*for Information Systems* -

# *Spatial Data Transfer Standard (SDTS)* - *Part 1, Logical Specifications*

American National Standard
for Information Systems -

# Spatial Data Transfer Standard (SDTS) -
# Part 1, Logical Specifications



Secretariat

**United States Geological Survey, National Mapping Division**

DRAFT for Review, November 20, 1997

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Published by

**American National Standards Institute**
**11 West 42nd Street, New York, New York 10036**

## Contents

Page

Page

Page

## Tables

## Figures

## Foreword (From the original version)

This document contains a specification of the Spatial Data Transfer Standard (SDTS), that will serve as a national spatial data transfer mechanism for the United States. As such it is designed to transfer a wide variety of data structures that are used in the spatial sciences. These sciences include cartography, geography, geology, geographic information systems and many other neighboring sciences. SDTS consists of three primary parts: the first is the SDTS logical superstructure that presents the organization and structure of the SDTS transfer mechanism; the second presents the definition of spatial features and attributes; and the third part presents the ISO 8211 data transfer implementation (*i.e.*, encoding method).

Work on a national spatial data transfer standard was begun by the National Committee for Digital Cartographic Data Standards in 1982 to develop a comprehensive set of data exchange standards for the profession. This work was funded by the U.S. Geological Survey through a grant to the American Congress on Surveying and Mapping. In 1985, the Standards Working Group of the Federal Interagency Coordinating Committee on Digital Cartography also began work on spatial data exchange standards. During 1987, the results of these parallel efforts were merged by the Digital Cartographic Data Standards Task Force into the proposed Digital Cartographic Data Standards, published as a special issue of The American Cartographer in January 1988. Subsequent testing, modification, and refining of the results of these efforts were done by the Spatial Data Transfer Standard Technical Review Board. The end product of all of this effort is the standard presented here.

This result represents a collaborative effort by these groups to define a standard that will support work with cartographic and geographic data systems and facilitate spatial data transfer. It is designed to serve the spatial data transfer needs of the Federal agencies, especially the proposed National Spatial Data Infrastructure, and the work of State and local governmental entities, the private sector, and research organizations.

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American National Standard for Information Systems

# Spatial Data Transfer Standard - Part 1, Logical Specification

## 1 Introduction

This Spatial Data Transfer Standard (SDTS) provides a solution to the problem of spatial (i.e., geographic and cartographic) data transfer from the conceptual level to the details of physical file encoding. Transfer of spatial data involves modeling spatial data concepts, data structures, and logical and physical file structures. To be useful, the data to be transferred must also be meaningful in terms of data content and data quality. SDTS addresses all of these aspects for both vector and raster data structures.

The base standard is in three parts. Part 1 addresses the logical specifications in terms of conformance requirements, a conceptual model, quality specifications, the data structure model, and the transfer format. Part 2 addresses data content by providing a standard list and definitions of spatial features and their attributes. Part 3 specifies the implementation of SDTS in terms of the International Organization for Standardization for a Data Descriptive File for Information Interchange. Subsequent part numbers are assigned to profiles. A SDTS Profile is a normative part of this standard and is a subset of this standard but may also include extensions to this standard. A SDTS Profile is defined for use with a specific data model, application domain, or other such purpose.

Section 1 of part 1 includes a statement of scope (1.1, Scope of SDTS) and conformance requirements (1.3, Conformance) for SDTS. It also includes normative references to other standards (1.4, References) and definitions of terms (1.5, Definitions).

The conceptual model of spatial data (2.1, Conceptual Model) is presented in section 2 to provide a framework for defining spatial features (2.1.3, Model of Spatial Features) and a context for the definition of a set of spatial objects (2.1.2, Model of Spatial Objects). This conceptual model supports the translation of user data models to and from the SDTS model. Within section 2 is a defined set of spatial objects, for zero, one, and two dimensions, used in spatial data systems to represent real-world spatial phenomena. Three or higher dimensional spatial objects have not been specified for vector objects, but definitions have been provided for multi-dimensional raster objects (2.3, Definition of Spatial Objects). The defined set of spatial objects will support the three major types of spatial data operations: geometry only, geometry and topology, and topology only. (2.2, Classification and Intended Use of Objects) These objects have been specified in a modular fashion so that more elaborate composite objects can be constructed from them.

Section 3, Spatial Data Quality, includes specifications for a quality report concerning the objects in a transfer and their attributes. The purpose of the quality report is to provide detailed information for a user to evaluate the fitness for a particular use. This style of standard can be characterized as "truth in labeling," rather than fixing arbitrary numerical thresholds of quality. To implement this portion of the standard, a producer is urged to include the most rigorous and quantitative information available on the components of data quality described in this section.

Sections 4, General Specification, and 5, Transfer Module Specification, present specifications for the transfer of spatial data. Section 4 contains general concepts and specifications (4.1, Spatial Data Transfer Models) of the underlying models that pertain to the transfer module specifications of section 5. Section 4 also specifies the general elements of an implementation, the relationships of the logical constructs of the data models to the general elements of a detailed implementation, and general constraints on the implementation (4.1.3, The Transfer Model.) Finally, section 4 presents the transfer module specification conventions used in section 5 (4.2, Transfer Module Specification Conventions). Logical modules consisting of detailed record, field and subfield specifications are presented in section 5, Transfer Module Specification.

### 1.1 Scope of SDTS

This standard specifies a structure and content for spatially referenced data in order to facilitate data transfer between dissimilar spatial data base systems. This standard is very appropriate for archive purposes because of its emphasis on self-documenting data transfers. It is also well suited to blind transfers where the producer of the data is not aware of all potential data consumers.

## 1.2 Implementation Resources

For this standard to be beneficial to the spatial data community, it must be widely implemented. To assist in this effort, explanatory material, reference software, and sample datasets are available from the secretariat for this standard. (For further details see Annex A.)

At a minimum, software tools are needed to convert from proprietary, native, internal formats and structures to the structures (and hence concepts) of this standard. Similarly, tools are needed to import SDTS transfer file sets into the internal, processing structures and formats of spatial data processing software.

## 1.3 Conformance

This standard anticipates products that do not contain instances of all the specified information and syntactic forms. This portion specifies the conditions of conformance and the requirements of a conformance statement. This standard does not specify requirements for processing data into and out of the standard, therefore such processing cannot itself conform to this standard.

### 1.3.1 General Conformance.

Any product claiming conformance to this standard must follow the applicable requirements and specifications of parts 1, 2, and 3 with respect to both the syntax and the semantics of all included data elements.

### 1.3.2 Data Quality

This standard requires that spatial data to be transferred must include a report on data quality. This Data Quality Report must always accompany the data in a standard transfer. It consists of five portions described in detail in section 3, Spatial Data Quality: lineage, positional accuracy, attribute accuracy, logical consistency, and completeness. Where a spatial variation in quality is known, the quality report must record that variation.

#### 1.3.2.1 Form of a Quality Report.

The Data Quality Report must always accompany the data in a standard transfer. Because the quality report will function in the assessment of fitness for use, it must also be obtainable in its entirety and separately from the actual data. This separate quality report may be issued as a Spatial Data Transfer or as a paper document.

#### 1.3.2.2 Tests for Data Quality.

In sections 3.2, Positional Accuracy, 3.3, Attribute Accuracy, and 3.4, Logical Consistency, options are described for different categories of testing. Informed assessment of fitness for use is best served by the most rigorous types of tests.

#### 1.3.2.3 Quality Overlays.

For those components of quality displaying spatial variation, a quality overlay system may be used. The producer of the quality report may choose to produce a comprehensive quality overlay describing all components of quality or separate overlays portraying various components. When the quality report is issued on paper, the quality overlays appear as diagrams with text labels or thematic map depictions. In digital form, the overlays must be encoded using the specifications of sections 4 and 5.

### 1.3.3 Conformance Statement

A statement claiming conformance to this standard must specify the profile and level of conformance for each applicable component of the Transfer Specification as defined in 1.2.4.

