



### DEFINITIONS.

UT0: mean solar time on the Greenwich meridian obtained from direct astronomical observation. The time 00 hours being at Greenwich mean mid-night.

UT1: UT0 corrected for polar motion.

UT2: UT1 corrected for seasonal variations in the Earth's rotation (a smoothed scale that doesn't reflect the real periodic variations in the Earth's angular position).

UTC: civil atomic time-scale on or about the Greenwich meridian kept within 0.9 seconds of UT1.

UT: An abbreviation that should be used to show approximation of all of the above.

### MATHEMATICAL FORMULÆ.

For the mathematically minded, the difference between UT2 and UT1 is as follows;

$$UT2-UT1 = +0.022\sin 2\pi t - 0.012\cos 2\pi t - 0.006\sin 4\pi t + 0.007\cos 4\pi t$$

where  $t = 2000.0000 + (\text{MJD}-51544.03)/365.2422$   
[the result is in seconds]

The Modified Julian Date (MJD) for  
2000 January 1st 00 h UT was 51544.0000,  
and for  
2010 January 1st 00h UT is 55197.0000.

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## POINTS TO REMEMBER

**GMT now has to be considered 'a figment of the general public's imagination'. It hasn't, any longer, any scientific basis at all! 'GMT' MUST NOT BE CONSIDERED AS ANY EXACT TIME-SCALE.**

**When the Royal Observatory, Greenwich, used the term GMT, it was measured from Greenwich mean MID-DAY, 12 hours BEHIND Universal Time (UT).**

**Atomic clocks cannot keep 'mean time'. Mean time is a measurement of the Earth's rotation, whereas atomic time is based on the frequency of the caesium 133 atom which oscillates at a frequency of 9 192 631 770 Hz.**

**All civil times are now 'atomic' and therefore, are on, or are a certain number of hours (and minutes) ahead of, or behind, Co-ordinated Universal Time (UTC).**

**The abbreviation UTC is language-independent. It is neither English nor French. It stands for both Co-ordinated Universal Time and Temps Universel Coordonné.**

**New Zealand Standard Time (NZST) and New Zealand Daylight Time (NZDT) are deemed, both scientifically and legally, as being 12 and 13 hours ahead of Co-ordinated Universal Time (UTC) respectively.**

# A BRIEFER HISTORY OF TIME

by  
Howard Barnes

with apologies to  
Stephen Hawking



A  
Georgi Dobrovolski Solar Observatory  
Publication



When the Royal Observatory was established at Greenwich, in 1675, time was considered mainly as a measurement of the Earth's rotation. 'Mean Time' is the measurement of the Earth's orientation with respect to the fictitious 'mean sun', which is at the centre of the Earth's orbit, and which 'appears' to travel around the Earth's equator. These two 'conditions' create what is known as the Equation of Time, the wavy line which appears on many, if not all, sundials.

In 1675, this 'mean time' and the Earth's rotation were considered constant. As this time was 'invented' by Greenwich astronomers for, and only for, Greenwich astronomy, and called 'Greenwich Mean Time' (GMT) it was measured from Greenwich mean **mid-day**. The practice of calling mid-day 00 h 00 m GMT, was to avoid changing dates while observing.

However, as the United Kingdom began to use the Greenwich meridian as its standard meridian, the term GMT was 'hijacked' to mean 'Greenwich civil time', 12 hours ahead of original (and proper) GMT. As the UK officially adopted the Greenwich meridian in 1880, followed by the world adopting the meridian as the prime meridian (0°) in 1884, the term GMT was increasingly misused and abused from that date.

The practice of having two GMTs (12 hours apart) was increasingly annoying for

astronomers, so in 1925 old (and proper) GMT was renamed 'Greenwich Mean Astronomical Time' (GMAT), and civil 'GMT' was, at first, 'officially' named as 'Greenwich Civil Time' (GCT). However, as the abbreviation GCT was a military term, 'Greenwich Civil Time' was objected to by the British Admiralty. Because of this objection, the term GCT never got established, and because the general public didn't know otherwise, GMT continued in public use.

Because of the objection to GCT, the Royal Observatory left the naming of 'Greenwich civil time' to the International Astronomical Union (IAU), which eventually adopted the name 'Universal Time' (UT) in 1928.

### **THE SPLITTING OF UNIVERSAL TIME (UT).**

Throughout the middle of the 20th century, it became increasingly noticeable that, amongst other things, UT was different if observed from different locations. Therefore, Universal Time had to be split into three main component scales. These scales are named UT0, UT1 and UT2, and deviate from each other by up to 50 milliseconds, a noticeable difference given today's technology. These 3 scales, which have been split again, to create UT0R, UT1R and UT2R, are not at all constant. Of all these six scales, UT1 is the most important.

### **THE ESTABLISHMENT OF ATOMIC TIME-SCALES.**

With the development of atomic clocks, it definitely became clear that all UT scales were irregular because of the rotation of the Earth. Various atomic scales were invented, but two were considered as the main time-scales. These are International Atomic Time (TAI), a laboratory time-scale with no perceivable step adjustments, which was started in 1958, in a manner that 1958 January 1, 00 hours 00 minutes TAI equalled that of UT2; and Co-ordinated Universal Time (UTC) which was started at the beginning of 1960. From 1960 to 1971, inclusive, UTC was 'stretched' to cope with the Earth's rotation. The UTC second was at first, 15 nanoseconds longer than the TAI second. It was then changed to 13 ns longer in 1962. Two further changes occurred in 1964 and 1966, when the UTC second reverted to 15 and then set at 30 ns longer respectively. However, as synchronisation was needed all the more, UTC was altered in 1972, to having a second equal to the TAI second, and 'leap seconds' were introduced. These are inserted whenever necessary, usually every 12 or 18 months. There has not been any need, yet, to delete any 'leap seconds'. UTC is now over ½ minute behind TAI. The difference is always an integral number of seconds. UTC is the system of Greenwich 'civil time', currently [2001] in use.

... and that, is a brief history of time.