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1. GENERAL BACKGROUND INFORMATION

ABBREVIATIONS AND ACRONYMS USED IN THIS BULLETIN

BIPM	- Bureau International des Poids et Mesures		
CCIR	- International Radio Consultative Committee		
cs	Cesium standard		
GOES	- Geostationary Operational Environmental Satellite		
GPS	- Global Positioning System		
IERS	- International Earth Rotation Service		
LORAN	- Long Range Navigation		
MC	Master Clock		
MJD	- Modified Julian Date		
NVLAP	- National Voluntary Laboratory Accreditation Program		
NIST	- National Institute of Standards & Technology		
NOAA	- National Oceanic and Atmospheric Administration	ns	- nanosecond
SI	International System of Units	µs	- microsecond
TA	Atomic Time	ms	- millisecond
TAI	International Atomic Time	s	- second
USNO	- United States Naval Observatory	min	- minute
UTC	- Coordinated Universal Time	h	- hour
VLF	very low frequency	d	- day

JUN 1997	MJD	UTI −UTC(NIST) (±5 ns)	UTC(USNO,MC) −UTC(NIST) (± 20 ns)

3. UT1 CORRECTIONS AND LEAP SECOND ADJUSTMENTS

The master clock pulses used by the WWV, **WWVH**, WWVB, and GOES time code transmissions are referenced to the UTC(NIST) time scale. Occasionally, 1 s is added to the UTC time scale. This second is called a leap second. Its purpose is to keep the UTC time scale within ±0.9 s of the UT1 astronomical time scale, which changes slightly due to variations in the rotation of the Earth.

Positive leap seconds, beginning at 23 h 59 min 60 s UTC and ending at 0 h 0 min 0 s UTC, were inserted in the UTC timescale on 30 June 1972,1981-1983,1985,1992, 1993, 1994, and 1997, and on 31 December 1972-1979,1987, 1989, 1990, and 1995.

The use of leap seconds ensures that UT1 − UTC will always be held within ±0.9 s. The current value of UT1 − UTC is called the DUTI correction. DUTI corrections are broadcast by WWV, **WWVH**, WWVB, and GOES and are printed below. These corrections may be added to received UTC time signals in order to obtain UT1.

DUTI = UT1 - UTC =	−0.4 s beginning 0000 UTC 08 May 1997
	−0.5 s beginning 0000 UTC 26 June 1997
	+0.5 s beginning 0000 UTC 01 July 1997

The deviation of UTC(NIST) from UTC has been less than +/- 100 ns since July 6, 1994. The table below shows values of UTC - UTC(NIST) as supplied by the BIPM in Circular T for the most recent 350 day period in which data are available. Data are given at ten day intervals. Five day interval data are available in Circular T.

0000 Hours Coordinated Universal Time

Date	MJD	UTC – UTC(NIST) ns
June 15, 96	50249	-23
June 25, 96	50259	-23
July 5, 96	50269	-25
July 15, 96	50279	-22
July 25, 96	50289	-24
Aug. 4, 96	50299	-29
Aug. 14, 96	50309	-23
Aug. 24, 96	50319	-16
Sep. 3, 96	50329	-7
Sep. 13, 96	50339	-3
Sep. 23, 96	50349	-2
Oct. 3, 96	50359	0
Oct. 13, 96	50369	2
Oct. 23, 96	50379	6
Nov. 2, 96	50389	13
Nov. 12, 96	50399	23
Nov. 22, 96	50409	34
Dec. 2, 96	50419	44
Dec. 12, 96	50429	49
Dec. 22, 96	50439	50
Jan. 1, 97	50449	44
Jan. 11, 97	50459	40
Jan. 21, 97	50469	36
Jan. 31, 97	50479	29
Feb. 10, 97	50489	27
Feb. 20, 97	50499	21
Mar. 2, 97	50509	20
Mar. 12, 97	50519	12
Mar. 22, 97	50529	10
Apr. 1, 97	50539	5
Apr. 11, 97	50549	6
Apr. 21, 97	50559	-3
May 1, 97	50569	-5
May 11, 97	50579	-7
May 21, 97	50589	-4
May 31, 97	50599	-5

4. PHASE DEVIATIONS FOR WWVB AND LORAN-C

WWVB - The values shown for WWVB are the time difference between the time markers of the UTC(NIST) time scale and the first positive-going zero voltage crossover measured at the transmitting antenna. The uncertainty of the individual measurements is $\pm 0.5\ \mu s$. The values listed are for 1300 UTC.

