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Spatial Entity Classification Standard (SpECS): A Proposed Standard for South Africa

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This paper describes the Spatial Entity Classification Standard (SpECS), which has been proposed as a standard for classifying digital geographical data in South Africa, for use in Geographical Information Systems (GIS). The paper begins with a detailed outline of the need for such classification standards and describes the different types of classification schemes that are used: linear list, fixed-level hierarchy, variable-level hierarchy and partially-ordered set. It also describes how non-spatial attributes are managed and how such schemes are encoded. After describing briefly a few other classification standards, the paper describes SpECS in detail, as well as the SpECS software tool, which can be used for creating and maintaining any classification scheme. A complete listing of the current version of SpECS is provided in an appendix.

Hierdie artikel beskryf die Ruimtelike Entiteit Klassifikasie Standaard (SpECS), wat voorgestel word as 'n standaard vir die klassifikasie van digitale geografiese data in Suid-Afrika vir gebruik in Geografiese Inligtingstelsels (GIS). Die artikel beskryf die wenslikheid van so 'n klassifikasie-standaard en die verskillende tipe klassifikasieskemas wat gebruik word: lineêre lys, vaste-vlak hierargies, wisselende-vlak hierargies en gedeeltelik-geordende stel. Dit beskryf ook hoe nie-ruimtelike attribute bestuur en geënkodeer word. Na 'n kort verwysing na enkele ander klassifikasie-standaarde, word SpECS in besonderhede beskryf, asook die programmatuur wat gebruik kan word om die klassifikasie te skep en te onderhou. 'n Volledige lys van die huidige weergawe van SpECS word in die bylae gegee.

Introduction

Geographical information systems (GIS) are currently being applied to many different fields and to varying degrees of sophistication (from using the system as a more cost-effective way to update maps, to using the system for complicated modelling) (Cooper, 1991). Their popularity stems from their ability to efficiently capture, store, retrieve, maintain, validate, manage, manipulate, analyse and display digital geographically referenced data. The future for GIS lies in its interoperability across technologies, systems and applications - provided their full potential is realised. Unfortunately, due mainly to difficulties of exchanging spatial data between different systems and users, that goal remains elusive.

Data exchange problems

An essential step in data sharing is to have a mechanism by which data can be transferred between computer systems without exchange difficulties such as data distortion or loss. Problems associated with data exchange difficulties include the fact that often spatial data are not readily interchangeable, resources are wasted and accuracy lost in the extended efforts to convert data, so that any real benefits from using the computer (such as timeliness, efficiency and/or replicability) are lost to the cost associated with dated, incomplete and inaccessible data (Wood & Douglas, 1984). These problems are of a technical nature and have been addressed partially by software vendors, who have developed data translators to the most popular data formats. Examples of these *de facto* standards are the DXF format created by AutoDesk for their product AutoCAD, the GBF/DIME and TIGER file formats of the US Census Bureau, DLG-E developed by the US Geological Survey and the ETAK format used for road and street network data. However, these formats were not designed to handle the full range of spatial and non-spatial data types catered for by GIS.

To simplify matters and make provision for the multi-dimensionality of geographical data, several attempts have been made at national and international levels to create so-called neutral data exchange standards. The Spatial Data Transfer Standard (SDTS) recently adopted by the United States of America is a prime example, while in South Africa the standard is the National Standard for the Exchange of Digital Geo-Referenced Information (NES), maintained by the Directorate: National Spatial Information Framework (NSIF) of the Chief Directorate: Cadastral Surveys in the Department of Land Affairs. In many other countries, national agencies developed their own exchange standards,. Unfortunately, none of these neutral standards has been widely accepted yet by the market place, mainly because of their inherent complexities.

Although data formats and data exchange standards are steps in the right direction for easing the data exchange problem, they stop short of a final solution. For an exchange of data to be successful, both the supplier and the recipient must have a common understanding of what is exchanged. The data in the data set created by the recipient out of the exchanged data must have the same meaning as the data in the original data set held by the supplier. One of the key aspects to this common understanding is the *classification scheme* (including how it is encoded) defining the features in the data set. Sometimes, a classification scheme is also called a *data dictionary*, though we prefer the former term. Few attempts have been made to specify a standard geographic feature classification and coding scheme for GIS as it poses a particularly difficult problem. If such a standard set of classes and codes can be designed and implemented successfully, it will greatly enhance the ease and efficiency with which data can be exchanged between different users, with additional benefits such as easier integration, increased availability, better assessment and reuse of geographic information. An additional indirect benefit is that new GIS users could use the national standard as their GIS's classification, cutting start-up costs, providing a solid theoretical base and enhancing compatibility with their data suppliers.

The International Organisation for Standardisation (ISO) has established a Technical Committee, TC 211, for Geographic Information/ Geomatics, which is developing the family of standards, ISO 15046, for geographic information. Their classification standard, **ISO 15046-10, Part 10: Feature Cataloguing Methodology** (ISO, 1998), currently in Committee Draft, is an abstract standard providing a methodology for feature cataloguing, but does not prescribe a specific set of standard feature classes. The standard only describes the normative structure of a compliant feature catalogue (i.e. it is a syntactical standard), but does not specify how the content should be developed (i.e. the semantics). No matter how useful the classes might be, any set of feature classes can be deemed to be an ISO-compliant feature catalogue if it meets the syntactical criteria laid out in ISO 15046-10 (Cooper, 1999).

The aim of this paper is to describe the work done in this regard by the CSIR in collaboration with Telkom SA Ltd, the Directorate: National Spatial Information Framework (and its predecessors in the Department of Land Affairs) and the Institute for Geographical Analysis (IGA) at the University of Stellenbosch. The project team has briefed many organisations and users around South Africa about the project and they have provided the team with much of the material incorporated into the resultant standard, known as the Spatial Entity Classification Standard (SpECS). The project has been funded by Telkom and SpECS will be maintained by the NSIF Directorate. The SpECS standard itself comprises a classification scheme, non-spatial attributes and a set of unique codes for geographical entities, and these are discussed in the next section to provide the rationale behind the proposed standard.

Classification Schemes

Grigg (1965) defines classification as the grouping of objects ... into classes ... on the basis of common properties or relations. Every class will have an unambiguous definition that will facilitate placing features from the set into the appropriate class. These definitions often constitute the only base for assigning real world entities to feature status in a classification.

Unfortunately, neither theoretical classification nor definitions result in a data set that completely reflects both real-world entities and human cognitive processes, since the concept of a feature is application-specific and resolution-dependent. Observers view geographic reality differently and structure the physical and cultural entities according to a particular application and resolution, resulting in different feature classification lists from organisation to organisation (Lynn Usery, 1993). A classification scheme does not have to be all-encompassing for all possible applications, but must provide the users of the data with the classes that are appropriate for their needs. For example, in a database used for urban planning of land areas, it would not be necessary for the classification scheme used with the database to cater for oceanographic classes (Cooper, 1993). To provide application-specific classifications one could take subsets of the base classification scheme to fit special application areas, a technique known as *profiling* (Østensen, 1995). For example, the Topological Vector Profile (TVP) is a profile of the Spatial Data Transfer Standard (SDTS) catering for vector data (Wortman, 1992).

