

Ontology over the Historical Maps of Gotland 1693-1705

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http://www.hgo.se/~gustaf/ontology/GM1700_ontology.html

Abstract. In many disciplines in the humanities and social sciences, like history, human geography and archeology, historical maps are of great importance as a source of information. They are used frequently in different studies for a variety of problems. Since the last decade or two, it has been more and more common to use data from historical maps in GIS-analysis. On Gotland, the large-scale map production has a more than 300-year history. There are several different map generations that are produced for different purposes. The scope of this work is a map series produced over the province of Gotland in 1693-1705. These maps have extensive text descriptions of different aspects of the mapped features. Via a code marking system they are attached to the maps. In this work a semantic analysis and an ontology over all the concepts found in the maps and text descriptions will be presented.

1 Introduction

Using Swedish large scale historical maps, which depicts the landscape at a land parcel level with extensive text descriptions, in a GIS environment is being more and more common in many academic disciplines and other fields, e.g. field archaeology, cultural heritage management and forestry.

Several projects have been conducted to find ways for digitizing these maps and store the information in various databases for example the *Mark Databas Gotland* project at Stockholm University, dept. of Human Geography [30], *KartGIS*, *LiM project Landskapsprojektet and Digitala Historiska Kartor* by Riksantikvarieämbetet [11] [8]. Most efforts of this kind are performed in an intuitive way and are very function oriented and do not retrieve all the data in the text descriptions.

On the international scene, the authors have not found any examples of work of this kind, except the work by Pearson and Collier [17] with the British maps made between 1836-50 in the Tithe Survey, which also depicts the land at land parcel level. Their work seems also function oriented and not all the information is extracted into databases and GIS-layers.

The aim of this work is to find methods and models for retrieving all of the information in large-scale historical maps so they can be stored in a Data warehouse. The Universe of Discourse (UoD) is the Gotlandic maps from 1693-1705, hence forth referred to as GM 1700. The first step is to model and analyze the UoD. The method chosen for this is an Ontological approach and tools.

Two words often used in this paper, concepts and features, are sometimes hard to separate. With feature means the form a concept takes in the maps, either in the text descriptions or as a geometrical shape or symbol in the maps themselves. The features can be regarded as instances of concepts.

2 Universe of Discourse and Scope

In Sweden, the domestic map making dates back to the late 16th and early 17th century. Maps in both small- and large-scales have been quite extensively produced in various time-periods. The large-scale maps are often called geometrical maps and depicts the landscape at land parcel level, normally in scales between 1:4 000 and 1:8 000. The small scales are called geographical maps.

These first generations of large scale maps are called *Äldre geometriska jordeböcker* (Older geometrical cadastres) and was created for about 25 years from 1630. The next phase of the geometrical mapping started in the 1680's for several reasons and the results are stored in *Yngre geometriska jordeböcker* (Younger geometrical cadastres). Among the reasons where fiscal reasons a prominent one, with the mapping as the basis for setting taxes. Gotland and other incorporated parts became in large extent mapped in this period [26] [29].

The results of all Swedish mapping conducted during several centuries are kept in various archives today and can be counted in millions. Sweden is rightfully famous for its large collection of large scale historical maps. In other countries maps of this kind do exist, but only sporadically based on private initiatives by single land owners, and not with a national extent by the Crown, as in Sweden.



Illustration 1. Part of a map and text description from the GM 1700 map series

The majority of agencies and researchers who have dealt with digitalization of historic maps, at least in Sweden, have done so from a need to solve some specific problems and for the use in special areas of interest, mostly concerning landscape analysis, archaeology or cultural management and by only using the geometrical and land use aspect of the maps. This is of course a very essential and important part of using the historical maps in modern research and cultural management. These *function oriented views* does not use the full potential and all of the information found in the maps and text descriptions. These efforts made in DHK and other digitalization projects are of low value for problems and analysis that have other focuses. If new questions were asked and new approaches found, there is, with the present systems, a need to redo all or parts of the work to collect new information.

