Open Geospatial Consortium

Submission Date: 2014-dd-mm>

Approval Date:2014-dd-mm>

Publication Date:2014-dd-mm>

External identifier of this OGC® document: <http://www.opengis.net/def/doc-type/standard/1.0>

Internal reference number of this OGC® document: 14-108

Version:0.3

Category: OGC® Best Practice

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OGC Temporal Domain Working Group: Best Practice for Time

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Document type:	OGC® Best Practice
Document subtype:	if applicable
Document stage:	Draft
Document language:	English

Contents

i. Abstract

In 2013, there was significant interest within the OGC in establishing a Temporal Domain Working Group, and much discussion in open forum has taken place with reference material and use cases accumulated, including discussions of sensible scopes.

Much geospatial software, systems and standards treat time as purely an attribute of features on maps, rather than as a first class coordinate entity along with location and altitude. In an increasingly mobile world, to know one's location, one needs to know *when*, especially for faster moving features.

There is much practice of handling time: some good, much indifferent and some bad. This Best Practice document aims to clarify the concepts of clocks, calendars, time scales, temporal notation and temporal coordinate reference systems in a geospatial context and identify those good practices and warn of the pitfalls.

The document also suggests areas where changes to existing standards and conceptual models should be considered.

ii. Keywords

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, time, calendar, clock, timescale, temporal, notation, CRS, coordinate reference system, best practice

iii. Preface

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Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

iv. Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

Met Office, UK
Universität Bremen, Germany
Technische Universität Dresden, Germany

v. Submitters

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1. Introduction

Quid est ergo tempus? Si nemo ex me quaerat, scio. Si quaerenti explicare velim, nescio.	What then is time? If no one asks me, I know. If I wish to explain to him who asks, I do not know.

Saint Augustine, Confessions, XI, 14

In the one and half millennia since Saint Augustine expressed his thoughts on time, we have learnt that the universe is 13.6 billion years old, that measuring to the precision of a millisecond has become commonplace, and to a precision of a nanosecond almost routine, and yet his writing still rings true.

We have everyday expectations to time events to the precision of a second rather than a day, yet software still calculates leap days wrongly, even in normal years, never mind every 100, 400, 1000 or 4000 years. It is rarely clear whether software purporting to record and use times to the precision of a second takes into account the leap seconds that occur every few years.

And much geospatial software, systems and standards treat time as purely an attribute of features on maps, rather than a first class coordinate entity along with location and altitude. In an increasingly mobile world, to know one's location, one needs to know *when*, especially for faster moving features.

In 2013, there was significant interest within the OGC in establishing a Temporal Domain Working Group, and much discussion in open forum has taken place with reference material and use cases accumulated, including discussions of sensible scopes.

There is much practice of handling time: some good, much indifferent and some bad. This Best Practice document aims to clarify the concepts of clocks, calendars, time scales, temporal notation and temporal coordinate reference systems in a geospatial context with a recommended terminology and identify those good practices and warn of the pitfalls.

The document also suggests areas where changes to existing standards and conceptual models should be considered.

2. Background

2.1 Calendars

We live our lives by calendars, which are our attempts to rationalise the arbitrary rotations of: the earth on its axis; the moon around the earth; and the earth around sun. Many calendars have been devised around the world, emphasising different aspects:

 Solar: rotations with respect to the sun;

 Sidereal: rotations with respect to the stars;

Lunar: emphasising the rotation of the moon;

And various combinations of the above, such as luni-solar, or even other possibilities.

The durations of these rotations are arbitrary, unconnected, and slowly changing. Consequently, many calendars choose convenient integers as approximations to these durations, such as 4, 7 or 19, and use 'intercalations' - arbitrary insertions of extra ad hoc units into regular multiples of units minimise the deviation of the calculated calendar from astronomical reality.

The structures of many calendars and units are inherited from the Babylonian sexagesimal counting system: a minute is 60 seconds (usually), an hour is 60 minutes. Many emphasise patterns of integers and prime numbers.

2.2 Year

A Year is the time for the earth to orbit the sun. Strictly this is the ‘Tropical Year’ and is difficult to measure, and is slowly changing. It was 365.242196 days in 1900, is about 365.242190 days now, and is expected to be about 365.242184 days in the year 2100.

The numbers quoted may look very precise, but they are only accurate to about one minute over the year. Accuracy of the order of a second every one year requires knowledge of the year length to a precision of 8 decimal places.

However, the year may vary by several minutes from year to year because of the gravitational influence of the other planets in the solar system.

