

DELIVERABLE 8.1

Ontology and corpus study of the cultural  
heritage domain

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# 1 Introduction

This document is the first deliverable corresponding to Work Package 8 (WP8) of the European Union Seventh Framework Programme MOLTO under grant agreement FP7-ICT 247914 *Case study: Cultural Heritage*. The duration of WP8 is 18 months starting from March 2011.

In this section we present the goals and the purpose of WP8. In the remaining sections we report on a study of existing metadata schemas adopted by museums in Sweden (Section 2). We then describe the ontology development that was based on this study (Section 3). Afterwards follows a specification of the syntactic structures and patterns for discourse generation that is a result of corpus analysis of cultural heritage texts (Section 4.1). In Section 5 we briefly describe the ontology alignment and the museum data integration into the Museum Reason-able View. We end with a description of the grammar implementation of the ontology models in GF (Section 6).

## 1.1 The goals of WP8

The goals of WP8 are to:

- build an ontology-based multilingual grammar for museum information for artefacts at Gothenburg City Museum (GCM) starting from the Conceptual Reference Model (CIDOC-CRM);
- cover 15 languages for baseline functionality and 5 languages with a more complete coverage;
- build a prototype of a cross-language retrieval and representation system to be tested with objects in the museum, and automatically generate Wikipedia articles for museum artefacts in 5 languages.

The workpackage is tightly related to WP2, *Grammar Developer's Tools* and WP4, *Knowledge Engineering*, whose task is to connect the museum data and cultural heritage ontology models to the BigOWLIM triple store (Bishop et al., 2011) and make them available via SPARQL endpoint (Eric and Andy, 2008).<sup>1</sup>

## 1.2 Description of work

The work of WP8 is started by a study of the existing categorizations and metadata schemas adopted by the museum, as well as a corpus of texts in the current documentation which describe these objects. We will transform the CIDOC-CRM into a specific ontology aligning it with the upper-level one in the base knowledge set (WP4) and modeling the museum object metadata as a domain specific knowledge base (D8.1). Through the interoperability engine from WP4 and the IDE (Integrated Development Environment) from

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<sup>1</sup><http://www.w3.org/TR/rdf-sparql-query/>

WP2, we will semi-automatically create the translation grammar in GF (Ranta, 2004) and further extend it (D8.2). The final result will be an online system enabling museum (virtual) visitors to use their language of preference to search for artefacts through semantic (structured) and natural language queries and examine information about them. We will also automatically generate a set of articles in the Wikipedia format describing museum artefacts in the 5 languages with extensive grammar coverage (D8.3).

This deliverable provides a study of the existing categorizations and metadata schemas of *Carlotta* information system that is adopted by the Gothenburg City Museum and many other museums in Sweden including: the Museum of World Culture,<sup>2</sup> the Museum of Ethnography,<sup>3</sup> the Museum of Mediterranean,<sup>4</sup> and Near Eastern Antiquities and the Museum of East Asia.<sup>5</sup> It describes the text collection of written object descriptions, the specific ontology model we have been developing, the syntactic structures and the discourse patterns that will be used in this workpackage to automatically generate Wikipedia articles for museum artefacts in 5 languages. This deliverable also presents ongoing work on aligning the ontology models and making the museum data accessible through SPARQL queries. It describes the grammar implementation for generating the information that is available in the Gothenburg City Museum database.

## 2 Study of museum metadata

The aim of the museum database analysis is to provide us with basic information on the metadata that is unique to artifact-based collections, with a view of producing an ontology that will capture the relation between natural language constructs and museum database structures. We hope the data study presented in this paper and the design of the ontology that follows from this study will help museums in Sweden to move from “local museum databases” towards Semantic Web standards by standardizing their collections and making them available for Semantic Web applications.

Chenhall and Vance (2010) have analyzed museum records in diverse museum databases. They found that the complexity of the structure of the information in the majority of the world’s museums lies somewhere between geology museums and art and photography museums. While the former requires simple terminology, the latter requires advanced classification categories system. They found that the emphasis placed upon objects in art museums, history museums, photography museums or natural history museums is quite different because of the functional utility of the objects, the background of what is known about the society that made and used them and the difference in what is most important to highlight. Their study revealed that despite the differences in the way information is stored, the metadata that is used to record object values is common for the majority of museums. Thus, understanding the structured information of existing systems will make

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<sup>2</sup><http://www.varldskulturmuseet.se/>

<sup>3</sup><http://www.etnografiska.se/>

<sup>4</sup><http://collections.smvk.se/pls/mm/rigby.Welcome>

<sup>5</sup><http://www.ostasiatiska.se/>

it easier to implement a standard for diverse museum resources.

According to Chenhall and Vance’s study, the most common museum artifact attributes are:

- Artifact Number
- Object Name
- Provenience – where did the object originate
- Price/Value
- Artist/Creator
- Location within the museum

In the light of this study, we examined the database of the GCM and the data values we are trying to control. As a result, we designed an ontology (see Section 3) which provides one alternative for instantiating museum data values.

## 2.1 The Gothenburg City Museum database

Relation databases (RDB) that have traditionally functioned as internal documents tailored to the needs of museum registers, conservators, curators and scientists are the primary means in which museums document their collections. A relation database provides record attributes such as object number, name, donor, condition, material, etc. to assist those who use museum collections to locate physical objects in the museum.

We have acquired a relational database from the Gothenburg City Museum. The museum relational database is centered around the museum’s collections. It consists of tables, each table corresponds to a specific collection. Tables contain record fields with information about the available data for each object in the collection. We have been experimenting with two of the database tables which correspond to two of the museum collections, i.e. Gothenburg Industry Museum (GIM) and Gothenburg Stads Museum (GSM). There are 8900 museum objects described in these database tables. Each of the database tables contains 39 record attributes for describing each object. Table 1 depicts 20 of these attributes and their data values translated to English. The complete set of record fields as they appear in the database is available in Appendix A.

The Gothenburg City Museum uses SWETERM classification system (Landahl, 1993) to document information about physical artwork objects. The Swedish classification system, although adapted after the International Committee for Documentation (CIDOC) standard, contains many concepts that are not directly available in CIDOC-CRM. For instance, there are no corresponding concepts for representing the record fields: *Value*, *Search work*, and *Method of acquisition*.



Record field	Value
Field nr.	4063
Prefix	GIM
Object nr.	8364
Search word	painting
Class nr	353532
Classification	Gothenburg portrait
Amount	1
Producer	E.Glud
Produced year	1984
Length cm	106
Width cm	78
Description	oilpainting represents a studio indoors
History	Up to 1986 belonged to Datema AB, Flöjelbergsg 8, Gbg
Material	oil colour
Current keeper	2
Location	Polstjärnegatan 4
Package nr.	299
Registration date	19930831
Signature	BI
Search field	BO:BU Bilder:TAVLOR PICT:GIM

Table 1: A painting object representation from the GCM database.

An elaborated metadata schema that captures record fields that are missing in existing standards was developed by the Swedish Open Cultural Heritage (SOCH).<sup>6</sup> SOCH is a web service used to search and fetch data from any organization that holds information related to the Swedish cultural heritage. The idea behind SOCH is to harvest any data format and structure that is used in the museum sector in Sweden and map it into SOCH’s categorization structure.

The metadata provided by SOCH helps to intermediate data between museums in Sweden and Semantic Web applications. Although the schema satisfies domain-specific requirements, it provides little support for expressing semantic knowledge. Consequently, we decided to develop an OWL ontology that combines the SOCH metadata and the CIDOC-CRM metadata standard for transforming the museum record fields into existing standards.

## 2.2 Transformation of museum data

The development of metadata standards for transforming museum data to enable distributed construction of database resources is not new (Bearman, 1995). Some experiments with cultural heritage data transformations (Cameron, 2005; Malmsten, 2008; Bryne, 2009)

<sup>6</sup><http://www.ksamsok.se/in-english/>

have showed that the process of transforming data from documentation tools to effective knowledge representation systems that are available on the Semantic Web requires an uniform, pre-defined meta model. Especially in the field of cultural heritage, and in particular museum databases, there has been recent initiatives for developing museum metadata that allows interoperability with already existing standards. The Museum Data Exchange 2010 project has developed a metadata publishing tool to extract data in XML.<sup>7</sup> Brugman et al. (2008) have developed an Annotation Meta Model providing a way of defining annotation values and anchors in an annotation for multimedia resources. Other related initiatives in the context of Semantic Web are: the Amsterdam Museum Linked Open Data project,<sup>8</sup> aiming at producing Linked Data within the Europeana data model (Dekkers et al., 2009; Haslhofer and Isaac 2011) and the National Database Project of Norwegian University Museums (Ore, 2001) who developed an unified interface for digitalizing cultural material.<sup>9</sup>

Although there exist automatic conversion tools to transform databases to Semantic Web standards, such as: R2O (Barrasa et al., 2004), Dartgrid (Wu et al., 2006) , D2RQ (Bizer and Cyganiak, 2007) and DB2OWL (Cullot et al., 2007), the complexity of developing a standard that captures the complete information of museum artifacts have led to emphasis on manual development of these specific schemas.

### 3 Modeling the Painting ontology

The domain and application specific ontology that we describe in this section represents an explicit specification of the conceptualization of paintings and painting collections. The conceptual organization of the ontology is intended to allow recording all information that is available in the history museum databases about painting objects. The objective of the model development is that physical objects in museums are sufficiently uniform that it is possible to develop standardized systems for the storage of the events surrounding objects and their representations in written records.

The painting ontology provides a model to represent and use painting objects in the framework of the Semantic Web. The purpose of the ontology is to establish a relationship between museum objects on the basis of extended museum database fields and Semantic Web ontologies. The top-level class hierarchy corresponding to basic concepts of the Painting ontology is shown in Figure 1. The painting ontology contains 197 classes, 24 stems from CRM, 15 equivalent to SOCH, and 45 equivalent to SUMO concepts, there are 107 properties, of which 17 are subproperties of the CRM properties.<sup>10</sup>

In this section we describe the ontology requirements, the development methodology, and the remaining schemas the ontology is merged with. We also illustrate how the ontology concepts are integrated with metadata terms from different models to enable interoperability and extensibility.

