6 Temporal coordinate systems

6.1 Introduction

There is a requirement to identify time as well as location in environmental representation. *Time* is that physical quantity perceived as the continued progress of existence measured by an observer as events which are relatively ordered as “before” or “after” and which, at a given point in time, give rise to the notions of past, present and future. Time and location are often used together by an application to describe when a given condition exists or when an object was present at a given location.

This International Standard uses the concept of time in several ways. Dynamic systems are treated as systems with a time parameter. These systems reduce to the case of a static relationship by fixing a value for the time parameter. Object reference model bindings are often based on physical measurements of objects or systems that change with time. Time is also used to identify the epoch for which these measurements are applicable.

A *temporal coordinate system* is a Euclidean 1D CS (see Table 5.35) that assigns distinct coordinates to distinct times so that larger coordinate values are assigned to later times. This International Standard uses Coordinated Universal Time (UTC) (see 6.2.4) to provide a temporal coordinate system that enables a unique temporal coordinate to be assigned to an event. In this International Standard, times and dates refer to UTC unless explicitly indicated otherwise.

6.2 Temporal coordinate systems

6.2.1 Integrated and dynamic temporal coordinate systems

An *integrated temporal coordinate system* is a Euclidean 1D CS (see Table 5.35) based on a unit of duration that is derived from a physical phenomenon. Fixing an origin (called the *epoch*) and then integrating continuously by accumulating units of the duration specifies an integrated temporal coordinate system.

EXAMPLE The wave length of certain atomic energy emissions determine a wave period which serves as the physical duration that is accumulated to specify atomic clock time.

A *dynamic temporal coordinate system* is a Euclidean 1D CS (see Table 5.35) based on data derived from the observation of a dynamic physical system, typically planetary motion. The specification of a dynamic temporal coordinate system depends on the observed system being described by a mathematical model where time is one of the parameters that unambiguously identifies the configuration of the system. The time measurement can then be considered to be a measurement of position with units defined as a specified duration. Fixing an origin by specifying the initial conditions of the physical system and then continuously accumulating units of the duration specifies a dynamic temporal coordinate system.

A dynamic temporal coordinate system differs from an integrated temporal coordinate system in that the former ties a mathematical model to the state of a physical system while the latter accumulates the duration of a periodic phenomenon.

6.2.2 Universal time

Universal time (UT) is a general designation of a set of dynamic temporal coordinate systems based on the rotation of the Earth. There are different forms of UT whose values may differ by a few hundredths of a second:

a) *Universal Time observed* (UT0) is the mean solar time of the prime meridian obtained from direct astronomical observation.

b) *Universal Time polar motion corrected* (UT1) is UT0 corrected for the effects of small movements of the Earth relative to the axis of rotation (polar variation).

c) *Universal Time Earth rotation corrected* (UT2) is UT1 corrected for the effects of a small seasonal fluctuation in the rate of rotation of the Earth.

Complete definitions of UT0, UT1, UT2, and the concepts involved in their definitions may be found in the publications of the International Earth Rotation Service [IERS] that maintains these three temporal coordinate systems.

6.2.3 International atomic time

Temps atomique international (TAI) (*international atomic time*) is the integrated temporal coordinate system with unit of duration of the SI second on the geoid and origin defined so that UT1-TAI was 0 on 1 January 1958. TAI is maintained by the Bureau International des Poids et Mesures (International Bureau of Weights and Measures) (BIPM) and is generated by collecting and combining the data from a worldwide ensemble of atomic clocks.

6.2.4 Coordinated universal time

Coordinated universal time (UTC) is a temporal CS that is based on TAI by identifying every time second of TAI. UTC is not an integrated temporal coordinate as described in 6.2.1, but rather is a system identifying every time second of TAI that is used worldwide to coordinate technical and scientific activities. UTC is specified by the Radiocommunication Bureau of the International Telecommunication Union (ITU-R) in publication TF.460-5:1997 [I460]. It is a compromise between highly stable TAI and irregular UT. UTC is maintained by the BIPM with assistance from the IERS. UTC is adjusted by the insertion or deletion of seconds (called positive or negative leap-seconds) to ensure approximate agreement with UT1. For any given date, UTC and TAI differ by an integer number of seconds. The difference between UTC and UT1 is maintained to less than 0,9 seconds, which is sufficient for purposes of astronomical navigation. Due to the latency of the UTC values, a timing centre that maintains one of the atomic clocks used to maintain TAI should be referenced for real-time realization of UTC.

6.3 Specified temporal coordinate systems

Each temporal coordinate system specification shall specify the values of all elements presented in Table 6.1. This International Standard specifies temporal coordinate systems in Table 6.2 and Table 6.3.

Table 6.1 — Temporal coordinate system specification elements

Element	Definition
Temporal CS label	The label (see 13.2.2) for the temporal coordinate system.
Temporal CS code	The code (see 13.2.3) for the temporal coordinate system.
Description	A description of the temporal coordinate system, including any common name.
Epoch	The time that specifies the origin.
Unit of duration	The physical quantity that corresponds to an abstract unit of duration.
Relationship to TAI	The conversions to and from the specified temporal coordinate system and TAI.
References	The references (see 13.2.5) for the temporal coordinate system.

Table 6.2 — International atomic time (TAI)

Element	Specification
Temporal CS label	TAI
Temporal CS code	1
Description	International atomic time (TAI)
Epoch	1 January 1958
Unit of duration	SI second (see [ISO 80000-3])
Relationship to TAI	The temporal coordinate system is TAI.
References	[I460]

Table 6.3 — Coordinated universal time (UTC)

Element	Specification
Temporal CS label	UTC
Temporal CS code	2
Description	Coordinated universal time (UTC)
Epoch	1 January 1958
Unit of duration	SI second (see [ISO 80000-3])
Relationship to TAI	UTC differs from TAI by an integral number of leap seconds, (presently 32), which are inserted on the advice of the IERS to ensure that, on average over the years, the Sun is overhead within 0.9 seconds of 12:00:00 UTC on the meridian of Greenwich.
References	[I460]

6.4 Registered temporal coordinate systems

This International Standard permits other temporal coordinate systems to be defined by registration. The guidelines that shall be followed in preparing registration proposals are specified in Clause 13. Registration proposals specify all values for the elements in Table 6.1 and accompanying administrative information.