Calendar Years that are calculated are often defined in terms of days, either with respect to the sun or the stars. The original Julian calendar defined a year as precisely 365.25 solar days. Then the Gregorian calendar defined a year as precisely 365.2425 solar days and this is the modern definition too.

Figure 1

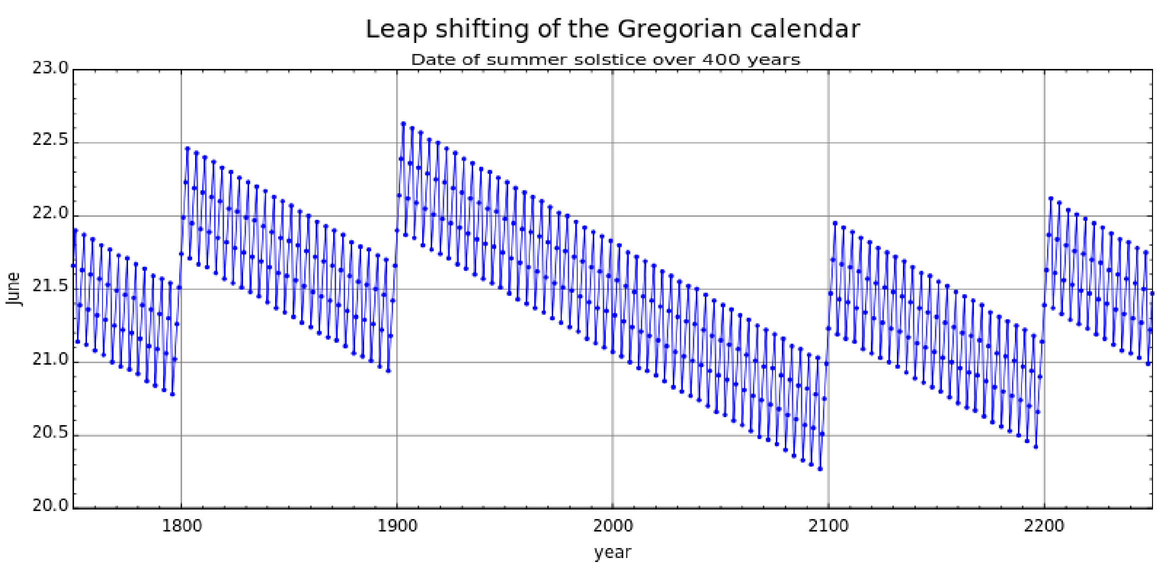

Figure 1 shows how the northern hemisphere summer solstice apparently varies as the various leap days of the Gregorian calendar are inserted, or not, into each year. Even the full set of Gregorian calendar algorithms results in regular deviations of at least one day over the course of a century.

2.3 Day

A (solar) Day is the time for the earth to rotate on its axis with respect to the sun. This duration was divided into precisely 24 hours, or 1440 minutes or 86400 seconds. However, the day may vary by tens of seconds throughout the year because the orbit around the sun is inclined and elliptical. Also, the day may vary by several milliseconds from day to day because of the influence of the earth's dynamic and molten core, earthquakes, weather and the demise of the last ice age. The day is also slowly getting longer by about 2 milliseconds per century because the earth's axial rotation is being slowed by tidal friction caused by the moon.

Days may start at midday (which is relatively easy to measure) and is convenient for astronomers who work at night. Other definitions have days starting at midnight, convenient for people who work in the daytime, or even at sunrise or sunset. These definitions are not possible if you live near the poles, away from the equator.

2.4 Second

A Second is now defined by atomic clocks, rather than as a fraction of a mean solar day. The current definition is accurate to about one tenth of a nanosecond per day, or one part in ten billion. Light can only travel about 30cms (about 1 foot) in one nanosecond.

In the next few years, the definition of a second is likely to increase in precision to the femtosecond level, and be accurate and stable enough to measure the life of the universe to less than a tenth of a second. One thousand femtoseconds equal one nanosecond.

As the solar and atomic definitions now slightly disagree, every few years an extra leap second may be inserted on one day to keep the atomic and solar time closely aligned. The International Earth Rotation and Reference Systems Service (IERS) gives several months notice of its intention to insert a leap second into Universal Coordinated Time (UTC).

These are usually inserted at midnight at the end of June, or possibly December if there were a need for 2 leap seconds in one year. There are also provisions for using March and September too.

