CRMtex

Textual Entities Model

Definition of the CRMtex
An Extension of CIDOC CRM to Model Ancient Textual Entities

Proposal for approval by CIDOC CRM - SIG

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Currently maintained by Francesca Murano and Achille Felicetti.

Contributors: Martin Doerr, Francesca Murano, Achille Felicetti

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1 Introduction

1.1 Scope

This document presents CRM*tex*, an extension of the CIDOC CRM created to support the study of ancient documents from their material form on and to identify relevant textual entities involved in their study; furthermore, it proposes the use of the CIDOC CRM to encode them and to model the scientific process of investigation related to the study of ancient texts in order to foster integration with other cultural heritage research fields. After identifying the key concepts, assessing the available technologies and analysing the entities provided by CIDOC CRM and by its extensions, this extension introduces new specific classes more adequate to the specific needs of the various disciplines involved (including papyrology, palaeography, codicology and epigraphy). The effective application of IT to the study of ancient direct sources for expanding our knowledge of the past is the inspiring principle of this work.

What is said and what is written

Although every speech can be transposed into an equivalent written message, and vice versa, speech has a priority over writing, at least in four respects: phylogenetic, ontogenetic, functional and structural [1]. In fact, all languages are spoken but not necessarily written; every human being learns to speak naturally and spontaneously, the ability to write coming only later and through specific training; the spoken language is used in a wider and differentiated range of uses and functions; writing originated as a representation of speech. According to Ferdinand de Saussure [2], in fact, «a language and its written form constitute two separate systems of signs. The sole reason for the existence of the latter is to represent the former».
In this semiotic perspective, it is worth considering that even in writing, as in the analysis of the linguistic system, it is necessary to distinguish the concrete level of the personal performance (i.e. the real act of tracing signs on a surface) from the abstract level which all the single execution must be took back to, on the basis of a sameness principle (e.g. the identification of an "A", independently from the peculiar shape somebody gives to it).

Investigating written documentation

The first written documents date back to the IV millennium BC. With the evolution of this technology, humans began to write texts on different supports using different techniques: inscriptions, papyri, manuscripts and other similar documents. Although from the semiotic point of view there is a single mechanism of production of written texts (i.e. supports, techniques, etc. are not relevant), traditionally, the study of ancient texts falls within different disciplines, generally grown around the specific characteristics of each class of documents (e.g., papyrology for the study of papyri and epigraphy for inscriptions). Nevertheless, an interdisciplinary approach is essential, and the identification of common elements is paramount in order to confer uniformity and interoperability to all these disciplines, as well as to exploit complementary skills from different approaches.
The first and normally most obvious feature that holds our attention examining these documents is the text they bear, even though deterioration may make sophisticated methods necessary to reveal the textual nature. The second thing that should be observed, specifically in ancient texts, is the special relationship between the text and its support. In comparison to modern digital or printed texts, ancient ones are characterised by their uniqueness, being they the result of manual work rather than a mechanised process, as occurs with modern printing.

This and other characteristics make the study and digitisation of this type of documentation particularly arduous: the close relationship between the text and its support requires careful analysis since they are inextricably linked to form a unique object of study. In particular, personal writing styles, slurry writing, and deterioration make reading a complex task often evaluating possible interpretations of the symbols used against plausible senses. As with any human activity, writing also happens *hic et nunc*, therefore, even in the case of texts written by the same person on identical media and with identical technique, hand-writing is never completely identical with itself. This is the case of the *codices* produced by the amanuenses in European monasteries during the Middle Ages. *Au contraire*, starting from the invention of printing press, modern printed copies of books and documents are totally indistinguishable from one specimen to another, since the characters are etched from an identical matrix.

In the ancient world, nevertheless, some types of inscriptions were created through mechanised processes, such as the legends of coins, medals, stamps and seals. Also, the early printed texts, created before the invention of new industrial processes, are unique exemplars, since they were produced through typefaces created by hand, in the same style as manuscript. But even for these classes of objects it is fundamental to investigate the close relation linking the text with the ancient object that carries it. The uniqueness of the written text remains unchanged in this case also, since it is characterised by the peculiar history of the support.

The first aim of this extension is therefore to identify and define in a clear and unambiguous way the main entities involved in the study and edition of ancient handwritten texts and then to describe them by means of appropriate ontological instruments in a multidisciplinary perspective.

Since writing is an intellectual process aimed at the encoding of a language, it is absolutely necessary to understand and follow the underlying semiotic mechanism and, therefore, to distinguish – as we have seen – between the physical manifestation of the text, understood as a set of physical features shown on a given support through the use of a specific technique (e.g. scribbled with ink, painted, engraved, etc.), from its abstract dimension, i.e. from the set of mental images represented by these same physical features. In writing, as in any semiotic system, every component (sign) possesses a dual nature, one physical and another conceptual. Writing, therefore, appears as a code requiring an encoding process by the creator or writer and a decoding one by the receiver or reader to be properly understood (see Figure 1).

In addition to dealing with text as an object, our model also focuses on the aspects of the research and provides classes and relationships to describe the typical operations that scholars from different disciplines put in place to gain knowledge about texts. It is evident, in this perspective, that the study of ancient texts typically starts from the analysis of the physical characteristics of the text itself before moving to the investigation of their archaeological, palaeographic, linguistic and historical features (see Figure 2).

Written text segments

In designing the entities of CRMtex we began by thoroughly investigating the interconnections existing between the text and its various components. Some elements have proved to be absolutely essential for this purpose. On the side of the reading process (i.e. the decoding of the text), and therefore of the investigation of the text by the scholars, one in particular has strongly claimed the scene: the text segment element. Examples of text segments are: text columns, text fragments, sections, paragraphs, single words or letters, or other specific components of the written text.

Scholars of different disciplines, on the basis of the requirements of their study, need to identify and focus their attention on different types of segments, in order to describe their physical conditions (form, layout, etc.), to verify their legibility and particular phenomena (e.g. linguistic or palaeographic) connected to them, etc. It is important to unambiguously represent the logic and sematic relation of meronymy, connecting the entire text with its constituent parts, i.e the identified segments. In this way it is possible to assign specific issues to the individual segments, independently of the text as a whole. In fact, particular production (i.e. TX2 *Writing*) or destruction (E6) events can be associated to single segments, as in the case of letters or words damaged or worn by atmospheric agents or human interventions.

Specifications about conditions (E3) for documenting its status during the observation process (S4) can be easily stated as well. This allows scholars to document different events for the investigated segments in a more precise and punctual way and to assign observations and interpretations to them (see Fig. 3).

Glyphs and Graphemes

The physical signs composing written text constitute the material manifestations (glyphs) of writing system units, i.e. the graphemes, the minimal functional distinctive units of writing. Ernst Pulgram stated that «in reducing a language to writing, that is, in making visible marks that evoke or recall linguistic performance, it would seem that each mark must represent a syntagmeme or a lexeme or a morpheme or a phoneme or whatever other kind of unit the inventor of the system may chose as his basis» [3]. For

instance: in a Latin inscription, single alphabet letters (glyphs) represent graphemes, a grapheme corresponding to a letter only in alphabetic system of writing. In Mycenaean Linear B inscriptions and in Old Persian cuneiform inscriptions glyphs represent syllabograms (graphemes representing a syllable, not a single sound); in an Egyptian hieroglyphic text, glyphs represent syllabic, alphabetic and also ideographic elements, i.e. elements standing for lexical/semantic units.

Phonographic writing systems [4][5] represent phonological units of one size or another, but the 1:1 correspondence between sound (phoneme, syllables, *etc*.) and sign (grapheme) is lost in diachrony, obscured by spelling conventions and phonetic changes to which linguistic systems are subjected in history. Examples are provided, for instance, in English, where there are many discrepancies in spelling between writing and phonetic values: for example, the grapheme <i> stands for various phonemes: /ɪ/ (as in *him*), /ʌɪ/ (as in *time*), /i/ (as in *police*), /a/ (as in *timbre*); *vice versa*, the phoneme /f/ can be represented by <f> (as in *film*), <ph> (as in *philology*) or <gh> (as in *enough*).

Reading and understanding the text

Reading refers to the semiotic procedure of decoding and therefore understanding a written text. This procedure can be carried out for scientific purposes, in order to analyse and study the text according to different disciplinary perspectives.

On the side of the message retrieval, since each grapheme is bound to a given linguistic unit of specific languages, reading the written message presupposes the ability to read the language of the writer.

On the level of the linguistic sounds, it will be the decoders (readers, including scholars), who from time to time, on the basis of the knowledge of the linguistic system, will attribute to each sign or group of signs the adequate phonetic value, also on the basis of spelling conventions in place in a given graphic system at a given historical moment, since the orthographic rules can change over time, even if less quickly than the linguistic system does.

In observing a text, thus, it is necessary to keep the deciphering procedure separate from the reading one. In the case of languages and writing systems that are no longer in use, in fact, it is possible that scholars are unable to decipher the signs, i.e to establish the value that those signs have within the system. A case of this kind is constituted by the Linear A and the writing of the Phaistos disc, of which the linguistic systems they represent are not known.
The deciphering of the signs can be achieved if the linguistic system represented is known. This is the case of Linear B, whose deciphering came after the understanding it represents a Greek language.
Since the writing systems have genealogical relationships with other known systems, it is possible that the writing systems do not present deciphering problems (so the scholar is able to attribute a rough value to the signs), even when the linguistic system it is not yet known. This is the case of the Etruscan writing system, which was deciphered from the beginning, the Etruscan system deriving from the Greek one, although knowledge of the linguistic system has progressed gradually among the scholars.

The reading activity, thus, is intended as a specific observation (S4) in which the decoding of the signs is performed, i.e. the linguistic value is recognised and the message is understood. Cases in which decoding does not happen (e.g., the observer is able to describe the signs but not to assign a specific linguist value to them), the S4 class could be used as it is.

For the goals of the study of texts, the reading activity requires a scientific autoptic examination of the text as preparatory action for the study. An autoptic examination consists of an accurate analysis of the surface and the signs and prescribes the use of specific tools and procedures, for establishing as faithfully as possible the exact value of each sign drawn on the physical feature.

Transcription and transliteration

Transcription consists in representing the sounds of a language using a writing system (TX3) different from that of the original text (e.g., Latin letters to render a Mycenaean text). Although in the literature the current term of transcription is often found, on a scientific level this operation often properly consists in a 'transliteration', i.e. the conversion of the graphemes of a writing system into the graphemes of

another writing system. Thus, transliteration implies a 1:1 relation between the signs of the two writing systems, graphemes of the starting system always corresponding to the same ones of the target system. A transliteration is never ambiguous. For example, the name of Thebes is written Θήβα in Greek alphabet; the sequence has transliteration 'Thēba' in Latin script but has transcription 'Thìva', according with modern Greek pronunciation; notice that transcription is based on the phonetics, thus pronunciation problems can arise: for example an English speaker might read 'Thìva' as [ˈθʌɪva] instead of [ˈθiva], and possibly transcribe 'Theeva').

Style and other palaeographic features

Since the stylistic variations of hand-written texts, fragments and glyphs (e.g. an 'A' uppercase, lowercase, italics, round, printed or written by hand, or in different font families) are constitutive of each manuscript text, a palaeographic study of stylistic variations has great importance in the description of ancient texts, using different styles for different purposes or at different times and places.

This approach is fundamental for the determination of the dating and origin of the texts, especially in reference to the individual styles developed in certain centres (for example in the scriptoria of the monasteries). It is also relevant for the description of all the entities of a given epoch and place, e.g. the Ptolemaic cursive of the Hellenistic Egypt, the capital uncial script (3rd-8th cent. AD), used both for Greek and Latin alphabets, or the more recent Carolingian minuscule, used from the beginning of the 8th cent. AD.
Therefore, in palaeography the concepts of stylistic class, style and canon are paramount to underline different meaningful observable aspects. The specific study of these stylistic variations needs to be properly addressed. The P15 was influenced by and the E83 Type Creation classes could constitute an optimal starting point for this activity.

Palaeography uses different concepts, including aspects of the style (TX10), ductus and other features related to the physical manner in which the text is written. Both individual and standardised styles (i.e., my personal handwriting and Carolingian minuscule) can be considered as subclasses of E29 Design or Procedure. TX1 Written Text is related to TX10 Style through the TXP12 has style property.

1.2 Status

CRMtex is the result of collaboration between scholars of many cultural heritage institutions. The first need that the model attempts to meet is to create a common ground for the integration and interoperability of records concerning ancient texts on every level, from the description of the supports and carried texts to the management of the documentation produced by various institutions using national and institutional standards (e.g. TEI/EpiDoc). This document describes a community model, under approval by CRM SIG as being formally and methodologically compatible with CIDOC CRM. However, in a broader sense, it is always open to any possible integration and addition that may become necessary as a result of its practical use on real problems on a large scale. The model is intended to be maintained and promoted as an international standard.

