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Date and time — Representations for information interchange —

Part 2: Extensions

AMENDMENT 1: Canonical expressions, extensions to time scale components and date time arithmetic

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Date and time — Representations for information interchange —

Part 2: Extensions

AMENDMENT 1: Canonical expressions, extensions to time scale components and date time arithmetic

3.1.2

Add the following terminological entries after 3.1.2.13:

3.1.2.14
canonical form
date and time expression where all its time scale components are *normalised* (3.1.2.15)

Note 1 to entry: The canonical form of a date and time expression implies it contains minimal underflow and no overflow.

3.1.2.15
normalise
process to ensure time scale components have values in their defined inclusive ranges

3.1.2.16
normalised duration
duration whose time scale components have values that are *normalised* (3.1.2.15)

Note 1 to entry: This also applies to negative durations.

3.1.2.17
overflow
state of a time scale component with a positive value when paired with a higher-order time scale component it is unequivocally convertible with, that holds a value representing a duration exceeding one unit of the higher-order time scale component

Note 1 to entry: A time scale component can only be in overflow when considered against a higher-order time scale component it is unequivocally convertible with.

Note 2 to entry: The state of overflow is considered resolved if the time scale component has a value representing a duration less than one unit of the higher-order time scale component.

EXAMPLE 1 A calendar day time scale component representing 10 calendar days is considered in overflow when the higher-order time scale component considered is a calendar week, as the calendar day and calendar week are an unequivocally convertible time scale component pair.

EXAMPLE 2 A calendar day time scale component representing 35 calendar days is not considered in overflow when the higher-order time scale component considered is a calendar month, as the calendar day and calendar month are not an unequivocally convertible time scale component pair.

3.1.2.18
underflow
state of a time scale component with a negative value when paired with a higher-order time scale component it is unequivocally convertible with, where the result of combining the duration represented by the higher-order time scale component and the duration represented by the lower-order time scale component is larger than or equal to zero

Note 1 to entry: A time scale component can only be in underflow when considered against a higher-order time scale component it is unequivocally convertible with.

Note 2 to entry: In resolving time scale component underflows, the negative value of the lower-order time scale component can be expressed in a semantically equivalent form using a combination of the lower-order and higher-order time scale components with values for both larger than or equal to zero.

EXAMPLE 1 A calendar month time scale component representing −8 calendar months is considered in underflow when the higher-order time scale component considered is a calendar year with a value of 1 (which is equivalent to 12 calendar months), as the calendar month and calendar year are an unequivocally convertible time scale component pair.

EXAMPLE 2 A calendar day time scale component representing −60 calendar days is not considered in underflow when the higher-order time scale component considered is a calendar month, as the calendar day and calendar month are not an unequivocally convertible time scale component pair.

EXAMPLE 3 A calendar day time scale component representing −10 calendar days is considered in underflow when the higher-order time scale component considered is a calendar week with a value of 2, but it is not considered in underflow when the calendar week has a value of 1, since a calendar week is equivalent to 7 calendar days, which when combined with −10 calendar days results in a duration less than zero.

14.5

Add the following subclause after 14.4:

14.5 Time scale component overflow and underflow

Time scale components described in this document and in ISO 8601-1 are each defined to accept a range of values, some with a defined minimum or maximum value.

A date and time expression can contain time scale components with values outside the acceptable value ranges of those components.

— A date and time expression is considered to have a normalised duration only if it does not contain any time scale component in the state of overflow or underflow.

— A date and time expression is considered to have an “overflow” if it contains at least one time scale component in the state of overflow.

EXAMPLE 1 The expression '1H90M' contains an overflow in the clock minute time scale component, as the meaning of '90M' is equivalent to the expression '1H30M'.

EXAMPLE 2 The expression '1M90S' does not contain an overflow in the clock second time scale component, as the meaning of '90S' cannot be identically expressed in an alternative combination of these two time scale components, given that the clock minute and clock second are not an unequivocally convertible time scale component pair.

— A date and time expression is considered to have an “underflow” if it contains at least one time scale component in the state of underflow.