### 1.3.4 Transfer Specification Conformance Field

The Identification module of the Transfer Specification (5.2.1, Identification Module) includes a Conformance field. This field contains subfields for a object specification, external spatial reference conformance, a level of conformance to spatial feature definitions, coding conformance, and nongeospatial dimension specification. Each subfield is required to contain one of the values enumerated in 5.2.1.2, Conformance Field.

#### 1.3.4.1 Object Specification.

The transfer must include the object specification described in 5.2.1.2.1, Object specification subfields.. This specification defines the domain of object types included in the transfer. Object types other than those identified in the Object Specification subfields must not be included in the transfer.

#### 1.3.4.2 External Spatial Reference Conformance.

Whether or not one of the three recommended reference systems-- Geographics, UTM/UPS, or State Plane-- has been used, must be specified in the External Spatial Reference subfield of the Conformance field of the Identification module, as described in 5.2.1.2.2, as well as in the Reference System Name subfield of the External Spatial Reference module (5.2.4.2).

#### 1.3.4.3 Features Level.

The level of conformance to the list of standard terms and definitions of spatial Entities and Attributes contained in part 2 of this standard must be specified in the Features Level subfield of the Conformance field of the Identification module. Each level has the meaning specified in 5.2.1.2.3.

### 1.3.5 Private Agreements

Private agreements limit the scope of the transfer and are discouraged. Recurring needs for similar private agreements should be referred to the maintenance organization for this standard.

## 1.4 References

This standard must be used in conjunction with the following normative references. When a publication is superseded by a revision approved by the authorizing organization, the revision must apply. (An informative list of references that includes the following in addition to other sources used in preparing this standard is contained in Annex I.)

**1.4.1** American National Standards Institute, Inc., 1986, American National Standards for Information Processing -- Coded Character Sets -- 7-Bit ASCII. American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018.

**1.4.2** American Society for Photogrammetry and Remote Sensing, Committee for Specifications and Standards, 1990, "ASPRS Accuracy Standards for Large-Scale Maps," (approved by ASPRS Professional Practicing Division, March 1990), Photogrammetric Engineering and Remote Sensing, Volume LVI, No. 7, July 1990, pp. 1068-1070.

**1.4.3** Calendar Date, 1968, FIPSPUB 4-1, 27 Jan 88; also ANSI/X3.30-1985.

**1.4.4** Catalog of Widely Used Code Sets, 1985, FIPSPUB 19-1, 7 Jan 85.

**1.4.5** Codes for Identification of Federal and Federally Assisted Organizations, 1982, FIPSPUB 95, 23 Dec 82.

**1.4.6** Codes for the Identification of Hydrologic Units in the United States and Caribbean Outlying Areas, 1983, FIPSPUB 103, 15 Nov 83; also ANSI/X3.145-1986.

**1.4.7** Computer Graphics Metafile (CGM), 1987, FIPSPUB 128, 16 Mar 1987; also ANSI/X3.122-1986; also ISO 8632-1987.

**1.4.8** Congressional Districts of the United States, 1969, FIPSPUB 9, 14 Nov 69.

**1.4.9** Counties, and County Equivalents of the States of the United States and District of Columbia, 1979, FIPSPUB 6-4 31 Aug 1990.

**1.4.10** Countries, Dependencies, Areas of Special Sovereignty and their Principal Administrative Division, 1984, FIPSPUB 10-3, 9 Feb 84.

**1.4.11** Database language SQL, American National Standard for Information Systems; ANSI/X3.135-1989 and ANSI/X3.168-1989; (FIPSPUB 127, 1986)

**1.4.12** Federal Geodetic Control Committee, 1984, Standards and Specifications for Geodetic Control Networks. Rockville, Maryland, Federal Geodetic Control Committee GPO-003-021-00031-9, 29 pp.

**1.4.13** Guideline for Implementation of ANSI Codes for the Implementation of Names of Countries, Dependencies and Areas of Special Sovereignty, 1983, FIPSPUB 104-1, 12 May 86.

**1.4.14** Guideline: Codes for Names of Populated Places, Primary County Divisions, Other Locational Entities in the United States, 1983, FIPSPUB 55-2, 3 Feb 87.

**1.4.15** Information processing -- Procedures for Registering of Graphical Items, ISO Technical Report 9973, 1988.

**1.4.16** Metropolitan Statistical Areas, 1984, FIPSPUB 8-5, 31 Oct 84.

**1.4.17** National Zip Code and Post Office Directory, U.S. Postal Service Publication 65.

**1.4.18** Programmers' Hierarchical Interactive Graphics System (PHIGS), 1988, FIPSPUB 153, 14 Oct 88; also ANSI/X3.144-1988 and ANSI/X3.144-1-1988.

**1.4.19** Power Plant Identification: Recommended Practice, 1983, IEEE 803-1983 and IEEE 803A-1983.

**1.4.20** Representation of Geographic Point Locations for Information Interchange, 1986, FIPSPUB 70-1, 14 Nov 86; also ANSI/X3.61-1986.

**1.4.21** Representations of Local Time of the Day for Information Interchange, 1979, FIPSPUB 58-1, 27 Jan 88; also ANSI/X3.43-1986.

**1.4.22** Representations of Universal Time, Local Time Differentials, and United States Time Zone References for Information Interchange, 1979, FIPSPUB 59, 1 Feb 79; also ANSI/X3.51-1975.

**1.4.23** Information Technology - Specification for a Data Descriptive File for Information Interchange (DDF), 1994, ANSI/IEC 8211:1994.

**1.4.24** Codes for Identification of the States, District of Columbia and Outlying Areas of the United States, 1970, FIPSPUB 5-2, 15 Jun 70.

**1.4.25** Stem, J., and T. Vincenty, 1987, The 1983 State Plane Coordinate System, NOS Technical Manual NOS-NGS-5.

**1.4.26** Defense Mapping Agency, 1990, Datums, Ellipsoids, Grids and Grid Reference Systems, DMA Technical Manual 83558.1, edition 1.

**1.4.27** Unrecorded Magnetic Tape for Information Interchange, ANSI X3.4-1983

## 1.5 Definitions

The following terms are used in the definitions of concepts essential to this standard. The concepts for which this standard provides normative definitions appear in section 2, Spatial Data Concepts; section 3, Spatial Data Quality; and section 4, General Specification. An informative list of all defined terms is contained in Annex H.

**1.5.1 Accuracy** - The closeness of results of observations, computations, or estimates to the true values or the values accepted as being true.

**1.5.2 Altitude** - Elevation above or below a reference datum, as defined in ANSI X3.61 (1.4.20); the z-value in a spatial address. See also 1.5.8 *Elevation*.

**1.5.3 Control (mapping)** - A system of points with established horizontal and vertical positions that are used as fixed references in positioning and relating map features.

**1.5.4 Coordinates** - see 1.5.33 *Spatial Address*

**1.5.5 Data base** - Related subject information stored as a volume set, volume, file set, or file.

**1.5.6 Data element** - A logically primitive item of data.

**1.5.7 Digital encoding** - To convert to a form that can be operated upon by electronic computer as binary digits.

**1.5.8 Elevation** - Conforming to FIPSPUB 70-1, the term "altitude" is used in this standard, rather than the common term elevation, for the z-value in a spatial address.

**1.5.9 Field** - Consists of one or more related subfields. It may contain part or all of a module field. It does not contain parts of two or more module fields.

**1.5.10 Field name** - A name associated with a field.

**1.5.11 File** - An identifiable collection of zero or more related records. It may contain part of, or all of one or many modules.

**1.5.12 File set** - An identifiable collection of zero or more related files.

**1.5.13 Geocodes** - A system of encoding used to represent an exhaustive list of a class of spatial features (usually applied to political units).

**1.5.14 Geospatial dimensions** - The dimensions used for specifying geographic data, longitude, latitude, and altitude; also called spatial dimensions, the terms spatial and geospatial are equivalent. See also 1.5.25 *Nongeospatial dimensions*.

**1.5.15 Implementation method** - A method of encoding data content and data structure to accomplish a transfer without loss of content, meaning, or structure.

**1.5.16 Map** - A spatial representation, usually graphic on a flat surface, of spatial phenomena.

**1.5.17 Media** - The physical devices used to record, store, and (or) transmit data.

**1.5.18 Media record** - A physical unit of data. The characteristics of a record and its means of delimitation are defined by standards specific to each given medium.