2.1 Scope

The scope of this work is to learn more about the maps and text descriptions themselves and to model how these maps are organized, what concepts they contain and what they mean and how they relate to each other. To do this there is a need for a broader perspective and a more *data oriented view* of the maps and text descriptions. The ontology will be a domain model which will be used as basis for a database model to enable the storing of these maps and all the information in databases *as close to the original structure as possible*. In accordance with Bittner's and Smith's [4] thoughts that a map itself is an ontology, we could say that the focus of this work is to elucidate, clarify and repack that ontology and thus making it more explicit and easily understood. For most researchers in the humanities the access to the unadulterated source is vital. This project is an attempt to make these maps available and manageable in a way that can be trusted by researchers in the humanities and reducing, or even eliminating, the need to go to the source itself, for most of the problems formulated.

The information in the GM 1700 is quite complex and reflects a society and administrative way that had bearing and was better understood by the contemporary surveyors, then by us today. Historians, ethnologists and archivist have done much research about the Gotland society and administration of the 18th century, for examples; see [15] [16] [20].

2.2 Universe of Discourse, UoD

The first large scale mapping of the Gotland was between 1693 and 1705. These maps are unique in the sense of completeness. All farms (with few exceptions) on the entire island were mapped, and also the islands only town, Visby. The purpose of the mapping was taxation and to gain knowledge about Gotland. The maps are made in the scale of 1:8 000 in the manner described in the instructions for the surveyors of the time. Jointly with the maps are text descriptions of the mapped features and additional information (ill 1). The mapped features and the texts are linked by a system of code markings. Not all features are code marked and not all text is linked to the map. There can be some variations in the contents and manner, depending on which surveyor

made the map [19]. An amateur researcher, Jakob Ronsten, have made transcripts of all the text descriptions, as seen in illustration 1.

The reasons for the mapping are reflected in what is mapped. No map is a true depiction of a piece of the Earth. It is always a selection of information. Depending on the purpose of the mapping, the information presented in the map differs. For the GM 1700 this means that the predominant features and information is about, for the 18th century, important economic matters. Since the taxes were mostly based on farming, the infields are best mapped. In addition, other resources closely connected to a rural economy like woods, fishing, mills etc are described, but not as precise as the infields. Roads, hydrology etc are also mapped, because the large-scale maps were also intended as a base for the small-scale map production, where these features were important. In addition much information on land disputes, co-ownership, crops, field rotation, owners and how they acquired their estates and much more, is noted.

95% of the surveying was done by 7 land surveyors during a period of 12 years. During this time there were new instructions issued from the central office in Stockholm [31]. But over all the maps indicates that the surveyors had a large degree of freedom to organize and make their own decisions about the maps, since the manners and information in the maps can differ quite a lot between them. It also looks like the surveyors manners changed over time. If this is due to the change in instructions or if it is based on their experience is hard to tell. Most of the parishes are mapped by one surveyor in one season, but some parishes are mapped over several years by up to 3 surveyors. The mapping season was from spring to autumn and in the winter they made the fair coping of the field map and compiled and calculated all the material collected in field maps and notations. This process together with difficulties in the field with geographically scattered estates, and to our belief, unclear conditions of the state of affairs in the Gotland countryside, has lead to a series of maps that is very in consequent and incoherent.

17 Röstäde in Eekeby Parish	True field		
	<i>Sq.ell</i>	<i>Tdl (acre)</i>	<i>Kpl (kappland)</i>
A a field Röstäde in Eekeby parish of clay	41,394	2.85	2.625

Table 1 An example of a piece of land (land parcel) that the surveyor probably did not know who owned or what status it had. It is listed as a Ru, with its own registration number (17) in Barlingbo parish. Most likely it belongs to a farm Röstede in Eekeby parish, but there are two farms Röstede in Eekeby parish, Stora Röstede and Lilla Röstede (translated)

The maps are organized in parishes (administrative and geographical areas) and lists a series of units, what we call Registration Units (Ru). Under these Ru:s are lists of features (land parcels and other resources) belonging to an estate or situated within an area. In the absolute majority of cases these Ru:s coincide with farms and other clearly defined estates, but in many cases the Ru:s are listings of land parcels belonging to farms situated in other parishes, church land and other concepts hard to exactly identify. Sometimes it's also clear that the surveyor is not sure of what it is he is mapping, as seen in table 1.