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<sup>7</sup><http://www.oclc.org/research/activities/museumdata/default.htm>

<sup>8</sup>[http://www.europeana.eu/portal/thoughtlab\\_linkedopendata.html](http://www.europeana.eu/portal/thoughtlab_linkedopendata.html)

<sup>9</sup><http://www.muspro.uio.no/engelsk-omM.shtml>

<sup>10</sup>The painting ontology:<http://spraakdata.gu.se/svedd/ontologies/painting/painting.owl>

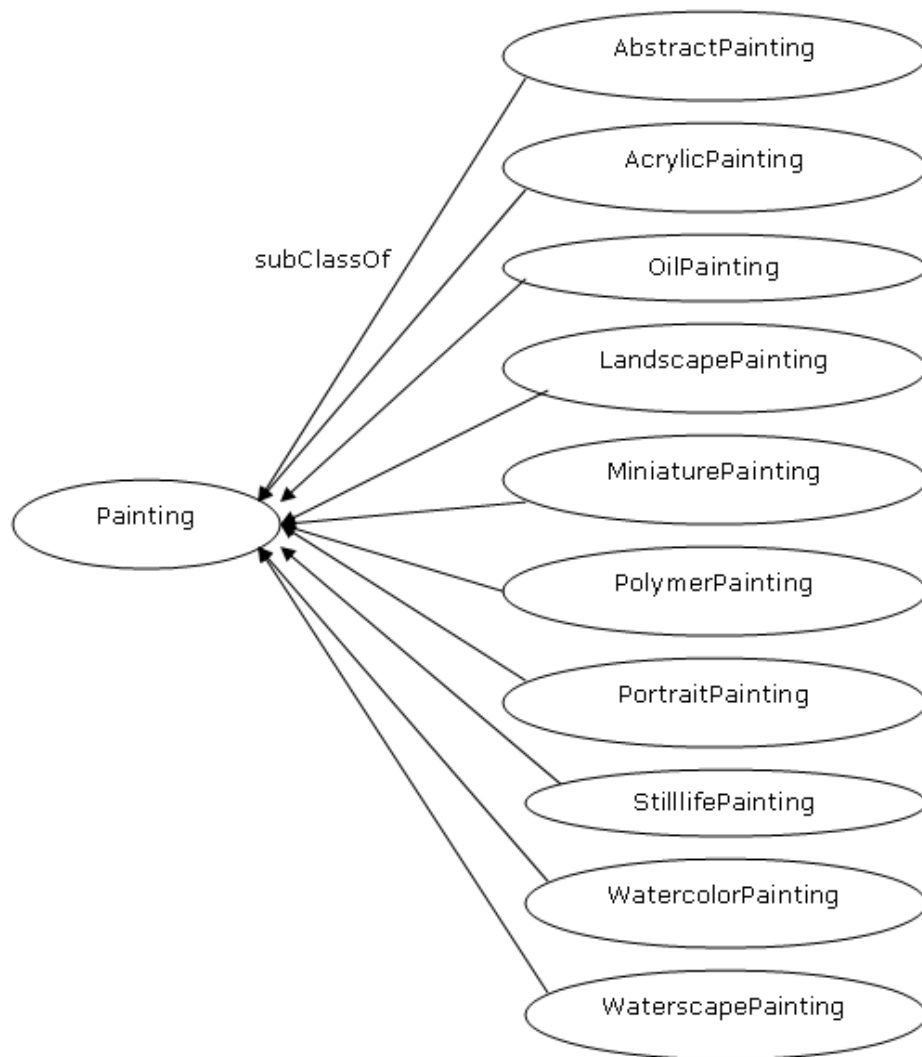


Figure 1: Top-level class hierarchy of the Painting ontology.

### 3.1 Ontology requirements

In order to delimit the scope and elicit the required features for the painting ontology, we have defined several use cases. Below we present a summary of the possible users and their needs being of relevance in the design of the painting ontology.

- The ontology should provide authors who are developing applications for information retrieval, information integration, knowledge management, e-learning etc. an off-the-shelf ontology that can be used for storage, exchange of data and reasoning;
- It will help ontologists to map, merge, match concepts and data with multiple ontologies;
- It should be flexible enough to allow grammarians to choose any content from it and realize it in natural language;
- We will provide an open content allowing any author to use and edit the ontology;
- The ontology will accommodate the many different web-browsers and ontology editors that are widely used by engineers and human editors to manipulate, edit and/or automatically extract cultural heritage content;
- It will help terminologists to develop class taxonomies and populate ontologies accordingly;
- The ontology will allow computer users and on-line museum visitors to navigate and browse for cultural heritage information using their own language.

Defining how classification schemes that describe museum collections are to be handled and standardized is an on-going integral transformative process that will allow to embrace the above user needs.

### 3.2 The ontology development methodology

The painting ontology is an application ontology. It is aligned to the domain specific CIDOC-CRM ontology which formalizes shared concepts within the CH knowledge domain. While the domain ontology supports tasks such as semantically annotating service capabilities and contents, the application ontology is designed to support integration and interoperability with other schemata. For example, the abstract classes delivered by the CIDOC-CRM cannot directly be used to document the value and current state of a specific artwork such as painting. But the generic nature of the model's classes and properties allows easy integration with additional ontology models that do support documentation of this kind of information about museum entities.

The ontology design follows the central elements in museum database including: people, places, things, and events. The main reference model of the painting ontology is the OWL 2

implementation of the CRM.<sup>11</sup> The additional models that are currently integrated in the ontology are: SOCH, Merge and Mid-Level-Ontology from SUMO.<sup>12</sup> The painting ontology was constructed manually using the Protégé editing tool.<sup>13</sup>

Integration of the ontology concepts are accomplished by using the OWL construct: *intersectionOf* as specified below. This is also illustrated in Figure 2.

```

<owl:Class rdf:about="&painting;Painting">
  <owl:equivalentClass>
    <owl:Class>
      <owl:intersectionOf rdf:parseType="Collection">
        <rdf:Description rdf:about="&ksasok;item"/>
        <rdf:Description rdf:about="&milo;PaintedPicture"/>
      </owl:intersectionOf>
    </owl:Class>
  </owl:equivalentClass>
  <rdfs:subClassOf rdf:resource="&core;E22_Man-Made_Object"/>
</owl:Class>

```

The schemas that are stated in the above example are denoted with the following prefixes: painting ontology (&painting), SOCH (&ksamsok), Mid-Level-Ontology (&milo) and CIDOC-CRM ontology (&core). In this example, the class *Painting* is defined in the painting ontology as a subclass of *E22\_Man-Made\_Object* class from the CIDOC-CRM ontology and is an intersection of two classes, i.e. *item* from the SOCH schema and *PaintedPicture* from the Mid-Level Ontology. The example above specifies that the members of the class *Painting* are those that exist as members of both *item*, and *PaintedPicture*, in other words, a painting object is a painted picture item.

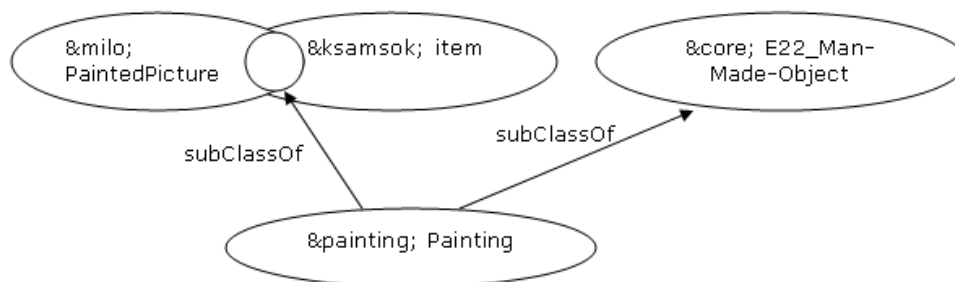


Figure 2: Integration of the painting ontology concepts with other models

Discovering correspondences between terms in different ontologies is a crucial process. Although there exists a number of tools supporting semi-automatic ontology integration (Chalupsky, 2000; Dou et al., 2002), strategies for dealing with heterogeneous concepts

<sup>11</sup><http://purl.org/NET/cidoc-crm/core>

<sup>12</sup><http://www.ontologyportal.org/>

<sup>13</sup><http://protege.stanford.edu/>

are not well developed, therefore integration processes are still largely conducted by hand. Below we specify the ontology models that are integrated with the painting ontology.

### **3.2.1 The CIDOC-CRM**

The International Committee for Documentation Conceptual Reference Model (CIDOC CRM) that was accepted by ISO in 2006 as ISO21127 (Crofts et al., 2008), is one of the most widely used standards that has been developed to facilitate the integration, mediation and interchange of heterogeneous cultural heritage information. The CIDOC-CRM class hierarchy consisting of about 90 classes and 148 properties (Doerr, Ore and Stead 2007; Doerr 2005).

The CIDOC CRM, independent of any specific application, is primarily defined as an interchange model for integrating information in the cultural heritage sector.

### **3.2.2 The Swedish Open Cultural Heritage (SOCH)**

SOCH functions as an exchange/aggregator where data from many local databases are made searchable and visible to the public and to the research community. It provides about 100 metadata elements that are used by the service.

More than 20 museums in Sweden have made their collections available through the SOCH service. By integrating the SOCH data schema in the ontological framework we gain automatic access to these collections in a semantically interoperable way.

### **3.2.3 The Suggested Upper Merged Ontology (SUMO)**

The Suggested Upper Merged Ontology (SUMO) is a general upper-level ontology which has been mapped with WordNet (Pease and Fellbaum, 2009; Niles and Pease 2003). It is based on the syntax and the semantics of the Knowledge Interchange Format (KIF).<sup>14</sup> The museum database analysis showed there is a considerable overlap with similar concepts from SUMO which links the domain specific concepts with domain independent information such as information about buildings, colors, material ect.

Linking the ontology concepts to SUMO concepts provides us not only extended knowledge about the 'world' but also access to English lexical units.

## **4 Corpus study**

This section describes the corpus analysis that was carried out as a part of the requirements for the language generation component.

The purpose of the text analysis was to identify and describe the syntactic constructions that are necessary for generating museum object descriptions. Based on these syntactic constructions, a grammar will be implemented to automatically generate these constructions from the ontology.

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<sup>14</sup><http://www.csee.umbc.edu/kse/kif/>

## 4.1 Languages and corpora

To identify the syntactic constructions that characterize the CH domain, we have collected parallel texts from Wikipedia in two languages: English and Swedish. In total, we analyzed 40 parallel texts that are available under the category *Painting*. Additionally, we performed a selection of files containing object descriptions from digital libraries that are available through museums online databases. The majority of the Swedish descriptions were taken from the World Culture Museum,<sup>15</sup> the majority of the English descriptions were collected from the Met Museum.<sup>16</sup> Table 2 provides a data statistics from these two text collections.

	English	Swedish
Number of tokens	42792	27142
Number of sentences	1877	2214
Avg. sentence length	24 (tokens)	13 (tokens)
Avg. description length	5 (sentences)	6 (sentences)

Table 2: Data statistics from the text collections.

## 4.2 Syntactic structures

A part of our study is to discover the patterns of regularity that exist in the grammatical systems of individual languages. Below we summarize some of the syntactic structures that our analysis revealed. These are the most frequent structures for describing museum objects.

