	***	***	***

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

11 HEWLETT-PACKARD 5060A
12 HEWLETT-PACKARD 5061A
13 EBAUCHES, OSCILLATOM B5000
14 HEWLETT-PACKARD 5061A OPT.4
16 OSCILLOQUARTZ 3200
17 OSCILLOQUARTZ 3000
18 FREQ. AND TIME SYSTEMS INC. 4000
19 RHODE AND SCHARZ XSC
21 OSCILLOQUARZ 3210
30 HEWLETT-PACKARD 5061B
31 HEWLETT-PACKARD 5061B OPT. 4
4x HYDROGEN MASERS
9x PRIMARY CLOCKS AND PROTOTYPES

Notes:

(1) As a consequence of the unification of Germany, the ASMW became a part of the PTB on 1990 October 3rd. It follows that clock ASMW 16 76, which continuously operated in 1990, is designated as PTB 16 76 for the last four months of the year.

(2) Clock F 14 347 was designated as F 12 347 in the previous Annual Report.

(3) Hydrogen masers SU 403801 and 403802 were designated as SU 40 381 and 40 382 in previous Annual Reports.

TABLE 11B. STATISTICAL DATA ON THE WEIGHTS ATTRIBUTED TO THE CLOCKS IN 1990

Interval 1990	Total number of clocks	Number of clocks with a given weight							
		weights 0*	weights 0**	weight 1-19	weight 20-39	weight 40-59	weight 60-79	weight 80-99	weight 100
Jan-Feb	178	33	13	68	19	11	7	2	25
Mar-Apr	184	40	14	63	20	10	8	5	24
May-Jun	194	38	19	64	20	9	7	6	31
Jul-Aug	181	25	18	60	21	16	6	5	30
Sep-Oct	192	29	14	61	23	13	10	8	34
Nov-Dec	192	37	18	50	24	16	6	7	34

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

** Null weight resulting from the statistics.

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

TABLE 12. MEASUREMENTS OF THE EAL AND TAI FREQUENCIES

The following table gives the differences of frequencies, measured in 1985-1990, between EAL, and TAI, and the laboratory cesium standards: CRL Cs1, NIST 6, NRC CsV, NRC CsVI A, B, C, PTB CS1, PTB CS2, SU MCsR 101, SU MCsR 102. The frequencies are expressed at sea level (gravitational corrections applied).

The standard CRL Cs1 (previously RRL Cs1) performs discontinuous calibrations of UTC(CRL) which are transferred to EAL by linear adjustment of EAL-UTC(CRL) over 60 days.

The standard NIST 6 (previously NBS 6) is operated in discontinuous mode. The calibration data, referred to UTC(NIST), are transferred to EAL and TAI by a linear adjustment of EAL-UTC(NIST) over 80 days.

The standard NRC CsV has been working as a clock since May 1975. The EAL and TAI calibrations result from a linear adjustment of EAL-standard over 60-day intervals.
The standards NRC Cs VI A and C have been used as clocks since the end of 1979 and the calibration data are transferred to EAL as for NRC CsV. The standard NRC Cs VI B was used as clock from the end of 1979 until the beginning of 1988.

The standard PTB CS1 was used as a frequency reference operating discontinuously until July 1978. Since then, it has been running as a clock, and the calibrations are obtained as for NRC CsV.
The standard PTB CS2 runs as a clock. The data, starting from August 1986, have been used in the same way as those of PTB CS1.

The standards SU MCsR 101 and 102 provide the frequency of TA(SU) and UTC(SU). The transfer to EAL is made by averaging the frequency difference of TA(SU) and EAL over several months.

TABLE 12. (CONT.)