In theory, the IERS can also subtract leap seconds to maintain the alignment, but at the time of writing, this has never happened. Consequently, in the current Gregorian calendar as defined by ISO 8601 [Ref 3], a minute may be 59, 60 or 61 seconds. A normal year (usually called a 'common year') could have as few as 31, 535,998 seconds and as many as 31, 536, 002 seconds, and leap year could be between 31, 622,398 and 31, 622,402 seconds.

Consequently, calendars are complex, and prone to being implemented in software imprecisely, or even wrongly.

Some calendars are even less amenable to automatic calculation in that they rely upon a physical observation made by a religious authority of an actual sunrise or sunset at a specific location, and this may be delayed by fog, cloud or storms, so may not be predictable.

2.5 Weeks and Months

A month is an approximation to the orbital period of the moon around the earth, with respect to the sun, and is slightly more than 29 days. This duration is usually approximated to 28 days, divided into 4 weeks of 7 days. Some cultures have opted for 7 weeks of four days each, and 8 day fortnights.

As 28, 7 and 4 do not divide exactly into 365, many ingenious schemes have been used for calculating the alignment of weeks and months with the solar year.

As the lunar month, determined by the phases of the moon, is about 29 1/2 days, 235 months correspond to nearly exactly 19 solar years. This cycle of 19 years is often used to construct calendars too.

Because of the complexity, this version of this document does not address time measured in weeks or months, though it is recognized that there are important use cases that require these units, such as accountancy and assessing visibility at night.

Problems with Existing Standards, Definitions and Conceptual Models

OGC Reference Model

The OGC Reference Model recognizes the use of time (as well as Altitude) as a Coordinate Reference System and that there may even be more than one time dimensions defined. An example is given of using two time dimensions. The Reference Model however has no explicit recognition that time may have much more structure, such as a calendar, than other coordinate dimensions.

ISO 19108 GC Reference Model

This standard only considers time as an attribute of features, rather than as a 'first class' Coordinate Reference System on par with location. Consequently, the standard suffices for the traditional 2D view of geospatial data, where features only change relatively slowly, and individual features can be time-stamped, but this approach may not be effective, or practical, if the features are intrinsically dynamic or large numbers of them need to be retrieved using time criteria rather than location.

Much environmental data is fundamentally 4D, and only some 'slices' of the data are conventional maps. Other data 'slice' presentations could be animations or elevation-time diagrams, for example.

ISO 8601

The well known ISO 8601:2004 standard contains much useful information and is widely promulgated, quoted and used. However, there is no clear distinction between its use as a notation for time stamping artifacts and features, and the associated underlying concepts of calendars, timescales and coordinate reference systems. The use of notation seems to imply the accompanying use of the Gregorian calendar and the pro-leptic versions for dates earlier that 1588.

The Gregorian calendar algorithms are explained, but there are no mechanisms for validating any software that claims to implement them.

```
>   Clocks/notations
>   1999/200/2001
>   1582/1700/1752/1923
>   2038
>
> Problem:
>   Other conceptual modelling problems (e.g. ISO19115)
ISO SQL Time TC21/SC32/WG3 (Matthias to describe?)
Other, software problems ?e.g. CRS transformations?, Quality of Service?
e.g. Missing Info on Maps vs zero info vs inapplicable (Phil Chaowei to describe?)
```

ISO8601 says leap seconds, ECMAscript says ignore.

C library calcalc converts Julian to Gregorian, but country definitions?

inconsistency in terminology in the use of coordinate system in 19111 versus 19108. It was decided that when it was revised, 19108 should be changed to follow the constructs of 19111 and so "temporal coordinate system" should mostly read "temporal coordinate reference system".

No stanrdisation of time zone names (BST, EDT, EST, JST)

```
> Stakeholders:
>   OGC/ISO include TimeSeriesML SWG for structures and interpolation
>   Others
>
> Proposed Basic model:

Hierarchy of generality and complexity:
Regime 0: Events, Allen operators – archaeological layers, sediments and ice core layers, geological. ISO7601 bad idea
Regime 1: Physical regular event defines a clock, timescales, precision integer arithmetic ordinals ‘intervals’, no time <0, TAI. ISO8601 bad idea
Regime 2: Temporal CRS with Epoch (datum), direction, tickmarks/precision, normal real arithmetic, realnumber line, to interpolate below precision, extrapolate before 0
Regime 3: Calendars, durations, complex calculations including the very simple Years BCE/CE. UT1 (UT0? UT2?)
```

```
Regime 4: astrronomical? local solar, sidereal time,
Notation: ISO8601
>
> Spatial Structures Metaphor:
>   Advantages
>   Disadvantages
>   When/where to use
>   When/where not to use
>
> Other proposals:
>   Preferred terminology and its scope
>   Augment OGC Reference Model
>   .
>   Profiles of existing standards? E.g. W3C profile of ISO8601
>   .
>   Change ISO19108
>   Change ISO8601? E.g. Z and Z’
>   Software certification schemes
>
> Conclusion
> References
> Example Use Cases
Leap second consequences: Big Ben, GPS, proposed abolition
Julian to Gregorian switch in 1922/1923 for ships’ logs data
Annexes
```