### 4.2.1 English

- PN  $\rightarrow$  NP  
Van Gogh
- Det  $\rightarrow$  CN  $\rightarrow$  NP  
The portrait
- NP  $\rightarrow$  Adv  $\rightarrow$  NP  
The bell in London
- V2  $\rightarrow$  PP  $\rightarrow$  VP  
displayed at the Paris Salon  
painted by Jamie Wyeth
- V2  $\rightarrow$  Adv  $\rightarrow$  VP  
displayed here suggest the hand of an artist

<sup>15</sup>See <<http://collections.smvk.se/pls/vkm/rigby.welcome>>

<sup>16</sup>See <<http://www.metmuseum.org>>

- V2 → NP → VP  
displays painting of tulip bearing her signature

#### 4.2.2 Swedish

- PN → NP  
Van Gogh
- Det → CN → NP  
Målningen
- NP → Adv → NP  
en målning av Gustaf Cederström
- V2 → PP → VP  
återfinns på Museo Reina Sofia
- VP → Adv → VP  
finns här sedan 1967
- V2 → NP → VP  
utförd 1886 på Dalarö

### 4.3 Discourse patterns

We attempted to identify how ontology statements are aggregated in the discourse using a discourse strategy approach. A discourse strategy is an approach to text structuring through which particular organizing principles for a text are defined. This approach is based on the observation that people follow certain standard patterns of discourse organization for different discourse goals in different domains. Through linguistic analysis we observed how the domain representation is encoded in the structured object descriptions that we have collected. We then followed the discourse structure to learn how the ontology statements are composed in English and Swedish.

Below we summarize the discourse patterns and the semantic concepts that we will focus on in the generation phase. Text strings are marked with the corresponding ontology concept they are associated with in the ontology.

#### 4.3.1 English

[*PAINTING CREATOR DATE SIZE COLOR LOCATION*]

Guernica *PAINTING* was painted by Pablo Picasso *CREATOR* in 1937 *DATE*. It is of size 349 on 776 cm *SIZE* and is painted in white, black and gray *COLOR*. The painting is displayed at Museo Reina Sofia from Madrid *LOCATION*.

[*PAINTING TYPE CREATOR LOCATION DATE*]



Guernica *PAINTING* is an oil painting *TYPE* by the Spanish artist Pablo Picasso *CREATOR*. The painting was displayed at Museo Reina Sofia *LOCATION* in 1937 *DATE*.

[*PAINTING TYPE LOCATION CREATOR SIZE*]

The Last Supper *PAINTING* is a mural painting *TYPE* in Milan *LOCATION* created by Leonardo da Vinci *CREATOR*. It measures 450 on 870 centimeters *SIZE*.

[*PAINTING TYPE CREATOR PLACE DATE LOCATION*]

The Massacre *PAINTING* at Chios *LOCATION* is an oil painting *TYPE* by the French artist Eugène Delacroix *CREATOR*. The painting was completed and displayed at the Salon *PLACE* of 1824 *DATE* and presently hangs at the Musée du Louvre in Paris *LOCATION*.

[*PAINTING TYPE DATE CREATOR*]

Valdemar Atterdag holding Visby to ransom *PAINTING* is an oil on canvas, signed in 1882 *DATE* by the Swedish historical painter Carl Gustaf Hellqvist *CREATOR* (1851 – 1890).

[*PAINTING TYPE CREATOR DATE SIZE*]

Olympia *PAINTING* is an oil on canvas painting *TYPE* by Édouard Manet *CREATOR*. Painted in 1863 *DATE*, it measures 130.5 by 190 centimetres (51 x 74.8 in) *SIZE*.

#### 4.3.2 Swedish

[*PAINTING CREATOR DATE SIZE LOCATION*]

Guernica *PAINTING* är en målning av Pablo Picasso *CREATOR* från 1937 *DATE*. Målningen mäter 349 × 776 cm *SIZE*. Den återfinns numera på Museo Reina Sofía i Spaniens huvudstad Madrid *LOCATION*.

[*PAINTING TYPE LOCATION CREATOR DATE*]

Skapelsen av Adam *PAINTING* är en takfresk *TYPE* i Sixtinska kapellet *LOCATION*, målrad av Michelangelo *CREATOR* cirka 1511 *DATE*.

[*PAINTING TYPE CREATOR DATE*]

Sagoprinsessan *PAINTING* är en oljemålning *TYPE* av John Bauer *CREATOR* från 1904 *DATE*.

[*PAINTING TYPE CREATOR DATE LOCATION*]

Frälsningsarmén *PAINTING* är en målning av Gustaf Cederström *CREATOR* från 1886 *DATE*. Originalen finns på Göteborgs konstmuseum *LOCATION*.

[*PAINTING TYPE CREATOR DATE PLACE*]

Sommarnöje *PAINTING* är en akvarell *TYPE* av Anders Zorn *CREATOR*, utförd 1886 *DATE* på Dalarö *LOCATION*.

[*PAINTING TYPE DATE CREATOR LOCATION*]

Nattvarden *PAINTING* är en muralmålning *TYPE* av Leonardo da Vinci *CREATOR* cirka 1495-1498 *DATE* i klostret Santa Maria delle Grazie, Milano *LOCATION*.

[*PAINTING CREATOR DATE SIZE LOCATION*]

Segern vid Narva *PAINTING*, målning av Gustaf Cederström *CREATOR*, påbörjad 1907 *DATE*, färdigställd 1910 *DATE*. Tavlan mäter 295 × 395 cm *SIZE* och innehas av Nationalmuseum i Stockholm *LOCATION*.

## 5 Ontologies alignment and querying

As a part of the work of WP4, the group in Ontotext have constructed the Museum Reasonable View with the data from the Gothenburg City Museum database (see Section 2.1), and made it a part of the Reasonable View. The process of integrating the Gothenburg City Museum data and the Painting ontology (see Section 3) into the Museum Reasonable View is described in details in Damova (2011) and in Damova and Dannélls (2011).

### Access to the museum's data through queries

A complementary way of arriving at the museum's knowledge to through questions. Orna and Pettitt (2010) name a number of typical queries about museum collections. Below follows some query examples:

- What is in the collections ?
- Why was it collected ?
- Where did it come from ?
- Where is it now ?

The Museum Reasonable View that has been loaded in OWLIM and is being accessible via SPARQL endpoint allows to formulate these kind of queries.<sup>17</sup> A description of the complete framework including the generation process that is described in the next section is provided in Dannélls et al. (2011).

## 6 Encoding the ontologies in GF

The capabilities of GF as a host-language for ontologies were investigated in Enache and Angelov (2010), where SUMO, the largest open-source ontology was translated to GF. It was shown that the type system provides a robust framework for encoding classes, instances and relations. The same basic implementation design that was used for encoding SUMO in GF is applied in this work for encoding the CIDOC-CRM OWL 2 ontology and the

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<sup>17</sup>The access to the museum data is available from: <http://museum.ontotext.com/SPARQL>

Painting ontology. Using this implementation design, classes and sub classes are encoded as functions in the GF grammar. Ontological information about individuals (i.e, museum data values) is encoded in GF as axioms, external to the grammar functions. For example, a representation of the instance *BigGardenObj* is defined as follows:

```
fun BigGardenObj : Ind Painting ;
```

Where *Painting* was defined previously as a class and the dependent type *Ind* is used to encode class information of instances. The abstract representations of this GF implementation for the two ontologies are provided in Appendix B and C.

The remaining information about *Big Garden* from the ontology is encoded as a set of axioms with the following syntax:

```
isPaintedOn (el BigGardenObj) (el Canvas)
```

```
createdBy (el BigGardenObj)(el CarlLarsson)
```

```
hasCreationDate (el BigGardenObj) (el (year 1937))
```

The wrapper function *el* is used to make the above-mentioned coercion, where the two types, along with the inheritance object that represents the proof that the coercion is valid are not visible here, since GF features implicit arguments.

## Verbalization of the ontology axioms

GF differentiates between domain dependent and domain independent linguistic resources, as it is designed to be applicable both to natural and to formal languages. One abstract grammar can have several corresponding concrete grammars; a concrete grammar specifies how the abstract grammar rules should be linearized in a compositional manner. Multilingual functional grammatical descriptions permit the grammar to be specified at a variety of levels of abstraction, which is especially relevant for ontology verbalization.

The natural language generation implementation in GF is based on composable templates. We obtain the verbalization of classes and templates automatically, mainly based on their Camel-Case representation. Below follows a few English sentence examples that we are able to generate based on the ontology axioms:

- *Big Garden* is a painting
- *Big Garden* is painted on canvas
- *Big Garden* is painted by Carl Larsson
- *Big Garden* was created in 1937

Since the parser uses the resource library grammars, the result sentence will be syntactically correct, regardless of the arguments we use it with. To generate a coherent text that follows the discourse patterns, as specified in Section 4.2, more work is needed, since a grammatically correct verbalization is not possible based only on the ontology information.

## 7 Summary

Current data standards for storing museum information do not address all the requirements for storing information about museum objects. We observed there are some possible directions for accessing museum knowledge outside the museum application. Since we are concerned with building an application that is capable of generating natural language from existing museum knowledge, we have developed an ontology that aggregates existing metadata schemas for expressing knowledge about paintings and painting collections. Through text analysis we identified the most common syntactic constructions and discourse patterns that are relevant for generating museum object descriptions within the framework of GF.

The proposed ontology model and the museum data that we have acquired from the Gothenburg City Museum database have been integrated into the Museum Reasonable View to allow convenient querying of museum objects from multiple datasets. We have described the grammar implementation for the language generation component through which multilingual descriptions about these museum objects will be generated.

Our future work includes: translation of the museum data values, implementation of discourse patterns for English, Finnish, French, German and Swedish and evaluation of the generation results using native speakers of the language.