**1.5.19 Misclassification Matrix** - Results of an attribute accuracy test given in the form of a row by column contingency table (crosstabulation) sometimes called a classification error matrix. The rows represent the interpretation tested and the columns represent the verification assumed to be correct. The diagonal elements represent the correct classifications when the matrix is square and the rows and columns are strictly comparable. The remaining elements can be treated row-wise as errors of commission, and column-wise as errors of omission.

**1.5.20 Module** - A logical collection of module records.

**1.5.21 Module field** - A defined set of one or more module subfields in a Spatial Data Transfer.

**1.5.22 Module record** - A defined set of one or more module fields in a Spatial Data Transfer.

**1.5.23 Module specification** - The meaning, identification, order requirements, and data structure requirements for data belonging to the module.

**1.5.24 Module subfield** - A logical construct defining a single data element in a Spatial Data Transfer.

**1.5.25 Nongeospatial dimensions** - Dimensions used for giving data nongeographic location in space, such as the time dimension. See also 1.5.14 *Geospatial dimensions*.

**1.5.26 Primitive** - The quality of not being subdivided; atomic.

**1.5.27 Quality** - An essential or distinguishing characteristic necessary for spatial data to be fit for use.

**1.5.28 Quality overlay** - A collection of points, lines, and areas organized to represent quality information for another set of map information. An overlay describing lineage may be termed a source data index; a positional accuracy overlay may be termed a reliability diagram.

**1.5.29 Record** - An implementation-dependent construct that consists of an identifiable collection of one or more related fields.

**1.5.30 Representation** - Graphical symbolization of a spatial object.

**1.5.31 Resolution** - The minimum difference between two independently measured or computed values that can be distinguished by the measurement or analytical method being considered or used.

**1.5.32 Spatial** - Synonymous with1.5.14 *geospatial*.

**1.5.33 Spatial Address** - Pairs of numbers expressing horizontal distances along orthogonal axes; alternatively, triplets of numbers measuring horizontal and vertical distances. Can be generalized to refer to an n-tuple with the first 2 or 3 dimensions being geospatial and the higher dimensions being nongeospatial.

**1.5.34 Spatial data transfer** - A collection of related modules.

**1.5.35 Subfield** - A physical area containing, or logical construct defining, a single data element.

**1.5.36 Theme** - A generalization of entity classes (e.g., culture, hydrography, transportation).

**1.5.37 Transfer construct** - A volume set, volume, file set, file, module, module record, module field, module subfield, field, subfield, record, or media record.

**1.5.38 Transformation** - A computational process of converting a position from one coordinate system to another.

**1.5.39 Volume** - A media-dependent construct consisting of an identifiable collection of part of or all of one or more files. A volume is a discrete interchange construct such as a unit of dismountable media or a single online session.

**1.5.40 Volume set** - A media-dependent construct consisting of an identifiable collection of one or more volumes containing a single file set.

# 2 Spatial Data Concepts

The basis of SDTS is a model of spatial data sufficiently general so that any user data model can be accepted.

## 2.1 Conceptual Model

The SDTS conceptual model has three parts: a model of spatial phenomena, a model of the spatial objects used to represent phenomena, and a model of spatial features that explains how spatial objects and spatial phenomena are related (also see Annex B.)

The following terms define the parts of the model.

a) *Phenomenon*. A fact, occurrence, or circumstance. Route 10, George Washington National Forest, and Chesterfield County are all phenomena.

b) *Classification*. The assignment of similar phenomena to a common class. An individual phenomenon is an instance of its class. Route 10 is an instance of the class road.

c) *Generalization*. A process in which classes are assigned to other classes. The general class includes all the instances of the constituent classes. Sewers are included in the more general class of utilities.

d) *Aggregation*. The operation of constructing more complex phenomena out of component phenomena. A lock is an aggregation of walls, gates, and a reservoir.

e) *Association*. The assignment of phenomena to sets, using criteria different from those used for classification. Concrete roads may be associated with concrete sewers, concrete locks, and other phenomena constructed of concrete.

### 2.1.1 Model of Spatial Phenomena

SDTS transfers information about phenomena that are defined in space and time and are described by using a fixed location-- spatial phenomena. All phenomena are defined as belonging to a class of phenomena. (Smith's Farm belongs to Farm.) A characteristic of such a class is called an attribute. (Acreage is an attribute for Farm.) An attribute value is a specific quantity or quality of the attribute assigned to a phenomenon in that class. (Smith's Farm has an Acreage of 160 acres.)

Whether a given phenomenon belongs to a class is determined by the definition of the class. The definition consists of a statement about characteristics that all members of the class have in common. It also includes characteristics that distinguish the class from other classes. These definitional characteristics are necessary and sufficient conditions for classifying some phenomena into the class and excluding others. The data collector may define which classes of phenomena are of interest. Those classes of phenomena are called entity types, and the individual phenomena are called entity instances.

Certain attributes are identified with each class. The attributes of a class include key attributes. The combination of values of the key attributes forms a unique identifier for each entity instance.

Entity instances may be aggregated into instances of a different type of entity.

Entity types can be generalized into themes based on definitional characteristics shared by more than one class. A theme can also have its own attributes, including name.

Associations of entity instances are defined in terms of characteristics other than those used to define an entity type. A common association is the spatial domain, which groups all entity instances having coordinates within a specified range. Another useful association is temporal domain. Values of a temporal attribute such as Age or a user-defined temporal dimension as in x,y,t may be assigned to entity instances and used to associate them into sets with a common extent in time.

A relationship is a special case of an association. A relationship exists between entity types. A relationship instance is an association between entity instances with a unique relationship value.

### 2.1.2 Model of Spatial Objects

Entity instances have a digital representation. That digital representation consists of one or more spatial objects. A spatial object may be an aggregation of other spatial objects, not all of which necessarily represent an entity instance. A spatial object that represents all of a single entity instance is an entity object. It may be classified into an entity object class. Entity objects have generalizations and associations as well: the representation of an entity theme is an object theme, and an entity spatial domain, an object spatial domain. In general, the correspondence between entity instance and entity object is paralleled by all characteristics of entities and objects.

Entity objects have locational attributes (spatial address), nonlocational attributes, and relationships (topology). The attributes and relationships of entity objects need not be as extensive as those of their corresponding entity instances. The key attributes used to distinguish a particular entity instance may not be present in the actual transfer; instead, the entity object record identifier may be the only way to distinguish between instances.

Spatial objects may have attributes independently of whether they are entity objects or not. All objects may be classified, aggregated, and associated in the same general manner that entity instances may be.

This standard defines a set of simple spatial objects. These simple spatial objects are either primitive objects (not aggregated from any other objects), or aggregated only from spatial objects belonging to different classes (polygons, for example, are not aggregated from polygons, only from rings, chains or strings). The only exception is the composite object. Composite spatial objects may be aggregated from simple objects or from other composites.

Spatial objects are classified into module types, one of the basic building blocks of the standard. Once defined, modules may be associated into sets by spatial domain, temporal domain, data quality, security requirements, topological relationships, or any other criteria.

#### 2.1.3 Model of Spatial Features

The terminology in geographic data handling has traditionally not distinguished between the phenomenon and its representation, referring to both as features. For the sake of clarity, a feature is defined as the combination of the phenomenon and its representation. A feature instance consists of an entity instance and the entity object that represents it, and belongs to a feature type (see Table 1).

**Table 1 - Feature Instance**

| **An instance of a defined entity and its object representation** |
|---|
| Feature Instance<br>is<br>Entity Instance: a spatial **phenomenon** of a defined type.<br>and<br>Entity object: a digital **representation** of an entity instance. |

### 2.2 Classification and Intended Use of Objects

This standard defines three classes of spatial objects. Two classes are defined explicitly: geometry only and geometry and topology. The third class, topology only, can be defined implicitly by removing the coordinates from the geometry and topology class of objects. The intended use of these three classes of objects is described in the following clauses.

a) Geometry only - for drawing, display, and geometrically defined operations on raster and vector data structures.

b) Geometry and topology - for vector data structures that use geometric drawing and topological operations.

c) Topology only - for certain analytical operations.