If one intends exchanging information with other users, then those users' requirements must be considered. It is not necessary that all users use the same classification scheme, but there must be appropriate mappings between the various schemes. Normally these mappings would be one-to-one from the classes in one scheme to those in another, but that is not necessary. The mapping might aggregate the classes used by the producer of the data if the recipient does not need to distinguish between the producer's detailed classes.

Normally, a producer of data will have a deeper (or the same) understanding of the data being transferred than the recipients of the data. In particular, in the transfer of an individual feature, it is more likely to be transferred from a scheme classifying it more precisely to one classifying it less precisely, than vice versa. Hence, either a one-to-one mapping (in the case when the feature is classified to the same precision by both users) or a many-to-one mapping (in the case when the sender has a more precise classification of the feature) between classification schemes is the norm.

The recipients of features would rarely classify features more precisely than the senders. Should this be required, the recipient of the data will have to decide manually on the new classification of the feature, perhaps using other known data. That is, the recipient will have to split the features in the sender's class into a number of the recipient's existing sub-classes. Such reclassification would be done on the basis of the non-spatial attributes of the feature, or other information known to the recipient (Cooper, 1993). For example, a lay person might notice that a particular feature has changed or moved (e.g. a navigational buoy moved by a flood), and might inform the custodian of the data about the change, using a high-level class to classify the feature. The custodian would then be able to use their knowledge to identify which feature had changed or moved, and reclassify more accurately the feature in the received data set.

To remain useful, a classification scheme must also be expandable as new features are included in a data set. Thus its notation must be flexible, employing terminology that is clear and descriptive with consistent meaning for both the classifier and the user. Many classification schemes have been unsuccessful because when they were first designed, an attempt was made to include every possible feature in the classification, without catering for expansion.

Multiple Classification Schemes

Any one data set can be viewed or accessed through a number of classification schemes. Each separate classification scheme would provide a different view of the data, tailored for particular applications.

Within each classification scheme, a feature should fall into only one class. The temptation to classify a feature into a number of classes would occur when one feature is perceived as having a number of functions, for example, a building in a village that serves as a post office and as a general dealer. However, in this example there are actually three features, at least. One feature is the physical building, with attributes such as its construction material, municipal rating and owner. Another feature is the post office (viewed as a service rather than the physical building), with attributes such

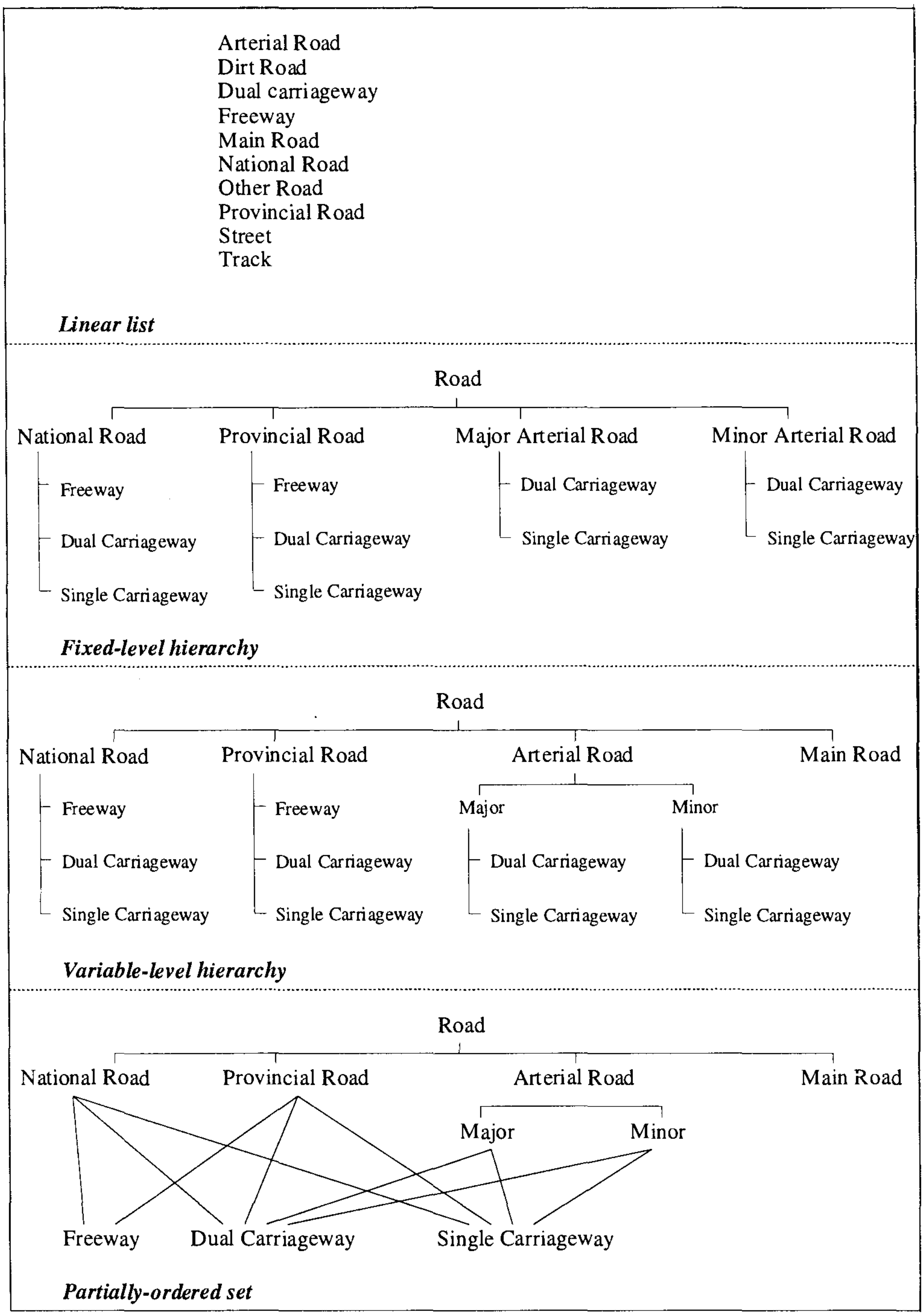

Figure 1: Classification Structures

as its name, postal code and the facilities it provides. The third feature in the example is the general dealer (again, viewed as the retail service, not the physical building), with attributes such as its turnover, manager and target market. All three features in this example share the same spatial attributes (Cooper, 1993), that is, all three are in the same place. In one's database then, one would have the three separate features, each with their own class and non-spatial attributes, sharing the same co-ordinates.

Types of Classification

A classification scheme defines classes of features. A *classification structure* provides a mechanism for including classes and their definitions into a scheme.

Commonly used classification structures are the *linear list* and *tree-like structures*, especially the *fixed-level hierarchy*. Newer tree-like structures are the *variable-level hierarchy* and the *partially ordered set*. Any structure may be used, but the variable level hierarchy is recommended. These structures are described below, and illustrated in Figure 1.