1.3 Naming Convention

All the classes declared were given both a name and an identifier constructed according to the conventions used in the CIDOC CRM model. For classes that identifier consists of the letter TX followed by a number. Resulting properties were also given a name and an identifier, constructed according to the same conventions. That identifier consists of the letters TXP followed by a number, which in turn is followed by the letter "i" every time the property is mentioned "backwards", i.e., from target to domain (inverse link). "TX" and "TXP" do not have any other meaning. They correspond respectively to letters "E" and "P" in the CIDOC CRM naming conventions, where "E" originally meant "entity" (although the CIDOC CRM "entities" are now consistently called "classes"), and "P" means "property". Whenever CIDOC CRM classes are used in our model, they are named by the name they have in the original CIDOC CRM. CRMsci classes and properties are referred with their respective names, classes denoted by S and properties by O.

Letters in red colour in CRM Classes and properties are additions/extensions coming by the scientific observation model.

2 Classes and properties hierarchies

The CIDOC CRM model declares no "attributes" at all (except implicitly in its "scope notes" for classes), but regards any information element as a "property" (or "relationship") between two classes. The semantics are therefore rendered as properties, according to the same principles as the CIDOC CRM model.

Although they do not provide comprehensive definitions, compact mono hierarchical presentations of the class and property IsA hierarchies have been found to significantly aid in the comprehension and navigation of the model, and are therefore provided below.

The class hierarchy presented below has the following format:

•   Each line begins with a unique class identifier, consisting of a number preceded by the appropriate letter "E", "TX", "S"

•   A series of hyphens ("-") follows the unique class identifier, indicating the hierarchical position of the class in the IsA hierarchy.

•   The English name of the class appears to the right of the hyphens.

•   The index is ordered by hierarchical level, in a "depth first" manner, from the smaller to the larger
   sub hierarchies.

•   Classes that appear in more than one position in the class hierarchy as a result of multiple inheritance are shown in an italic typeface.

2.1 CRMtex class hierarchy, aligned with portions from the CRMsci, LRMoo and the CIDOC CRM class hierarchies

This class hierarchy lists:
• all classes declared in Ancient Text model (CRMtex)
• all classes declared in CRM*sci* and CIDOC CRM that are declared as superclasses of classes declared in the Ancient Text Model,
• all classes declared in CRM*sci* or CIDOC CRM that are either domain or range for a property declared in the Ancient Text Model,
• all classes declared in CRM*sci* and CIDOC CRM that are either domain or range for a property declared in Ancient Text Model or CIDOC CRM that is declared as superproperty of a property declared in the Ancient Text Model,
• all classes declared in CRM*sci* and CIDOC CRM that are either domain or range for a property that is part of a complete path of which a property declared in Ancient Text Model is declared to be a shortcut.

E1   CRM Entity
S15   -   Observable Entity
E2   -   -   Temporal Entity
E5   -   -   -   Event
E7   -   -   -   -   Activity
TX6   -   -   -   -   -   Transcription
E13   -   -   -   -   -   Attribute Assignment
S4   -   -   -   -   -   -   Observation
TX5   -   -   -   -   -   -   -   Reading
E63   -   -   -   -   Beginning Of Existence
E12   -   -   -   -   -   Production
F28   -   -   -   -   -   -   Expression Creation
TX2   -   -   -   -   -   -   -   Writing
E77   -   -   Persistent Item
E70   -   -   -   Thing
E72   -   -   -   -   Legal Object
E18   -   -   -   -   -   Physical Thing
E26   -   -   -   -   -   -   Physical Feature
E25   -   -   -   -   -   -   -   Man-made Feature
TX1   -   -   -   -   -   -   -   -   Written Text
TX7   -   -   -   -   -   -   -   -   -   Written Text Segment
TX9   -   -   -   -   -   -   -   -   Glyph
TX4   -   -   -   -   -   -   -   -   Writing Field
E71   -   -   -   Man-made Thing
E28   -   -   -   -   Conceptual Object
E90   -   -   -   -   -   Symbolic Object
TX8   -   -   -   -   -   -   Grapheme
E73   -   -   -   -   -   -   Information Object
E29   -   -   -   -   -   -   -   Design or Procedure
TX3   -   -   -   -   -   -   -   -   Writing System
TX10   -   -   -   -   -   -   -   -   Style

2.2 CRMtex property hierarchy, aligned with portions from the CRMsci and the CIDOC CRM property hierarchies

This property hierarchy lists:
• all properties declared in Ancient Text Model,
• all properties declared in CRM*sci* and CIDOC CRM that are declared as superproperties of properties declared in Ancient Text Model,
• all properties declared in CRM*sci* and CIDOC CRM that are part of a complete path of which a property declared in Ancient Text Model, is declared to be a shortcut.

| Property id	Property Name	Entity - Domain	Entity - Range
TXP1	used writing system (writing system used for)	TX2 Writing	TX3 Writing System
TXP2	includes (is included within)	TX4 Writing Field	TX1 Written Text
TXP3	rendered (is rendered by)	TX6 Transcription	TX5 Reading
TXP4	has segment (is segment of)	TX1 Written Text	TX7 Written Text Segment
TXP5	wrote (was written by)	TX2 Writing	TX1 Written Text
TXP6	encodes (is encoding of)	TX3 Writing System	E33 Linguistic Object
TXP7	has item (is item of)	TX3 Writing System	TX8 Grapheme
TXP8	has component (is component of)	TX1 Written Text	TX9 Glyph
TXP9	is encoded using (was used to encode)	TX1 Written Text	TX3 Writing System
TXP10	read (was read by)	TX5 Reading	TX1 Written Text
TXP11	transcribed (was transcribed by)	TX6 Transcription	TX8 Grapheme
TXP12	has style (is style of)	TX1 Written Text	TX10 Style

3 Graphical overview
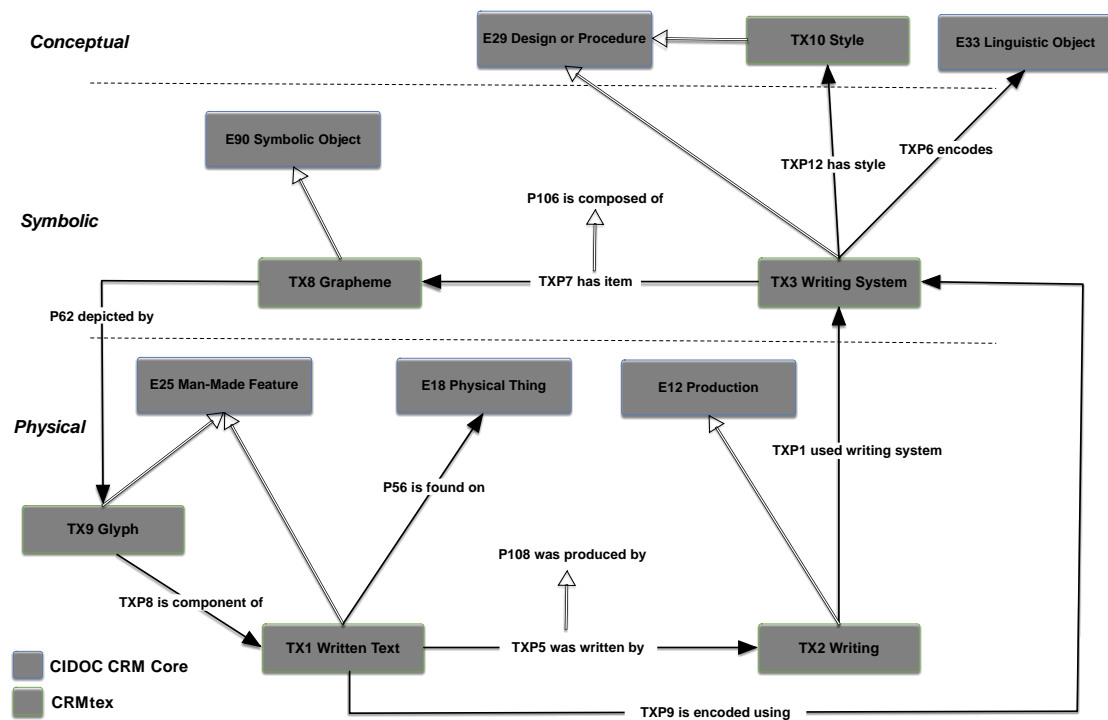
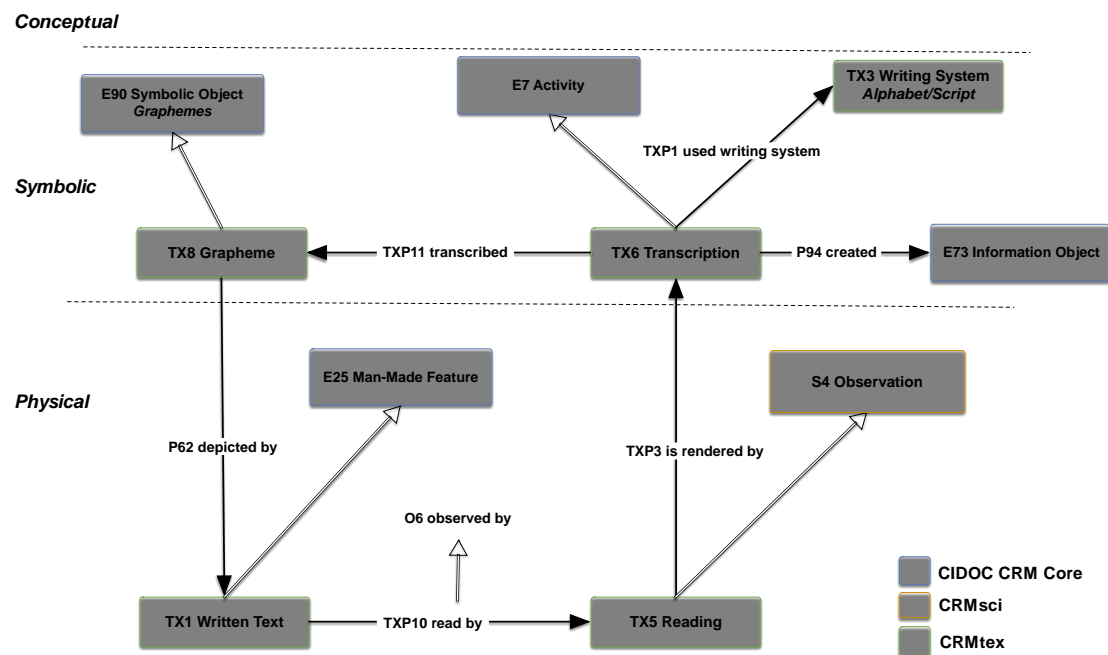**Figure 1: Text entities and text production in CRMtex**

Figure 2: The process of investigation of ancient texts in CRMtex
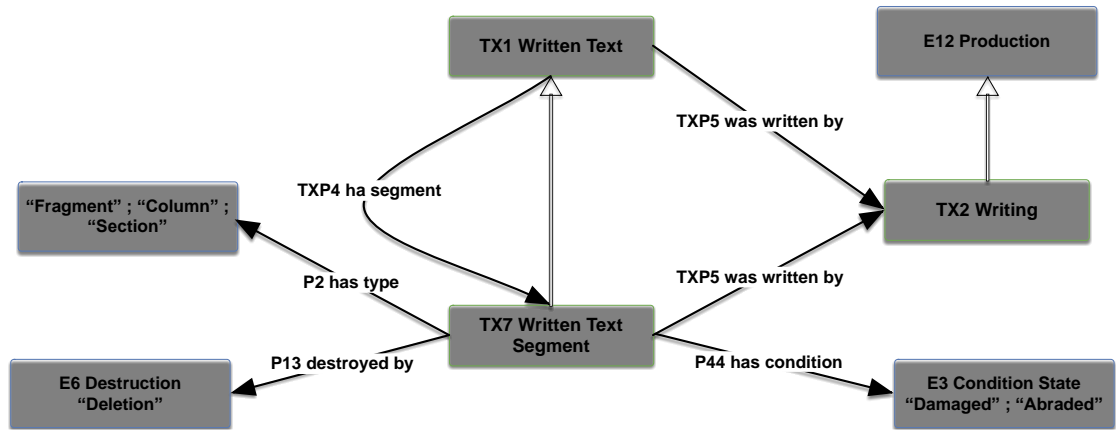
Figure 3: Written Text and Written Text Segments in CRMtex.

4 Classes and properties usage examples

The following example is intended to illustrate how CRMtex classes and properties could be used to encode, for instance, epigraphic information. The inscriptions on the Arch of Constantine, one of the most famous ancient monuments in Rome, have been chosen as examples of an ancient text occurring on a physical carrier in order to show how they can be semantically described in relation to the archaeological object carrying them.

The monument, still located in its original position between the Colosseum and the Roman Forum, is a triumphal marble arch – the largest monument of this kind in Roman Empire – dedicated in 315/316 A.D. by the Roman Senate to the emperor Constantine after his victory over Maxentius in the Battle of the Milvian Bridge in 312 A.D.