The relationship between the explicitly defined classes of objects and their intended use is specified in Table 2.

**Table 2 - Intended use of defined spatial objects**

| Number of geospatial dimensions | Intended use | |
|---|---|---|
| | Geometry only (G) | Geometry and topology (GT) |
| zero dimensions | point[1] | node |
| one dimension | line segment | link |
| | string | chain[2] |
| | arc | |
| | G-ring | GT-ring |
| two dimensions | G-polygon | GT-polygon[3] |
| | pixel | |
| | grid cell | |
| three dimensions | voxel | |

1) There are additional special objects defined for the point of entity point, area point, and label point.

2) There are additional special objects defined for the chain of complete chain, area chain and network chain.

3) There are additional special objects defined for the GT-polygon of universe and void polygon.

## 2.3 Definition of Spatial Objects

The spatial objects specified in 2.3.1, 2.3.2, 2.3.3, and 2.3.5.1 represent the simple objects required for digital spatial processing which can be used to construct well-defined aggregates or user-defined composite objects that represent a more complex realization of the real world. The following zero, one, and two dimension definitions are valid in planar and non-planar, Euclidean geometry, as well as simple curved surfaces such as the sphere or ellipsoid. Each object type is associated with one or more two-character object representation codes. Use of the codes is explained in 5.6, Vector Modules, 5.5, Composite Module and, 5.7, Raster Modules.

Composite objects (object representation code FF) are constructed from the simple objects by aggregation. Specifically, a composite object consists of one or more other objects, either simple or composite.

### 2.3.1 Definition of Zero-dimensional Spatial Object

#### 2.3.1.1 Point (NP).

A zero-dimensional object that specifies geometric location. One coordinate pair or triplet specifies the location (see Figure 1).

The three point definitions that follow are special implementations of the general case.

**Figure 1 - Point**

##### 2.3.1.1.1 Entity point (NE).

A point used for identifying the location of point features (or areal features collapsed to a point), such as towers, buoys, buildings, places, etc.

##### 2.3.1.1.2 Label point (NL).

A reference point used for displaying map and chart text (e.g., feature names) to assist in feature identification.

##### 2.3.1.1.3 Area point (NA).

A representative point within an area usually carrying attribute information about that area.

### 2.3.1.2 Node (NO, NN).

A zero-dimensional object that is a topological junction of two or more links or chains, or an end point of a link or chain (see Figure 2).

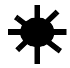

**Figure 2 - Node**

### 2.3.2 Definition of One-dimensional Spatial Objects

A line is a generic term for a one-dimensional object.

### 2.3.2.1 Line Segment.

A direct line between two points. (see Figure 3)

**Figure 3 - Line Segment**

### 2.3.2.2 String (LS).

A connected nonbranching sequence of line segments specified as the ordered sequence of points between those line segments. Note: A string may intersect itself or other strings (see Figure 4).

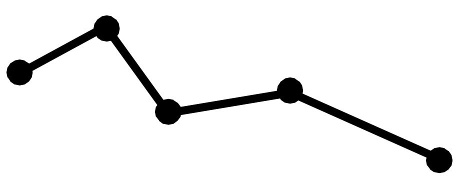

**Figure 4 - String**

### 2.3.2.3 Arc (AC, AE, AU, AB).

A locus of points that forms a curve that is defined by a mathematical expression (see Figure 5).

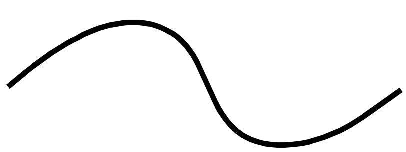

**Figure 5 - Arc**

### 2.3.2.4 Link (LQ).

A topological connection between two nodes. A link may be directed by ordering its nodes (see Figure 6).

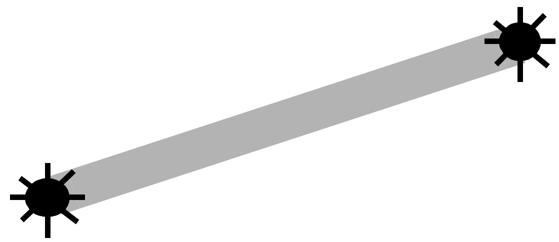

**Figure 6 - Link**

### 2.3.2.5 Chain.

A directed nonbranching sequence of nonintersecting line segments and (or) arcs bounded by nodes, not necessarily distinct, at each end.

The following three objects are special cases of chain. They share all characteristics of the general case as defined above.

### 2.3.2.5.1 Complete chain (LE).

A chain that explicitly references left and right polygons and start and end nodes (see Figure 7). It is a component of a two-dimensional manifold (2.3.4.5.2.)

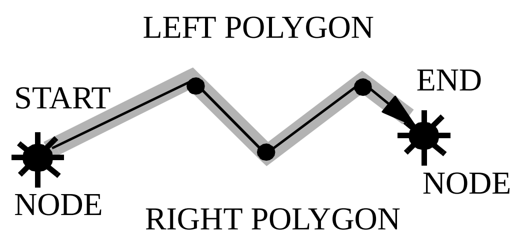


**Figure 7 - Complete Chain**

### 2.3.2.5.2 Area chain (LL).

A chain that explicitly references left and right polygons and not start and end nodes (see Figure 8). It is a component of a two-dimensional manifold (2.3.4.5.2).

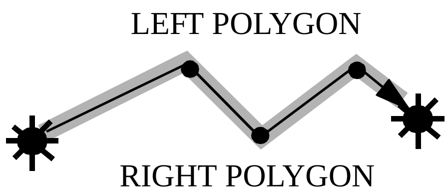


**Figure 8 - Area chain**

### 2.3.2.5.3 Network chain (LW, LY).

A chain that explicitly references start and end nodes and not left and right polygons (see Figure 9). It is a component of a network (2.3.4.5.3).

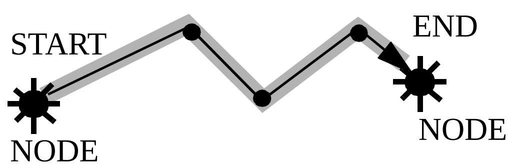


**Figure 9 - Network Chain**

### 2.3.2.6 Ring.

A sequence of nonintersecting chains or strings and (or) arcs, with closure. A ring represents a closed boundary, but not the interior area inside the closed boundary.

### 2.3.2.6.1 G-ring (RS, RA, RM).

A ring created from strings and (or) arcs (see Figure 10).

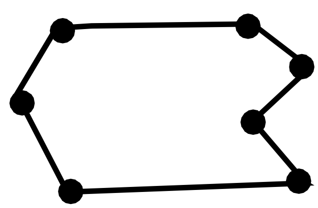

**Figure 10 - G-ring**

### 2.3.2.6.2 GT-ring (RU).

A ring created from complete and (or) area chains (see Figure 11).

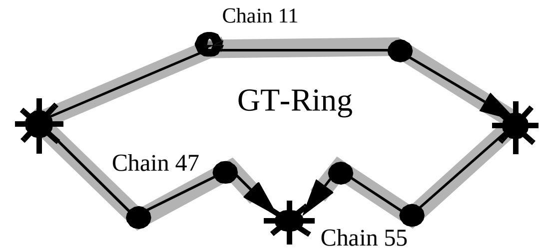


**Figure 11 - GT-ring**

## 2.3.3 Definition of Two-dimensional Spatial Objects

An area is a generic term for a bounded, continuous, two-dimensional object that may or may not include its boundary.

### 2.3.3.1 Interior Area.

An area not including its boundary (see Figure 12).

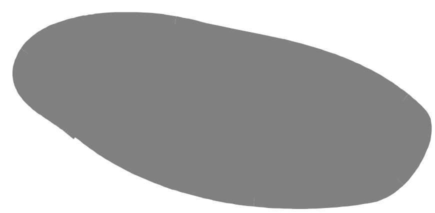

**Figure 12 - Interior Area**

### 2.3.3.2 G-Polygon (PG).

An area consisting of an interior area, one outer G-ring and zero or more nonintersecting, nonnested inner G-rings. No ring, inner or outer, must be collinear with or intersect any other ring of the same G-polygon (see Figure 13).