Interval MJD	Central date	NRC CsV	NRC CsVIA	NRC CsVIB	NRC CsVIC	PTB CS1	PTB CS2
		f(EAL) - f(Standard) in 10^{-13}					
46059-46119	1985 Jan 24	7.19	8.81	8.45	7.72	8.66	
46119-46179	1985 Mar 25	7.51	7.52	8.05	7.82	8.19	
46179-46239	1985 May 24	8.27	8.03	6.52	8.17	8.36	
46239-46299	1985 Jul 23	8.47	8.04	7.03	7.08	8.17	
46299-46369	1985 Sep 26	8.58	6.86	7.55	7.03	7.93	
46369-46429	1985 Nov 30	8.47	9.22	9.90	6.74	8.57	
46429-46489	1986 Jan 29	8.70	8.93	9.69	8.21	8.58	
46489-46549	1986 Mar 30	8.62	8.68	9.62	8.16	8.36	
46549-46609	1986 May 29	8.81	8.39	8.78	8.63	8.05	
46609-46669	1986 Jul 28	8.11	9.25	9.02	8.80	7.85	
46669-46729	1986 Sep 26	8.05	9.77	9.35	9.17	8.02	7.61
46729-46789	1986 Nov 25	8.56	8.53	8.99	8.79	8.06	7.85
46789-46849	1987 Jan 24	7.99	8.01	9.18	8.90	8.18	7.98
46849-46909	1987 Mar 25	8.33	8.13	8.41	8.65	8.36	7.91
46909-46969	1987 May 24	7.03	7.46	8.70	8.26	7.99	7.69
46969-47029	1987 Jul 23	6.40	7.01	8.38	7.00	8.20	7.64
47029-47099	1987 Sep 26	6.50	7.79	7.55	6.43	7.82	7.68
47099-47159	1987 Nov 30	7.11	8.78	10.48	6.87	8.04	7.79
47159-47219	1988 Jan 29	9.71	10.70	-	8.18	7.97	7.85
47219-47279	1988 Mar 29	8.56	7.78	-	7.48	8.16	7.79
47279-47339	1988 May 28	8.16	7.16	-	7.59	8.11	7.76
47339-47399	1988 Jul 27	9.14	5.98	-	7.39	7.80	7.64
47399-47459	1988 Sep 25	4.47	4.91	-	7.22	7.82	7.62
47459-47519	1988 Nov 24	4.79	4.13	-	4.77	7.87	7.76
47519-47579	1989 Jan 23	6.77	5.17	-	5.93	8.21	7.87
47579-47639	1989 Mar 24	7.64	5.71	-	9.12	8.14	7.72
47639-47699	1989 May 23	6.93	5.48	-	6.24	7.80	7.59
47699-47769	1989 Jul 27	4.18	4.73	-	6.62	7.66	7.42
47769-47829	1989 Sep 30	4.78	4.46	-	5.68	7.64	7.54
47829-47889	1989 Nov 29	4.52	5.66	-	6.99	7.85	7.61
47889-47949	1990 Jan 28	5.06	6.89	-	8.06	7.82	7.55
47949-48009	1990 Mar 29	8.44	7.40	-	8.22	7.77	7.49
48009-48069	1990 May 28	9.62	7.95	-	-2.09	7.82	7.53
48069-48129	1990 Jul 27	7.95	7.50	-	5.74	7.83	7.62
48129-48189	1990 Sep 25	6.66	7.70	-	7.38	7.69	7.21
48189-48249	1990 Nov 24	7.65	8.49	-	7.09	7.51	7.60

TABLE 12. (CONT.)

Interval MJD	Central date	CRL Cs1	NIST NBS6	SU MCsR 101	SU MCsR 102
		f(EAL) - f(Standard) in 10^{-13}			
46079-46139	1985 Feb 13	7.54			
46080-46096	1985 Jan 23				6.14
46100-46110	1985 Feb 9				5.78
46156-46159	1985 Apr 3				6.23
46201-46216	1985 May 24			5.87	
46230-46244	1985 Jun 21			7.04	
46247-46277	1985 Jul 16			6.39	
46279-46300	1985 Aug 13			5.75	
46312-46335	1985 Sep 16			6.84	
46339-46367	1985 Oct 15			5.90	
46370-46381	1985 Nov 7			5.83	
46502-46516	1986 Mar 20				5.87
46509-46569	1986 Apr 19	7.22			
46521-46543	1986 Apr 12				5.61
46563-46580	1986 May 22				5.76
46585-46600	1986 Jun 11				5.28
46684-46732	1986 Oct 5			5.99	
46737-46762	1986 Nov 16			5.58	
46773-46794	1986 Dec 19				5.35
46801-46816	1987 Jan 14				5.06
46859-46919	1987 Apr 5	8.73			
46886-46914	1987 Apr 14			5.37	
46919-46941	1987 May 15			5.67	
46947-46976	1987 Jun 15			6.11	
46959-47019	1987 Jul 13		9.65		
46977-46998	1987 Jul 11			6.09	
47061-47063	1987 Sep 24			5.59	
47083-47097	1987 Oct 21				5.76
47098-47124	1987 Nov 13				5.76
47130-47150	1987 Dec 11				5.36
47164-47173	1988 Jan 9				5.37
47215-47222	1988 Feb 28			5.45	
47256-47278	1988 Apr 16				5.87
47286-47288	1988 May 6				5.67
47354-47361	1988 Jul 16				5.77
47416-47433	1988 Sep 20				5.57
47437-47439	1988 Oct 4				5.64
47949-48009	1990 Apr 5	8.04			

TABLE 12. (CONT.)