2.2.1 Modeling

As modeling technique, the ontological approach was chosen. We believe it has advantages to more traditional ones. It can facilitate the interaction between the domain experts and modelers and create a semantically clearer and richer model, less prone to

misinterpretation, and more [3]. In this work no specified methodology will be used, as e.g [12][28], but we will try to achieve some generally accepted criteria for what makes a good ontology [1]: *1. Clarity and Objectivity, 2. Completeness, 3. Coherence 4. Maximum monotonic extendibility, 5. Minimal ontological commitments, 6. Ontological Distinction Principle, 7 Diversification of hierarchies, 8. Modularity, 9 Minimization of the semantic distance between sibling concepts 10. Standardization of names.* For this work Protégé 3.0 was chosen as a modeling environment. Before we start presenting the ontology, there are some general discussions we have to undertake about the nature of the maps and some central concepts and what we are trying to model.

2.2.2 Real Estate and Land Parcels

The main concept in the maps is the real estate and its resources. Of the resources the land each estate possessed is most important, especially the infields. The infields consist of the fields and the meadows. Real estate is in the Swedish Encyclopedia (NE) defined as “a unit of immovable property (land) established by a set of rule of law”. In the Swedish law, there is no explicit definition of what a real estate is, but it is normally said that “Every legal real estate must be entered in the national cadastre (real-estate register)” [5]. The definition shows that research around real estate is in a very high degree a multi disciplinary involving law, economics and political science. Stubkjaer [24] lists these areas as the ones which have to be involved when trying to establish an ontology of real estate. In our case, when we are dealing with a situation 300 years ago, we have to add discipline of history as the main subject, when trying to establish what constituted a real estate on Gotland around the year 1700. Basically the same definitions could probably be used for this time period, but there are no explicit definitions made by Swedish historians about the concept of real estate 300 years ago in Sweden. Among historians by trade there seems however to be a generally accepted fact, that a real estate is land registered in a Cadastre or other historical documents with equivalent status and different types of real estate are surrounded with different kinds of laws, practice, tax rules etc.

This ontology can not have the scope of an real estate ontology for Gotland, since the objective is to keep it as close to the original source, the maps, as possible. Smith & Zaibert [22] distinguishes three different aspects when studying landed property; the geographical, the ontological and the cognitive aspect. In this work it is the geographical aspect which deals with how the real estate is related to the land itself, that is in focus and not the ontological aspects of what a real estate really is or the cognitive which is closely related to cultural issues. The concept of real estate must, however, play an important part, since the surveyors had it as a central concept. The real estate concepts we use in this ontology do not cover all aspects of a real estate, since not all aspects of the real estate are in the maps or known.

A modern digital Cadastre for Sweden is developed, but this have a very different focus, with the administrative and transaction parts as core classes [25]. A modern cadastre have many functions for handling processes and administrative work. This makes it more of a SPAN-ontology, which models processes, as explained below. This ontology can however be aligned, on some parts, with our ontology for temporal studies.

2.2.3 Space and Time

The land belonging to the estates is mapped in land parcels. The land parcels as we see them in the maps are no natural phenomenon. They are man made artifacts, so called *fiat objects* of a social nature. This means that the objects limits, boundaries, are not natural, but rather decided by humans based on social criteria. The opposite of fiat objects is *bona fide objects* or boundaries, that are natural, like rivers, shorelines etc [21]. In our case fiat objects can be made up from both fiat- and bona fide boundaries, e.g. when a meadow goes down to the shore.

These land parcels, themselves fiat object, form another fiat object, the real estate itself, which is the mereological sum of all the estates land parcels outer boundaries. This can be of scattered land parcels and thus, forms a fiat object of a “higher-order” [21].