The *linear list* is merely a list of all the feature classes, all on the same level. There is no inherent relationship between any of the classes. The advantage of the linear list is that new classes are added easily without affecting the structure of the classification - they are merely defined unambiguously, given unique names and codes, and added to the list. The disadvantage of the linear list lies in its lack of a structure. As all the classes are in a long list (usually alphabetical) they can prove difficult and inefficient to use when there are a substantial number of classes (Rugg & Schmidt, 1986) - which is invariably the case. In a linear list, the classes cannot be grouped together logically, as there are no relationships between the classes. The result is that users take longer to classify features (especially those in classes that are not used often by the user) and a significant number of features get classified into the wrong classes.

Tree-like structures include fixed and variable level hierarchies and partially ordered sets. In general, tree-like structures may be used to introduce inherent relationships between classes. A few broad classes are defined on the first level, and are refined on each successive level to distinguish further between the classes. Refinements of a particular class are *child classes* of that class, and a class that has associated child classes is their *parent class*. A class that has no children is a *leaf class*. In tree-like structures, each class on each level has a class name, known as a *label*. Each label should be unique within the classification scheme. The ordered set of labels from the first level down to level *n*, including the label from each intermediate level, is known as the *path name* of the class on level *n*. It is preferable to use the path name of a class rather than the label of the class for its *class name*, because the path name identifies the class fully and provides a better indication of the nature of the class (Cooper & Scheepers, 1989).

One could view any tree-like structure as a linear list, by taking the path name of each class as its name and disposing of the structure. In fact, they are often implemented as linear lists, although the user sees them in the format of the defined tree-like structure. If a tree-like structure has several levels, path names may become rather long, especially if useful labels have been used, and specifying the complete path name for a particular class becomes inconvenient. Hence, use of encoding schemes becomes desirable.

The *fixed level hierarchy* is a tree-like structure with a fixed number of levels, with classes on every level, with all the leaf classes on the final level, and where each child class has one and only one parent class. The main advantage of fixed level hierarchies over linear lists is that one is able to use the hierarchical structure to determine the correct class for a particular feature more easily.

There is a perceived disadvantage to fixed level hierarchies when compared to linear lists, namely that once the classification has been set up, it is difficult to add further classes. However, this disadvantage is only manifested when the user errs by making the classification scheme dependent on the coding scheme, and not vice versa, resulting in a "shortage" of codes for new children for a particular parent class. The real disadvantage of the fixed level hierarchy is that all classes have to be refined down to the same (fixed) level - an unnecessary limitation.

The *variable level hierarchy* is a tree-like structure with classes on every level, where leaf classes may be on any level, and where each child class has one and only one parent class. A variable level hierarchy is similar to a fixed level hierarchy with the exception that a class need only be refined if appropriate for one's view of the information. Thus, the classes within one's areas of speciality would be refined to many levels, while the first-level classes that provide background information might not be refined at all (Scheepers *et al*, 1986).

The disadvantage of a variable-level hierarchy is that it is perceived as being difficult to implement because a complex coding mechanism is required. However, once the classification has been developed, the codes could be assigned automatically and transparently to the users. The implementation is then merely a case of mapping the path names of the classes (as they would appear in the user interface to a GIS) to their codes. Effectively, the classification is reduced to a linear list when encoded, but with the advantage that the user still sees the hierarchy which facilitates the correct selection of classes.

The disadvantage of the tree-like structures discussed above is that in the real world, a class might have more than one parent class. Thus, either the child class must be placed in more than one position in the hierarchy, or only one class may be selected as its parent. With the child class placed in more than one position in the hierarchy, there is a problem of ambiguity, in that the user of the classification might pick the incorrect class. With the child class having only one class as its parent, there is the problem that the users of the classification have difficulty finding the appropriate classification for a particular feature.

The *partially ordered set* (normally abbreviated to *poset*), is a variable level hierarchy where any child class may have more than one parent class, provided that the parent class is on any level in the hierarchy that is above the level of the child class. A parent may not be on the same level as its child (Van Biljon, 1987). Posets solve the problem of a class with more than one parent class. However, an interesting problem is introduced when one attempts to attach non-spatial attributes to child classes in a poset (see Section 2.3 below). Another disadvantage of posets is that their visual representation may be complex. A graph drawn of a poset could have many intersecting connections and could have connections between levels that are far apart. However, through the coding mechanism and a menu-driven user interface, the complexity of the poset structure could be made transparent to the user (Cooper & Scheepers, 1989).

When drafting a classification scheme based on posets, ambiguous path names are to be avoided. These can be prevented by ensuring that all labels in the scheme are unique. This is not as onerous as it appears, as a scheme based on posets would need fewer labels than the same scheme based on a variable-level hierarchy. While it could be possible to use a network or relational structure for classification, infinitely long definition paths could be set up because of recursion (Cooper, 1993).

It is more natural for people to use a classification based on a hierarchical scheme rather than one based on a linear list, as shown by Rugg & Schmidt (1986). According to Wood & Douglas (1984), complete hierarchies can be built on a single set of explicitly defined classifying criteria. Of the hierarchical structures for a classification scheme, it would appear that posets are the most sophisticated and best yet devised. However, they are not yet well understood and much research has to be done on using posets for the underlying structure of classification schemes. Hence, the use of variable-level hierarchies is recommended, bearing in mind the problem of classes that logically fall under more than one parent class. This can be addressed by using aliases, that is, alternative names for classes that guide the user to the correct class. The advantage of the variable-level hierarchy over the fixed-level hierarchy is that it is much more flexible and it is much easier to establish the classification scheme, as one does not have to define all the feature classes *ab initio.*

Mapping one classification scheme onto another should be independent of the structures used. The structure merely provides a mechanism for describing the scheme. Problems that could occur when mapping one scheme onto another will be caused by factors other than the mechanisms used, such as when the classification is based on quantitative characteristics and not on qualitative characteristics. Problems will also be caused when mapping between poorly designed classifications.

Classification Structures and Non-Spatial Attributes

Some interesting problems occur when non-spatial attributes are attached to feature classes, some of which are related to the classification structure used. These problems are outlined below, though it is not in the scope of this paper to attempt to answer them:

1. **Inheritance:** should a class inherit the non-spatial attributes of its parent classes (Scheepers *et al*, 1986)? That is, should the set of attributes (not their values) of a parent class be passed on to its children (e.g. the non-spatial attribute "Surface Material" being defined for the class "Road" so that all child classes of "Road" then have the attribute "Surface Material")? This becomes particularly complex with a poset where the child class parents have different attributes.
2. **Common attribute definitions:** should non-spatial attributes be defined across all classes, or should they be defined for each class separately (Cooper & Scheepers, 1989)?
3. **Sharing attributes:** can non-spatial attributes and/or non-spatial attribute values be shared by more than one feature (Greenwood, 1988)?

Encoding a Classification Scheme

When a classification scheme is actually used, it is desirable to replace the full definitions of the classes, and even the class names, with *codes*, either numeric or alphanumeric, because the full definitions could be unwieldy to use. The encoding scheme used should be dependent on the classification, and not vice versa. That is, the classification must be designed without concern for how the classification will be encoded.

Unfortunately, a number of classification-scheme implementations made the classification dependent on the encoding scheme. Such schemes met with severe problems when new feature classes needed to be added to the classification. This is especially true of classification schemes based on a hierarchical structure, which had a poor success record in the early 1980s (Cooper, 1993). Exact codes should be calculated by an algorithm, with the exact numbering system and the numbers themselves of little concern to the user. In other words the concern of the designer should be directed towards providing algorithmic consistency and not towards numbers or codes. The ultimate objective with encoding should be to create an optimal set of codes that is inclusive, flexible and open-ended for utilisation in a general classification scheme.