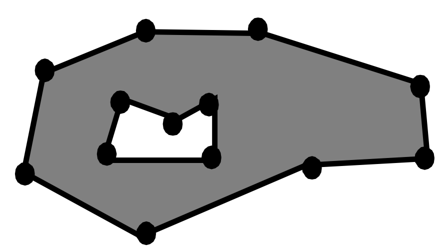

**Figure 13 - G-Polygon**

### 2.3.3.3 GT-Polygon (PR, PC).

An area that is an atomic two-dimensional component of one and only one two-dimensional manifold. The boundary of a GT-polygon may be defined by GT-rings created from its bounding chains. A GT-polygon may also be associated with its chains (either the bounding set, or the complete set) by direct reference to these chains. The complete set of chains associated with a GT-polygon may also be found by examining the polygon references on the chains.

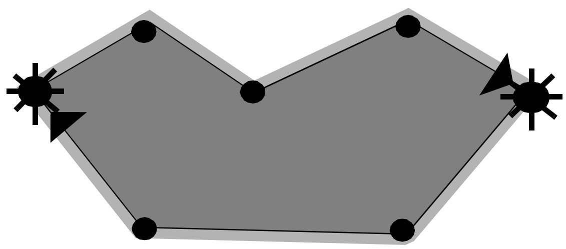

**Figure 14 - GT-Polygon**

#### 2.3.3.3.1 Universe polygon (PU, PW).

Defines the part of the universe that is outside the perimeter of the area covered by other GT-polygons ("covered area") and completes the two-dimensional manifold. This polygon completes the adjacency relationships of the perimeter links. The boundary of the universe polygon is represented by one or more inner rings and no outer ring. Attribution of the universe polygon may not exist, or may be substantially different from the attribution of the covered area (see Figure 15).

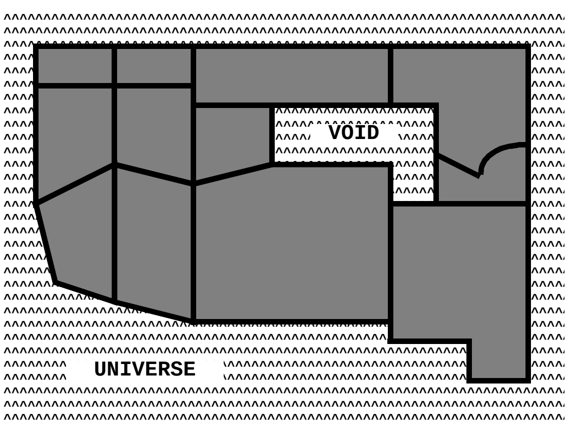


**Figure 15 - Universe & Void Polygons**

#### 2.3.3.3.2 Void polygon (PV, PX).

Defines a part of the two-dimensional manifold that is bounded by other GT-polygons, but otherwise has the same characteristics as the universe polygon. The geometry and topology of a void polygon are those of a GT-polygon. Attribution of a void polygon may not exist, or may be substantially different from the attribution of the covered area (see Figure 15).

### 2.3.3.4 Pixel.

A two-dimensional (geospatial) picture element that is the smallest nondivisible element of a digital image (2.3.4.1). (see Figure 16).

**Figure 16 - Pixel**

### 2.3.3.5 Grid Cell.

A two-dimensional (geospatial) object that represents the smallest nondivisible element of a grid (2.3.4.2). (see Figure 17).

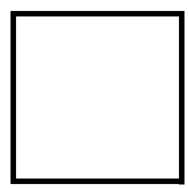

**Figure 17 - Grid Cell**

## 2.3.4 Definition of Two Dimensional Aggregate Spatial Objects

Certain two-dimensional aggregate spatial objects must be defined to provide context for many of the simple objects defined above. These aggregate objects are necessary for the definition of (a) raster objects (grid, image, layer, and raster) and (b) topology objects (three types of graphs, with or without geometry).

### 2.3.4.1 Digital Image (G2).

A two-dimensional (geospatial) array of regularly spaced picture elements (pixels) constituting a picture. (see Figure 18).

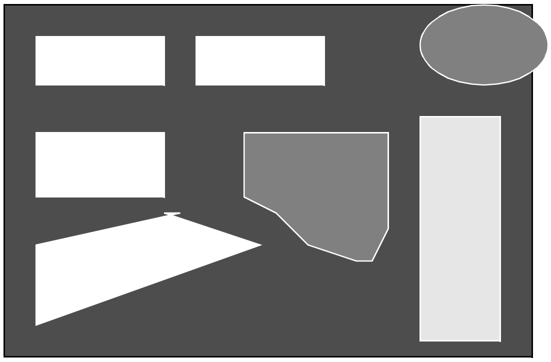

Figure 18 - Digital Image.

### 2.3.4.2 Grid (G2).

A two-dimensional (geospatial) set of grid cells forming a regular tesselation of a surface. (see Figure 19).

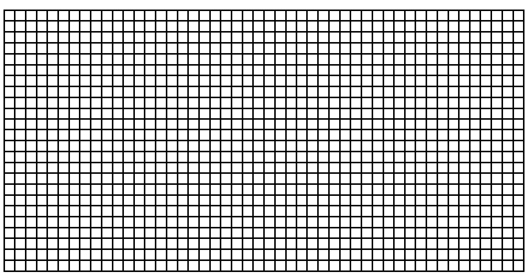

Figure 19 - Grid.

### 2.3.4.2.1 Rectangle Variant Grid (GV).

Each row and column of the grid may have an independent thickness or width (see Figure 20).

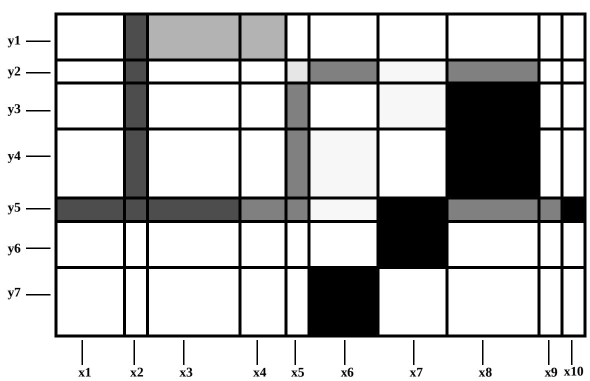


Figure 20 - Rectangle Variant Grid.

### 2.3.4.3 Layer.

An areally distributed set of spatial data representing entity instances within one theme, or having one common attribute or attribute value in an association of spatial objects. In the context of raster data, a layer is specifically a two, three or N-dimensional array of attribute values associated with all or part of a grid, image, voxel space or any other type of raster data.(see Figure 21)

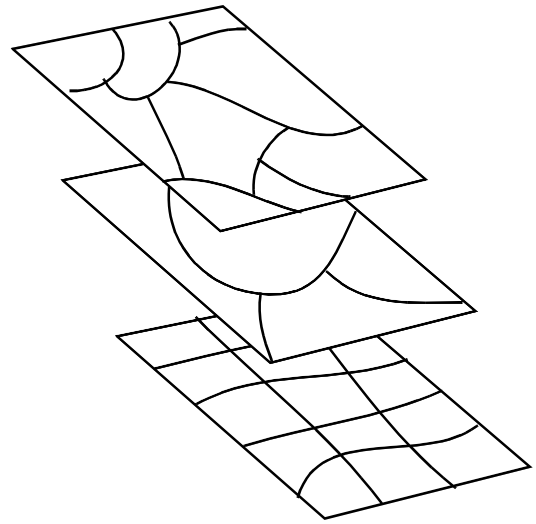

Figure 21 - Layer

### 2.3.4.4 Raster.

One or more related overlapping layers for the same grid, digital image, voxel space or any other type of raster data. The corresponding cells between layers are registered to the same raster object scan reference system. The layers overlap but need not be of the same spatial extent.