Among the other decorations (including statues, panels, reliefs and similar decorative material), the arch carries, on its attic, two identical inscriptions (reference number: CIL VI 1139), originally inlaid with gilded bronze letters, explaining the reason of its construction.
As of today, the bronze letters are lost and only the large cuttings in the marble, in which the bronze letters sat, remain. The inscription (Figure 5) is repeated, identically, on the South and North faces of the arch's attic. A transcription and a translation in English of the same inscription is presented below.
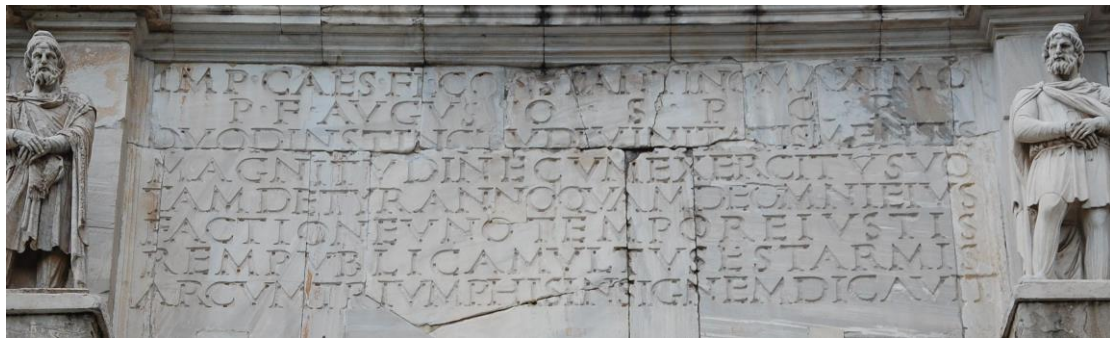

Figure 4: The inscription on the South face on the attic of the Arch of Constantine.

Inscription Transcription

IMP(ERATORI) · CAES(ARI) · FL(AVIO) · CONSTANTINO · MAXIMO · P(IO) · F(ELICI) · AVGUSTO · S(ENATUS) · P(OPULUS) · Q(UE) · R(OMANUS) · QVOD · INSTINCTV · DIVINITATIS · MENTIS · MAGNITVDINE · CVM · EXERCITV · SVO · TAM · DE · TYRANNO · QVAM · DE · OMNI · EIVS · FACTIONE · VNO · TEMPORE · IVSTIS · REMPVBLICAM · VLTVS · EST · ARMIS · ARCVM · TRIVMPHIS · INSIGNEM · DICAVIT

Inscription Translation

To the Emperor Caesar Flavius Constantine, the Greatest, Pius, Felix, Augustus: inspired by (a) divinity, in the greatness of his mind, he used his army to save the state by the just force of arms from a tyrant on the one hand and every kind of factionalism on the other; therefore, the Senate and the People of Rome have dedicated this exceptional arch to his triumphs.

CRMtex description of the text

The Arch is an archaeological object and according to the CIDOC CRM it can be represented as an instance of the E22 *Man-made Object* class. The monument, made of marble, was overall intended to commemorate the emperor and not to carry the various the inscriptions present on it. A writing event (TX2) can be assigned to the inscriptions, thus it is always possible to distinguish the production event of the monument from that one of the inscriptions when it is needed.

CRMtex can be used to describe the two inscriptions appearing on the arch and relate them to the monument via the P56 *bears feature (is found on)* property. Each of the two inscriptions can be rendered as a TX1 *Written Text*, being the physical features intended to carry a particular significance. A TX2 *Writing event* can be specified for each TX1 via the TXP5 *was written by* property to render the production of the cuttings made to host the bronze letters. Since there are two inscriptions, we have the opportunity, this way, to distinguish the two processes that led to the production of each of them.

A TX4 *Writing Field* class can be used to describe the portion of the surface of the arch reserved by the builders and appositely arranged for accommodating the inscription, in order to highlight it from the other parts of the object and to enhance its readability. Thus, the CRMtex encoding in this case will include two TX4s instances.

The linguistic message to be conveyed (E33 Linguistic Object) encoded by means of a language (E56 *Language*) and by means of the writing system (TX3 *Writing System*) this language uses. From this follows that the TX1 *Written Text* class is the concrete graphical manifestation (i.e. a set of signs – in this case the engraved letters – we can read on the stone) of the conceptual level of encoding a linguistic expression through the semiotic activity of writing (TX2 *Writing*) by means of a TX3 *Writing System* (in this case, Latin alphabet) and of the graphemes (TX8) composing it.

The reading of a text, from a semiotic point of view, is a decoding activity. In CRMtex a reading – specially carried out for scientific purposes – can be documented using the TX5 *Reading* class, a subclass of the S4 *Observation* CRMsci class, underlying the scientific nature of the investigation.

In fact, over the centuries, the arch of Constantine has been investigated thousands of times by scholars from all over the world and also reproduced by famous illustrators such as Giovan Battista Piranesi. Also, the inscriptions have been studied and transcribed several times in order to understand its nature, clarify the meaning of each section and improve its historical comprehension so as to put it in direct relation with the events that determined its creation. For this type of activity, specific classes and properties. The transcription of the text(s) present in *Corpus Inscriptionum Latinarum* (CIL VI 1139), for instance, can be represented via the TX6 *Transcription* class, while the analysis of the same inscription(s) carried out by Rodolfo Lanciani in 1892 [6] can be documented using the reading (TX5) class. Reading and transcription (TX6) activities can be related via the TXP3 *rendered* property, inherited by CIDOC CRM core.

The TX7 *Written Text Segment* class can be used to highlight specific portions of text on which the study focuses, on which specific phenomena appear or from which it is possible to derive special meanings. Figure 5 shows a CRMtex conceptualisation of the South inscriptions on the Arch of Constantine.
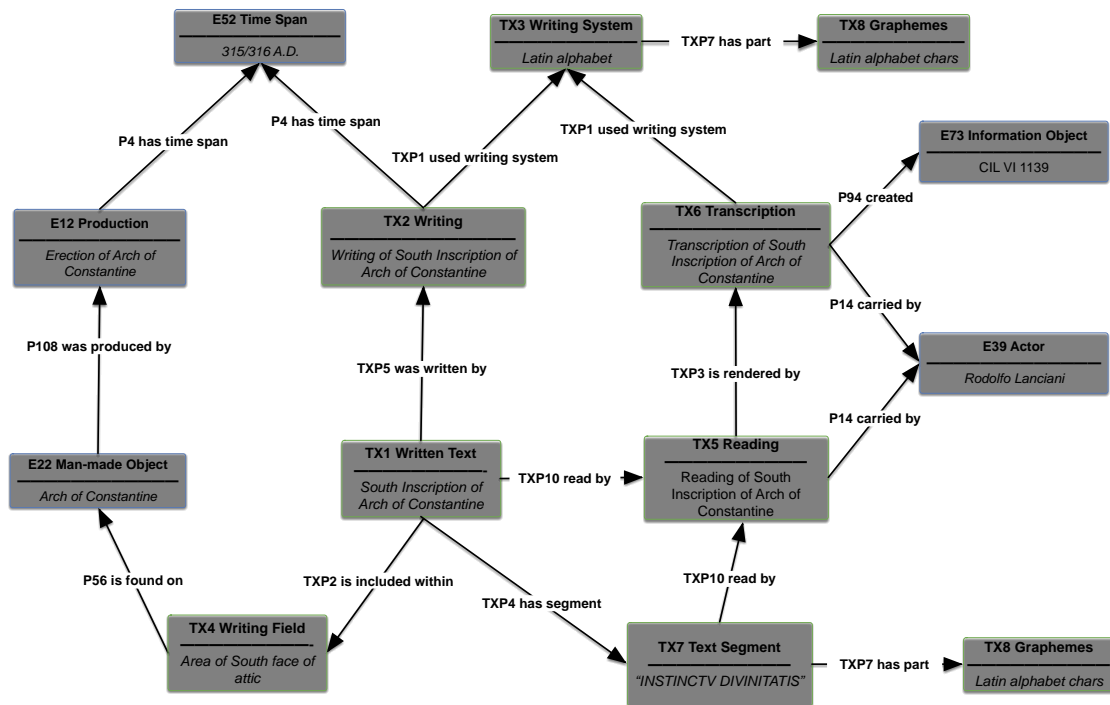
Figure 5: CRMtex encoding of one of the inscriptions (South) on the Arch of Constantine.

5 CRMtex - Classes and properties

5.1 CRMtex - Classes declarations

The classes are comprehensively declared in this section using the following format:

- Class names are presented as headings in bold face, preceded by the class's unique identifier;
- The line "Subclass of:" declares the superclass of the class from which it inherits properties;
- The line "Superclass of:" is a cross-reference to the subclasses of this class;
- The line "Scope note:" contains the textual definition of the concept the class represents;
- The line "Examples:" contains a bulleted list of examples of instances of this class.
- The line "Properties:" declares the list of the class's properties;
- Each property is represented by its unique identifier, its forward name, and the range class that it links to, separated by colons;
- Inherited properties are not represented;
- Properties of properties, if they exist, are provided indented and in parentheses beneath their respective domain property.

TX1 Written Text

Subclass of: E25 Man-Made Feature

Scope Note: This class comprises visible set of symbols (glyphs or graphs) intentionally traced (i.e. "written") on some kind of physical support by using specific techniques and having semiotic significance and the purpose of conveying a message towards a given addressee or group of addressees.

Examples:

- The inscription engraved on the South side of the attic of the Arch of Constantine (E22) in Rome (see section 1.3.1).

In First Order Logic:

     TX1(x) ⊃ E25(x)

Properties:

     TXP4 has segment (is segment of): TX7 Written Text Segment
     TXP8 has component (is component of): TX9 Glyph
     TXP9 is encoded using (was used to encode): TX3 Writing System

TX2 Writing

Subclass of: F28 Expression Creation
Superclass of:
Scope Note: Subclass of F28 Expression Creation indicating the activity of physically creating a text, using various techniques (painting, sculpture, etc.) and by means of specific tools, on a given carrier in a non-mechanical way.

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Examples:

- The process of engraving in the marble of the inscription (TX1) placed on the South attic of the Arch of Constantine (E22) in Rome (see section 1.3.1).

In First Order Logic:

     TX2(x) ⊃ F28(x)

Properties:

     TXP1 used writing system (writing system used by): TX3 Writing System
     TXP5 wrote (was written by): TX1 Written Text

TX3 Writing System

Subclass of: E29 Design or Procedure
Superclass of:
Scope Note: Subclass of E29 Design or Procedure refers to a conventional system consisting of a set of signs (graphemes, TX8) used to codify a natural language, by means of specific rules in the combination and phonological value assignment of the chosen graphemes. As each code, a writing systems requires shared understanding between writers and readers allowing the transmission of the message. It is used to produce a TX1 Written Text during a TX2 Writing event.

Examples:

- The Latin alphabet used for codifying the inscriptions (TX1) in Latin language occurring on the Arch of Constantine (E22).

- The Cypriot syllabary used in Iron Age Cyprus for codifying the Arcado-Cypriot dialect.

In First Order Logic:

TX3(x) ⊃ E29(x)

Properties:

TXP6 encodes (is encoding of): E33 Linguistic Object
TXP7 has item (is item of): TX8 Grapheme

TX4 Writing Field

Subclass of: E25 Man-Made Feature
Superclass of:
Scope Note: Subclass of E25 Man-Made Feature, it is the portion of the physical carrier arranged and usually reserved and delimited for the purpose of accommodating a written text, highlighting and isolating it from the other parts of the object to which it belongs, enhancing and guaranteeing its readability. This entity is paramount specially in epigraphy, in which a specific element called "epigraphic field" has been defined by the discipline itself. Its importance is also evident in papyrology and codicology, where a clear distinction between area(s) containing the written text and empty parts of the support (margins, *intercolumnia*, etc.) is significant for the definition of styles and periods of the document.

Examples:

- The portion of the marble surface of the South part of the attic of the Arch of Constantine (E22) reserved by the builders for accommodating the South inscription (TX1) (see section 1.3.1).
- The areas reserved to writing by the scribe in a papyrus scroll.

In First Order Logic:

TX4(x) ⊃ E25(x)

Properties:

TXP2 includes (is included within): TX1 Written Text

TX5 Reading

Subclass of: S4 Observation
Superclass of:
Scope Note: Subclass of the S4 Observation, referring to the semiotic procedure of decoding (and therefore understanding) a written text. This procedure can be carried out for scientific purposes, in order to analyse and study the text according to different disciplinary perspectives. The reading activity, thus, is intended as a specific observation (S4) in which the decoding of the signs is performed, i.e. the linguistic value is recognised and the message is understood. Cases in which decoding does not happen (e.g., the observer is able to describe the signs but not to assign a specific linguist value to them), the S4 class could be used as it is. For study purposes, the reading procedure requires a scientific autoptic examination of the text as preparatory action for the study. An autoptic examination consists of an accurate analysis of the surface and the signs and prescribes the use of specific tools and procedures, for establishing as faithfully as possible the exact value of each sign drawn on the physical feature.

Examples:

- The autoptic investigation of the South inscription (TX1) on the Arch of Constantine (E22) made by Rodolfo Lanciani between 1893 and 1901.
- The reading of the Greek text present on the Derveni papyrus (E22).