EXAMPLE 3 The expression '1H-10M' contains an underflow in the clock minute time scale component, as the meaning of '1H-10M' (1 hour with 10 minutes before) can be identically expressed as '50M'.

EXAMPLE 4 The expression '2M-10S' does not contain an underflow in the clock second time scale component, as the meaning of '2M-10S' cannot be identically expressed in an alternative combination of these two time scale components, given that the clock minute and clock second are not an unequivocally convertible time scale component pair.

An algorithm for resolving time scale component overflows within a date and time expression is provided in D.3.1.

An algorithm for resolving time scale component underflows within a date and time expression is provided in D.3.3.

14.6

Add the following subclause after the newly added 14.5:

14.6 Time scale component conversion boundaries

Conversion of a time scale component into another time scale component is not always possible without loss of information.

Certain pairs of time scale components are unequivocally convertible into each other as their conversions are governed by deterministic relationships. These conversions are transitive.

Some pairs of time scale components cannot be unequivocally converted into each other, as they depend on context-dependent duration (see D.2.2) or speculative duration (see D.2.3).

The presence of such a time scale components pair in a date and time expression marks a “time scale component conversion boundary”, where conversions cannot occur across the pair without loss of information.

In the Gregorian calendar with the UTC 24-hour clock system, the following pairs of time scale components are unequivocally convertible from and to each other:

— calendar century and calendar decade;

NOTE 1 In the Gregorian calendar system, a calendar century contains 10 calendar decades.

EXAMPLE 1 The date and time expression '28C' can always be converted into '280D' as the calendar century and calendar year are an unequivocally convertible pair.

— calendar decade and calendar year;

NOTE 2 In the Gregorian calendar system, a calendar decade contains 10 calendar years.

EXAMPLE 2 The date and time expression '33D' can always be converted into '330Y' as the calendar decade and calendar year are an unequivocally convertible pair.

— calendar year and calendar month;

NOTE 3 In the Gregorian calendar system, a calendar year contains 12 calendar months.

EXAMPLE 3 The date and time expression '20M' can always be converted into '1Y8M' as the calendar year and calendar month are an unequivocally convertible pair.

— calendar week and calendar day;

NOTE 4 In the Gregorian calendar system, a calendar week contains 7 calendar days.

EXAMPLE 4 The date and time expression '108D' can always be converted into '15W3D' as the calendar week and calendar day are an unequivocally convertible pair.

— calendar day and clock hour;

NOTE 5 In the Gregorian calendar system as applied with the UTC 24-hour clock system, a calendar day contains 24 clock hours.

EXAMPLE 5 The date and time expression 'T26H' can always be converted into '1DT2H' as the calendar day and clock hour are an unequivocally convertible pair.

— clock hour and clock minute.

NOTE 6 In the UTC 24-hour clock system, a clock hour contains 60 clock minutes.

EXAMPLE 6 The date and time expression 'T1H120M' can always be converted into 'T3H' as the clock hour and clock minute are an unequivocally convertible pair.

The following pairs of time scale components are not unequivocally convertible from and to each other:

— calendar year and calendar week;

NOTE 7 In the Gregorian calendar system, a calendar year contains 52 or 53 calendar weeks.

EXAMPLE 7 The date and time expression '3Y55W' cannot be unequivocally converted into '4Y3W' as the calendar year and calendar week are not an unequivocally convertible pair.

— calendar year and calendar day

NOTE 8 In the Gregorian calendar system, a calendar year contains 365 or 366 calendar days.

EXAMPLE 8 The date and time expression '1Y366D' cannot be unequivocally converted into '2Y1D' or '2Y' as the calendar year and calendar day is a time scale component conversion boundary pair that depends on context-dependent duration. In this example the results are ambiguous depending on the actual calendar year this expression is evaluated in.

— calendar month and calendar day

NOTE 9 In the Gregorian calendar system, a calendar month contains 28, 29, 30 or 31 calendar days.