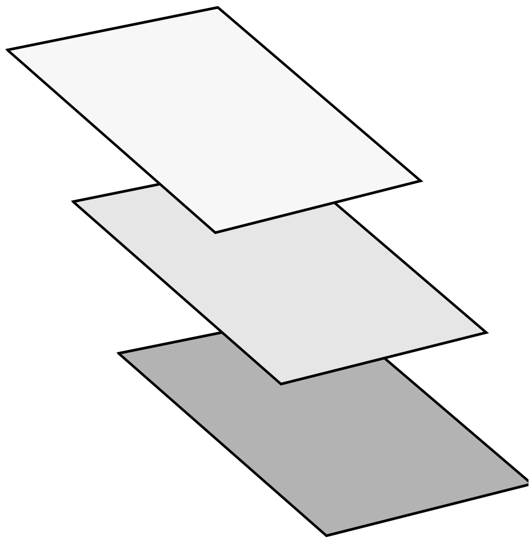

Figure 22 - Raster

### 2.3.4.5 Graph.

A set of topologically interrelated zero-dimensional (node), one-dimensional (link or chain), and sometimes two-dimensional (GT-polygon) objects that conform to a set of defined constraint rules. Numerous rule sets can be used to distinguish different types of graphs. Three such types, planar graph, network, and two-dimensional manifold, are used in this standard. All three share the following rules: each link or chain is bounded by an ordered pair of nodes, not necessarily distinct; a node may bound one or more links or chains; and links or chains may only intersect at nodes.

Planar graphs and networks are two specialized types of graphs, and a two-dimensional manifold is an even more specific type of planar graph.

#### 2.3.4.5.1 Planar graph (GP).

The node and link or chain objects of the graph occur or can be represented as though they occur upon a planar surface. Not more than one node may exist at any given point on the surface. Links or chains may only intersect at nodes (see Figure 23).

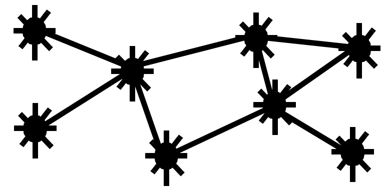

Figure 23 - Planar Graph.

#### 2.3.4.5.2 Two-dimensional manifold (GT).

A planar graph and its associated two dimensional objects. Each chain bounds two and only two, not necessarily distinct, GT-polygons. The GT-polygons are mutually exclusive and completely exhaust the surface (see Figure 24).

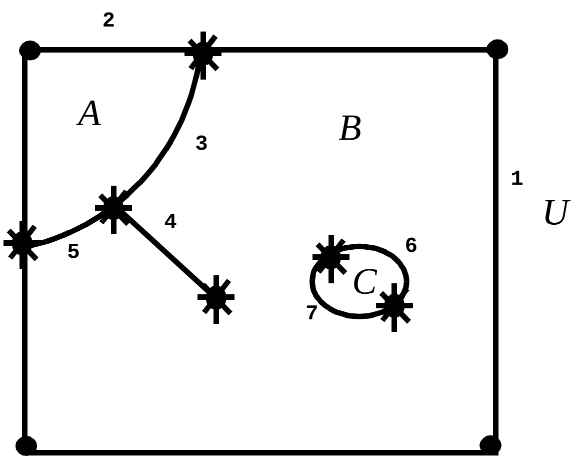


Figure 24 - Two-Dimensional Manifold

#### 2.3.4.5.3 Network (GN).

A graph without two dimensional objects. If projected onto a two-dimensional surface, a network can have either more than one node at a point and (or) intersecting links or chains without corresponding nodes (see Figure 25).

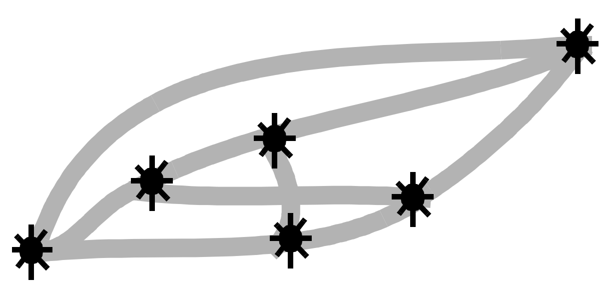

Figure 25 - Network

### 2.3.5 Definition of Three-dimensional Spatial Objects

A volume is a generic term for a bounded, continuous, three-dimensional object that may or may not include its bounding surfaces.

#### 2.3.5.1 Voxel.

A three-dimensional (geospatial) object that represents the smallest nondivisible unit of a voxel space (volume). (The voxel is the three-dimensional conceptual equivalent of the two-dimensional pixel or grid cell.) (see Figure 26).

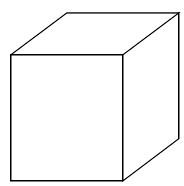

**Figure 26 - Voxel.**

#### 2.3.5.2 Voxel Space (G3).

A three-dimensional (geospatial) array of voxels in which the volumetric dataset (the object) resides. The volume represents some measurable properties or independent variables of a real object or phenomenon. (see Figure 27).

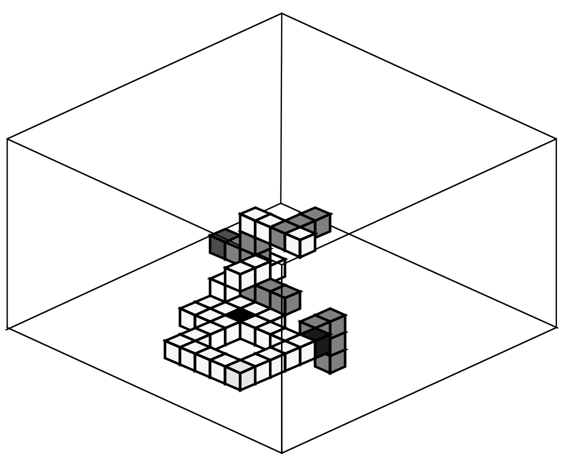

**Figure 27 - Voxel Space**

# 3 Spatial Data Quality

The Data Quality Report consists of five portions covering lineage, positional accuracy, attribute accuracy, logical consistency, and completeness. Each portion of the report must contain reference to temporal information.

## 3.1 Lineage

The lineage portion of a quality report must include a description of the source material from which the data were derived and the methods of derivation, including all transformations involved in producing the final digital files. The description must include the dates of the source material and the dates of ancillary information used for update. The date assigned to a source must reflect the date that the information corresponds to the ground; however, if this date is not known, then a date of publication may be used, if declared as such.

Any data base created by merging information obtained from distinct sources must be described in sufficient detail to identify the actual source for each element in the file. In these cases, either a lineage code on each element or a quality overlay (source data index, etc.) must be required.

The lineage portion must also include reference to the specific control information used. Control from the National Geodetic Reference System must be identified according to identifiers in that system, while other points used for control must be described with sufficient detail to allow recovery.

The lineage portion must describe the mathematical transformations of coordinates used in each step from the source material to the final product. The locations of any registration points for coordinate transformations must be given. The methods used to make coordinate transformations must be documented. To fulfill this standard, it is acceptable to make reference to separate documentation for the coordinate transformation algorithm used, but the specific parameters applied must be described for the particular case. Documentation of a transformation algorithm must include the nature of computational steps taken to avoid loss of digits through roundoff and must include a set of sample computations including numerical values of coefficients to confirm equivalence of transformations. The documentation of a transformation algorithm must be available on request by a user obtaining digital data even if that user is not licensed to use the particular software.

## 3.2 Positional Accuracy

The quality report portion on positional accuracy must include the degree of compliance to the spatial registration standard (see section 4.1.3.5). Quality of control surveys must be reported by using the procedures established in the geodetic standard. If a separate control survey has been used, it must be described in the standard form, even if results fall below the recognized classification thresholds.

Descriptions of positional accuracy must consider the quality of the final product after all transformations. The information on transformations forms a part of the lineage portion of the quality report.

The report of any test of positional accuracy must include the date of the test. Variations in positional accuracy must be reported either as additional attributes of each spatial object or through a quality overlay (reliability diagram).

Measures of positional accuracy may be obtained by one of the following optional methods.

### 3.2.1 Deductive Estimate.

Any deductive statement based on knowledge of errors in each production step must include reference to complete calibration tests and must also describe assumptions concerning error propagation. Results from deductive estimates must be distinguished from results of other tests.