In First Order Logic:

TX5(x) ⊃ S4(x)

Properties:

TXP10 read (was read by): TX1 Written Text

## TX6 Transcription

Subclass of: E7 Activity
Superclass of:
Scope Note: Subclass of E7 Activity, referring to the activity of re-writing the text conducted by an editor. This operation could involve a writing system (TX3) different from that of the original text, implying a transposition of the sounds of a language from a writing system to another one (e.g., Latin letters to render a Mycenaean text). For scientific purposes, this operation often consists in a 'transliteration', because it implies a 1:1 relation between the signs of the two writing systems. The P16 used specific object (was used for) property can be used to specify the role of the original graphemes during the commuting operations.

Examples:

- Transcription, in Latin letters, of the inscription(s) (TX1) on the Arch of Constantine (E22) reported in *Corpus Inscriptionum Latinarum* (CIL VI 1139).
- The transliteration and the transcription of the ancient Persian name of king Darius I, written in Persian cuneiform 𒁔𒀸𒊑𒅀𒬣𒜖, into Latin script as respectively 'da-a-ra-ya-va-u-ša' and 'Dârayavauš'.

In First Order Logic:

TX6(x) ⊃ E7(x)

Properties:

TXP3 renders (is rendered by): TX5 Reading
TXP11 transcribed (was transcribed by): TX8 Grapheme

TX7 Written Text Segment

Subclass of: TX1 Written Text
Superclass of:
Scope Note: Subclass of TX1 Written Text intended to identify portions of text considered to be of particular significance by scholars, as witnesses of a certain meaning or bearers of a particular phenomenon relevant to the investigation, study and understanding of the ancient text. Examples of such text portions are: columns, fragments, sections, paragraphs, as well as single words or letters, or other components of the written text. To each of these entities can be associated a single production event (TX2) or destruction event (E6), as in the case of letters or words damaged or worn by atmospheric agents or human interventions, as well as specific conditions (E3) for documenting its status during the observation process (S4). The relationship between a written text (TX1) and its components is documented through the TXP4 *has segment* property.

Examples:

- The "INSTINCTV DIVINITATIS" text portion of the inscription (TX1) on the Arch of Constantine (E22), commented by Rodolfo Lanciani in 1892, in his book *Pagan and Christian Rome* (see section 1.3.1).
- The first paragraph of the long Darius I's inscription (TX1) in Bagistan.

In First Order Logic:

TX7(x) ⊃ TX1(x)

TX8 Grapheme

Subclass of: E90 Symbolic Object
Superclass of:
Scope Note: Subclass E90 Symbolic Object used to represent the abstract units with distinctive value in a given writing system. A grapheme is a character or sequence of characters that functions as a distinct unit within an orthography. It may be a single character, a multigraph, or a diacritic, but in all cases graphemes are defined in relation to the particular orthography. Most graphemes represent a single phoneme, but some represent a sequence of phonemes. For instance, the character sequence ‹ch› is often used to represent the phoneme /tʃ/ in English, while the single letter ‹x› usually represents the phoneme sequence /ks/. In a highly phonemic writing system, there is a close correspondence between graphemes and phonemes. English (written with Latin script) is an example of a writing system that is not highly phonemic, and therefore the mappings between graphemes and phonemes are more complex. Graphemes are often written enclosed in angle brackets (‹›).

Examples:
- The ideal letter "S" of the Latin alphabet, used to represent the /s/ sound, rendered by the specific S-shaped feature engraved on the second line of the South inscription on the attic of the Arch of Constantine (see section 1.3.1)
- The ideal 'da' syllabogram of the ancient Persian syllabary, used to represent the /da/ syllable rendered by the cuneiform sign 𒁕 engraved on the first line of Darius I's inscription (TX1) in Bagistan.

In First Order Logic:

TX8(x) ⊃ E90(x)

TX9 Glyph

Subclass of: E25 Man-Made Feature
Superclass of:
Scope Note: Subclass of E25 Man-Made Feature intended to represent the concrete manifestation of single signs traced by the writer while codifying a linguistic expression. Glyphs are typically observed by the scholar during a reading activity (TX5) carried out to decode and recognise the graphemes (TX8) they represent.

Examples:
- The S-shaped feature engraved on the second line of the South inscription on the Arch of Constantine, representing the letter (grapheme) "S" of the Latin writing system used to render the sound of the /s/ phoneme (see section 1.3.1).
- The feature 𒁕 engraved on the first line of Darius I's inscription (TX1) in Bagistan, representing the ideal syllabogram 'da' of the ancient Persian syllabary, used to render the /da/ syllable.

In First Order Logic:

TX9(x) ⊃ E25(x)

TX10 Style

Subclass of: [E29](#) Design or Procedure
Superclass of:
Scope Note: Subclass of [E29](#) Design or Procedure that describes styles and variations of texts, including local script styles (Carolingian minuscule) and individual scribal hands. It includes: the general appearance of the script, in terms of general design, aspects related to a bilinear system (i.e. upper and lowercases), measures (i.e. large, medium or small), shape and number of strokes forming a character, its order and direction. A style includes also information about ductus (the direction the text is written), ligatures and *nexi* (i.e. the connection between characters obtained tracing them without detaching the writing instrument from the support and using one or more strokes in common), and the writing angle (i.e. the position the writing instrument is located with respect to the support). The style corresponds to fonts and their variations in modern printing process.

Examples:

- The *Roman square capitals* style, also called *capitalis monumentalis*, or *capitalis quadrata* used to write the inscription on the Arch of Constantine.
- The "Carolingian minuscule" style used in the Carolingian Gospel Book identified as "British Library, Add MS 11848".

In First Order Logic:
    [TX10](#)(x) ⊃ [E29](#)(x)

5.2 CRMtex - Properties declarations

The properties are comprehensively declared in this section using the following format:
- Property names are presented as headings in bold face, preceded by unique property identifiers;
- The line "Domain:" declares the class for which the property is defined;
- The line "Range:" declares the class to which the property points, or that provides the values for the property;
- The line "Superproperty of:" is a cross-reference to any subproperties the property may have;
- The line "Scope note:" contains the textual definition of the concept the property represents;
- The line "Examples:" contains a bulleted list of examples of instances of this property.

TXP1 used writing system (writing system used for)

Domain: TX2 Writing
Range: TX3 Writing System
Subproperty of: P33 used specific technique (was used by)

Quantification: many to many (0,n:0,n)

Scope note: This property is intended to identify the specific instance of TX3 Writing System employed during the writing event that led to the creation of a TX1 Written Text.

Examples:
- The Roman stonecutter *used* the Latin *writing system* (TX3) for the engraving (TX2) of the inscription on the Arch of Constantine (TX1) (see section 1.3.1)

- The Greek scribe *used* the Greek *writing system* (TX3) to trace (TX2) in ink the letters that compose the text of the Papyrus of Derveni (TX1).

In First Order Logic:
> TXP1(x,y) ⊃ TX2(x)
> TXP1(x,y) ⊃ TX3(y)
> TXP1(x,y) ⊃ P33(x,y)

TXP2 includes (is included within)

Domain: TX4 Writing Field
Range: TX1 Written Text
Subproperty of: P56 bears feature

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

Scope note: This property is intended to describe the relation existing between a TX1 Written Text and the TX4 Writing Field, specifically created to accommodate the text, within which it is inscribed. This relation becomes quite relevant in the very frequent case where more than a single text is found on different areas of a specific support.

Examples:
- The South framework (TX4) carved by the Roman stonecutter on top of the Arch *includes* the inscription on the South face of the Arch of Constantine (TX1).

In First Order Logic:
> TXP2(x,y) ⊃ TX1(x)
> TXP2(x,y) ⊃ TX4(y)
> TXP2(x,y) ⊃ P56(x,y)

TXP3 rendered (is rendered by)

Domain: TX6 Transcription
Range: TX5 Reading
Subproperty of   P20 had specific purpose (was purpose of)

Quantification: one to one (0,1:1,1)

Scope note: This property is intended to emphasize the close connection for scientific purposes between the TX5 Reading and TX6 Transcription activities, by outlining, in particular,

the accurate observation required by scholars in order to perform a valid transcription of a given text.

Examples:

- The transcription (TX6) of the inscription on South Attic of the Arch of Constantine, carried out by Rodolfo Lanciani, *rendered* its reading (TX5) of the same inscription done by him in 1892 (see section 1.3.1).

In First Order Logic:

TXP3(x,y) ⊃ TX5(x)
TXP3(x,y) ⊃ TX6(y)
TXP3(x,y) ⊃ P20(x,y)

TXP4 ha segment (is segment of)

Domain: TX1 Written Text
Range: TX7 Written Text Segment
Subproperty of: P46 is composed of (forms part of)

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

Scope note: This property is intended to correlate a text and the different parts of which a scholar can identify, such as: letters, words, lines, columns, pages, or any other scan that can be made by scholars because considered to have a particular relevance for the investigation of the text itself.

Examples:

- The "INSTINCTV DIVINITATIS" text portion *is segment of* the inscription (TX1) on the Arch of Constantine reported and commented by Rodolfo Lanciani in 1892 in his book *Pagan and Christian Rome* (see section 1.3.1).
- The phrase "xšâyathiya xšâyâthiânâm" ("King of Kings") recognised by Grotefend in1802 on the Achaemenid inscription from Persia.

In First Order Logic:

TXP4(x,y) ⊃ TX1(x)
TXP4(x,y) ⊃ TX7(y)
TXP4(x,y) ⊃ P46(x,y)

TXP5 wrote (was written by)

Domain: TX2 Writing
Range: TX1 Written Text
Subproperty of P108 has produced (was produced by)

Quantification: one to one (0,1:1,1)

Scope note: This property is used to describe in detail the close relationship between a text and the writing event that led to its production.

Examples:

- The activity (TX2) carried out by the Greek stonecutters *wrote* the Gortyn Law inscription (TX1) on the wall of the Amphitheatre of Gortyn, Crete.

In First Order Logic:

TXP5(x,y) ⊃ TX2(x)

TXP5(x,y) ⊃ TX1(y)
TXP5(x,y) ⊃ P108(x,y)

TXP6 encodes (is encoding of)

Domain: TX3 Writing System
Range: E33 Linguistic Object
Subproperty of   P2 has type

Quantification: many to many (0,n:0,n)

Scope note   This property is used to indicate the language encoded by the TX3 Writing System and used for writing, reading or rendering (i.e. transcribing) a TX1 Written Text. The specification of the language is fundamental for understanding the writing phenomena and the rules of the writing system used for the production or transcription of a specific text.

Examples:

- The Latin alphabet (TX3), used to encode the identical inscriptions (TX1) on the Arch of Constantine, *encodes* the Latin language (E33) used to convey the message of the inscriptions.

In First Order Logic:
TXP6(x,y) ⊃ TX3(x)
TXP6(x,y) ⊃ E33(y)
TXP6(x,y) ⊃ P2(x,y)

TXP7 has item (is item of)

Domain: TX3 Writing System
Range: TX8 Grapheme
Subproperty of   P106 is composed of (forms part of)

Quantification: one to one (0,1:1,1)

Scope note: This property is used to state the (conceptual) belonging of a TX8 Grapheme to a given TX3 Writing System.

Examples:

- The Latin alphabet (TX3), used to encode the inscription (TX1) on South face of the Arch of Constantine, *has item* the idel letter "S" (TX8) used in this alphabet to represent the /s/ sound.

In First Order Logic:
TXP7(x,y) ⊃ TX3(x)
TXP7(x,y) ⊃ TX8(y)
TXP7(x,y) ⊃ P106(x,y)

TXP8 has component (is component of)

Domain: TX1 Written Text
Range: TX9 Glyph
Subproperty of   P46 is composed of (forms part of)

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

Scope note: This property is used to state the (physical) belonging of a glyph to a given TX1 Written Text.

Examples:
- The inscription (TX1) on South face of the Arch of Constantine, *contains* the S-shaped glyph (TX9) engraved on the second line, representing the letter (TX8) "S" of the Latin writing system (TX3).

In First Order Logic:
TXP8(x,y) ⊃ TX1(x)
TXP8(x,y) ⊃ TX9(y)
TXP8(x,y) ⊃ P46(x,y)

TXP9 is encoded using (was used to encode)

Domain: TX1 Written Text
Range: TX3 Writing System

Quantification: many to many (0,n:0,n)

Scope note: This property has the purpose of directly associating a TX1 Written Text with the TX3 Writing System from which the signs used for its writing and therefore incorporated in the text have been taken. It is a shortcut of the more fully articulated path from TX1 Written Text, through TXP5 wrote (was written by), TX2 Writing, TXP1 used writing system (writing system used for) to TX3 Writing System.

Examples:
- The Gortyn Law inscriptions (TX1), engraved on the wall of the Amphitheatre of Gortyn (Crete), *is encoded by* means of the Greek alphabet (TX3).

In First Order Logic:
TXP9(x,y) ⊃ TX1(x)
TXP9(x,y) ⊃ TX3(y)

TXP10 read (was read by)

Domain: TX5 Reading
Range: TX1 Written Text
Subproperty of O8 observed (was observed by)

Quantification: one to one (0,1:1,1)

Scope note: This property links an instance of TX1 Written Text with the TX5 Reading event carried out to investigate its intrinsic characteristics and to perform its decoding.