Existing Classification Schemes

A number of classification schemes have beedeveloped as parts of exchange standards by countries in the Northern hemisphere. For example, SDTS is promoted by the USGS and consists of specifications for the organisation and structure of digital data transfer, definitions of spatial features and attributes, and encoding instructions for data transfer. The SDTS was approved as a Federal Information Processing Standard (FIPS) in 1992 and is also available for use by State and local governments in the USA (Wortman, 1992). The USGS also compiled the feature-based DLG-E, defining five views - cover, division, ecosystem, geoposition, and morphology - concerning more than 200 unique features that describe the geographical phenomena portrayed on the series of 1: 24 000-scale topographic maps of the USA (Tang *et al*, 1996). To support the 1990 census, the US Census Bureau developed the TIGER system, which incorporates geographic features such as transportation and hydrography with data such as zip codes and address ranges. At an analytical level, this ensures that geographic features become the standard representational object to support GIS analysis on commercial as well as governmental spatial databases (Lynn Usery, 1993).

The Digital Geographic Information Exchange Standard (DIGEST) is a product of the Digital Geographic Information Working Group (DGIWG), consisting of members from eleven North American and European countries, all members of the North Atlantic Treaty Organisation (NATO). DIGEST addresses the needs for interchange of different types of data at several levels of topology, using a standard feature and attribute coding scheme. The coherent structure for the exchange of all of these data types is provided in the body of the DIGEST standard. Product specifications are defined in parallel to the DIGEST standard addressing specific data products. DIGEST is designed to handle exchange of raster, matrix, and vector data, including the entire range of topological structures from no topology to full topology.

The Spatial Entity Classification Standard (SpECS)

The Spatial Entity Classification Standard (SpECS) (Cooper *et al.*, 1997) has been designed to provide a general purpose classification scheme for GIS users in South Africa, especially, but not exclusively, for those exchanging data with other users. As such, it focuses on those features that are in general use in South Africa and that are likely to be exchanged between users. However, it does not neglect specialised feature classes not normally exchanged, and it has been designed to allow such classes to be added by users as required (see below). For example, SpECS provides significant detail for the various types of roads, the sort of data that are often exchanged by many users (usually perceived as "base data"), but not for atmospheric phenomena, which are infrequently exchanged.

Where possible, existing classification schemes already in use in South Africa or elsewhere were incorporated into SpECS. It will also be relatively straightforward to make SpECS comply with the requirements of ISO 15046-10: Feature Cataloguing Methodology, once that abstract standard has been completed and its implementation defined in a profile (Cooper, 1999).

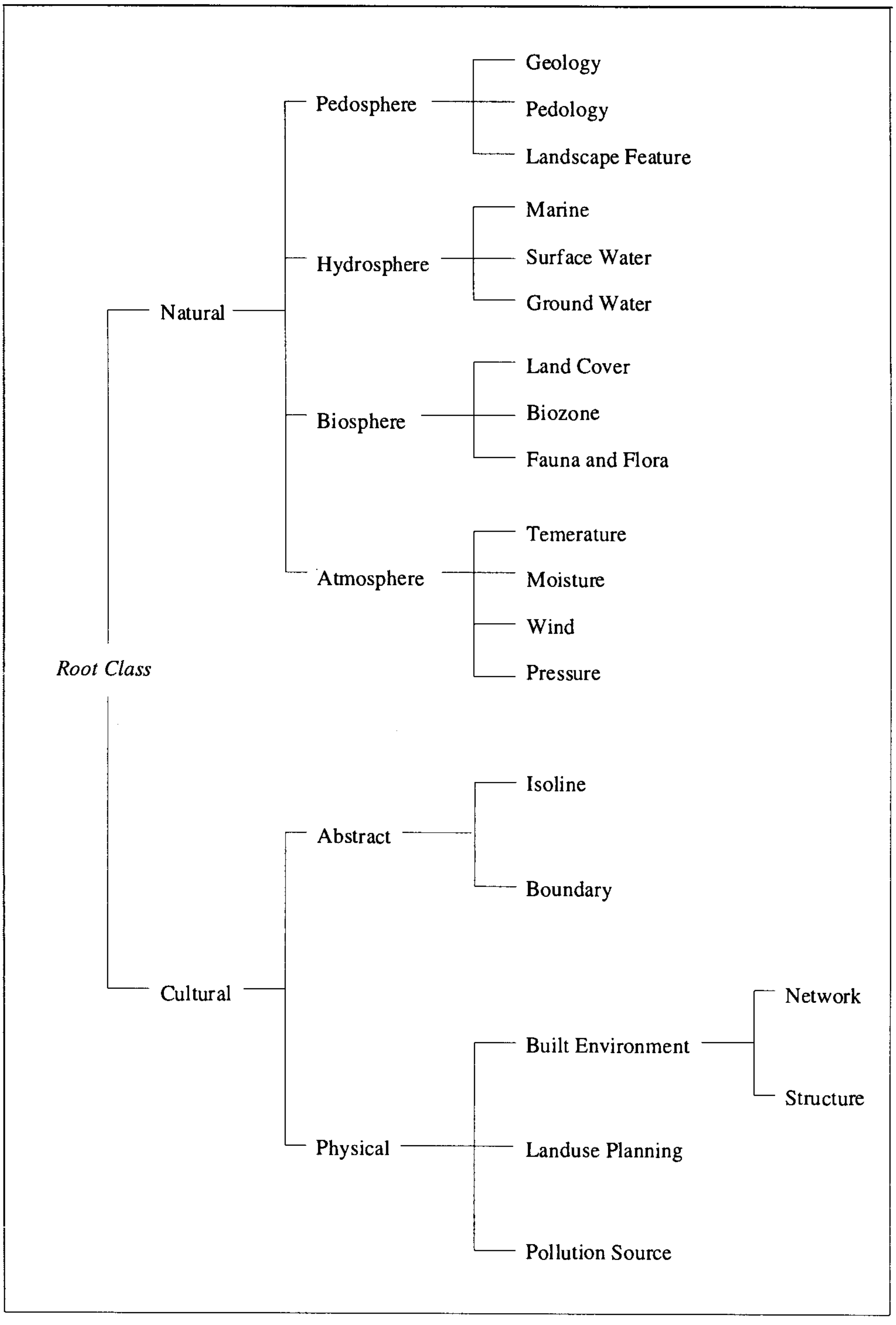

Figure 2: The Top-Level Structure of SpECS

The Structure of the Classification Scheme

The Spatial Entity Classification Standard (SpECS) uses a variable-level hierarchy for its structure. That is, it has a number of levels of classes, where the child classes provide a more refined classification of their parent class, and there is no restriction on the number of levels of classes that should appear below each parent class. Hence, the leaf class **"Cultural/ Physical/ Built Environment/ Network/ Transportation/ Road/ Street/ Private Road"** is on the eighth level, while the leaf class **"Natural/ Atmosphere/ Temperature"** is only on the third level. A user is not restricted to using only the leaf classes, and may use a parent class if it is more appropriate. For example, if there is no need to differentiate between sheet, rill and gully erosion, one could use their parent class, **"Natural/ Pedosphere/ Landscape Feature/ Erosion"**, instead. The top-level structure of SpECS is shown in Figure 2.