### 3.2.2 Internal Evidence.

Federal Geodetic Control Committee procedures will be used for tests based on repeated measurement and redundancy such as closure of traverse or residuals from an adjustment.

### 3.2.3 Comparison to Source.

When using graphic inspection of results ("check plots"), the geometric tolerances applied must be reported and the method of registration must also be described. Use of check plots must be included in the lineage portion.

### 3.2.4 Independent Source of Higher Accuracy.

The preferred test for positional accuracy is a comparison to an independent source of higher accuracy. The test must be conducted using the rules prescribed in the "ASPRS Accuracy Standards for Large Scale Maps" (see 1.3.3). When the dates of testing and source material differ, the report must describe the procedures used to ensure that the results relate to positional error and not to temporal effects. The numerical results in ground units, as well as the number and location of the test points, must be reported. A statement of compliance to a particular threshold is not adequate in itself. This test may only be applicable to well-defined points.

## 3.3 Attribute Accuracy

Accuracy assessment for measures on a continuous scale must be performed using procedures similar to those used for positional accuracy (providing a numerical estimate of expected discrepancies). The report of a test of attribute accuracy must include the date of the test and the dates of the materials used. In the case of different dates, the report must describe the rates of change in the phenomena classified. Spatial variations in attribute accuracy may be reported in a quality overlay.

Accuracy tests for categorical attributes may be performed by one of the following methods. All methods must make reference to map scale in interpreting classifications.

### 3.3.1 Deductive Estimate.

Any estimate, even a guess based on experience, is permitted. The basis for the deduction must be explained. Statements such as "good" or "poor" should be explained in as quantitative a manner as possible.

### 3.3.2 Tests Based on Independent Samples.

A misclassification matrix must be reported as counts of sample units crosstabulated by the categories of the sample and of the tested material. The sampling procedure and the location of sample units must be described.

### 3.3.3 Tests Based on Polygon Overlay.

A misclassification matrix must be reported as areas. The relationship between the two maps must be explained; as far as possible, the two sources should be independent and one should have higher accuracy.

## 3.4 Logical Consistency

A report on logical consistency must describe the fidelity of relationships encoded in the data structure of the digital spatial data. The report must detail the tests performed and the results of the tests.

### 3.4.1 Tests of Valid Values.

Tests for permissible values may be applied to any data structure. Such a test can detect gross blunders, but it does not ensure all aspects of logical consistency.

### 3.4.2 General Tests for Graphic Data.

A data base containing lines may be subjected to the following general questions:

- Do lines intersect only where intended?
- Are any lines entered twice?
- Are all areas completely described?
- Are there any overshoots or undershoots?
- Are any polygons too small, or any lines too close?

Different tests may be applied to address these questions, but the quality report must contain a description of the tests applied or a reference to documentation of the software used. The report must state whether all inconsistencies were corrected or it must detail the remaining errors by case.

### 3.4.3 Specific Topological Tests.

For exhaustive areal coverage data transmitted as chains or derived from chains, it is permissible to report logical consistency as "Topologically Clean" under the condition that an automated procedure has verified the following conditions:

a) All chains intersect at nodes. Use of exact case or tolerance must be reported.

b) Cycles of chains and nodes are consistent around polygons. Or, alternatively, cycles of chains and polygons are consistent around nodes.

c) Inner rings embed consistently in enclosing polygons.

The quality report must identify the software (name and version) used to verify these conditions.

### 3.4.4 Date of Test.

The report must include the date on which the tests were applied. If corrections and modifications have occurred after the test for logical consistency, the quality report must indicate how the new information was checked for logical consistency.

## 3.5 Completeness

The quality report must include information about selection criteria, definitions used and other relevant mapping rules. For example, geometric thresholds such as minimum area or minimum width must be reported.

In encoding spatial entities, standard geocodes (such as described in the FIPS codes for States, counties, municipalities, and places) must be employed if possible. Deviations from standard definitions and interpretations must be described.

The report on completeness must describe the relationship between the objects represented and the abstract universe of all such objects. In particular, the report must describe the exhaustiveness of a set of features. Exhaustiveness concerns spatial and taxonomic (attribute) properties, both of which can be tested. A test for spatial completeness can be obtained from topological tests for logical consistency described in 3.4.3. Tests for taxonomic completeness operate by comparison of a master list of geocodes to the codes actually appearing in the file. The procedures used for testing and the results must be described in the quality report.

# 4 General Specification

This section contains general concepts and specifications that pertain to the transfer module specifications of section 5. It also specifies the general elements of an implementation and the relationships of the logical constructs of the data models to the general elements of a detailed implementation as well as general constraints on implementations. This section consists of two main parts: (1) the underlying models and (2) specific transfer module specification conventions used in section 5. This section also contains specifications for the relationships of the logical constructs of the model to the general constructs of an implementation.

## 4.1 Spatial Data Transfer Models

Three data models-- the conceptual model, the data structure model, and the transfer model-- form the basic foundation for the process of converting from a user representation of a spatial entity to a corresponding digital object representation in a spatial data transfer.

### 4.1.1 The Conceptual Model of Spatial Data.

This model describes the spatial objects, as well as the logical and topological relationships between the spatial objects and the captured spatial entities. This general model is object oriented and is also based on existing topological and graph models for spatial data. The conceptual model is presented in section 2 and more fully described in annex A.

### 4.1.2 The Data Structure Model.

This model is used to express the spatial objects of the conceptual model in terms of transfer data structures. The data structures used in this transfer standard are based on the traditional relational and network models. Data structures viewed as spatial data structures are both the traditional vector and raster models. One or more data structures used in the transfer are encoded in the Object Specification subfields of the Conformance field in the Identification module.

### 4.1.3 The Transfer Model.

This model is used to express the logical constructs of the transfer form in terms of implementation-media constructs. The implementation constructs are made operational by an implementation method. The implementation method selects one or more media and defines the constructs pertaining to those media.

The transfer model is defined in terms of its constructs and logical relationships. It deals with three types of transfer constructs: (1) logical constructs solely pertaining to this standard, (2) constructs relating to the implementation method, and (3) constructs solely pertaining to the transfer media. The three types are summarized in Tables 3 and 4. Logical characteristics of constructs are defined in 4.2 that have physical instances that are implementation and (or) medium dependent. Definitions for the corresponding physical constructs may be found in the implementation requirements of part 3 where additional constraints exist.

Table 4 depicts the relationships of the logical constructs specified in part 1 of this standard to the implementation constructs of part 3 and to typical media constructs.

The transfer model specifies relationships of the following basic types: (1) implicit relationships between constructs expressed through order and (2) explicit cross-references between constructs.

#### 4.1.3.1 Ordering Concepts.

An implementation of this standard must preserve the meaning of the data including any logical associations required by this standard. The specifications require:

- the preservation of or means for reconstruction of a logical order in which the recipient may retrieve data comprising module subfields, module fields, module records, and modules.
- the preservation of the identity of the interchange data elements.

The general principles behind these requirements are explained as follows.

Order is the sequential arrangement of elements in a construct. In a data transfer, the reason for a sequential arrangement is that each element has an implied sequence number that serves to identify its participation in the construct, so that its structure can be preserved.

:

## Table 3 - Transfer constructs of this standard

| Construct | Logical | Implementation | Media |
|---|---|---|---|
| Spatial Data Transfer | X | X | X |
| Module | X | | |
| Module record | X | | |
| Module field | X | | |
| Module subfield | X | | |
| Subfield | | X | |
| Field | | X | |
| Record | | X | |
| File | | X | X |
| File set | | X | |
| Volume | | | X |
| Volume set | | | X |
| Media record | | | X |

## Table 4 - Relationships between the transfer logical constructs, implementation constructs, and typical medium constructs.[1]

| Logical Constructs of this Standard | | Implementation Constructs | | Medium Constructs |
|---|---|---|---|---|
| spatial data transfer | > | file set | > | volume set |
| | | | | ^ |
| | | | | ^ |
| ^ | | ^ | | volume |
| ^ | | ^ | | ^ |
| | | | | ^ |
| | | | | p |
| module | p>> | file | = | file |
| ^ | | ^ | | ^ |
| ^ | | ^ | | ^ |
| module record | p>> | record | p>> | media record |
| ^ | | ^ | | |
| ^ | | ^ | | |
| module field | p>> | field | | |
| ^ | | ^ | | |
| ^ | | ^ | | |
| module subfield | = | subfield | | |

1)

| | | | |
|---|---|---|---|
| B | = | A | implies functional equivalence of A and B |
| B | > | A | implies A contains one of B |
| B | >> | A | implies A contains one or more of B |
| B | p>> | A | implies A contains part of, or one or more of B |

This standard does not impose general ordering requirements for transfer constructs with specific identification.  In particular, most modules, which are assigned unique module names, and fields and subfields that carry names assigned by the standard, need not occur in any specific order in the context in which they are used.  However, the order of presentation in the standard is recommended as a default order.