LORAN-C - The values shown for Loran-C represent the daily accumulated phase shift (in nanoseconds). The phase shift is measured by comparing the output of a Loran receiver to the UTC(NIST) time scale for a period of 24 h. If data were not recorded on a particular day, the symbol (-) is printed.

The master stations monitored are Dana, IN (8970) and Fallon, NV (9940). The monitoring is done from the NIST laboratories in Boulder, CO.

Note: The values shown for Loran-C are in nanoseconds.

DATE	MJD	UTC(NIST)-WWVB(60 kHz) ANTENNA PHASE (μs)	UTC(NIST) - LORAN PHASE (ns) LORAN-C (DANA) (8970)	LORAN-C (FALLON)* (9940)
6/01/97	50600	5.70	+263	−113
6/02/97	50601	5.74	−454	(-)
6/03/97	50602	5.78	−641	+183
6/04/97	50603	5.75	−54	−201
6/05/97	50604	5.80	−52	−129
6/06/97	50605	5.66	−213	−5
6/07/97	50606	5.70	−306	−126
6/08/97	50607	5.78	−127	+16
6/09/97	50608	5.84	+129	−50
6/10/97	50609	5.75	−231	−127
6/11/97	50610	5.83	−312	−169
6/12/97	50611	5.83	+223	−113
6/13/97	50612	5.84	−260	−396
6/14/97	50613	5.80	−292	−59
6/15/97	50614	5.78	−408	−501
6/16/97	50615	5.74	(-)	+203
6/17/97	50616	5.81	(-)	−352
6/18/97	50617	5.81	−538	(-)
6/19/97	50618	5.85	+11	−177
6/20/97	50619	5.74	+117	+247
6/21/97	50620	5.73	+1	−25
6/22/97	50621	5.73	−359	+178
6/23/97	50622	5.72	+73	−159
6/24/97	50623	5.76	(-)	+191
6/25/97	50624	5.68	+89	−368
6/26/97	50625	5.72	(-)	+199
6/27/97	50626	5.73	−594	−107
6/28/97	50627	5.73	+242	−328
6/29/97	50628	5.73	(-)	−187
6/30/97	50629	5.73	−188	+95

5. GOES TIME CODE INFORMATION

A. TIME CODE PERFORMANCE **(1-30 June 1997)**

GOES/East:
Currently using the GOES-8 satellite at 75° west longitude. Timing uncertainty is ±100 μs with respect to UTC(NIST).

GOES/West:
Currently using the GOES-9 satellite at 135° west longitude. Timing uncertainty is ±100 μs with respect to UTC(NIST).

Stationkeeping maneuver on GOES-9 was performed on June 19th at 0700 UTC.

6. BROADCAST OUTAGES OVER *5* MINUTES AND WWVB PHASE PERTURBATIONS

OUTAGES							PHASE PERTURBATIONS WWVB *60* KHz			
Station	JUN 1997	MJD	Began UTC	Ended UTC	Freq.		JUN 1997	MJD	Began UTC	End UTC
WWVB	6/23 6/24	50622 50623	1840 0030	2020 1230	60 KHz					
WWV	6/23	50622	1840	1900	All Frequencies					
WWVH										

7. NOTES ON NIST TIME SCALES AND PRIMARY STANDARDS

Primary frequency standards developed and maintained by NIST are used to provide accuracy (rate) input to the BIPM. NBS-6, which served as the U.S. primary standard from 1975 through 1992, has been replaced by NISI-7, an optically pumped cesium-beam standard. The uncertainty of the new standard is currently 1 part in 10^{14}.

Since 1981, TA(NIST) has been computed retrospectively each month using a Kalman algorithm. The purpose of TA(NIST) was to provide a flywheel that realized our best estimate of the SI second between calibrations of our primary frequency standard, but the algorithm we have been using is not optimum for this purpose and is particularly unsuited to our new higher-accuracy environment. We therefore stopped computing TA(NIST) on 31 October 1993. We are studying alternate methods for incorporating the rate accuracy of NIST-7 into our time-scale algorithm, but no changes are likely until a thorough evaluation of the new procedure has been completed.

The AT1 scale is run in real time using data from an ensemble of cesium standards and hydrogen masers. It is a free-running scale whose frequency is maintained as constant as possible by choosing the optimum weight for each clock that contributes to the computation.

UTC(NIST) is generated as an offset from our real-time scale AT1. It is steered in frequency towards UTC using data published by the BIPM in its Circular T. Changes in the steering frequency will be made only at 0000 UTC on the first day of any month, and the change in frequency in any month is limited to ±2 ns/day. The frequency of UTC(NIST) is kept as stable as possible at other times.