Viewing and Editing the Classification Scheme

The project team working on the classification scheme felt that it would not be sufficient to design the scheme alone, without creating a software tool for developing, managing and presenting the scheme. This tool is known as the SpECS tool, and it presents the Spatial Entity Classification Scheme using the standard MS Windows hierarchical format. For each class, the tool displays the class name, code, definition, source of definition, aliases, parent class name and code, and attributes, and for each attribute, the name, definition, type and units. The SpECS tool can be used to develop, manage and present schemes other than SpECS the classification scheme.

The tool works under MS Windows 3.x and MS Windows 95, adhering to the normal Windows interface standards. SpECS runs as a stand-alone process, using MS Access as its database, and the user can interact with other programs by cutting and pasting text or by accessing the database file directly. Note that MS Access is not needed on one's computer to use the tool. The SpECS tool offers the following functions:

- **Open, Close, Copy, Exit:** these commands open, close or copy allowing one to work on a selected a database (containing a classification scheme), or exit the program. When opening a database, the normal MS Windows file selection interface is presented.
- **Print tree**: this command prints a copy of the entire classification structure to a file, which can be printed or exported to a word processor.
- **Print details:** this command prints a copy of all the data for every class to a file, which can be printed or exported to a word processor.
- **Find, Find next:** these commands search for a particular class, using any of the fields entered in the database.
- **Export branch, Import branch:** these commands export (with the highlighted class as the root class) or import (as children to the highlighted class) part of the hierarchy of a classification scheme.
- **Freeze, Thaw:** these commands freeze the database (prevent updates) or thaw it (allow updates), both using the classic password, xyzzy, to prevent mistakes. Help is also provided.
- **Auto expand:** this command expands the classification for display.
- **Help:** this document is provided under the help command.

Using buttons on the screen, the user can also hide or reveal parts of the classification scheme in the display, re-arrange the children of a class, add a new class, and edit the fields of a class. The user can and delete a class that has no children, again using the classic password xyzzy to prevent mistakes. There are three separate tabbed screens for recording or editing a class' definition, attributes and aliases.

The Rationale Behind the Major Classes

According to Lynn Usery (1993), a basic level of abstraction of the reality exists, that possesses common attributes and similarities in shape. This logically forms the most basic category and provides a single level for devising a **feature-based** classification scheme for GISs. Recognising the objects at the basic level is not easy, but each category may be best defined by a prototypical member about which there is no doubt of membership in the category. The prototype serves as the defining member of the category and elements that share more similarity to the prototype of one category than another become members of the former category. Care must be taken for the classification scheme not to be become a mere representation of features appearing on paper maps rather than representing the core geographical data - needed for the production of digital products.

In the SpECS classification scheme, the two classes at the first level are:

1. **Natural:** Features existing in or caused by nature; not artificial. **Feature code: 1**
2. **Cultural:** Features made by humans or the interaction of humans with the natural world. **Feature code: 2**

The reasons these were selected is that the provide the most obvious divide between the types of data (and applications) used in GISs. Within the **'Natural'** class, the four main classes (i.e. the second-level classes) are:

1. **Pedosphere:** Features concerning the structure and form of the earth and its crust. It includes the following three classes on the third level: Geology, Pedology and Landscape Features. **Feature code: 11**
2. **Hydrosphere**: Features concerning the waters of the earth. It includes the following three

Name: Continental shelf area
Class Code: 12010105 **Class Num:** 9430
Source: IHO Dictionary, SP-32, 4th Edition
Definition: A continental (or island) shelf in a zone adjacent to a continent (or around an island), extending form the low water line to the depth at which there is usually a marked increase of slope to greater depths. A continental shelf limit is the limit of the Continental shelf or continental margin determined in accordance with the provisions of the United Nations Convention on the Law of the Sea. The outer limit of the Continental shelf of the RSA has been co-ordinated. Any exploration or exploration of the seabed and subsoil thereof shall be subject to the relevant laws of the RSA.
Attributes: Name and Description Type Measurement Unit

Name: Custom zone
Class Code: 12010106 **Class Num:** 9431
Source:
Definition: The area where national custom regulations are in force
Attributes: Name and Description Type Measurement Unit

Name: Exclusive economic zone
Class Code: 12010107 **Class Num:** 9432
Source: IHO Dictionary, SP-32, 4th Edition
Definition: An area not exceeding 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, subject to a specific legal regime established in the United Nations Convention on the Law of the Sea under which the coastal state has certain rights and jurisdiction. The sea beyond Territorial Waters to a distance of 200 nautical miles from the baseline in the Exclusive Economic Zone of the RSA. All natural resources in the Exclusive Economic Zone shall be subject to the same rights, powers and responsibilities that the RSA has in respect of its Territorial Waters
Attributes: Name and Description Type Measurement Unit

Figure 3: Example of 3 Definitions of Classes in the Scheme

classes on the third level: Marine, Surface Water and Groundwater. **Feature code: 12**

3. **Biosphere:** Features concerning the living organisms occupying the earth's crust and atmosphere. It includes the following three classes on the third level: Landcover, Biozone and Fauna and Flora. **Feature code: 13**
4. **Atmosphere:** Features concerning the envelope of air around the earth and what occurs within it. It includes the following four classes on the third level: Temperature, Pressure, Wind and Moisture. **Feature code: 14**

Within the **"Cultural"** class, the two main classes (i.e. the second-level classes) are:

1. **Abstract:** Features created by humans that are not in themselves tangible, concrete or visible, though they might follow or be represented by other, tangible, features. It includes the following two classes on the third level: Isoline and Boundary. **Feature code: 21**
2. **Physical:** Features created by humans that are tangible, concrete and/or visible. It includes the following three classes on the third level: Built Environment, Landuse and Pollution Source. **Feature code: 22**

The Details of the Classification Scheme

Although the SpECS classification scheme has a hierarchical structure, each and every class has also been given an unique name or label, to reduce the chances of ambiguity. Some classes also have aliases, or alternative names, to facilitate searching for the correct class. For example, the class **"Natural/ Hydrosphere/ Surface Water/ River"** has eight aliases, including: **"Brook"**, **"Stream"**, **"Rivulet"** and **"Tributary"**. Every class has an unique hierarchical numeric code - although this then makes the classification dependent on the coding scheme, and not vice versa. A hierarchical code was used as all users requested it. Hopefully, sufficient scope has been allowed for in the allocation of codes to each level (10 codes for each of the first two levels and 100 codes for the remaining levels) to ensure that in the future, there are no problems when additional classes are added to SpECS. Classes also have definitions which are very important, because they reduce ambiguity and help users find the correct class more quickly. This is especially relevant given the diverse range of fields that GIS data encompass. The sources of the definitions are also provided. Unfortunately, time and budgetary constraints have prevented us from providing definitions for each and every class.

Some classes also have non-spatial attributes, which allow the user to cater for more information about the feature. In turn, each attribute has a definition, and its type (such as text or integer) and measurement units can be specified.