A real estate does not only have an extension in space but also in time. Most of the estates we meet in the maps still exists today and was formed long before the creation of the maps. This is also true for some of the land parcels. The temporal nature of an estate, and a land parcel, is that it has a beginning and an end, and can during its life cycle change its nature and boundaries, but it is in any given time wholly present. The last property makes it an *endurant*, as opposed to a *perdurant* which is never wholly present in any given time. The ontology we are making can be regarded as an SNAP-ontology. The maps are just a snapshot in time of enduring objects. This is in contrast to SPAN-ontologies which are dealing with perduring objects. SPAN-ontologies are used more to model processes etc. [4]. To analyze how these enduring objects, real estates and other features, behave over time is not necessary for this work since we only work with one time-index. This is however something that has to be addressed when several time indices along the same spatial region is involved, e.g. if we introduce another map series of a later date. This is something that will be done in future work.

2.2.4 Uncertainty

Every UoD has some amount of uncertainty in different aspects. When dealing with a UoD created more then 300 years ago, the uncertainty is, more or less, everywhere. You can group the uncertainty into two major groups. The first one deals with uncertainties you can expect in any material of maps and descriptions, also modern ones. This we call *normal uncertainty*. The other group of uncertainties is related to the historical dimension of the UoD, which we call *historical uncertainty*. To the latter kind is, for example, the discussion above about what constitutes a real estate in 17th century or what the measurement unit “Manslätt” was, which is used for measuring meadows, and other measurement units which today is not fully understood. Uncertainties of these kinds require the methodology and toolboxes of history to analyze. But a full understanding will most likely not be reached. The source material is mostly to scarce. For this work these uncertainties is something we have to accept. For those cases where there have been a need to dig deeper in a concept, we rely on research already done by scholars of history and adjacent disciplines

Among the general uncertainty are the semantic problems with unclear or multiple meanings of concepts or terms used. In a contemporary material, this can in many cases be handled by communicating with the creators of the material. In a historical material this can be a two folded problem with both the general uncertainty kind and the historical uncertainty kind, as in the uncertainty around the concept of “deserted”, that is used for farms or land parcels. It can have many meanings and not all are fully un-

derstood [27]. Also many of the quantifications are expressed in a qualitative manner, like some, few, many or big, small and some are expressed in numbers, in descriptions of the same kind of features, etc.

Some of these normal uncertainties can be dealt with using various methods. This is a big area of research and numerous theories and methods are developed, for example Probabilistic or Logical reasoning [7]. However, this is a problem hard to tackle and something which we believe is a non trivial problem to solve in any trustworthy way accepted by scholars of the humanities. This is very essential, since they are the assumed users of the system and, at least in



Illustration 2 Land parcels of different kinds in one of the maps over Fröjel parish

Europe, quantitative methods are not always accepted among scholars of history and adjacent disciplines. This goes probably in an even higher degree for “letting the computer do the interpretations”.

2.2.5 Completeness and Coherence

One of the requirements of an ontology is for it to be complete and coherent, as mentioned in section 2.2.1. For this OWL, which is based on Descriptive Logic (DL) was tried in the modeling process [2]. It was however not possible to use formal logic, due to the nature of the UoD. We will exemplify why it is not possible to use DL on these maps and use the concepts of FIELD and FARMS in our examples.

10 Guffrede a Crown farm with the hide 1		<i>true field</i>			
		yield	Sq.ell	acres	kappland
a	Hemåker is of gravel and mould with flat rock underneath. Fraudulent, is harmed by dryness during dry (years)., sowed with 1 lop (1/4 of a barrel)	2	5,279		12
The fields of this farm is annually sowed in two field rotation with rye, easy to ploughed and 1 acre can, with a good pair of draught-animal, be ploughed per day					

Table 2 A very good, but unusual, field description. There are more fields and resources to this farm (translated)

Table 2 shows a very good description of one of the fields belonging to a farm. It contains nearly all the information ever noted for a field, but this is unusual. Normally only parts of this information is noted for a field. There is a great variation on what information the field descriptions contain and different combinations of the above are noted. In the worse cases the information is only a name and acreage, as in table 3.

