# Space Primitive and Spacetime Primitive

## New Classes

**Exx Space Primitive**

Subclass of: [E59](#_E59_Primitive_Value) Primitive Value

Scope Note: This class comprises instances of E59 Primitive Value for space that should be implemented with appropriate validation, precision and references to spatial coordinate systems to express geometries identifying places on an E18 Physical Thing like the earth, a ship, the moon, a map or areas of a manuscript page which are relevant to cultural and scientific documentation. Formats and syntax used to encode geometries may be specified through P2 has Type.

An Exx Space Primitive defines an E53 Place in the sense of a declarative Place as elaborated in CRMgeo (Doerr and Hiebel 2013), which means that the identity of the place is derived from its geometric definition. This declarative Place allows for the application of all Place properties to relate phenomenal Places to their approximations expressed with geometries. The property *P157 is at rest relative to* may be used to explicitly state the E18 Physical Thing that provides the reference space for the declarative place defined by the Exx Space Primitive.

Space Primitives provide the ability to link CRM encoded data to geometries used in maps or Geoinformation systems. They may be used for visualisation of Places in their geographic context and computing topological relations of Places based on these geometries.

Exx Space Primitive is not further elaborated upon within the model. If it is necessary to document details of a used spatial reference system, or to define geometric details the CRMgeo model may be used.

Examples:

* Coordinate Information in Geography Markup Language (GML) like <gml:Point gml:id="p21" srsName="http://www.opengis.net/def/crs/EPSG/0/4326"> <gml:coordinates>45.67, 88.56</gml:coordinates> </gml:Point>
* Coordinate Information in lat, long 48,2 13,3
* Well Known Text like POLYGON ((30 10, 40 40, 20 40, 10 20, 30 10))

Properties:

Pxxx defines place (place is defined by): [E53](#_E53_Place) Place

**Ex1 Spacetime Primitive**

Subclass of: [E59](#_E59_Primitive_Value) Primitive Value

Scope Note: This class comprises instances of E59 Primitive Value for spacetime volumes that should be implemented with appropriate validation, precision, interval logic and reference systems to express date ranges and geometries relevant to cultural documentation. A Spacetime Primitive may consist of one expression including temporal and spatial information like in GML or a different form of expressing spacetime in an integrated way like a formula containing all 4 dimensions.

An Exx Spacetime Primitive defines an E92 Spacetime Volume in the sense of a declarative Spacetime Volume as defined in CRMgeo (Doerr & Hiebel 2013), which means that the identity of the Spacetime Volume is derived from its geometric and temporal definition. This declarative Spacetime Volume allows for the application of all Spacetime Volume properties to relate phenomenal Spacetime Volumes of Periods and Physical Things to propositions about their spatial and temporal extents.

Examples:

* Spatial and temporal information in KML for the maximum extent of the Byzantine Empire

<Placemark>

 <name> Byzantine Empire </name>

 <styleUrl>#style\_1</styleUrl>

 <TimeSpan>

 <begin>330</begin>

 <end>1453</end>

 </TimeSpan>

<Polygon><altitudeMode>clampToGround</altitudeMode><outerBoundaryIs><LinearRing>

<coordinates>18.452787460,40.85553626,0 17.2223187,40.589098,........0 17.2223,39.783

</coordinates>

</Polygon>

</Placemark>

* a spacetime volume expressed in GML defining the spatial extent of France from 1792-1816 giving one spatial extent for each year

Properties:

Pxx1defines spacetime volume (spacetime volume is defined by): E92 Spacetime Volume

## New Properties

**Pxxx defines place (place is defined by)**

|  |
| --- |
| Domain: Exx Space Primitive  |
| Range: [E53](#_E53_Place) Place  |
|  |

Scope note: This property associates an instance of Exx Space Primitive with the instance of [E53](#_E53_Place) Place it defines. Syntactic variants or use of different scripts may result in multiple instances of SP5 Geometric Place Expression defining exactly the same place. Transformations between different reference systems in general result in new definitions of places approximating each other.