3. Scope

This Best Practice does not address any calendars other than the Gregorian (and the proleptic Gregorian, which indicates dates before that calendar was introduced, but using the calendar consistently, and retrospectively) as described in ISO 8601:2004 [Ref 3] and defined, along with Universal Coordinated Time (UTC), by the Bureau International des Poids et Mesures (BIPM) and the International Earth Rotation and Reference Systems Service (IERS).

The many other calendars, whether solar, sidereal, lunar, luni-solar, etc, and high quality algorithms for innumerable conversions, are exhaustively and authoritatively documented in the book Calendrical Calculations by Dershowitz and Reingold [Ref 1] and their website [Ref 2].

The various uses of weeks within the Gregorian calendar as defined by ISO 8601:2004 are not addressed. Weeks are fundamentally related to lunar months, and do not impact the use of years, days, hours, minutes and seconds.

The problems of relativistic time dilation and moving inertial reference frames and non-terrestrial timing are also out of scope, though it is recognized that these topics are becoming more relevant and may need to be tackled in the future.

This document describes a consistent set of concepts forming a conceptual model, and recommends consistent terminology to be used to avoid confusion.

It recommends also a set of practices to avoid common pitfalls and identifies areas in existing standards documents that should be changed for consistency with this Best Practice.

It also recommends a restrictive profile of ISO8601:2004 to be used in preference to the full flexibility of the standard, to increase interoperability.

In scope: ??

Out of scope: ??

4. Temporal Regimes

To help us think more clearly about time, this paper adopts the term “Regime” to describe the fundamentally different types of time under consideration. This is a pragmatic approach that allows the grouping of recommendations and best practices in a practical way, but without obscuring the connection to the underlying theoretical concepts.

The first three regimes have deep underlying physical and mathematical foundations which cannot be legislated away. The fourth regime, of calendars, uses a seemingly random mixture of ad hoc algorithms, arithmetic, numerology and measurements. Paradoxically, this regime has historically driven advances in mathematics and physics.

4.1 Regime 0: Events and Operators

In this regime, no clocks or time measurement are defined, only events, that may be ordered in relation to each other. For example, geological layers, sediment or ice core layers, archaeological sequences, sequential entries in computer logs without coordinated time . One set of events may be completely ordered with respect to each other, but another set of similar internally consistent events cannot be cross-referenced until extra information is available.

In this regime, the Allen Operators [Allen, Ref 3] can be used. If A occurs before B and B occurs before C, then we can correctly deduce that A occurs before C. The full set of operators also covers pairs of intervals. So in our example, B occurs in the interval (A,C). However, we cannot perform operations like (C-A) as we have not defined any timescale or measurements. For example ‘subtracting’ Ordovician from Jurassic is meaningless.

4.2 Regime 1: Simple Clocks and Discrete Timescales

In this regime, a clock is defined as any regularly repeating physical phenomena, such as pendulum swings, earth rotations, heart beats, or vibrations of electrically stimulated quartz crystals. Some phenomena make better clocks that others, in terms of the number of repetitions possible, the consistency of each repetition and the precision of each ‘tick’.

There is no sub-division of a single clock tick. Measuring time consists of counting the complete number of repetitions since the clock started, or since some other event at a given clock count.

There is no time measurement before the clock started.

It may seem that time can be measured between ‘ticks’ by interpolation, but this needs another clock, with faster ticks. This processing of devising more precise clocks continues down to the atomic scale, and then the process of physically trying to interpolate between ticks is not possible.

The internationally agreed atomic time, TAI, is an example of a timescale with an integer count as the measure of time.

4.3 Regime 2: CRS and Continuous Timescales

This regime takes a clock from the previous regime ans assumes that between any two adjacent ticks, it is possible to interpolate indefinitely to finer and finer precision, using arithmetic.

It is also assumed that time can be extrapolated to before the time when the clock started.