13 Hessle Crown farm, ½ hide and all deserted		field	
		acre	knl
A	Stufåker	1	
B	Lilla åker		40.25

Table 3 A very poor field description on a deserted farm

There are two properties which are found in every instance of a field. They are acreage and name. These could then be set as necessary & sufficient conditions for that class, and thus defining it. We believed it was only fields that had acreage in the

specified units. This was an approach that we hoped to follow for most of the concepts. The problem is that the maps are so full of exceptions and anomalies that it could not be accomplished. In the case of the fields, it turned out that one of the surveyors calculated all land parcels in these units and thus acreage in tunnland or kappland/kannland did not define a field. Another example was the farm concept, which we believed could be defined with the necessary & sufficient condition of all having a hide (mantal), which is what defines a farm [20]. Other agricultural estates are not supposed to have hides at this time (in the 1740's all Vicarages and Crown estates gets a hide). However, it turned out that some farms lacked a hide and some vicarages had a hide.

Features of different concepts found in the maps are defined by the fact that someone states that this is a feature of this kind. A field is always a field no matter what it is used for or even if it has not been ploughed in 40 years (such examples exist). This is probably because many of the features, mostly the infields, are noted in older cadastres, which the surveyor had access to. The infields were also tax objects and their status could not easily be changed. The surveyor then describes it in a manner that he uses for fields. The problem is that this manner is not coherent among the different surveyors or even the same surveyor. It seems like every time there is something unusual to tell about a feature, they tend to note the anomalies and forget the regular descriptions.

This fact that actually no properties or combinations of them, were found which could be used for any necessary and sufficient conditions for any concept lead us to abandon OWL and descriptive logic. The main point with using logic is to be able to reason about the ontology [23]. This was not possible, at least not in any significant degree. Trying to impose some kind of logic to the ontology would compromise the most fundamental goal of the ontology; the ambition of keeping it as close to the original maps as possible. For this reason the standard features, without logic, of Protégé was chosen because they are enough and more easily understood.

3 The Ontology of the GM1700 maps

The ontology consists, at present, of 536 frames divided into 232 classes, 83 slots, 2 facets and 219 instances not including the system frames. The full ontology can be downloaded or viewed at www.hgo.se/~gustaf/ontology/GM1700_ontology.html. There are 9 root classes of which 2 are core classes, modeling all the central concepts. The remaining 7 classes model smaller concepts found in descriptions of the core features or are created for design purposes and clarity of the ontology [13].

The concept of RU has partly already been described. It has two subclasses; REALESTATES and NONREALESTATES. Siltberg [20] identifies the following real estate types to be present on Gotland, according to the cadastres of 1654 and 1747: *Farms, Sites, Free soils, Floating soils, Outland soils, Hospitals soils, Other Lands (= Common lands, Grazing lands, Woods, Meadows), Islands, Fisheries, Lime works, Mills*.

For this work, we use Siltberg's categorization of real estates, with some additions and alterations. The real estate types of Grazing lands, woods and meadows are grouped under the superclass OTHERESTATE, but not common lands. This is because common lands are not so unusual and can be of any type of land, but the other ones

are of land types that exist as classes under `LANDPARCELS` and are very rare (10 instances altogether 1654). Also two estate types are added; `CROWNESTATE` and `PARISHESTATE`. This is because the two biggest agricultural estates on the island are owned by the Crown and the estates owned by the Church are all regarded as farms by Siltberg for practical reasons. Furthermore, there are `RU:s` of free soils, floating soils, outland soils, hospitals soils, common lands, where it is not absolutely clear if they are one or more estates, but to clarify this is a research endeavor of its own, and for this ontology we regard them as one estate if they are noted under one `RU`.

The class `NONREALESTATES` is created for all the `RU:s` where features are listed under it for other reasons than forming an estate. This can be that they belong to an estate situated in another parish or their status is unknown.

The other core root class is the one covering all features found in the maps, the class `FEATURES`. It is subdivided into the classes `MAPPEDFEATURES`, `UNMAPPEDFEATURES` and `NAMEDPLACES`. The class `UNMAPPEDFEATURES` is created for concepts found in the descriptions of real estates and land parcels and are linked to them. These are the concepts (classes) of `TAXES` and `DOCUMENTS`. The class `NAMEDPLACES` holds all the instances of places mentioned in the texts. These named places can in many cases be found in the maps and in some not. For those found in the maps, a geometry can be assigned, or if the named place is a `RU` or `MAPPEDFEATURES` that already exists as an instance that instance can be selected.