Interval MJD	Central date	NRC CsV	NRC CsVIA	NRC CsVIB	NRC CsVIC	PTB CS1	PTB CS2
		f(TAI) - f(Standard) in 10^{-13}					
46059-46119	1985 Jan 24	-0.81	0.81	0.45	-0.28	0.66	
46119-46179	1985 Mar 25	-0.49	-0.48	0.05	-0.18	0.19	
46179-46239	1985 May 24	0.27	0.03	-1.48	0.18	0.36	
46239-46299	1985 Jul 23	0.47	0.04	-0.97	-0.92	0.17	
46299-46369	1985 Sep 26	0.58	-1.14	-0.45	-0.97	-0.07	
46369-46429	1985 Nov 30	0.47	1.22	1.90	-1.26	0.57	
46429-46489	1986 Jan 29	0.70	0.93	1.69	0.21	0.58	
46489-46549	1986 Mar 30	0.62	0.68	1.62	0.16	0.36	
46549-46609	1986 May 29	0.81	0.39	0.78	0.63	0.05	
46609-46669	1986 Jul 28	0.11	1.25	1.02	0.80	-0.15	
46669-46729	1986 Sep 26	0.05	1.77	1.35	1.17	0.02	-0.39
46729-46789	1986 Nov 25	0.56	0.53	0.99	0.79	0.06	-0.15
46789-46849	1987 Jan 24	-0.02	0.00	1.17	0.89	0.17	-0.04
46849-46909	1987 Mar 25	0.32	0.12	0.40	0.64	0.35	-0.10
46909-46969	1987 May 24	-0.99	-0.55	0.69	0.25	-0.03	-0.32
46969-47029	1987 Jul 23	-1.61	-1.01	0.37	-1.01	0.19	-0.37
47029-47099	1987 Sep 26	-1.51	-0.22	-0.46	-1.58	-0.19	-0.34
47099-47159	1987 Nov 30	-0.91	0.77	2.46	-1.14	0.02	-0.23
47159-47219	1988 Jan 29	1.71	2.70	-	0.18	-0.03	-0.15
47219-47279	1988 Mar 29	0.56	-0.22	-	-0.52	0.16	-0.21
47279-47339	1988 May 28	0.16	-0.84	-	-0.41	0.11	-0.24
47339-47399	1988 Jul 27	1.14	-2.02	-	-0.61	-0.20	-0.36
47399-47459	1988 Sep 25	-3.53	-3.09	-	-0.78	-0.18	-0.38
47459-47519	1988 Nov 24	-3.21	-3.87	-	-3.23	-0.13	-0.24
47519-47579	1989 Jan 23	-1.23	-2.83	-	-2.07	0.21	-0.13
47579-47639	1989 Mar 24	-0.36	-2.29	-	1.12	0.14	-0.28
47639-47699	1989 May 23	-1.07	-2.52	-	-1.76	-0.20	-0.41
47699-47769	1989 Jul 27	-3.77	-3.22	-	-1.33	-0.29	-0.53
47769-47829	1989 Sep 30	-3.17	-3.49	-	-2.27	-0.31	-0.41
47829-47889	1989 Nov 29	-3.43	-2.29	-	-0.96	-0.10	-0.34
47889-47949	1990 Jan 28	-2.84	-1.01	-	0.16	-0.08	-0.35
47949-48009	1990 Mar 29	0.59	-0.45	-	0.37	-0.08	-0.36
48009-48069	1990 May 28	1.82	0.15	-	-9.89	0.02	-0.27
48069-48129	1990 Jul 27	0.20	-0.25	-	-2.01	0.08	-0.13
48129-48189	1990 Sep 25	-1.04	0.00	-	-0.32	-0.01	-0.49
48189-48249	1990 Nov 24	-0.05	0.79	-	-0.61	-0.19	-0.10

TABLE 12. (CONT.)

Interval MJD	Central date	CRL Cs1	NIST NBS6	SU MCsR 101	SU MCsR 102
		f(TAI) - f(Standard) in 10^{-13}			
46079-46139	1985 Feb 13	-0.46			
46080-46096	1985 Jan 23				-1.86
46100-46110	1985 Feb 9				-2.22
46156-46159	1985 Apr 3				-1.77
46201-46216	1985 May 24			-2.13	
46230-46244	1985 Jun 21			-0.96	
46247-46277	1985 Jul 16			-1.61	
46279-46300	1985 Aug 13			-2.25	
46312-46335	1985 Sep 16			-1.16	
46339-46367	1985 Oct 15			-2.10	
46370-46381	1985 Nov 7			-2.17	
46502-46516	1986 Mar 20				-2.13
46509-46569	1986 Apr 19	-0.78			
46521-46543	1986 Apr 12				-2.39
46563-46580	1986 May 22				-2.24
46585-46600	1986 Jun 11				-2.72
46684-46732	1986 Oct 5			-2.01	
46737-46762	1986 Nov 16			-2.42	
46773-46794	1986 Dec 19				-2.65
46801-46816	1987 Jan 14				-2.94
46859-46919	1987 Apr 5	0.73			
46886-46914	1987 Apr 14			-2.64	
46919-46941	1987 May 15			-2.34	
46947-46976	1987 Jun 15			-1.09	
46959-47019	1987 Jul 13		1.64		
46977-46998	1987 Jul 11			-1.92	
47061-47063	1987 Sep 24			-2.42	
47083-47097	1987 Oct 21				-2.26
47098-47124	1987 Nov 13				-2.26
47130-47150	1987 Dec 11				-2.66
47164-47173	1988 Jan 9				-2.63
47215-47222	1988 Feb 28			-2.55	
47256-47278	1988 Apr 16				-2.13
47286-47288	1988 May 6				-2.33
47354-47361	1988 Jul 16				-2.23
47416-47433	1988 Sep 20				-2.43
47437-47439	1988 Oct 4				-2.36
47949-48009	1990 Apr 5	0.19			

