**T I M E S C A L E S**

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*1993? First version as an ASCII document.  
1995 and on: Posted on*[*Usenet*](https://en.wikipedia.org/wiki/Usenet)*several times and became part of the*[*sci.astro FAQ*](http://sciastro.astronomy.net/)[*part 3*](http://sciastro.astronomy.net/sci.astro.3.FAQ) *2004-09-?? First HTML version, for an article in the Swedish ham radio magazine*[*QTC*](http://www.ssa.se/ssa/medlemstidningen-qtc/) *2005-04-19 Replaced obsolete links with working ones  
2005-06-22 Major overhaul: corrected several small errors, updated tables, added new links.  
Thanks to John Stockton (*[*http://www.merlyn.demon.co.uk/*](https://web.archive.org/web/20121231004642/http:/www.merlyn.demon.co.uk:80/)*) for a number of suggestions to this page.  
2005-07-10 Added a link to Steve Allen's*[*detailed history of the time scales*](http://www.ucolick.org/~sla/leapsecs/timescales.html)*. 2017-09-30 Updated or removed obsolete links.*

* [The different time scales](http://stjarnhimlen.se/comp/time.html#timescales)
* [Delta-T](http://stjarnhimlen.se/comp/time.html#deltat)
* [Delta-T 1972-present](http://stjarnhimlen.se/comp/time.html#deltat72p)
* [Delta-T 1620-1972](http://stjarnhimlen.se/comp/time.html#deltat16201972)
* [Links to more information](http://stjarnhimlen.se/comp/time.html#links)
* [Time signals by shortwave radio](http://stjarnhimlen.se/comp/time.html#timesignals)
* [World standard time zones](http://stjarnhimlen.se/comp/time.html#timezones)

**The different time scales**

TAI = International Atomic Time (Temps Atomique International = TAI) is

defined as the weighted average of the time kept by about 200

atomic clocks in over 50 national laboratories worldwide.

TAI-UT1 was approximately 0 on 1958 Jan 1.

UTC = Coordinated Universal Time. Differs from TAI by an integral

number of seconds. When needed, leap seconds are introduced in UTC

to keep the difference between UTC and UT less than 0.9 s.

UTC was introduced in 1972.

UT = Universal time. Defined by the Earth's rotation, formerly determined

by astronomical observations but today GPS satellites are used

instead. This time scale is slightly irregular. There are several

different definitions of UT, but the difference between them is always

less than about 0.03 s.

UT0 = "raw", uncorrected UT as derived from meridian circle observations

or from more modern methods involving GPS satellites.

UT1 = UT0 corrected for polar wandering - usually one means UT1 when

saying UT.

UT2 = UT1 corrected for seasonal variations in the Earth's rotational

speed, by adding

+ 0.022 \* sin(2\*pi\*t) - 0.017 \* cos(2\*pi\*t)

- 0.007 \* sin(4\*pi\*t) + 0.006 \* cos(4\*pi\*t)

seconds to UT1, where t is the fraction of the year (zero at 1 Jan).

UT2 is nowadays considered obsolete.

ET = Ephemeris Time. Was used 1960-1983, and was replaced by TDT and TDB

in 1984. For most purposes, ET up to 1983 Dec 31 and TDT from 1984

Jan 1 can be regarded as a continuous time-scale.

TDT = Terrestial Dynamical Time. Was used 1984-2000 as a time-scale of

ephemerides from the Earth's surface. TDT = TAI + 32.184. Replaced

ET (Ephemeris Time) in 1984, was replaced by TT (Terrestial Time)

in 2001.

TDB = Barycentric Dynamical Time. Used as a time-scale of ephemerides

referred to the barycentre of the solar system. Differs from TDT

by at most a few milliseconds.

TDB = TT + 0.001 658s \* sin(g) + 0.000 014s \* sin(2\*g)

g = 357.53\_d + 0.985 600 28\_d \* ( JD - 245 1545.0 )

(higher order terms neglected; g = Earth's mean anomaly)

TT = Terrestial Time. Originally used instead of TDT or TDB when the

difference between them didn't matter. Was defined in 1991 to be

consistent with the SI second and the General Theory of Relativity.