EXAMPLE 9 The date and time expression '3M30D' cannot be unequivocally converted into another expression form as the calendar month and calendar day is a time scale component conversion boundary pair that depends on context-dependent duration. In this example the results are ambiguous depending on the actual calendar month this expression is evaluated in.

— clock minute and clock second

NOTE 10 In the UTC 24-hour clock system, a clock minute contains 59, 60 or 61 clock seconds.

EXAMPLE 10 The date and time expression '59M120S' cannot be further simplified without further context as the clock minute and clock second is a time scale component conversion boundary pair that depends on context-dependent duration.

The notion of context-independent conversion extends beyond the explicit pairs of time scale components mentioned. The result of a date and time expression does not change with time scale component conversion as long as the time scale component conversion boundaries are not crossed. Certain date and time expressions syntaxes that do not depend on context-dependent durations can also be unequivocally converted.

EXAMPLE 11 The date and time expression '59O' can be unequivocally converted into '2M28D' as the 59th ordinal day of any Gregorian year is always February 28th.

EXAMPLE 12 The date and time expression '60O' cannot be unequivocally converted into a calendar month and calendar day combination because the 60th ordinal day of a Gregorian year can be either February 29th in a leap year or March 1st in a regular year.

In a date and time expression, time scale component conversion boundaries can be relaxed accordingly when context-dependent durations can be resolved to actual values.

EXAMPLE 13 The date and time expression '2023Y60O' can be unequivocally converted into '2023Y3M1D' as the 60th ordinal day of 2023 is March 1st. However, the date time expression '2020Y60O', despite sharing the '60O' syntax, is converted into '2020Y2M29D' as the 60th ordinal day of 2020 is February 29th.

EXAMPLE 14 The date and time expression '2016Y12M31DT60S' can be converted into '2017Y1M1DT1S' as a leap second was inserted into the last clock minute on 2016-12-31.

When resolving overflow and underflow conditions, the time scale component conversion boundaries cannot be crossed, as the boundaries are used to enforce the semantic equivalence of date and time expression.

In cases where the exact duration is not necessary or does not apply, nominal duration rules can be used to specify nominal durations for time scale components (see D.2.3) in order to relax certain time scale component conversion boundaries. A nominal duration rule enforces a defined value for context-dependent or speculative durations.

EXAMPLE 15 A possible nominal duration rule in the UTC 24-hour clock system specifies that 1 clock minute is always equal to 60 clock seconds, ignoring the possibility of a leap second.

EXAMPLE 16 Some weather forecast models adopt nominal duration rules to limit algorithmic complexity. A model that uses the Gregorian calendar with the UTC 24-hour clock system adopts the following nominal duration rules: a) 1 clock minute is always equal to 60 clock seconds; b) 1 calendar month always contains 30 calendar days. In this context, the date and time expression '2016Y12M31DT60S' is unequivocally converted into '2017Y1M1DT1S'. The UTC leap second at '2016Y12M31DT60S' is ignored due to the adopted nominal duration rules.

EXAMPLE 17 In financial transactions and agreements, a calendar year is sometimes specified as 360 days. To conform with terms of an agreement for the calculation of interest rate payments, the following nominal duration rules are adopted: a) 1 calendar year contains 360 calendar days; b) 1 calendar month contains 30 calendar days. The 31st of the month and the 29th of February are considered to be the 30th day for the calculation of interest in the agreement.

14.7

Add the following subclause after the newly added 14.6:

14.7 Canonical form of date and time expressions

14.7.1 General

A date and time expression can be expressed in a canonical form. The canonical form of a date and time expression enables comparison between two expressions that potentially utilize different combinations of timescale components and values.

14.7.2 Date and time expressions with concrete context

For date and time expressions with concrete context, it is simple to derive its canonical expression.

EXAMPLE The following date and time expressions all point to the same date: '2020Y3M30D', '2020Y4M-1D', '2020Y2M59D' and '2019Y3M396D'. The first instance is the canonical form as it contains minimal underflow and no overflow.

14.7.3 Context-dependent expressions

The composite duration form in effect delays resolution of a date time expression until context-dependent durations are resolved.

For date and time expressions not anchored in context, there are additional considerations in order to derive their canonical form.