This gives us a continuous number line to perform theoretical measurements. It is a coordinate system. With a datum/origin/epoch, a unit of measure (‘tick marks’ on the axis), positive and negative directions and the full range of normal arithmetic, we have a Coordinate Reference System.

Some examples are:

Unix milliseconds since 1970-01-01T00:00:00.0Z

Julian Days, and fractions of a day, since noon on 1st January, 4713 BCE.

4.4 Regime 3: Calendars

In this regime, counts and measures of time are related to the rotations of the earth, moon and sun. There is no simple arithmetic, so for example, the current civil year count of years in the Current Era (CE) and Before Current Era (BCE) must be a calendar, albeit a very simple one, as ther is no year zero. That is, Year 4CE – Year 2CE is a duration of 2 years. Year 1CE-Year 1BCE is one year, not two.

This Best Practice paper only addresses the internationally agreed Gregorian calendar. [Ref 1] gives overwhelming detail for conversion to numerous other calendars that have developed around the world and over the millennia.

4.5 Regime 4: Others

This may in fact be a series of regimes, which are out of scope of this document. This could include local solar time, useful, for example, for the calculation of illumination levels and the length of shadows on aerial photography.

A regime may be needed for ‘space time’, off the planet Earth, such as for recording and predicting space weather approaching from the sun, where the speed of light and relativistic effects may be relevant.

5. Temporal reference systems

5.1 Discrete and continuous time

Time is an abstract ordering concept for events. Formally, it has the structure of an ordered set (Zeigler 2000):

$$\text{time} = (T,<)$$

T – the domain of events t

< – an ordering relation on T. For global temporal reference systems such as Unix time or the Julian date “<” defines a *total* order on T.

There are two topologically distinct modelling approaches for time. Depending on the topology of T, continuous time and discrete time can be distinguished.

In *continuous time*, T is dense and its elements are uncountable. Events may be specified with arbitrary precision. Between any two events t_1, t_2 with $t_1 <> t_2$, there is an infinite number of events t_i. Continuous time is usually represented as a subset of $\mathbb{R}$.

In *discrete time*, T is discrete and its elements are countable. The use of discrete time may either restrict the precision of the temporal domain to a manageable or meaningful resolution or simply acknowledge the fact that time can only be measured down to individual ticks on an atomic clock.

Examples

Geological time scale: The geological time scale consists of Eons, Eras, Periods, and Epochs, each defining a different partition of the past. Altogether, the geological time scale is a partially ordered set since ordering relations are only defined within each level of the hierarchy.

Julian date: The Julian date is a floating point representation of the days that have passed since 1 January, (minus) 4712 (=4713 BC), 12:00. The floating point representation of events may be stated with arbitrary precision and thus be considered a dense set equivalent to the set of real numbers $\mathbb{R}$. The elements of the Julian date are totally ordered, i.e. "distances" can be calculated between any two given dates.

5.2 Points and intervals in time

Continuous and discrete time immediately allow the specification of "moments" or "points" with an arbitrary or predefined precision. If "<" specifies a *total* order on T, a metric on T may be specified. This metric defines the distance between any two elements of T, that is, the timespan between these two events. With the notion of a total order and a distance metric on T the following terms can be defined:

- An indivisible element on a time scale is referred to as an *instant*.
- A structure that is started by an instant and ended by another instant is referred to as an *interval*.
- The distance between two instants is referred to as a *duration*.

For the remainder of this Best Practice paper, instants, intervals, and durations are recommended terminology used to discuss properties of temporal events and processes.

5.3 Conversion between continuous and discrete time systems

In practice, conversion issues arise when temporal structures must be transferred from one time system to another.

(1) If the conversion happens between two continuous time systems, the conversion is a matter of defining and applying an isomorphism to convert between different representations of an instant.

(2) Conversion between a continuous and a discrete time system.

(2.1) A conversion from a continuous to a discrete system generally decreases precision due to reduced precision and / or discretization error. Nevertheless, the morphism from the continuous to the discrete time system is a functional relation, i.e. each instant in the continuous time system is mapped to one and only one instant in the discrete time system.

(2.2) The opposite case, mapping an instant in the discrete system to an instant in the continuous time system is not a definite mapping. A corresponding morphism would yield a set of (connected) instants in the continuous time system, that is, an interval.

(3) The conversion between two different discrete time systems T_A and T_B is not trivial.

(3.1) T_A and T_B are related in such a way that all elements of T_A exactly fit into elements of T_B the conversion task is equivalent to (2.1).

