

SWISK 45

A national standard for the exchange of digital geo-referenced information

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NASIONALE NAVORSINGSINSTITUUT VIR WISKUNDIGE WETENSKAPPE
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This document is being made available now because of its historical importance in the development of the geographical information sciences in South Africa; to make available the extensive glossary included in the document; and for anyone interested in the standard, including those wishing to decode a data set encoded according to this standard. Please note that version 2 of this standard was published in November 1990.

Antony K Cooper
CSIR
5 October 2018

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**A national standard for the exchange of
digital geo-referenced information**

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SPESIALE VERSLAG

**NASIONALE NAVORSINGSINSTITUUT VIR WISKUNDIGE WETENSKAPPE
NATIONAL RESEARCH INSTITUTE FOR MATHEMATICAL SCIENCES
WNNR**

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ABSTRACT

Geographically referenced (geo-referenced) information consists of all information that refers to the man-environment system and that can be localized in space and time. The basic entity of geo-referenced information is the feature, which has spatial and non-spatial attributes. To distribute geo-referenced information effectively, one needs an efficient mechanism that will exchange the data without losing, reducing or altering the information. To satisfy this requirement, an exchange standard must, amongst other facilities, provide a means for recording information on data quality, for retaining all topological information and for classifying the features and their attributes present in the data. In addition, an exchange standard must be flexible, easy to use, complete and unambiguous.

This document is the final version of a proposed South African national standard for the exchange of digital geo-referenced information. The authors constitute a project team funded by the National Programme for Remote Sensing, under the auspices of the CSIR. There are a number of organizations in South Africa with computerized cartographic and geographical information systems and many more on the verge of acquiring such systems. To be effective, these systems need large volumes of geo-referenced information in a digital form. It is inefficient for each organization to capture all its own data - it is far more efficient for users to be able to receive data from those who have already captured them. This exchange standard is designed to provide the efficient mechanism through which users can exchange digital geo-referenced information.

KEYWORDS

Geo-referenced Information, Exchange Standard, Data Quality,
Feature, Attribute, Classification, Topology, Relation.

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FOREWORD

The National Standard for the Exchange of Digital Geo-referenced Information presented here is the result of the work of a project team working under the auspices of the National Committee for Remote Sensing, CSIR and consisting of the following four members:

D G Clarke, Chief Directorate of Surveys and Mapping - Project Leader;
Miss M H van Rooyen, National Research Institute for Mathematical Sciences, CSIR - Project Co-leader;
A K Cooper, National Research Institute for Mathematical Sciences, CSIR;
Prof E C Liebenberg, Department of Geography, UNISA.

One may ask why there is a need for an exchange standard. The value of an exchange standard can only be proved through experience, but it is appropriate to consider some factors here. Geographical information systems (GIS) are multi-disciplinary in nature, and therefore the structuring of databases will differ from organization to organization. The data capture process is expensive and time consuming, and in most cases it will be possible to obtain the data required from another organization, immediately and at a reduced cost. For the efficient transfer of data from the supplier's database to that of the recipient an interface program is required. Without an exchange standard, the recipient would require an interface program for each supplier. However, if an exchange standard is used, then the recipient needs only one interface program. Thus, it makes good sense to have a national standard for the exchange of digital geo-referenced information.

Exchange standards exist for Computer-aided design (CAD) systems, but these standards are intended for graphics data and world-wide have been found to be inadequate or too complicated for the exchange of geo-referenced information as used in a GIS. Exchange standards for geo-referenced information have been or are being prepared in a number of countries. After studying these standards, the project team has applied their good points to the local situation and has attempted to find alternative solutions to their weaknesses.

The standards being produced overseas concentrate on cartographic and cadastral information, whereas the project team have attempted to cater for all types of geo-referenced information.

This document is the final version of the proposed standard. A draft version of the exchange standard was presented at public hearings during April and May 1987. The project team acknowledges the incompleteness of parts of this exchange standard, particularly with regard to data quality and classification. These aspects require expansions once the user community is in a position to pass comment. It is, however, considered necessary to put forward this exchange standard as a foundation upon which future versions can be built. An exchange standard needs to be accepted in its own right by its user community, otherwise it will fail. It cannot succeed if it is imposed by law. It is the responsibility of the user community to work together to ensure that only one national standard for the exchange of digital geo-referenced information is used in South Africa.

An exchange standard such as this should be maintained on a co-ordinated basis and a maintenance body should be set up for this purpose. The National Research Institute for Mathematical Sciences (NRIMS) of the CSIR intends to promote the viability and acceptance of this proposed standard, in association with the user community and the National Programme for Remote Sensing.

Pending the establishment of a maintaining authority, all comments on the exchange standard and requests for updates should be submitted to:

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AUGUST 1987

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CHAPTER 1

INTRODUCTION TO THE PROPOSED EXCHANGE STANDARD

1.1 Layout of this document

This document describes a standard for the exchange of digital geo-referenced information. The issues involved are discussed in the first four chapters, and the exchange format is presented in chapter 5.

The first chapter gives an overview of the exchange standard and its use. It also describes geo-referenced information (the information for which the exchange standard should be used) and the relational and modular structure of the exchange standard. The exchange standard may be used for alphanumeric data, raster data, vector data, or a combination thereof. In addition, it caters for basic topology. While the structure of the exchange standard may be relational, it can be used in conjunction with any database, whatever its internal structure. Users will have to provide an interface program that converts data from the format of their databases to that of the exchange standard, and vice versa.

The second chapter discusses data quality - what it is, how it is assessed and how information on data quality is exchanged. This version of the exchange standard will only allow information on data quality to be exchanged as free text included within the data.

The third chapter discusses the classification of geo-referenced information. Guidelines are presented for drawing up a classification scheme. An incomplete standard classification scheme is presented in Appendix B.

The fourth chapter discusses the physical media used for the exchange of digital geo-referenced information.

Chapter 5 presents the standard structure of a data set for exchange. Any set of data being exchanged is termed a logical file. A logical file may exist on one or more physical storage volumes, such as magnetic tapes or floppy discs. Every volume begins with a File Identification, which identifies the data on the volume. Every logical file contains a Global Information Section, which gives details of the set of data being exchanged, followed by the Geo-referenced Information Relation Sections. The contents and use of the File Identification, Global Information Section and relations are described and examples are given.

Appendix A contains a glossary of some geo-referenced information terms and their Afrikaans translations. Appendix B contains a partial classification and non-spatial attribute scheme. Appendix C contains a summary of the File Identification, Global Information Section and the geo-referenced information relations. Appendix D contains a few examples of data in the exchange format.

1.2 Use of the exchange standard

Without an exchange standard, each user would need a separate interface program for each organization from which data are received, or to which data are supplied. When an exchange format is used, only one interface program is required, namely to read and write data in the exchange format. Whenever two organizations wish to exchange data, the supplying organization would transform the data from the internal format of its own system into the exchange format by means of its interface program. The data would then be given to the recipient in the exchange format. The recipient organization would use its interface program to transform the data from the exchange format into the internal format of its own system. This process is illustrated in Figure 1.1.

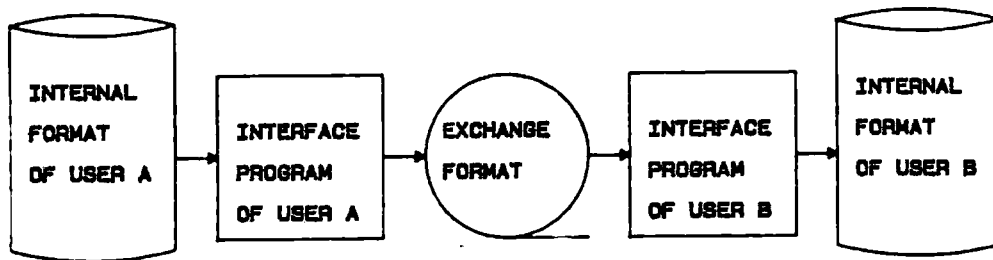


Figure 1.1

Note that the interface programs are not part of the standard - they differ from one organization to another because of different data formats being used by the different systems.

Furthermore, the exchange standard does not place any restrictions on the structure of the databases in the various organizations. It does, however, require meaningful information from these databases for exchange purposes.

The exchange standard addresses two basic aspects of exchange: firstly, the format of the exchange, and secondly, the scope of information that may be exchanged using the standard. Standardization of the format is mandatory to enforce a single interface program in each organization. For the sake of efficiency, variations such as, for example, ASCII or binary coding are allowed. Standardization of the scope of information would be ideal, but is unfortunately impractical. Organizations cannot be expected to supply information that is not known to them, or do not need in their specific applications, or for which their own systems do not cater. This implies that the amount of information exchanged for a given feature of a given class may differ, depending on the supplier. Recipients should be aware of this fact and be able to cope with receiving either less or more information than needed for their own

applications. The exchange format caters for both simple and sophisticated data sets, by allowing selective use of the set of data relations. The exchange format has been designed with built-in flexibility to cater for users from different disciplines and with different applications.

The biggest teething problems can be expected in feature classification, non-spatial attributes and data quality. On these issues, the exchange standard attempts to provide a mechanism for standardization with the ultimate goal being a standard itself. However, these issues require maturing through the use of computerized systems before such standardization is possible. In the meantime, each interface program needs a set of translation tables for each relevant classification and non-spatial attribute system. Data quality will initially be handled as human readable text only.

It is advised that a centralized body be established to maintain the exchange standard. All changes and enhancements suggested by users should then be channelled through this body.

It is foreseen that the standard will need revision from time to time, especially during its initial operational phases. However, the project team trusts that the standard will provide a sound beginning towards a widely used national standard.

1.3 The basic concepts of geo-referenced information

Geo-referenced information consists of all information that refers to the man-environment system and that can be localized in space and time. Computerization of geo-referenced information started with the statistical processing of thematic data and with automated cartography. This has now developed to **geographical information systems (GIS)**. A GIS consists of a database of spatially (geographically) referenced data and a collection of utilities for efficiently inputting, storing, retrieving, maintaining, manipulating, analysing and displaying the data.

A true GIS is a system that is orientated to the **analysis** of geo-referenced data to produce useful information (Cooper 1986b). To do this, the GIS database must cater for the description of geo-referenced information in its three forms - **vector**, **raster** and **alphanumeric**. It must provide a **topological structure** for the spatial data - that is, a structure that explicitly encodes the spatial relationships inherent in the data.

This exchange standard is an attempt at providing the structures to exchange all types of geo-referenced information, and not just computerized cartographic information.

1.3.1 Features

Features are the basic entities of geo-referenced information. Features have **spatial** (that is, fixed in time and space) and **non-spatial** (that is, descriptive information) components, known as the **attributes** of the feature. Thus, descriptive information is fixed in time and space through the features. In fact, without features, a GIS cannot hold any information. However, data being exchanged are a subset of the data in a GIS, and thus there do not have to be any features in any data set being exchanged. For example, a data set being exchanged might contain update information correcting errors in spatial attributes.

Spatial attributes may be **vector** (that is, positional data recorded as coordinate tuples forming nodes, chains, etc) or **raster** (that is, data expressed as a tessellation of cells, with spatial position implicit in the ordering of the cells). An example of vector data is a road network stored as a set of lines representing the roads, and an example of raster data is a digital terrain model (DTM).

A simple **feature** is a set of one or more uniquely identifiable objects in the real world where the defined characteristics of the objects are consistent throughout all the objects.

An **attribute** is a defined characteristic of any feature about which information is stored.

Non-spatial attributes are attributes that are independent of the position of the feature - often termed the descriptive data of the feature.

Classification is the arrangement of features into classes or groups and must be done on the basis of the **qualitative** characteristics of the objects, such as their function, and not on their **quantitative** characteristics. A feature's classification should be done on the basis of those of its characteristics that are least likely to change. Classification is described in more detail in Chapter 3.

There is a fine distinction between the non-spatial attributes of a feature and its classification because for different users, different criteria apply. One could even consider classification to be a non-spatial attribute.

Figure 1.2 illustrates the relationships between the basic concepts of geo-referenced information.

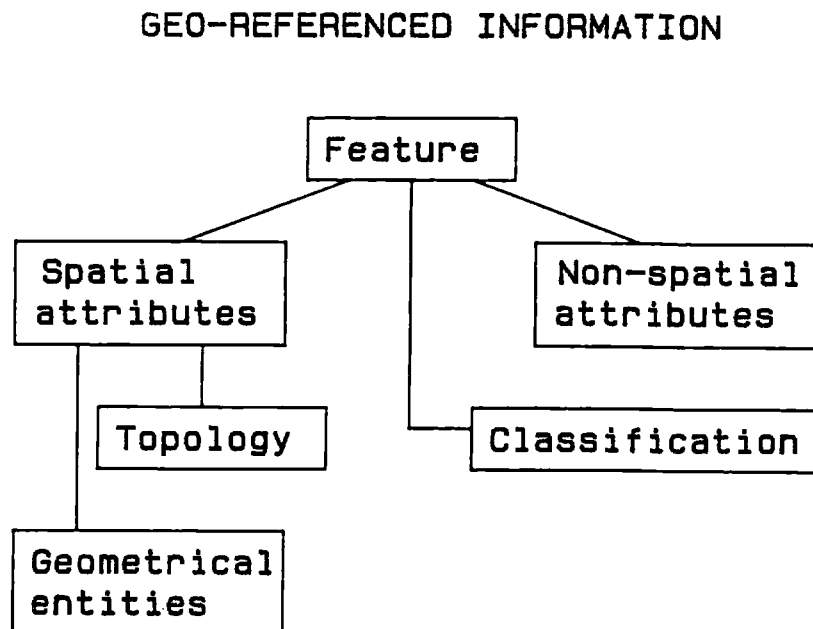


Figure 1.2

An example of a feature is a land parcel. Its non-spatial attributes include the owner of the land and its zoning. While it is possible to classify the land parcel by its owner or zoning, it is better to classify it as a land parcel - if the owner or zoning changes, the feature does not change, whereas if the land parcel is no longer a land parcel, then the feature does change.

Another example of a feature is a population centre. One of its non-spatial attributes would be its population. It is possible to classify the centre according to its population. However, to do so, the population variable would have to be reduced to a discrete number of ranges, which would mean that the exact population figure would be lost. In addition, were the population of the centre to change so that it moved into a different range, the feature's classification would have to change.

Within this exchange standard, features are grouped on the basis of the nature of their **spatial attributes**. The three types of **vector** features are **point**, **line** and **area** and the **raster** type of feature is a **grid**. There is also a **compound feature**, being a collection of other features.

1.3.2 Spatial attributes

A **spatial attribute** is an attribute whose value is a subset of any two- or three-dimensional space. The first two dimensions are planimetric - in the plane of the surface of the celestial body to which the spatial attribute is fixed, normally the earth. This surface is modelled by an ellipsoid or sphere, for example the Clarke 1880 ellipsoid (see section 5.3.3). Planimetric coordinates include latitude and longitude. The third dimension is the vertical distance above (or below) a reference surface, for example a geoid, that models the surface of the celestial body (see section 5.3.14). Two and three dimensions are widely used in GIS's in South Africa, while the fourth dimension (time) is rarely used. Thus, this version of the exchange standard does not cater for time as a coordinate - it may still be used as a non-spatial attribute. Three-dimensional vector spatial attributes, namely **solids**, are not yet well understood and this version of the exchange standard does not cater for them.

The three fundamental types of two-dimensional **vector** spatial attributes are **nodes**, **chains** and **regions**. The fundamental **raster** spatial attribute is the **matrix**.

A **node** is a 0-dimensional object with an n-tuple of coordinates specifying its position in n-dimensional space, where n is 2 or 3 and in future, could be extended. Topologically, it is known as a 0-cell.

The position of a **point feature** is described by a single node.

Figure 1.3 illustrates the concepts of a node and point features (a post office, a windmill and a dipping tank).

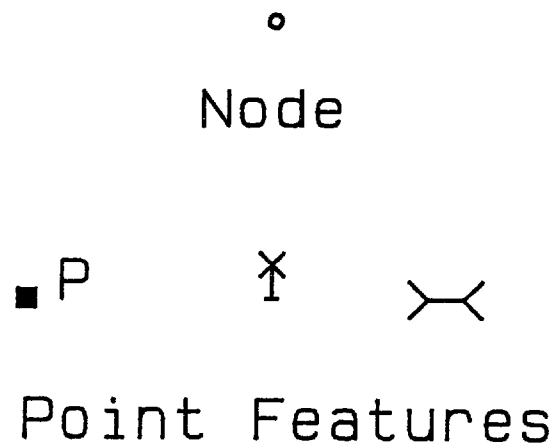


Figure 1.3

A **chain** is an ordered undirected sequence of n-tuples of coordinates with a **node** at each end. The direction of the chain is defined when the chain is used in a specific region or line feature (see below).

An **arc** is any continuous part of the circumference of a circle with a **node** at each end. The arc is defined by giving the start and end nodes of the arc and one other point on the arc. Topologically, chains and arcs are known as 1-cells.

The position of a **line feature** is described by a set of chains and/or arcs. These chains and arcs do not necessarily form a continuous object.

Figure 1.4 illustrates the concepts of a chain and line features (telephone lines and non-perennial stream).

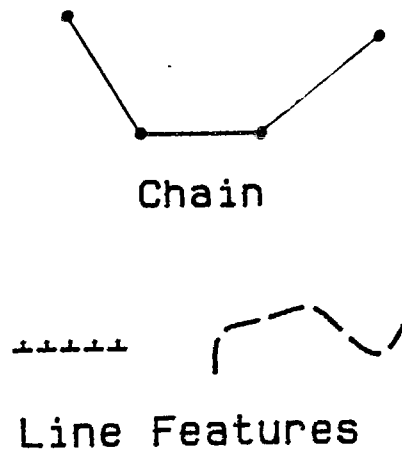


Figure 1.4

A **region** is the interior of a continuous and closed sequence of one or more chains, known as the region's outer boundary. A region may have islands, which are other regions contained within the region's outer boundary but not forming a part of the region (see section 1.2.3). Topologically, a region is known as a 2-cell.

The position of an **area feature** is described by a set of regions. These regions do not necessarily form a continuous object.

In the example of the land parcel, the land parcel is an area feature and its spatial attributes are the region(s) that make up the land parcel. The boundary of the land parcel is in turn represented by chains.

Figure 1.5 illustrates the concepts of a region and area features (cultivated land and dense bush).

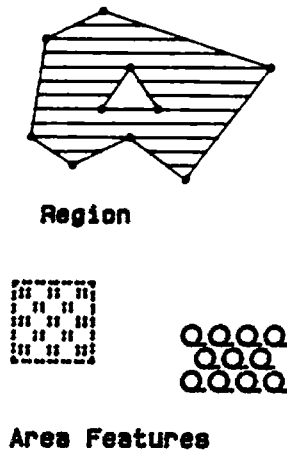


Figure 1.5

A **matrix** consists of an n -tuple of coordinates, defining its origin and an m -dimensional rectangular tessellation of data values encoded in a pre-defined format. When more complex tessellations for geo-referenced information are understood better, they will be added to later versions of this standard. For the purposes of topology (see section 1.3.3), a **matrix** is similar to a region.

The position of a **grid feature** is described by a set of matrices. These matrices do not necessarily form a continuous object.

Figure 1.6 illustrates the concept of a matrix.

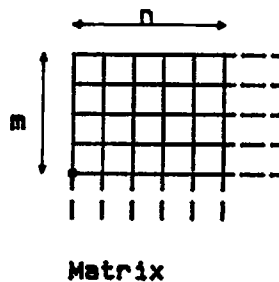


Figure 1.6

Owing to the complex nature of geo-referenced information, it is desirable to be able to combine a number of different features to form one feature. These are called **compound** features, which are collections of other features. A compound feature may not be a constituent part of itself.

Thus, features and their spatial attributes are linked by the relationships that take care of a node representing a point feature, networks of chains that form a line feature, disjoint regions that form an area feature and different matrices that form a grid feature.

Chains and arcs have inherent ordering, which is the sequence in which their internal coordinate tuples are stored. When chains and arcs are used by line features (as their spatial attributes) and regions (as their boundaries), they are not necessarily used in the direction in which the internal coordinate tuples are stored. Thus, when using a chain or an arc, one has to specify the direction in which it is used - forwards (in the direction of the internal coordinate tuples) or backwards (in the opposite direction of the ordering of the internal coordinate tuples).

1.3.3 Topology

In the real world, features are interrelated in terms of their positions relative to each other, for example, neighbouring farms or a road crossing a river. The modelling of these interrelationships in a GIS is called topology. Since topology is dependent on position only, the topology of a feature is described in terms of its spatial attributes.

In principle it is possible to derive topology from spatial attributes. However, this approach is not without its problems. Consider, for example, a provincial boundary running along a river. If these two features are captured independently without care being taken of the fact that they share a chain or set of chains as spatial attributes, these chains will not coincide exactly, causing slivers in the database. These are narrow areas of overlap (where the river crosses the boundary) and underlap (gaps between the river and the boundary). Furthermore, it may

not be easy for the GIS to detect automatically that the river and boundary are coincident. These problems may be overcome by capturing the common part only once and sharing these chains between the river and boundary features.

The alternative approach then is to capture topology explicitly and to store it in the database. This facilitates reduced redundancy (for example, shared chains are stored only once); enhanced consistency (for example, a chain shared by two features represents exactly the same location and not slightly different ones); enhanced completeness, in the sense that more information about features is available; and speeds up queries on topology.

Topology is normally implemented as a mathematical model, following certain mathematical rules. However, the concept of topology is not yet fully understood. What topological aspects should be modelled, and how? This exchange standard has thus attempted to cater for only those aspects of topology that are known and used. As the knowledge of topology matures, these aspects should be extended to a more complete set of topology relations.

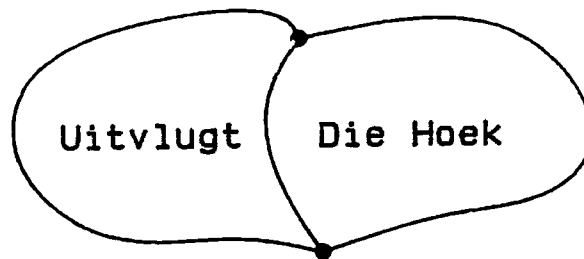
Only two topological relations are provided in the exchange format, namely coincidence and exclusion. Coincidence refers to sharing of spatial attributes, whereas exclusion currently only caters for area features that exclude contained 'islands'.