The `MAPPEDFEATURES` class is subdivided into the `DESCRIBEDFEATURES` which contains all the features described in the text part and is mainly linked to the maps via the code marking system. Here the inconsistency of the maps is also notable, since not all features supposed to have code markings, have one. This is due to various reasons. It seems like it mostly depends on which surveyor carried out the mapping. Some are more careful than others in this respect. Examples of mapped features are the classes `LANDPARCEL` and `OTHERESTATERESOURCES`. The latter is often linked to the map via the `NAMEDPLACES` class. The subclasses of the class `UNDESCRIBEDFEATURES` hold all map features not described in the text part. They can be roads, fences, other buildings, text written in the map itself, etc.



Illustration 3. The class hierarchy of `RU`

3.1 Value Partitions

Value partitions are classes or instances used to describe the values of qualities that other concepts can take. Classes will typically be used representing a continuous space which is partitioned by the values in the collection of values. This is used because the classes can be subdivided and thus refining the values in a continuous way. Instances are used when an enumerated list is primarily wanted, since instances cannot be refined [18].

It is normally advised against using both types of value partitions in the same ontology, yet this is done here. The class `VALUEPARTIONS` and its subclasses are enumerated lists of all the values different concepts can take. The classes `PRODUCTSANDLIVESTOCK` and `DESCRIPTIVEWORDS` and their subclasses are a maybe not genuine value partitions, but act as such. The difference between these classes and commonly used value partitions is that they have slots which can hold quantitative values or values from the class `VALUEPARTIONS`. This can be explained with an example.

`BEAMS` is a subclass of `WOODPRODUCTS` under the class `PRODUCTSANDLIVESTOCK`. `BEAMS` hold all the varieties for the concept beams we can find in the descriptions of taxes (as a tax commodity) or woods (as a product) and also meadows (as a product). A description can be something like “Tax is paid with some beams...” or “Stoore forest...small beams, saw logs...”. The class `BEAMS` have the slots `qualitativeAmount` and `qualitativeSize` which can take instances from the classes `QUALITATIVEAMOUNTS` and `QUALITATIVEIZES` respectively, which are subclasses of `VALUEPARTIONS`. The class `BEAMS` also have the slot `quantativeAmountInteger`, because some times the value can be the number of beams produced. In this fashion we can create all the values needed to describe all the variations of the concept beams. The number of values are not known, but judging from the sample descriptions, there are not so many variations for the different concepts modeled in this way.