**Pxx1 defines spacetime volume (spacetime volume is defined by)**

|  |
| --- |
| Domain: Ex1 Spacetime Primitive |
| Range: E92 Spacetime Volume |
|  |

Scope note: This property associates an instance of SP12 Spacetime Volume Expression with the instance of SP7 Declarative Spacetime Volume it defines. Syntactic variants or use of different scripts may result in multiple instances of SP12 Spacetime Volume Expressions defining exactly the same SP7 Declarative Spacetime Volume. Transformations between different temporal or spatial reference systems in general result in new definitions of Spacetime Volumes approximating each other.

**Pxx2 defines time (time is defined by)**

|  |
| --- |
| Domain: E61Time Primitive  |
| Range: [E52](#_E53_Place) Time Span  |
|  |

Scope note: This property associates an instance of E61Time Primitive with the instance of [E52](#_E53_Place) Time Span it defines. Syntactic variants or use of different scripts may result in multiple instances of SP5 Geometric Place Expression defining exactly the same place. Transformations between different reference systems in general result in new definitions of places approximating each other.

**Pxx3 at some place within**

|  |
| --- |
| Domain: [E53](#_E53_Place) Place |
| Range: Exx Space Primitive |

Scope note: This property describes the maximum spatial extent within which an E53 Place falls. Since Places may not have precisely known spatial extents, the CRM supports statements about maximum spatial extents of Places. This property allows a Places’s maximum spatial extent (i.e. its outer boundary) to be assigned an Exx Space Primitive value.

*Pxx3 at some place within* is a shortcut through a not represented declarative Place as defined in CRMgeo (Doerr and Hiebel 2013) to a Space Primitive.

Space Primitives are treated by the CRM as application or system specific spatial intervals, and are not further analysed.

Examples:

* the spatial extent of the Acropolis of Athens (E53) is *at some place within* POLYGON ((37.969172 23.720787, 37.973122 23.721495 37.972741 23.728994, 37.969299 23.729735, 37.969172 23.720787)) (Exx)

**Pxx4 contains**

|  |
| --- |
| Domain: [E53](#_E53_Place) Place |
| Range: Exx Space Primitive |

Scope note: This property describes a minimum spatial extent which is contained within an E53 Place. Since Places may not have precisely known spatial extents, the CRM supports statements about minimum spatial extents of Places. This property allows a Places’s minimum spatial extent (i.e. its inner boundary or a point being within a Place) to be assigned an Exx Space Primitive value.

Pxx4 *contains* is a shortcut through a not represented declarative Place as defined in CRMgeo (Doerr and Hiebel 2013) to a Space Primitive.

Space Primitives are treated by the CRM as application or system specific spatial intervals, and are not further analysed.

Examples:

* the spatial extent of the Acropolis of Athens (E53) *contains* POINT (37.971431 23.725947) (Exx)

## Related CRM Classes and properties

**E52 Time-Span**

Subclass of: [E1](#_E1_CRM_Entity) CRM Entity

Scope note: This class comprises abstract temporal extents, in the sense of Galilean physics, having a beginning, an end and a duration.

Time Span has no other semantic connotations. Time-Spans are used to define the temporal extent of instances of E4 Period, E5 Event and any other phenomena valid for a certain time. An E52 Time-Span may be identified by one or more instances of E49 Time Appellation.

Since our knowledge of history is imperfect, instances of E52 Time-Span can best be considered as approximations of the actual Time-Spans of temporal entities. The properties of E52 Time-Span are intended to allow these approximations to be expressed precisely. An extreme case of approximation, might, for example, define an E52 Time-Span having unknown beginning, end and duration. Used as a common E52 Time-Span for two events, it would nevertheless define them as being simultaneous, even if nothing else was known.

 Automatic processing and querying of instances of E52 Time-Span is facilitated if data can be parsed into an E61 Time Primitive.

