QTR ? (what time is it?)

Having a *standard* time throughout the world is a fairly recent introduction. I only realised just how recently (1847) after watching one of the "What the Victorians did for us" series on UK television.

With my curiosity piqued sufficiently to read more on the subject I quickly became aware that GMT, UT, and UTC, are not different terms for the same thing, as I had always assumed, but more on that later.

LOCAL TIME

To begin with, every locality in the UK set its own time based on the sun. It was noon at that location when the sun was highest in the sky. Alternatively known as "apparent solar time", it can be measured using a sundial.

Basically a very simple device, a sundial consists of a marked plate (usually horizontal) and a rod called a 'gnomon' to cast a shadow, but they gradually became more intricate. One sundial of special interest to Radio Amateurs can be found in the churchyard at Bosham village, in Sussex, as a memorial to Gerald Marcuse (G2NM) who's early experiments proved the viability of a 'BBC World Service'.

The 'Marcuse' Sundial, located in the churchyard at Bosham

Timekeeping in the absence of sunlight was initially accomplished using water clocks, or candle clocks [2] but it was not until the advent of mechanical clocks that accuracy began to improve. Even then it was not until the invention of the Marine Chronometer [3] that accurate location at sea became possible to determine.

A Standard Time throughout the country became essential when transport systems became so quick that they could not operate properly without it. Standard time throughout the world only became possible after the invention of the telegraph, and later radio.

Britain became the first country to have its time set to one standard, after intense lobbying by the railway companies. The Great Western Railway was first one to adopt GMT across its network in November 1840.

In September 1847 the Railway Clearing House (the Railways Standards Institute) recommended that Greenwich Mean Time (GMT) be adopted at all stations. By 1855 most public clocks in Britain were set to GMT, but it would take another 34 years before all the USA railroads agreed on a common time standard.

Despite how logical & useful a country wide time system was, the resistance to adopting GMT is indicated by the fact that for a few years after its introduction some enterprising souls made a living supplying clocks with an hour hand and ***two*** minute hands. One was set to Local Time, and the other to GMT.

One such clock exists to this day, on the front face of the 'Royal Corn Exchange Building' in Bristol, UK.

'The Exchange' is a Grade 1 listed building, constructed in 1741 by John Wood the Elder, on Corn Street, near the junction with Broad Street in Bristol. Originally referred to as The Royal Corn Exchange Building, because it was used as a corn and general trade exchange, it is now used as offices and St Nicholas Market.

At first glance the front facade seems little different from any other public building of a similar age in the UK, but look closer and you'll see that it has two minute hands.

The Greenwich Meridian

The Royal Observatory at Greenwich was established as the reference point for time keeping, serving the maritime interests of the UK. Mariners kept their navigation timepieces on GMT in order to be able to calculate their longitude, relative to the Greenwich Meridian, whilst still using solar time to determine "ship-borne time".

