

A formal ontology for historical maps

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Abstract. Historical maps are a major component of our scientific and cultural heritage collections. Apart from the aesthetic value of the artifacts, maps also deliver valuable historical and geographic information. In order to use the historical cartographic information effectively, the semantic documentation of maps becomes a necessity and ontologies are suggested to achieve this. This paper examines how the top level ontology CIDOC-CRM “handles” historical maps and presents a formal description of the “Carte de la nouvelle frontière Turco-Grecque”, a map attached to the Convention of Constantinople that set the borderlines between Greece and Ottoman Empire in 1881.

Keywords: CIDOC-CRM, historical map, ontology

1. Introduction

Maps are the graphical representation of geographical space and spatial phenomena. Historical maps are a valuable source of historical information since they actually document the spatiotemporal evolution of entities. In order to use the historical cartographic information effectively, the semantic documentation of maps becomes a necessity. The semantic definition of a map restores any semantic ambiguities. In addition structures the relationship between historical and current geographical space. As a result: a) the correlation between an entity’s spatiotemporal changes and their causes is explicitly attributed, b) semantic search of geospatial data on the web using spatial and conceptual criteria (for example based on toponymy or geometry) is possible and c) the development of interoperability mechanisms in several web – spatial or not – applications that use maps is facilitated. Ontologies could be used to achieve these goals.

Furthermore, historical maps are a major component of our scientific and cultural heritage collections. The use of ontologies to document cultural

collections can facilitate interoperability especially concerning their spatial facets and give the possibility for semantic querying and representation of information (Kauppinen et al. 2010).

In order to explore how ontologies can meet the before mentioned requirements we have researched on how a historical map is represented in the CIDOC Conceptual Reference Model. Firstly, we created a formal description of the historical map “Carte de la nouvelle frontière Turco-Grecque”. Secondly, we identified problems and gaps in modeling some parts of the geometric and thematic attributes of the map suggesting some possible solutions.

2. Ontologies and Historical Maps

2.1 Overview

Bittner and Smith were the first who revealed the close relationship between maps and ontologies and stated that “a map is a specific, simplified and therefore highly efficient representation of the ontology of a certain part of geographical space. It is an ontology because it is an inventory of things that exist in a certain part of the world and of some of the properties and relations between them” (Bittner et al. 2004).

Following this approach, Svedjemo and Jungert (2006), applied the theory of SNAP ontologies to cadastre map for the region of Gotland, Sweden, having in mind that ontologies have an advantage from other methods to provide a conceptually explicit model.

Another characteristic example is the CultureSampo Project, whose purpose is the creation of a semantic web portal for Finland’s cultural heritage. The developers of the portal have concluded that using ontologies to document cultural collections facilitates interoperability especially concerning their spatial facets and gives the possibility for semantic querying and representation of information (Kauppinen et al. 2010).

Bibliographic search indicates that there are ontologies that describe spatial entities, historical events and cultural heritage artifacts. Nevertheless, historical maps lie in a rather special domain since these are means of delivering historical, spatial and geometric information as well as objects of art.

2.2 The CIDOC Conceptual Reference Model

The CIDOC CRM (International Committee for Documentation of the International Council of Museums - Conceptual Reference Model) is a formal

ontology intended to facilitate the integration, mediation and interchange of heterogeneous cultural heritage information (Crofts et al. 2011). Since 9/12/2006 it is official standard ISO 21127:2006.

The purpose of CIDOC CRM is to model all information required for the exchange and integration of heterogeneous scientific documentation of museum collections. The term “museum collections” cover all types of material collected and displayed in museums and related institutions. *This includes collections, sites and monuments related to social history, ethnography, archaeology, fine and applied arts, natural history, history of sciences and technology. The CRM is specifically intended to cover contextual information: the historical, geographical and theoretical background that gives museum collections much of their cultural significance and value* (Crofts et al. 2011).

CIDOC CRM is a property-centric top level ontology intending to cover the meaning of all the data structures used to encode “information required for the scientific documentation of cultural heritage collections”, under certain semantic restrictions (Doerr 2003). The model contains 90 classes and 149 properties. A qualitative metaschema can be seen in *Figure 1*.