Examples:

* 1961
* From 12-17-1993 to 12-8-1996
* 14h30 – 16h22 4th July 1945
* 9.30 am 1.1.1999 to 2.00 pm 1.1.1999
* duration of the Ming Dynasty

Properties:

[P78](#_P78_is_identified_by (identifies)) is identified by (identifies): [E49](#_E49_Time_Appellation) Time Appellation

[P79](#_P79_beginning_is_qualified by) beginning is qualified by: [E62](#_E62_String) String

[P80](#_P80_end_is_qualified by) end is qualified by: [E62](#_E62_String) String

[P81](#_P81_ongoing_throughout) ongoing throughout: [E61](#_E61_Time_Primitive) Time Primitive

[P82](#_P82_at_some_time within) at some time within: [E61](#_E61_Time_Primitive) Time Primitive

**E61 Time Primitive**

Subclass of: [E59](#_E59_Primitive_Value) Primitive Value

Scope Note: This class comprises instances of E59 Primitive Value for time that should be implemented with appropriate validation, precision and interval logic to express date ranges relevant to cultural documentation.

E61 Time Primitive is not further elaborated upon within the model.

Examples:

* 1994 – 1997
* 13 May 1768
* 2000/01/01 00:00:59.7
* 85th century BC

**E49 Time Appellation**

Subclass of: [E41](#_E41_Appellation) Appellation

Superclass of [E50](#_E50_Date) Date

Scope Note: This class comprises all forms of names or codes, such as historical periods, and dates, which are characteristically used to refer to a specific E52 Time-Span.

The instances of E49 Time Appellation may vary in their degree of precision, and they may be relative to other time frames, “Before Christ” for example. Instances of E52 Time-Span are often defined by reference to a cultural period or an event e.g. ‘the duration of the Ming Dynasty’.

Examples:

* “Meiji” [Japanese term for a specific time-span]
* “1st half of the XX century”
* “Quaternary”
* “1215 Hegira” [a date in the Islamic calendar]
* “Last century”

**E59 Primitive Value**

Superclass of: [E60](#_E60_Number) Number

 [E61](#_E61_Time_Primitive) Time Primitive

 [E62](#_E62_String) String

Scope Note: This class comprises primitive values used as documentation elements, which are not further elaborated upon within the model.

As such they are not considered as elements within our universe of discourse. No specific implementation recommendations are made. It is recommended that the primitive value system from the implementation platform be used to substitute for this class and its subclasses.

Examples:

* ABCDEFG (E62)
* 3.14 (E60)
* 0
* 1921-01-01 (E61)

**E53 Place**

Subclass of: [E1](#_E1_CRM_Entity) CRM Entity

Scope note: This class comprises extents in space, in particular on the surface of the earth, in the pure sense of physics: independent from temporal phenomena and matter.

The instances of E53 Place are usually determined by reference to the position of “immobile” objects such as buildings, cities, mountains, rivers, or dedicated geodetic marks. A Place can be determined by combining a frame of reference and a location with respect to this frame. It may be identified by one or more instances of E44 Place Appellation.

 It is sometimes argued that instances of E53 Place are best identified by global coordinates or absolute reference systems. However, relative references are often more relevant in the context of cultural documentation and tend to be more precise. In particular, we are often interested in position in relation to large, mobile objects, such as ships. For example, the Place at which Nelson died is known with reference to a large mobile object – H.M.S Victory. A resolution of this Place in terms of absolute coordinates would require knowledge of the movements of the vessel and the precise time of death, either of which may be revised, and the result would lack historical and cultural relevance.

Any object can serve as a frame of reference for E53 Place determination. The model foresees the notion of a "section" of an E19 Physical Object as a valid E53 Place determination.

Examples:

* the extent of the UK in the year 2003
* the position of the hallmark on the inside of my wedding ring
* the place referred to in the phrase: “Fish collected at three miles north of the confluence of the Arve and the Rhone”
* here -> <-

Properties:

[P87](#_P87_is_identified_by (identifies)) is identified by (identifies): [E44](#_E44_Place_Appellation) Place Appellation

[P89](#_P89_falls_within_(contains)) falls within (contains): [E53](#_E53_Place) Place

[P121](#_P121_overlaps_with) overlaps with: [E53](#_E53_Place) Place

[P122](#_P122_borders_with) borders with: [E53](#_E53_Place) Place

[P157](#_P157(Px2)_is_at) is at rest relative to (provides reference space for): [E18](#_E18_Physical_Thing) Physical Thing

**E44 Place Appellation**

Subclass of: [E41](#_E41_Appellation) Appellation

Superclass of [E45](#_E45_Address) Address

[E46](#_E46_Section_Definition) Section Definition

[E47](#_E47_Spatial_Coordinates) Spatial Coordinates

[E48](#_E48_Place_Name) Place Name

Scope Note: This class comprises any sort of identifier characteristically used to refer to an E53 Place.