The various instances of coincidence as modelled in the exchange standard are the following:

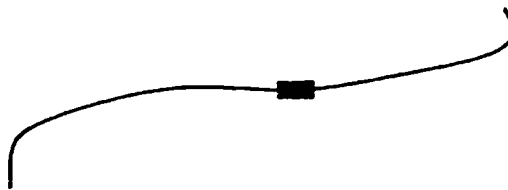
- point features at the same location : the node is shared.
- a point feature on a line feature : the node of the point feature is shared with an end node of a chain of the line feature.
- a point feature on the boundary of an area feature : the node of the point feature is shared with an end node of a chain of the boundary of the region describing the area feature.

- line features being (partially) coincident : one or more chains are shared between the features.
- a line feature running along the boundary of an area feature : one or more chains of the line feature are shared with the boundary of the area.
- adjacent area features : one or more chains are shared by the boundaries of the area features.
- coincident area features : the same region(s) is(are) shared by the features.

The following examples illustrate coincidence:



Farms sharing a boundary

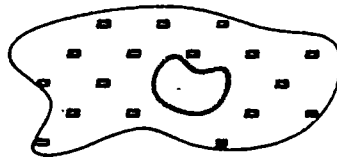


Station on a railway line

Figure 1.7

Exclusion is currently implemented for area features only. An area feature may exclude a region, which may in itself either be another area feature, or not related to a feature at all.

The following examples illustrate exclusion:



Island in a dam



Dam in a disjoint field

Figure 1.8

Other topological aspects not currently modelled include containment of point and line features within area features and intersection of line features with other line features or area features.

These topological aspects are catered for in the exchange format by the relational structure. However, geographical information containing no topology may be exchanged with the same ease as that containing topology.

1.3.4 Alternate spatial attributes

Spatial attributes are captured at a particular scale, for example, at the scale of a source document or at 1 to 1. Generally, the larger the scale, the more accurate the spatial attributes and the more coordinate tuples are recorded. In principle, large volumes of large-scale data can be reduced to smaller volumes of small-scale data (that is, containing less information) through a process called generalization.

However, automatic generalization of spatial attributes is not yet possible across significant scale ranges. On the other hand, large-scale data cannot be derived from small-scale data, since additional detail is required. Therefore it is useful to be able to store spatial information to different levels of detail, related to particular scales. Note that the coordinate system in which the data is stored is typically independent of scale, for example, latitude and longitude. It is the amount of detail stored that is scale dependent.

One way of doing this is to have separate databases, one for each scale. While this is conceptually easy to understand and easy to implement, it could create redundancies (storing the non-spatial information repeatedly for each database) and could mean that one cannot make enquiries involving all the features (some features on the largest scale database might not be on the smallest scale database, and vice versa).

The second option is to store all the spatial data related to their various scales in the same database. The different spatial versions of a feature are then stored together with the non-spatial attribute information of the feature, which is invariant with respect to scale. While this method is conceptually more difficult to understand, it does mean that one's data are properly integrated and sophisticated operations are facilitated. These different versions of spatial attributes are known as **alternate spatial attributes**.

Alternate spatial attributes are generally dependent on scale. However, at any particular scale one may have more than one alternate spatial attribute for a feature. The mapping of the alternate spatial attributes to scale must be fixed across all feature classes throughout a data set being exchanged.

Alternate spatial attributes are intended not only for storing spatial information at different scales. They may also be used to store different versions of the same spatial attributes - at the same scale. For example, in an area with too much spatial information for legible output, one might prefer to store detailed versions of the spatial attributes for analysis and generalized versions for display.

This version of the exchange standard caters for alternate spatial attributes (see 5.3.26 and some of the relations in 5.4).

1.4 Remotely sensed data

A number of sensors aboard air- and space-borne platforms provide voluminous amounts of data in digital form. The data from these sensors are a valuable source of information for a GIS and are thus worthy of consideration.

It is accepted that the remotely sensed data are not regarded as geo-referenced information until they have been geo-coded, regardless of what other processing may have taken place. This means that even a classified image is not regarded as geo-referenced information until it has been geo-coded. The reason is that the information extracted from an image prior to geo-coding is not in a form readily usable in a GIS.

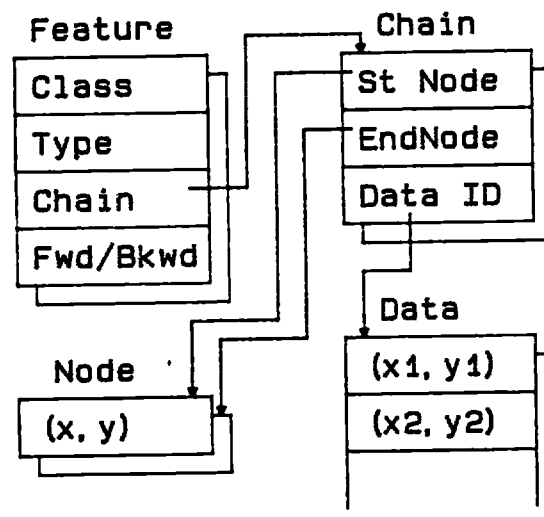
Most satellite remotely sensed data emanate from satellite receiving stations or associated organizations and are disseminated to users in accordance with existing exchange standards. It is recommended that the status quo be maintained. However, any remotely sensed data that have been geo-coded should be regarded differently and be handled in accordance with this national standard. These data will be dealt with in the same manner as any other raster (grid cell) data. The statements on data quality should contain information such as the sensor type, date of imaging, radiometric and geometric corrections, method of resampling and method of classification (if applicable).

1.5 The relational structure

A data set in the format of an exchange standard is not a database - it is merely a set of data that has been extracted from one database with the purpose of being incorporated into another database. To be successful, an exchange standard must be independent of the database structures of the GIS's that use it. While this exchange standard has a relational structure, it may be used by any GIS, whatever its internal structure.

There are three common models used for data structures, namely the **hierarchical**, the **network** and the **relational**. The hierarchical and network models are the older models, and they are being replaced by the more powerful and more precise relational model. The Australian exchange standard (Standards Association of Australia 1982) uses a hierarchical structure, while the British standard (Sowton & Haywood 1987) uses a combination of the network and relational models for its data structure.

Figure 1.9 illustrates the network structure and should be compared to figure 1.10, which illustrates the relational structure.

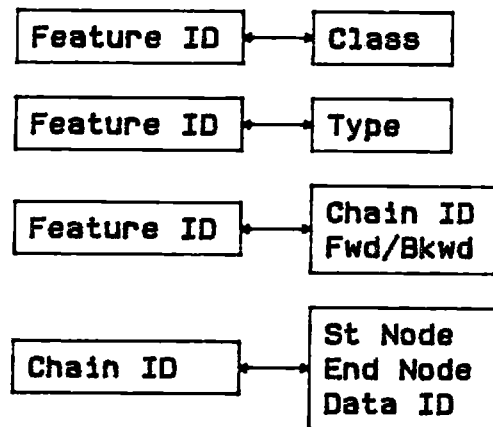


A network data structure

Figure 1.9

Two major disadvantages of these models are that firstly, the users have to enter data into a number of fields that they may not wish to use, and secondly, the structures are rigid and can only be changed with difficulty to cater for new types of data, such as the third dimension.

A relation is a two-dimensional table in which the columns are called attributes and the rows are called tuples. The attributes are drawn from domains (fixed sets of values) and each tuple consists of one value from each attribute. The associations between tuples are represented by common values for the same attributes. The relational structure has all the data represented in a single uniform manner, and thus operations on the data are robust and simple to implement. There are a number of good introductory texts to database theory, for example, (Date 1981) and (Ullman 1982), giving more information about relations and database theory in general.



A relational data structure

Figure 1.10

A relational structure is inherently modular. Thus, users merely omit those relations for which they have no data, and it is almost trivial to add new relations to an existing exchange standard. In fact, data that can be exchanged through a modular exchange structure can always be exchanged through the structure, no matter how many new relations are added to cater for new types of data.

The project team has studied the hierarchical, network and relational data models in the context of geo-referenced information and believes that the relational model is the only one that provides the power and flexibility required.

Although a relational model is being used for the proposed exchange standard, use of the standard is not restricted to relational databases. On the contrary, any type of database can use this exchange standard. To write an interface to the proposed exchange standard will not be a trivial task, but, because the proposed exchange has a modular and relational structure the interface program writer can select which relations he wishes to use and can ignore the rest. This means that for a simple database, the interface program will be relatively simple.

In a file of data being exchanged, the geo-referenced information is stored using relations. A section contains a number of entries, each of which is an instance of the same relation. Thus, the section corresponds to a table in a relational database and an entry to a tuple. The definitions of the relations (see 5.4) contain definitions of fields, which correspond to the attributes of a relational database. The entries in the data being exchanged contain instances of these field definitions.

It is desirable to have a degree of normalization in data in a relational form (Val Roessel 1987). In the Geo-referenced Information Relation Sections (see 5.4), some of the sections could often have a number of entries (instances of a particular relation) with the same key. To normalize these relations, a **sequence number** has been added to the keys. However, this is an artificial device that does not actually appear in the data being exchanged because the entries in a particular section will have an ordering, based purely on their position in the file. Thus, an entry's position in the file is its sequence number which does not have to appear explicitly in the data.

CHAPTER 2

DATA QUALITY

2.1 Introduction

Exchange information should include a quality report to provide sufficient information to enable users to determine whether the digital geo-referenced data are suitable for a particular use. This requirement is deemed necessary as the concept of data quality is an important and contentious issue in the field of spatial data handling, especially for the purpose of data exchange. Ever-increasing volumes of geo-referenced data generated by different sources such as remote sensing, digital cartography and land information systems are becoming available in digital form and are exchanged and disseminated amongst different geographical information systems developed by different disciplines with different tasks requiring different quality levels. For such data to be exchanged effectively and used optimally some measure of the level of data quality is of primary importance. Users can only determine whether data are suitable for their purpose if producers give an indication of the quality of the relevant data.

In the context of geo-referenced data, data quality is an elusive concept that is difficult to define as it brings to mind terms such as **precision**, **spatial resolution**, **horizontal and vertical accuracy** (relative and absolute) and **completeness**. In a GIS environment these terms all refer to different applications:

Precision is usually seen as a statistical measure of repeatability, which means that it refers to the exactness with which a value is expressed, regardless of whether the value is right or wrong.

Spatial resolution is a functional characteristic of a piece of equipment such as a digitizer or plotter, with high resolution implying a high degree of spatial discrimination but not necessarily implying accuracy.

Accuracy is usually defined as the closeness of observations, computations or estimates to the true values or the values that are accepted as being true. Higher accuracy therefore implies that a measurement is nearer the truth, with the truth being either absolute or relative.

Completeness can be seen as having all the necessary or normal parts.

All the above terms refer to some **aspect** of data quality. Therefore data quality itself has variously been defined as "fitness for use", "meeting an expectation", "degree of excellence" and "conformance to a standard" (Chrisman, 1986).

2.2 Truth in labelling and fitness for use

Most mapping agencies are involved in setting certain map standards and in evaluating the maps they produce to ensure that these standards are met. Computerized cartography, however, is but one part of a GIS, and the potential uses of spatial information stored in a GIS are so diverse that specifying a standard that sets fixed quality levels for geo-referenced data on a national basis would be impractical. The actual properties of the data should rather be communicated in such a way that users can make their own informed decisions on the quality of the data. In other words, the issue should be regarded as a **contractual** matter between the user and the supplier (Haywood, 1986).

This style of standard can be characterized as **truth in labelling**, aiming at **fitness for use** (Moellering, 1985). According to this concept, the producer of the data base is responsible for verifying the quality levels and for furnishing the prospective user with this information. The prospective user is then responsible for evaluating the quality of information provided and for deciding whether the data quality levels are appropriate for the intended use.

According to Chrisman (1986), truth in labelling promises to alter the operation of producers and consumers of digital geographical data. Although it will permit producers to distribute whatever data are obtained, they will be more likely to upgrade the quality of their product when they have to report all the detail to the professional community. Consumers, on the other hand, will have to become aware of the issues of data quality and ensure that they do not acquire data that do not fulfil their needs.

2.3 The assessment of data quality

The final quality of a data set can be assessed in two ways (Haywood, 1986):

First, a sample of the end product is tested against an independent source of higher accuracy. In the case of digital cartographic data the graphic plot could be compared to a map that complies with the national mapping standard for positional accuracy. For topographic data, this testing procedure would involve a visit to the relevant area and some further survey activities.

In the second method, the influence of equipment and processes used at various stages of production is determined and used to estimate the final accuracy of the product. This is less reliable than the previous method, but is often the only practical solution.

The use of either method is in itself subject to quality considerations. A numerical expression of data quality is of no value without knowledge of how it was derived. This problem is particularly relevant in the case of data derived from different data collection methods and processes over a period of time. Some points might have been fixed by instrumental survey and the remainder graphically, and some features might have resulted from photogrammetric plotting, or field survey, or both. Although these data might not be subjected to different accuracy tests, variations in the overall expected accuracy are to be expected. One data set that is supposed to be 99% correct is not necessarily comparable to another that is 99% correct (Haywood, 1986). Knowledge of

how the individual items of data were collected is therefore useful, especially if the method or process has a stated implication in terms of accuracy.

As assessing the quality of digital geo-referenced data by means of quantifiable methods is as yet not well understood, the exchange standard refrains from establishing rules as to how this should be done. Instead, it specifies the following five fundamental categories of information on quality that the producer of the data should supply to the user.

2.3.1 Lineage

Lineage involves a statement describing to the user the origin of the database, or its components, as well as all the processes and transformations leading to the final product - the GIS. It is a pedigree report required by the prospective user to evaluate the quality of the data and to decide whether the stated quality levels are appropriate for the intended use.

The lineage report provides information on the following aspects of the GIS:

- Date and scale of the source material.
- Organization, for example, into map sheets or administrative units.
- Data capture method, for example, photogrammetry, field survey or map digitizing.
- Accuracy of the capture method(s). In the case of an air survey this would include the aerial photography specifications and the calibration record.
- Objectives, such as completeness and maintenance policies.

2.3.2 Positional accuracy

The positional accuracy of a geo-referenced feature has two components, namely **planimetric** accuracy, which is defined with reference to a standard reference surface, and **vertical** accuracy, which is defined with reference to a standard datum. Ideally, positional accuracy should be calculated on the basis of standard error or circular error and be expressed in terms of metres in the real world to make it independent of scale.

2.3.2.1 Planimetric accuracy

The planimetric accuracy of coordinates can be quantified by using standard statistical procedures to compare the GIS values of a sample of points to the values for the same points as provided by a survey of higher accuracy. The preferred method is to use the national circular map accuracy standard, which specifies that 90% of the sample points should be within a certain distance (e.g. 20 m) from their correct planimetric position.

2.3.2.2 Vertical accuracy

The vertical accuracy of coordinates in the GIS can be quantified by using standard statistical procedures to compare the values pertaining to a sample of points to the values for the same points as provided by a survey of higher accuracy. The preferred method is to use the national linear map accuracy standard, which specifies that 90% of the sample points should be within a certain vertical distance from their true elevation. In cartographic applications this distance is usually taken as half the contour interval.

2.3.3 Attribute accuracy

In a GIS context a feature is a uniquely identifiable object in the real world, such as a river, a tree or a road, and an attribute is a defined characteristic of any feature about which information is stored. Attributes can be either **discrete** or **continuous** and can be measured on either the **nominal**, the **ordinal**, the **interval** or the **ratio** scales. (Stevens, 1948).

Each measuring scale determines the appropriate mathematical operations that can be applied to the data, and the limitation of each level of measurement must be recognized in any technique used to determine quality. For example, for two nominal measurements only equivalence can be determined as distinctions are based only on qualitative considerations without any quantitative relationship being implied. Ordinal scales involve nominal classification, but also differentiate within a class of data on the basis of rank. The numbers therefore have some associated implications of magnitude, and one can tell that a certain number is larger or smaller than another, even though one does not know by how much. Like the ordinal scale, the interval scale is a relative measure, but here the distances between all successive numbers are of the same size so that one has the added feature of uniformity of difference. Because interval scales lack true zero points, they can never be used to measure absolute magnitudes. The ratio scale provides the maximum information in that it possesses a true zero point indicating the least possible amount of whatever is being measured. Precise differences can be calculated, and all the measurements retain the same ratio to one another, no matter what units are employed.

In statistical methodology, it is common to group nominal and ordinal scales under the general title of discrete or categorical measures, and interval and ratio scales under that of continuous measures.

2.3.3.1 Discrete or categorical attribute accuracy

The classification of discrete attributes can either be correct or wrong; this can be checked by comparing a sample in the database with the original source of a source of higher accuracy (in remote sensing applications this source is often referred to as ground truth). The attribute accuracy can then be expressed as a percentage of the sample points found to be correct.

In statistics the allocation of individual features to existing groups is known as discrimination, and the accuracy of the classification can be quantified as a statistical measure of the probability of correct classification by means of techniques such as discriminant analysis (Mather, 1976).

2.3.3.2 Numeric variable accuracy

Some attributes are continuous or measured values, and apart from measurement errors, they are also subject to the inaccuracies of the measuring device. As in the case of position, the accuracy of these attributes can be quantified as a statistical measure of the probability of being within a specified tolerance of the stated value.

2.3.4 Logical consistency

A report on logical consistency should describe the fidelity of relationships encoded in the data structure of the digital geo-referenced data, that is, the topology used should be mentioned explicitly. The report should also detail the editing tests performed and the results of the tests. This information is of much use to the user as retaining node-chain-region relationships in the GIS must be positionally and qualitatively accurate if the data set is to be found useful. Chains should begin and end at nodes; no chains should intersect without the presence of a node; and no chain should be entered twice. In the case of digital cartography, sheet borders should match satisfactorily, and the data should be properly integrated over the source document borders. Logical consistency covers errors of commission.

2.3.5 Currency and completeness

The quality report must include information about the temporal qualities of the data as time is not only an important element of geo-referenced data but also contributes towards the assessment of the quality of the data. Data might be either too old or too new for a particular use and some aspects of data quality such as positional or attribute accuracy might change with time. Examples of data that change with time are the planimetric and vertical accuracy of points in areas subject to seismic activity, and the status of a road or the population of a city.

There is a link between currency and completeness in that a data set that is out of date is unlikely to be regarded as complete. However, it is also possible for a data set to be current and yet incomplete. Examples would be a photogrammetric survey that has not been field completed, and a map digitization that has achieved only part of the capture specification. Completeness therefore covers errors of omission and raises questions about how exhaustively a GIS captures each type of feature. Provided that the user is aware of the data being incomplete, the data may still be of considerable value. Completeness is a common concern in analytical applications, and it is imperative that the supplier of the data should provide some indication of completeness in the quality report and of the tests conducted to enable the user to ascertain whether or not the data are complete.

2.4 The exchange of data quality

Information on data quality being transferred from the producer of the data to the user can be divided into three categories: that which takes the form of a separate paper document, that which exists in a separate file on the exchange medium, and that which is incorporated into the data structures of the standard.

This standard allows information on data quality to be exchanged in the form of free text within the exchange format. We have not attempted to provide a means for quantifying data quality as the subject is not yet well understood - such a facility will be added when required. The contents of the Global Information Section (see 5.2) may be regarded as part of data quality, in as much that it is essential for interpreting the data being exchanged.

If preferred, the user may supply additional information on data quality on separate documents. The drawback is that the documents may easily become separated from the exchange medium.

CHAPTER 3

CLASSIFICATION AND NON-SPATIAL ATTRIBUTES

3.1 Introduction

In the exchange of geo-referenced information, features need to be classified according to a known feature classification scheme to ensure the correct identification of the features by the receiver. To this end it is desirable to establish a standard feature classification to which the majority of users can subscribe. Additionally, guidelines should be established for the design of other feature classification schemes such that mapping from one scheme to another (including the standard) is trivial.

Classification schemes other than the standard feature classification can be used in this exchange standard. This may be applicable to those organizations that have an existing classification scheme that is successfully in operation and for those specialized applications for which the standard feature classification does not cater. In these cases it will be the supplier's responsibility to ensure that the recipient has all the information on the classification scheme. Users should, however, be encouraged to use the standard classification.

The characteristics of a feature are defined by the non-spatial attributes attached to that feature. As all features with similar characteristics are classified in one feature class, it implies that each feature class has a unique list of non-spatial attributes defined on it. For example, a feature can be identified as a road (feature class) with the characteristics (non-spatial attributes) of being a freeway, with four lanes and a status of 'in use'. Where to stop classifying a feature and start describing its characteristics is not clear and some users may have a classification scheme with a breakdown of feature classes incorporating aspects of the non-spatial attributes. Care must be exercised in these cases. Taking the above example again, a classification scheme might have a feature class of a freeway or even a feature class of a freeway with four lanes. As stated, the cut-off

point is not clearly defined, but again the situation should not become absurd. However, it can be seen that it is possible to have different classification schemes that can be mapped from one to the other.

Non-spatial information associated with a feature can be linked to that feature through its non-spatial attributes, for example, the rainfall measured at a meteorological station.

3.2 Guidelines for the design of a feature classification scheme

To exchange information efficiently, the structure of the feature classification schemes used should be compatible. The following guidelines are provided for the design of a feature classification scheme.

- The classification scheme must be based on feature entities. Features can be real or abstract. It must be possible to classify all features.
- The scheme must be scale independent. That is, it must represent the real world and not a map. The characteristics of a feature, especially those of a quantitative nature, must be described by its associated attributes and not by a further breakdown in the feature classification.
- The classification scheme must have a hierarchical structure. The structure should be of variable levels, allowing for the various feature classes to be defined at different levels. A feature class will then be unambiguously identified by its path in the hierarchical structure (for example, GEOMORPHOLOGY/LANDFORM/CLIFF identifies the feature class 'cliff'). The path length should be kept to a minimum. The structure must be open-ended and flexible to allow for additions and other changes without the entire scheme having to be restructured. The hierarchical structure will also permit generalization of the classification by reducing the path length to the desired level. All the feature classes occurring at the end of the path links that have been removed will automatically be incorporated at the level identified by the reduced path.