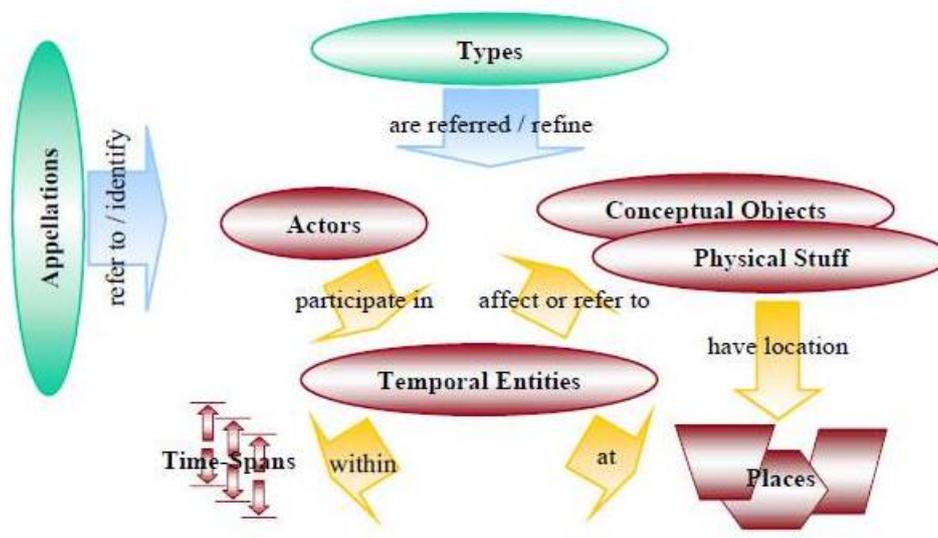


Figure 1. Qualitative metaschema of CIDOC-CRM (Doerr 2003).

Actors participate in Temporal Entities (within Time -Spans at Places) and relate material or conceptual (Conceptual Objects and Physical Stuff). Ap-

pellation (name) identifies a class while Types classify in detail instance classes (Doerr 2003).

Regarding the spatial reasoning, the class E53 Place represents a spatial concept. As of *Figure 2*, an instance of E53 Place is identified by an instance of E44 Place Appellation, which may be an instance of E45 Address, E47 Spatial Coordinates, E48 Place Name, or E46 Section Definition.

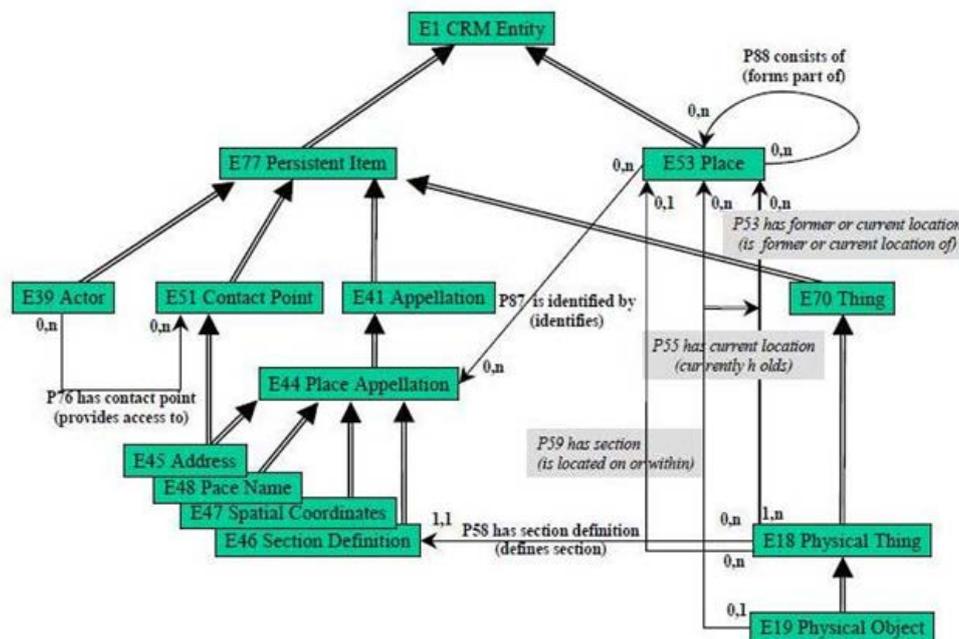


Figure 2. Spatial information in CIDOC-CRM (Crofts et al. 2011).