Examples:
- The autoptic investigation (TX5) carried out by Rodolfo Lanciani between 1893 and 1901, *read* the South inscription (TX1) on the Arch of Constantine.

In First Order Logic:
TXP10(x,y) ⊃ TX5(x)
TXP10(x,y) ⊃ TX1(y)
TXP10(x,y) ⊃ O8(x,y)

TXP11 transcribed (was transcribed by)

Domain: TX6 Transcription
Range: TX8 Grapheme
Subproperty of: P16 used specific object (was used for)

Quantification: many to many (0,n:0,n)

Scope note: This property highlights the specific way in which an activity of TX6 Transcription
                results in the rendering of the specific TX8 Grapheme(s) of which an instance of TX1
                Written Text is composed.

Examples:
                ▪   The transcription (TX6) of the S-shaped feature engraved on the second line of
                    the South inscription of the Arch of Constantine *transcribed* the prototypical letter
                    "S" (TX8) of the Latin writing system (TX3).

In First Order Logic:
        TXP11(x,y) ⊃ TX6(x)
        TXP11(x,y) ⊃ TX8(y)
        TXP11(x,y) ⊃ P16(x,y)

TXP12 has style (is style of)

Domain: TX1 Written Text
Range: TX10 Style
Subproperty of: P33 used specific technique (was used by)

Quantification: many to many (0,n:0,n)

Scope note: This property assigns information to a certain script in order to accurately determine
                the style used for the realization of the written text. The *TPX12.1 has typ*e property of
                TXP12 has style allows the nature of the style to be specified reading from domain to
                range, for example to record the ductus, orientation or the linear system of the text.

Examples:
                ▪   The Latin text in the Carolingian Gospel Book identified as "British Library, Add
                    MS 11848", has style "Carolingian minuscule"

                ▪   The inscription on the Arch of Constantine has ductus (TPX12 has style +
                    TPX12.1 has type "ductus") *dextroverse*

In First Order Logic:
        TXP12(x,y) ⊃ TX1(x)
        TXP12(x,y) ⊃ TX10(y)
        TXP12(x,y) ⊃ P33(x,y)

Properties: TXP12.1 has type: E55 Type

6 Referred to CIDOC CRM Classes and properties

Since the Textual Entities Model refers to and reuses, wherever appropriate, large parts of the CIDOC Conceptual Reference Model, this section provides a comprehensive list of all constructs used from CIDOC CRM, together with their definitions following the CIDOC CRM, ver.6.2.2, September 2017, maintained by CIDOC CRM – SIG.

6.1 CIDOC CRM Classes

E1 CRM Entity
Superclass of: E2 Temporal Entity
                E52 Time-Span
                E53 Place
                E54 Dimension
                E77 Persistent Item
                E92 Spacetime Volume

Scope note: This class comprises all things in the universe of discourse of the CIDOC Conceptual Reference Model.

It is an abstract concept providing for three general properties:
1. Identification by name or appellation, and in particular by a preferred identifier
2. Classification by type, allowing further refinement of the specific subclass an instance belongs to
3. Attachment of free text for the expression of anything not captured by formal properties

With the exception of E59 Primitive Value, all other classes within the CRM are directly or indirectly specialisations of E1 CRM Entity.

Examples:
- the earthquake in Lisbon 1755 (E5)

In First Order Logic:
        E1(x)

Properties:
        P1 is identified by (identifies): E41 Appellation
        P2 has type (is type of): E55 Type
        P3 has note: E62 String
            (P3.1 has type: E55 Type)
        P48 has preferred identifier (is preferred identifier of): E42 Identifier
        P137 exemplifies (is exemplified by): E55 Type
            (P137.1 in the taxonomic role: E55 Type)

E2 Temporal Entity
Subclass of: E1 CRM Entity
Superclass of: E3 Condition State
                E4 Period

Scope note: This class comprises all phenomena, such as the instances of E4 Periods, E5 Events and states, which happen over a limited extent in time. This extent in time must be contiguous, i.e., without gaps. In case the defining kinds of phenomena for an instance of E2 Temporal Entity cease to happen, and occur later again at another time, we regard that the former E2 Temporal Entity has ended and a new instance has come into existence. In more intuitive terms, the same event cannot happen twice.

In some contexts, these are also called perdurants. This class is disjoint from E77 Persistent Item. This is an abstract class and has no direct instances. E2 Temporal Entity is specialized into E4 Period, which applies to a particular geographic area (defined with a greater or lesser degree of precision), and E3 Condition State, which applies to instances of E18 Physical Thing.

Examples:

- Bronze Age (E4)
- the earthquake in Lisbon 1755 (E5)
- the Peterhof Palace near Saint Petersburg being in ruins from 1944 – 1946 (E3)

In First Order Logic:

E2(x) ⊃ E1(x)

Properties:

P4 has time-span (is time-span of): E52 Time-Span
P114 is equal in time to: E2 Temporal Entity
P115 finishes (is finished by): E2 Temporal Entity
P116 starts (is started by): E2 Temporal Entity
P117 occurs during (includes): E2 Temporal Entity
P118 overlaps in time with (is overlapped in time by): E2 Temporal Entity
P119 meets in time with (is met in time by): E2 Temporal Entity
P120 occurs before (occurs after): E2 Temporal Entity
P173 starts before or at the end of (ends with or after the start of): E2 Temporal Entity
P174 starts before (starts after the start of): E2 Temporal Entity
P175 starts before or with the start of (starts with or after the start of) : E2 Temporal Entity
P176 starts before the start of (starts after the start of): E2 Temporal Entity
P182 ends before or at the start of (starts with or after the end of) : E2 Temporal Entity
P183 ends before the start of (starts after the end of) : E2 Temporal Entity
P184 ends before or with the end of (ends with or after the end of) : E2 Temporal Entity
P185 ends before the end of (ends after the end of): E2 Temporal Entityy

E5 Event

Subclass of: E4 Period
Superclass of: E7 Activity
                E63 Beginning of Existence
                E64 End of Existence

Scope note: This class comprises changes of states in cultural, social or physical systems, regardless of scale, brought about by a series or group of coherent physical, cultural, technological or legal phenomena. Such changes of state will affect instances of E77 Persistent Item or its subclasses.

                The distinction between an E5 Event and an E4 Period is partly a question of the scale of observation. Viewed at a coarse level of detail, an E5 Event is an 'instantaneous' change of state. At a fine level, the E5 Event can be analysed into its component phenomena within a space and time frame, and as such can be seen as an E4 Period. The reverse is not necessarily the case: not all instances of E4 Period give rise to a noteworthy change of state.

Examples:

- the birth of Cleopatra (E67)
- the destruction of Herculaneum by volcanic eruption in 79 AD (E6)
- World War II (E7)
- the Battle of Stalingrad (E7)

- ▪ the Yalta Conference (E7)
- ▪ my birthday celebration 28-6-1995 (E7)
- ▪ the falling of a tile from my roof last Sunday
- ▪ the CIDOC Conference 2003 (E7)

In First Order Logic:

E5(x) ⊃ E4(x)

Properties:

P11 *had participant (participated in):* E39 *Actor*
P12 *occurred in the presence of (was present at):* E77 *Persistent Item*

E6 Destruction

Subclass of: E64 End of Existence

Scope note: This class comprises events that destroy one or more instances of E18 Physical Thing such that they lose their identity as the subjects of documentation.

Some destruction events are intentional, while others are independent of human activity. Intentional destruction may be documented by classifying the event as both an E6 Destruction and E7 Activity.

The decision to document an object as destroyed, transformed or modified is context sensitive:
1. If the matter remaining from the destruction is not documented, the event is modelled solely as E6 Destruction.
2. An event should also be documented using E81 Transformation if it results in the destruction of one or more objects and the simultaneous production of others using parts or material from the original. In this case, the new items have separate identities. Matter is preserved, but identity is not.
3. When the initial identity of the changed instance of E18 Physical Thing is preserved, the event should be documented as E11 Modification.

Examples:

- ▪ the destruction of Herculaneum by volcanic eruption in 79 AD
- ▪ the destruction of Nineveh (E6, E7)
- ▪ the breaking of a champagne glass yesterday by my dog

In First Order Logic:

E6(x) ⊃ E64(x)

E7 Activity

Subclass of: E5 Event
Superclass of: E8 Acquisition
                        E9 Move
                        E10 Transfer of Custody
                        E11 Modification
                        E13 Attribute Assignment
                        E65 Creation
                        E66 Formation
                        E85 Joining
                        E86 Leaving
                        E87 Curation Activity

Scope note: This class comprises actions intentionally carried out by instances of E39 Actor that result in changes of state in the cultural, social, or physical systems documented.

This notion includes complex, composite and long-lasting actions such as the building of a settlement or a war, as well as simple, short-lived actions such as the opening of a door.

Examples:

- the Battle of Stalingrad
- the Yalta Conference
- my birthday celebration 28-6-1995
- the writing of "Faust" by Goethe (E65)
- the formation of the Bauhaus 1919 (E66)
- calling the place identified by TGN '7017998' 'Quyunjig' by the people of Iraq
- Kira Weber working in glass art from 1984 to 1993
- Kira Weber working in oil and pastel painting from 1993

In First Order Logic:

$$E7(x) \supset E5(x)$$

Properties:

P14 carried out by (performed): E39 Actor
    (P14.1 in the role of: E55 Type)
P15 was influenced by (influenced): E1 CRM Entity
P16 used specific object (was used for): E70 Thing
    (P16.1 mode of use: E55 Type)
P17 was motivated by (motivated): E1 CRM Entity
P19 was intended use of (was made for): E71 Man-Made Thing
    (P19.1 mode of use: E55 Type)
P20 had specific purpose (was purpose of): E5 Event
P21 had general purpose (was purpose of): E55 Type
P32 used general technique (was technique of): E55 Type
P33 used specific technique (was used by): E29 Design or Procedure
P125 used object of type (was type of object used in): E55 Type
P134 continued (was continued by): E7 Activity

E12 Production

Subclass of: E11 Modification
                   E63 Beginning of Existence

Scope note: This class comprises activities that are designed to, and succeed in, creating one or more new items.

It specializes the notion of modification into production. The decision as to whether or not an object is regarded as new is context sensitive. Normally, items are considered "new" if there is no obvious overall similarity between them and the consumed items and material used in their production. In other cases, an item is considered "new" because it becomes relevant to documentation by a modification. For example, the scribbling of a name on a potsherd may make it a voting token. The original potsherd may not be worth documenting, in contrast to the inscribed one.

This entity can be collective: the printing of a thousand books, for example, would normally be considered a single event.

An event should also be documented using E81 Transformation if it results in the destruction of one or more objects and the simultaneous production of others using parts or material from the originals. In this case, the new items have separate identities and matter is preserved, but identity is not.

Examples:

- the construction of the SS Great Britain
- the first casting of the Little Mermaid from the harbour of Copenhagen

- Rembrandt's creating of the seventh state of his etching "Woman sitting half dressed beside a stove", 1658, identified by Bartsch Number 197 (E12,E65,E81)

In First Order Logic:

E12(x) ⊃ E11(x)
E12(x) ⊃ E63(x)

Properties:

P108 has produced (was produced by): E24 Physical Man-Made Thing
P186 produced thing of product type (is produced by): E99 Product Type

E13 Attribute Assignment

Subclass of: E7 Activity
Superclass of: E14 Condition Assessment
                  E15 Identifier Assignment
                  E16 Measurement
                  E17 Type Assignment

Scope note: This class comprises the actions of making assertions about properties of an object or any relation between two items or concepts.

This class allows the documentation of how the respective assignment came about, and whose opinion it was. All the attributes or properties assigned in such an action can also be seen as directly attached to the respective item or concept, possibly as a collection of contradictory values. All cases of properties in this model that are also described indirectly through an action are characterised as "short cuts" of this action. This redundant modelling of two alternative views is preferred because many implementations may have good reasons to model either the action or the short cut, and the relation between both alternatives can be captured by simple rules.

In particular, the class describes the actions of people making propositions and statements during certain museum procedures, e.g. the person and date when a condition statement was made, an identifier was assigned, the museum object was measured, etc. Which kinds of such assignments and statements need to be documented explicitly in structures of a schema rather than free text, depends on if this information should be accessible by structured queries.

Examples:

- the assessment of the current ownership of Martin Doerr's silver cup in February 1997

In First Order Logic:

E13(x) ⊃ E7(x)

Properties:

P140 assigned attribute to (was attributed by): E1 CRM Entity
P141 assigned (was assigned by): E1 CRM Entity

E18 Physical Thing

Subclass of: E72 Legal Object
                  E92 Spacetime Volume
Superclass of: E19 Physical Object
                  E24 Physical Man-Made Thing
                  E26 Physical Feature

Scope Note: This class comprises all persistent physical items with a relatively stable form, man-made or natural.

Depending on the existence of natural boundaries of such things, the CRM distinguishes the instances of E19 Physical Object from instances of E26 Physical Feature, such as holes, rivers, pieces of land etc. Most instances of E19 Physical Object can be moved (if not too heavy), whereas features are integral to the surrounding matter.