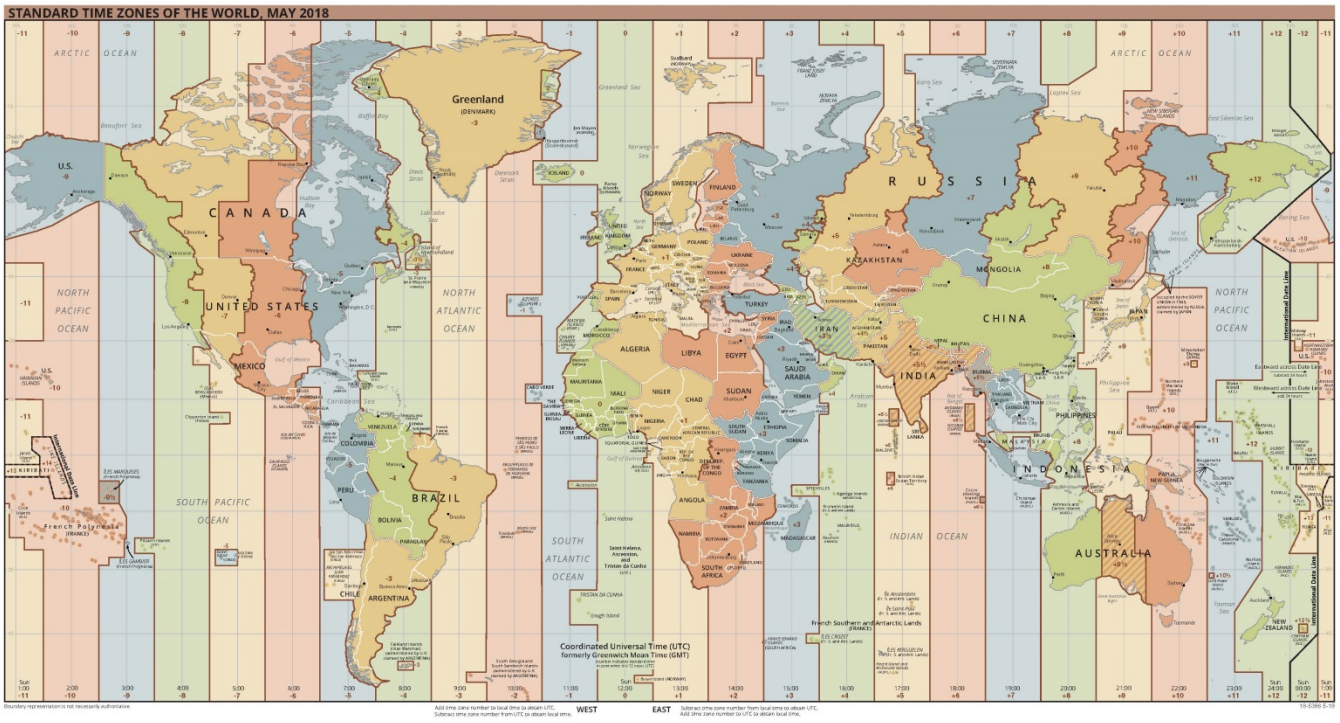
This was mainly because mariners of all nations already made extensive use of Nevil Maselyne's "method of Lunar distances" (based on observations at Greenwich).

GMT was established as a world time standard at the International Meridian Conference in 1884, along with different 'Time Zones' around the world. Halfway around the world

from the Greenwich Meridian is the 'International Date Line', also known as the line of demarcation. It runs from the North Pole to the South Pole but it is not straight and zigzags to avoid political and country borders. [1]

If each time zone was 1 hour apart, and organised strictly along lines of longitude, there would be 24 of them but allowing for national boundaries complicates things.

Most, if not all, readers will be familiar with the time-zone map of the world.



GMT, UTC, and UT

There is more to GMT than everyone just using the time of day that the sun is directly over the Greenwich Meridian. The earth's orbit is elliptical, and its axis is tilted, so solar time can be plus or minus about 15 minutes at certain times of the year.

This non-linear timescale was transformed into a linear one (mean solar time) by averaging time over a year, based on the position of an imaginary sun that moves across the sky with uniform speed. GMT is the mean solar time on the Greenwich meridian based on the position of this 'mean sun' and NOT on the position of the real sun.

The difference between apparent solar time and mean solar time is known as "the equation of time". Greenwich was certainly not the first location to use "mean solar time" instead of "apparent solar time". Many methods have been used to simulate mean solar time throughout history. The earliest were Clepsydras (water clocks) used from the second millennium BC until the early second millennium.

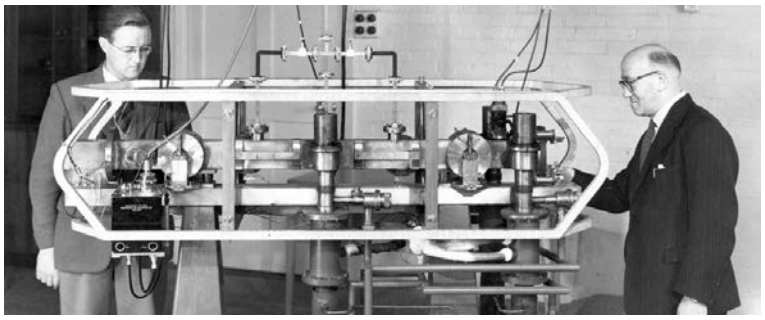
Before the middle of the first millennium BC they were adjusted to agree with apparent solar time and were thus no different from the shadow cast by a "gnomon" (a vertical pole), except that they could be used at night.