EXAMPLE 1 The expression '18Y1M' has a canonical form of exactly itself as it does not contain any overflow or underflow.

EXAMPLE 2 The expression '3H3M3S' has a canonical form of exactly itself as it does not contain any overflow or underflow.

EXAMPLE 3 The expression '7Y24M' has a canonical form of '9Y', as the overflow in the calendar month component '24M' can be expressed as '2Y'.

EXAMPLE 4 The expression '1H90M' has a canonical form of '2H30M', as the overflow in the clock minute component '90M' can be expressed as '1M30M'.

EXAMPLE 5 The expression '1H-10M' has a canonical form of '50M', as it contains an underflow in the clock minutes time scale component '-10M', which can be resolved by applying '-10M' with the higher-order component of '1H' into '50M'.

EXAMPLE 6 In the expression '3DT-10M', the underflow component of '-10M' can be eliminated by the transitive conversion of time scale components from calendar day, to clock hour, to clock minutes, into the canonical form of '2DT23H50M'.

It is possible that date and time expressions that contain time scale components with values that are context-dependent are not fully able to eliminate underflow.

EXAMPLE 7 In the expression '3M100S', the overflow component of '100S' cannot be eliminated because clock minute and clock second is a time scale component conversion boundary (see 14.6).

EXAMPLE 8 In the expression '3Y-1D', the underflow component of '-1D' cannot be eliminated because calendar year and calendar day is a time scale component conversion boundary (see 14.6).

EXAMPLE 9 In the expression '1M-2000S', the underflow component of '-2000S' cannot be eliminated because clock minute and clock second is a time scale component conversion boundary (see 14.6).

EXAMPLE 10 In the expression '3DT-10S', the underflow component of '-10S' cannot be eliminated because the conversion of clock second to calendar day crosses a time scale component conversion boundary: clock second, to clock minute, to clock hour, to calendar day; where clock second and clock minute is a boundary.

Detection of a canonical form of a date and time expression can only be achieved by algorithmically deriving its canonical form and comparing with the original expression. An algorithm for deriving canonical form is given in D.5.

15.3

Add the following subclause after the existing 15.2:

15.3 Expression template

An expression template describes an allowed pattern of a date time expression, specifying the following:

— time scale components supported;

— accepted value ranges of those time scale components;

— appearance order of those time scale components.

The expression template is described through the format representation syntax described in ISO 8601-1:2019, 3.2. They are enclosed between single quotation marks in this document.

Time scale components used in an expression template are defined in ISO 8601-1 and this document. The specification of value ranges accepted by the time scale components are described in the definition of the time scale components.

EXAMPLE 1 The expression template for a date and time expression that fits the 'YYYYMMDD' pattern is expressed as:

[year][month][day]

Where, 'year', 'month', 'day' are components defined in ISO 8601-1:2019, 3.2.

This expression template accepts the expression '20230210' which identifies 10 February 2023.

EXAMPLE 2 The expression template for a date and time expression that fits the 'YYYY-MM-DD' pattern is expressed as:

[year]["-"][month]["-"][day]

Where, 'year', 'month', 'day' are components defined in ISO 8601-1:2019, 3.2.

This expression template accepts the expression '2023-02-10' which identifies 10 February 2023.

EXAMPLE 3 The expression template for a date and time expression that fits the '(YYYY)(MM)(DD)' pattern is expressed as:

["("][year][")"]["("][month][")"]["("][day][")"]

Where, 'year', 'month', 'day' are components defined in ISO 8601-1:2019, 3.2.

This expression template accepts the expression '(2023)(02)(10)' which identifies 10 February 2023.

EXAMPLE 4 The expression template for a date and time expression that fits the 'YYYYYY"WK"WWKK' and '-YYYYYY"WK"WWKK' patterns is expressed as:

[±][year(6)]["WK"][week][dayk]

Where, 'year(6) ', 'week', 'dayk' are components defined in ISO 8601-1:2019, 3.2.

This expression template accepts the expression '002023WK065' which identifies calendar year 2023, Friday of the calendar week 6, 10 February 2023.