An instance of E18 Physical Thing occupies not only a particular geometric space, but in the course of its existence it also forms a trajectory through spacetime, which occupies a real, that is phenomenal, volume in spacetime. We include in the occupied space the space filled by the matter of the physical thing and all its inner spaces, such as the interior of a box. Physical things consisting of aggregations of physically unconnected objects, such as a set of chessmen, occupy a number of individually contiguous spacetime volumes equal to the number of unconnected objects that constitute the set.

We model E18 Physical Thing to be a subclass of E72 Legal Object and of E92 Spacetime volume. The latter is intended as a phenomenal spacetime volume as defined in CRMgeo (Doerr and Hiebel 2013). By virtue of this multiple inheritance we can discuss the physical extent of an E18 Physical Thing without representing each instance of it together with an instance of its associated spacetime volume. This model combines two quite different kinds of substance: an instance of E18 Physical Thing is matter while a spacetime volume is an aggregation of points in spacetime. However, the real spatiotemporal extent of an instance of E18 Physical Thing is regarded to be unique to it, due to all its details and fuzziness; its identity and existence depends uniquely on the identity of the instance of E18 Physical Thing. Therefore this multiple inheritance is unambiguous and effective and furthermore corresponds to the intuitions of natural language.

The CIDOC CRM is generally not concerned with amounts of matter in fluid or gaseous states.

Examples:

- the Cullinan Diamond (E19)
- the cave "Ideon Andron" in Crete (E26)
- the Mona Lisa (E22)

In First Order Logic:

E18(x) ⊃ E72(x)
E18(x) ⊃ E92(x)

Properties:

P44 has condition (is condition of): E3 Condition State
P45 consists of (is incorporated in): E57 Material
P46 is composed of (forms part of): E13 Physical Thing
P49 has former or current keeper (is former or current keeper of): E39 Actor
P50 has current keeper (is current keeper of): E39 Actor
P51 has former or current owner (is former or current owner of): E39 Actor
P52 has current owner (is current owner of): E39 Actor
P53 has former or current location (is former or current location of): E53 Place
P58 has section definition (defines section): E46 Section Definition
P59 has section (is located on or within): E53 Place
P128 carries (is carried by): E90 Symbolic Object
P156 occupies (is occupied by): E53 Place

E22 Man-Made Object
Subclass of: E19 Physical Object
                E24 Physical Man-Made Thing
Superclass of: E84 Information Carrier

Scope note: This class comprises physical objects purposely created by human activity.

No assumptions are made as to the extent of modification required to justify regarding an object as man-made. For example, an inscribed piece of rock or a preserved butterfly are both regarded as instances of E22 Man-Made Object.

Examples:
- Mallard (the World's fastest steam engine)
- the Portland Vase
- the Coliseum

In First Order Logic:
$$E22(x) \supset E19(x)$$
$$E22(x) \supset E24(x)$$

E25 Man-Made Feature

Subclass of: E24 Physical Man-Made Thing
             E26 Physical Feature

Scope Note: This class comprises physical features that are purposely created by human activity, such as scratches, artificial caves, artificial water channels, etc.

No assumptions are made as to the extent of modification required to justify regarding a feature as man-made. For example, rock art or even "cup and ring" carvings on bedrock a regarded as types of E25 Man-Made Feature.

Examples:
- the Manchester Ship Canal
- Michael Jackson's nose following plastic surgery

In First Order Logic:
$$E25(x) \supset E26(x)$$
$$E25(x) \supset E24(x)$$

E26 Physical Feature

Subclass of: E18 Physical Thing
Superclass of: E25 Man-Made Feature
             E27 Site

Scope Note: This class comprises identifiable features that are physically attached in an integral way to particular physical objects.

Instances of E26 Physical Feature share many of the attributes of instances of E19 Physical Object. They may have a one-, two- or three-dimensional geometric extent, but there are no natural borders that separate them completely in an objective way from the carrier objects. For example, a doorway is a feature but the door itself, being attached by hinges, is not.

Instances of E26 Physical Feature can be features in a narrower sense, such as scratches, holes, reliefs, surface colours, reflection zones in an opal crystal or a density change in a piece of wood. In the wider sense, they are portions of particular objects with partially imaginary borders, such as the core of the Earth, an area of property on the surface of the Earth, a landscape or the head of a contiguous marble statue. They can be measured and dated, and it is sometimes possible to state who or what is or was responsible for them. They cannot be separated from the carrier object, but a segment of the carrier object may be identified (or sometimes removed) carrying the complete feature.

This definition coincides with the definition of "fiat objects" (Smith & Varzi, 2000, pp.401-420), with the exception of aggregates of "bona fide objects".

Examples:

- the temple in Abu Simbel before its removal, which was carved out of solid rock
- Albrecht Duerer's signature on his painting of Charles the Great
- the damage to the nose of the Great Sphinx in Giza
- Michael Jackson's nose prior to plastic surgery

In First Order Logic:

$$E26(x) \supset E18(x)$$

E28 Conceptual Object

Subclass of: E71 Man-Made Thing
Superclass of: E55 Type
E89 Propositional Object
E90 Symbolic Object

Scope note: This class comprises non-material products of our minds and other human produced data that have become objects of a discourse about their identity, circumstances of creation or historical implication. The production of such information may have been supported by the use of technical devices such as cameras or computers.

Characteristically, instances of this class are created, invented or thought by someone, and then may be documented or communicated between persons. Instances of E28 Conceptual Object have the ability to exist on more than one particular carrier at the same time, such as paper, electronic signals, marks, audio media, paintings, photos, human memories, etc.

They cannot be destroyed. They exist as long as they can be found on at least one carrier or in at least one human memory. Their existence ends when the last carrier and the last memory are lost.

Examples:

- Beethoven's "Ode an die Freude" (Ode to Joy) (E73)
- the definition of "ontology" in the Oxford English Dictionary
- the knowledge about the victory at Marathon carried by the famous runner
- 'Maxwell equations' [preferred subject access point from LCSH, http://lccn.loc.gov/sh85082387, as of 19 November 2012]
- 'Equations, Maxwell' [variant subject access point, from the same source]

In First Order Logic:

$$E28(x) \supset E71(x)$$

Properties: P149 is identified by (identifies): E75 Conceptual Object Appellation

E29 Design or Procedure

Subclass of: E73 Information Object

Scope note: This class comprises documented plans for the execution of actions in order to achieve a result of a specific quality, form or contents. In particular it comprises plans for deliberate human activities that may result in the modification or production of instances of E24 Physical Thing.

Instances of E29 Design or Procedure can be structured in parts and sequences or depend on others. This is modelled using *P69 has association with (is associated with)*..

Designs or procedures can be seen as one of the following:

1. A schema for the activities it describes
2. A schema of the products that result from their application.
3. An independent intellectual product that may have never been applied, such as Leonardo da Vinci's famous plans for flying machines.

Because designs or procedures may never be applied or only partially executed, the CRM models a loose relationship between the plan and the respective product.

Examples:
- the ISO standardisation procedure
- the musical notation for Beethoven's "Ode to Joy"
- the architectural drawings for the Kölner Dom in Cologne, Germany
- The drawing on the folio 860 of the Codex Atlanticus from Leonardo da Vinci, 1486-1490, kept in the Biblioteca Ambrosiana in Milan

In First Order Logic:
$$E29(x) \supset E73(x)$$

Properties:
P68 foresees use of (use foreseen by): E57 Material
P69 has association with (is associated with): E29 Design or Procedure
(P69.1 has type: E55 Type)

In First Order Logic:
$$E33(x) \supset E73(x)$$

E33 Linguistic Object
Subclass of: E73 Information Object
Superclass of: E34 Inscription
E35 Title

Scope note: This class comprises identifiable expressions in natural language or languages.

Instances of In First Order Logic:
$$E33(x) \supset E73(x)$$

Properties:
P72 has language (is language of): E56 Language
P73 has translation (is translation of): E33 Linguistic Object
Linguistic Object can be documented in a note by P3 has note: E62 String

Examples:
- the text of the Ellesmere Chaucer manuscript
- the lyrics of the song "Blue Suede Shoes"
- the text of the Jabberwocky by Lewis Carroll
- the text of "Doktoro Jekyll kaj Sinjoro Hyde" (an Esperanto translation of Dr Jekyll and Mr Hyde)

E56 Language
Subclass of: E55 Type

Scope note: This class is a specialization of E55 Type and comprises the natural languages in the sense of concepts.

This type is used categorically in the model without reference to instances of it, i.e. the Model does not foresee the description of instances of instances of E56 Language, e.g.: "instances of Mandarin Chinese".

It is recommended that internationally or nationally agreed codes and terminology are used to denote instances of E56 Language, such as those defined in ISO 639:1988.

Examples:

- el   [Greek]
- en   [English]
- eo   [Esperanto]
- es   [Spanish]
- fr   [French]

In First Order Logic:

E56(x) ⊃ E55(x)

E63 Beginning of Existence

Subclass of: E5 Event
Superclass of: E12 Production
E65 Creation
E66 Formation
E67 Birth
E81 Transformation

Scope note: This class comprises events that bring into existence any E77 Persistent Item.

It may be used for temporal reasoning about things (intellectual products, physical items, groups of people, living beings) beginning to exist; it serves as a hook for determination of a terminus post quem and ante quem.

Examples:

- the birth of my child
- the birth of Snoopy, my dog
- the calving of the iceberg that sank the Titanic
- the construction of the Eiffel Tower

In First Order Logic:

E63(x) ⊃ E5(x)

Properties:

P92 brought into existence (was brought into existence by): E77 Persistent Item

E70 Thing

Subclass of: E77 Persistent Item
Superclass of: E71 Man-Made Thing
E72 Legal Object

Scope note: This general class comprises discrete, identifiable, instances of E77 Persistent Item that are documented as single units, that either consist of matter or depend on being carried by matter and are characterized by relative stability.

They may be intellectual products or physical things. They may for instance have a solid physical form, an electronic encoding, or they may be a logical concept or structure.

Examples:

- my photograph collection (E78)
- the bottle of milk in my refrigerator (E22)

- the plan of the Strassburger Muenster (E29)
- the thing on the top of Otto Hahn's desk (E19)
- the form of the no-smoking sign (E36)
- the cave of Dirou, Mani, Greece (E27)

In First Order Logic:
E70(x) ⊃ E77(x)

E71 Man-Made Thing

Subclass of: E70 Thing
Superclass of: E24 Physical Man-Made Thing
                        E28 Conceptual Object

Scope note: This class comprises discrete, identifiable man-made items that are documented as
single units.

These items are either intellectual products or man-made physical things, and are
characterized by relative stability. They may for instance have a solid physical form,
an electronic encoding, or they may be logical concepts or structures.

Examples:
- Beethoven's 5th Symphony (E73)
- Michelangelo's David
- Einstein's Theory of General Relativity (E73)
- the taxon *'Fringilla coelebs* Linnaeus,1758' (E55)

In First Order Logic:
E71(x) ⊃ E70(x)

Properties

P102 has title (is title of): E35 Title
        (P102.1 has type: E55 Type)
P103 was intended for (was intention of): E55 Type

E72 Legal Object

Subclass of: E70 Thing
Superclass of: E18 Physical Thing
                        E90 Symbolic Object

Scope note: This class comprises those material or immaterial items to which instances of E30
Right, such as the right of ownership or use, can be applied.

This is true for all E18 Physical Thing. In the case of instances of E28 Conceptual
Object, however, the identity of the E28 Conceptual Object or the method of its use
may be too ambiguous to reliably establish instances of E30 Right, as in the case of
taxa and inspirations. Ownership of corporations is currently regarded as out of scope
of the CRM.

Examples:
- the Cullinan diamond (E19)
- definition of the CIDOC Conceptual Reference Model Version 2.1 (E73)

In First Order Logic:
E72(x) ⊃ E70(x)

Properties:

P104 is subject to (applies to): E30 Right
P105 right held by (has right on): E39 Actor

E73 Information Object

Subclass of: E89 Propositional Object
                E90 Symbolic Object
Superclass of: E29 Design or Procedure
                E31 Document
In First Order Logic:

$$E33(x) \supset E73(x)$$

Properties:

P72 has language (is language of): E56 Language
P73 has translation (is translation of): E33 Linguistic Object
Linguistic Object
E36 Visual Item

Scope note: This class comprises identifiable immaterial items, such as a poems, jokes, data sets, images, texts, multimedia objects, procedural prescriptions, computer program code, algorithm or mathematical formulae, that have an objectively recognizable structure and are documented as single units. The encoding structure known as a "named graph" also falls under this class, so that each "named graph" is an instance of an E73 Information Object.
An E73 Information Object does not depend on a specific physical carrier, which can include human memory, and it can exist on one or more carriers simultaneously.

Instances of E73 Information Object of a linguistic nature should be declared as instances of the In First Order Logic:

$$E33(x) \supset E73(x)$$

Properties:

P72 has language (is language of): E56 Language
P73 has translation (is translation of): E33 Linguistic Object
Linguistic Object subclass. Instances of E73 Information Object of a documentary nature should be declared as instances of the E31 Document subclass. Conceptual items such as types and classes are not instances of E73 Information Object, nor are ideas without a reproducible expression.