TABLE 13. MEAN DURATION OF THE TAI SCALE INTERVAL IN SI SECONDS AT SEA LEVEL

The estimate of the mean duration of the TAI scale interval in SI seconds at sea level, is computed by the BIPM according to the method described in ' Azoubib J., Granveaud M., Guinot B., Metrologia 13, 1977, pp. 87-93 ' and is based on the calibrations of Table 12.

In the BIH Annual Reports from 1984 to 1987, the uncertainty was conservatively estimated to 5 10^{-14} since 1979. In the above table, the uncertainty is strictly the output of the computation and is based on the uncertainties reported by the laboratories.

For the months	Mean duration	Uncertainty
1984 Jan - Feb	1 - 2 10^{-14}	4 10^{-14}
1984 Mar - Apr	- 0	4
1984 May - Jun	+ 2	4
1984 Jul - Aug	+ 3	4
1984 Sep - Oct	+ 4	4
1984 Nov - Dec	+ 3	4
1985 Jan - Feb	1 + 0.9 10^{-14}	2.1 10^{-14}
1985 Mar - Apr	+ 1.8	2.0
1985 May - Jun	+ 1.3	2.0
1985 Jul - Aug	+ 1.3	2.0
1985 Sep - Oct	+ 0.8	2.0
1985 Nov - Dec	- 1.6	2.0
1986 Jan - Feb	1 - 2.9 10^{-14}	2.0 10^{-14}
1986 Mar - Apr	- 2.2	2.0
1986 May - Jun	- 0.9	1.9
1986 Jul - Aug	+ 0.4	1.9
1986 Sep - Oct	+ 2.1	1.3
1986 Nov - Dec	+ 0.6	1.3
1987 Jan - Feb	1 - 0.4 10^{-14}	1.3 10^{-14}
1987 Mar - Apr	- 0.1	1.3
1987 May - Jun	+ 2.1	1.3
1987 Jul - Aug	+ 2.6	1.3
1987 Sep - Oct	+ 2.7	1.3
1987 Nov - Dec	+ 1.5	1.3
1988 Jan - Feb	1 + 0.9 10^{-14}	1.3 10^{-14}
1988 Mar - Apr	+ 1.0	1.3
1988 May - Jun	+ 1.5	1.3
1988 Jul - Aug	+ 2.6	1.3
1988 Sep - Oct	+ 3.0	1.3
1988 Nov - Dec	+ 2.7	1.3
1989 Jan - Feb	1 + 0.8 10^{-14}	1.3 10^{-14}
1989 Mar - Apr	+ 1.9	1.3
1989 May - Jun	+ 3.5	1.3
1989 Jul - Aug	+ 4.5	1.3
1989 Sep - Oct	+ 3.8	1.3
1989 Nov - Dec	+ 2.9	1.3
1990 Jan - Feb	1 + 2.9 10^{-14}	1.3 10^{-14}
1990 Mar - Apr	+ 2.8	1.3
1990 May - Jun	+ 1.9	1.3
1990 Jul - Aug	+ 1.1	1.3
1990 Sep - Oct	+ 3.3	1.3
1990 Nov - Dec	+ 1.2	1.3

PART C

Time signals

PARTIE C

Signaux horaires

The time signal emissions reported here follow the UTC system, in accordance with the Recommendation 460-4 of the International Radio Consultative Committee (CCIR), unless otherwise stated.

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

The following tables are based on information received at the BIPM in February and March 1991.