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## A Record fields in the GCM database

---

FALT1  
PREFIX  
FOREMALSNUMMER  
UNDERNUMMER  
SAKORD  
KLASS\_1  
KLASS\_2  
ANTAL  
TILLVERKARE  
TILLVERKNINGSTID  
MODELL\_MARKE  
TILLBEHOR  
LANGD  
BREDD  
HOJD  
DIAM  
VIKT  
BESKRIVNING  
HISTORIA  
MATERIAL  
KONSERVERING  
FORVARVAT\_FRAN  
FORVARVSDATUM  
TIDIGARE\_INVENTARIENUMMER  
PLACERING  
KOLLINUMMER  
NEGATIVNUMMER  
BILAGOR  
REGISTRERINGSDATUM  
SIGNATUR  
FALTANDRING\_SENASTE\_INVENTERINGSDATUM  
STOLDBEGARLIGHET  
FORSAKRINGSVARDE  
SAMTIDIGT\_FORVARVAT  
FOTOGRAFERINGSDATUM  
FALT35  
FALT36  
BILSOKFALT

---

## B The CIDOC-CRM OWL 2 in GF

```
abstract Cidoc = Basic ** {  
  
  cat CRM_Literal ;  
  
  -----  
  -- CONCEPTS  
  -----  
  
  fun E1_CRM_Entity : Class ;  
  fun E2_Temporal_Entity : Class ;  
  fun E2_Temporal_Entity_Class : SubClass E2_Temporal_Entity E1_CRM_Entity ;  
  fun E3_Condition_State : Class ;  
  fun E3_Condition_State_Class : SubClass E3_Condition_State E2_Temporal_Entity ;  
  fun E4_Period : Class ;  
  fun E4_Period_Class : SubClass E4_Period E2_Temporal_Entity ;  
  fun E5_Event : Class ;  
  fun E5_Event_Class : SubClass E5_Event E4_Period ;  
  fun E6_Destruction : Class ;  
  fun E6_Destruction_Class : SubClass E6_Destruction E64_End_of_Existence ;  
  fun E7_Activity : Class ;  
  fun E7_Activity_Class : SubClass E7_Activity E5_Event ;  
  fun E8_Acquisition : Class ;  
  fun E8_Acquisition_Class : SubClass E8_Acquisition E7_Activity ;  
  fun E9_Move : Class ;  
  fun E9_Move_Class : SubClass E9_Move E7_Activity ;  
  fun E10_Transfer_of_Custody : Class ;  
  fun E10_Transfer_of_Custody_Class : SubClass E10_Transfer_of_Custody E7_Activity ;  
  fun E11_Modification : Class ;  
  fun E11_Modification_Class : SubClass E11_Modification E7_Activity ;  
  fun E12_Production : Class ;  
  fun E12_Production_Class : SubClass E12_Production (both E11_Modification E63_Beginning_of_Existence) ;  
  fun E13_Attribute_Assignment : Class ;  
  fun E13_Attribute_Assignment_Class : SubClass E13_Attribute_Assignment E7_Activity ;  
  fun E14_Condition_Assessment : Class ;  
  fun E14_Condition_Assessment_Class : SubClass E14_Condition_Assessment E13_Attribute_Assignment ;  
  fun E15_Identifier_Assignment : Class ;  
  fun E15_Identifier_Assignment_Class : SubClass E15_Identifier_Assignment E13_Attribute_Assignment ;  
  fun E16_Measurement : Class ;  
  fun E16_Measurement_Class : SubClass E16_Measurement E13_Attribute_Assignment ;  
  fun E17_Type_Assignment : Class ;  
  fun E17_Type_Assignment_Class : SubClass E17_Type_Assignment E13_Attribute_Assignment ;  
  fun E18_Physical_Thing : Class ;  
  fun E18_Physical_Thing_Class : SubClass E18_Physical_Thing E72_Legal_Object ;  
  fun E19_Physical_Object : Class ;  
  fun E19_Physical_Object_Class : SubClass E19_Physical_Object E18_Physical_Thing ;  
  fun E20_Biological_Object : Class ;  
  fun E20_Biological_Object_Class : SubClass E20_Biological_Object E19_Physical_Object ;  
  fun E21_Person : Class ;  
  fun E21_Person_Class : SubClass E21_Person (both E20_Biological_Object E39_Actor) ;  
  fun E22_Man_Made_Object : Class ;  
  fun E22_Man_Made_Object_Class : SubClass E22_Man_Made_Object (both E19_Physical_Object E24_Physical_Man_Made_Thing) ;  
  fun E24_Physical_Man_Made_Thing : Class ;  
  fun E24_Physical_Man_Made_Thing_Class : SubClass E24_Physical_Man_Made_Thing (both E18_Physical_Thing E71_Man_Made_Thing) ;  
  fun E25_Man_Made_Feature : Class ;  
  fun E25_Man_Made_Feature_Class : SubClass E25_Man_Made_Feature (both E24_Physical_Man_Made_Thing E26_Physical_Feature) ;  
  fun E26_Physical_Feature : Class ;  
  fun E26_Physical_Feature_Class : SubClass E26_Physical_Feature E18_Physical_Thing ;  
  fun E27_Site : Class ;  
  fun E27_Site_Class : SubClass E27_Site E26_Physical_Feature ;  
  fun E28_Conceptual_Object : Class ;  
  fun E28_Conceptual_Object_Class : SubClass E28_Conceptual_Object E71_Man_Made_Thing ;  
  fun E29_Design_or_Procedure : Class ;  
  fun E29_Design_or_Procedure_Class : SubClass E29_Design_or_Procedure E73_Information_Object ;  
  fun E30_Right : Class ;  
  fun E30_Right_Class : SubClass E30_Right E89_Propositional_Object ;  
  fun E31_Document : Class ;  
  fun E31_Document_Class : SubClass E31_Document E73_Information_Object ;  
  fun E32_Authority_Document : Class ;  
  fun E32_Authority_Document_Class : SubClass E32_Authority_Document E31_Document ;  
  fun E33_Linguistic_Object : Class ;  
  fun E33_Linguistic_Object_Class : SubClass E33_Linguistic_Object E73_Information_Object ;  
  fun E34_Inscription : Class ;  
  fun E34_Inscription_Class : SubClass E34_Inscription (both E33_Linguistic_Object E37_Mark) ;  
  fun E35_Title : Class ;  
  fun E35_Title_Class : SubClass E35_Title (both E33_Linguistic_Object E41_Appellation) ;  
  fun E36_Visual_Item : Class ;  
  fun E36_Visual_Item_Class : SubClass E36_Visual_Item E73_Information_Object ;  
  fun E37_Mark : Class ;  
  fun E37_Mark_Class : SubClass E37_Mark E36_Visual_Item ;  
  fun E38_Image : Class ;  
  fun E38_Image_Class : SubClass E38_Image E36_Visual_Item ;  
  fun E39_Actor : Class ;  
  fun E39_Actor_Class : SubClass E39_Actor E77_Persistent_Item ;  
  fun E40_Legal_Body : Class ;  
  fun E40_Legal_Body_Class : SubClass E40_Legal_Body E74_Group ;
```



```

fun E41_Appellation : Class ;
fun E41_Appellation_Class : SubClass E41_Appellation E90_Symbolic_Object ;
fun E42_Identifier : Class ;
fun E42_Identifier_Class : SubClass E42_Identifier E41_Appellation ;
fun E44_Place_Appellation : Class ;
fun E44_Place_Appellation_Class : SubClass E44_Place_Appellation E41_Appellation ;
fun E45_Address : Class ;
fun E45_Address_Class : SubClass E45_Address (both E44_Place_Appellation E51_Contact_Point) ;
fun E46_Section_Definition : Class ;
fun E46_Section_Definition_Class : SubClass E46_Section_Definition E44_Place_Appellation ;
fun E47_Spatial_Coordinates : Class ;
fun E47_Spatial_Coordinates_Class : SubClass E47_Spatial_Coordinates E44_Place_Appellation ;
fun E49_Time_Appellation : Class ;
fun E49_Time_Appellation_Class : SubClass E49_Time_Appellation E41_Appellation ;
fun E50_Date : Class ;
fun E50_Date_Class : SubClass E50_Date E49_Time_Appellation ;
fun E51_Contact_Point : Class ;
fun E51_Contact_Point_Class : SubClass E51_Contact_Point E41_Appellation ;
fun E52_Time_Span : Class ;
fun E52_Time_Span_Class : SubClass E52_Time_Span E1_CRM_Entity ;
fun E53_Place : Class ;
fun E53_Place_Class : SubClass E53_Place E1_CRM_Entity ;
fun E54_Dimension : Class ;
fun E54_Dimension_Class : SubClass E54_Dimension E1_CRM_Entity ;
fun E55_Type : Class ;
fun E55_Type_Class : SubClass E55_Type E28_Conceptual_Object ;
fun E56_Language : Class ;
fun E56_Language_Class : SubClass E56_Language E55_Type ;
fun E57_Material : Class ;
fun E57_Material_Class : SubClass E57_Material E55_Type ;
fun E58_Measurement_Unit : Class ;
fun E58_Measurement_Unit_Class : SubClass E58_Measurement_Unit E55_Type ;
fun E63_Beginning_of_Existence : Class ;
fun E63_Beginning_of_Existence_Class : SubClass E63_Beginning_of_Existence E5_Event ;
fun E64_End_of_Existence : Class ;
fun E64_End_of_Existence_Class : SubClass E64_End_of_Existence E5_Event ;
fun E65_Creation : Class ;
fun E65_Creation_Class : SubClass E65_Creation (both E63_Beginning_of_Existence E7_Activity) ;
fun E66_Formation : Class ;
fun E66_Formation_Class : SubClass E66_Formation (both E63_Beginning_of_Existence E7_Activity) ;
fun E67_Birth : Class ;
fun E67_Birth_Class : SubClass E67_Birth E63_Beginning_of_Existence ;
fun E68_Dissolution : Class ;
fun E68_Dissolution_Class : SubClass E68_Dissolution E64_End_of_Existence ;
fun E69_Death : Class ;
fun E69_Death_Class : SubClass E69_Death E64_End_of_Existence ;
fun E70_Thing : Class ;
fun E70_Thing_Class : SubClass E70_Thing E77_Persistent_Item ;
fun E71_Man_Made_Thing : Class ;
fun E71_Man_Made_Thing_Class : SubClass E71_Man_Made_Thing E70_Thing ;
fun E72_Legal_Object : Class ;
fun E72_Legal_Object_Class : SubClass E72_Legal_Object E70_Thing ;
fun E73_Information_Object : Class ;
fun E73_Information_Object_Class : SubClass E73_Information_Object (both E89_Propositional_Object E90_Symbolic_Object) ;
fun E74_Group : Class ;
fun E74_Group_Class : SubClass E74_Group (both E39_Actor E40_Legal_Body) ;
fun E75_Conceptual_Object_Appellation : Class ;
fun E75_Conceptual_Object_Appellation_Class : SubClass E75_Conceptual_Object_Appellation E41_Appellation ;
fun E77_Persistent_Item : Class ;
fun E77_Persistent_Item_Class : SubClass E77_Persistent_Item E1_CRM_Entity ;
fun E78_Collection : Class ;
fun E78_Collection_Class : SubClass E78_Collection E24_Physical_Man_Made_Thing ;
fun E79_Part_Addition : Class ;
fun E79_Part_Addition_Class : SubClass E79_Part_Addition E11_Modification ;
fun E80_Part_Removal : Class ;
fun E80_Part_Removal_Class : SubClass E80_Part_Removal E11_Modification ;
fun E81_Transformation : Class ;
fun E81_Transformation_Class : SubClass E81_Transformation (both E63_Beginning_of_Existence E64_End_of_Existence) ;
fun E82_Actor_Appellation : Class ;
fun E82_Actor_Appellation_Class : SubClass E82_Actor_Appellation E41_Appellation ;
fun E83_Type_Creation : Class ;
fun E83_Type_Creation_Class : SubClass E83_Type_Creation E65_Creation ;
fun E84_Information_Carrier : Class ;
fun E84_Information_Carrier_Class : SubClass E84_Information_Carrier E22_Man_Made_Object ;
fun E85_Joining : Class ;
fun E85_Joining_Class : SubClass E85_Joining E7_Activity ;
fun E86_Leaving : Class ;
fun E86_Leaving_Class : SubClass E86_Leaving E7_Activity ;
fun E87_Curation_Activity : Class ;
fun E87_Curation_Activity_Class : SubClass E87_Curation_Activity E7_Activity ;
fun E89_Propositional_Object : Class ;
fun E89_Propositional_Object_Class : SubClass E89_Propositional_Object E28_Conceptual_Object ;
fun E90_Symbolic_Object : Class ;
fun E90_Symbolic_Object_Class : SubClass E90_Symbolic_Object (both E28_Conceptual_Object E72_Legal_Object) ;

-----
-- RELATIONS :
-----