Replaced TDT in the ephemerides from 2001 and on.

TCG = Geocentric Coordinate Time. Defined in 1991 along with TT

TCB = Barycentric Coordinate Time. Defined in 1991 along with TT

delta-T =

ET - UT prior to 1984

TDT - UT 1984 - 2000

TT - UT from 2001 and on

delta-UT = UT - UTC

DUT = predicted value of delta-UT, rounded to 0.1s, given in some radio

time signals.

GPS time = TAI - 19 seconds. GPS time matched UTC from 1980-01-01

to 1981-07-01. No leap seconds are inserted into GPS time, thus

GPS time is 13 seconds ahead of UTC on 2000-01-01. The GPS epoch

is 00:00 (midnight) UTC on 1980-01-06.

The differences between GPS Time and International Atomic Time (TAI)

and Terrestrial Time (TT), also know as Terrestrial Dynamical Time

(TDT), are constant at the level of some tens of nanoseconds while

the difference between GPS Time and UTC changes in increments of

seconds each time a leap second is added to UTC time scale.

GPS week = a numbering of weeks starting at the GPS epoch 1980-01-06 00:00

GPS time (which back then was equal to UTC). Weeks are numbered from

0 and up until 1023, then it "rolls back" to 0 and are again numbered

from 0 and up, etc. One GPS week rollover cycle is therefore 1024

weeks = 7168 days = ca 19.62 years. So far there's been one such GPS

week number roll-over, on 1999-08-22 00:00 GPS time - a few older GPS

receivers then ceased to show the correct date.

ET 1960-1983

TDT 1984-2000

UTC 1972- GPS 1980- TAI 1958- TT 2001-

----+---------+-------------+-------------------------+-----

| | | |

|<------ TAI-UTC ------>|<----- TT-TAI ----->|

| | | 32.184s fixed |

|<GPS-UTC>|<- TAI-GPS ->| |

| | 19s fixed | |

| |

<> delta-UT = UT1-UTC |

| (max 0.9 sec) |

-----+------------------------------------------------+-----

|<-------------- delta-T = TT-UT1 -------------->|

UT1 (UT) TT/TDT/ET

Older time scales:

GMT = Greenwich Mean Time. It's ambiguous, and is now used (although

not in astronomy) in the sense of UTC in addition to the earlier

sense of UT (in astronomical navigation, GMT still means UT).

Prior to 1925, GMT was reckoned for astronomical purposes from

Greenwich mean noon (12h UT) to avoid a date change in the middle

of the night in Europe - a new GMT date then started 12 hours after

the start of the corresponding civil date. (Prior to 1805 the

Royal Navy Day started 12 hour before local mean solar time, thus

the Royal Navy Day was then approx. 24 hours ahead of GMT).

GCT = Greenwich Civil Time. Used in the US from 1925 to mean the "new"

GMT starting at Greenwich mean midnight, to distinguish it from

the "old" GMT. When UT was adopted, GCT fell out of use.

LMT = Local Mean Time. The mean solar time at the local meridian.

LCT = Local Civil Time, the same as LMT. Used in the US together with GCT.

**Delta-T**

delta-T varies continuously, depending on the Earth's rotation.  
  
UT1 is variable with respect to UTC. Leap seconds were introduced in UTC to keep delta-UT within +-0.9s.  
  
TAI-UTC is always an integral number of seconds, and is varied when leap seconds are added (or removed, but that hasn't happened yet) at the end of every year, or every half-year, or every third month, in that order of priority.