Instances of E44 Place Appellation may vary in their degree of precision and their meaning may vary over time - the same instance of E44 Place Appellation may be used to refer to several places, either because of cultural shifts, or because objects used as reference points have moved around. Instances of E44 Place Appellation can be extremely varied in form: postal addresses, instances of E47 Spatial Coordinate, and parts of buildings can all be considered as instances of E44 Place Appellation.

Examples:

* “Vienna”
* “CH-1211, Genève”
* “Aquae Sulis Minerva”
* “Bath”
* “Cambridge”
* “the Other Place”
* “the City”

**E47 Spatial Coordinates**

Subclass of: [E44](#_E44_Place_Appellation) Place Appellation

Scope Note: This class comprises the textual or numeric information required to locate specific instances of E53 Place within schemes of spatial identification.

Coordinates are a specific form of E44 Place Appellation, that is, a means of referring to a particular E53 Place. Coordinates are not restricted to longitude, latitude and altitude. Any regular system of reference that maps onto an E19 Physical Object can be used to generate coordinates.

Examples:

* “6°5’29”N 45°12’13”W”
* “Black queen’s bishop 4” [chess coordinate]

**P81 ongoing throughout**

Domain: [E52](#_E52_Time-Span) Time-Span

Range: [E61](#_E61_Time_Primitive) Time Primitive

Quantification: many to one, necessary (1,1:0,n)

Scope note: This property describes the minimum period of time covered by an E52 Time-Span.

Since Time-Spans may not have precisely known temporal extents, the CRM supports statements about the minimum and maximum temporal extents of Time-Spans. This property allows a Time-Span’s minimum temporal extent (i.e. its inner boundary) to be assigned an E61 Time Primitive value. Time Primitives are treated by the CRM as application or system specific date intervals, and are not further analysed.

Examples:

* the time-span of the development of the CIDOC CRM (E52) *ongoing throughout* 1996-2002 (E61)

**P82 at some time within**

Domain: [E52](#_E52_Time-Span) Time-Span

Range: [E61](#_E61_Time_Primitive) Time Primitive

Quantification: many to one, necessary (1,1:0,n)

Scope note: This property describes the maximum period of time within which an E52 Time-Span falls.

Since Time-Spans may not have precisely known temporal extents, the CRM supports statements about the minimum and maximum temporal extents of Time-Spans. This property allows a Time-Span’s maximum temporal extent (i.e. its outer boundary) to be assigned an E61 Time Primitive value. Time Primitives are treated by the CRM as application or system specific date intervals, and are not further analysed.

Examples:

* the time-span of the development of the CIDOC CRM (E52) *at some time within* 1992-infinity (E61)

## Related CRMgeo Classes and properties

**SP5 Geometric Place Expression**

|  |
| --- |
| Subclass of: [E73](#_E73_Information_Object) Information Object , [E47](#_E47_Spatial_Coordinates) Spatial Coordinates, [Geometry](#_Geometry)   |

Scope note: This class comprises definitions of places by quantitative expressions. An instance of SP5 Geometric Place Expression can be seen as a prescription of how to find the location meant by this expression in the real world (S), which is based on measuring where the quantities referred to in the expression lead to, beginning from the reference points of the respective reference system.

A form of expression may be geometries or map elements defined in a SP4 Spatial Coordinate Reference System that unambiguously identify locations in a SP3 Reference Space. Other forms may refer to areas confined by imaginary lines connecting Phenomenal Places such as trees, islands, cities, mountain tops.

The identity of a SP5 Place Expression is based on its script or symbolic form (I). Several SP5 Place Expressions can denote the same SP6 Declarative Place .

Instances of SP5 Geometric Place Expressions that exist in one SP4 Spatial Coordinate Reference System can be transformed to geometries in other SP4 Spatial Coordinate Reference System if there is a known and valid transformation. The product of the transformation in general defines a new instance of SP6 Declarative Place , albeit close to the source of the transformation. This can be due to distortions resulting from the transformation and the limited precision by which the relative position of the reference points differing between the respective reference systems are determined.