```

```

fun P1_is_identified_by : El E1_CRM_Entity -> El E41_Appellation -> Formula ;
fun P2_has_type : El E1_CRM_Entity -> El E55_Type -> Formula ;
fun P3_has_note : El E52_Time_Span -> CRM_Literal -> Formula ;
fun P4_has_time_span : El E2_Temporal_Entity -> El E52_Time_Span -> Formula ;
fun P5_consists_of : El E3_Condition_State -> El E3_Condition_State -> Formula ;
fun P7_took_place_at : El E4_Period -> El E53_Place -> Formula ;
fun P8_took_place_on_or_within : El E4_Period -> El E19_Physical_Object -> Formula ;
fun P9_consists_of : El E4_Period -> El E4_Period -> Formula ;
fun P10_falls_within : El E4_Period -> El E4_Period -> Formula ;
fun P11_had_participant : El E5_Event -> El E39_Actor -> Formula ;
fun P12_occurred_in_the_presence_of : El E5_Event -> El E77_Persistent_Item -> Formula ;
fun P13_destroyed : El E6_Destruction -> El E18_Physical_Thing -> Formula ;
fun P14_carried_out_by : El E7_Activity -> El E39_Actor -> Formula ;
fun P15_was_influenced_by : El E7_Activity -> El E1_CRM_Entity -> Formula ;
fun P16_used_specific_object : El E5_Event -> El E70_Thing -> Formula ;
fun P17_was_motivated_by : El E7_Activity -> El E1_CRM_Entity -> Formula ;
fun P19_was_intended_use_of : El E7_Activity -> El E71_Man_Made_Thing -> Formula ;
fun P20_had_specific_purpose : El E7_Activity -> El E5_Event -> Formula ;
fun P21_had_general_purpose : El E7_Activity -> El E55_Type -> Formula ;
fun P22_transferred_title_to : El E8_Acquisition -> El E39_Actor -> Formula ;
fun P23_transferred_title_from : El E8_Acquisition -> El E39_Actor -> Formula ;
fun P24_transferred_title_of : El E8_Acquisition -> El E18_Physical_Thing -> Formula ;
fun P25_moved : El E9_Move -> El E19_Physical_Object -> Formula ;
fun P26_moved_to : El E9_Move -> El E53_Place -> Formula ;
fun P27_moved_from : El E9_Move -> El E53_Place -> Formula ;
fun P28_custody_surrendered_by : El E10_Transfer_of_Custody -> El E39_Actor -> Formula ;
fun P29_custody_received_by : El E10_Transfer_of_Custody -> El E39_Actor -> Formula ;
fun P30_transferred_custody_of : El E10_Transfer_of_Custody -> El E18_Physical_Thing -> Formula ;
fun P31_has_modified : El E11_Modification -> El E24_Physical_Man_Made_Thing -> Formula ;
fun P32_used_general_technique : El E7_Activity -> El E55_Type -> Formula ;
fun P33_used_specific_technique : El E5_Event -> El E29_Design_or_Procedure -> Formula ;
fun P34_concerned : El E14_Condition_Assessment -> El E18_Physical_Thing -> Formula ;
fun P35_has_identified : El E14_Condition_Assessment -> El E3_Condition_State -> Formula ;
fun P37_assigned : El E15_Identifier_Assignment -> El E42_Identifier -> Formula ;
fun P38_deassigned : El E15_Identifier_Assignment -> El E42_Identifier -> Formula ;
fun P39_measured : El E16_Measurement -> El E1_CRM_Entity -> Formula ;
fun P40_observed_dimension : El E16_Measurement -> El E54_Dimension -> Formula ;
fun P41_classified : El E17_Type_Assignment -> El E1_CRM_Entity -> Formula ;
fun P42_assigned : El E17_Type_Assignment -> El E55_Type -> Formula ;
fun P43_has_dimension : El E70_Thing -> El E54_Dimension -> Formula ;
fun P44_has_condition : El E18_Physical_Thing -> El E3_Condition_State -> Formula ;
fun P45_consists_of : El E18_Physical_Thing -> El E57_Material -> Formula ;
fun P46_is_composed_of : El E18_Physical_Thing -> El E18_Physical_Thing -> Formula ;
fun P48_has_preferred_identifier : El E1_CRM_Entity -> El E42_Identifier -> Formula ;
fun P49_has_former_or_current_keeper : El E18_Physical_Thing -> El E39_Actor -> Formula ;
fun P50_has_current_keeper : El E18_Physical_Thing -> El E39_Actor -> Formula ;
fun P51_has_former_or_current_owner : El E18_Physical_Thing -> El E39_Actor -> Formula ;
fun P52_has_current_owner : El E18_Physical_Thing -> El E39_Actor -> Formula ;
fun P53_has_former_or_current_location : El E18_Physical_Thing -> El E53_Place -> Formula ;
fun P54_has_current_permanent_location : El E19_Physical_Object -> El E53_Place -> Formula ;
fun P55_has_current_location : El E19_Physical_Object -> El E53_Place -> Formula ;
fun P56_bears_feature : El E19_Physical_Object -> El E26_Physical_Feature -> Formula ;
fun P56_has_number_of_parts : El E19_Physical_Object -> CRM_Literal -> Formula ;
fun P58_has_section_definition : El E18_Physical_Thing -> El E46_Section_Definition -> Formula ;
fun P59_has_section : El E18_Physical_Thing -> El E53_Place -> Formula ;
fun P62_depicts : El E24_Physical_Man_Made_Thing -> El E1_CRM_Entity -> Formula ;
fun P65_shows_visual_item : El E24_Physical_Man_Made_Thing -> El E36_Visual_Item -> Formula ;
fun P67_refers_to : El E89_Propositional_Object -> El E1_CRM_Entity -> Formula ;
fun P68_foresees_use_of : El E29_Design_or_Procedure -> El E57_Material -> Formula ;
fun P69_is_associated_with : El E29_Design_or_Procedure -> El E29_Design_or_Procedure -> Formula ;
fun P70_documents : El E31_Document -> El E1_CRM_Entity -> Formula ;
fun P71_lists : El E32_Authority_Document -> El E55_Type -> Formula ;
fun P72_has_language : El E33_Linguistic_Object -> El E56_Language -> Formula ;
fun P73_has_translation : El E33_Linguistic_Object -> El E33_Linguistic_Object -> Formula ;
fun P74_has_current_or_former_residence : El E39_Actor -> El E53_Place -> Formula ;
fun P75_possesses : El E39_Actor -> El E30_Right -> Formula ;
fun P76_has_contact_point : El E39_Actor -> El E51_Contact_Point -> Formula ;
fun P78_is_identified_by : El E52_Time_Span -> El E49_Time_Appellation -> Formula ;
fun P79_beginning_is_qualified_by : El E52_Time_Span -> CRM_Literal -> Formula ;
fun P80_end_is_qualified_by : El E52_Time_Span -> CRM_Literal -> Formula ;
fun P81_ongoing_throughout : El E52_Time_Span -> CRM_Literal -> Formula ;
fun P82_at_some_time_within : El E52_Time_Span -> CRM_Literal -> Formula ;
fun P83_had_at_least_duration : El E52_Time_Span -> El E54_Dimension -> Formula ;
fun P84_had_at_most_duration : El E52_Time_Span -> El E54_Dimension -> Formula ;
fun P86_falls_within : El E52_Time_Span -> El E52_Time_Span -> Formula ;
fun P87_is_identified_by : El E53_Place -> El E44_Place_Appellation -> Formula ;
fun P88_consists_of : El E53_Place -> El E53_Place -> Formula ;
fun P89_falls_within : El E53_Place -> El E53_Place -> Formula ;
fun P90_has_value : El E54_Dimension -> CRM_Literal -> Formula ;
fun P91_has_unit : El E54_Dimension -> El E58_Measurement_Unit -> Formula ;
fun P92_brought_into_existence : El E63_Beginning_of_Existence -> El E77_Persistent_Item -> Formula ;
fun P93_took_out_of_existence : El E64_End_of_Existence -> El E77_Persistent_Item -> Formula ;
fun P94_has_created : El E65_Creation -> El E28_Conceptual_Object -> Formula ;
fun P95_has_formed : El E66_Formation -> El E74_Group -> Formula ;
fun P96_by_mother : El E67_Birth -> El E21_Person -> Formula ;
fun P97_from_father : El E67_Birth -> El E21_Person -> Formula ;
fun P98_brought_into_life : El E67_Birth -> El E21_Person -> Formula ;