**Table of time scales 1972-present, and some predictions**

TT = TAI+32.184s ==> UT1-UTC = TAI-UTC - (TT-UT1) + 32.184s

Starting at TAI-UTC GPS-UTC TT-UT1 UT1-UTC

1972-01-01 +10 - +42.23 -0.05

1972-07-01 +11 - +42.80 +0.38

1973-01-01 +12 - +43.37 +0.81

1973-07-01 " - +43.93 +0.25

1974-01-01 +13 - +44.49 +0.69

1974-07-01 " - +44.99 +0.19

1975-01-01 +14 - +45.48 +0.70

1975-07-01 " - +45.97 +0.21

1976-01-01 +15 - +46.46 +0.72

1976-07-01 " - +46.99 +0.19

1977-01-01 +16 - +47.52 +0.66

1977-07-01 " - +48.03 +0.15

1978-01-01 +17 - +48.53 +0.65

1978-07-01 " - +49.06 +0.12

1979-01-01 +18 - +49.59 +0.59

1979-07-01 " - +50.07 +0.11

1980-01-01 +19 0 +50.54 +0.64

1980-07-01 " " +50.96 +0.22

1981-01-01 " " +51.38 -0.20

1981-07-01 +20 1 +51.78 +0.40

1982-01-01 " " +52.17 +0.01

1982-07-01 +21 2 +52.57 +0.61

1983-01-01 " " +52.96 +0.22

1983-07-01 +22 3 +53.38 +0.80

1984-01-01 " " +53.79 +0.39

1984-07-01 " " +54.07 +0.11

1985-01-01 " " +54.34 -0.16

1985-07-01 +23 4 +54.61 +0.57

1986-01-01 " " +54.87 +0.31

1986-07-01 " " +55.10 +0.08

1987-01-01 " " +55.32 -0.14

1987-07-01 " " +55.57 -0.39

1988-01-01 +24 5 +55.82 +0.36

1988-07-01 " " +56.06 +0.12

1989-01-01 " " +56.30 -0.12

1989-07-01 " " +56.58 -0.40

1990-01-01 +25 6 +56.86 +0.32

1990-07-01 " " +57.22 -0.04

1991-01-01 +26 7 +57.57 +0.61

1991-07-01 " " +57.94 +0.24

1992-01-01 " " +58.31 -0.13

1992-07-01 +27 8 +58.72 +0.46

1993-01-01 " " +59.12 +0.06

1993-07-01 +28 9 +59.55 +0.63

1994-01-01 " " +59.98 +0.20

1994-07-01 +29 10 +60.38 +0.80

1995-01-01 " " +60.78 +0.40

1995-07-01 " " +61.20 -0.02

1996-01-01 +30 11 +61.63 +0.55

1996-07-01 " " +61.96 +0.22

1997-01-01 " " +62.29 -0.11

1997-07-01 +31 12 +62.63 +0.55

1998-01-01 " " +62.97 +0.21

1998-07-01 " " +63.22 -0.04

1999-01-01 +32 13 +63.47 +0.71

1999-07-01 " " +63.66 +0.52

2000-01-01 " " +63.82 +0.36

2000-07-01 " " +63.98 +0.20

2001-01-01 " " +64.09 +0.09

2001-07-01 " " +64.20 -0.02

2002-01-01 " " +64.30 -0.12

2002-07-01 " " +64.41 -0.23

2003-01-01 " " +64.47 -0.29

2003-07-01 " " +64.55 -0.37

2004-01-01 " " +64.57 -0.39

2004-07-01 " " +64.65 -0.47

2005-01-01 " " +64.68 -0.50

2005-07-01 " " +64.80 -0.62

2006-01-01 +33 14 +64.85 +0.33

2006-07-01 " " +64.99 +0.19

2007-01-01 " " +65.15 +0.03

2007-07-01 " " +65.34 -0.16

2008-01-01 " " +65.45 -0.27

2008-07-01 " " +65.63 -0.45

2009-01-01 +34 15 +65.78 +0.40

2009-07-01 " " +65.95 +0.23

2010-01-01 " " +66.07 +0.11

2010-07-01 " " +66.24 -0.06

2011-01-01 " " +66.32 -0.14

2011-07-01 " " +66.47 -0.29

2012-01-01 " " +66.60 -0.42

2012-07-01 +35 16 +66.77 +0.41

2013-01-01 " " +66.91 +0.27

2013-07-01 " " +67.13 +0.05

2014-01-01 " " +67.28 -0.10

2014-07-01 " " +67.49 -0.31

2015-01-01 " " +67.64 -0.46

2015-07-01 +36 17 +67.86 +0.32

2016-01-01 " " +68.10 +0.08

2016-07-01 " " +68.40 -0.22

2017-01-01 +37 18 +68.59 +0.59

2017-07-01 " " +68.81 +0.37

2018-01-01 " " +69.0 0.2 *(pred)*

2019-01-01 " " +69.5 -0.3 *(pred)*

2020-01-01 " " +69.9 -0.7 *(pred)*

2021-01-01 ? ? +70 *(pred)*

2022-01-01 ? ? +70 *(pred)*

2023-01-01 ? ? +71 *(pred)*

2024-01-01 ? ? +71 *(pred)*

2025-01-01 ? ? +71 *(pred)*

2026-01-01 ? ? +72 *(pred)*

2027-01-01 ? ? +72 *(pred)*

*(last updated 2017-09-30)*

**Delta-T 1620-1972**

delta-T = ET - UT for the years 1620 - 1972

ET-UT, s

Year +0.0 +1.0 +2.0 +3.0 +4.0

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1620 +124 +119 +115 +110 +106