Examples:

* Coordinate Information in GML like <gml:Point gml:id="p21" srsName="http://www.opengis.net/def/crs/EPSG/0/4326"> <gml:coordinates>45.67, 88.56</gml:coordinates> </gml:Point>
* The expression of a polygon defining the extent of France

Properties:

|  |
| --- |
| [Q9](#_Q9_is_expressed) is expressed in terms of: [**SP4**](#_SP4_Spatial_Coordinate) Spatial Coordinate Reference System[Q10](#_Q10_defines_place) defines place: [**SP6**](#_SP6_Declarative_Place)Declarative Place |

**SP6 Declarative Place**

|  |
| --- |
| Subclass of: [E53](#_E53_Place) Place  |

Scope note: This class comprises instances of E53 Place (S) whose extent (U) and position is defined by a SP5 Geometric Place Expression (S). There is one implicit or explicit SP3 Reference Space in which the SP5 Place Expression describes the intended place. Even though SP5 Geometric Place Expressions have an unlimited precision, measurement devices and the precision of the position of reference features relating the SP4 Spatial Coordinate Reference System to a SP3 Reference Space impose limitations to the determination of a SP6 Declarative Place in the real world (U).

Several SP5 Geometric Place Expressions may denote the same SP6 Declarative Place if their precision falls within the same range (I).

Instances of SP6 Declarative Places may be used to approximate instances of E53 Places or parts of them. They may as well be used to define the location and spatial extent of property rights or national borders.

Examples:

* the place defined by <gml:Point gml:id="p21" srsName="http://www.opengis.net/def/crs/EPSG/0/4326"> <gml:coordinates>45.67, 88.56</gml:coordinates> </gml:Point>
* the place defined by a line approximating the Danube river
* The place of the Orinoco river defined in the map of Diego Ribeiro
* the place defined through a polygon that represents the boundaries of the
* UK in the year 2003

Properties:

|  |
| --- |
| [Q11](#_Q11_approximates) approximates: [**E53**](#_E53_Place) Place |

**SP12 Spacetime Volume Expression**

|  |
| --- |
| Subclass of: [E73](#_E73_Information_Object) Information Object, [Geometry](#_Geometry)  |

Scope note: This class comprises definitions of Spacetime Volumes by quantitative expressions(S). An instance of SP12 Spacetime Volume Expression can be seen as a prescription of how to find the projected declarative place of a Spacetime Volume meant by this expression in the actual real world. In addition the SP12 Spacetime Volume Expression states a temporal interval at what projected time interval this declarative Spacetime Volume existed.

The expression can be a combination of a "SP 5 Geometric Place Expression" and an "SP 14 Declarative Time-Span" or a different form of expressing spacetime in an integrated way like a formula containing all 4 dimensions.

Examples:

* Spatial and temporal information in KML for Byzantine Empire

<Placemark>

 <name> Byzantine Empire </name>

 <styleUrl>#style\_1</styleUrl>

 <TimeSpan>

 <begin>330</begin>

 <end>1453</end>

 </TimeSpan>

<Polygon><altitudeMode>clampToGround</altitudeMode><outerBoundaryIs><LinearRing>

<coordinates>18.452787460,40.85553626,0 17.2223187,40.589098,........0 17.2223,39.783

</coordinates>

</Polygon>

</Placemark>

* a spacetime volume expressed in GML defining the extent of France from 1792-1816

Properties:

[Q17](#_Q17_is_expressed) is expressed in terms of: [SP11](#_SP11_Temporal_Reference) Temporal Reference System

[Q18](#_Q18_is_expressed) is expressed in terms of: [**SP4**](#_SP4_Spatial_Coordinate) Spatial Coordinate Reference System

**SP7 Declarative Spacetime Volume**

|  |
| --- |
| Subclass of: [SP8](#_SP8_Spacetime_Volume) Spacetime Volume |

Scope note: This class comprises instances of SP8 Spacetime Volumes (S) whose temporal and spatial extent (U) and position is defined by a SP12 Spacetime Volume Expression. There is one implicit or explicit SP3 Reference Space in which the SP12 Spacetime Volume Expression describes the intended Spacetime Volume. As we restrict the model to Galilean physics and explicitly exclude systems with velocities close to the speed of light we do not model a “Reference Time” as it would be necessary for relativistic physics. This implies that there is only one Reference Time.