UTC is generated at the BIPM using a post-processed time-scale algorithm and is not available in real-time. The parameters that we use to generate UTC(NIST) in real-time are therefore based on an extrapolation of UTC from the most recent data available.

8. BIBLIOGRAPHY

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Table **7.1** is a list of the parameters that are used to define UTC(NIST) with respect to our real-time scale AT1. **To** find the value of UTC(NIST) − AT1 at any time T (expressed as a Modified Julian Day, including a fraction if needed), the appropriate equation to use is the one for which the desired T is greater than or equal to the entry in the T_0 column and less than the entry in the last column. The values of x_{ls}, x, and y for that month are then used in the equation below to find the desired value. The parameters x and y represent the offset in time and in frequency, respectively, between UTC(NIST) and AT1; the parameter x_{ls} is the number of leap seconds applied to both UTC(NIST) and UTC as specified by the IERS. Leap seconds are not applied to AT1.

Month	x_{ls} (s)	x (ns)	y (ns/day)	T_0 (MJD)	Valid until 0000 UT (MJD)
Sep 95	−29	−133364	−43.0	49961	49991
Oct 95	−29	−134654	−43.5	49991	50022
Nov 95	−29	−136003	−44.0	50022	50052
Dec 95	−29	−137323	−44.0	50052	50083
Jan 96	−30	−138687	−43.5	50083	50114
Feb 96	−30	−140035	−43.5	50114	50143
Mar 96	−30	−141297	−43.5	50143	50174
Apr 96	−30	−142645	−43.5	50174	50204
May 96	−30	−143950	−43.5	50204	50235
Jun 96	−30	−145299	−43.5	50235	50265
Jul 96	−30	−146604	−44.0	50265	50296
Aug 96	−30	−147968	−44.5	50296	50327
Sep 96	−30	−149347	−44.5	50327	50357
Oct 96	−30	−150682	−44.0	50357	50388
Nov 96	−30	−152046	−44.0	50388	50418
Dec 96*	−30 −30	−153366 −154066.8	−43.8 −42.6	50418 50434	50434 50449
Jan 97	−30	−154705.8	−42.5	50449	50480
Feb 97	−30	−156023.3	−42.5	50480	50508
Mar 97	−30	−157213.3	−42.7	50508	50539
Apr 97	−30	−158537	−42.5	50539	50569
May 97	−30	−159812	−43.0	50569	50600
Jun 97	−30	−161145	−43.0	50600	50630
Jul 97	-31	−162435	-43.0	50630	50661
Aug 97	-31	−163768	-43.0'	50661	50692

*Note rate change in mid-month

9. SPECIAL ANNOUNCEMENTS

TRACEABLE FREQUENCY CALIBRATIONS
(Now NVLAP **Certified)**

Anyone needing traceable frequency calibrations can get them by subscribing to the NIST Frequency Measurement and Analysis Service. This service is offered on a lease basis by NIST to provide an easy and inexpensive means to obtain traceability of a laboratory main oscillator and, in addition, to calibrate other devices in the lab. This service has been designed for ease of operation and as a practical lab calibration tool.

All the equipment and software needed are provided by NIST. Users must provide their own oscillator(s) and an ordinary telephone line *so* that NIST can access the system by modem. A total of four oscillators can be calibrated at the same time. Radio signals from either Loran-C or GPS satellite are used. Results for either are at about the same accuracy.

The calibration data are displayed in color and a graph is plotted daily for each oscillator connected. Data are also stored on disk. The user can call up any of the data and view them onscreen or in the form of plots. Many months of data can be plotted.

The system plots are easy to read and understand. The system manual is written for easy understanding and the NIST staff is available by telephone to assist. The modem connection allows NIST to access the data and to prepare a monthly traceability report which is mailed to the user.

Frequency sources of any accuracy can be calibrated. The FMAS is particularly useful at the highest levels of performance. This is because each user of the system contributes information and calibration data for the others. If an uncertainty arises, it is possible for NIST to call by modem to another user nearby. In this way problems in data interpretation can be resolved.

NVLAP certification requirements for frequency measurement are met by following the NIST-FMAS operating manual. This service does not eliminate the NVLAP audits but, when installed and operated per the NIST guidelines, audit requirements are easily met.

NIST retains title to the equipment and supplies any needed system spares. Equipment that fails is replaced by overnight shipment. Training for use of the system is available if requested by the user.

The NIST Frequency Measurement and Analysis Service provides a complete solution to nearly all frequency measurement and calibration problems. For a free information package, please call Michael Lombardi at (303) 497-3212, or write to: Michael Lombardi, NIST, Division 847, 325 Broadway, Boulder, CO 80303.