AUTHORITIES RESPONSIBLE FOR THE TIME SIGNAL EMISSIONS

Signal	Authority
ATA	National Physical Laboratory Dr. K.S. Krishnan Road New Delhi - 110012, India
BPM	Shaanxi Astronomical Observatory Chinese Academy of Sciences P.O. Box 18 - Lintong Shaanxi, China
BSF	Telecommunication Laboratories Directorate General of Telecommunications Ministry of Communications P.O. Box 71 - Chung-Li 32099 Taiwan, R.O.C.
CHU	National Research Council Institute for National Measurement Standards - Time Standards Attn : Dr. R.J. Douglas Ottawa, Ontario, Canada K1A OR6
DCF77	Physikalisch-Technische Bundesanstalt, Lab. Zeiteinheit Bundesallee 100 W - 3300 Braunschweig Federal Republic of Germany
DGI	Amt für Standardisierung, Messwesen und Warenprüfung Zeit - und Frequenzdienst der DDR Fürstenwalder Damm 388 DDR 1162 Berlin From 1990 October 3rd PTB-Institut Berlin Fürstenwalder Damm 388 O - 1162 Berlin Federal Republic of Germany
EBC	Real Instituto y Observatorio de la Armada - San Fernando Cadiz, Spain

Signal		Authority
HBG		Service horaire HBG Observatoire Cantonal CH - 2000 Neuchâtel, Suisse
HLA		Time and Frequency Laboratory Korea Standards Research Institute P. O. Box 3, Taedok Science Town Taejon 305-606, Republic of Korea
IAM		Istituto Superiore delle Poste e delle Telecomunicazioni Ufficio 8°, Rep.2° - Viale Europa 190 00144 - Roma, Italy
IBF		Istituto Elettrotecnico Nazionale Galileo Ferraris Strada delle Cacce, 91 10135 - Torino, Italy
JJY, JG2AS		Standards and Measurements Division Communications Research Laboratory 2-1, Nukui-kitamachi 4-chome Koganei-shi, Tokyo 184 Japan
LOL		Director Observatorio Naval Av. Espana 2099 1107 - Buenos-Aires, Republica Argentina
MSF		National Physical Laboratory Division of Electrical Science Teddington, Middlesex TW11 OLW United Kingdom
OMA	/1	Time information Astronomicky ustav CSAV, Budecska 6 120 23 Praha 2, Vinohrady, Czechoslovakia
	/2	Standard frequency information Ustav radiotechniky a elektroniky CSAV, Chaberska 57 182 51 Praha 8, Kobylisy, Czechoslovakia

Signal	Authority
PPE, PPR	Departemento Serviço da hora Observatorio Nacional (CNPq) Rua General Bruce, 586 20921 Rio de Janeiro - RJ, Brasil
RBU, RCH, RID, RTA, RTZ, RWM, UNW3, UPD8, UQC3, USB2,UTR3	VNIIFTRI Mendeleevo Moscow Region 141570 USSR
TDF	Centre National d'Etudes des Télécommunications - PAB - STC Etalons de fréquence et de temps 196 avenue Henri Ravera 92220 - Bagneux, France
WWV,WWVH WWVB	Time and Frequency Division, 847.00 National Institute of Standards and Technology - 325 Broadway Boulder, Colorado 80303, U.S.A.
YVTO	Direccion de Hidrografia y Navegacion Observatorio Cagigal Apartado Postal No 6745 Caracas, Venezuela

Note

The emission of time signals by OLB5 and OMA(2500 kHz) stations, Liblice Czechoslovakia, ceased on 1990, June 3. The emission of time signals by Y3S, Nauen Germany, ceased on 1990, July 1st.

TIME SIGNALS EMITTED IN THE UTC SYSTEM

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
ATA	Greater Kailash New Delhi India 28° 34'N 77° 19'E	5 000 10 000 15 000	12 h 30 m to 3 h 30 m continuous 3 h 30 m to 12 h 30 m	Second pulses of 5 cycles of a 1 kHz modulation. Minute pulses of 100 ms duration. (The time signals are advanced by 50 ms on UTC).
BPM	Pucheng China 35° 0'N 109° 31'E	2 500 5 000 10 000 15 000	7 h 30 m to 1 h continuous continuous 1 h to 9 h	UTC time signals (The signals are emitted in advance on UTC by 20 ms). Second pulses of 10 ms of 1 kHz modulation. Minute pulses of 300 ms of 1 kHz modulation. From minutes 0 to 10, 15 to 25, 30 to 40, 45 to 55. UT1 time signals are emitted from minutes 55 to 59.
BSF	Chung-Li Taiwan ROC 24° 57'N 121° 9'E	5 000 15 000	continuous except interruption between minutes 35 and 40	(a) From min. 5 to 10, 15 to 20, 25 to 30, 45 to 50, 55 to 60, second pulses of 5 ms duration without 1 kHz modulation. (b) From min. 0 to 5, 10 to 15, ..., 50 to 55, second pulses of 5 ms duration with 1 kHz modulation. The 1 kHz modulation is interrupted 40 ms before and after the pulses. (c) Minute pulses are extended to 300 ms. (d) DUT1: CCIR code by lengthening.
CHU	Ottawa Canada 45° 18'N 75° 45'W	3 330 7 335 14 670	continuous	Second pulses of 300 cycles of a 1 kHz modulation, with 29th and 51st to 59th pulses of each minute omitted. Minute pulses are 0.5 s long. Hour pulses are 1.0 s long, with the following 1st to 10th pulses omitted. A bilingual (Fr. Eng.) announcement of time (UTC) is made each minute following the 50th second pulse. FSK time code after 10 cycles of 1 kHz on the 31st to 39th seconds. Broadcast is single sideband; upper sideband with carrier reinsert. DUT1 : CCIR code by split pulses.
DCF77	Mainflingen Germany, F.R. 50° 1'N 9° 0'E	77.5	continuous	At the beginning of each second (except the 59th second) the carrier amplitude is reduced to about 25 % for a duration of 0.1 s or 0.2 s. Coded transmission of year, month, day, hour, minute and day of the week in a BCD code from second marker No 21 to No 58(The second marker durations of 0.1 s or 0.2 s correspond to a binary 0 or a binary 1 respectively). The coded time information is related to legal time of FRG and second markers 17 and 18 indicate if the transmitted time refers to UTC(PTB) + 2 h (summer time) or UTC(PTB) + 1 h. Second marker No 15 is prolonged to 0.2 s, if the reserve antenna is in use. To achieve a more accurate time transfer and better use of the frequency spectrum available, an additional pseudo random phase - shift keying of the carriePr is superimposed to the AM second markers. No transmission of DUT1.