Most people use the terms GMT, UTC, and UT, as different expressions for the same thing, but they actually represent different standards. In 1928 astronomers introduced

the term Universal Time (UT) to indicate time measured from GMT midnight.

To be entirely accurate, they actually introduced 3 different variants of Universal Time (UT0, UT1, UT2) but as the maximum difference between all of them is around 50 milliseconds it is hardly surprising that most people are unaware of them. The term UT is generally used without any qualification.

Artificial time standards became more accurate than standards based on astronomers' observations, or the rotation of the earth, when atomic clocks were introduced in the 50's. In 1967 the standard (SI) second was re-defined, based on the time generated by a caesium atomic clock.

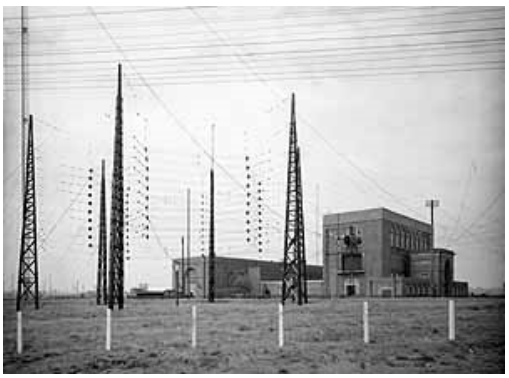


Louis Essen and J.V.L. Parry standing next to the world's first atomic clock, developed at the National Physical Laboratory in 1955

The international time scale based on this SI-second is International Atomic Time (TAI). This time scale was synchronised with UT at the beginning of 1958, but UT and TAI gradually drift apart because they are based on totally different principles.

Universal Co-ordinated Time (UTC), sometimes referred to as "zulu time" is a compromise between TAI and UT. It was introduced in 1972 but runs fractionally faster than UT. To ensure that the difference is never more than 1 second, a "leap second" is added each time that UTC gains about half a second. Leap seconds are "added" by pausing the UTC clock for one second. Standard time signals are all based on UTC.

The National Physics Laboratory (NPL) broadcast UK time on 60kHz from Rugby for many years, but in 2007 transmissions were relocated to Anthorn in Cumbria. Central European Time is broadcast on 77.5kHz from DCF77 at Frankfurt.



VLF aerial feed for Radio Station GBR Located at Rugby in England

SPACE TIME

Time is now based on an SI second, which is based on the atomic resonance of Caesium and has nothing but coincidence to do with a fraction of a 'real' day. Newton's laws of motion depend on time for accuracy, but we've fudged the definition of time.

For everyday use the differences are of little consequence, but what about space travel? Enter "Barycentric Dynamical Time" (TDB). Apparently this form of atomic time is now used when calculating the orbital positions of planets and other solar system objects. Historically, positions were given as printed tables of values, given at regular intervals of date and time.

The orbital position tables (ephemerides) used to be tied to direct observations of planetary motion. Fragments of Babylonian tablets containing such tables have been discovered from as far back as the 1st Century BC. More recently printing tables of ephemeris was one of the first tasks assigned to mechanical computers.

Modern ephemerides are usually computed electronically from mathematical models of the motion of astronomical objects and the earth instead of observation, but printed ephemerides are still produced as they are useful when computational devices are not available.

The TDB timescale is then 'fitted' so that Newton's Laws of Motion (with corrections for General Relativity) are followed.

It seems to me that whichever of the multitude of time standards you use, a 'fiddle-factor' has been applied. Maybe there is actually no such thing as the 'correct' time.

One final thing...
Have you ever wondered why each hour is divided into multiples of 60 and not 100? It dates back to the ancient Sumerians, in the 3rd millennium BC and has as much to do with pure mathematics as time-keeping. A full explanation can be found at [4]

David G3ZPF

References

[1] www.timeanddate.com/time/dateline.html
[2] https://en.wikipedia.org/wiki/Clock
[3] https://en.wikipedia.org/wiki/Marine_chronometer
[4] https://en.wikipedia.org/wiki/Sexagesimal

An earlier version of this article appeared in 'OT News', the quarterly magazine of the Radio Amateur Old Timers' Association. Contrary to what many people believe, you do not need to be old, or to have held a licence for 25 years, to become a member.

Our members may have an interest in the past, but we definitely live in the present and the articles in OT News reflect that. Full details can be found at www.raota.org.

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