(3.2) Vice versa: If T_A and T_B are related in such a way that all elements of T_B exactly fit into elements of T_A the conversion task is equivalent to (2.2).

(3.3) If (3.1) and (3.2) does not apply, the conversion involves a third intermediate temporal system.

(3.3.1) If the intermediate system is continuous, the conversion steps follow the cases (2.1) and (2.2).

(3.3.2) If the intermediate system T_C is discrete and fine enough (all elements of T_C fit exactly into elements of T_A and T_B), the conversion task is equivalent to a sequence of cases (2.2), (2.1).

(3.4) If no intermediate system TC is used or if its elements do not exactly fit into elements T_A and T_B, the behaviour of the conversion cannot be described in general.

5.4 Temporal coordinate systems

A temporal coordinate system is specified by one temporal unit and a reference point in time, so that any other position can be described by the distance from that position to the reference point.

TODO: Further definition.

Def. of an instant in a TCS.

Def. of an interval in a TCS.

Def. of a duration in a TCS.

5.5 Calendar and clock systems

In scope: Gregorian + UTC

TODO: Definition.

Def. of an instant in a CC.

Def. of an interval in a CC.

Def. of a duration in a CC.

5.6 Ordinal temporal reference systems

TODO: Definition.

Def. of an instant in an OTS.

Def. of an interval in an OTS.

Def. of a duration in an OTS.

6. Temporal Geometry

With the notion of instants and intervals, time has similar geometric properties as space. In contrast to space, a single time axis may only represent zero and one dimensional geometries. The geometric primitives instant, interval and duration have been described in section 5.2.

In addition many applications provide extended modelling capabilities to account for repeated or even periodic events. For instance ISO 8601:2004, a common temporal encoding standard, provides a shorthand constructor notation for periodic instants. The class hierarchy for temporal geometries (Figure 1) provides the following geometry classes:

Instant – (see, section 5.2)

Interval – (see section 5.2), an interval is sufficiently defined by a start and end instant.

Multi-instant – a set of instants.

Multi-interval – a set of intervals.

Regular multi-instant – a tuple (<i>, <instant>, <duration>) that represents a constructor for an equidistant multi-instant. It consists of a first instant I_0, a duration (distance) between I_i and I_{i+1}, and an integer for the number of construction iterations. The total number of instants within a regular multi-instant is (i+1).

Regular multi-period - a tuple (<regular multi-instant>, <duration>) that represents a constructor for an equidistant multi-interval. It consists of an equidistant multi-instant representing the start instants of each contained interval, and a duration expressing the distance between each pair of start and end instant. The total number of intervals within a regular multi-interval equals the total number of instants in <regular multi-instant>.

