

TIME

1. Introduction

The TCS requires access to time in various forms and accuracies. This document briefly explains the various time scale, illustrate the mean to obtain the time, and discusses the TCS implementation.

2. Time scales

International Atomic Time (TIA) is a man-made, laboratory timescale. Its units the SI seconds which is based on the frequency of the cesium-133 atom. **TAI** is the International Atomic Time scale, a statistical timescale based on a large number of atomic clocks.

Coordinated Universal Time (UTC) – UTC is the basis of civil timekeeping. The UTC uses the SI second, which is an atomic time, as it fundamental unit. The UTC is kept in time with the Earth rotation. However, the rate of the Earth rotation is not uniform (with respect to atomic time). To compensate a leap second is added usually at the end of June or December about every 18 months.

Also the earth is divided in to standard-time zones, and UTC differs by an integral number of hours between time zones (parts of Canada and Australia differ by $n+0.5$ hours). You local time is UTC adjusted by your timezone offset.

Universal Time (UT1) – Universal time or, more specifically UT1, is counted from 0 hours at midnight, with unit of duration the *mean solar day*, defined to be as uniform as possible despite variations in the rotation of the Earth. It is observed as the diurnal motion of stars or extraterrestrial radio sources. It is continuous (no leap second), but has a variable rate due the Earth's non-uniform rotational period. It is needed for computing sidereal time. To obtain UT1 you need to look up the $ut1-utc$ value published by the International Earth Rotation Service. This quantity, kept in range $\pm 0.9s$ by means of the UTC leap seconds.

Dynamical Time replaced ephemeris time as the independent argument for theories which describe the motion of solar system bodies. It is used to compute solar system ephemeris. There are two type of Dynamical Time:

Terrestrial Time (TT) (or Terrestrial Dynamical Time TDT) has units of the SI seconds. It is an independent argument of apparent *geocentric* ephemerides (used in calculations of ephemerides of solar-system bodies). $TDT = TAI + 32.184$ seconds.

Baycentric Dynamical Time (TDB) differs from TT by at most by 1.7 ms, the difference being related to the motion of the Earth on it elliptical orbit around the Sun (relativistic effect). Because this very small difference, TT can be used in place of TDB for most practical purpose (for the TCS).

Sidereal time is based on the apparent motion of the distant, “fixed” stars across the sky.

The Greenwich Mean Sidereal Time (GMST) is link to UT1 by a numerical formula. Since the seconds change in length along with the UT1 seconds, this makes the timescale useful for predicting apparent direction of celestial sources.