TIME SIGNALS EMITTED IN THE UTC SYSTEM

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
DGI	Oranienburg Germ.Dem.Rep. 52° 48'N 13° 24'E	182	5 h 59 m 30 s to 6 h 00, 11 h 59 m 30 s to 12 h 00, 17 h 59 m 30 s to 18 h 00	A2 type second pulses of 0.1 s duration for seconds 30-40, 45-50, 55-60. The last pulse is prolonged. (One hour earlier in summer time)
EBC	San Fernando Spain 36° 28'N 6° 12'W	12 008 6 840	10 h 00 m to 10 h 25 m 10 h 30 m to 10 h 55 m	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: CCIR code by double pulse.
HBG	Prangins Switzerland 46° 24'N 6° 15'E	75	continuous	Interruption of the carrier at the beginning of each second, during 100 ms. The minutes are identified by a double pulse, the hours by a triple pulse. No transmission of DUT1. Time code and other coded information.
HLA	Taedok Science Town Republic of Korea 36° 23'N 127° 22'E	5 000	Continuous	Pulses of 9 cycles of 1800 Hz modulation. 29th and 59th second pulses omitted. Hour identified by 0.8 second long 1500 Hz tone. Beginning of each minute identified by 0.8 second long 1800 Hz tone. Voice announcement of hours and minutes each minute following 52nd second pulse. BCD time code given on 100 Hz subcarrier. DUT1 : CCIR code by double pulse.
IAM	Rome Italy 41° 47'N 12° 27'E	5 000	7 h 30 m to 8 h 30 m 10 h 30 m to 11 h 30 m except sunday and national holidays. Advance by 1 hour in summer.	Second pulses of 5 cycles of 1 kHz modulation. Minute pulses of 20 cycles. Voice announcements every 15 m beginning at 0 h 0 m. Time announcement by Morse code beginning at 0 h 5 m. DUT1 : CCIR code by double pulse.
IBF	Torino Italy 45° 2'N 7° 42'E	5 000	During 15 m preceding 7 h, 9 h, 10 h, 11 h, 12 h, 13 h, 14 h, 15h, 16 h, 17 h, 18 h. Advanced by 1 hour in summer.	Second pulses of 5 cycles of 1 kHz modulation. These pulses are repeated 7 times at the minute. Voice announcements at the beginning and end of each emission. Time announcement (C.E.T.) by Morse code every ten minutes beginning at 0 h 0 m. DUT1 : CCIR code by double pulse.
JG2AS	Sanwa Ibaraki Japan 36° 11'N 139° 51'E	40	continuous, except interruptions during communications.	A1 type second pulses of 0.5 s duration. Second 59 is of 0.2 s duration. No DUT1 code. During experimental coded transmission of the total day, hour, minute and DUT1, second pulses are 0.2 s, 0.5 s and 0.8 s duration.
JJY	Sanwa Ibaraki Japan 36° 11'N 139° 51'E	2 500 5 000 8 000 10 000 15 000	continuous, except interruption between minutes 35 and 39.	Second pulses of 8 cycles of 1 600 Hz modulation. Minute pulses are preceded by a 600 Hz modulation. DUT1 : CCIR code by lengthening.
LOL1	Buenos-Aires Argentina 34° 37'S 58° 21'W	5 000 10 000 15 000	11 h to 12 h, 14 h to 15 h, 17 h to 18 h, 20 h to 21 h, 23 h to 24 h	Second pulses of 5 cycles of 1 000 Hz modulation. Second 59 is omitted. Announcement of hours and minutes every 5 minutes, followed by 3 m of 1 000 Hz or 440 Hz modulation. DUT1 : CCIR code by lengthening.