- The scheme must ensure that there is no loss of information. For this purpose the non-spatial attributes are defined as a list, with attribute values attached to the attributes. The attribute value can be fixed (predefined) or variable.
- It must ensure consistency. Definitions of all feature classes must be given together with all the included names for the same feature class. Included names are alternate names for feature classes; they are also known as aliases, and are of importance as the different disciplines often have different names for the same feature.
- A coding scheme may be used to shorten the feature class names, but it is not essential. If a coding scheme is used the feature codes must be assigned in accordance with the classification scheme. The feature codes must be unique. The feature coding scheme must be flexible to allow for additions and other changes in accordance with the changes taking place in the classification scheme without feature codes being 'renumbered'. Attributes may also be coded, but the coding must not lead to a loss or restriction of information. The feature coding scheme should be easy to use. If direct human interpretation is required, then the feature codes should be human readable.
- It must be possible to use only a subset of the classification scheme.

3.3 The standard feature classification

The standard feature classification is not intended to be imposed as a compulsory classification. If the standard is not used, then the supplier of the information must fully describe the feature classification used. This can be done by supplying the classification to the receiver in advance or by including the classification as part of the exchange (see 5.4.4 and 5.4.5).

The standard feature classification consists of:

- (i) the feature classification identifying the feature classes,
- (ii) the non-spatial attribute list for each feature class,
- (iii) definitions of feature classes and their non-spatial attributes, including the attribute values allowed, and
- (iv) the feature coding scheme.

The constituent parts of the standard classification are given here in their correct pecking order. That is, if the feature classification is changed, then all the other items will be changed. A change can, however, be made to the feature coding scheme without a change being made to the feature classification.

The standard feature classification must not be static, but must rather be maintained to update the classification when changes are required. A national co-ordinating body should be responsible for the maintenance of the classification.

The standard feature classification is given in Appendix B.

CHAPTER 4

PHYSICAL EXCHANGE MEDIA

The proposed exchange standard is, where possible, based on existing standards in the computer industry and will change accordingly. The generally accepted standard for the physical medium for the exchange of digital information is the nine-track, half inch (12.7 mm), 1600 bits per inch (62.99 bits per mm) magnetic tape. The end of the last data set on a volume must be indicated by two end-of-file markers on the magnetic tape. A physical record size of 2048 bytes (2 K) and a blocking factor of 1 are recommended. These are defined by the user in the File Identification (see 5.2.15 and 5.2.16). The geo-referenced information relations may spread over more than one physical record. An end-of-file marker must appear after every physical file (see 5.1). We recommend that a gummed paper label be stuck onto the magnetic tape reel, specifying important information such as the name of the data set, the physical record size and the blocking factor.

Currently, magnetic tape is the preferred medium of exchange because of the volumes of data involved, the robustness of the media, the availability of tape drives at installations and the standardization of tapes. Although other media, such as floppy discs or telecommunications, could be successfully used for exchange, they were not thoroughly investigated. Users of the exchange standard must ensure that both the recipient and the supplier are aware of the exact specifications of the physical medium being used for exchange.

The character set to be used is the American Standard Coded Information Interchange (ASCII) 7-bit character set as defined in ANSI X3.4: 'American National Standard Code for Information Interchange', published by the American National Standards Institute in 1977. This is the same as ISO 646.

CHAPTER 5

THE STANDARD STRUCTURE OF A DATA SET FOR EXCHANGE

5.1 Introduction

A set of data that is exchanged through this exchange standard is termed a **logical file**. A logical file may be stored on one or more **physical volumes**, such as magnetic tapes. A logical file consists of two **physical files** for each volume on which it resides. These physical files are separated by end of file markers. Each logical file consists of a number of **sections**. Every section consists of one or more **entries**. Each entry consists of one or more **fields**.

The first physical file on a volume (known hereafter as the first physical file) contains the first section of a logical file, namely the **File Identification**, a fixed size (2048 bytes), fixed format section in 7-bit ASCII that identifies the data in the logical file on the volume. The File Identification and its entries are described in 5.2.

The second physical file on a volume (known hereafter as the second physical file) contains the **Global Information Section** and the **Geo-referenced Information Relation Sections**.

The Global Information Section gives general details of the data being exchanged and may appear only once. The Global Information Section entries are identified by **identification tags**. Most have a default value and are therefore optional. All entries must appear in a fixed order. The Global Information Section and its entries are described in 5.3.

The remaining sections contain the **Geo-referenced Information Relations**, the actual data being exchanged. This information is structured according to the relational data model. Each of these sections contains entries that are instances of a particular relation. While most of the sections may appear as often as required and in any order, the entries

in some of these sections may be dependent on the entries in other sections. It is assumed that users will be aware of these dependencies and will structure their data accordingly.

Every entry has a set of one or more fields that form a unique key. While normalization of the relations can be beneficial, for example, removing anomalies of updating, it is possible to 'over-normalize' spatial data (Van Roessel 1987). We have attempted to normalize to at least the third normal form. The Global Information Relations and their entries are described in 5.4.

The data in the Global Information Section and in the Geo-referenced Information Relation Sections may be in either 7-bit ASCII or binary format. We recommend the use of 7-bit ASCII as it is universal, more intelligible to humans, less likely to be confused with terminator characters on the recipient's computer and less susceptible to noise (the eighth bit may be used as a parity bit). Furthermore, binary formats are computer architecture dependent, and therefore not necessarily compatible between different computers. If binary is used, the creator of the file must provide the recipient with details of the binary format used. The creator of the file must specify in the File Identification whether 7-bit ASCII or binary has been used (see 5.2.13).

For the sake of illustration, an example of the use of an entry follows the description of each entry in the descriptions of the File Identification, Global Information Section and Geo-referenced Information Relation Sections. These examples are generally extracted from the examples in Appendix D. Throughout the examples delimiters are used, rather than explicit lengths. Delimiters and explicit lengths are described in 5.1.1.

These examples have been printed in this document in lines of 64 characters each. This is a purely artificial device to make the examples more legible to the reader. These line breaks must not appear in the actual data being exchanged.

The layout of the format of the exchange standard for a logical file on more than one volume is as follows:

File

Volume

File Identification

End of File Marker

Global Information Section

Geo-referenced Information Relations

.

.

.

End of Volume Marker

Volume

File Identification

End of File Marker

Geo-referenced Information Relations

.

.

.

End of Volume Marker

.

.

.

End of File Marker

End of File Marker

On the other hand, more than one logical file of geo-referenced information may be exchanged on the same physical volume. Each logical file must then begin with a File Identification. An example of this is:

Volume

File

File Identification

End of File Marker

Global Information Section

Geo-referenced Information Relations

End of File Marker

File

File Identification

End of File Marker

Global Information Section

Geo-referenced Information Relations

End of File Marker

.

.

.

End of File Marker

Note that the last physical file on a volume must be followed by two end of file markers.

The contents of the File Identification, Global Information Section and the Geo-referenced Information Relations are summarized in Appendix C, which may be used as an index into this chapter.

5.1.1 The use of delimiters and explicit lengths

The exchange standard allows the use of delimiters or explicit lengths to differentiate between the fields, entries and sections in all occurrences of the second physical file, but only one method may be used in any particular logical file. The creator of the data must specify in the File Identification which method is used (see 5.2.14).

When delimiters are used, reserved characters (known as delimiters) are placed between successive fields, entries and sections. In the exchange standard, we use the standard 7-bit ASCII delimiters as follows:

Unit separator (US) [Hex: 1F] at the end of fields,

Record separator (RS) [Hex: 1E] at the end of entries,

Group separator (GS) [Hex: 1D] at the end of sections,

File separator (FS) [Hex: 1C] at the end of a volume.

The unit separator at the end of the last field in an entry is optional, as is the record separator at the end of the last entry in a section.

By their nature, delimiters are unprintable characters and thus cannot be used in the printed examples illustrating the exchange standard. Within the printed examples in this document, we have used standard punctuation marks to stand for the delimiters, as follows:

Unit separator (US) is denoted by a comma ','.

Record separator (RS) is denoted by a semi-colon ';'.

Group separator (GS) is denoted by a reversed slash '\'.

File separator (FS) is denoted by a full stop '.'.

Delimiters may only be used with 7-bit ASCII data and not with binary data, as the binary data could be confused with the delimiters.

When **explicit lengths** are used, the number of bytes allocated for these lengths is specified in the File Identification (see 5.2.14) and is fixed throughout the second physical file. A length must be placed at the beginning of every field in the Global Information Section. In the Geo-referenced Information Relations, a template relation is used to predefine the lengths of the fields in the entries (see 5.4.3). If a length of zero is specified in the template, then the field has a variable length and every occurrence of the field must be preceded by a length field. Explicit lengths may be used with either 7-bit ASCII or binary and will themselves be in the form of the data, that is, in 7-bit ASCII or binary. These lengths are omitted in the descriptions of the entries in the following paragraphs.

We stress that we recommend the use of delimiters.

The remaining paragraphs of this chapter describe the format of the exchange standard in detail.

5.2 File Identification

The File Identification acts as an identification tag for the logical file. For this reason, and to make it easy for a program to read the File Identification off the exchange medium, the File Identification is of a fixed size, fixed format and in 7-bit ASCII. The size of the File Identification is 2048 bytes (2K). This allows sufficient space for the necessary information, without being too large. The fixed format makes it easier for a program (or human) to extract the fields from the File Identification. The 7-bit ASCII character set, as defined by ANSI X3.4 (1977) and ISO 646, is the internationally accepted standard for encoding data.

The File Identification contains some information in a human-readable form and the rest in a computer-readable form to be used by an interface program to interpret data in the exchange standard format. The purpose of the human-readable information is to allow the user to rapidly determine the nature and location of the information that follows. Gummed paper labels stuck onto physical media, such as magnetic tape reels, are small and restricted in the amount of information they can carry; in addition, they could fall off the physical medium.

In a multi-volume logical file, there could be File Identifications that have different values for entries other than the Volume Number (see 5.2.2). These would change the manner in which the data are to be interpreted midway through a logical file. **This should not be done.** The File Identification is placed at the beginning of every volume so that each individual physical medium may be easily identified.

The descriptions of the entries in the File Identification follow. Each entry is described on a separate page. The description consists of the name of the entry, the size of the entry in bytes, a textual description of the entry and an example of the use of the entry. All entries are compulsory and must appear in the order given. The entries are of a fixed size and have one field each. These entries have no tags. No delimiters or explicit lengths are used in the File Identification.

5.2.1 Data identification

Size in bytes: 128

This entry contains a textual description of the information being exchanged in the logical file. It may contain any ASCII text.

Example of use:

1:500000 2726 KROONSTAD Administrative Edition, First Edition, published in 1980 (The magisterial districts are as at July 1985)

5.2.2 Volume number

Size in bytes: 8

This entry is an eight-digit ASCII number identifying the volume in the logical file. It may be filled with zeros or spaces from the left.

Example of use:

00000001

5.2.3 Source organization

Size in bytes: 256

This entry identifies the organization that produced the logical file being exchanged. It must be the final and not the initial source organization. The data given in this field must be sufficient for the recipient to identify and contact the organization.

Example of use:

Computer Science Division, National Research Institute for Mathematical Sciences (NRIMS), Council for Scientific and Industrial Research (CSIR), P O Box 395, PRETORIA, 0001, South Africa. Telephone (012) 841-4185.

5.2.4 Maintenance organization

Size in bytes: 256

This entry identifies the organization responsible for producing the data and providing updates and corrections. This is not necessarily the same organization as the Source Organization. The data given in this field must be sufficient for the recipient to identify and contact the organization.

Example of use:

Computer Science Division, National Research Institute for Mathematical Sciences (NRIMS), Council for Scientific and Industrial Research (CSIR), P O Box 395, PRETORIA, 0001, South Africa. Telephone (012) 841-4185.

5.2.5 Copyright statement

Size in bytes: 256

This entry identifies the holder and nature of the copyright on the data.

Example of use:

The copyright on these data is held by the Council for Scientific and Industrial Research (CSIR), but they may be used without permission for research purposes.

5.2.6 Access privileges

Size in bytes: 256

This entry specifies who may have access to the data.

Example of use:

There are no restrictions on the access to these data.

5.2.7 Date stamp

Size in bytes: 8

This entry identifies the day on which the logical file was created for exchange. The date and time stamps (see 5.2.8) are to be used to identify the currency of the data. The project team felt that date and time stamps were more meaningful than serial numbers. This entry consists of a four-digit ASCII number giving the year and two two-digit ASCII numbers giving the month and the day, in the form 'yyyymmdd'. There are no separators between the numbers.

Example of use:

19870903

5.2.8 Time stamp

Size in bytes: 6

This entry identifies the time when the logical file was created for exchange. The entry consists of three two-digit ASCII numbers giving the hours, minutes and seconds in South African Standard Time, in the form 'hhmmss'. There are no separators between the numbers.

Example of use:

181751

The following four entries (5.2.9 - 5.2.12) give the bounding box of the data in the second physical file and thus allow the recipient to quickly locate the position of the data on the earth's surface. This will assist him in determining whether or not he wishes to read the data into his database. The coordinates are given in degrees, minutes and seconds.

5.2.9 Northern latitudinal limit of the data

Size in bytes: 8

This entry identifies the northern limit of the data in the second physical file. The entry consists of a three-digit ASCII number giving the degrees, two two-digit ASCII numbers giving the minutes and the seconds, and either an 'N' [Hex: 4E] for North or an 'S' [Hex: 53] for South. There are no separators between the numbers.

Example of use:

0274028S

5.2.10 Southern latitudinal limit of the data

Size in bytes: 8

This entry identifies the southern limit of the data in the second physical file. The entry consists of a three-digit ASCII number giving the degrees, two two-digit ASCII numbers giving the minutes and the seconds and either an 'N' [Hex: 4E] for North or an 'S' [Hex: 53] for South. There are no separators between the numbers.

Example of use:

0282041S

5.2.11 Western longitudinal limit of the data

Size in bytes: 8

This entry identifies the western limit of the data in the second physical file. The entry consists of a three-digit ASCII number giving the degrees, two two-digit ASCII numbers giving the minutes and the seconds and either a 'W' [Hex: 57] for West or an 'E' [Hex: 45] for East. There are no separators between the numbers.

Example of use:

0262851E

5.2.12 Eastern longitudinal limit of the data

Size in bytes: 8

This entry identifies the eastern limit of the data in the second physical file. The entry consists of a three-digit ASCII number giving the degrees, two two-digit ASCII numbers giving the minutes and the seconds and either a 'W' [Hex: 57] for West or an 'E' [Hex: 45] for East. There are no separators between the numbers.

Example of use:

0271519E

5.2.13 ASCII / Binary

Size in bytes: 1

This entry identifies whether the data in the second physical file are in 7-bit ASCII format or in a binary format. If the data are in a binary format, the specific format must be agreed upon by both the supplier and recipient. With the binary format delimiters cannot be used as the data might be confused with the delimiters, while with the ASCII format either delimiters or explicit lengths can be used (see 5.2.14). The entry consists of either an 'A' [Hex: 41] for 7-bit ASCII or a 'B' [Hex: 42] for binary.

Example of use:

A

5.2.14 Explicit Lengths / Delimiters

Size in bytes: 1

This entry identifies whether the individual fields, entries and sections, in the Global Information Section (see 5.3) and the Geo-referenced Information Relations (see 5.4), are separated by delimiters, or whether an explicit length field specifies the length of each field, entry and section.

The entry consists of either a 'D' [Hex: 44] for delimiters or a one-digit 7-bit ASCII number between 1 and 9 inclusive specifying how many bytes are to be used for the length fields. This means that from 1 to 9 bytes are allocated for the lengths. It is unlikely that a length of more than 999999999 will be required for any data field being exchanged through this standard. The standard 7-bit ASCII delimiters will be used as follows:

Unit Separator (US) [Hex: 1F] between fields.

Record Separator (RS) [Hex: 1E] between entries.

Group Separator (GS) [Hex: 1D] between sections and

File Separator (FS) [Hex: 1C] at the end of a volume.

Example of use:

D

5.2.15 Physical record size

Size in bytes: 8

As mentioned in chapter 4, the creator of a logical file must specify the physical record size and blocking factor (see 5.2.16) of the second physical file. The first physical file has a fixed physical record size of 2048 bytes and a blocking factor of 1. The physical record size of the second physical file is determined by this field. We recommend a physical record size of 2048 bytes.

Example of use:

00002048

5.2.16 Blocking factor

Size in bytes: 8

The blocking factor (in number of physical records) of the first physical file is fixed at 1. This entry determines the blocking factor for the second physical file. We recommend a blocking factor of 1.

Example of use:

00000001

5.2.17 Comments

Size in bytes: 824

This entry may be used by the supplier for any comments.

Example of use:

These data are merely a small example of data in the format required for the exchange standard. The spatial data were digitized on a digitizing table with a resolution of 0.1 mm and then reduced (generalized) - that is, the number of internal coordinate tuples in the chains was reduced. This reduces the amount of data that has to be added to this document, but it also reduces the accuracy, so do not view the data as being accurate. The statistical data used for non-spatial data were taken from publications of the Central Statistical Services. The example has been provided to illustrate the use of the exchange standard. The origin of the spatial data lies at 30 South and 28 East, that is, at the intersection of the standard meridian and the parallel midway between the two standard parallels.

5.3 Global information section

The **Global Information Section** gives general details of the data being exchanged. Some consider this information to be information on the quality of the data being exchanged - we consider it to be essential for the interpretation of the data being exchanged.

All the information in the Global Information Section is encoded so that the interface program can automatically incorporate the data into the recipient's database. Most of the entries have default values, and thus may be omitted from the Global Information Section of a file being exchanged. However, while this is a convenient facility, the creator of the file must not blindly assume that the defaults are appropriate for his data.

The entries are identified in the logical file by four-character 7-bit ASCII **identification tags**. These identification tags appear at the beginning of each entry in this section.

If **explicit lengths** are used, as determined by the Explicit Lengths/Delimiters entry in the File Identification (see 5.2.14), each field in each entry will be preceded by a **length field** (whose size is determined by the aforementioned entry) specifying the length of the value field. Otherwise, if delimiters are used, each field will be terminated by the **unit separator** [Hex: 1F] and each entry will be terminated by the **record separator** [Hex: 1E].

Because different computer systems have different ways of dealing with real numbers, the exchange standard only allows integers for coordinate values, rather than real numbers. This must be borne in mind when the resolution of the coordinates is determined (see 5.3.4, 5.3.5 and 5.3.9 - 5.3.12).

The following are the entries in the Global Information Section. Each entry is described on a separate page. The description consists of the name of the entry, the identification tag of the entry, the default value for the entry (if there is no default, it is so stated), a textual description of the entry, a list of possible values (for some of the entries) and an example of the use of the entry.

In the data being exchanged, only the entry identification tag and the relevant fields, with delimiters or explicit lengths, are specified.

The entries must appear in the order given below as some of the entries are dependent on others. However, entries may be omitted if their default values are valid for the data being exchanged.

5.3.1 Projection or coordinate system

ID tag: P/CS

Default value: Gauss Conformal

This entry identifies the projection or coordinate system used throughout the second physical file. All coordinates will be in the units of this system. As 'Gauss Conformal' is the South African coordinate system, it is the default. Mirror image and rotated axis systems (such as internal Gauss formats) must be translated to the standard definition of the projection for exchange purposes.

Projection and coordinate systems and their abbreviations (to be used in the data being exchanged) are given below. With each, the number of standard meridians and parallels required for the system are given, and if a scale factor for the origin is required, it is so indicated (see 5.3.2).

Projection / coordinate system:	Abbreviation:
Gauss Conformal (1 meridian)	GAUS
Universal Transverse Mercator (1 meridian)	UTM
Lambert Conformal (2 parallels, 1 meridian)	LAMB
Albers Equal Area (2 parallels, 1 meridian)	ALBE
Mercator (1 meridian, 1 optional parallel)	MERC
Gnomonic (1 parallel, 1 meridian, scale factor)	GNOM
Polar Stereographic Conformal (1 parallel, 1 meridian, scale factor)	POLA
Azimuthal Meridional Equal Area (Zenithal) (1 meridian)	AZIM
Geographical coordinates (latitude & longitude)	GEO
Other system - by arrangement between the creator and recipient	OTHE

Example of use:

P/CSLAMB;

5.3.2 Standard meridians & parallels & scale factor

ID tag: **SM&P**

There is no default value.

This entry identifies the standard meridians and parallels used for the Projection or Coordinate System used (see 5.3.1) and the scale factor at the origin, if it is not implicit in the definition of the projection or coordinate system. The number and nature of the values in this entry are dependent on the Projection or Coordinate System used and must be given in the order specified (see 5.3.1). This entry **must appear** in the Global Information Section, otherwise all coordinates are meaningless. There can be no default values as the values are dependent on the area of interest and the projection or coordinate system used. The coordinates must be given in degrees, minutes and seconds as necessary with colons (':') [Hex: 3A]) between the values with an 'N', 'S', 'W' or 'E' for North, South, West and East respectively. If explicit lengths are used (see 5.2.14) and optional parameters, such as the optional parallel for the Mercator system (see 5.3.1), are not defined, they must be specified by giving a length of 0 (zero) and no value field. The scale factor must be given as an integer, which, when divided by 1000000 (one million), will give the real scale factor.

Example of use:

SM&P26:40S,33:20S,28E;

5.3.3 Reference surface

ID tag: REFS

Default value: Clarke 1880

This entry identifies the reference surface (ellipsoid or sphere) used as the basis for planimetric measurements. 'Clarke 1880' is the default as it is the standard surface used in South Africa.

Reference surfaces and their abbreviations (to be used in the data being exchanged) are given below.

Reference surface:	Abbreviation:
Clarke 1880	CLARKE
Bessel 1847	BESSEL
World Geodetic System 1972	WGS72
International 1924	INTERNAT
A sphere with a radius of 'nnnnnnnn' in tenths of a metre.	nnnnnnnn

Example of use:

REFSCLARKE;

5.3.4 Planimetric coordinate resolution: units

ID tag: PCRU

Default value: **cm**

This entry identifies the units of the resolution of the planimetric coordinates in the data. It is used in conjunction with Planimetric Coordinate Resolution: Increment (see 5.3.5). The values used for this field must be standard metric abbreviations or 'deg' for degrees, 'min' for minutes, or 'sec' for seconds. The default is 'cm' 'Centimetres' as they are most commonly used in the Gauss system.