EXAMPLE 5 The expression template for a date and time expression that fits the desired explicit date pattern using 5-digit years and week date syntax is expressed as:

[yearE(5)][weekE][daykE]

Where, 'yearE(5)', 'weekE', 'daykE' are components defined in ISO 8601-2:2019, 3.2.

This expression template accepts the expression '02023Y6W5K' which identifies calendar year 2023, Friday of the calendar week 6, which is 10 February 2023.

D.3.1

Replace the text with the following:

An “overflow” of a date and time expression is defined as assigning a value exceeding the maximum value accepted by the time scale component.

EXAMPLE 1 An increase of 'P1M' (duration) to '2018Y12M' (date) results in the immediate date and time expression '2018Y13M', where the calendar month component is in overflow with value '13'.

An overflow is considered resolved once the excess value of the lower-order time scale component has transferred its excess to the immediate higher-order time scale component through the carry-over operation. The carry-over operation converts the excess value of one or more lower-order time scale components into a positive value in a higher-order time scale component.

EXAMPLE 2 The date and time expression '2018Y13M' contains the calendar month time scale component in overflow, and can be resolved to '2019Y1M' through the carry-over of the excess '12M' into '1Y', as the calendar month and calendar year time scale components are an unequivocally convertible time scale component pair.

An overflow can trigger multiple carry-over operations when the overflow not only causes the immediate higher-order time scale component to overflow, but also subsequent higher-order components.

EXAMPLE 3 The date and time expression '2018Y12M366D' contains the calendar day time scale component in overflow, it can be resolved to the immediate date and time expression '2018Y24M1D' (which still contains an overflow), which can be resolved to '2019Y12M1D' (where there is no more overflow).

EXAMPLE 4 The date and time expression 'P1Y12M366D' does not contain sufficient context to resolve the calendar day overflow, as the calendar day and calendar year do not form an unequivocally convertible time scale component pair.

D.3.2, EXAMPLE 4

Replace EXAMPLE 4 with the following:

EXAMPLE 4 The out of bounds expression '2020Y367O' can be truncated to '2020Y366O'. 366O is a valid ordinal day in 2020 as it is a leap year, according to ISO 8601-1:2019, Table 1.

D.3.3

Add the following subclause after the existing D.3.2:

D.3.3 Borrow to resolve underflow in time scale components

An “underflow” of a date and time expression is defined as assigning a value less than the minimum value accepted by the time scale component.

EXAMPLE 1 A reduction of 'P15M' (duration) to '2023Y12M' (date) results in the immediate expression '2023Y-3M', where the calendar month component is in underflow with value '-3'.

An underflow is considered resolved once the time scale component in underflow has transferred its depletion to a higher-order time scale component, through the borrow operation. The borrow operation expands values in a higher-order time scale component into the corresponding values for one or more lower-order components.

EXAMPLE 2 The date and time expression '2023Y-3M' contains the calendar month time scale component in underflow. One calendar year '1Y' can be borrowed and expanded into '12M', which results in the expression '2022Y9M' that does not contain any time scale component in underflow.

A single underflow can require multiple borrow operations across higher-order time scale components to resolve.

EXAMPLE 3 The date and time expression '2024Y3M-300D' contains the calendar day time scale component in underflow. When considered with the calendar year time scale component with value 2024, the underflow means '300 days prior to the beginning of 2024 March', and can be resolved to '2023Y5M6D', where there is no more underflow. In the resulting expression, both the calendar year and calendar month components have their values affected by borrow operations.

Underflow conditions that arise from context-dependent duration or speculative durations cannot be resolved.

EXAMPLE 4 In the date and time expression '3M-300D', the calendar day component '-300D' in underflow cannot be resolved through the borrow operation against calendar day because calendar month and calendar day do not form an unequivocally convertible time scale component pair.

D.4.2

Add the following text after EXAMPLE 2:

Given two or more composite duration components, it is possible to combine them while preserving semantics. The resulting expression can be rephrased in canonical form using the algorithm provided in D.5.