Examples:

- image BM000038850.JPG from the Clayton Herbarium in London
- E. A. Poe's "The Raven"
- the movie "The Seven Samurai" by Akira Kurosawa
- the Maxwell Equations
- The Getty AAT as published as Linked Open Data, accessed 1/10/2014

In First Order Logic:

$$E73(x) \supset E89(x)$$
$$E73(x) \supset E90(x)$$

E77 Persistent Item

Subclass of: E1 CRM Entity
Superclass of: E39 Actor
                E70 Thing

Scope note: This class comprises items that have a persistent identity, sometimes known as "endurants" in philosophy.

They can be repeatedly recognized within the duration of their existence by identity criteria rather than by continuity or observation. Persistent Items can be either physical entities, such as people, animals or things, or conceptual entities such as ideas, concepts, products of the imagination or common names.

The criteria that determine the identity of an item are often difficult to establish -; the decision depends largely on the judgement of the observer. For example, a building is regarded as no longer existing if it is dismantled and the materials reused in a different configuration. On the other hand, human beings go through radical and profound changes during their life-span, affecting both material composition and form, yet preserve their identity by other criteria. Similarly, inanimate objects may be subject to exchange of parts and matter. The class E77 Persistent Item does not take any position about the nature of the applicable identity criteria and if actual knowledge about identity of an instance of this class exists. There may be cases, where the identity of an E77 Persistent Item is not decidable by a certain state of knowledge.

The main classes of objects that fall outside the scope the E77 Persistent Item class are temporal objects such as periods, events and acts, and descriptive properties.

Examples:

- Leonard da Vinci
- Stonehenge
- the hole in the ozone layer
- the First Law of Thermodynamics
- the Bermuda Triangle

In First Order Logic:

E77(x) ⊃ E1(x)

E90 Symbolic Object

Subclass of: E28 Conceptual Object
               E72 Legal Object
Superclass of: E73 Information Object
               E41 Appellation

Scope note:

This class comprises identifiable symbols and any aggregation of symbols, such as characters, identifiers, traffic signs, emblems, texts, data sets, images, musical scores, multimedia objects, computer program code or mathematical formulae that have an objectively recognizable structure and that are documented as single units.

It includes sets of signs of any nature, which may serve to designate something, or to communicate some propositional content.

An instance of E90 Symbolic Object does not depend on a specific physical carrier, which can include human memory, and it can exist on one or more carriers simultaneously. An instance of E90 Symbolic Object may or may not have a specific meaning, for example an arbitrary character string.

In some cases, the content of an instance of E90 Symbolic Object may completely be represented by a serialized digital content model, such as a sequence of ASCII-encoded characters, an XML or HTML document, or a TIFF image. The property *P3 has note* allows for the description of this content model. In order to disambiguate which symbolic level is the carrier of the meaning, the property *P3.1 has type* can be used to specify the encoding (e.g. "bit", "Latin character", RGB pixel).

Examples:

- 'ecognizabl'
- The "no-smoking" sign (E36)
- "BM000038850.JPG" (E75)
- image BM000038850.JPG from the Clayton Herbarium in London (E38)
- The distribution of form, tone and colour found on Leonardo da Vinci's painting named "Mona Lisa" in daylight (E38)

The Italian text of Dante's "Divina Commedia" as found in the authoritative critical edition *La Commedia secondo l'antica vulgata a cura di Giorgio Petrocchi*, Milano: Mondadori, 1966-67 (= Le Opere di Dante Alighieri, Edizione Nazionale a cura della Società Dantesca Italiana, VII, 1-4) (In First Order Logic:

E33(x) ⊃ E73(x)

Properties:

> P72 has language (is language of): E56 Language
> P73 has translation (is translation of): E33 Linguistic Object
> ▪)

In First Order Logic:

> E90(x) ⊃ E28(x)
> E90(x) ⊃ E72(x)

Properties:

> P106 is composed of (forms part of): E90 Symbolic Object

6.2 CIDOC CRM Properties

This section contains the complete definitions of the properties of the CIDOC CRM Conceptual Reference Model vers. 6.2 May, 2015 referred to by Excavation Model

P16 used specific object (was used for)

Domain:	E7 Activity
Range:	E70 Thing
Subproperty of:	E5 Event. P12 occurred in the presence of (was present at): E77 Persistent Item E7 Activity. P15 was influenced by (influenced): E1 CRM Entity
Superproperty of:	E7 Activity.P33 used specific technique (was used by):E29 Design or Procedure E15 Identifier Assignment. P142 used constituent (was used in): E90 Symbolic Object E79 Part Addition. P111 added (was added by):E18 Physical Thing

Quantification: many to many (0,n:0,n)

Scope note: This property describes the use of material or immaterial things in a way essential to the performance or the outcome of an E7 Activity.

This property typically applies to tools, instruments, moulds, raw materials and items embedded in a product. It implies that the presence of the object in question was a necessary condition for the action. For example, the activity of writing this text required the use of a computer. An immaterial thing can be used if at least one of its carriers is present. For example, the software tools on a computer.

Another example is the use of a particular name by a particular group of people over some span to identify a thing, such as a settlement. In this case, the physical carriers of this name are at least the people understanding its use.

Examples:

> ▪ the writing of this scope note (E7) *used specific object* Nicholas Crofts' computer (E22) *mode of use* Typing Tool; Storage Medium (E55)
> ▪ the people of Iraq calling the place identified by TGN '7017998' (E7) used specific object "Quyunjig" (E44) *mode of use Current*; Vernacular (E55)

In First Order Logic:

> P16 (x,y) ⊃ E7(x)
> P16 (x,y) ⊃ E70(y)
> P16 (x,y) ⊃ P12(x,y)
> P16 (x,y) ⊃ P15(x,y)
> P16(x,y,z) ⊃ [P16(x,y) ∧ E55(z)]

Properties: P16.1 mode of use: E55 Type

P20 had specific purpose (was purpose of)

Domain: E7 Activity
Range: E5 Event
Quantification: many to many (0,n:0,n)

Scope note: This property identifies the relationship between a preparatory activity and the event it is intended to be preparation for.

This includes activities, orders and other organisational actions, taken in preparation for other activities or events.

P20 had specific purpose (was purpose of) implies that an activity succeeded in achieving its aim. If it does not succeed, such as the setting of a trap that did not catch anything, one may document the unrealized intention using *P21 had general purpose (was purpose of):E55 Type* and/or *P33 used specific technique (was used by): E29 Design or Procedure*.

Examples:
- Van Eyck's pigment grinding in 1432 (E7) *had specific purpose* the painting of the Ghent altar piece (E12)

In First Order Logic:
            P21(x,y) ⊃ E7(x)
            P21(x,y) ⊃ E55(y)

P33 used specific technique (was used by)

Domain: E7 Activity
Range: E29 Design or Procedure
Subproperty of: E7 Activity. P16 used specific object (was used for): E70 Thing
Quantification: many to many (0,n:0,n)

Scope note: This property identifies a specific instance of E29 Design or Procedure in order to
carry out an   instance of E7 Activity or parts of it.

The property differs from P32 used general technique (was technique of) in that P33 refers to an instance of E29 Design or Procedure, which is a concrete information object in its own right rather than simply being a term or a method known by tradition.

Typical examples would include intervention plans for conservation or the construction plans of a building

Examples:
- Ornamentation of silver cup 232 (E11) *used specific technique* 'Instructions for golden chase work by A N Other' (E29)
- Rebuilding of Reichstag (E11) *used specific technique* Architectural plans by Foster and Partners (E29)

In First Order Logic:
            P33(x,y) ⊃ E7(x)
            P33(x,y) ⊃ E29(y)
            P33(x,y) ⊃ P16(x,y)

P46 is composed of (forms part of)

Domain: E18 Physical Thing
Range: E18 Physical Thing

Subproperty of: E92 Spacetime Volume. P132 spatiotemporally overlaps with: E92 Spacetime Volume
Superproperty of:E19 Physical Object. P56 bears feature (is found on): E26 Physical Feature
Quantification: many to many (0,n:0,n)

Scope note: This property allows instances of E18 Physical Thing to be analysed into component
                   elements.

                   Component elements, since they are themselves instances of E18 Physical Thing,
                   may be further analysed into sub-components, thereby creating a hierarchy of part
                   decomposition. An instance of E18 Physical Thing may be shared between multiple
                   wholes, for example two buildings may share a common wall. This property does not
                   specify when and for how long a component element resided in the respective whole.
                   If a component is not part of a whole from the beginning of existence or until the end
                   of existence of the whole, the classes E79 Part Addition and E90 Part Removal can
                   be used to document when a component became part of a particular whole and/or
                   when it stopped being a part of it. For the time-span of being part of the respective
                   whole, the component is completely contained in the place the whole occupies.

                   This property is intended to describe specific components that are individually
                   documented, rather than general aspects. Overall descriptions of the structure of an
                   instance of E18 Physical Thing are captured by the *P3 has note* property.

                   The instances of E57 Material of which an item of E18 Physical Thing is composed
                   should be documented using *P45 consists of (is incorporated in)*.
Examples:
                   ▪   the Royal carriage (E22) *forms part of* the Royal train (E22)
                   ▪   the "Hog's Back" (E24) *forms part of* the "Fosseway" (E24)

In First Order Logic:
      P46(x,y) ⊃ E18(x)
      P46(x,y) ⊃ E18(y)
      P46(x,y) ⊃ P132(x,y)
      P46(x,y) ⊃ (∃uzw)[E93(u) ∧ P166 (x,u) ∧ E52(z) ∧ P164(u,z) ∧ E93(w) ∧ P166 (y,w) ∧
      P164(w,z) ∧ P10(w,u)]

P56 bears feature (is found on)
Domain: E19 Physical Object
Range: E26 Physical Feature
Subproperty of: E18 Physical Thing. P46 is composed of (forms part of): E18 Physical Thing

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

Scope note: This property links an instance of E19 Physical Object to an instance of E26 Physical
                   Feature that it bears.
                    An E26 Physical Feature can only exist on one object. One object may bear more than
                   one E26 Physical Feature. An E27 Site should be considered as an E26 Physical Feature
                   on the surface of the Earth.
                    An instance B of E26 Physical Feature being a detail of the structure of another
                   instance A of E26 Physical Feature can be linked to B by use of the property P46 is
                   composed of (forms part of). This implies that the subfeature B is P56i found on the
                   same E19 Physical Object as A.
                    P56 bears feature (is found on) is a shortcut. A more detailed representation can make
                   use of the fully developed (i.e. indirect) path 'E19 Physical Object', through, 'P59 has
                   section', 'E53 Place', 'P53i is former or current location of', to, 'E26 Physical
                   Feature'.
Examples:
                   ▪   silver cup 232 (E22) *bears feature* 32 mm scratch on silver cup 232 (E26)

In First Order Logic:

$P56(x,y) \supset E19(x)$

$P56(x,y) \supset E26(y)$

$P56(x,y) \supset P46(x,y)$

P62 depicts (is depicted by)

Domain: E24 Physical Man-Made Thing
Range: E1 CRM Entity

Quantification: many to many (0,n:0,n)

Scope note: This property identifies something that is depicted by an instance of E24 Physical
               Man-Made Thing. Depicting is meant in the sense that an E24 Physical Man-Made
               Thing intentionally shows, through its optical qualities or form, a representation of
               the entity depicted. Photographs are by default regarded as being intentional in this
               sense. Anything that is designed to change the properties of the depiction, such as an
               e-book reader, is specifically excluded. The property does not pertain to inscriptions
               or any other information encoding.

               This property is a shortcut of the more fully developed path from E24 Physical Man-
               Made Thing through *P65 shows visual item*, E36 Visual Item, *P138 represents,*
               E1CRM Entity. P138.1 mode of representation "depiction" allows the nature of the
               depiction to be refined.

Examples:
   ▪ The painting "La Liberté guidant le peuple" by Eugène Delacroix (E84) *depicts*
     the French "July Revolution" of 1830 (E7)
   ▪ the 20 pence coin held by the Department of Coins and Medals of the British
     Museum under registration number 2006,1101.126 (E24) *depicts* Queen Elizabeth
     II (E21) *mode of depiction* Profile (E55)

In First Order Logic:

$P62(x,y) \supset E24(x)$

$P62(x,y) \supset E1(y)$

$P62(x,y,z) \supset [P62(x,y) \wedge E55(z)]$

Properties: P62.1 mode of depiction: E55 Type

P67 refers to (is referred to by)

Domain: E89 Propositional Object
Range: E1 CRM Entity
Superproperty of: E31 Document. P70 documents (is documented in): E1 CRM Entity
                   E32 Authority Document. P71 lists (is listed in): E1 CRM Entity
                   E89 Propositional Object. P129 is about (is subject of): E1 CRM Entity
                   E36 Visual Item. P138 represents (has representation): E1 CRM Entity
                   E29 Design or Procedure.P68 foresees use of (use foreseen by): E57 Material

Quantification: many to many (0,n:0,n)

Scope note: This property documents that an E89 Propositional Object makes a statement about
                   an instance of E1 CRM Entity. *P67 refers to (is referred to by)* has the *P67.1 has type*
                   link to an instance of E55 Type. This is intended to allow a more detailed description
                   of the type of reference. This differs from *P129 is about (is subject of)*, which
                   describes the primary subject or subjects of the E89 Propositional Object.