Example of use:

PCRUm;

5.3.5 Planimetric coordinate resolution: increment

ID tag: PCRI

Default value: 1

This entry identifies the numeric value of the resolution of the planimetric coordinates of the data. It is used in conjunction with Planimetric Coordinate Resolution: Units (see 5.3.4). This version of the exchange standard does not cater for planimetric coordinates whose resolutions differ from each other.

Example of use:

PCRI1;

5.3.6 First planimetric coordinate offset

ID tag: FPCO

Default value: 0

This entry identifies the offset for the first coordinate in any coordinate tuple in the data. This value must be added to the first coordinate of all absolute points to give the true coordinate. It allows much shorter coordinates to be used in the data and can thus reduce the volume of the data substantially. The offset must be given in the Units and the Increment of the Planimetric Coordinate Resolution (see 5.3.4 and 5.3.5). The first planimetric coordinate includes the 'Y' coordinate in the South African Gauss system and latitude in geographical coordinates.

Example of use:

FPCO0;

5.3.7 Second planimetric coordinate offset

ID tag: SPCO

Default value: 0

This entry identifies the offset for the second coordinate in any coordinate tuple in the data. This value must be added to the second coordinate of all absolute points to give the true coordinate. It allows much shorter coordinates to be used in the data and can thus reduce the volume of the data substantially. The offset must be given in the Units and the Increment of the Planimetric Coordinate Resolution (see 5.3.4 and 5.3.5). The second planimetric coordinate includes the 'X' coordinate in the South African Gauss system and longitude in geographical coordinates.

Example of use:

SPCO222264;

5.3.8 Dimension of the coordinates

ID tag: **DIMC**

Default value: **2**

This entry identifies the number of dimensions of the coordinates. Its value is either '2' or '3'. The first two dimensions are planimetric (on the surface of the reference surface - see 5.3.3) and the third dimension is vertical elevation above the geoid (see 5.3.12 and 5.3.13). This version of the exchange standard does not cater for time as a coordinate although time may always be a non-spatial attribute of a feature.

Example of use:

DIMC2;

5.3.9 Vertical coordinate resolution: units

ID tag: **VCRU**

Default value: **centimetres**

This entry identifies the units of the resolution of the vertical coordinates in the data. It is used in conjunction with Vertical Coordinate Resolution: Increment (see 5.3.10). If the Dimension of the Coordinates (see 5.3.8) is two, then this field is unnecessary. The values used for this field must be standard metric abbreviations.

Example of use:

VCRUcm;

5.3.10 Vertical coordinate resolution: increment

ID tag: VCRI

Default value: 1

This entry identifies the numeric value of the resolution of the vertical coordinates of the data. It is used in conjunction with Vertical Coordinate Resolution: Units (see 5.3.9).

Example of use:

VCRI1;

5.3.11 Indication of absolute or relative coordinates in chains

ID tag: A/RC

Default value: A

This entry identifies whether the internal coordinates (planimetric and vertical) in a chain description are absolute (given with reference to the offsets as defined in 5.3.6, 5.3.7 and 5.3.12) or relative to the coordinates of the preceding internal chain coordinate tuple. Both types of coordinates are given in the planimetric and vertical resolutions specified (see 5.3.4, 5.3.5, 5.3.9 & 5.3.10). Thus, absolute internal chain coordinate tuples are given in exactly the same manner as all other coordinates, while relative internal chain coordinate tuples are given as offsets from the previous coordinate tuple in the chain. For any chain, the number of its relative coordinate tuples is one more than the number of its absolute coordinate tuples because with relative coordinates, the offset to the end node must be given so that the chain may be traversed in the reverse direction. The value is either 'A' [Hex: 41] for absolute coordinates or 'R' [Hex: 52] for relative coordinates.

Example of use:

A/RCA;

5.3.12 Height datum in text form

ID tag: **HDTF**

Default value: Mean Sea Level

This entry gives a textual description of the height datum used for the data with reference to Mean Sea Level, the standard height datum for South Africa.

Example of use:

HDTFMean sea level;

5.3.13 Height datum above mean sea level

ID tag: HDAT

Default value: 0

This entry identifies the elevation of the height datum used for the data being exchanged, in metres above Mean Sea Level, the standard height datum for South Africa. A negative value implies a datum below mean sea level. The number must be given in the Units and the Increment of the Vertical Coordinate Resolution (see 5.3.9 and 5.3.10).

Example of use:

HDATO:

The following four fields (see 5.3.14 - 5.3.17) define a bounding planimetric quadrilateral for the data in the second physical file. They are similar to the limits given in the File Identification (see 5.2.9 - 5.2.12). The difference is that the limits here are given in the Coordinate System units and are subject to the Units and Increments of the Planimetric Coordinate Resolution (see 5.3.4 and 5.3.5) and the Planimetric Offsets (see 5.3.6 and 5.3.7). They are applicable if the creator of the file wishes to give a more accurate description of the spatial domain of the data than the limits given in the File Identification. As the coordinate tuples must form a quadrilateral, they may be specified in any order.

5.3.14 First bounding planimetric quadrilateral coordinate tuple

ID tag: **BPQ1**

There is no default.

This entry specifies the first planimetric coordinate tuple of the bounding quadrilateral. The entry contains two fields, one for each of the planimetric coordinates.

Example of use:

BPQ1-149888,26013;

5.3.15 Second bounding planimetric quadrilateral coordinate tuple

ID tag: **BPQ2**

There is no default.

This entry specifies the second planimetric coordinate tuple of the bounding quadrilateral. The entry contains two fields, one for each of the planimetric coordinates.

Example of use:

BPQ2-82149,26013;

5.3.16 Third bounding planimetric quadrilateral coordinate tuple

ID tag: BPQ3

There is no default.

This entry specifies the third planimetric coordinate tuple of the bounding quadrilateral. The entry contains two fields, one for each of the planimetric coordinates.

Example of use:

BPQ3-82149,-27126;

5.3.17 Fourth bounding planimetric quadrilateral coordinate tuple

ID tag: **BPQ4**

There is no default.

This entry specifies the fourth planimetric coordinate tuple of the bounding quadrilateral. The entry contains two fields, one for each of the planimetric coordinates.

Example of use:

BPQ4-149888,-27126;

5.3.18 Data quality scheme used

ID tag: **QUAL**

Default value: **Exchange standard data quality scheme**

This entry identifies the data quality scheme used. As the quantification of information on data quality is not yet well understood, the only information on data quality currently catered for are comments.

Example of use:

QUALExchange Standard;

5.3.19 Data quality scheme release number

ID tag: QUNO

Default value: 1

This entry identifies the release number of the data quality information scheme used.

Example of use:

QUNO1;

5.3.20 Feature classification scheme used

ID tag: **CLAS**

Default value: **Standard Exchange Classification Scheme**

This entry identifies the feature classification scheme used. The default is the exchange standard classification scheme in Appendix B.

Example of use:

CLASExchange Standard;

5.3.21 Feature classification scheme release number

ID tag: CLNO

Default value: 1

This entry identifies the release number of the feature classification scheme used.

Example of use:

CLNO1;

5.3.22 Attribute scheme used

ID tag: ATTR

Default value: Standard Exchange Attribute Scheme

This entry identifies the attribute scheme used. The default is the standard exchange attribute scheme in Appendix B.

Example of use:

ATTRExample attribute scheme\

5.3.23 Attribute scheme release number

ID tag: ATNO

Default value: 1

This entry identifies the release number of the attribute scheme used.

Example of use:

ATNO1;

5.3.24 Alternate spatial attribute scheme

ID tag: **ASAS**

Default value: Alternate spatial attributes are not used.

This entry identifies the alternate spatial attribute scheme used (see 1.3.4).

Example of use:

ASASnone;

5.3.25 Alternate spatial attribute scheme release number

ID tag: **ASNO**

Default value: **1**

This entry identifies the release number of the alternate spatial attribute scheme.

Example of use:

ASNO1;

5.4 Geo-referenced information relations

The Geo-referenced Information Relation Sections contain the actual data being exchanged. Each section contains a sequence of instances of a particular relation. A section corresponds to a table in a relational database. With the exception of the statements on data quality, which take on the form of free text, the contents of the relations are explicitly encoded for automatic processing by the interface program of the recipient.

The sections are identified by eight-character 7-bit ASCII identification tags, indicating the relevant relation. These identification tags appear at the beginning of each section in the data being exchanged. Most of the sections may appear in any order and as often as required; however, the administrative sections must appear at the beginning and may appear only once (see 5.4.2 and 5.4.3). Each entry in a section is a particular instance of the relation concerned. There may be zero or more entries in a section. Each entry contains a number of fields. For most of the relations the number of fields are fixed; however, for those geometric data relations that contain the raw coordinate data, some of the fields may appear a variable number of times (see 5.4.30 and 5.4.33).

The following is a summary of the relations that exist in this version of the exchange standard:

Administrative relations:

RELALIST - list of relations used.

TEMPLATE - templates of the relations.

Relations for exchange of classification, attribute and alternate spatial attribute schemes:

EXCHCLAS - exchange classification scheme.

EXCHATTR - exchange non-spatial attribute scheme.

EXCHASAS - exchange alternate spatial attribute scheme.

Data quality relation:

DATAQUAL - information on data quality.

General feature information relations:

FEATCLAS - features and their classification.

CLASFEAT - feature classes and their features.

FEATNSAT - features and their non-spatial attributes.

FEATTYPE - types of features.

FEATSDOM - spatial domain of features.

Feature to spatial attribute relations:

FEATNODE - point features and their constituent nodes.

NODEFEAT - nodes and the point features they represent.

FEATCHAI - line features and their constituent chains and arcs.

CHAI FEAT - chains and arcs and the line features they represent.

FEATREGI - area features and their constituent regions.

REGI FEAT - regions and the area features they represent.

FEATMATR - grid features and their constituent matrices.

MATRFEAT - matrices and the grid features they represent.

COMPFEAT - compound features and their constituent features.

FEATCOMP - features and their parent compound features.

Topology relations:

CHAINODE - chains and their terminal nodes.

NODECHAI - nodes and the chains that they terminate.

REGICHAI - regions and their boundary chains and arcs.

CHAI REGI - chains and arcs and the regions they bound.

REGIEXCL - regions and their excluded regions.

EXCLREGI - regions and those regions from which they are excluded.

Geometric data relations:

- NODECOORD - Nodes and their coordinate tuples.
- CHAIDATA - chains and their constituent coordinate tuples.
- ARCCDATA - arcs and the coordinate tuples that describe them.
- MATRDATA - matrices and pointers to their raster data.
- RASTDATA - raster data.

As can be seen, some relations have inverses although they are not necessarily exact inverses. This is to provide the user with a choice for representing his data - he should use whichever is more appropriate for his data. A user is not expected to use both a relation and its inverse to represent the same relations in his data, although this may be useful in some cases. It is not necessary that all these relations appear in the data being exchanged - the user merely uses those required.

The following are the sections that constitute the Geo-referenced Information Relations. Each section is described on a separate page. The description consists of the name of the section, the identification tag of the section, the key fields in an entry in the section, the remaining fields in an entry, a textual description of the section, a textual description of the fields in the entries and an example of the use of the section.

In the data being exchanged, the identification tag is given once for each section. For each entry, all fields, with delimiters or explicit lengths, are specified. To ensure that the relations are **normalized**, a number of the relations have a 'Sequence Number' field as one of their keys. In the actual implementation, this field is omitted as it will be **implicit** - the entries in the section will be ordered and will be numbered implicitly.

The two administrative sections, the List of Relations Used (see 5.4.2) and the Templates of the Relations (see 5.4.3), may appear only once, immediately after the Global Information Section. This is because they provide some information to the recipient about the relations being used.

The List of Relations Used (see 5.4.2) may appear if delimiters are being used, as determined by the Explicit Lengths/Delimiters entry in the File Identification (see 5.2.14). It allows the creator of the file to list all the relations that he uses in the file so that the recipient may know which relations to expect. However, use of this section is optional.

If explicit lengths are used, the Templates of the Relations (see 5.4.3) must appear.

All other relations are optional and may appear in any order and as often as required. However, the fields of some entries in certain relations are dependent on the values of fields in other relations. For example, the Non-spatial Attribute ID field in the Feature/Non-spatial Attributes relation (see 5.4.10) is dependent on the classification of the feature, as defined in the Feature/Classification relation (see 5.4.8). It is assumed that the user will be aware of these dependencies and will use the relations accordingly. It is recommended that the user divide the data into logical groupings (if necessary), and for each grouping, use the relations in the order given below.

The two administrative sections may have one entry per relation, whereas all other sections may have any number of entries. Each entry will consist of the fields specified in the description of the relation.

5.4.1 Generic definitions of fields

There are a number of fields that occur in many relations. For the sake of convenience, their definitions are given here, and in the definitions of the relations, a cross-reference is given to this paragraph.

5.4.1.1 Feature ID

A feature identification must uniquely differentiate a feature from all other features. Typically, feature identifications are numbers and are allocated sequentially to features as they are entered into a database.

5.4.1.2 Alternate spatial attribute

Alternate spatial attributes are a number of different sets of spatial attributes for the same feature. The Alternate Spatial Attribute Scheme entry in the Global Information Section (see 5.3.24), determines whether or not alternate spatial attributes are used in the data being exchanged. If they are not being used, this field is omitted completely from all relations in the data being exchanged. If they are being used, the Alternate Spatial Attribute Scheme (see 5.3.24) and/or the Exchange of Alternate Spatial Attribute Scheme (see 5.4.6) will determine the meaning of this field. See 1.3.4 for a more detailed discussion of alternate spatial attributes.

5.4.1.3 Spatial attribute ID

A spatial attribute identification must uniquely differentiate a spatial attribute from all other spatial attributes, regardless of the nature of the spatial attribute (node, chain, arc, region or matrix). Typically, spatial attribute identifications are numbers and are allocated sequentially to spatial attributes as they are entered into a database.

5.4.1.4 Direction of chains and arcs

Chains and arcs have inherent ordering, which is the sequence in which their internal coordinate tuples are stored. When chains and arcs are used by line features (as their spatial attributes) and regions (as their boundaries), they are not necessarily used in the direction in which the internal coordinate tuples are stored. Thus, when using a chain or an arc, one has to specify the direction in which it is used - forwards (in the direction of the internal coordinate tuples) or backwards (in the opposite direction of the ordering of the internal coordinate tuples).

5.4.1.5 Coordinate tuples

In this version of the exchange standard, coordinates are either two- or three-dimensional, as determined by the Dimension of Coordinates (see 5.3.8). Planimetric coordinates are given in the Planimetric Coordinate Resolution: Units used (see 5.3.4) and Planimetric Coordinate Resolution: Increment used (see 5.3.5), bearing in mind the Projection or Coordinate System used (see 5.3.1), the Standard Meridians and Parallels and Scale Factor used (see 5.3.2), the Reference Surface used (see 5.3.3) and the Planimetric Coordinate Offsets used (see 5.3.6 and 5.3.7). Vertical coordinates are given in the Vertical Coordinate Resolution: Units used (see 5.3.9) and Vertical Coordinate Resolution: Increment used (see 5.3.10), bearing in mind the Height Datum used (see 5.3.12 and 5.3.13). The internal coordinate tuples of chains are either absolute coordinates or relative coordinates, as determined by Indication of Absolute or Relative Coordinates in Chains (see 5.3.11).

5.4.1.6 Sequence number

Sequence numbers are an artificial device that have been added to some of the relations to normalize them. However, **sequence numbers do not appear in any data being exchanged**. They are implicit in the data being exchanged and only occur in the descriptions of the relations (see 1.5).

5.4.2 List of relations used

ID tag: RELALIST

Key fields:

Relation name

Sequence number

There are no other fields.

This relation allows one to indicate which relations are used in a specific set of data being exchanged.

Description of the fields:

Relation name:

The 8-byte ASCII identification tag for each relation, as specified in the definition of the relation.

Example of use:

RELALISTEXCHATTR;DATAQUAL;FEATCLAS;FEATNSAT;FEATTYPE;FEATREGI;CO
MPFEAT;CHAINODE;REGICHA;NODECOOR;CHAIDATA\

5.4.3 Templates of the relations

ID tag: **TEMPLATE**

Key fields:

Relation name

Other fields:

Number of fields in the relation

Length of each field in the relation

This relation allows one to fix the sizes of the fields in the relations to reduce the volume of the data. This relation must be used when explicit lengths are used, as determined by the Explicit Lengths / Delimiters entry in the File Identification (see 5.2.14). This relation may not be used if delimiters are used.

Description of the fields:

Relation name:

The 8-byte ASCII identification tag for each relation, as specified in the definition of the relation.

Number of fields in the relation:

This field specifies the number of fields in a particular relation. This determines the number of occurrences of the next field in the template.

Length of each field in the relation:

This field must be repeated for every field in the relation. It sets a fixed size for the field that will apply throughout the rest of the logical file. If the length of a particular field is variable within the exchange, then the value of this field must be zero and the length must be given before each occurrence of the field. An example is the Non-spatial Attribute Value field in the

Feature / Non-spatial Attributes relation (see 5.4.6) whose size could be dependent on the Attribute Scheme Used (see 5.3.24), as defined in the Global Information Section.

Example of use:

TEMPLATE0016DATAQUAL00010000

5.4.4 Exchange of classification scheme

ID tag: **EXCHCLAS**

Key field:

Class path name

Other fields:

Classification code

Description

This relation allows one to exchange the classification scheme being used for the data in the second physical file, and must be used if the recipient does not know the classification scheme. This relation defines the classes in the Feature Classification Scheme (see 5.3.23).

Description of the fields:

Class path name:

This is the full path name of the feature class name (see chapter 3).

Classification code:

The encoded form of the feature class name. This code is used in the data being exchanged. If it has no value, then the full path name of the feature class must be used.

Description:

This is a textual description of the feature class and should be human readable.

Example of use:

EXCHCLASSSocial and cultural/Social statistical/Demographic enumeration area,211,Area for which statistical data are published\

5.4.5 Exchange of non-spatial attribute scheme

ID tag: EXCHATTR

Key field:

Non-spatial attribute name

Other fields:

Non-spatial attribute code

Nature of the value

Description

This relation allows one to exchange the non-spatial attribute scheme being used for the data in the second physical file, and must be used if the recipient does not know the non-spatial attribute scheme. This relation defines the non-spatial attributes in the Attribute Scheme Used (see 5.3.22).

Description of the fields:

Non-spatial attribute name:

This is the full name of the non-spatial attribute.

Non-spatial attribute code:

The encoded form of the non-spatial attribute name. This code is used in the data being exchanged. If it has no value, then the full name of the non-spatial attribute must be used.

Nature of the value:

One byte with one of the following values:

'N' [Hex: 4E] (Numeric value), 'T' [Hex: 54] (Text).

Description:

This is a textual description of the non-spatial attribute and its possible values and should be human readable.

Example of use:

EXCHATTRNAME.1,T,The name of a feature;REMUNERATION,2,N,Total remuneration of employees in thousands of Rand for 1978;WHEAT,3,N,Wheat production in metric tons for 1980\

5.4.6 Exchange of alternate spatial attribute scheme

ID tag: **EXCHASAS**

Key field:

Alternate spatial attribute ID

Other fields:

Description

This relation allows one to exchange the alternate spatial attribute scheme being used for the data in the second physical file, and must be used if the recipient does not know the alternate spatial attribute scheme. This relation defines the alternate spatial attributes in the Alternate Spatial Attribute Scheme used (see 5.3.24).

Description of the fields:

Alternate spatial attribute ID:

The encoded form of the alternate spatial attribute level.

Description:

This is a textual description of the alternate spatial attribute and it should be human readable.

Example of use:

EXCHASAS1,Scale smaller than 1:25000000

5.4.7 Information on data quality

ID tag: DATAQUAL

Key fields:

Comment

Sequence number

There are no other fields.

This relation allows one to give information concerning the quality of the data being exchanged. As data quality information is not yet well defined, this relation will initially consist of textual comments. Comments may contain any 7-bit ASCII character, except the standard delimiters (see 5.1.1).

Description of the fields:

Comment:

The data quality information provided by the producer.

Example of use:

DATAQUAL These data were digitized off the Bril Blue sheet of the 1:500000 2726 Kroonstad Administrative Edition (1st Edition of 1980) and reduced so that the number of coordinates would be manageable (which reduces the accuracy)\

5.4.8 Feature / classification

ID tag: **FEATCLAS**

Key fields:

Feature ID

Other fields:

Classification

An entry in this relation classifies a feature into a feature class.

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Classification:

The classification value, which indicates the feature class, is either the full path name of a feature class, or an encoded version thereof. The classification scheme used is determined by the Feature Classification Scheme field in the Global Information Section (see 5.3.23) and the Exchange of Classification Scheme relation (see 5.4.4).

Example of use:

FEATCLAS1,211;2,211;3,211;4,212;5,212

5.4.9 Classification / features

ID tag: CLASFEAT

Key fields:

Classification
Sequence number

Other fields:

Feature ID

This relation indicates which features belong to which feature class. It is the inverse of the Feature / Classification relation (see 5.4.8).

Description of the fields:

Classification:

The classification value, which indicates the feature class, is either the full path name of a feature class, or an encoded version thereof. The classification scheme used is determined by the Feature Classification Scheme field in the Global Information Section (see 5.3.23) and the Exchange of Classification Scheme relation (see 5.4.4).

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Example of use:

CLASFEAT211,1;211,2

5.4.10 Feature / non-spatial attributes

ID tag: FEATNSAT

Key fields:

Feature ID

Sequence number

Other fields:

Non-spatial attribute ID

Non-spatial attribute value

An entry in this relation describes the non-spatial attributes and their values of a feature. The non-spatial attributes are dependent on the Non-spatial Attribute Scheme used (see 5.3.27).

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Non-spatial Attribute ID:

Its value is determined by the Attribute Scheme used, as defined in the Global Information Section (see 5.3.27).