3. Historical Maps in CIDOC-CRM

3.1 Describing a historical map in CIDOC-CRM

The class of CIDOC-CRM under which a historical map can be best represented is the class Information Carrier – E84. This class comprises all instances of E22 Man-Made Object that are explicitly designed to act as persistent physical carriers for instances of E73 Information Object. A map “carries” geographical, historical and metrical information that may exist in one or more maps at the same time. The Historical map usually belongs to a map or other collection. Collection is described by the class Collection – E78. This class comprises aggregations of instances of E18 Physical Thing

that are assembled and maintained (“curated” and “preserved,” in museological terminology) by one or more instances of E39 Actor over time for a specific purpose and audience, and according to a particular collection development plan. Nevertheless, CIDOC CRM doesn’t have a link to connect an object with its collection (e.g. property *is part of*).

The creator, publisher and collector of a map are described by the general class Actor – E39. This class comprises people, either individually or in groups, who have the potential to perform intentional actions for which they can be held responsible. The activity of the creation and publicity are described by the classes E65 Creation and E12 Production respectively, both subclasses of the E7 Activity.

The map has a title described by the class Title - E35 in CIDOC CRM. This class comprises the names assigned to works, such as texts, artworks or pieces of music. It has also an identifier described in class “E42 – Identifier”. This class comprises strings or codes assigned to instances of E1 Entity in order to identify them uniquely and permanently within the context of one or more organizations. More technical details for a map are represented in the following classes (the definitions are those cited at (Crofts et al.2011)):

- E55 Type: This class comprises concepts denoted by terms from thesauri and controlled vocabularies used to characterize and classify instances of CRM classes. It is a generic class and it can be used to describe map types (e.g. topographic), the nature of the map (e.g. copy or original) etc..
- E54 Dimension: This class comprises quantifiable properties that can be measured by some calibrated means and can be approximated by values, i.e. points or regions in a mathematical or conceptual space, such as natural or real numbers, RGB values etc.. In our case it refers to the length and width of the map.
- E57 Material: This class comprises identifiable immaterial items that make propositions about reality. Instances of E57 Material may denote properties of matter before its use, during its use, and as incorporated in an object, such as ultramarine powder, tempera paste, reinforced concrete. It refers to the material from which the map is made from (e.g. paper).
- E56 Language: This class is a specialization of E55 Type and comprises the natural languages in the sense of concepts. It is used to denote the languages that have been used for the map (place names, inscriptions, notes etc.).

- E36 Visual Item: This class comprises the intellectual or conceptual aspects of recognizable marks and images. By this class, specific symbols in maps can be described (e.g. the North Arrow).
- E34 Inscription: This class comprises recognizable, short texts attached to instances of E24 Physical Man-Made Thing. It refers to any notes the map may have.
- E53 Place: This class comprises extents in space, in particular on the surface of the earth, in the pure sense of physics: independent from temporal phenomena and matter. It refers to any place information concerning the map (e.g. place of publication, location where the map is now preserved etc.).
- E48 Place Name: This class comprises particular and common forms of E44 Place Appellation.
- E50 Date: This class comprises specific forms of E49 Time Appellation. It refers to any concepts of time are related to the map (date of publication, creation etc.).
- E52 Time Span: This class comprises abstract temporal extents, in the sense of Galilean physics, having a beginning, an end and duration. For example in our case, the duration of a geographic entity that is depicted in a map (e.g. a lake that has now been dried up).
- E5 Event: 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. This class connects the map with a historical event that may be related to it.
- E31 Document: This class comprises identifiable immaterial items that make propositions about reality. These propositions may be expressed in text, graphics, images, audiograms, videograms or by other similar means. This class is used to describe a document that may be attached to a map.

To represent the geographic entities that are depicted in maps CIDOC offers a more abstract reasoning. Apart from the class E53 Place, the following classes are also used:

- E26 Physical Feature: This class comprises identifiable features that are physically attached in an integral way to particular physical objects (e.g. the relief).
- E27 Site: This class comprises pieces of land or sea floor. In contrast to the purely geometric notion of E53 Place, this class describes constellations of matter on the surface of the Earth or other celestial body, which can be represented by photographs, paintings and maps (e.g. a river).