Examples:

the eBay auction listing of 4 July 2002 (E73) *refers to* silver cup 232 (E22) *has type* item for sale (E55)

In First Order Logic:

P67(x,y) ⊃ E89(x)
P67(x,y) ⊃ E1(y)
P67(x,y,z) ⊃ [P67(x,y) ∧ E55(z)]

Properties: P67.1 has type: E55 Type

P94 has created (was created by)

Domain: E65 Creation
Range: E28 Conceptual Object
Subproperty of: E63 Beginning of Existence. P92 brought into existence (was brought into existence by): E77 Persistent Item
Superproperty of: E83 Type Creation. P135 created type (was created by): E55 Type

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

Scope note: This property allows a conceptual E65 Creation to be linked to the E28 Conceptual Object created by it.

It represents the act of conceiving the intellectual content of the E28 Conceptual Object. It does not represent the act of creating the first physical carrier of the E28 Conceptual Object. As an example, this is the composition of a poem, not its commitment to paper.

Examples:

▪ the composition of "The Four Friends" by A. A. Milne (E65) *has created* "The Four Friends" by A. A. Milne (E28)

In First Order Logic:

P94(x,y) ⊃ E65(x)
P94(x,y) ⊃ E28(y)
P94(x,y) ⊃ P92(x,y)

P106 is composed of (forms part of)

Domain: E90 Symbolic Object
Range: E90 Symbolic Object

Quantification: many to many (0,n:0,n)

Scope note: This property associates an instance of E90 Symbolic Object with a part of it that is by itself an instance of E90 Symbolic Object, such as fragments of texts or clippings from an image.
This property is transitive.

Examples:

This Scope note P106 (In First Order Logic:
E33(x) ⊃ E73(x)

Properties:

P72 has language (is language of): E56 Language
P73 has translation (is translation of): E33 Linguistic Object
) is composed of fragments of texts (In First Order Logic:

E33(x) ⊃ E73(x)

Properties:

> P72 has language (is language of): E56 Language
> P73 has translation (is translation of): E33 Linguistic Object
> ■   )
> ■   'recognizable' P106 (E90) is composed of 'ecognizabl' (E90)

In First Order Logic:

> P106(x,y) ⊃ E90(x)
> P106(x,y) ⊃ E90(y)

P108 has produced (was produced by)

Domain: E12 Production
Range: E24 Physical Man-Made Thing
Subproperty of: E11 Modification. P31 has modified (was modified by): E24 Physical Man-Made Thing

> E63 Beginning of Existence. P92 brought into existence (was brought into existence by): E77 Persistent Item

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

Scope note: This property identifies the E24 Physical Man-Made Thing that came into existence as a result of an E12 Production.

> The identity of an instance of E24 Physical Man-Made Thing is not defined by its matter, but by its existence as a subject of documentation. An E12 Production can result in the creation of multiple instances of E24 Physical Man-Made Thing.

Examples:

> ■   The building of Rome (E12) *has produced* The Colosseum (E22)

In First Order Logic:

> P108(x,y) ⊃ E12(x)
> P108(x,y) ⊃ E24(y)
> P108(x,y) ⊃ P31(x,y)
> P108(x,y) ⊃ P92(x,y)

7 Referred CRMsci classes and properties

Since Excavation Model refers to and reuses, wherever appropriate, large parts of Scientific Observation Model this section provides a comprehensive list of all constructs used from that model, together with their definitions following the CRM*sci*, together with their definitions following version 1.2 maintained by FORTH.

7.1 CRMsci Classes

This section contains the complete definitions of the classes of the Scientific Observation Model referred to by Excavation Model

S4 Observation

Subclass of: E13 Attribute Assignment
Superclass of: S21 Measurement
                S19 Encounter Event

Scope note: This class comprises the activity of gaining scientific knowledge about particular states of physical reality gained by empirical evidence, experiments and by measurements.

We define observation in the sense of natural sciences, as a kind of human activity: at some place and within some time-span, certain physical things and their behavior and interactions are observed, either directly by human sensory impression, or enhanced with tools and measurement devices.

The output of the internal processes of measurement devices that do not require additional human interaction are in general regarded as part of the observation and not as additional inference. Manual recordings may serve as additional evidence. Measurements and witnessing of events are special cases of observations. Observations result in a belief about certain propositions. In this model, the degree of confidence in the observed properties is regarded to be "true" by default, but could be described differently by adding a property *P3 has note* to an instance of S4 Observation, or by reification of the property *O16 observed value*.

Primary data from measurement devices are regarded in this model to be results of observation and can be interpreted as propositions believed to be true within the (known) tolerances and degree of reliability of the device.

Observations represent the transition between reality and propositions in the form of instances of a formal ontology, and can be subject to data evaluation from this point on. For instance, detecting an archaeological site on satellite images is not regarded as an instance of S4 Observation, but as an instance of S6 Data Evaluation. Rather, only the production of the images is regarded as an instance of S4 Observation.

Examples:

- The excavation of unit XI by the Archaeological Institute of Crete in 2004.

.

In First Order Logic:

        S4(x) ⊃ E13(x)

Properties:

        O8 observed (was observed by): S15 Observable Entity
        O9 observed property type (property type was observed by): S9 Property Type
        O16 observed value (value was observed by): E1 CRM Entity

S15 Observable Entity

Subclass of: E1 CRM Entity
Superclass of: E2 Temporal Entity
                 E77 Persistent Item

Scope note:

> This class comprises instances of E2 Temporal Entity or E77 Persistent Item, i.e.
> items or phenomena that can be observed, either directly by human sensory
> impression, or enhanced with tools and measurement devices, such as physical
> things, their behavior, states and interactions or events.
> Conceptual objects can be present in events by their carriers such as books, digital
> media, or even human memory. By virtue of this presence, properties of conceptual
> objects, such as number of words can be observed on their carriers. If the respective
> properties between carriers differ, either they carry different instances of conceptual
> objects or the difference can be attributed to accidental deficiencies in one of the
> carriers. In that sense even immaterial objects are observable. By this model we give
> credit to the fact that frequently, the actually observed carriers of conceptual objects
> are not explicitly identified in documentation, i.e., the actual carrier is assumed
> having existed but is unknown as an individual.

Examples:

- The domestic goose from Guangdong in China.
- The crow flight over the waters of Minamkeak Lake during summer.
- The eruption of Krakatoa volcano at Indonesia in 1883.

In First Order Logic:

$$S15(x) \supset E1(x)$$

Properties:

> O12 has dimension (is dimension of): E54 Dimension

7.2 CRMsci Properties

This section contains the complete definitions of the properties of the Scientific Observation Model
referred to by Excavation Model

O6 forms former or current part of (has former or current part)

Domain: S12 Amount of Fluid
Range: S14 Fluid Body
Subproperty of: S10 Material Substantial: O25 contains (is contained in): S10 Material Substantial
Quantification: many to many (0,n:0,n)

Scope note: This property associates an instance of S12 Amount of Fluid with an instance of S14
                Fluid Body which forms part of it. It allows instances of S14 Fluid Body to be
                analyzed into elements of S12 Amount of Fluid.

Examples:

- J.K.'s blood sample 0019FCF5 (S12) *is part of* J.K.'s blood (S14).

In First Order Logic:

$$O6(x,y) \supset S12(x)$$
$$O6(x,y) \supset S14(y)$$

O8 observed (was observed by)

Domain: S4 Observation
Range: S15 Observable Entity
Subproperty of: E13 Attribute Assignment. P140 assigned attribute to (was attributed by): E1 CRM Entity
Superproperty of: S21 Measurement. O24 measured (was measured by): S15 Observable Entity
Quantification: many to one, necessary (1,1:0,n)

Scope note: This property associates an instance of S4 Observation with an instance of S15 Observable Entity that was observed. Specifically it describes that a thing, a feature, a phenomenon or its reaction is observed by an activity of Observation.

Examples:
- This document is about the rotational landslide that was observed by engineers on the slope of Panagopoula coastal site, near Patras, on the 25th–26th April 1971 and the 3rd May 1971 (Tavoularis et al., 2017)1.
- The survey (S4) of Sinai MS GREEK 418 observed a detached triple-braided clasp strap (S15). (Honey, A. and Pickwoad, N., 2010)

In First Order Logic:
    O8(x,y) ⊃ S4(x)
    O8(x,y) ⊃ S15(y)
    O8(x,y) ⊃ P140(x,y)

O16 observed value (value was observed by)

Domain: S4 Observation
Range: E1 CRM Entity
Subproperty of: E13 Attribute Assignment. P141 assigned (was assigned by): E1 CRM Entity
Superproperty of: E16 Measurement. P40 observed dimension (was observed in): E54 Dimension (inconsistent with E21 Measurement as long as Observable Entity is not moved to CRM.

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

Scope note: This property associates a value assigned to an entity observed by S4 Observation.

Examples:
- The surface survey at the bronze age site of Mitrou in east Lokris carried out by Cornell University in 1989 *observed value* 600 (and *observed* sherds).

In First Order Logic:
    O16(x,y) ⊃ S4(x)
    O16(x,y) ⊃ E1(y)
    O16(x,y) ⊃ P141(x,y)

8 Referred LRMoo classes and properties

8.1 LRMoo Classes

F28 Expression Creation

Subclass of: E12 Production
                 E65 Creation

Superclass of: F29 Recording Event
                 F30 Manifestation Creation

Scope note: This class comprises activities that result in instances of F2 Expression coming into existence. This class characterises the externalisation of an F1 Work. The creation of an instance of F1 Work is considered to occur at the time of creation (F28) of its first F2 Expression.

                 Although F2 Expression is an abstract entity, a conceptual object, the creation of an expression inevitably also affects the physical world: when you scribble the first draft of a poem on a sheet of paper, you produce an instance of F3 Manifestation. F28 Expression Creation is a subclass of E12 Production because the recording of the expression causes a physical modification of the E18 Physical Thing that serves as the carrier. The work becomes manifest by being expressed on a physical carrier other than the creator's brain. The spatio-temporal circumstances under which the expression is created are necessarily the same spatio-temporal circumstances under which the first instance of F3 Manifestation is produced.

                 The mechanisms through which *oral tradition* (of myths, tales, music, etc.) operates are not further investigated in this model. As far as bibliographic practice is concerned, only those instances of F2 Expression that are externalised on physical carriers other than both the creator's brain and the auditor's brain are taken into account (for a discussion of the modelling of oral traditions, see: Nicolas, Yann. 'Folklore Requirements for Bibliographic Records: oral traditions and FRBR.' In: *Cataloging & Classification Quarterly* (2005). Vol. 39, No. 3-4. P. 179-195).

                 It is possible to use the *P2 has type (is type of)* property in order to specify that the creation of a given expression of a given work played a particular role with regard to the overall bibliographic history of that work (e.g., that it was the creation of the progenitor expression on which all other expressions of the same work are based; or that it was the creation of the critical edition that served as the basis for canonical references to the work).

                 An instance of F28 Expression Creation may use as source material a specific existing F2 Expression. The property P16 *used specific object (was used for)* can be used to specify the source expression for the derivation. In cases such as a translation or a revised edition, etc., a new F2 Expression of the same F1 Work, a derived expression, is created. In the situation where an expression of one F1 Work serves as source material for the creation of the first expression of a new instance of F1 Work, the relationship is indicated using the property *R2 is derivative of (has derivative)* between the two instances of F1 Work. Path: F1 Work(1). *R3 is realised in:* F2 Expression(1). *P16i was used for:* F28 Expression Creation. *R17 created* :F2 Expression(2). *R3i realises:* F1 Work(2). *R2 is derivative of*: F1 Work(1)

Examples: The creation of the original manuscript score of 'Uwertura tragiczna' by Andrzej Panufnik in 1942 in Warsaw

                 The reconstruction from memory of the manuscript score of 'Uwertura tragiczna' by Andrzej Panufnik in 1945 after the original score was destroyed during the war

                 The creation, by Lord Byron, of the English text of his work entitled 'Manfred' (*P2 has type:* E55 Type {major original contribution})

The creation, by Woldemar Starke, of his German translation of Lord Byron's text entitled 'Manfred' (*P2 has type:* E55 Type {translation})

The recording of the third alternate take of 'Blue Hawaii' performed by Elvis Presley in Hollywood, Calif., Radio Recorders, on March 22nd, 1961 [each individual take is a distinct instance of F2 Expression]

Properties: R19 created a realisation of (was realised through): F1 Work [might move to domain F56]

References

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[3] E. Pulgram, The Typologies of Writing-Systems, in: Writing Without Letters, W. Haas, ed., Manchester, Manchester University Press, 1976, 1–28.

[4] G. Sampson, Writing Systems: A Linguistic Introduction, London, Hutchinson, 1985 (2nd ed. Sheffield, Equinox, 2015).

[5] H. Rogers H., Writing Systems: A Linguistic Approach, Oxford, Blackwell, 2005.

[6] Lanciani, R.: *The significance of the inscription on the Arch of Constantine,* in *Pagan and Christian Rome,* Houghton, Mifflin and Company, Boston and New York, 1892.