TIME SIGNALS EMITTED IN THE UTC SYSTEM

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
LOL2 LOL3	Buenos-Aires Argentina 34° 37'S 58° 21'W	4 856 8 030 17 180	1 h, 13 h, 21 h	A1 second pulses during the 5 minutes preceding the indicated times. Second 29 is omitted. Minute pulses are prolonged. DUT1 : CCIR code by double pulse.
MSF	Rugby United Kingdom 52° 22'N 1° 11'W	60	continuous except for an interruption for maintenance from 10 h 0 m to 14 h 0 m on the first Tuesday in each month.	Interruptions of the carrier of 100 ms for the second pulses, of 500 ms for the minute pulses. The signal is given by the beginning of the interruption. BCD NRZ code, 100 bits/s (month, day of month, hour, minute), during minute interruption. BCD PWM code, 1 bit/s (year, month, day of month, day of week, hour, minute) from seconds 17 to 59 in each minute. DUT1 : CCIR code by double pulse.
OMA (1)	Liblice Czechoslovakia 50° 4'N 14° 53'E	50	continuous (from 6 h to 12 h on the first Wednesday in each month, emitted from Podebrady with reduced power)	Interruption of the carrier of 100 ms at the beginning of every second, of 500 ms at the beginning of every minute. The precise time is given by the beginning of the interruption. Phase coded announcement of date, UT and local civil time, leap second and civil time change, and identification of the transmitter in operation. No DUT1 code.
PPE	Rio-de-Janeiro Brasil 22° 54'S 43° 13'W	8 721	0 h 30 m, 11 h 30 m, 13 h 30 m, 19 h 30 m, 20 h 30 m, 23 h 30 m	Second ticks, of A1 type, during the five minutes preceding the indicated times. The minute ticks are longer. DUT1 : CCIR code by double pulse.
PPR	Rio-de-Janeiro Brasil 22° 59'S 43° 11'W	435 4 244 8 634 13 105 17 194.4 22 603	1 h 30 m, 14 h 30 m, 21 h 30 m	Second ticks, of A1 type, during the five minutes preceding the indicated times. The minute ticks are longer.
RBU (2)	Moscow USSR 55° 48'N 38° 18'E	66	continuous	DXXXW type signals. The time of day in hours, minutes and seconds is transmitted in BCD code. From 9 h to 11 h, 19 h to 23 h, NON type signals.
RCH (2)	Tashkent USSR 41° 19'N 69° 15'E	 2 500 5 000 10 000	between minutes 0 and 10, 30 and 40 0 h to 4 h 40 m 6 h to 23 h 40 m 0 h to 4 h 40 m 15 h to 23 h 40 m 6 h to 14 h 10 m	A1X type second pulses. The pulses at the beginning of the minute are prolonged to 0.5 s.

Notes : see p. C-10

TIME SIGNALS EMITTED IN THE UTC SYSTEM

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
RID (2)	Irkutsk USSR 52° 26'N 104° 2'E	5 004 10 004 15 004	The station simultaneously operates on three frequencies between minutes 20 and 30, 50 and 60	A1X type second pulses. The pulses at the beginning of the minute are prolonged to 0.5 s.
RTA (2)	Novosibirsk USSR 55° 4'N 82° 58'E	 10 000 15 000	between minutes 0 and 10, 30 and 40 0 h to 6 h 10 m 15 h to 23 h 40 m 7 h 30 m to 14 h 10 m	A1X type second pulses. The pulses at the beginning of the minute are prolonged to 0.5 s.
RTZ (2)	Irkutsk USSR 52° 26'N 104° 2'E	50	between minutes 0 and 5 0 h to 21 h 05 m 23 h to 23 h 05 m	A1X type second pulses. The pulses at the beginning of the minute are prolonged to 0.5 s.
RWM (2)	Moscow USSR 55° 48'N 38° 18'E	4 996 9 996 14 996	The station simultaneously operates on three frequencies between minutes 10 and 20, 40 and 50	A1X type second pulses. The pulses at the beginning of the minute are prolonged to 0.5 s.
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 + and - 1 radian 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 one 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.
UNW3	Molodechno USSR 54° 26'N 26° 48'E	25	Winter schedule : 8 h 13 m to 8 h 22 m 14 h 13 m to 14 h 22 m Summer schedule : 7 h 13 m to 7 h 22 m 13 h 13 m to 13 h 22 m	A1N type 0.1 second pulses of 0.025 s duration. Second pulses are prolonged to 0.1 s. 10 second pulses are prolonged to 1 s and minute pulses are prolonged to 10 s. No transmission of DUT1 code.
UPD8	Arkhangelsk USSR 64° 24'N 41° 32'E	25	Winter schedule : 12 h 13 m to 12 h 22 m 22 h 13 m to 22 h 22 m Summer schedule : 3 h 13 m to 3 h 22 m 9 h 13 m to 9 h 22 m	A1N type 0.1 second pulses of 0.025 s duration. Second pulses are prolonged to 0.1 s. 10 second pulses are prolonged to 1 s and minute pulses are prolonged to 10 s. No transmission of DUT1 code.