1625 +102 +98 +95 +91 +88

1630 +85 +82 +79 +77 +74

1635 +72 +70 +67 +65 +63

1640 +62 +60 +58 +57 +55

1645 +54 +53 +51 +50 +49

1650 +48 +47 +46 +45 +44

1655 +43 +42 +41 +40 +38

1660 +37 +36 +35 +34 +33

1665 +32 +31 +30 +28 +27

1670 +26 +25 +24 +23 +22

1675 +21 +20 +19 +18 +17

1680 +16 +15 +14 +14 +13

1685 +12 +12 +11 +11 +10

1690 +10 +9 +9 +9 +9

1695 +9 +9 +9 +9 +9

1700 +10 +9 +9 +9 +9

1705 +9 +9 +9 +10 +10

1710 +10 +10 +10 +10 +10

1715 +10 +10 +11 +11 +11

1720 +11 +11 +11 +11 +11

1725 +11 +11 +11 +11 +11

1730 +11 +11 +11 +11 +12

1735 +12 +12 +12 +12 +12

1740 +12 +12 +12 +12 +13

1745 +13 +13 +13 +13 +13

1750 +13 +14 +14 +14 +14

1755 +14 +14 +14 +15 +15

1760 +15 +15 +15 +15 +15

1765 +16 +16 +16 +16 +16

1770 +16 +16 +16 +16 +16

1775 +17 +17 +17 +17 +17

1780 +17 +17 +17 +17 +17

1785 +17 +17 +17 +17 +17

1790 +17 +17 +16 +16 +16

1795 +16 +15 +15 +14 +14

1800 +13.7 +13.4 +13.1 +12.9 +12.7

1805 +12.6 +12.5 +12.5 +12.5 +12.5

1810 +12.5 +12.5 +12.5 +12.5 +12.5

1815 +12.5 +12.5 +12.4 +12.3 +12.2

1820 +12.0 +11.7 +11.4 +11.1 +10.6

1825 +10.2 +9.6 +9.1 +8.6 +8.0

1830 +7.5 +7.0 +6.6 +6.3 +6.0

1835 +5.8 +5.7 +5.6 +5.6 +5.6

1840 +5.7 +5.8 +5.9 +6.1 +6.2

1845 +6.3 +6.5 +6.6 +6.8 +6.9

1850 +7.1 +7.2 +7.3 +7.4 +7.5

1855 +7.6 +7.7 +7.7 +7.8 +7.8

1860 +7.88 +7.82 +7.54 +6.97 +6.40

1865 +6.02 +5.41 +4.10 +2.92 +1.81

1870 +1.61 +0.10 -1.02 -1.28 -2.69

1875 -3.24 -3.64 -4.54 -4.71 -5.11

1880 -5.40 -5.42 -5.20 -5.46 -5.46

1885 -5.79 -5.63 -5.64 -5.80 -5.66

1890 -5.87 -6.01 -6.19 -6.64 -6.44

1895 -6.47 -6.09 -5.76 -4.66 -3.74

1900 -2.72 -1.54 -0.02 +1.24 +2.64

1905 +3.86 +5.37 +6.14 +7.75 +9.13

1910 +10.46 +11.53 +13.36 +14.65 +16.01

1915 +17.20 +18.24 +19.06 +20.25 +20.95

1920 +21.16 +22.25 +22.41 +23.03 +23.49

1925 +23.62 +23.86 +24.49 +24.34 +24.08

1930 +24.02 +24.00 +23.87 +23.95 +23.86

1935 +23.93 +23.73 +23.92 +23.96 +24.02

1940 +24.33 +24.83 +25.30 +25.70 +26.24

1945 +26.77 +27.28 +27.78 +28.25 +28.71

1950 +29.15 +29.57 +29.97 +30.36 +30.72

1955 +31.07 +31.35 +31.68 +32.18 +32.68

1960 +33.15 +33.59 +34.00 +34.47 +35.03

1965 +35.73 +36.54 +37.43 +38.29 +39.20

1970 +40.18 +41.17 +42.23

**Links to more information**

More information can be obtained at:  
  
Wikipedia: <http://en.wikipedia.org/wiki/International_Atomic_Time>  
  