```

```

fun P99_dissolved : El E68_Dissolution -> El E74_Group -> Formula ;
fun P100_was_death_of : El E69_Death -> El E21_Person -> Formula ;
fun P101_had_as_general_use : El E70_Thing -> El E55_Type -> Formula ;
fun P102_has_title : El E71_Man_Made_Thing -> El E35_Title -> Formula ;
fun P103_was_intended_for : El E71_Man_Made_Thing -> El E55_Type -> Formula ;
fun P104_is_subject_to : El E72_Legal_Object -> El E30_Right -> Formula ;
fun P105_right_held_by : El E72_Legal_Object -> El E39_Actor -> Formula ;
fun P106_is_composed_of : El E90_Symbolic_Object -> El E90_Symbolic_Object -> Formula ;
fun P107_has_current_or_former_member : El E74_Group -> El E39_Actor -> Formula ;
fun P108_has_produced : El E12_Production -> El E77_Persistent_Item -> Formula ;
fun P109_has_current_or_former_curator : El E78_Collection -> El E39_Actor -> Formula ;
fun P110_augmented : El E79_Part_Addition -> El E24_Physical_Man_Made_Thing -> Formula ;
fun P111_added : El E79_Part_Addition -> El E18_Physical_Thing -> Formula ;
fun P112_diminished : El E80_Part_Removal -> El E18_Physical_Thing -> Formula ;
fun P113_removed : El E80_Part_Removal -> El E18_Physical_Thing -> Formula ;
fun P114_is_equal_in_time_to : El E2_Temporal_Entity -> El E2_Temporal_Entity -> Formula ;
fun P115_finishes : El E2_Temporal_Entity -> El E2_Temporal_Entity -> Formula ;
fun P116_starts : El E2_Temporal_Entity -> El E2_Temporal_Entity -> Formula ;
fun P117_occurs_during : El E2_Temporal_Entity -> El E2_Temporal_Entity -> Formula ;
fun P118_overlaps_in_time_with : El E2_Temporal_Entity -> El E2_Temporal_Entity -> Formula ;
fun P119_meets_in_time_with : El E2_Temporal_Entity -> El E2_Temporal_Entity -> Formula ;
fun P120_occurs_before : El E2_Temporal_Entity -> El E2_Temporal_Entity -> Formula ;
fun P121_overlaps_with : El E53_Place -> El E53_Place -> Formula ;
fun P122_borders_with : El E53_Place -> El E53_Place -> Formula ;
fun P123_resulted_in : El E81_Transformation -> El E77_Persistent_Item -> Formula ;
fun P124_transformed : El E81_Transformation -> El E77_Persistent_Item -> Formula ;
fun P125_used_object_of_type : El E7_Activity -> El E55_Type -> Formula ;
fun P126_employed : El E11_Modification -> El E57_Material -> Formula ;
fun P127_has_broader_term : El E55_Type -> El E55_Type -> Formula ;
fun P128_carries : El E24_Physical_Man_Made_Thing -> El E73_Information_Object -> Formula ;
fun P129_is_about : El E89_Propositional_Object -> El E1_CRM_Entity -> Formula ;
fun P130_shows_features_of : El E70_Thing -> El E70_Thing -> Formula ;
fun P131_is_identified_by : El E39_Actor -> El E82_Actor_Appellation -> Formula ;
fun P132_overlaps_with : El E4_Period -> El E4_Period -> Formula ;
fun P133_is_separated_from : El E4_Period -> El E4_Period -> Formula ;
fun P134_continued : El E7_Activity -> El E7_Activity -> Formula ;
fun P135_created_type : El E83_Type_Creation -> El E55_Type -> Formula ;
fun P136_was_based_on : El E83_Type_Creation -> El E1_CRM_Entity -> Formula ;
fun P137_exemplifies : El E1_CRM_Entity -> El E55_Type -> Formula ;
fun P138_represents : El E36_Visual_Item -> El E1_CRM_Entity -> Formula ;
fun P139_has_alternative_form : El E41_Appellation -> El E41_Appellation -> Formula ;
fun P140_assigned_attribute_to : El E13_Attribute_Assignment -> El E1_CRM_Entity -> Formula ;
fun P141_assigned : El E13_Attribute_Assignment -> El E1_CRM_Entity -> Formula ;
fun P142_used_constituent : El E15_Identifier_Assignment -> El E41_Appellation -> Formula ;
fun P143_joined : El E85_Joining -> El E39_Actor -> Formula ;
fun P144_joined_with : El E85_Joining -> El E74_Group -> Formula ;
fun P145_separated : El E86_Leaving -> El E39_Actor -> Formula ;
fun P146_separated_from : El E86_Leaving -> El E74_Group -> Formula ;
fun P147_curated : El E87_Curation_Activity -> El E78_Collection -> Formula ;
fun P148_has_component : El E89_Propositional_Object -> El E89_Propositional_Object -> Formula ;
}

```

## C The Painting ontology in GF

```
abstract Painting =
  Basic **
  open (C=Cidoc),
        (ML=MidLevelOntology),
        (S=Merge )
  in {

-----
-- CONCEPTS
-----

fun Resurser_place : Class ;
fun Resurser_collection : Class ;
fun Resurser_item : Class ;
fun Resurser_itemClass : Class ;
fun Resurser_itemColor : Class ;
fun Resurser_itemDescription : Class ;
fun Resurser_itemMaterial : Class ;
fun Resurser_itemMeasurement : Class ;
fun Resurser_itemName : Class ;
fun Resurser_itemNumber : Class ;
fun Resurser_itemTechnique : Class ;
fun Resurser_itemTitle : Class ;
fun Resurser_nameAuth : Class ;
fun Presentation_OrganizationShort : Class ;
fun MidLevelOntology_OilMedium : Class ;
fun S_Abstract_Class : SubClass S.Abstract Painting_RepresentedEntity ;
fun SUMO_Causes : Class ;
fun SUMO_Causes_Class : SubClass SUMO_Causes Painting_Purpose ;
fun S_Communication_Class : SubClass S.Communication Painting_Purpose ;
fun S_ContentDevelopment_Class : SubClass S.ContentDevelopment Painting_Purpose ;
fun S_Directing_Class : SubClass S.Directing Painting_Purpose ;
fun S_EducationalProcess_Class : SubClass S.EducationalProcess Painting_Purpose ;
fun S_Foot : Class ;
fun S_Foot_Class : SubClass S.Foot Painting_UnitOfMeasure ;
fun S_FruitOrVegetable_Class : SubClass S.FruitOrVegetable Painting_ConcreteThing ;
fun S_GraphArc_Class : SubClass S.GraphArc S.GraphElement ;
fun S_GraphElement_Class : SubClass S.GraphElement S.Abstract ;
fun S_IntentionalProcess_Class : SubClass S.IntentionalProcess S.Process ;
fun S_IntentionalPsychologicalProcess_Class : SubClass S.IntentionalPsychologicalProcess Painting_Purpose ;
fun S_LandArea_Class : SubClass S.LandArea Painting_ConcreteThing ;
fun S_Man_Class : SubClass S.Man S.Human ;
fun S_Process_Class : SubClass S.Process Painting_RepresentedEntity ;
fun S_StateChange_Class : SubClass S.StateChange Painting_RepresentedEntity ;
fun S_SubjectiveAssessmentAttribute_Class : SubClass S.SubjectiveAssessmentAttribute Painting_PaintingDescriptor ;
fun S_Substituting_Class : SubClass S.Substituting Painting_Purpose ;
fun S_UnilateralGiving_Class : SubClass S.UnilateralGiving Painting_Purpose ;
fun S_WaterArea_Class : SubClass S.WaterArea Painting_ConcreteThing ;
fun S_Woman_Class : SubClass S.Woman S.Human ;
fun Painting_AbstractPainting : Class ;
fun Painting_AcrylicMedium : Class ;
fun Painting_AcrylicPainting : Class ;
fun Painting_Artwork : Class ;
fun Painting_BarkPainting : Class ;
fun Painting_Birth : Class ;
fun Painting_Bottle : Class ;
fun Painting_Bottle_Class : SubClass Painting_Bottle Painting_ConcreteThing ;
fun Painting_ChinaPainting : Class ;
fun Painting_Collection : Class ;
fun Painting_Collector : Class ;
fun Painting_Collector_Class : SubClass Painting_Collector Painting_Human ;
fun Painting_Color : Class ;
fun Painting_Color_Class : SubClass Painting_Color Painting_PaintingDescriptor ;
fun Painting_ColorAttribute : Class ;
fun Painting_ColorAttribute_Class : SubClass Painting_ColorAttribute S.SubjectiveAssessmentAttribute ;
fun Painting_ConcreteThing : Class ;
fun Painting_ConcreteThing_Class : SubClass Painting_ConcreteThing Painting_RepresentedEntity ;
fun Painting_CottonFabric : Class ;
fun Painting_CottonFabric_Class : SubClass Painting_CottonFabric Painting_Fabric ;
fun Painting_Device : Class ;
fun Painting_Dimension : Class ;
fun Painting_Document : Class ;
fun Painting_EncausticPainting : Class ;
fun Painting_Exhibition : Class ;
fun Painting_Fabric : Class ;
fun Painting_Fabric_Class : SubClass Painting_Fabric Painting_SurfaceMaterial ;
fun Painting_Flower : Class ;
fun Painting_Flower_Class : SubClass Painting_Flower Painting_ConcreteThing ;
fun Painting_Gallery : Class ;
fun Painting_Gallery_Class : SubClass Painting_Gallery Painting_Place ;
fun Painting_Glass : Class ;
fun Painting_Glass_Class : SubClass Painting_Glass Painting_SurfaceMaterial ;
fun Painting_GroupPortrait : Class ;
fun Painting_Human : Class ;
```

```

fun Painting_IdentifierType : Class ;
fun Painting_King : Class ;
fun Painting_King_Class : SubClass Painting_King Painting_Human ;
fun Painting_LandscapePainting : Class ;
fun Painting_Material : Class ;
fun Painting_Measure : Class ;
fun Painting_Measure_Class : SubClass Painting_Measure C.E55_Type ;
fun Painting_Medieval : Class ;
fun Painting_Medium : Class ;
fun Painting_Miniaturist : Class ;
fun Painting_Miniaturist_Class : SubClass Painting_Miniaturist Painting_Human ;
fun Painting_Modern : Class ;
fun Painting_Museum : Class ;
fun Painting_Museum_Class : SubClass Painting_Museum Painting_Organization ;
fun Painting_MuseumBuilding : Class ;
fun Painting_MuseumBuilding_Class : SubClass Painting_MuseumBuilding Painting_Place ;
fun Painting_NameType : Class ;
fun Painting_Nationality : Class ;
fun Painting_ObjectName : Class ;
fun Painting_OilPainting : Class ;
fun Painting_Organization : Class ;
fun Painting_OrganizationAbbreviation : Class ;
fun Painting_PWN_LU : Class ;
fun Painting_PWN_LU_Class : SubClass Painting_PWN_LU Painting_WordSense ;
fun Painting_Paint : Class ;
fun Painting_Paint_Class : SubClass Painting_Paint Painting_Material ;
fun Painting_Painter : Class ;
fun Painting_Painter_Class : SubClass Painting_Painter Painting_Human ;
fun Painting_Painting : Class ;
fun Painting_PaintingDescriptor : Class ;
fun Painting_PaintingStyle : Class ;
fun Painting_PaintingStyle_Class : SubClass Painting_PaintingStyle Painting_PaintingDescriptor ;
fun Painting_PaintingTechnique : Class ;
fun Painting_Paper : Class ;
fun Painting_Paper_Class : SubClass Painting_Paper Painting_SurfaceMaterial ;
fun Painting_Place : Class ;
fun Painting_PlaceAppellation : Class ;
fun Painting_PlaceAppellation_Class : SubClass Painting_PlaceAppellation C.E44_Place_Appellation ;
fun Painting_PlaceCoordinates : Class ;
fun Painting_PlantMaterial : Class ;
fun Painting_PlantMaterial_Class : SubClass Painting_PlantMaterial Painting_SurfaceMaterial ;
fun Painting_Point : Class ;
fun Painting_PolymerPainting : Class ;
fun Painting_PortraitPainting : Class ;
fun Painting_Purpose : Class ;
fun Painting_Reference : Class ;
fun Painting_Reference_Class : SubClass Painting_Reference Painting_PaintingDescriptor ;
fun Painting_Region : Class ;
fun Painting_RepresentedEntity : Class ;
fun Painting_Saldo_LU : Class ;
fun Painting_Saldo_LU_Class : SubClass Painting_Saldo_LU Painting_WordSense ;
fun Painting_SelfPortrait : Class ;
fun Painting_Signature : Class ;
fun Painting_Silk : Class ;
fun Painting_Silk_Class : SubClass Painting_Silk Painting_Fabric ;
fun Painting_StateOfObject : Class ;
fun Painting_StateOfRepresented : Class ;
fun Painting_StillLifePainting : Class ;
fun Painting_SurfaceMaterial : Class ;
fun Painting_SurfaceMaterial_Class : SubClass Painting_SurfaceMaterial Painting_Material ;
fun Painting_ThematicCategory : Class ;
fun Painting_ThematicCategory_Class : SubClass Painting_ThematicCategory C.E55_Type ;
fun Painting_TimePeriod : Class ;
fun Painting_Title : Class ;
fun Painting_UniqueIdentifier : Class ;
fun Painting_UnitOfMeasure : Class ;
fun Painting_University : Class ;
fun Painting_University_Class : SubClass Painting_University Painting_Organization ;
fun Painting_VisualItem : Class ;
fun Painting_WatercolorPainting : Class ;
fun Painting_WaterscapePainting : Class ;
fun Painting_Wood : Class ;
fun Painting_Wood_Class : SubClass Painting_Wood Painting_SurfaceMaterial ;
fun Painting_WordSense : Class ;
fun Painting_Year : Class ;
fun GeoF_country : Class ;
fun GeoF_municipality : Class ;
fun GeoF_Year : Class ;
fun Owl_Thing : Class ;

-----
-- RELATIONS :
-----

fun R_coordinates : El Painting_Place -> El Painting_PlaceCoordinates -> Formula ;
fun Painting_depicts : El Painting_Painting -> El Painting_RepresentedEntity -> Formula ;
fun Painting_assignedAttributeBy : El S.SubjectiveAssessmentAttribute -> El Painting_Human -> Formula ;
fun Painting_belongsTo : El Painting_Painting -> El Painting_Collection -> Formula ;