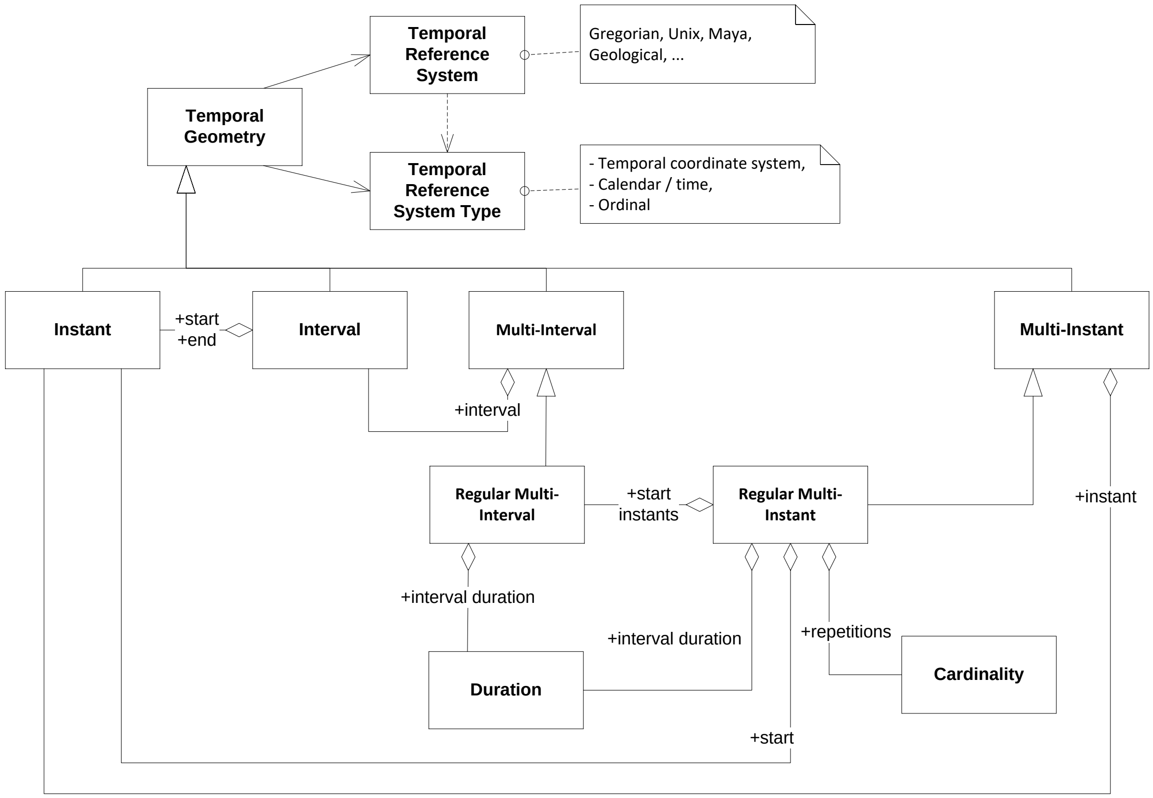

Figure 1: Temporal geometry class hierarchy for common temporal objects

7. Critical review of time encoding standards

7.1 ISO 8601:2004

7.2 ISO 19107:2006

7.3 GML and temporal geometry?

8. Conformance

This standard defines XXXX.

Requirements for N standardization target types are considered:

- AAAA
- BBBB

Conformance with this standard shall be checked using all the relevant tests specified in Annex A (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies and Procedures and the OGC Compliance Testing web site[1].

In order to conform to this OGC™ interface standard, a software implementation shall choose to implement:

a) Any one of the conformance levels specified in Annex B (normative).

b) Any one of the Distributed Computing Platform profiles specified in Annexes TBD through TBD (normative).

All requirements-classes and conformance-classes described in this document are owned by the standard(s) identified.

9. References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

[1] Calendrical Calculations, Nachum Dershowitz, Edward M. Reingold. Paperback: 512 pages. Cambridge University Press; 3rd edition (10 Dec 2007) Language: English. ISBN-10: 0521702380 ISBN-13: 978-0521702386

[2] http://emr.cs.iit.edu/home/reingold/calendar-book/third-edition

1 www.opengeospatial.org/cite

[3] Allen, J. F., 'Maintaining Knowledge about Temporal Intervals', Communications of the ACM, 1983, vol. 26 pp. 832-843.

[4] ISO 8601:2004, Data elements and interchange formats - Information interchange - Representation of dates and times.

Universal Coordinated Time (UTC),

Bureau International des Poids et Mesures (BIPM)

International Earth Rotation and Reference Systems Service (IERS).

ISO 19107:

ISO191??

10. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

For the purposes of this document, the following additional terms and definitions apply.

Atomic clock
Axis
Axis Direction
Calendar
Clock
Coordinate Reference System
Datum
Day
Duration
Solar Day
Epoch
Hour
Instant
Interval
Leap day
Leap second
Leap year
Minute
Second
Timescale
Year
Sidereal Year
Operation
Calculation
Algebra
Unit/precision?

11. Conventions

This sections provides details and examples for any conventions used in the document. Examples of conventions are symbols, abbreviations, use of XML schema, or special notes regarding how to read the document.

12. Clauses not Containing Normative Material

Paragraph

12.1 Clauses not containing normative material sub-clause 1

Paragraph

12.1.1 Clauses not containing normative material sub-clause 2

13. Clause containing normative material

Paragraph

13.1 Requirement Class A or Requirement A Example

Paragraph – intro text. The following table is an example only. Modify as necessary.

Requirements Class	
http://www.opengis.net/spec/ABCD/m.n/req/req-class-a	
Target type	Token
Dependency	**http://www.example.org/req/blah**
Dependency	**urn:iso:ts:iso:19139:clause:6**
Requirement	**http://www.opengis.net/spec/ABCD/m.n/req/req-class-a/req-name-1** *requirement description*
Requirement	**http://www.opengis.net/spec/ABCD/m.n/req/req-class-a req-name-2** *requirement description*
Requirement	**http://www.opengis.net/spec/ABCD/m.n/req/req-class-a /req-name-3** *requirement description*.