Even though SP12 Spacetime Volume Expressions have an unlimited precision, measurement devices and the precision of the position of reference features relating the SP4 Spatial Coordinate Reference System to a SP3 Reference Space impose limitations to the determination of the spatial part of a SP7 Declarative Spacetime Volume in the real world (U).

The same limitation to precision is true for the temporal part of a SP7 Declarative Spacetime Volume due to precision of time measurement devices and of the determination of the reference event of a SP11 Temporal Reference System.

 Several SP12 Spacetime Volume Expressions may denote the same SP7 Declarative Spacetime Volume if their precision falls within the same range (I).

Instances of SP7 Declarative Spacetime Volumes may be used to approximate instances of SP8 Spacetime Volumes or parts of them. They may as well be used to define the spatial and temporal extent of property rights or national borders.

Examples:

* the spacetime volume defined by a polygon approximating the Danube river flood in Austria between 6th and 9th of August 2002
* the spacetime volume of the Orinoco river in 1529 defined in the map of Diego Ribeiro in 1529
* the spacetime volume representing the boundaries of the UK from 1900-1950

Properties:

[Q12](#_Q12_approximates) approximates: [SP8](#_SP8_Spacetime_Volume) Spacetime Volume

**Q11 approximates**

|  |
| --- |
| Domain: [SP6](#_SP6_Declarative_Place) Declarative Place |
| Range: [E53](#_E53_Place) Place |
| Quantification: many to one (0,1:0,n) |

Scope note: This property approximates an E53 Place which is defined in the same reference space.

The property does not state the quality or accuracy of the approximation, but states the intention to approximate the place.

**Q12 approximates**

|  |
| --- |
| Domain: [SP7](#_SP7_Declarative_Spacetime) Declarative Spacetime Volume |
| Range: [SP8](#_SP8_Spacetime_Volume) Spacetime Volume |
| Quantification: many to one (0,1:0,n) |

Scope note: This property approximates a SP8 Spacetime Volume. The property does not state the quality or accuracy of the approximation, but states the intention to approximate the spacetime volume.

**Q10 defines place**

|  |
| --- |
| Domain: [SP5](#_SP5_Geometric_Place) Geometric Place Expression  |
| Range: [SP6](#_SP6_Declarative_Place) Declarative Place  |
| Quantification: many to one, necessary, dependent (1,1:1,n) |

Scope note: This property associates an instance of SP5 Geometric Place Expression with the instance of SP6 Declarative Place it defines. Syntactic variants or use of different scripts may result in multiple instances of SP5 Geometric Place Expression defining exactly the same place. Transformations between different reference systems in general result in new definitions of places approximating each other.

**Q14 defines time**

|  |
| --- |
| Domain: [SP14](#_SP14_Time_Expression) Time Expression |
| Range: [SP10](#_SP10_DeclarativeTime-Span) Declarative Time-Span |
| Quantification: many to one, necessary, dependent (1,1:1,n) |

Scope note: This property associates an instance of SP14 Time Expression with the instance of SP10 Declarative Time Span it defines. Syntactic variants or use of different scripts may result in multiple instances of SP14 Time Expression defining exactly the same time span. Transformations between different temporal reference systems in general result in new definitions of time spans approximating each other.

**Q16 defines spacetime volume**

|  |
| --- |
| Domain: SP12 Spacetime Volume Expression |
| Range: SP7 Declarative Spacetime Volume |
| Quantification: many to one, necessary, dependent (1,1:1,n) |

Scope note: This property associates an instance of SP12 Spacetime Volume Expression with the instance of SP7 Declarative Spacetime Volume it defines. Syntactic variants or use of different scripts may result in multiple instances of SP12 Spacetime Volume Expressions defining exactly the same SP7 Declarative Spacetime Volume. Transformations between different temporal or spatial reference systems in general result in new definitions of Spacetime Volumes approximating each other.