```

```

fun Painting_bought : El Painting_Human -> El Painting_Painting -> Formula ;
fun Painting_broughtIntoLife : El Painting_Birth -> El Painting_Human -> Formula ;
fun Painting_createdBy : El Painting_Artwork -> El Painting_Human -> Formula ;
fun Painting_currentOwnerOf : El Painting_Human -> El S.Collection -> Formula ;
fun Painting_displayedAt : El Painting_Painting -> El Painting_Place -> Formula ;
fun Painting_documents : El Painting_Document -> El Painting_Artwork -> Formula ;
fun Painting_exhibitionOf : El Painting_Exhibition -> El Painting_Human -> Formula ;
fun Painting_exhibits : El Painting_Exhibition -> El Painting_Painting -> Formula ;
fun Painting_hasAcronym : El Painting_Organization -> El Painting_OrganizationAbbreviation -> Formula ;
fun Painting_hasAssignedAttribute : El Painting_Painting -> El S.SubjectiveAssessmentAttribute -> Formula ;
fun Painting_hasCategory : El Painting_Artwork -> El Painting_ThematicCategory -> Formula ;
fun Painting_hasColor : El Painting_Painting -> El Painting_Color -> Formula ;
fun Painting_hasColorAttribute : El Painting_Color -> El Painting_ColorAttribute -> Formula ;
fun Painting_hasCondition : El Painting_Artwork -> El Painting_StateOfObject -> Formula ;
fun Painting_hasCreationDate : El Painting_Artwork -> El Painting_TimePeriod -> Formula ;
fun Painting_hasCreationLocation : El Painting_Painting -> El Painting_Place -> Formula ;
fun Painting_hasCurrentLocation : El Painting_Painting -> El Painting_Place -> Formula ;
fun Painting_hasCurrentOwner : El Painting_Collection -> El Painting_Human -> Formula ;
fun Painting_hasDimension : El Painting_Painting -> El Painting_Dimension -> Formula ;
fun Painting_hasEngWNID : El Owl_Thing -> El Painting_PWN_LU -> Formula ;
fun Painting_hasFormerOrCurrentLocation : El Painting_Artwork -> El Painting_Place -> Formula ;
fun Painting_hasGeoPos : El Painting_PlaceCoordinates -> El Painting_Point -> Formula ;
fun Painting_hasGeographicLocation : El Painting_Place -> El Painting_Region -> Formula ;
fun Painting_hasIdentifierType : El Painting_UniqueIdentifier -> El Painting_IdentifierType -> Formula ;
fun Painting_hasIdentifierValue : El Painting_UniqueIdentifier -> El S.Number -> Formula ;
fun Painting_hasMeasure : El Painting_Dimension -> El Painting_Measure -> Formula ;
fun Painting_hasMedium : El Painting_Paint -> El Painting_Medium -> Formula ;
fun Painting_hasMember : El Painting_Organization -> El Painting_Human -> Formula ;
fun Painting_hasName : El Painting_Artwork -> El Painting_ObjectName -> Formula ;
fun Painting_hasNameType : El Painting_Artwork -> El Painting_NameType -> Formula ;
fun Painting_hasNationality : El Painting_Human -> El Painting_Nationality -> Formula ;
fun Painting_hasPaintType : El Painting_Painting -> El Painting_Paint -> Formula ;
fun Painting_hasPaintingDescriptor : El Painting_Painting -> El Painting_PaintingDescriptor -> Formula ;
fun Painting_hasPaintingMaterial : El Painting_Painting -> El Painting_Material -> Formula ;
fun Painting_hasPaintingTechnique : El Painting_Painting -> El Painting_PaintingTechnique -> Formula ;
fun Painting_hasPermanentLocation : El Painting_Region -> El Painting_Region -> Formula ;
fun Painting_hasPresentationDate : El Painting_Painting -> El Painting_TimePeriod -> Formula ;
fun Painting_hasPresentationLocation : El Painting_Painting -> El Painting_Region -> Formula ;
fun Painting_hasPurpose : El Painting_Artwork -> El Painting_Purpose -> Formula ;
fun Painting_hasReference : El Painting_Painting -> El Painting_Reference -> Formula ;
fun Painting_hasRepresentedState : El Painting_ConcreteThing -> El Painting_StateOfRepresented -> Formula ;
fun Painting_hasSaldoID : El Owl_Thing -> El Painting_Saldo_LU -> Formula ;
fun Painting_hasSense : El Owl_Thing -> El Painting_WordSense -> Formula ;
fun Painting_hasTitle : El Painting_Painting -> El Painting_Title -> Formula ;
fun Painting_hasType : El Owl_Thing -> El C.E55_Type -> Formula ;
fun Painting_hasUniqueIdentifier : El Owl_Thing -> El Painting_UniqueIdentifier -> Formula ;
fun Painting_hasUnitOfMeasure : El Painting_Dimension -> El S.UnitOfMeasure -> Formula ;
fun Painting_isCreatorOf : El Painting_Human -> El Painting_Artwork -> Formula ;
fun Painting_isEvaluationStateOf : El Painting_StateOfObject -> El Painting_Artwork -> Formula ;
fun Painting_isIdentifiedBy : El Painting_Place -> El Painting_PlaceAppellation -> Formula ;
fun Painting_isKnownFor : El Painting_Human -> El Painting_PaintingTechnique -> Formula ;
fun Painting_isLocatedIn : El Painting_Place -> El Painting_Place -> Formula ;
fun Painting_isMediumOf : El Painting_Medium -> El Painting_Paint -> Formula ;
fun Painting_isPaintedOn : El Painting_Painting -> El Painting_SurfaceMaterial -> Formula ;
fun Painting_isPaintedWith : El Painting_Painting -> El Painting_Device -> Formula ;
fun Painting_isStateOf : El Painting_StateOfRepresented -> El Painting_RepresentedEntity -> Formula ;
fun Painting_periodBegins : El Painting_TimePeriod -> El Painting_TimePeriod -> Formula ;
fun Painting_periodEnds : El Painting_TimePeriod -> El Painting_TimePeriod -> Formula ;
fun Painting_proclaims : El Painting_PaintingStyle -> El Painting_TimePeriod -> Formula ;
fun Painting_purchaseDate : El Painting_Painting -> El Painting_Year -> Formula ;
fun Painting_registrationDate : El Painting_Artwork -> El Painting_Year -> Formula ;
fun Painting_represents : El Painting_VisualItem -> El Painting_Artwork -> Formula ;
fun Painting_soldTo : El Painting_Painting -> El Painting_Human -> Formula ;
fun Time_after : El Painting_TimePeriod -> El Painting_TimePeriod -> Formula ;
fun Time_before : El Painting_TimePeriod -> El Painting_TimePeriod -> Formula ;

```

```

-----
-- INSTANCES
-----

```

```

fun MidLevelOntology_Studio : Ind Painting_Place ;
fun Grid : Ind S.Abstract ;
fun Guide : Ind S.Abstract ;
fun Stimulation : Ind SUMO_Causes ;
fun Symbolize : Ind (both S.Communication S.Substituting) ;
fun Painting_24254 : Ind S.Number ;
fun Painting_Acrylic : Ind Painting_Paint ;
fun Painting_AcrylicGlazingLiquid : Ind Painting_AcrylicMedium ;
fun Painting_AerosolPaint : Ind Painting_Paint ;
fun Painting_AerosolSpray : Ind Painting_PaintingTechnique ;
fun Painting_Africa : Ind Painting_Region ;
fun Painting_AfricanArt : Ind Painting_ThematicCategory ;
fun Painting_Agitate : Ind S.IntentionalPsychologicalProcess ;
fun Painting_Airbrush : Ind Painting_Device ;
fun Painting_Allay : Ind S.IntentionalPsychologicalProcess ;
fun Painting_Amaze : Ind S.IntentionalPsychologicalProcess ;
fun Painting_AmericanArt : Ind Painting_ThematicCategory ;
fun Painting_Arabesque : Ind S.SubjectiveAssessmentAttribute ;