SpECS allows the user to add their own, private classes to their classification scheme. Of course, these classes could be of use to other users in other organisations, so the maintenance authority, currently the Directorate: National Spatial Information Framework of the Chief Directorate: Cadastral Surveys, will have to establish procedures for admitting private classes into the national classification standard. One alternative would be to allocate blocks of codes in a sub-section of the hierarchy to a relevant user group or specialist organisation, which they could use for their private classes which are most likely to become public.

The complete listing of all the classes in the classification scheme together with their codes is presented in Appendix A. Space does not permit the inclusion of all the definitions, aliases or attributes, though these form an important part of the scheme. An example of them is presented in Figure 3.

Implementation of Classification Scheme

Accommodating data demands is difficult, involving data transfer between different data producers and users, with regular differences in data formats. A standard classification scheme will to a large extent enable easier data transfer. However, from a user's point of view a number of questions related to classification schemes in general as well as the specific scheme under discussion here, remain to be answered. Some of these questions are tentatively formulated below:

1. Why should a unique classification scheme be developed for South Africa with a multitude of schemes already available?
2. With a unique South African classification scheme, what are the implications for international data exchange? Coupled to this, will this scheme eventually be registered at the ISO Technical Committee 211 as a South African standard?
3. What are the software requirements to run the classification scheme? Will software tools be available to support encoding and decoding of spatial data?
4. What practical steps must be taken for the classification scheme to be implemented on a corporate geographical data set and how is compatibility between the classification scheme and the data set established and ensured?
5. What are the rules of use of the classification scheme, e.g.: suppose it must be expanded, will there be access to a central register that registers changes? Who will be responsible for the maintenance of the classification scheme?

Conclusions

In this paper we have introduced the Spatial Entity Classification Standard (SpECS), a proposed standard for South Africa for classifying features in geographical information systems (GIS), and have described its components. SpECS is also made available with a tool which can be used for querying or updating any classification scheme. We have also described why classification is necessary for GIS data and have presented several different types of classification structures, describing how they can be used and encoded.

Copies of the SpECS classification scheme and the tool SpECS may be obtained from:

Directorate: National Spatial Information Framework
Chief Directorate: Cadastral Surveys
Private Bag X954
Pretoria 0001
8th Floor, South Block, Fedsure Building,
cnr. Pretorius & Van der Walt Streets, Pretoria.
Telephone: (012) 322 5400
Facsimile: (012) 322 5418
Email: NSIF@csg.pwv.gov.za

These materials are currently distributed free to the South African GIS community. The Directorate: National Spatial Information

Framework will be responsible for managing SpECS, and they will allocate codes for new classes. It might also be feasible for them to allocate a range of codes to a particular organisation with the necessary domain expertise, allowing them to create new classes in a particular part of the SpECS hierarchy.

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We would also like to acknowledge the contributions made by all those who were interviewed by the project team and/or provided us with material on the classification schemes they used.

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Appendix A
A full list of classes in SpECS v1b

[0] Root Class
[1] Natural
  [11] Pedosphere
    [1101] Geology
      [110101] Lithology
        [11010101] Lithostratigraphy
      [110102] Geological Structure
      [110103] Mineral Resource
      [110104] Geochemistry
      [110105] Geophysics
        [11010501] Gravity Point
        [11010502] Magnetic point
        [11010503] Seismic Event Observation
      [110106] Engineering Geology
      [110107] Marine Geology
    [1102] Pedology
      [110201] Modal Profile
      [110202] Soil Survey
      [110203] Soil Unit
    [1103] Landscape Feature
      [110301] Coast
      [110302] Crest
        [11030201] Bornhart
        [11030202] Mesa
        [11030203] Tor
      [110303] Dune
        [11030301] Shifting Dune
        [11030302] Stabilised Dune
      [110304] Cliff
      [110305] Plain
      [110306] Slope
        [11030601] Concave Slope
        [11030602] Convex Slope
        [11030603] Fan
        [11030604] Landslide
        [11030605] Pediment
        [11030606] Talus Slope
      [110307] Solution Feature
        [11030701] Sinkhole
      [110308] Erosion
        [11030801] Gully Erosion
        [11030802] Sheet Erosion
        [11030803] Rill Erosion
  [12] Hydrosphere
    [1201] Marine
      [120101] Hydrography
        [12010101] Anchorage Area
        [12010102] Cargo Transhipment Area
        [12010103] Maritime Caution Area
        [12010104] Maritime Contiguous Zone
        [12010105] Continental Shelf Area
        [12010106] Custom Zone
        [12010107] Exclusive Economic Zone
        [12010108] Navigation Fairway
        [12010109] Fishery Zone
        [12010110] Free Port Area
        [12010111] Harbour Area
        [12010112] Maritime Restricted Area
        [12010113] Straight Territorial Sea Baseline
        [12010114] Territorial Sea Area
        [12010115] Internal Waters
      120102] Oceanography
    [1202] Surface water
      [120201] Drainage Region
      [120202] Drainage Basin
      [120203] Flood Zone
      [120204] Lake
        [12020401] Historical Flood Zone
        [12020402] Probability Flood Zone
      [120205] Pan
      [120206] River
      [120207] Vlei
        [12020701] River Point
        [12020702] River Reach
        [12020703] Drainage Path
        [12020704] Watercourse
        [12020705] River Channel
        [12020706] River System
        [12020707] River Network
        [12020708] Estuary
        [12020709] River Structure
        [12020710] River Mouth
        [12020711] Stream
        [12020712] Runoff
      [120208] Swamp
      [120209] Catchment Area
      [120210] Water Reservoir
    [1203] Groundwater
      [120301] Aquifer
  [13] Biosphere
    [1301] Landcover
      [130101] Forest and Woodland
        [13010101] Forest
        [13010102] Woodland
        [13010103] Wooded Grassland
      [130102] Thicket, Bushland, Scrub Forest and High Fynbos
        [13010201] Thicket
        [13010202] Scrub Forest
        [13010203] Bushland
        [13010204] Bush Clumps
        [13010205] High Heathland (High Fynbos)
      [130103] Shrubland and Low Fynbos
        [13010301] Shrubland
        [13010302] Low Fynbos (Heathland)
      [130104] Herbland
      [130105] Grassland
        [13010501] Unimproved Grassland
        [13010502] Improved Grassland
      [130106] Barren Land
        [13010601] Bare Rock or Soil
    [1302] Biozone
      [130201] Acock's Veld Types
    [1303] Fauna and Flora
      [130301] Biogeographical Region
      [130302] Biological Survey Site
      [130303] Natural Community Area
      [130304] Biome Area
      [130305] Species Observation Point
      [130306] Species Population Area
      [130307] Species Range
  [14] Atmosphere
    [1403] Pressure
    [1404] Temperature
    [1405] Wind
    [1406] Moisture
      [140601] Humidity
      [140602] Clouds and Fog
      [140603] Precipitation
[2] Cultural
  [21] Abstract