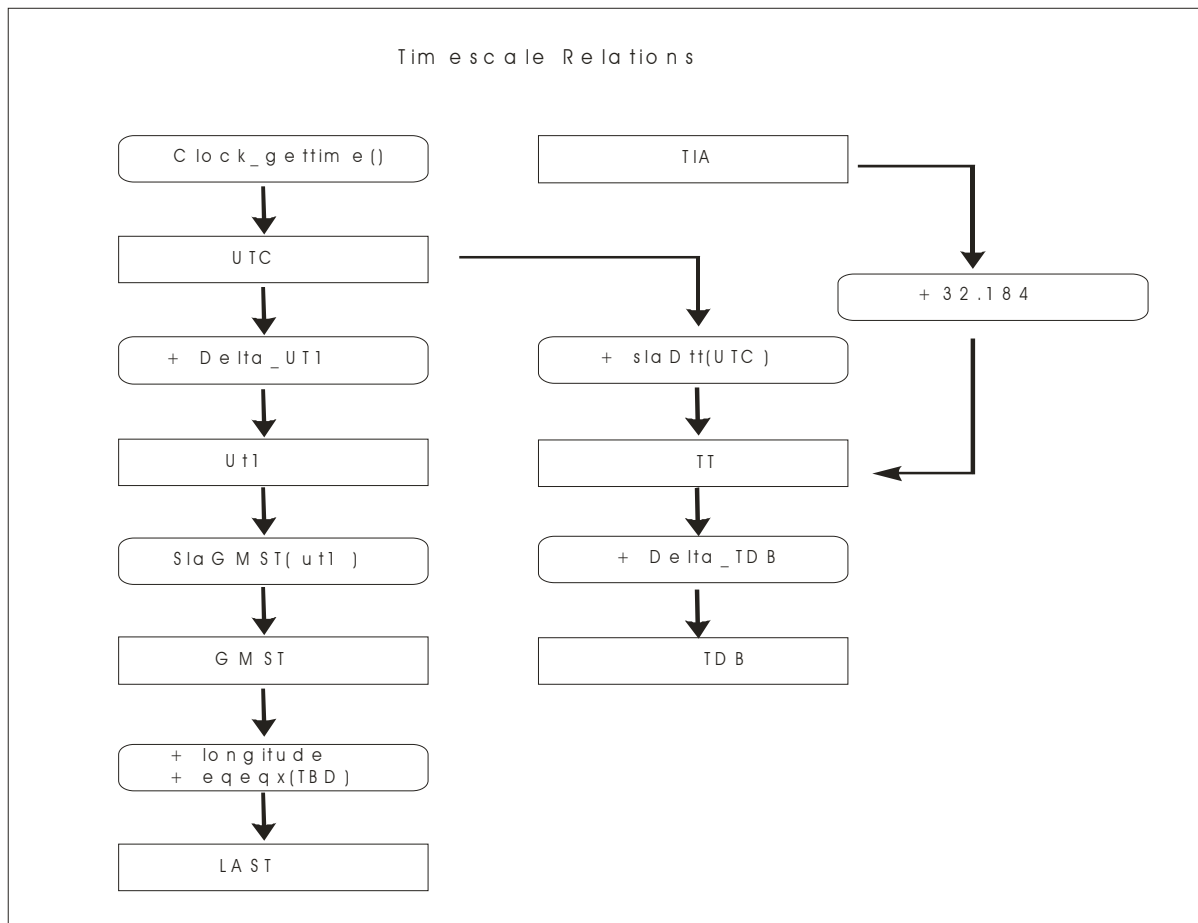
The **Local Apparent Sidereal Time (LAST)** is the apparent right ascension of the local meridian. It can be obtained from the GMST by adding the east longitude and the *equation of the equinoxes*.

Julian Day Number is a count of days elapsed since Greenwich mean noon on 1 January 4713 B.C., Julian proleptic calendar. The **Julian Date** is the Julian day number followed by the fraction of the day elapsed *since the preceding noon*.

We frequently make use of the **Modified Julian Date (MJD)**, which is defined as $MJD = JD - 2400000.5$. An MJD day thus begins at midnight, civil date. Julian dates can be expressed in UT, TAI, TDT, etc. and so for precise applications the timescale should be specified, *e.g.* MJD 49135.3824 TAI.

3. Time Scale relationship.

The following diagram shows the relationship between the various time scale and their relations.



4. TCS Implementation Details.

The IRTF's GPS satellite receiver is the basic for time for the observatory. It support NTP and the TCS computer will sync to the GPS receiver using NTP.

The tcs software can obtain UTC by querying the computer's system clock using the `clock_gettime()` function:

```
clock_gettime( CLOCK_REALTIME, &vtcs->in.tcs_utc );
```

The time is then rounded down to the nearest millisecond by the vtcs process.

DUT1 (ut1-utc) obtained from International Earth Rotation Service's Bulletin B reports. (<http://maia.usno.navy.mil>). This value changes by 1-2 ms per day. Use the `ut1delta` command to enter this value into the TCS.

Longitude obtained from IRTF GSP: 155:28.19.20 w. Use the `longitude` to enter this value into the TCS.

The Delta_TT (TDB-TT) is calculated by the pslow process every 5 seconds. (Although only need to updated daily).

The eqeqx is calculated by the pslow process every 5 seconds.

ukm – distance from Eath spix axis (km):+ 6006.27676866569

vkm – distance north of Earth equatorial plane (km): +2151.06069660526

Note: ukm and vkm obtained from Genimi TCS documentation.