Depending on the case, all classes of the CIDOC can be used in order to describe a map as a cultural object e.g. if the map has been removed from one

museum to another (E10 Transfer of Custody) etc.. Selecting the appropriate properties to connect the classes listed previously from CIDOC, the formal general description of the historical map is (*Figure 3*):

A Historical Map (E84 Information Carrier)

is identified by (P1) E42 Identifier

has current owner (P52) E39 Actor

has current location (P55) E53 Place

has title (P102) E35 Title

has type (P2) E55 Type

has number of parts (P57) E60 Number

has dimension (P43) E54 Dimension

consists of (P5) E57 Material

has condition (P44) E3 Condition State

has language (P72) E56 Language

was created by (P94) E65 Creation

carried out by (P14) E39 Actor

took place at (P7) E53 Place

had specific purpose (P20) E5 Event

was produced by (P108) E12 Production

carried out by (P14) E39 Actor

took place at (P7) E53 Place

used specific technique (P33) E29 Design or Procedure

has time span (P4) E50 Date

is documented in (P70) E31 Document

is result of (P123) E5 Event

depicts (P62) E53 Place/E26 Physical Feature/E27 Site

is identified by (P1) E48 Place Name

has note (P3) E34 Inscription

shows visual item (P65) E36 Visual Item

has current curator (P109) E39 Actor

“Carte de la Nouvelle Frontiere Turco-Grecque” is a Historical Map (E84 Information Carrier).

is identified by MPBRA.029 (E42 Identifier)

has current owner Hellenic Literary and Historical Archive (E39 Actor)

has type Foundation (E55 Type)

has contact point 5 Aghiou Andreou Str. Athens (E45 Address)

has current location Floor 2 (E53 Place)

falls within Hellenic Literary and Historical Archive Building (E53 Place)

has type Foundation building (E53 Type)

is identified by 5 Aghiou Andreou Str. (E45 Address)

falls within Athens (E53 Place)

has type City (E53 Place)

falls within Greece (E53 Place)

has title Carte de la Nouvelle Frontiere Turco-Grecque (E35 Title)

has type Copy of Carte de la Nouvelle Frontiere Turco-Grecque (E55 Type)

has type Original Carte de la Nouvelle Frontiere Turco-Grecque (E55 Type)

has current owner French Embassy (E39 Actor)

has current location Istanbul (E53 Place)

has type City (E53 Place)

falls within Turkey (E53 Place)

has number of parts 14 (13 map sheets and one index) (E60 Number)

has dimension (E54 Dimension)

length 60 cm

width 46.50 cm

consists of Paper (E57 Material)

has condition Cloth-bound (E3 Condition State)

has language French (E56 Language)

was created by Creation of Carte de la Nouvelle Frontiere Turco-Grecque
(E65 Creation)

carried out by Commission for the Delimitation of the Greek-Turkish borders

was based on Surveying works (E7 Activity)

took place at Greece (E53 Place)

has type Country (E55 Type)

falls within Europe (E53 Place)

carried out by M.Le Ardagh (E39 Actor)

has type Commander (E55 Type)

had specific purpose Delimitation between Greece and Ottoman Empire

was produced by Publication (E12 Production)

carried out by Intelligence Department War Office (E39 Actor)

took place at London (E53 Place)

has type City (E55 Type)

falls within United Kingdom (E53 Place)

used specific technique Zincography (E29 Design or Procedure)

has time span

begins at 08/1881 (E50 Date)

ends at 03/1882 (E50 Date)

is documented in Convention of Constantinople (E31 Document)

took place at Istanbul (E53 Place)

is identified by Constantinople (E48 Place Name)

has type City (E53 Place)

falls within Turkey (E53 Place)

has time span

begins at 24-05-1881 (E50 Date)

ends at 24-05-1881 (E50 Date)

is result of the capitulation between Greece and Ottoman Empire
(E5 Event)

depicts Greek north frontier line (E1 Entity)

depicts Thessaly (E53 Place)

has type Region (E55 Type)

falls within Greece (E53 Place)

depicts Epirus (E53 Place)

has type Region (E55 Type)

falls within Greece (E53 Place)

depicts Araxthos (E27 Site)

has type river

has note (E34 Inscription)

Bottom center of index: “Terrain indiqué par Courbes de Niveau équidistantes approximativement de 100 Pieds Anglais, (=30.48 metres). Hauteurs fixées par triangulation_6859. Hauteurs approximatives déterminées po interpolations barométriques_3650”.

Bottom right: “Certifié conforme à l'original déposé aux archives de l'Am-bassade de France à Constantinople” – signature of M. Le Ardagh.