Non-spatial Attribute Value:

The nature of its value is determined by the Attribute Scheme used, as defined in the Global Information Section (see 5.3.27).

Example of use:

FEATNSAT1.1.Virginia;1.2.110826;1.3.11529;2.1.Welkom;2.2.331062\

5.4.11 Feature / feature types

ID tag: FEATTYPE

Key fields:

Feature ID

Alternate spatial attribute

Other fields:

Feature Type

This relation indicates the type of the features for their various alternate spatial attributes.

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used only if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is omitted. For a definition, see 5.4.1.2.

Feature Type:

One byte with one of the following values -

'P' [Hex: 50] (Point), 'L' [Hex: 4C] (Line),

'A' [Hex: 41] (Area), 'G' [Hex: 47] (Grid),

'C' [Hex: 43] (Compound), 'N' [Hex: 4E] (Not Applicable).

Example of use:

FEATTYPE1,A;2,A;3,A;4,C;5,C\

5.4.12 Feature / spatial domain

ID tag: FEATSDOM

Key fields:

Feature ID

Alternate spatial attribute

Other fields:

Minimum value of first planimetric coordinate

Maximum value of first planimetric coordinate

Minimum value of second planimetric coordinate

Maximum value of second planimetric coordinate

This relation indicates the extent of the planimetric spatial domain (also known as the min-max box) of a feature. The coordinates are given in the units of the Coordinate System used (see 5.3.1) and are subject to the Units and Increments of the Planimetric Coordinate Resolution (see 5.3.4 and 5.3.5) and the Planimetric Offsets (see 5.3.6 and 5.3.7), as defined in the Global Information Section.

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Minimum value of first planimetric coordinate:

As defined above.

Maximum value of first planimetric coordinate:

As defined above.

Minimum value of second planimetric coordinate:

As defined above.

Maximum value of second planimetric coordinate:

As defined above.

Example of use:

FEATSDOM99,-127525,-102450,-8162,12250\

5.4.13 Point feature / node

ID tag: FEATNODE

Key fields:

Feature ID

Alternate spatial attribute

Other fields:

Node ID

This relation indicates which node represents the position of a point feature.

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Node ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Example of use:

FEATNODE98,3\

5.4.14 Node / point features

ID tag: **NODEFEAT**

Key fields:

Node ID

- **Sequence number**

Other fields:

Feature ID

Alternate spatial attribute

This relation indicates which point features have their positions determined by which nodes. It is the inverse of the Point Feature / Node relation (see 5.4.13).

Description of the fields:

Node ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Example of use:

NODEFEAT3,98

5.4.15 Line feature / chains & arcs & direction

ID tag: FEATCHAI

Key fields:

Feature ID
Alternate spatial attribute
Sequence number

Other fields:

Indication of chain or arc
Chain/Arc ID
Direction indicator

This relation indicates which chains and/or arcs represent the position of a line feature.

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Indication of Chain or Arc:

This is either 'A' [Hex: 41] for an Arc or 'C' [Hex: 43] for a Chain.

Chain/Arc ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Direction indicator:

This indicates the direction in which the chain or arc is used, either forwards, 'F' [Hex: 46], or backwards, 'B' [Hex: 42]. For an explanation of the direction of chains and arcs, see 5.4.1.4.

Example of use:

FEATCHAI97,C,5,F;96,A,95,B\

5.4.16 Chain & arc / line features

ID tag: CHAIFEAT

Key fields:

Chain/Arc ID
Sequence number

Other fields:

Feature ID
Alternate spatial attribute
Direction indicator

This relation indicates which line features have their positions determined by which chains and arcs. It is the inverse of the Line Feature / Chains & Arcs & Direction relation (see 5.4.15).

Description of the fields:

Chain/Arc ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Direction indicator:

This indicates the direction in which the chain or arc is used, either forwards, 'F' [Hex: 46], or backwards, 'B' [Hex: 42]. For an explanation of the direction of chains and arcs, see 5.4.1.4.

Example of use:

CHAI FEAT5,97,F\

5.4.17 Area feature / included regions

ID tags: FEATREGI

Key fields:

Feature ID

Alternate spatial attribute

Sequence number

Other fields:

Region ID

This relation indicates which regions represent the position of an area feature.

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Region ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Example of use:

FEATREGI1,11;2,12;3,13\

5.4.18 Regions / area features

ID tags: **REGIFEAT**

Key fields:

Region ID

Sequence number

Other fields:

Feature ID

Alternate spatial attribute

This relation indicates which area features have their positions determined by which included regions. It is the inverse of the Area Feature / Included Regions relation (see 5.4.17).

Description of the fields:

Region ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used only if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is omitted. For a definition, see 5.4.1.2.

Example of use:

REGIFEAT11,1;12,2;13,3

5.4.19 Grid feature / matrices

ID tag: FEATMATR

Key fields:

Feature ID
Spatial Alternate
Sequence number

Other fields:

Matrix ID

This relation indicates which matrices represent the position of a grid feature.

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Matrix ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Example of use:

FEATMATR94,93;92,91\

5.4.20 Matrix / grid features

ID tag: **MATRFEAT**

Key fields:

Matrix ID

Sequence number

Other fields:

Feature ID

Alternate spatial attribute

This relation indicates which grid features have their positions determined by which matrices. It is the inverse of the Grid Feature / Matrices relation (see 5.4.19).

Description of the fields:

Matrix ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Feature ID:

This identification must be unique across all features (see 5.4.1.1).

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Example of use:

MATRFEAT91,92;93,94

5.4.21 -- Compound feature / features

ID tag: COMPFEAT

Key fields:

Feature ID
Alternate spatial attribute
Sequence number

Other fields:

Feature ID

This relation indicates which features constitute a compound feature.

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1). This is the Feature ID of the compound feature.

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Feature ID:

This identification must be unique across all features (see 5.4.1.1). This is the Feature ID of the constituent feature.

Example of use:

COMPFEAT4,1;4,2;5,3\

5.4.22 Feature / compound features

ID tag: **FEATCOMP**

Key fields:

Feature ID

Sequence number

Other fields:

Feature ID

Alternate spatial attribute

This relation indicates which compound features consist of which features. It is the inverse of the Compound Feature / Features relation (see 5.4.21).

Description of the fields:

Feature ID:

This identification must be unique across all features (see 5.4.1.1). This is the Feature ID of the constituent feature.

Feature ID:

This identification must be unique across all features (see 5.4.1.1). This is the Feature ID of the compound feature.

Alternate spatial attribute:

This field is used **only** if an Alternate Spatial Attribute Scheme is being used (see 5.3.24). Otherwise, this field is **omitted**. For a definition, see 5.4.1.2.

Example of use:

FEATCOMP1.4;2.4;3.5

5.4.23 Chain / nodes & coordinate tuples

ID tag: **CHAINODE**

Key field:

Chain ID

Other fields:

Node ID

Node ID

Length of Chain

Data ID

This relation links a chain to its terminal nodes and the set of its internal chain coordinate tuples. For an explanation of the direction of a chain, see 5.4.1.4.

Description of the fields:

Chain ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Node ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3. This is the start node of the chain and the internal chain coordinate tuples follow on in sequence.

Node ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3. This is the end node of the chain and follows the last of the internal chain coordinate tuples in sequence.

Length of Chain:

This gives the number of internal chain coordinates in the Chain. The nature of the internal chain coordinates (absolute or relative) is determined by the Indication of Absolute or Relative Coordinates in Chain, as defined in the Global Information Section (see 5.3.11). With absolute coordinates, this number will be the number of internal points. With relative coordinates, this number will be one more than the number of internal points because the offset must be given from the last internal point to the end node. This allows one to go backwards along a chain.

Data ID:

This points to the internal chain coordinates in the Chain Data Relation (see 5.4.30).

Example of use:

CHAINODES,2,1,72,1;6,1,3,10,2;7,3,2,13,3;8,1,4,50,4;9,4,3,6,5;10
.4,2,67,6\

5.4.24 Node / chains & arcs

ID tag: NODECHAI

Key fields:

Node ID

Sequence number

Other fields:

Chain ID

This relation indicates which chains and arcs terminate at which nodes. It is the inverse of the Chain / Nodes & Coordinate Tuples relation (see 5.4.23).

Description of the fields:

Node ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Chain/Arc ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Example of use:

NODECHAI2,5;1,5;1,6;3,6;3,7;2,7;1,8\

5.4.25 Region / chains & arcs & direction

ID tag: **REGICHAI**

Key fields:

Region ID

Sequence number

Other fields:

Indication of chain or arc

Chain/Arc ID

Direction indicator

This relation indicates which chains and arcs make up the outer boundary of a region. The inner boundaries of a region are the outer boundaries of its excluded regions (see 5.4.27).

Description of the fields:

Region ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Indication of chain or arc:

This is either 'A' [Hex: 41] for an Arc or 'C' [Hex: 43] for a Chain.

Chain/Arc ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Direction indicator:

This indicates the direction in which the chain or arc is used, either forwards, 'F' [Hex: 46], or backwards, 'B' [Hex: 42]. For an explanation of the direction of chains and arcs, see 5.4.1.4.

Example of use:

REGICHA11,C,5,F;11,C,6,F;11,C,7,F;12,C,8,F;12,C,9,F;12,C,6,B;13
,C,10,F;13,C,7,B;13,C,9,B\

5.4.26 Chain & arc / regions

ID tag: CHAIREGI

Key fields:

Chain/Arc ID**Sequence number**

Other fields:

Region ID**Direction indicator**

This relation indicates which regions have which chains and arcs as a part of their boundary. It is the inverse of the Region / Chains & Arcs & Direction relation (see 5.4.25).

Description of the fields:

Chain/Arc ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Region ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Direction indicator:

This indicates the direction in which the chain or arc is used, either forwards, 'F' [Hex: 46], or backwards, 'B' [Hex: 42]. For an explanation of the direction of chains and arcs, see 5.4.1.4.

Example of use:

CHAIREGI5,11,F;6,11,F;6,12,B\

5.4.27 Region / excluded regions

ID tag: **REGIEXCL**

Key fields:

Region ID

Sequence number

Other fields:

Region ID

This relation indicates which regions are excluded from (that is, are islands within) another region.

Description of the fields:

Region ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3. This is the ID of the excluding region.

Region ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3. This is the ID of the excluded region.

Example of use:

REGIEXCL90,89

5.4.28 Excluded region / regions

ID tag: **EXCLREGI**

Key fields:

Region ID

Sequence number

Other fields:

Region ID

This relation indicates which regions exclude which other regions. It is the inverse of the Region / Excluded Region relation (see 5.4.27).

Description of the fields:

Region ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3. This is the ID of the excluded region.

Region ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3. This is the ID of the excluding region.

Example of use:

EXCLREGI89,90

5.4.29 Node / coordinate tuple

ID tag: **NODECOORD**

Key field:

Node ID

Other fields:

Coordinate Tuple

This relation indicates the actual position of a node.

Description of the fields:

Node ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Coordinate Tuple:

One coordinate tuple defines the position of a node. See 5.4.1.5 for details on how coordinate tuples must be given.

Example of use:

NODECOORD1,-127525,-8162;2,-102450,-6900;3,-113812,1262

5.4.30 Chain data

ID tag: CHAIDATA

Key field:

Data ID

Other fields:

Coordinate tuples

This relation indicates the values of the internal chain coordinates of the chains.

Description of the fields:

Data ID:

The ID value must be unique across all instances of this relation. It is used by the Chain / Nodes & Coordinate Tuples relation (see 5.4.23).

Coordinate tuples:

This field occurs a variable number of times, as the previous field determines the number of coordinate tuples needed to define the position of a chain. The coordinates are either absolute or relative, as determined by the Indication of Absolute or Relative Coordinates in Chain (see 5.4.11). See 5.4.1.5 for details on how coordinate tuples must be given.

Example of use:

CHAIDATA5,-112025,10700,-112050,9037,-112337,8987,-112800,8887,-
116350,8087,-116125,6337;

5.4.31 Arc / curve data

ID tag: **ARCCDATA**

Key field:

Arc ID

Other fields:

Start node ID

End node ID

Coordinate tuple for third point

This relation indicates the actual positions of the arcs, which are stored using the terminal nodes of the arc and a third point on the arc.

Description of the fields:

Arc ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

Node ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3. This is the start node of the arc.

Node ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3. This is the end node of the arc.

Coordinate tuple for third point:

One coordinate tuple defines the position of the third point. See 5.4.1.5 for details on how coordinate tuples must be given.

Example of use:

ARCCDATA88,1,2,-113812,1262

5.4.32 Matrix / raster data

ID tag: MATRDATA

Key fields:

Matrix ID

Sequence number

Other fields:

First coordinate tuple

Second coordinate tuple

Third coordinate tuple

Ordering of matrix elements

Compaction encoding

Length in first dimension

Length in second dimension

Length in third dimension

Data ID

This relation indicates which raster data represent which matrix and how the matrix is orientated in three-dimensional space. If one stands at the first coordinate tuple looking towards the second coordinate tuple, then the matrix lies to one's right-hand side, with the third coordinate tuple within the matrix. If the matrix is three-dimensional, then the additional planes of data lie above and parallel to the first plane. The cells are processed in exactly the same manner as those on the first plane. The planimetric and vertical resolutions of the cells (that is, the sizes of the cells) are as defined in the Global Information Section (see 5.3.4, 5.3.5, 5.3.9 and 5.3.10). Thus, the position of any cell in three-dimensional space may be determined by first orientating the matrix, using the three coordinate tuples given, and then determining the offset from the origin, using the resolutions of the cells (see 5.3.4, 5.3.5, 5.3.9 and 5.3.10). The raster data are stored in rows of cells. The rows are parallel to the line running from the first coordinate tuple through the second coordinate tuple. Columns lie at right angles to the rows in the plane.

Figure 5.4.32.1 illustrates the orientation of a matrix in three-dimensional space.

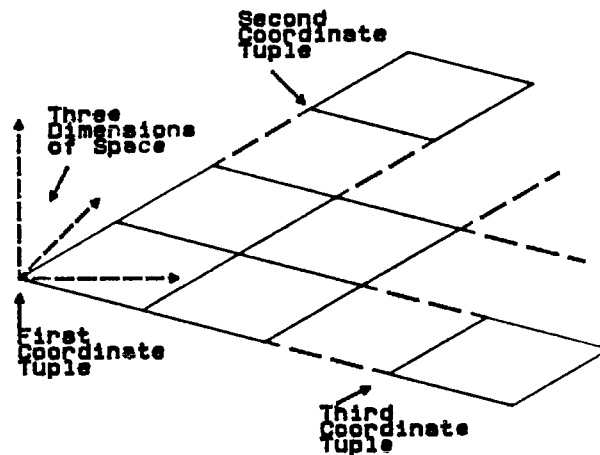


Figure 5.4.32.1

Description of the fields:

Matrix ID:

This identification must be unique across all spatial attributes. For a generic definition of the spatial attribute ID fields, see 5.4.1.3.

First coordinate tuple:

One coordinate tuple must be given (see 5.4.1.5). This gives the position of the initial cell in the matrix.

Second coordinate tuple:

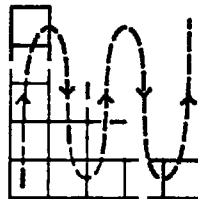
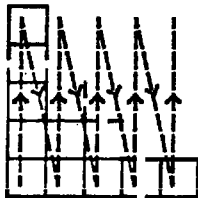
One coordinate tuple must be given (see 5.4.1.5). This gives the position of any cell in the first row of data, preferably one near the end - the further it is from the first coordinate tuple, the more accurate the orientation will be. This coordinate tuple must not be the same as the first coordinate tuple.

Third coordinate tuple:

One coordinate tuple must be given (see 5.4.1.5). This gives the position of any cell in the plane, excluding those in the first row of data. It should preferably be in the first column of data near the end - the further it is from the first row of cells, the more accurate the orientation will be. This must not be the same as the first or second coordinate tuple.

Ordering of matrix elements:

This may be either meandering, 'M' [Hex: 4D], or saw tooth, 'S' [Hex: 53], as follows:

**Meander****Saw tooth****Figure 5.4.32.2****Compaction encoding:**

In this version of the exchange standard, the only value allowed for this field is 'N' [Hex: 4E], for no compaction encoding.

Length in first dimension:

This gives the number of cells in the first row of the raster data. A value of 1 or less implies that there is only one row of data.

Length in second dimension:

This gives the number of cells in the first column of the raster data. A value of 1 or less implies that there is only one column of data.

Length in third dimension:

This gives the number planes of the raster data. A value of 1 or less implies that there is only one plane of data.

Data ID:

This points to the values in the Raster Data relation (see 5.4.33).

Example of use:

MATRDATA77,-110000,0,-110000,1000,105000,0,S,N,2,3,1,66\

5.4.33 Raster data

ID tag: **RASTDATA**

Key field:

Data ID

Other fields:

Minimum value

Maximum value

Null value

Values

This relation contains the values making up the matrix spatial attributes.

Description of the fields:

Data ID:

The ID value must be unique across all instances of this relation.

Minimum value:

The minimum value for a cell in the matrix. These two range fields allow the recipient to know in advance the size of the values and whether or not there are negative values.

Maximum value:

The maximum value for a cell in the matrix.

Null value:

This value is used for those cells that have no actual value, that is, are undefined. If this value is outside the range specified by the minimum and maximum values, it implies that all cells have defined values.

Values:

The values at each cell in the matrix must be given in the order specified in the Ordering of Matrix Elements field and in the form specified by the Compaction Encoding field, both fields are in the Matrix / Raster Data relation (see 5.4.32).

Example of use:

RASTDATA66,0,255,-1,10,6,60,29,10,62

APPENDIX A**GLOSSARY OF GEO-REFERENCED INFORMATION TERMS****A.1 Introduction**

This glossary of terms pertaining to geo-referenced and related information was drawn up to clarify the terminology used in this document. It is largely based on the glossary distributed with the draft proposed exchange standard in March 1987 (Clarke et al 1987). However, matured ideas have been incorporated into the new glossary.

Section A.2 consists of a list of English terms in alphabetical order. Opposite each English term is its Afrikaans translation and an index number. This index number is a pointer to the definition of the term in English in Section A.3. No attempt has been made to give the definitions in Afrikaans as it was felt that the effort required was beyond the scope of the project.

A.2 English / Afrikaans translations

The following is a list, in alphabetical order, of geo-referenced information related terms in English. Opposite each term is its Afrikaans translation and an index number cross-referencing an English description of the term in Section A.3, the Glossary. The entries in the Glossary have been placed into logical groups rather than an alphabetical order.

ACCURACY -- AKKURAATHEID (106)
 ALTERNATE SPATIAL ATTRIBUTE -- ALTERNATIEWE RUIMTELIKE ATTRIBUUT (7)
 ARC -- BOOG (115)
 AREA FEATURE -- AREAVERSKYNSEL (119)
 AREA OF OVERLAP -- AREA VAN OORVLEUELING (125)
 AREA OF UNDERLAP -- GAPING (126)
 ASCII -- ASCII (6)
 ATTRIBUTE -- ATTRIBUUT (24)
 ATTRIBUTE VALUE -- ATTRIBUUTWAARDE (25)

BATCH PROCESSING -- BONDELVERWERKING (38)
 BOUNDARY -- GRENS (118)

CADASTRAL MAP -- KADASTRALE KAART (94)
 CARTOGRAPHIC FEATURE -- KARTOGRAFIESE VERSKYNSEL (27)
 CARTOGRAPHIC GENERALIZATION -- KARTOGRAFIESE VERALGEMENING (100)
 CARTOGRAPHY -- KARTOGRAFIE (58)
 CHAIN -- KETTING (114)
 CHOROPLETH MAP -- CHOROPLEETKAART (99)
 CLASSIFICATION -- KLASSIFIKASIE (29)
 CODES -- KODES (5)
 COINCIDENCE -- SAMEVALLING (90)
 COMPLETENESS -- VOLLEDIGHEID (35)
 COMPOUND FEATURE -- SAAMGESTELDE VERSKYNSEL (122)
 CONTAINMENT -- BEVATTING (87)
 CONTROL POINT -- BEHEERPUNT (75)
 CURRENCY -- HUIDIGHEID (36)

DATA -- DATA (3) \
 DATA ACQUISITION -- DATA-INSAMELING (42)
 DATABASE -- DATABASIS (9)
 DATABASE MANAGEMENT SYSTEM -- DATABASISBESTUURSTELSEL (13)
 DATA CAPTURE -- DATAVASLEGGING (44)
 DATA DISPLAY -- DATAVERTOON (48)
 DATA EXCHANGE FORMAT -- DATA-UITRUII FORMAAT (2)
 DATA INPUT -- DATA-INVOER (43)
 DATA SIMPLIFICATION -- DATAVEREENVOUDIGING (101)
 DATA QUALITY -- DATAKWALITEIT (32)
 DATUM -- VERWYSINGSPUNT/VLAK (60)
 DELIMITER -- SKEISIMBOOL (7)
 DIGITIZE -- VERSYFER (45)

EDITING -- REDIGERING (47)
 ELECTROMAGNETIC RADIATION (EMR) -- ELEKTROMAGNETIESE UITSTRALING (53)
 ELECTROMAGNETIC SPECTRUM -- ELEKTROMAGNETIESE SPEKTRUM (54)
 ENTITY -- ENTITEIT (23)
 EXCLUSION -- UITSLUITING (88)

FEATURE -- VERSKYNSEL (26)
 FEATURE CLASS -- VERSKYNSELKLAS (28)
 FIELD -- VELD (10)

GEO-CODING -- GEOKODERING (76)
 GEOGRAPHICAL INFORMATION SYSTEM (GIS) -- GEOGRAFIESE
 INLIGTINGSTELSEL (1)
 GEO-REFERENCED COORDINATES -- GEOVERWYSDE KOÖRDINATE (73)
 GEO-REFERENCED DATA -- GEOVERWYSDE DATA (18)
 GEOID -- GEOÏED (63)
 GEOMETRIC INTEGRATION -- GEOMETRIESE INTEGRASIE (15)
 GRANULARITY -- KORRELRICHEID (33)
 GRAPHICS WORKSTATION -- GRAFIESE WERKSTASIE (49)
 GRID FEATURE -- ROOSTERVERSKYNSEL (121)