13.2 Requirement Class B or Requirement B Example

Paragraph – intro text. The following table is an example only. Modify as necessary.

Req 1 <Example – remove from document> When a WCS server encounters an error while performing a `GetCapabilities` operation, the server shall return an exception report message as specified in Clause 8 of [OGC 06-121r8]. http://opengis.net/spec/WCS/2.0/core/exception.

13.3 Dictionary table example

Paragraph – intro text. The following table is an example only. Modify as necessary.

Names	**Definition**	**Data type and values**	**Multiplicity and use**
mime MIME	A supported output format for the operation response	ows:MimeType	One (mandatory)
fileExtension FileExtension	File extension compatible with output format without the initial dot	Character String type, not empty	Zero or one (optional) Include when RESTful resource oriented architecture style is allowed

14. Media Types for any data encoding(s)

A section describing the MIME-types to be used is mandatory for any standard involving data encodings. If no suitable MIME type exists in http://www.iana.org/assignments/media-types/index.html then this section may be used to define a new MIME type for registration with IANA.

Annex A: Conformance Class Abstract Test Suite (Normative)

A.1 Conformance class: AAAA (repeat as necessary)

Annex B: Revision history

Date	Release	Author	Paragraph modified	Description
2014-08-14	**0.1**	**C Little**	**First few written**	**Initial very early draft to start**
2014-08-18	**0.2**	**M Mueller**	**4,5**	**Work on temporal reference systems and temporal geometry**
2014-11-08	0.3	C Little	2, Annex C	Expanded background, annex on standards organisations, described Temporal Regimes.

Annex C: Existing standards and their organisations

ISO, the International Standards Organisation, is a governmental international treaty-based organisation, with representation from national standards organisations and at the highest level, voting is based on one country, one vote, though at the detailed technical expert level, it is more consensus based. The standards cover an enormous range of activity.

Standards have a five year life cycle, when they can be re-endorsed or revised. Popular standards can persist for many years unchanged. The organisation does not concern itself with implementation of its standards.

Standards documents have to be bought.

There have been several standards relating to time, most of which have been superseded by ISO 8601:2004. In particular, ISO standards 2014, 2015, 2711, 3307 and 4031 are all superseded, as are the previous version of ISO 8601: 1988 and 2000.

Several other ISO standards address aspects of time, besides ISO8601 and 19108:

ISO SQL??

??

BIPM, the Bureau Internationale de Poids et Mésures, is a governmental international treaty-based organisation that maintains the fundamental measures on which all of our science and technology is based, such as the kilogram and the metre. In particular, they coordinate a global network of atomic clocks that define the second, our time and offer various time calibration services.

When asked in 2014, they did not consider that hosting an online registry of temporal definitions relevant to geospatial location was in their remit, other than the most fundamental definitions and the details of the reference network of atomic clocks.

They also offer the **IERS, the International Earth Rotation Service**, which relates their atomic time services to the timing determined by astronomy and the rotation of the earth. The service determines when leap seconds are needed to maintain any discrepancy to less than 0.9 second per year.

ITU, the International Telecommunications Union, is a governmental international treaty-based organisation that deals with telecommunications in all its forms, such as cable and radio based, including electromagnetic spectrum allocation.

Representation is from the national telecommunication authorities, but there is widespread involvement of private service providers and manufacturers in the technical committees. At the highest level, voting is based on one country, one vote, though at the detailed technical expert level it is more ‘one expert - one vote’.

Standards are called Recommendations, and have a four year life cycle, when they can be re-endorsed or revised. Popular standards can persist unchanged for many decades. The recommendations cover the complete range of telecommunications activity. The organisation is involved with underlying practical implementations of its standards.

Standards documents have to be bought.

OGC, the Open Geospatial Consortium, is a voluntary, consensus based standards organisation, composed of nearly 500 members, who may be private profit making companies, non-profit, government or academic institutions, or individuals, who are all interested in increasing interoperability of geospatial information. The organisation's standards have had a significant impact in the last 20 years since its inception.

OGC's approach has been to focus on interoperability Experiments and a relatively rapid development cycle of about a year or so, though most popular standards have become long-lived and also adopted by other standards organisations, such as ISO.

At the technical level, consensus is achieved by one member – one vote, though more expensive membership levels enable members to influence the strategic direction of the organisation.

Standard documents are freely available online.

The OGC also has an online registry of controlled information, such as definitions, that can be interrogated by software.

Annex D: Bibliography

<A Bibliography, if present, shall appear as the last annex. >