Bottom left: “E de Paris” , Echelle 1:50000

Top right: “Signatures des Commissaires Constantinople le 27 Novembre 1881”.

has current curator [Name of curator] (E39 Actor)

4. Problems and suggestions

Even though the previous example indicates that historical maps can be well documented in CIDOC model, there are some map elements that have been omitted. These are the scale of map, spatial reference system, orientation, legend and any notes on metric information (e.g. heights, accuracy etc.) as well as the link between a map and a collection. An effort was made to describe them but not without ambiguity. For example, “scale” could be represented by the class E65 Number but there was not a property appropriate to be used and clearly answer a query about the scale of the map.

For this reason, the following classes and properties are suggested:

a. Classes

- Reference System: it is set as an enumerated class. The individuals that are members of this class are the specific Spatial Reference Systems.

- Orientation: it is a class representing the orientation of the map (e.g. North or East for T and O maps).
 - Projection: an enumerated class representing the projection used for the creation of the map.
- b. Properties
- *has scale*: this is set as a functional property (for a given individual, there can be at most one individual that is related to the individual via the property) It is set as its domain the entity Historical Map (E84 Information Carrier) and as range an exactly one value (e.g. 1:50000).
 - *has Reference System*: it is a functional property having as domain the entity Historical Map and as range the class Reference System (exactly one value).
 - *has orientation*: it is a functional property having as domain the entity Historical Map and as range the class Orientation (exactly one value).
 - *hasProjection*: a functional property having as domain the entity Historical Map and as range the class Projection (exactly one value).
 - *is part of*: it is a property that connects the Historical Map (domain) to the Collection (E78 entity) that the map belongs to.

In order to describe in depth the geographic entities and relations depicted on historical maps, a geographic domain ontology is necessary. Various geographic ontologies are currently tested in order to select the appropriate one. For the purpose of this research, we have focused on the new frontier line that is defined by the Convention of Constantinople that is after all the main subject of our case study map. The following properties have been created:

- *isBorderOf*: it is a property that connects the geographic entity “frontier line” (domain) to the countries of which is border (range) with the restriction to take two values at the minimum (two countries).
- *is valid at*: this property has as domain the geographic entity “frontier line” and as range the class E50 Date and refers to when the borderline was designated.
- *is valid until*: this property has as domain the geographic entity “frontier line” and as range the class E50 Date and refers to until when the borderline was valid.
- *is designated by*: this property has as domain the geographic entity “frontier line” and as range the class E31 Document and refers to the document (here convention) that designated the borderline.
- *splits*: this property has as domain the geographic entity “frontier line” and as range the class E53 Place and refers to when a geographic entity splits another geographic entity.

Using the above suggested classes and properties the description of the historical map “Carte de la Nouvelle Frontiere Turco-Grecque” is completed as following:

has scale 1:50000

has Reference System Paris Prime Meridian

has orientation North

is part of the Map collection of the Hellenic Literary and Historical Archive (E78 Collection).

depicts Greek north frontier line (E1 Entity)

separates Greece and Ottoman Empire (E53 Place)

is valid at 24-05-1881 (E50 Date)

is valid until 1913 (E50 Date)

has time span From 24-05-1881 until 1913

is designated by Convention of Constantinople

splits Epirus (E53 Place)

has type Region (E55 Type)

falls within Greece (E53 Place)

resulted in Epirus part 1

resulted in Epirus part 2

is annexed to Greece (see *Figure 5*)



Figure 5. The frontier line of 1881 (in blue) and the annexation of Epirus part 2 to Greece.

5. Conclusion

A historical map is a complex scientific and cultural object. To fully describe it, knowledge from different domains is needed (culture heritage management, cartography, history, geography). The extension of CIDOC -with this knowledge- will fulfill the requirements for a detailed semantic definition of historical maps. The extension of the CIDOC includes the following future steps:

- Determine the geographic ontology that will be subsumed in CIDOC CRM. This will describe the geographic entities depicted in historical maps and their spatial relations.
- Extend the geographic ontology suggesting these properties that will describe the spatiotemporal evolution and changes of the entities.
- Describe and model more complicated elements of the map. These include the graphic properties of the map, symbols, legends and notes about metric information.

Acknowledgments

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Pro-

gram "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Heracleitus II. Investing in knowledge society through the European Social Fund.

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