HIERARCHY -- HIERARGIE (30)

IDENTIFICATION TAG -- IDENTIFIKASIE-ETIKET (12)
 IMAGE -- BEELD (50)
 IMAGE PROCESSING -- BEELDVERWERKING (51)
 INCLUSION -- INSLUITING (89)
 INFORMATION -- INLIGTING (4)
 INTERACTIVE PROCESSING -- INTERAKTIEWE VERWERKING (39)
 INTERSECTION -- SNYDING (91)
 INTERVAL DATA -- INTERVALDATA (21)
 ISARITHMIC MAP -- ISARITMIESE KAART (96)
 ISOLINE MAP -- ISOLYNKAART (96)
 ISOMETRIC LINE MAP -- ISOMETRIESE LYNKAART (97)
 ISOPLETH MAP -- ISOPLEETKAART (98)

 KEY -- SLEUTEL (11)

 LARGE-SCALE MAP -- GROOTSKAALKAART (80)
 LATITUDE & LONGITUDE -- BREEDTEGRAAD & LENGTEGRAAD (67)
 LINEAGE -- HERKOMS (34)
 LINE FEATURE -- LYNVERSKYNSEL (116)
 LOGICAL CONSISTENCY -- LOGIESE NIE-STRYDIGHEID/KONSEKWENTHEID (37)

 MATRIX -- MATRIKS (120)
 MEDIUM-SCALE MAP -- MEDIUMSKAALKAART (81)
 MERIDIAN -- MERIDIAAN (68)
 MULTISPECTRAL -- MULTISPEKTRAAL (55)

 NODE -- NODUS (112)
 NOMINAL DATA -- NOMINALE DATA (19)

 ORDINAL DATA -- ORDINALE DATA (20)

 PARALLEL -- PARALLEL (69)
 PHOTOGRAMMETRY -- FOTOGAMMETRIE (57)
 PIXEL -- BEELDELEMENT (109)
 PLANIMETRIC -- PLANIMETRIES (70)
 POINT -- PUNT (111)
 POINT FEATURE -- PUNTVERSKYNSEL (113)

PRECISION -- NOUKEURIGHEID (105)
 PROJECTION -- PROJEKSIE (59)
 PROJECTION COORDINATES -- PROJEKSIEKOÖRDINATE (72)
 PROJECTION PARAMETERS -- PROJEKSIEPARAMETERS (62)

RASTER DATA -- ROOSTERDATA (108)
 RATIO DATA -- VERHOUDINGDATA (22)
 REAL-TIME PROCESSING -- INTYDSE VERWERKING (40)
 REFERENCE SURFACE -- VERWYSINGSVLAK (61)
 REGION -- STREEK (117)
 RELATION -- RELASIE (14)
 REMOTE SENSING -- AFSTANDSWAARNEMING (52)
 RESOLUTION -- RESOLUSIE (102)
 RESPONSE TIME -- REAKSIETYD (41)

SCALE -- SKAAL (78)
 SCALE INDEPENDENCE & DEPENDENCE -- SKAALONAFHANKLIKHEID &
 -AFHANKLIKHEID (79)

SLIVERS -- SPLINTERS (124)
 SMALL-SCALE MAP -- KLEINSKAALKAART (82)
 SOURCE DOCUMENT -- BRONDOKUMENT (46)
 SPATIAL DATA -- RUIMTELIKE DATA (17)
 SPATIAL DOMAIN -- RUIMTELIKE GEBIED (123)
 SPATIAL RESOLUTION -- RUIMTELIKE RESOLUSIE (104)
 SPECTRAL BAND -- SPEKTRALE BAND (56)
 SPECTRAL RESOLUTION -- SPEKTRALE RESOLUSIE (103)
 SPHERE, SPHEROID & ELLIPSOID -- SFEER, SFEROÏED & ELLIPSOÏED (64)
 STATISTICAL SURFACE -- STATISTIESE OPPERVLAK (95)
 SYMBOLOGY -- SIMBOLOGIE (31)

TEMPLATE -- SJABLOON (8)
 TESSELATION -- MOSAÏEKWERK (107)
 THEMATIC MAP -- TEMATIESE KAART (93)
 TOPOGRAPHICAL MAP -- TOPOGRAFIESE KAART (92)
 TOPOLOGICAL DATA -- TOPOLOGIESE DATA (86)
 TOPOLOGICAL INTEGRATION -- TOPOLOGIESE INTEGRASIE (16)
 TOPOLOGICALLY STRUCTURED DATA -- TOPOLOGIES-GESTRUKTUREERDE DATA (85)

TOPOLOGY -- TOPOLOGIE (84)

TUPLE -- TAL (74)

ULTIMATE PRECISION -- EINDNOUKEURIGHEID (66)

VECTOR DATA -- VEKTORDATA (110)

VERTICAL -- VERTIKAAL (71)

VERY SMALL-SCALE MAP -- BAIE KLEINSKAALKAART (83)

ZERO DIMENSION -- NUL-AFMETING (65)

A.3 Glossary

The following are definitions of some geo-referenced information related terms, given in English. They have been grouped into logical rather than alphabetical order.

Searching of this glossary may be done by finding the term in Section A.2, which acts as an index to this glossary, and using the index number opposite the term to find the definition in this glossary.

1. GEOGRAPHICAL INFORMATION SYSTEM (GIS)

A GIS consists of a database of spatially (geographically) referenced data and a collection of utilities for efficiently inputting, storing, retrieving, maintaining, manipulating, analysing and displaying the data. Problems peculiar to GIS's are :

- Enormous volumes of data.
- Data captured at different scales.
- Varying quality of data captured, both in the source and the capture method.
- Generalization of the data.
- Different types of data (vector, raster and alphanumeric).
- Descriptive information attached to coordinates.
- The need to have the data accurately fixed to a well-defined model of the earth.
- Attributes varying from feature class to feature class with location being the only attribute common to all classes.
- Geometric and topological integration.

Because of its nature and the volumes involved, geographical data need the special handling that is not efficiently provided by conventional database management systems. A true GIS is a system that is orientated to the analysis of geo-referenced data to produce useful information. A Land Information System (LIS) is a GIS that deals with physical phenomena, rather than statistical or abstract phenomena.

2. DATA EXCHANGE FORMAT

The procedures and/or rules used in the exchange of data between computer systems having different software and/or hardware.

3. DATA

A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means (Edson & Denegre 1980).

4. INFORMATION

Knowledge that was not previously known to its receiver. Information can be derived from data only to the extent that the data are accurate, timely, unexpected and relevant to the subject under consideration (Sippl & Sippl 1974). The information $I(x)$ for event x of probability $p(x)$ is given by $I(x) = -\log p(x)$, that is, the information is highest for the least probable event (Longley & Shain 1982).

5. CODES

A set of items, such as abbreviations or numbers, representing the members of another set (Moellering 1985).

6. ASCII

American Standard Code for Information Interchange, as defined in ANSI X3.4 published by the American National Standards Institute in 1977 (it is the same as ISO 646). It is a seven information bit and one parity bit standard character set used for exchanging computer data. This is the character set used in this exchange standard.

7. DELIMITER

A specified character used to denote the end of a field (Longley & Shain 1982). In the exchange standard, the delimiters used are the standard ASCII delimiters, namely (in ascending order) the Information Unit Separator (US), 31 (1F in hexadecimal); the Information Record Separator (RS), 30 (1E in hexadecimal); the Information Group Separator (GS), 29 (1D in hexadecimal); and the Information File Separator (FS), 28 (1C in hexadecimal).

8. TEMPLATE

A pattern governing the assembly of some data. In the exchange standard, templates are used to fix the lengths of the relations when delimiters are not being used.

9. DATABASE

A collection of interrelated data stored so that they may be accessed by authorized users with simple user friendly dialogues. The database structure is independent of the programs using the data and a common controlled approach is employed in adding, deleting or modifying the data contained therein (Longley & Shain 1982). Commercial databases are designed to handle precise, non-spatial alphanumeric data.

10. FIELD

A specified area in a record in a database reserved for a particular category of data.

11. KEY

A set of one or more fields that uniquely identifies a record in the database.

12. IDENTIFICATION TAG

A string of characters that uniquely identifies a group of data. In the exchange, identification tags are used to identify the relations and the entries in the File Header.

13. DATABASE MANAGEMENT SYSTEM

A special data processing system, or part of a data processing system, which aids in the storage, manipulation, reporting, management and control of data (Moellering 1985).

14. RELATION

A two-dimensional flat file. The rows in the relation are called tuples, and the columns are called attributes.

15. GEOMETRIC INTEGRATION

Geometric integration is the process of combining the spatial attributes of features from adjacent or coincident source documents so that the whole area appears to have been digitized from one source document.

16. TOPOLOGICAL INTEGRATION

Topological integration is the process of combining features from adjacent or coincident source documents so that the topology of the data is maintained.

17. SPATIAL DATA

Data that have a position in an n-dimensional space. The basic entities in two-dimensional spatial data are nodes, chains, arcs, regions and matrices. These entities are also known as the spatial attributes of features. Three-dimensional space is not yet widely used in geo-referenced information.

18. GEO-REFERENCED DATA

Data that refer to the man-environment-system and that can be localized in space and time. Their three dimensions in space are the two planimetric dimensions (typically latitude and longitude) and the vertical distance from some reference surface.

19. NOMINAL DATA

The nominal measuring level is employed when distinguishing among a set of features only on the basis of their intrinsic character, that is, the distinctions are based only on qualitative considerations without any implication of a quantitative relationship.

20. ORDINAL DATA

Ordinal scales involve nominal classification, and also differentiate within a class of data on the basis of rank according to some quantitative measure. Rank only is involved, that is, the order of the variables from lowest to highest is given, but no definition of the numerical values.

21. INTERVAL DATA

The interval level of measurement assigns an exact numerical value so that the difference between any two items on the scale is known precisely. Interval scales lack true zero points and can therefore be used only to measure differences and not absolute magnitudes. Scaling methods for measuring attitudes and preferences are usually given measurements at this level.

22. RATIO DATA

This scale provides the maximum amount of information. All ratio scales possess a true zero point, as well as permitting precise differences to be calculated, so that measurements retain the same ratio to one another, no matter what units are employed.

23. ENTITY

An object or event about which information is stored in a database (Longley & Shain 1982).

24. ATTRIBUTE

A defined characteristic of an entity. In a GIS, attributes can be spatial (dependent on the entity's position in the n-dimensional space) or non-spatial (independent of the entity's position). Non-spatial attributes are also known as the DESCRIPTIVE attributes of an entity.

25. ATTRIBUTE VALUE

A specific quality or quantity assigned to an attribute (Moellering 1985).

26. FEATURE

A set of one or more uniquely identifiable objects in the real world where the defined characteristics of the objects are consistent throughout all the objects. These defined characteristics are the attributes of the feature, be they spatial or non-spatial. In a database, a feature can be represented by one or more entities. At different degrees of generalization, a feature could be represented by different types of entity, be they point, line, area, grid or compound features. Features can be man-made or natural, real or abstract.

27. CARTOGRAPHIC FEATURE

A term applied to the natural or cultural items shown on a map or chart. The three main categories are: 'point feature', 'line feature' and 'area feature' (Edson & Denegre 1980).

28. FEATURE CLASS

A specified group of features (Moellering 1985).

29. CLASSIFICATION

The arrangement of features into classes or groups on the basis of the defined characteristics of the features. Classification should be done on the basis of the qualitative characteristics of the features, such as their function, and not on the basis of their quantitative characteristics. This is done to speed up the retrieval of data from a database and to group the data for other purposes, such as symbology.

30. HIERARCHY

An organization with grades or classes ranked one above another (Sykes 1983). A hierarchy is one of the three standard database models. In the exchange standard, the classification is done as a variable-level hierarchy.

31. SYMBOLOGY

The assignment of icons, for cartographic or other output, to groups of features based on the classification of the features or some attribute(s) of the features.

32. DATA QUALITY

Indications of the degree of excellence of the data. This includes information about the lineage, completeness, currency, logical consistency and accuracy of the data.

33. GRANULARITY

The granularity of information on data quality is an indication of the level of the information in the structure of a GIS. Thus, information with a fine granularity would be attached to individual coordinates, while information with a coarse granularity would be attached to the database as a whole.

34. LINEAGE

A part of data quality -- the record of the origin of the geo-referenced information and the processes and transformations through which it has gone to reach its current state.

35. COMPLETENESS

An aspect of data quality, indicating whether the set of geo-referenced information has all its necessary parts.

36. CURRENCY

The period during which the data are current.

37. LOGICAL CONSISTENCY

An aspect of data quality - the degree to which geo-referenced information is accurately represented in the data structure and fulfills all the internal requirements of the data structure (modified from Moellering 1985). This reflects the fidelity of the information.

38. BATCH PROCESSING

(1) The processing of data where a number of similar input items are grouped for processing during the same machine run, or (2) the technique of executing a set of computer programs such that each is completed before the next program is started (Longley & Shain 1982). No interaction with the user takes place during program execution.

39. INTERACTIVE PROCESSING

The processing of data in a conversational system where a dialogue takes place between one or more users and the computer. Typical response times are between one-tenth of a second and 15 seconds and are very dependent on the load on the computer and the complexity of the individual transactions.

40. REAL-TIME PROCESSING

The processing of data in a sufficiently rapid manner so that the results of the processing are available in time to influence the process being monitored or controlled (Sippl & Sippl 1974). Real-time processing is generally used in those applications that are too fast for human intervention - typical response times ranging from milliseconds down to the absolute limits of processing speed, currently picoseconds.

41. RESPONSE TIME

The time taken by a system to attain a specified state, or produce a specified output, after receiving input (Longley & Shain 1982).

42. DATA ACQUISITION

The process of gathering data.

43. DATA INPUT

The process of entering data into a computer system by means of peripheral devices. Spatial data are most often captured by digitizing source documents.

44. DATA CAPTURE

The process of recording data on any selected medium.

45. DIGITIZE

To convert an analogue measurement of a physical variable into a discrete numerical value, thereby expressing the quantity in digital form (Sippl & Sippl 1974).

46. SOURCE DOCUMENT

A document that supplies the basic data to be input into the data processing system. The data could consist of text or could be in a graphical format (for capture by digitizing).

47. EDITING

The process of modifying data input to the system. This may involve verifying the validity of input and adding or deleting information in the database. Editing can be fully automatic or it can be performed with varying degrees of operator intervention.

48. DATA DISPLAY

Visual representation of data on a screen as a report, graph or drawing.

49. GRAPHICS WORKSTATION

A stand-alone collection of peripherals including one or more of the following: display screens, keyboards, digitizing tables or tablets, local memory, local discs and local processors, which usually have special graphics handling capabilities. A graphics workstation may be connected by means of data communications to a host computer or to a network.

50. IMAGE

A spatial representation of an object or scene. Mathematically, an image may be thought of as a continuous function of two variables defined on some bounded region of a plane (Edson & Denegre 1982).

51. IMAGE PROCESSING

Image processing encompasses all the various operations that can be applied to photographic or image data. These include, but are not limited to, image compression, image restoration, image enhancement, pre-processing, quantization, spatial filtering and other image pattern recognition techniques (Colwell 1983).

52. REMOTE SENSING

Remote sensing is the acquisition of data and derivative information about objects or materials (targets) located on the earth's surface or in its atmosphere by using sensors mounted on platforms located at a distance from the targets to take measurements (usually multispectral) of interactions between the targets and electromagnetic radiation (Short 1982).

53. ELECTROMAGNETIC RADIATION (EMR)

Energy propagated through space or through material media in the form of an advancing interaction between electric and magnetic fields (Colwell 1983).

54. ELECTROMAGNETIC SPECTRUM

The ordered array of known electromagnetic radiations extending from the shortest cosmic rays, through gamma rays, X-rays, ultra-violet radiation, visible radiation, infrared radiation, and including microwave and all other wavelengths of radio energy (Colwell 1983).

55. MULTISPECTRAL

The use of two or more spectral bands.

56. SPECTRAL BAND

An interval in the electromagnetic spectrum defined by two wave-lengths, frequencies or wave-numbers (Colwell 1983).

57. PHOTOGAMMETRY

The art, science and technology of obtaining reliable measurements of physical objects and the environment through processes of recording, measuring and interpreting photographic images.

58. CARTOGRAPHY

The art, science and technology of map-making.

59. PROJECTION

A map projection is a transformation for representing 'all or part of a round body on a flat sheet. Since this cannot be done without distortion, the cartographer must choose the characteristic which is to be shown accurately at the expense of others, or a compromise of several characteristics' (Snyder 1984).

60. DATUM

Any numerical or geometrical quantity or set of such quantities that may serve as a reference or base for other quantities (Moellering 1985). The height datum is usually the 'smooth mathematical surface that closely fits the mean sea-level surface throughout the area of interest' (Snyder 1984).

61. REFERENCE SURFACE

A standard sphere, spheroid or ellipsoid that is used as the planimetric datum. In South Africa, the standard reference surface is the Clarke 1880 ellipsoid.

62. PROJECTION PARAMETERS

The function defining the one-to-one mapping of the lines and / or points of latitude and longitude between the reference surface and the projection surface.

63. GEOID

The universally accepted best approximation of the shape of the earth is the equipotential surface at mean sea level, called the geoid. It is undulatory, smooth and continuous, fictitiously extending under the continents at the same level, and by definition, perpendicular at any point to the direction of gravity. The surface is not symmetrical about the axis of rotation, the distribution of the density within the earth's body being irregular (Richardus & Adler 1972).

64. SPHERE, SPHEROID & ELLIPSOID

Because of the difficulty in using a geoid for calculating planimetric coordinates, distances and angles, and because the geoid is not completely known for the whole earth, a symmetrical surface of revolution is used as a best fit of the total geoid. However, the relative positions of the continents on the earth are not known to a necessary degree of precision to make it possible to map the whole world on one ellipsoid. Thus one uses an ellipsoid whose surface constitutes the best fit for one's region of interest. A spheroid is an ellipsoid with less flattening. A sphere can be used when the zero dimension of the map is greater than the loss of accuracy that would be incurred by the use of the less accurate spherical surface.

65. ZERO DIMENSION

Measurements taken from a map cannot be more precise than the zero dimension of the map, which is the ultimate precision of the plotting of the map scaled to the real world. Zero dimension is a measure of the resolution of a map.

66. ULTIMATE PRECISION

The ultimate precision of a map is the degree of discrimination with which the map has been plotted and may be read. It is generally 0.15 mm, independent of the scale of the map.

67. LATITUDE & LONGITUDE

The latitude of a point on the ellipsoid is defined as the angular distance between the normal at the point and the plane of the equator of the ellipsoid. The longitude of a point on the ellipsoid is the angular distance between a meridian plane through the point and an arbitrarily defined meridian (usually the Greenwich Meridian).

68. MERIDIAN

A circle passing through the celestial poles and zenith of any place on the earth's surface. A prime meridian is one from which longitude is reckoned (Sykes 1983).

69. PARALLEL

One of the parallel circles of constant latitude on the earth's surface (Sykes 1983).

70. PLANIMETRIC

Taken in the plane of the earth's surface. Also known as horizontal.

71. VERTICAL

Taken perpendicular to the plane of the earth's surface. Vertical measurements reflect elevation and height.

72. PROJECTION COORDINATES

The coordinates of a position given in the projection system.

73. GEO-REFERENCED COORDINATES

The coordinates of a position given in degrees of latitude and longitude. There is a one-to-one relationship between the geo-referenced coordinates and the projection coordinates.

74. TUPLE

A related set of values (Longley & Shain 1982)

75. CONTROL POINT

Any station in a horizontal and vertical control system that is identified in the cartographic data and used for correlating the cartographic data with the horizontal and vertical control systems (Moellering 1985).

76. GEO-CODING

The use of geographical coordinates (longitude and latitude) as key information of data items (Edson & Denegre 1982).

77. ALTERNATE SPATIAL ATTRIBUTE

Alternate spatial attributes are multiple sets of data for the same feature, thus describing the feature with differing amounts of detail. Generally, spatial alternates are scale dependent, but not necessarily so.

78. SCALE

The ratio between a distance on a map, graphics screen or any other display device or medium and the corresponding distance in the real world. A scale of 1 : 10 000 is a larger scale than one of 1 : 250 000.

79. SCALE INDEPENDENCE & DEPENDENCE

Data can be independent of scale (such as non-spatial attributes) or dependent of scale (such as entities that are not displayed at large scales).

80. LARGE-SCALE MAPS

Maps at scales larger than 1 : 25 000.

81. MEDIUM-SCALE MAPS

Maps at scales varying from 1 : 25 000 to 1 : 250 000.

82. SMALL-SCALE MAPS

Maps at scales varying from 1 : 250 000 to 1 : 2 500 000.

83. VERY SMALL-SCALE MAPS

Maps at scales smaller than 1 : 2 500 000.

84. TOPOLOGY

The branch of mathematics that 'treats ideas like dimension and continuous deformation. These ideas are especially important in the construction of automated systems because, in a machine, human intuition is absent' (White 1984). Topology is the relationship between the spatial attributes of the same or different features.

85. TOPOLOGICALLY STRUCTURED DATA

Data that have the spatial relationships inherent in the data explicitly coded (USGS Digital Cartographic Data Standards 1984).

86. TOPOLOGICAL DATA

Data that are invariant under geometrical deformations and stretchings (Moellering 1985).

87. CONTAINMENT

Any spatial attribute that lies within another spatial attribute is contained by that spatial attribute. The two forms of containment are exclusion and inclusion.

88. EXCLUSION

Any spatial attribute that is contained by another spatial attribute but does not form a part of that spatial attribute is excluded by that spatial attribute.

89. INCLUSION

Any spatial attribute that is contained by another spatial attribute and forms a part of that spatial attribute is included by that spatial attribute.

90. COINCIDENCE

If more than one feature shares the same spatial attributes then they are coincident with each other. Intersection is a special form of coincidence.

91. INTERSECTION

Intersection is that form of coincidence where one or more spatial attributes have one coordinate tuple in common.

92. TOPOGRAPHICAL MAPS

Topographical maps (Greek **topos** = place, **graphos** = describe or write) are maps at large and medium scales showing the exact position of the main physical and cultural features within a certain area according to given specifications. The basic topographic coverage (a country's largest scale map series) is based on field survey and/or photogrammetrical results. Derived topographical maps (of medium and small scales) are prepared by reduction and generalization from the original base maps.