- [2101] Isoline
  - [210101] Isobar
  - [210102] Isohyet
  - [210103] Isotherm
  - [210104] Isovap
  - [210105] Isoneph
  - [210106] Contour
  - [210107] Isobath
- [2102] Boundary
  - [210201] Regulatory
    - [21020101] Suburb
    - [21020102] Health District
    - [21020103] Health Region
    - [21020104] Education District
    - [21020105] Education Region
    - [21020106] Transport Zone
    - [21020107] South African Police Service
      - [2102010701] CAS Block
      - [2102010702] Police Station Area of Jurisdiction
      - [2102010703] Police Area
    - [21020108] South African National Defence Force
      - [2102010801] Commands
    - [21020109] Welfare
    - [21020110] Land Affairs
    - [21020111] Environmental Affairs
    - [21020112] Tourism
    - [21020113] Trade and Industry
    - [21020114] Agriculture
    - [21020115] Housing
    - [21020116] Mineral and Energy Affairs
  - [210202] Cadastral
    - [21020201] Servitude
    - [21020202] Urban Cadastral
      - [2102020201] Erf
      - [2102020202] Subdivision
      - [2102020203] Remainder (Erf)
      - [2102020204] Township
      - [2102020205] Extension
    - [21020203] Rural Cadastral
      - [2102020301] Farm
      - [2102020302] Portion
      - [2102020303] Remainder (Farm)
  - [210203] Administrative
    - [21020301] Current Administrative Boundary
      - [2102030101] Provincial Boundary
      - [2102030102] International Boundary
      - [2102030103] Magisterial District
      - [2102030104] Environmentally Protected Areas
      - [2102030105] Metropolitan Council
      - [2102030106] Metropolitan Substructure
      - [2102030107] Rural District Council
      - [2102030108] Local Authority Council
      - [2102030109] Supreme Court Division
    - [21020302] Historical Administrative Boundary
      - [2102030201] TBVC State
      - [2102030202] Self Governing Territory
      - [2102030203] Group Area
      - [2102030204] RSC or JSB
      - [2102030205] Divisional Council
      - [2102030206] Pre-1994 Province
      - [2102030207] Mineral Rights
  - [210204] Business Management
    - [21020401] Telephone Exchange Area
    - [21020402] Sales Territory
    - [21020403] Generation Area
    - [21020404] Distribution Area
    - [21020405] Water Board Area
  - [210205] Social Statistical
    - [21020501] Enumerator Area
    - [21020502] Census District
    - [21020503] Statistical Region
    - [21020504] Planning Region
    - [21020505] Statistical Suburb

- [22] Physical
  - [2201] Built Environment
    - [220101] Network
      - [22010101] Fluid Network
        - [2201010101] Petroleum and Chemical
          - [220101010101] Pipe
            - [22010101010101] Pump
            - [22010101010102] Pump Station
            - [22010101010103] Valve
            - [22010101010104] Join
            - [22010101010105] Inspection Point
        - [2201010102] Gas
          - [220101010201] Gas Pipe
          - [22010101020101] Gas Pump
          - [22010101020102] Gas Pump Station
          - [22010101020103] Gas Valve
          - [22010101020104] Gas Join
          - [22010101020105] Gas Inspection Point
        - [2201010103] Sewerage
          - [220101010301] Bulk Sewer
          - [220101010302] Sewer
          - [220101010303] Connector
          - [220101010304] Sewer Inspection Point
        - [2201010104] Water
          - [220101010401] Water Bulk
            - [22010101040101] Water Pipe
            - [22010101040102] Water Canal
              - [2201010104010201] Sluice
              - [2201010104010202] Water Extraction Point
          - [220101010402] Water Connector
            - [22010101040201] Water Connector Pipe
            - [22010101040202] Water Connector Canal
        - [2201010105] Storm-water
          - [220101010501] Storm-water Canal
          - [220101010502] Storm Pipe
      - [22010102] Electricity
        - [2201010201] Transmission
          - [220101020101] High-voltage Powerline
            - [22010102010101] High-voltage Tower
            - [22010102010102] High-voltage Conductor
          - [220101020102] Transmission Substation
        - [2201010202] Generation
          - [220101020201] Power Station
        - [2201010203] Distribution
          - [220101020301] Distribution Centre
          - [220101020302] Distribution Powerline
            - [22010102030201] Distribution Tower
            - [22010102030202] Distribution Conductor
          - [220101020303] Distribution Substation
      - [22010103] Telecommunication
        - [2201010301] Manhole
        - [2201010302] Jointing Pit
        - [2201010303] Pillar Joint
        - [2201010304] Pipe Run
        - [2201010305] Cable
        - [2201010306] Street Distribution Cabinet
        - [2201010307] Distribution Point
        - [2201010308] Local
        - [2201010309] Pipe Junction Box
        - [2201010310] Joint
        - [2201010311] Pole

[22010104] Transportation
[2201010401] Road
[220101040101] National Road
[22010104010101] Freeway (National)
[22010104010102] Dual Carriageway (National)
[22010104010103] Single Carriageway (National)
[220101040102] Provincial Road
[22010104010201] Freeway (Provincial)
[22010104010202] Dual Carriageway (Provincial)
[22010104010203] Single Carriageway (Provincial)
[220101040103] Arterial Road
[22010104010301] Major
[2201010401030101] Dual Carriageway (Major)
[2201010401030102] Single Carriageway (Major)
[22010104010302] Minor
[2201010401030201] Dual Carriageway (Minor)
[2201010401030202] Single Carriageway (Minor)
[220101040105] Street
[22010104010501] Residential Access Collector
[22010104010502] Residential Access Loop
[22010104010503] Access Cul-de-sac
[22010104010504] Access way, Court or Strip"
[22010104010505] Alleyway
[22010104010506] Private Road
[220101040106] Other Road
[22010104010601] Dirt Road
[22010104010602] Track
[2201010402] Sea Transportation
[220101040201] Route
[2201010403] Inland Waterway
[2201010404] Rail
[2201010405] Air Transportation
[2201010406] Pedestrian
[220101040601] Footpath
[220102] Structure
[22010201] Structure for Fluids
[2201020101] Treatment Plant
[220102010101] Chemical
[220102010102] Dip
[220102010103] Artificial Wetland
[220102010104] Sewage Works
[2201020102] Dam
[220102010201] Dam Wall
[220102010202] Sluice Gate
[2201020103] Water Purification Plant
[2201020104] Open Reservoir
[2201020105] Closed Reservoir
[220102010501] Storage Tank
[220102010502] Closed Water Reservoir
[220102010503] Water Tower
[22010202] Agricultural Structure
[2201020201] Barn
[2201020202] Silo
[2201020203] Livestock Dip
[2201020204] Sty
[2201020205] Chicken Run
[2201020206] Windmill
[2201020207] Drinking or Feeding Trough
[2201020208] Stile
[2201020209] Cattle Grid
[22010203] Residential Structure
[2201020301] Formal Housing
[220102030101] Detached House
[220102030102] Block of Flats
[22010203010201] Flat
[220102030103] Semi-detached House
[220102030104] Townhouse
[220102030105] Formal Tenant Structure
[220102030106] Retirement Village House
[2201020302] Institution
[220102030201] Hostel
[22010203020101] School Hostel
[22010203020102] University or Technikon Residence
[22010203020103] Nurses Hostel
[22010203020104] Police Hostel
[22010203020105] Mine Hostel
[22010203020106] Local Authority Hostel
[220102030202] Retirement Home
[220102030203] Accommodation
[22010203020301] Hotel
[22010203020302] Motel
[22010203020303] Youth Hostel
[22010203020304] Boarding House
[22010203020305] Bed and Breakfast
[2201020303] Informal Housing
[220102030301] Shack
[220102030302] Hut
[2201020304] Ancillary Residential Structure
[220102030401] Garage
[220102030402] Shed
[220102030403] Storage Hut
[220102030404] Fence
[220102030405] Wall
[220102030406] Gate
[220102030407] Hedge
[2201020305] Mobile Residential Structure
[220102030501] Caravan
[220102030502] Transportable Hut
[220102030503] Mobile Home
[22010204] Commercial Structure
[2201020401] Office
[2201020402] Warehouse
[2201020403] Shopping Centre
[2201020404] Shop
[22010205] Public Structure
[2201020501] Telephone Exchange
[2201020502] Police Station
[2201020503] Post Office
[2201020504] Religious Building
[2201020505] Recreation Facility
[2201020506] Sport Facility
[2201020507] Memorial
[2201020508] Community Hall
[2201020509] Museum
[2201020510] Government Offices
[2201020511] Military Base
[2201020512] Medical Facility
[220102051201] Hospital
[220102051202] Clinic
[220102051203] Hospice
[2201020513] Cemetery
[22010206] Other Structure
[2201020601] Shipwreck
[2201020602] Monument
[2201020603] Telecom Tower
[22010207] Beacon and Signage
[2201020701] Cadastral Beacon
[220102070101] Trigonometric Beacon
[220102070102] Town Survey Mark
[220102070103] Benchmark
[2201020702] Aeronautical Navigation Beacon