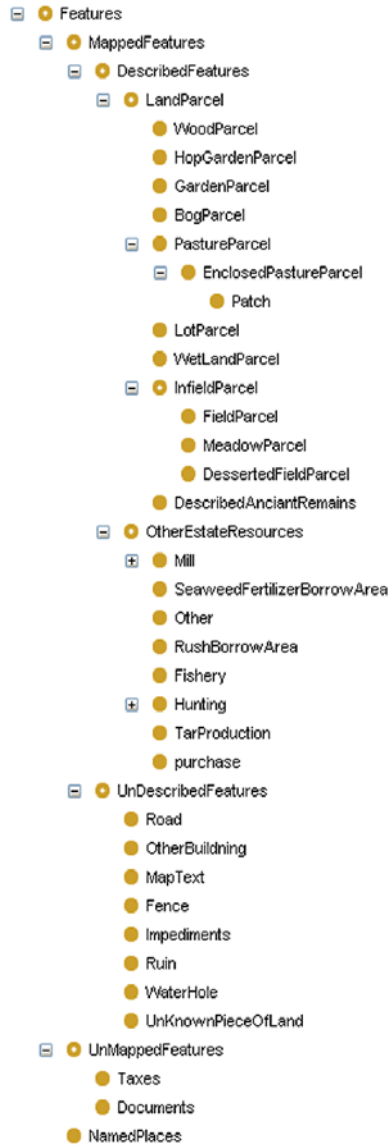


Illustration 4. The class hierarchy of Features

3.2 The remaining classes

The remaining root classes are PERSONS, MEASUREMENTS, GEOMETRIES and FARM SPECIFICS. The class PERSONS is very straight forward and contains all the persons mentioned in the maps (subclass NATURALPERSON) and also the legal persons (subclass LEGALPERSON) existing at that time (the Crown, the Church and the Hospital). The natural persons are mostly owners and leasers of farms. MEASUREMENTS holds all the ACRAGES, PLOUGINGTIMES and LENGTH found in the maps, in respective subclasses. The class GEOMETRIES is not meant for instantiations, since creating geometries in an ontology would be very complex and without meaning. Every node would need an instance of its own with its coordinates. The class is only made for modeling purposes, to show which concepts can have geometries and of what kind. Class FARM SPECIFICS is created for design purposes, since a FARM ESTATE can be divided in many shares, which have different owners and leasers, hide, soil nature etc. One FARM ESTATE can have relations to many FARM SPECIFICS. Some VICARAGE ESTATE also have one relation to FARM SPECIFICS, since they have a hide as explained above.

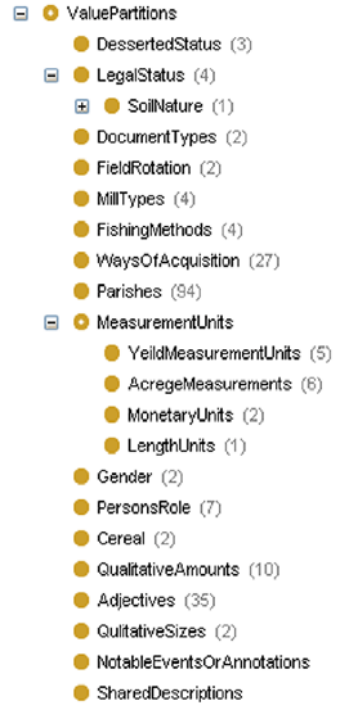


Illustration 5. The class hierarchy of ValuePartitions with the number of instances

4 Conclusions and future work

The ontology created for the GM1700 maps does not meet all the requirements for an ontology presented under section 2.2, but this is seldom the case.

- Clarity and objectivity* is for this ontology the most vital requirement and it is covered as far as possible, when dealing with a historical material.
- Completeness and coherence* are not possible to meet as explained above. The structure of the maps is far too inconsistent and incoherent to allow any formal logic and inference.
- Maximum monotonic extendibility* we believe that the ontology can be extended in a way which will not need the revision of existing definitions. If new concepts are found in the maps, they can simply be added in the existing hierarchy.
- Minimal ontological commitments and modularity* is irrelevant in this case, since the ontology is about one single world and one module.
- Ontological distinction principle* is met since the basic assumption in environment used is that all classes are disjoint.

- f) *Minimization of the semantic distance between sibling concepts* is met as far as can be expected with this kind of UoD, where there is a large heterogeneity among the concepts.
- g) *Standardization of names* have, when possible, been done but the readability and easiness to understand the names of the concepts have been in focus.

We believe that the important items are met, except the coherence and completeness, which are impossible to fulfill in this UoD without compromising the objectives of the ontology or without extensive research within the field of history, as explained in section 2.2.5.

We believe that the main purpose of the ontology is achieved with the presented ontology. These are the objectives of presenting how the maps are organized and what concepts they contain and how these concepts are related to each other. As an domain model for a database implementation it will also be appropriate.

The next phase in this work will be mapping this ontology to a ER-database model and implementing it in a database. Then the geometrical side of the maps will be handled. This concerns mostly how to best handle the uneven distribution of errors which is a known problem with old maps.

Further ahead in the future, is the introduction of later map generations. These are made for different purposes, mainly as tools for land redistributions under different acts of parliament, and thus have different focuses. Whether these can be fitted in this ontology or if new ones have to be created and all of them aligned, remains to be investigated.

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