93. THEMATIC MAPS

A thematic map is an illustration of a special theme, usually compiled by individual researchers or research organizations, rather than by large mapping organizations. The objective is to portray the form or structure of a spatial distribution, and the mapped information is usually collected by means of physical, socio-economic and geographical surveys, which differ from land surveys in purpose and technique. Thematic maps are usually compiled at medium, small and very small scales.

94. CADASTRAL MAPS

Cadastral maps are large-scale maps based on accurate land survey and show administrative and property boundaries and the outlines of individual buildings. These maps are used for administrative purposes, for the identification of properties described in legal documents, and for various detailed proceedings regarding land tenure.

95. STATISTICAL SURFACE

A statistical surface implies a base datum and a distribution of z-values on an ordinal, interval or ratio scale measured at right angles to that datum. By connecting the z-values, a smooth undulating statistical surface is formed, and the character of this surface is displayed on the map.

96. ISARITHMIC MAP

An isarithmic map is the orthogonal projection of the traces of the intersections of a number of z-level planes, parallel to the horizontal datum, with a continuous statistical surface. The word isarithm is derived from the Greek *isos* = equal and *rithmos* = number, and is a general term referring to any line on a map that joins points having the same z-value. Synonyms for isarithm are isoline and isogram.

97. ISOMETRIC LINE MAP

An isometric line map is an isarithmic or isoline map on which the z-values represent actual or derived values that can occur at points on the earth's surface. Actual values that can occur at points are exemplified by data such as elevation above sea-level, while derived values that can occur at points are either measures of dispersion such as means, medians or standard deviations, or ratios and percentages of point values.

98. ISOPLETH MAP

An isopleth map is an isarithmic or isoline map on which the z-values represent derived values that cannot occur at points on the earth's surface. Representative of this class are percentages and other kinds of ratios that include area in their definition directly or by implication, such as persons per square kilometre.

99. CHOROPLETH MAP

A choropleth map is a map on which the data appear as representative of certain units of surface area, so that each data zone on the map is demarcated by a boundary that is related to an actual unit area. The name is derived from the Greek **choros** = place and **plethos** = magnitude. The statistical surface represented is discontinuous or stepped. The unit areas employed are usually administrative or enumeration areas, and the value of a single point is assigned to the whole data zone.

100. CARTOGRAPHIC GENERALIZATION

Cartographic generalization is the process by which the amount of information shown on the map is reduced when the scale of the map is reduced. It is usually defined in terms of three interrelated sets of processes, namely simplification, classification and symbolisation.

101. DATA SIMPLIFICATION

Data simplification is defined as the determination of the important characteristics of the data, the elimination of unwanted detail, and the retention and possible exaggeration of the important characteristics. Simplification algorithms can be classed into two classes, namely elimination routines and modification routines. Elimination routines include point elimination and feature elimination, whereas simplification by modification refers to smoothing operators such as surface-fitting techniques and enhancement routines applied to raster data.

102. RESOLUTION

The smallest unit that can be detected. Resolution provides a limit to precision and accuracy (Moellering 1985).

103. SPECTRAL RESOLUTION

Spectral resolution is the number of different bands of the electromagnetic spectrum in which a multi-scanner operates.

104. SPATIAL RESOLUTION

The spatial resolution of digitizing equipment is the minimum distance that the equipment can detect between any two points, while the spatial resolution of a plotter is the minimum increment with which the pen can be moved in the X or Y directions.

105. PRECISION

Statistical measure of repeatability. It is usually expressed as variance or standard deviation of repeated measurements (Edson & Denegre 1980). If one repeatedly digitizes the same point, precision is the measure of how close the digitized values are to each other - ideally, they will all be equal. In computing, the precision of a number is determined by the number of bits allocated to the number.

106. ACCURACY

The closeness of results of observations, computations or estimates to the true values - or the values that are accepted as being true (Moellering 1985). Accuracy is the final measure of the worth of the data - how closely do they represent the real world ?

107. TESSELATION

A repeating pattern of either regular or irregular shapes (Moellering 1985).

108. RASTER DATA

Data stored as a three-dimensional rectangular tessellation, with a two-dimensional matrix of elements as a base and one or more values associated with each element (cell).

109. PIXEL

A single picture element. The smallest displayable area on the display surface whose characteristics can differ from those of its nearest neighbours. It generally applies to raster displays (Yen & Kelly 1980), and is data element having both spatial and spectral aspects (Colwell 1983).

110. VECTOR DATA

Data stored as a set of nodes, chains, arcs and regions having position. Additionally, the chains and arcs have magnitude and direction and the regions have magnitude.

111. POINT

A 0-dimensional object with a geometric location specified by a set of coordinates.

112. NODE

A point indicating a topological junction, the end of a chain or arc, or the spatial attribute of a point feature.

113. POINT FEATURE

The representation in a database of a feature whose position is described by a node.

114. CHAIN

An ordered undirected sequence of n-tuples of coordinates with a node at each end. The direction of the chain is defined when the chain is used in a specific feature.

115. ARC

An arc is any continuous part of the circumference of a circle with a node at each end. The arc is defined by giving the start and end nodes of the arc and either the centre of the circle or any other point on the arc.

116. LINE FEATURE

The representation in a database of a feature whose position is described by one or more chains and/or arcs joined together.

117. REGION

The interior of a continuous and closed sequence of one or more chains, known as the region's outer boundary.

118. BOUNDARY

The boundary of a region consists of one or more chains and/or arcs. It is closed, that is, its initial and terminal nodes coincide.

119. AREA FEATURE

The representation in a database of a feature whose position is described by one or more regions that do not necessarily form a continuous object.

120. MATRIX

A matrix consists of an n-tuple of coordinates, that define its origin and an m-dimensional rectangular tessellation of data values encoded in a pre-defined format.

121. GRID FEATURE

The representation in a database of a feature whose position is described by one or more matrices that do not necessarily form a continuous object.

122. COMPOUND FEATURE

The representation in a database of a feature whose position is described by one or more other features that do not necessarily form a continuous object.

123. SPATIAL DOMAIN

The scope of the spatial attributes of a feature.

124. SLIVERS

The narrow areas of overlap and underlap created by the misalignment of boundaries in the database.

125. AREA OF OVERLAP

The intersection of two areas in the database that do not intersect in the real world.

126. AREA OF UNDERLAP

The area between two areas in the database that are adjacent in the real world.

APPENDIX B

STANDARD FEATURE CLASSIFICATION FOR THE EXCHANGE
OF GEO-REFERENCED INFORMATION

Please note: This classification is incomplete. Interested persons are requested to submit suggestions for its completion.

It is imperative that the standard feature classification scheme together with the feature coding scheme and list of non-spatial attributes be maintained centrally by a national co-ordinating body.

B.1 Standard feature classification scheme - version 1.0

The standard feature classification scheme is represented by a variable level hierarchical structure in list form. The different levels are shown by indentations. For example:

COMMUNICATION NETWORK	LEVEL I
ROAD	LEVEL II
ROADS	LEVEL III
FOOTPATH	LEVEL III
PASS	LEVEL III
INTERSECTION	LEVEL III
TOLLGATE	LEVEL III
RAIL	LEVEL II
RAILWAY	LEVEL III
STATION	LEVEL III
PIPELINE	LEVEL II
TELECOMMUNICATION	LEVEL II
GEOMORPHOLOGY	LEVEL I

Level I is the major class, with subsequent breakdown to sublevels until the level that identifies the feature class (feature level) is reached. The path to identify the feature class 'RAILWAY' is 'COMMUNICATION NETWORK/RAIL/RAILWAY'. Its path length is 2 and it is at level 3.

Level I is divided into twelve major classes, which can be extended when the need arises. The twelve Level I classes are:

- BIOLOGY
- BUILDING AND STRUCTURE
- CLIMATOLOGY AND METEOROLOGY
- COMMUNICATION NETWORK
- CONTROL SURVEYS
- GEOLOGY AND GEOPHYSICS
- GEOMORPHOLOGY
- HYDROLOGY AND HYDROGRAPHY
- OCEANOLOGY
- PEDOLOGY
- SOCIAL AND CULTURAL

A feature class appears once and only once in the feature classification scheme. Each feature class has been inserted into the scheme in its most probable position. However, some users may find it more convenient for their application to have certain feature classes in a different position, that is, under a different 'parent'. In these cases, the user's interface to the national standard classification must provide the link to associate the feature class with the new parent. For example, the feature class 'CANAL' is given in the standard feature classification as 'BUILDING AND STRUCTURE/CANAL' whereas in an application it might be viewed as a conveyor of water and be classified as 'COMMUNICATION NETWORK/CANAL'. The link can be done by the use of identical data but different feature code dictionaries to allow the translation to the respective feature classifications.

B.2 Feature coding scheme - version 1.0

A feature is identified by its feature class, which in turn has to be identified by its full path name in the feature classification scheme. For the sake of brevity, it is sometimes desirable to represent the feature class path name by a coding scheme.

Human readable codes are desirable if direct human interpretation is required. A mnemonic coding scheme is often used in these cases. In a mnemonic coding scheme a unique mnemonic code is assigned to abbreviate the feature class path name. However, in a large classification scheme it becomes difficult to find a unique mnemonic code that adequately represents the feature class path name.

The feature coding scheme used here is based on computer-readable codes. These codes are taken from the set of natural numbers and are arbitrarily allocated to the feature classes. A feature code dictionary is used to translate from the feature path name to the numeric code, and vice versa.

The advantages of this coding scheme are:

- Very short codes are used (directly related to the number of feature classes in the classification scheme).
- No 'renumbering' of codes is necessary as the 'next number' is allocated to a new feature class.
- Computer-readable codes mean more efficient computer handling.
- The codes are not of fixed length codes.
- These codes are not used at the human interface level and are completely transparent to the user, but can easily be translated into human readable feature class path names.

B.3 Non-spatial attribute lists for each class - version 1.0

The non-spatial attributes of a feature class are given in a non-spatial attribute list. Each feature class has a unique non-spatial attribute list. The name of a non-spatial attribute may appear in the non-spatial attribute list of another feature class, possibly with another definition. It is not necessary for all the attributes to be given to a particular feature. In this case the characteristics of the feature

described by the omitted non-spatial attributes are unknown or undefined. The non-spatial attribute list can be an empty (null) list, implying that no information is available to describe the characteristics of that feature.

A non-spatial attribute attached to a 'parent' feature class implies that all the 'children' (lower level) feature classes have that non-spatial attribute. In this case the inherited non-spatial attribute does not have to be explicitly given in the non-spatial attribute list for the 'child' feature classes.

A non-spatial attribute is further described by assigning an attribute value. The attribute value can be one of a set of predefined values or a variable (numeric or string). For example, a bridge with a status of 'IN USE', a width of 10 metres and a name 'CONNAUGHT BRIDGE' would have the following values:

STATUS	=	IN USE	:	predefined value
WIDTH	=	10	:	numeric value
NAME	=	CONNAUGHT BRIDGE	:	string value

The relation in the standard structure of a data set for the exchange of non-spatial attributes (see 5.4.8) requires the attribute values to be atomic, that is, only one value for each non-spatial attribute. If a non-spatial attribute has more than one value, then the relation must be repeated for each value.

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL			(* Compulsory attribute)
I	II	III	
BIOLOGY		10	REFERENCE, ALIAS
	SPECIES OBSERVATION POINT	11	TAXON*, OBSERVATION NUMBER*, TYPE, DATE, TIME, NUMBERS
	SPECIES POPULATION AREA	12	TAXON*, POPULATION NUMBER*, SURVEY NUMBER*, TYPE, DATE, TIME, DEMOGRAPHY CLASS, DEMOGRAPHY TOTAL, DEMOGRAPHY STATUS, CONSERVATION MANAGEMENT STATUS, CONSERVATION THREAT STATUS, CONSERVATION GENETIC STATUS
	SPECIES RANGE	13	TAXON*, REGION*, RANGE NUMBER*, TYPE, DATE, TIME, POPULATION NUMBER, INDIVIDUAL NUMBER
	BIOLOGICAL SURVEY SITE	14	SYSTEM, SURVEY SERIES, SITE NUMBER, SAMPLE NUMBER, DATE, TIME
	NATURAL COMMUNITY AREA	15	SYSTEM, COMMUNITY TYPE, COMMUNITY BLOCK, COMMUNITY OCCURENCE, DATE, TIME
	BIOME-TYPE AREA	16	SYSTEM, BIOME TYPE, BIOME BLOCK, BIOME OCCURENCE
	BIOGEOGRAPHICAL REGION	17	SYSTEM, REGION TYPE, REGION BLOCK, REGION OCCURENCE

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

BUILDING AND STRUCTURE	18	NAME, CONSTRUCTION
BUILDING	19	CATEGORY, USE, NUMBER OF FLOORS, HEIGHT
BRIDGE	20	CATEGORY, FEATURE CLASS CARRIED, FEATURE CLASS CROSSED, STATUS, CLEARANCE HEIGHT, LENGTH, WIDTH, LOAD RATING
TUNNEL	21	FEATURE CLASS CARRIED, LENGTH, WIDTH, CLEARANCE HEIGHT, LINING, STATUS
WINDMILL	22	HEIGHT, WHEEL DIAMETER, FUNCTION
CANAL	23	WIDTH, DEPTH, CAPACITY, GRADIENT
TOWER	24	FUNCTION, LIGHTED, HEIGHT
TELEPHONE/TELEGRAPH POLE	25	HEIGHT, REFERENCE NUMBER
BARRIER	26	TYPE, HEIGHT, WIDTH
DAM WALL	27	LENGTH, WIDTH, HEIGHT
JETTY	28	LENGTH, WIDTH
WHARF	29	FRONTAGE, WIDTH
RESERVOIR	30	TYPE, DIAMETER, CAPACITY, HEIGHT
MINE HEADGEAR	31	FUNCTION, LOAD RATING
SILLO	32	TYPE
STORAGE TANK	33	SUBSTANCE STORED
BREAKWATER	34	LENGTH
CHIMNEY	35	HEIGHT, LIGHTED
CUTTING	36	
EMBANKMENT	37	
CRANE	38	TYPE, LOAD RATING
PLATFORM	39	FUNCTION, LENGTH

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

CLIMATOLOGY AND METEOROLOGY

40

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL		
I	II	III
COMMUNICATION NETWORK	41	
ROAD	42	NAME
ROADS	43	CLASS, ROUTE NUMBER, NUMBER OF CARRIAGEWAYS, NUMBER OF LANES, SURFACE, USE, ACCESS, STATUS
FOOTPATH	44	
PASS	45	GRADIENT
INTERSECTION	46	TYPE
TOLLGATE	47	NUMBER OF GATES, TOLL
RAIL	48	
RAILWAY	49	NUMBER OF LINES, GAUGE, USE, STATUS, GRADIENT, ELECTRIFIED
STATION	50	NAME, TYPE
AIR	51	
AIRPORT	52	NAME, TYPE, ELEVATION
RUNWAY	53	LENGTH, WIDTH, ORIENTATION, NUMBER, SURFACE, STATUS
HELIPAD	54	DIAMETER, ELEVATION, SURFACE, STATUS
CONTROLLED FLYING AREA	55	MINIMUM ALTITUDE, TYPE OF CONTROL
NAVIGATION/FLYING AID	56	TYPE
SEA AND INLAND WATER	57	
FERRY	58	TYPE, CAPACITY
HARBOUR	59	NAME
ANCHORAGE AREA	60	MINIMUM DRAUGHT, BOTTOM TYPE
DOCK	61	MINIMUM DRAUGHT, NAME, HANDLING CAPACITY
CHANNEL	62	MINIMUM DRAUGHT, NAME
MARINE NAVIGATION AID	63	TYPE
PIPELINE	64	FUNCTION, DIAMETER, CONSTRUCTION, CAPACITY, SURFACE
TELECOMMUNICATION	65	FREQUENCY, POWER, DIRECTION, SPREAD ANGLE
ELECTRIC TRANSMISSION	66	RATING
POWERLINE	67	TYPE
CABLE	68	
AERIAL CABLEWAY	69	FUNCTION, LOAD RATING
CONVEYOR BELT	70	LOAD RATING

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

CONTROL SURVEYS	71	REFERENCE, NUMBER
TRIGONOMETRICAL BEACON	72	NAME, TYPE, HEIGHT OF BEACON, HEIGHT OF PLATFORM, HEIGHT OF SIGNAL, WITNESS MARK, STATUS, ELEVATION
TOWN SURVEY MARK	73	REFERENCE, NUMBER, STATUS, ELEVATION
BENCH MARK	74	ROUTE, ELEVATION, STATUS
STANDARDISATION BASE	75	NUMBER OF LEGS, LEG NUMBER, DISTANCE
PHOTO CONTROL	76	TYPE
TIDE GAUGE	77	TYPE, STATUS

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

GEOLOGY AND GEOPHYSICS	78	
GRAVITY STATION	79	REFERENCE, NAME, TYPE, ELEVATION, G-VALUE
GRAVITY POINT	80	G-VALUE
GRAVITY ANOMALY CONTOUR	81	G-VALUE
MAGNETIC STATION	82	REFERENCE, NAME, TYPE, MAGNETIC DECLINATION, DATE
MAGNETIC POINT	83	MAGNETIC DECLINATION, DATE
ISOGONIC LINE	84	MAGNETIC DECLINATION
CONTACT	85	TYPE, LITHOLOGICAL UNIT SEPARATED
JOINT	86	TYPE, ORIENTATION
FAULT	87	TYPE, RELATIVE DIRECTION OF MOVEMENT, LITHOLOGICAL UNIT LEFT, LITHOLOGICAL UNIT RIGHT, NAME
LINEATION	88	TYPE, DIRECTION
YOUNGING	89	DIRECTION
DIP AND STRIKE	90	DIRECTION, ANGLE, STATUS
FOLD AXIS	91	TYPE, NAME, DIRECTION, ANGLE
MINERAL DEPOSIT	92	MINERAL, NAME, STATUS
LITHOLOGICAL UNIT	93	NAME, ROCK TYPE, AGE, MINERAL COMPOSITION
RADIOMETRIC AGE	94	VALUE, METHOD

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

GEOMORPHOLOGY	95	
RELIEF	96	ELEVATION, TYPE
CONTOUR	97	
SPOT HEIGHT	98	
DEPTH SOUNDING	99	DEPTH
LANDFORM	100	NAME
ALLUVIAL FAN	101	
CAPE	102	
BAY	103	
BEACH	104	
COASTLINE	105	
CAVE	106	
CLIFF	107	
DONGA	108	
DELTA	109	
DEPRESSION	110	
ESCARPMENT	111	
ESTUARY	112	
FLACON PLAIN	113	

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

LANDFORM (CONTINUED)

GORGE	114
HILL	115
HEADLAND	116
ISLAND	117
ISTHMUS	118
LANDSLIDE	119
MARSH	120
MOUNTAIN RANGE	121
MUD FLAT	122
OLD RIVER COURSE	123
PLAIN	124
PLATEAU	125
PENINSULA	126
POORT	127
PEAK	128
POTHOLE	129
RIVER TERRACE	130
RIVER MEANDER	131

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

LANDFORM (CONTINUED)

RIDGE	132
REEF	133
ROCK OUTCROP	134
RAPIDS	135
SAND BAR	136
SAND BANK	137
SAND DUNE	138
SEA ARCH	139
STACK	140
SADDLE	141
SINKHOLE	142
VALLEY	143
VLEI	144
WATERFALL	145
WATERSHED	146
ERODED AREA	147

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

HYDROLOGY AND HYDROGRAPHY

148

NAME, MINERAL COMPOSITION

RIVER

149

TYPE, FLOW CAPACITY

DAM

150

CAPACITY

LAKE

151

LAGOON

152

PAN

153

TYPE

WATER POINT SOURCE

154

STRENGTH, TYPE

SUBTERRANEAN WATER

155

DRAINAGE BASIN

156

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

LAND USE	157	
INDUSTRIAL	158	ACTIVITY
COMMERCIAL	159	ACTIVITY
RESIDENTIAL	160	TYPE
RECREATION	161	TYPE
CULTURAL	162	TYPE
AGRICULTURAL	163	
CULTIVATED LAND	164	TYPE, YIELD, IRRIGATION
VINEYARD	165	TYPE, YIELD, IRRIGATION
ORCHARD	166	TYPE, YIELD, IRRIGATION
PLANTATION	167	TYPE
STOCK	168	TYPE
POULTRY	169	
GARDEN	170	COVERED
MINING	171	
OPENCAST	172	TYPE, YIELD STATUS
UNDERGROUND	173	TYPE, YIELD, STATUS
PROPECTING	174	
DUMP	175	
MINE SHAFT	176	
SLIMES DAM	177	
MILITARY	178	
RELIGION	179	TYPE
EDUCATION	180	TYPE
GOVERNMENT	181	
MEDICAL	182	TYPE
COMMUNICATION	183	TYPE
UTILITY	184	TYPE
CONSERVATION AREA	185	TYPE, NAME

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

OCEANOLOGY

186

NAME

OCEAN

187

SEA

188

CURRENT

189

FLOW DIRECTION, SPEED

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

PEDOLOGY

190

STANDARD FEATURE CLASSIFICATION
VERSION 1.0

FEATURE CODE
VERSION 1.0

NON-SPATIAL ATTRIBUTE LIST
VERSION 1.0

LEVEL
I II III

SOCIAL AND CULTURAL	191	
CADASTRAL	192	
CADASTRAL BEACON	193	DESCRIPTION
CADASTRAL BOUNDARY	194	TYPE, DESCRIPTION
LAND PARCEL	195	TYPE, DESIGNATION, SITUATION, DEED NUMBER, PARENT DEED NUMBER, LEGAL AREA, SIDE, DIRECTION, CO-ORDINATES, OWNER, STREET ADDRESS
SERVITUDE	196	TYPE, DESCRIPTION, OWNER
SECOND PARTY LEGAL RIGHTS	197	TYPE, OWNER
ADMIN/REGISTRATION-		
DISTRICT	198	
ADMINISTRATIVE AREA	199	NAME
INTERNATIONAL	200	
PROVINCIAL	201	
MAGISTERIAL DISTRICT	202	
LOCAL AUTHORITY	203	TYPE
REGIONAL SERVICES COUNCIL	204	
PROCLAIMED RESTRICTION	205	TYPE
STATE FOREST	206	
NATURE RESERVE	207	TYPE
SOCIAL STATISTICAL	208	NAME
ELECTORAL DIVISION	209	
POLLING DISTRICT	210	
DEMOGRAPHIC ENUMERATION-		
AREA	211	STATISTICS
STATISTICAL REGION	212	STATISTICS
DEVELOPMENT REGION	213	STATISTICS

APPENDIX C:

SUMMARY OF THE EXCHANGE STANDARD

C.1 File identification

The following are the entries in the File Identification. For ease of use, the entries are of a predetermined fixed size and the size of the entire File Identification is 2048 bytes. For a detailed description of the File Identification, its contents and function, see 5.2. The size in bytes of the entries is given opposite each entry's name.