Notes : see p. C-10

TIME SIGNALS EMITTED IN THE UTC SYSTEM

Station	Location Latitude Longitude	Frequency (kHz)	Schedule (UTC)	Form of the signal
UQC3	Chabarovsk USSR 48° 30'N 134° 51'E	25	Winter schedule : 3 h 13 m to 3 h 22 m 9 h 13 m to 9 h 22 m 15 h 13 m to 15 h 22 m Summer schedule : 2 h 13 m to 2 h 22 m 8 h 13 m to 8 h 22 m 14 h 13 m to 14 h 22 m	A1N type 0.1 second pulses of 0.025 s duration. Second pulses are prolonged to 0.1 s. 10 second pulses are prolonged to 1 s and minute pulses are prolonged to 10 s. No transmission of DUT1 code.
USB2	Frunze USSR 43° 04'N 73° 39'E	25	Winter schedule : 5 h 13 m to 5 h 22 m 11 h 13 m to 11 h 22 m 17 h 13 m to 17 h 22 m Summer schedule : 4 h 13 m to 4 h 22 m 10 h 13 m to 10 h 22 m 20 h 13 m to 20 h 22 m	A1N type 0.1 second pulses of 0.025 s duration. Second pulses are prolonged to 0.1 s. 10 second pulses are prolonged to 1 s and minute pulses are prolonged to 10 s. No transmission of DUT1 code.
UTR3	Gorki USSR 56° 11'N 43° 58'E	25	Winter schedule : 6 h 13 m to 6 h 22 m 20 h 13 m to 20 h 22 m Summer schedule : 5 h 13 m to 5 h 22 m 19 h 13 m to 19 h 22 m	A1N type 0.1 second pulses of 0.025 s duration. Second pulses are prolonged to 0.1 s. 10 second pulses are prolonged to 1 s and minute pulses are prolonged to 10 s. No transmission of DUT1 code.
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 : CCIR 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 savings 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 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 : CCIR code by double pulse. BCD time code given on 100 Hz subcarrier, includes DUT1 correction.
YVTO	Caracas Venezuela 10° 30'N 66° 56'W	5 000	continuous	Second pulses of 1 kHz modulation with 0.1 s duration. The minute is identified by a 800 Hz tone and a 0.5 s duration. Second 30 is omitted. Between seconds 40 and 50 of each minute, voice announcement of the identification of the station. Between seconds 52 and 57 of each minute, voice announcement of hour, minute and second.

NOTES ON THE CHARACTERISTICS OF THE SIGNALS

(1) OMA, 50 kHz
The main transmitter in Liblice radiates approximately 7 kW and the stand-by transmitter in Podebrady (50° 9'N, 15° 9'E) approximately 50 W. The details of the time code were published in Nomenclature des stations de radiorepérage et des stations effectuant des services spéciaux. Liste VI, Volume I, édition 7 de U.I.T. in Geneva in July 1980.

(2) USSR radiostation emitting DUT1 information in accordance with the CCIR 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 21th and 24th second so that dUT1 = +p.0,02 s. Negative values of dUT1 are transmitted by the marking of q second markers within the range between the 31th and the 34th second, so that dUT1 = -q.0,02 s.

ACCURACY OF THE CARRIER FREQUENCY

Station	Relative uncertainty of the carrier frequency in 10^{-10}
ATA	0.1
BPM	0.1
BSF	0.1
CHU	0.05
DCF77	0.005 (10d-mean)
EBC	0.1
HBG	0.005
HLA	0.1
IAM	0.5
IBF	0.1
JJY, JG2AS	0.1
LOL	0.1
MSF	0.02
OMA	0.5
RBU, RTZ	0.05
RCH, RID, RTA, RWM	0.5
TDF	0.02
UNW3, UPD8, UQC3,	0.05
USB2, UTR3	0.05
WWV	0.1
WWVB	0.1
WWVH	0.1

Erratum

Annual Report for 1989:

page A-11, Table B, add

Lab	1988	1987	1986
APL	42 6	42 6 + 1.60	42 6 + 1.60
	42 13	42 13 - 1.55	42 13 - 1.55
	42 14	42 14 + 4.39	42 14 + 4.39

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