Steve Allen's detailed history of the different time scales: <http://www.ucolick.org/~sla/leapsecs/timescales.html>  
  
BIPM - Bureau International des Poids et Mesures: <http://www.bipm.fr/en/scientific/tai/>  
  
USNO Time Service Department: <http://tycho.usno.navy.mil/>  
  
IERS - International Earth Rotation and Reference Systems Service: [http://www.iers.org/](http://www.iers.org/iers/)  
  
Past leap seconds info:  
<ftp://maia.usno.navy.mil/ser7/tai-utc.dat>  
  
Delta-T data: <ftp://maia.usno.navy.mil/ser7/deltat.data> TT/ET - UT1 UT1-UTC data: <ftp://maia.usno.navy.mil/ser7/>  
Daily data since 1972, and predictions -- large! <ftp://maia.usno.navy.mil/ser7/finals.all>  
Explanation to the previous file: <ftp://maia.usno.navy.mil/ser7/readme.finals>  
Predictions of TT-UT and UT1-UTC: <http://maia.usno.navy.mil/ser7/deltat.preds>   
Rapid service and prediction of Earth orientation parameters: <http://maia.usno.navy.mil/>  
  
IERS - International Earth Rotation Service: <http://hpiers.obspm.fr/>  
IERS Leap Seconds Bulletins: <ftp://hpiers.obspm.fr/iers/bul/bulc/> <ftp://hpiers.obspm.fr/iers/bul/bulc/bulletinc.dat>   
Info on GPS time:  
<http://tycho.usno.navy.mil/gpstt.html>  
<http://tycho.usno.navy.mil/gps_datafiles.html>

**Time signals by shortwave radio**

Europe:

[RWM (Moscow) CW 4996, 9996, 14996 kHz](http://www.irkutsk.com/radio/tis.htm)

North America:

[WWV (USA) AM 2500, 5000, 10000, 15000, 20000 kHz](https://www.nist.gov/pml/time-and-frequency-division/radio-stations/wwv)

[CHU (Canada) AM 3330, 7850, 14670 kHz](https://www.nrc-cnrc.gc.ca/eng/services/time/short_wave.html)

[Worldwide list](http://www.smeter.net/stations/hf-time-frequency.php) - [Another list](http://www.dxinfocentre.com/time.htm) - [Time signals (Wikipedia)](http://en.wikipedia.org/wiki/Time_signal)

**World standard time zones**

In October 1884, an International Time Conference adopted the Greenwich Meridian as the prime meridian or zero degree point and divided the world into 24 equal divisions of 15 degrees each.  
  
Here is a table and a map of the current International Time Zones:  
[http://en.wikipedia.org/wiki/Time\_zone](http://en.wikipedia.org/wiki/Time_zone#List_of_time_zones_and_contained_areas)  
[Map of time zones](http://en.wikipedia.org/wiki/Image:Timezones.png)