Size in bytes:

5.2.1	Data identification	128
5.2.2	Volume number	8
5.2.3	Source organization	256
5.2.4	Maintenance organization	256
5.2.5	Copyright statement	256
5.2.6	Access privileges	256
5.2.7	Date stamp	8
5.2.8	Time stamp	6
5.2.9	Northern latitudinal limit of the data	8
5.2.10	Southern latitudinal limit of the data	8
5.2.11	Western longitudinal limit of the data	8
5.2.12	Eastern longitudinal limit of the data	8
5.2.13	ASCII / Binary	1
5.2.14	Explicit Lengths / Delimiters	1
5.2.15	Physical record size	8
5.2.16	Blocking factor	8
5.2.17	Comments	824
	Total size	2048

C.2 Global information section

The following are the entries in the Global Information Section. For a detailed description of the Global Information Section, its contents and function, see 5.3.valid for the data being exchanged. The four-character, 7-bit ASCII identification tags of the entries are given opposite each entry's name.

Identification tag:

5.3.1	Projection or coordinate system	P/CS
5.3.2	Standard meridians & parallels & scale factor	SM&P
5.3.3	Reference surface	REFS
5.3.4	Planimetric coordinate resolution: units	PCRU
5.3.5	Planimetric coordinate resolution: increment	PCRI
5.3.6	First planimetric coordinate offset	FPCO
5.3.7	Second planimetric coordinate offset	SPCO
5.3.8	Dimension of the coordinates	DIMC
5.3.9	Vertical coordinate resolution: units	VCRU
5.3.10	Vertical coordinate resolution: increment	VCRI
5.3.11	Indication of absolute or relative coordinates in chains	A/RC
5.3.12	Height datum in text form	HDTF
5.3.13	Height datum above mean sea level	HDAT
5.3.14	First bounding planimetric quadrilateral coordinate tuple	BPQ1
5.3.15	Second bounding planimetric quadrilateral coordinate tuple	BPQ2
5.3.16	Third bounding planimetric quadrilateral coordinate tuple	BPQ3
5.3.17	Fourth bounding planimetric quadrilateral coordinate tuple	BPQ4

5.3.18	Data quality scheme used	QUAL
5.3.19	Data quality scheme release number	QUNO
5.3.20	Feature classification scheme used	CLAS
5.3.21	Feature classification scheme release number	CLNO
5.3.22	Attribute scheme used	ATTR
5.3.23	Attribute scheme release number	ATNO
5.3.24	Alternate spatial attribute scheme	ASAS
5.3.25	Alternate spatial attribute scheme release number	ASNO

5.4 Geo-referenced information relations

The following are the geo-referenced information relation sections that may appear in a file being exchanged. For a detailed description of the geo-referenced information relations, their contents and function, see 5.4. The eight-character, 7-bit ASCII identification tags of the sections are given opposite each entry's name. The fields that constitute any entry (an instance of a relation) in a section are listed below the sections name - the key fields on the first indentation and the other fields on the second indentation.

Identification tag:

5.4.2	List of relations used	RELALIST
	Relation name	
	Sequence number	
5.4.3	Templates of the relations	TEMPLATE
	Length of template	
	Relation name	
	Number of fields in the relation	
	Length of each field in the relation	
5.4.4	Exchange of classification scheme	EXCHCLAS
	Class path name	
	Classification code	
	Description	
5.4.5	Exchange of non-spatial attribute scheme	EXCHATTR
	Non-spatial attribute name	
	Non-spatial attribute code	
	Nature of the value	
	Description	

5.4.6	Exchange of alternate spatial attribute scheme	EXCHASAS
	Alternate spatial attribute ID	
	Description	
5.4.7	Information on data quality	DATAQUAL
	Comment	
	Sequence number	
5.4.8	Feature / classification	FEATCLAS
	Feature ID	
	Classification	
5.4.9	Classification / features	CLASFEAT
	Classification	
	Sequence number	
	Feature ID	
5.4.10	Feature / non-spatial attributes	FEATNSAT
	Feature ID	
	Sequence number	
	Non-spatial attribute ID	
	Non-spatial attribute value	
5.4.11	Feature / feature types	FEATTYPE
	Feature ID	
	Alternate spatial attribute	
	Feature Type	
5.4.12	Feature / spatial domain	FEATSDOM
	Feature ID	
	Alternate spatial attribute	
	Minimum value of first planimetric coordinate	
	Maximum value of first planimetric coordinate	
	Minimum value of second planimetric coordinate	
	Maximum value of second planimetric coordinate	

5.4.13	Point feature / node	FEATNODE
	Feature ID	
	Alternate spatial attribute	
	Node ID	
5.4.14	Node / point features	NODEFEAT
	Node ID	
	Sequence number	
	Feature ID	
	Alternate spatial attribute	
5.4.15	Line feature / chains & arcs & direction	FEATCHAI
	Feature ID	
	Alternate spatial attribute	
	Sequence number	
	Indication of chain or arc	
	Chain/Arc ID	
	Direction indicator	
5.4.16	Chain & arc / line features	CHAIFEAT
	Chain/Arc ID	
	Sequence number	
	Feature ID	
	Alternate spatial attribute	
	Direction indicator	
5.4.17	Area feature / included regions	FEATREGI
	Feature ID	
	Alternate spatial attribute	
	Sequence number	
	Region ID	
5.4.18	Regions / area features	REGIFEAT
	Region ID	
	Sequence number	
	Feature ID	
	Alternate spatial attribute	

5.4.19	Grid feature / matrices	FEATMATR
	Feature ID	
	Spatial Alternate	
	Sequence number	
	Matrix ID	
5.4.20	Matrix / grid features	MATRFEAT
	Matrix ID	
	Sequence number	
	Feature ID	
	Alternate spatial attribute	
5.4.21	Compound feature / features	COMPFEAT
	Feature ID	
	Alternate spatial attribute	
	Sequence number	
	Feature ID	
5.4.22	Feature / compound features	FEATCOMP
	Feature ID	
	Sequence number	
	Feature ID	
	Alternate spatial attribute	
5.4.23	Chain / nodes & coordinate tuples	CHAINODE
	Chain ID	
	Node ID	
	Node ID	
	Length of Chain	
	Data ID	
5.4.24	Node / chains & arcs	NODECHAI
	Node ID	
	Sequence number	
	Chain ID	

5.4.25	Region / chains & arcs & direction	REGICHAI
	Region ID	
	Sequence number	
	Indication of chain or arc	
	Chain/Arc ID	
	Direction indicator	
5.4.26	Chain & arc / regions	CHAIREGI
	Chain/Arc ID	
	Sequence number	
	Region ID	
	Direction indicator	
5.4.27	Region / excluded regions	REGIEXCL
	Region ID	
	Sequence number	
	Region ID	
5.4.28	Excluded region / regions	EXCLREGI
	Region ID	
	Sequence number	
	Region ID	
5.4.29	Node / coordinate tuple	NODECOORD
	Node ID	
	Coordinate Tuple	
5.4.30	Chain data	CHAINDATA
	Data ID	
	Coordinate tuples	
5.4.31	Arc / curve data	ARCCDATA
	Arc ID	
	Start node ID	
	End node ID	
	Coordinate tuple for third point	

5.4.32 Matrix / raster data

MATRDATA

Matrix ID

Sequence number

First coordinate tuple

Second coordinate tuple

Third coordinate tuple

Ordering of matrix elements

Compaction encoding

Length in first dimension.

Length in second dimension

Length in third dimension

Data ID

5.4.33 Raster data

RASTDATA

Data ID

Minimum value

Maximum value

Null value

Values

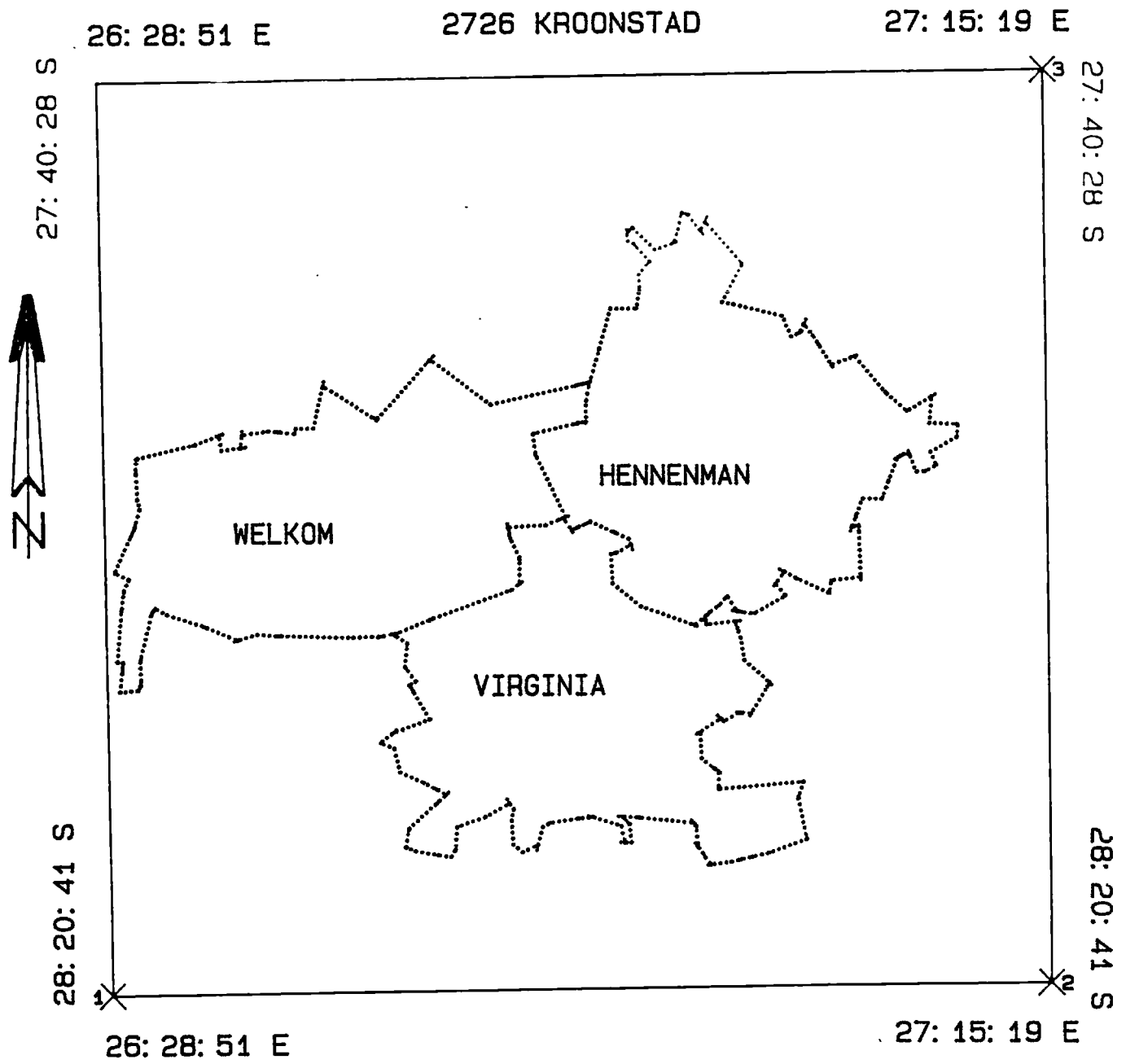
APPENDIX D

AN EXAMPLE OF THE USE OF THE EXCHANGE STANDARD

D.1 Introduction

The following is an example of data in the format required by the exchange standard. The data are not highly accurate, they are merely being used to illustrate the use of the exchange standard. The example has been printed in this document with 64 characters per line. This is purely to make the example legible. These line breaks (or carriage returns) **must not appear** in any data being exchanged. The File Identification, Global Information Section and Geo-referenced Information Relations are each illustrated in separate paragraphs.

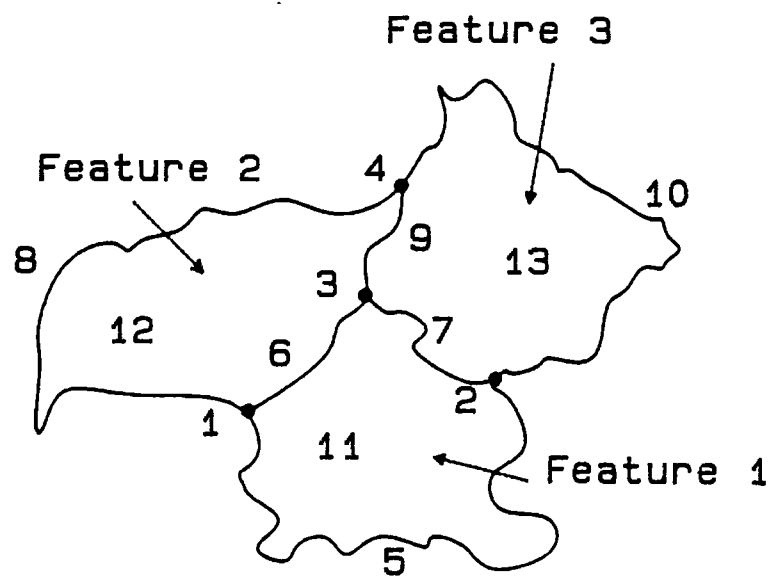
The example consists of three adjacent magisterial districts with some attached non-spatial information. Figure D.1 shows the spatial data plotted to scale and figure D.2 shows the features and the spatial attributes.



SCALE 1: 500000

PROJECTION: LAMBERT

PARAMETERS: 26: 40: 00 S 33: 20: 00 S



Nodes: 1, 2, 3, 4
Chains: 5, 6, 7, 8, 9, 10
Regions: 11, 12, 13

Figure A.2

D.2 Example of the file identification

1:500000 2726 KROONSTAD Administrative Edition, First Edition, published in 1980 (The magisterial districts are as at July 1985)
 00000001Computer Science Division, National Research Institute for Mathematical Sciences (NRIMS), Council for Scientific and Industrial Research (CSIR), P O Box 395, PRETORIA, 0001, South Africa. Telephone (012) 841-4185.

Computer Science Division, National Research Institute for Mathematical Sciences (NRIMS), Council for Scientific and Industrial Research (CSIR), P O Box 395, PRETORIA, 0001, South Africa. Telephone (012) 841-4185.

The copyright on these data is held by the Council for Scientific and Industrial Research (CSIR), but they may be used without permission for research purposes.

There are no restrictions on the access to these data.

198709031817510274028S0282041S0262851E0271519EAD00002048
 00000001These data are merely a small example of data in the format required for the exchange standard. The spatial data were digitized on a digitizing table with a resolution of 0.1 mm and then reduced (generalized) - that is, the number of internal coordinate tuples in the chains was reduced. This reduces the amount of data that has to be added to this document, but it also reduces the accuracy, so do not view the data as being accurate. The statistical data used for non-spatial data were taken from publications of the Central Statistical Services. The example has been provided to illustrate the use of the exchange standard. The origin of the spatial data lies at 30 South and 28 East, that is, at the intersection of the standard meridian and the parallel midway between the two standard parallels.

D.3 Example of the global information section

P/CSLAMB;SM&P26:40S,33:20S,28E;PCRUM;SPC0222264;BPQ1-149888,26013;BPQ2-82149,26013;BPQ3-82149,-27126;BPQ4-149888,-27126;ATTRExample attribute scheme\

D.4 Example of the geo-referenced information relations

RELALISTEXCHATTR;DATAQUAL;FEATCLAS;FEATNSAT;FEATTYPE;FEATREGI;COMPFEAT;CHAINODE;REGICHA;NODECOORD;CHAIDATA\EXCHATTRNAME,1,T,The name of a feature;REMUNERATION,2,N,Total remuneration of employees in thousands of Rand for 1978;WHEAT,3,N,Wheat production in metric tons for 1980\DATAQUALThese data were digitized off the Bril Blue sheet of the 1:500000 2726 Kroonstad Administrative Edition (1st Edition of 1980) and reduced so that the number of coordinates would be manageable (which reduces the accuracy)\FEATCLASS1,211;2,211;3,211;4,212;5,212\FEATNSAT1,1,1,10826;1,3,11529;2,1,Welkom;2,2,331062;2,3,3630;3,1,Henneman;3,2,8349;3,3,12829;4,1,Region 62;5,1,Region 64\FEATTYPE1,A;2,A;3,A;4,C;5,C\FEATREGI1,11;2,12;3,13\COMPFEAT4,1;4,2;5,3\CHAINODE5,2,1,72,1;6,1,3,10,2;7,3,2,13,3;8,1,4,50,4;9,4,3,6,5;10,4,2,67,6\REGICHA11,C,5,F;11,C,6,F;11,C,7,F;12,C,8,F;12,C,9,F;12,C,6,B;13,C,10,F;13,C,7,B;13,C,9,B\NODECOORD1,-127525,-8162;2,-102450,-6900;3,-113812,1262;4,-111687,12250\CHAIDATA1,-102387,-7550,-100137,-7275,-99925,-7850,-99625,-8675,-99350,-10475,-97375,-12300,-97562,-12612,-98900,-14825,-99800,-14737,-99862,-14762,-101087,-15450,-101350,-15200,-103087,-16375,-102937,-16475,-102812,-18475,-101850,-19262,-101500,-19512,-101475,-20762,-101525,-20962,-99812,-20825,-94675,-20387,-95112,-21637,-94412,-25087,-97462,-26175,-98825,-26500,-99762,-26725,-100550,-26912,-102150,-27125,-102575,-26537,-103175,-25687,-103350,-23937,-103550,-23700,-107912,-23250,1092,12,-23162,-108650,-23800,-108487,-25300,-109087,-25262,-109350,-23912,-111662,-23187,-112025,-23237,-112800,-23325,-115162,-23637,-115762,-23987,-116150,-25450,-117387,-26012,-118150,-25375,-118275,-23425,-118087,-22562,-118437,-22025,-120375,-23137,-12267

5, -23925, -122800, -25775, -123200, -26387, -124225, -26200, -126050, -2
 5862, -126762, -25575, -126525, -24075, -124262, -21987, -123512, -21275
 , -124287, -20862, -125325, -20300, -127237, -19425, -127712, -17475, -12
 8762, -17037, -127775, -16225, -124787, -15137, -126112, -12887, -126162
 , -12800, -126475, -12350, -125925, -12050, -126787, -10900, -126562, -89
 50; 2, -124775, -7025, -124437, -6900, -118200, -4637, -117500, -4125, -11
 7475, -2125, -118250, -437, -118337, 0, -118462, 500, -115362, 637, -11418
 7, 1112; 3, -113825, 1112, -113250, 212, -112800, 400, -112262, 650, -11171
 2, 887, -109800, 0, -108587, -562, -108425, -1012, -109575, -1625, -110075
 , -1737, 109937, -4137, -107612, -6062, -103337, -7612; 4, -128525, -8362,
 -130925, -8450, -136662, -8275, -136937, -8275, -138587, -8137, -140137,
 -8612, -142850, -7487, -145925, -6475, -146875, -5937, -147125, -6337, -1
 48075, -10162, -148012, -11862, -148250, -12662, -148862, -12712, -14970
 0, -12787, -149525, -11225, -149425, -10375, -149887, -10325, -149537, -6
 175, -149350, -4612, -148975, -3662, -148962, -3612, -148975, -3599, -150
 125, -3075, -149012, -662, -148712, 0, -148512, 437, -148437, 712, -148025
 , 2149, -148237, 2900, -148362, 5100, -148275, 6250, -143487, 7362, -14153
 7, 8137, -141325, 6887, -139775, 7100, -139687, 8162, -137587, 8437, -1368
 62, 8362, -135487, 8212, -135387, 8612, -133937, 8675, -133175, 12100, -12
 9237, 9487, -128787, 9437, -124662, 14112, -124587, 14200, -119787, 10500
 , -112800, 12000, -112375, 12100, ; 5, -112025, 10700, -112050, 9037, -1123
 37, 8987, -112800, 8887, -116350, 8087, -116125, 6337; 6, -110900, 15025, -
 110487, 16475, -110012, 18237, -107862, 18262, -107625, 19712, -107687, 2
 1012, -106800, 22025, -108125, 23512, -108575, 23712, 108637, 24212, -108
 187, 24862, -106362, 22987, -104875, 23550, -104475, 24662, -104200, 2601
 2, -103750, 25875, -102675, 24475, -102337, 25287, -100187, 22762, -99387
 , 21812, -100175, 20375, -101050, 18737, -100150, 18525, -96187, 17550, -9
 5462, 15850, -94812, 16212, -94475, 16925, -93762, 15925, -93300, 15187, -
 92275, 13537, -90437, 14262, -87950, 11287, -87825, 11175, -86225, 9762, -
 84237, 10987, -84462, 8775, -82150, 8700, -82237, 7650, -84375, 6425, -838
 62, 5375, -84862, 4862, -85562, 4812, -86075, 6250, -86575, 6250, -87025, 5
 987, -87762, 4100, -88337, 2624, -89900, 2650, -90362, 1325, -90425, 1137,
 -90762, 287, -90162, 487, -90150, 0, -90012, -3750, -92412, -4024, -92550,
 -5075, -95225, -3812, -96187, -3274, -96875, -4287, -96012, -5225, -98600
 , -6662, -99700, -6525, -99937, -6487, -100000, -6475, -100762, -5225, -10
 1412, -5987, -102200, -6550\

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