EXAMPLE 3 The expression 'P1Y10M3D – P2Y5MT10M' results in 'P3Y15M3DT-10M'.

EXAMPLE 4 'P1Y-10M3D + P2Y-5M' results in 'P3Y-15M3D'.

EXAMPLE 5 'PT1H60S – PT122M' results in 'PT1H-122M60S'.

EXAMPLE 6 'PT5H120S – PT1M' results in 'PT5H-1M120S'.

D.4.6

Add the following subclause after the existing D.4.5:

D.4.6 Involving negative duration

Date and time arithmetic involving negative durations often leads to underflow time scale components, which rely on the underflow resolution algorithm described in D.3.3.

The steps are as follows.

a) Starting at the rightmost side of the composite duration expression, process every underflow durational component one by one as follows.

   1) From the underflow time scale component, find in the expression a higher-order time scale component that is unequivocally convertible (i.e. does not cross conversion boundaries) and has a positive value.

      NOTE There can be multiple higher-order components that can be unequivocally convertible, such as clock minute and clock hour, calendar day and clock minute.

   2) Borrow components from the higher-order value until the current underflow time scale component is positive. Ensure all time scale components being modified are properly updated.

   3) Once the current underflow time scale component becomes positive, or if there are no more unequivocally convertible components (even if the component with underflow still contains a negative value), continue with step 1) on the resulting duration expression.

b) Once all durational components have been processed, the current date and time expression under consideration is the result.

EXAMPLE 1 Calculation of '2022Y2M2D – P1Y10M3D':

— The calculation is in accordance with this annex; the intermediate date and time expression is computed as '(2022-1)Y(2-10)M(2-3)D' which results in '2021Y-8M-1D'.

— Underflow time scale components are resolved as follows.

  — The first underflow component from the right is processed: '-1D'.

  — The calendar day component does not have an unequivocally convertible higher-order component in this date and time expression.

  — The second durational component from the right is processed: '-8M'.

  — The calendar month component can be unequivocally convertible with the higher-order component calendar year in this expression.

  — The calendar month component borrows 1 calendar year, which is equal to 12 calendar months. The partial date and time expression under consideration of '2021Y-8M' becomes '2020Y(12-8)M', which resolves to '2020Y4M'.

  — The intermediate date and time expression becomes '2020Y4M-1D'.

  — There are no more underflow components.

— The resulting date and time expression after underflow resolution is '2020Y4M-1D'.

EXAMPLE 2 Calculation of '2025Y59O – P20DT1H30M':

— The former and latter expressions use 'O' and 'D' to express the same time scale component of calendar day respectively. This means that their values can be calculated within the same time scale component. To preserve the meaning of the “ordinal day” time scale component, 'O' is selected as the component to perform calculations on.

— The calculation is in accordance with this annex; the intermediate date and time expression is computed as '2025Y(59-20)OT(-1)H(-30)M' which results in '2025Y39OT-1H-30M'.

— Underflow time scale components are resolved as follows.

  — The first underflow time scale component from the right is processed: '-30M'.

  — The clock minute time scale component can be unequivocally convertible with the higher-order time scale component clock hour in this date and time expression.

  — The clock minute time scale component borrows 1 clock hour, which is equal to 60 clock minutes. The partial date and time expression under consideration of 'T-1H-30M' becomes 'T(-1-1)H(60-30)M', which resolves to 'T-2H30M'.

  — The second durational time scale component from the right is processed: '-2H'.

  — The clock hour time scale component can be unequivocally convertible with the higher-order time scale component calendar day in this date and time expression.

  — The clock hour time scale component borrows 1 calendar day, which is equal to 24 clock hours. The partial date and time expression under consideration of '39OT-2H' becomes '(39-1)OT(24-2)H', which resolves to '38OT22H'.

  — The intermediate date and time expression becomes '2025Y38OT22H'.

  — There are no more underflow time scale components.

— The resulting date and time expression after underflow resolution is '2025Y38OT22H'.

EXAMPLE 3 Calculation of 'T10H10M10S – PT5H30M20S':