```

```

fun Painting_Aristotle : Ind S.Man ;
fun Painting_AsienArt : Ind Painting_ThematicCategory ;
fun Painting_Attention : Ind S.IntentionalPsychologicalProcess ;
fun Painting_Bark : Ind Painting_PlantMaterial ;
fun Painting_BarkCloth : Ind Painting_Fabric ;
fun Painting_Baroque : Ind Painting_PaintingStyle ;
fun Painting_BelgianLinen : Ind Painting_Fabric ;
fun Painting_Black : Ind Painting_Color ;
fun Painting_BreenberghCollection : Ind Painting_Collection ;
fun Painting_BroadTerm : Ind Painting_NameType ;
fun Painting_BrownOchre : Ind Painting_Paint ;
fun Painting_Brush : Ind Painting_Device ;
fun Painting_Canvas : Ind Painting_CottonFabric ;
fun Painting_CatalogueNr : Ind Painting_IdentifierType ;
fun Painting_CentralAmerica : Ind Painting_Region ;
fun Painting_Century19th : Ind Painting_Modern ;
fun Painting_Century5th : Ind Painting_TimePeriod ;
fun Painting_Charity : Ind S.UnilateralGiving ;
fun Painting_ClarissaPetersRussell : Ind (both S.Man Painting_Painter) ;
fun Painting_CollectionNr : Ind Painting_IdentifierType ;
fun Painting_ColorFieldPainting : Ind Painting_AbstractPainting ;
fun Painting_Complex : Ind S.SubjectiveAssessmentAttribute ;
fun Painting_Copy : Ind S.ContentDevelopment ;
fun Painting_Decoration : Ind S.UnilateralGiving ;
fun Painting_Delicate : Ind Painting_ColorAttribute ;
fun Painting_Derivera : Ind Painting_Exhibition ;
fun Painting_DispersantMedium : Ind Painting_AcrylicMedium ;
fun Painting_DryBrush : Ind Painting_PaintingTechnique ;
fun Painting_Drybrush : Ind Painting_Device ;
fun Painting_Dutch : Ind Painting_Nationality ;
fun Painting_Earthquake : Ind S.Process ;
fun Painting_EastAsia : Ind Painting_Region ;
fun Painting_Element : Ind S.GraphArc ;
fun Painting_Enamel : Ind Painting_Paint ;
fun Painting_EncausticPaint : Ind Painting_Paint ;
fun Painting_Europe : Ind Painting_Region ;
fun Painting_EuropeanArt : Ind Painting_ThematicCategory ;
fun Painting_Exquisite : Ind S.SubjectiveAssessmentAttribute ;
fun Painting_Famous : Ind S.SubjectiveAssessmentAttribute ;
fun Painting_Furu : Ind Painting_Wood ;
fun Painting_Glaze : Ind Painting_PaintingTechnique ;
fun Painting_Gold : Ind Painting_Color ;
fun Painting_Gouache : Ind Painting_Paint ;
fun Painting_Gray : Ind Painting_Color ;
fun Painting_Greek : Ind Painting_Nationality ;
fun Painting_GuernicaDimension : Ind Painting_Dimension ;
fun Painting_GuernicaJPG : Ind Painting_VisualItem ;
fun Painting_GuernicaObj : Ind (both Painting_Painting Painting_Reference) ;
fun Painting_GuernicaTitle : Ind Painting_Title ;
fun Painting_HallwylskaCatalogue : Ind Painting_Document ;
fun Painting_Height : Ind (both C.E55_Type Painting_Measure) ;
fun Painting_IdNr : Ind Painting_IdentifierType ;
fun Painting_Illustration : Ind S.Communication ;
fun Painting_Image : Ind S.IntentionalPsychologicalProcess ;
fun Painting_ImpressionistStyle : Ind Painting_PaintingStyle ;
fun Painting_Impressive : Ind S.SubjectiveAssessmentAttribute ;
fun Painting_Instruction : Ind (both S.Communication (both S.Directing S.EducationalProcess)) ;
fun Painting_InternationalExposition : Ind Painting_Exhibition ;
fun Painting_InventoryNr : Ind Painting_IdentifierType ;
fun Painting_Lace : Ind Painting_Fabric ;
fun Painting_Landscape : Ind S.LandArea ;
fun Painting_Light : Ind Painting_ColorAttribute ;
fun Painting_LinseedOil : Ind MidLevelOntology_OilMedium ;
fun Painting_LocalName : Ind Painting_NameType ;
fun Painting_Louisiana : Ind Painting_MuseumBuilding ;
fun Painting_MaarCatalogue : Ind Painting_Document ;
fun Painting_Major : Ind S.SubjectiveAssessmentAttribute ;
fun Painting_Marble : Ind Painting_Color ;
fun Painting_Masonite : Ind Painting_SurfaceMaterial ;
fun Painting_MorsMossa : Ind Painting_Gallery ;
fun Painting_MotiveWord : Ind Painting_NameType ;
fun Painting_MuseoReinaSofiaLongLat : Ind Painting_Point ;
fun Painting_MuseoReinaSofiaPosition : Ind Painting_PlaceCoordinates ;
fun Painting_MuseoReinaSofia : Ind Painting_MuseumBuilding ;
fun Painting_NOMU : Ind Painting_OrganizationAbbreviation ;
fun Painting_NameSweden : Ind Painting_PlaceAppellation ;
fun Painting_NarrowTerm : Ind Painting_NameType ;
fun Painting_NicoHvanHeek : Ind S.Man ;
fun Painting_NicoHvanHeekCollection : Ind Painting_Collection ;
fun Painting_NineteenthCentury : Ind Painting_Modern ;
fun Painting_NordicMuseum : Ind Painting_Museum ;
fun Painting_NorthAmerica : Ind Painting_Region ;
fun Painting_Oak : Ind Painting_Wood ;
fun Painting_ObjectTitle : Ind Painting_NameType ;
fun Painting_Oil : Ind Painting_Paint ;
fun Painting_OlleSkagerfors : Ind S.Man ;
fun Painting_Outstanding : Ind S.SubjectiveAssessmentAttribute ;
fun Painting_PabloPicasso : Ind Painting_Painter ;

```

```

fun Painting_PabloPicassoBirth : Ind Painting_Birth ;
fun Painting_PaintOntoBrush : Ind Painting_PaintingTechnique ;
fun Painting_PaintOntoPalette : Ind Painting_PaintingTechnique ;
fun Painting_Parisian : Ind Painting_Nationality ;
fun Painting_Pastel : Ind Painting_Paint ;
fun Painting_Pen : Ind Painting_Device ;
fun Painting_Pencil : Ind Painting_Device ;
fun Painting_PeterEccchers : Ind (both S.Man Painting_Painter) ;
fun Painting_PolymerPaint : Ind Painting_Paint ;
fun Painting_PoppyseedOil : Ind MidLevelOntology_OilMedium ;
fun Painting_PortraitOfFamily : Ind Painting_PortraitPainting ;
fun Painting_Post_PainterlyAbstraction : Ind Painting_AbstractPainting ;
fun Painting_Present : Ind S.UnilateralGiving ;
fun Painting_PureSilk : Ind Painting_Silk ;
fun Painting_Recreation : Ind S.ContentDevelopment ;
fun Painting_RedOcher : Ind Painting_Paint ;
fun Painting_Rembrandt : Ind (both S.Man Painting_Painter) ;
fun Painting_Reproduce : Ind S.ContentDevelopment ;
fun Painting_RetarderMedium : Ind Painting_AcrylicMedium ;
fun Painting_Retouch : Ind Painting_StateOfObject ;
fun Painting_Rich : Ind Painting_ColorAttribute ;
fun Painting_RisePaper : Ind Painting_Paper ;
fun Painting_SafflowerOil : Ind MidLevelOntology_OilMedium ;
fun Painting_SearchWord : Ind Painting_NameType ;
fun Painting_SecondaryNr : Ind Painting_IdentifierType ;
fun Painting_Sketch : Ind Painting_PaintingTechnique ;
fun Painting_SlatePanel : Ind Painting_SurfaceMaterial ;
fun Painting_Sonorous : Ind Painting_ColorAttribute ;
fun Painting_SpanishArt : Ind Painting_ThematicCategory ;
fun Painting_SprayPaint : Ind Painting_Paint ;
fun Painting_StandOil : Ind MidLevelOntology_OilMedium ;
fun Painting_Strong : Ind Painting_ColorAttribute ;
fun Painting_Study : Ind S.EducationalProcess ;
fun Painting_Sumptuous : Ind Painting_ColorAttribute ;
fun Painting_Sun_thickenedLinseedOil : Ind MidLevelOntology_OilMedium ;
fun Painting_TerBorch : Ind (both S.Man Painting_Painter) ;
fun Painting_TextureMedium : Ind Painting_AcrylicMedium ;
fun Painting_TheBritishMuseum : Ind Painting_MuseumBuilding ;
fun Painting_TheCrucifixionObj : Ind Painting_Painting ;
fun Painting_TheNightWatch : Ind Painting_Painting ;
fun Painting_TheSecondAnnualExhibition : Ind Painting_Exhibition ;
fun Painting_TheShootingCompanyofFransBanningCocq : Ind Painting_Painting ;
fun Painting_TheWhiteDress : Ind Painting_Painting ;
fun Painting_TheodoreDuret : Ind (both S.Man Painting_Collector) ;
fun Painting_ThreeA : Ind S.Number ;
fun Painting_TissuePaper : Ind Painting_Paper ;
fun Painting_URL : Ind Painting_IdentifierType ;
fun Painting_UniversityOfArt : Ind Painting_University ;
fun Painting_Variegated : Ind Painting_ColorAttribute ;
fun Painting_Vase : Ind Painting_Bottle ;
fun Painting_Vivid : Ind Painting_ColorAttribute ;
fun Painting_WalnutOil : Ind MidLevelOntology_OilMedium ;
fun Painting_WashTechnique : Ind Painting_PaintingTechnique ;
fun Painting_Watercolor : Ind Painting_Paint ;
fun Painting_Waterscape : Ind S.WaterArea ;
fun Painting_Week : Ind Painting_ColorAttribute ;
fun Painting_Weight : Ind (both C.E55_Type Painting_Measure) ;
fun Painting_WestAsia : Ind Painting_Region ;
fun Painting_White : Ind Painting_Color ;
fun Painting_Width : Ind (both C.E55_Type Painting_Measure) ;
fun Painting_WorldWarI : Ind S.IntentionalProcess ;
fun Painting_WornOut : Ind Painting_StateOfObject ;
fun Painting_Year1468 : Ind Painting_TimePeriod ;
fun Painting_Year1656 : Ind Painting_TimePeriod ;
fun Painting_Year1699 : Ind Painting_TimePeriod ;
fun Painting_Year1700 : Ind Painting_TimePeriod ;
fun Painting_Year1799 : Ind Painting_TimePeriod ;
fun Painting_Year1800 : Ind Painting_TimePeriod ;
fun Painting_Year1899 : Ind Painting_TimePeriod ;
fun Painting_Year1928 : Ind Painting_TimePeriod ;
fun Painting_Year1937 : Ind Painting_TimePeriod ;
fun Painting_Year1999 : Ind Painting_TimePeriod ;
fun Painting_YellowOcher : Ind Painting_Paint ;
fun Painting_ZanobiStrozzi : Ind (both S.Man Painting_Painter) ;
fun Painting_centimeter : Ind Painting_UnitOfMeasure ;

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