[220102070201] Obstruction Light
[220102070202] Electronic Navigation Beacon
[220102070203] Runway Lights
[220102070204] Runway Markings
[2201020703] Marine Navigation Beacon
[220102070301] Lighthouse
[2201020704] Road Sign
[220102070401] Robot
[220102070402] Warning Light
[220102070403] Regulatory Sign
[220102070404] Warning Sign
[220102070405] Information Sign
[2201020705] Rail Sign
[220102070501] Rail Robot
[2201020706] Outdoor Advertising
[220102070601] Billboard
[22010208] Industrial Structure
[2201020801] Factory
[2201020802] Refinery
[2201020803] Waste Dump
[220102080301] Household and General
[220102080302] Chemical and Toxic
[220102080303] Nuclear
[22010209] Transport Structure
[2201020901] Harbour
[2201020902] Airport
[220102090201] Landing Strip
[2202] Landuse Planning
[220201] Historical Landuse
[22020101] Undeveloped Land (Historical)
[22020102] Residential Landuse (Historical)
[2202010201] Detached Housing Landuse (Historical)
[2202010202] Cluster Housing Landuse (Historical)
[2202010203] Other Residential Landuse (Historical)
[22020103] Commercial Landuse (Historical)
[22020104] Agricultural Landuse (Historical)
[22020105] Public Service Landuse (Historical)
[22020106] Transportation Landuse (Historical)
[22020107] Industrial Landuse (Historical)
[2202010701] Light Manufacturing Landuse (Historical)
[2202010702] Heavy Manufacturing Landuse (Historical)
[22020108] Informal Landuse (Historical)
[22020109] Cultural Landuse (Historical)
[22020110] Entertainment Landuse (Historical)
[22020111] Recreational Landuse (Historical)
[2202011101] Active Recreational Landuse (Historical)
[2202011102] Passive Recreational Landuse (Historical)
[220202] Landuse Zoning
[22020201] Undeveloped Land (Zoned)
[22020202] Residential Landuse (Zoned)
[2202020201] Detached Housing Landuse (Zoned)
[2202020202] Cluster Housing Landuse (Zoned)
[2202020203] Other Residential Landuse (Zoned)
[22020203] Commercial Landuse (Zoned)
[22020204] Agricultural Landuse (Zoned)
[22020205] Public Service Landuse (Zoned)
[22020206] Transportation Landuse (Zoned)
[22020207] Industrial Landuse (Zoned)
[2202020701] Light Manufacturing Landuse (Zoned)
[2202020702] Heavy Manufacturing Landuse (Zoned)
[22020208] Informal Landuse (Zoned)
[22020209] Cultural Landuse (Zoned)
[22020210] Entertainment Landuse (Zoned)
[22020211] Recreational Landuse (Zoned)
[2202021101] Active Recreational Landuse (Zoned)
[2202021102] Passive Recreational Landuse (Zoned)
[220203] Current Landuse
[22020301] Undeveloped Land (Current)
[22020302] Residential Landuse (Current)
[2202030201] Detached Housing Landuse (Current)
[2202030202] Cluster Housing Landuse (Current)
[2202030203] Other Residential Landuse (Current)
[22020303] Commercial Landuse (Current)
[22020304] Agricultural Landuse (Current)
[22020305] Public Service Landuse (Current)
[22020306] Transportation Landuse (Current)
[22020307] Industrial Landuse (Current)
[2202030701] Light Manufacturing Landuse (Current)
[2202030702] Heavy Manufacturing Landuse (Current)
[22020308] Informal Landuse (Current)
[22020309] Cultural Landuse (Current)
[22020310] Entertainment Landuse (Current)
[22020311] Recreational Landuse (Current)
[2202031101] Active Recreational Landuse (Current)
[2202031102] Passive Recreational Landuse (Current)
[220204] Proposed Landuse
[22020401] Undeveloped Land (Proposed)
[22020402] Residential Landuse (Proposed)
[2202040201] Detached Housing Landuse (Proposed)
[2202040202] Cluster Housing Landuse (Proposed)
[2202040203] Other Residential Landuse (Proposed)
[22020403] Commercial Landuse (Proposed)
[22020404] Agricultural Landuse (Proposed)
[22020405] Public Service Landuse (Proposed)
[22020406] Transportation Landuse (Proposed)
[22020407] Industrial Landuse (Proposed)
[2202040701] Light Manufacturing Landuse (Proposed)
[2202040702] Heavy Manufacturing Landuse (Proposed)
[22020408] Informal Landuse (Proposed)
[22020409] Cultural Landuse (Proposed)
[22020410] Entertainment Landuse (Proposed)
[22020411] Recreational Landuse (Proposed)
[2202041101] Active Recreational Landuse (Proposed)
[2202041102] Passive Recreational Landuse (Proposed)
[2203] Pollution Source
[220301] Air Pollution
[22030101] Point Source for Air Pollution
[22030102] Area Source for Air Pollution
[220302] Sea Pollution
[22030201] Point Source for Sea Pollution
[22030202] Area Source for Sea Pollution
[220303] Surface Water Pollution
[22030301] Point Source for Surface Water Pollution
[22030302] Area Source for Surface Water Pollution
[220304] Groundwater Pollution
[22030401] Point Source for Groundwater Pollution
[22030402] Area Source for Groundwater Pollution
[220305] Soil Pollution
[22030501] Point Source for Soil Pollution
[22030502] Area Source for Soil Pollution
[220306] Noise Pollution
[22030601] Point Source for Noise Pollution
[22030602] Area Source for Noise Pollution