The standard imposes ordering requirements on unnamed or nonuniquely named transfer constructs such as elements in repetitive lists resulting from repeated fields and subfields.  This ordering can be imposed on repeated instances of fields or subfields to capture the structure of the data to be transferred in such a repetitive list.  For example, repeated instances of the Spatial Address field containing point data for a line must be encoded in a certain order and decoded in the same order to fully preserve the meaning of the line.  Ordering can also be imposed on repetitive instances of two or more types of fields when elements of repetitive lists are correlated.  Ordering requirements of this type are imposed on a field by field basis as set out in 4.1.3.3.3 and 4.2.3.3.

Wherever repetitive lists occur on which the standard does not impose any ordering requirements, a user of the standard may still encode the field instances in a significant order, and decode these instances in the same order, because any implementation must preserve the order for a repetitive list.  This is explicitly stated in 4.1.3.3.8, Preservation of Order.

### 4.1.3.2    Backus-Naur Form.

For clarification, the Backus-Naur Form (BNF) is used to concisely express structure, relationships, and layout of the transfer constructs in this specification.

Each production rule has a left side (identifier) and a right side (expression) connected by the symbol "::=", meaning that the left side is replaced by or produces the right side.  Terms in the right side either match other identifiers or are terminal symbols.  Making substitutions using matching symbols in the production rules therefore leads to explaining the highest level identifier in terms of the lowest level terminal symbols.  Other identifiers are intermediate, explaining the organization of the lower level symbols, and it is this expressive power of BNF that is used to define the organization of the transfer constructs in this standard. Most often the terminal symbols will actually be absent, but the production rules are presented in an indented form which indicates the levels of organization. The BNF used here is an extension from normal usage, where the order of the terms in the right hand side of the production rule implies a physical ordering of these terms (as characters in a sentence, for example).  However, for data transfer, order may not be important at times, and the terms may be considered a set.  When order is not important, the convention of separating the terms with a "," will be used.

The symbols used in the production rules have the meaning described in Table 5 -, BNF Notation.

**Table 5 - BNF Notation**

| Symbol | Meaning |
|---|---|
| **::=** | is replaced by, produces, consist of |
| **\|** | exclusive or |
| **[ ]** | term enclosed is optional (not used or used once) |
| **{ }** | term enclosed is used any number of times (not used, used once, or used several times) |
| **< >** | term enclosed is nontermina |
| **,** | exists together with (no order implied) |
| **...** | indicates a repetitive list of similar items |

### 4.1.3.3    Implicit Relationships between Constructs.

The ordering relationships between the logical constructs of this standard in the transfer are designated in Table 4.  This table also designates the relationships between the logical constructs and the implementation and media constructs.

### 4.1.3.3.1    Modules within a Spatial Data Transfer.

Spatial data transfers may occur on sequential media where order is significant, or on random access media where, depending on the level of detail, order might not be significant. On a medium where order is significant, the Identification Module and the Catalog modules must be the first modules in the sequence. Unless otherwise specified by the Catalog/Directory module, the remaining modules must be organized in the order that they appear in section 5, Transfer Module Specification. When the Catalog/Directory module implies a different ordering, this default ordering for the remaining modules is not required. For random access media the Identification modules and Catalog modules must be easily identifiable, preferably through file names that reflect the module type. Regardless of the type of media used, each global information module (Table 10 -, Global module types) must be contained in one or more separate files that contain only that module.

Modules may be included or omitted, with the following exceptions:

a) Modules referred to by foreign identifiers in other modules in the transfer must also be present in the transfer.

b) The global modules stated as required in 5.2 must always be present.

c) The inclusion of the Identification module is mandatory.

d) When the Attribute Authority or Entity Authority subfield of any Data Dictionary/Schema module is null, or when the authority referred to is an authority other than this standard, appropriate Data Dictionary modules to define the entity or attributes and (or) the entity or attribute authority must be used. Detailed conventions for the use of the authority subfields are found in 5.2.6.

Data Dictionary/Definition and Data Dictionary/Domain modules may be separate and external to a transfer, but if separate, they must be uniquely referenced (by module name and version) and labeled as "external" in Catalog/Directory records. The separate Data Dictionary modules must easily merge with SDTS transfer data which reference them (e.g. no module name conflicts, no file name conflicts, and only editing of the Volume and External subfields of the Catalog/Directory module records for the Data Dictionary/Definition and Data Dictionary/Domain modules).

e) The five quality modules described in 5.3 must always be included.

Data Quality modules may be separate and external to a transfer, but if separate, they must be uniquely referenced (by module name and version) and labeled as "external" in Catalog/Directory records. In addition, external Data Quality modules must have no records with foreign identifier fields. The separate Data Quality modules must easily merge with SDTS transfer data sets which reference them (e.g. no module name conflicts, no file name conflicts, and only editing of the Volume and External subfields of the Catalog/Directory module records for the Data Quality modules).

f) For each Attribute Primary, Attribute Secondary or Cell module there must be a related Schema module.

g) For each Cell module there must be a related Layer Definition module, which in turn must have a related Raster Definition module. For each Raster Definition module there must be at least one Layer Definition module. Each Layer Definition module must have at least one related Cell module (or alternatively an equivalent adjunct file.)

h) For the Line Representation, Symbol Representation, and Area Fill Representation modules, a standard field can take on specified values that are defined in the domain description column, or additional values defined in a Data Dictionary module. If additional values are used, the values and the authority for the values must be defined in an associated Data Dictionary module, and the Data Dictionary module must always be present.

i) Any nongeospatial dimensions subfields added to a spatial address field must be defined in a related Dimension Definition module.

#### 4.1.3.3.2 Module Records within Modules.

Module records should preferably occur in ascending sorted order, according to the module record identifier field. Module records representing spatial objects or relationships between components of spatial objects must occur in the order dictated by the spatial data model (2.1.2).

#### 4.1.3.3.3 Module Fields within Module Records.

It is recommended that module fields within module records occur according to the sequence specified in section 5. Module fields may occur in a different order on a module by module basis, provided that each field is identified through the selected implementation method and that significant relationships between fields are preserved. Within a module, the ordering, type and number of types of fields must be identical for each module record. Multiple Object Representation codes are allowed within the same module.

Module fields within each module description are arranged so that within a given module record the primary module field will not repeat, whereas the instances of the secondary module field may repeat a fixed or variable number of times.

The structure of a module record with a primary field "Primfield" and secondary fields "Secfield1, Secfield2,...,Secfieldn" is expressed as:

```
<module record>::= <Primfield>,
            {<Secfield1>}, {<Secfield2>}, ...,
            {<Secfieldn>}
```

The rules for the case where a field is absent are given in 4.1.3.3.5.

The order of repetition of a module field can be significant. Moreover, the order of repetition can be correlated with the order of repetition of another field. The following three classes are therefore recognized:

a) The order of repetition is not significant.

b) The order of repetition is significant.

c) The order of repetition is significant and is correlated with the repetition of another field.

This standard dictates for each field which of the above conditions apply through an appropriate code in the field description for each field (see 4.2.3). This indicates whether ordered information must be supplied for that field.

A number of modules in this specification have a simple relational structure in which all subfields may be represented as an n-tuple within a single implementation field. A module is said to have a relational structure when either one of the following conditions exists:

a) there is only a single primary field per module record and no variably repeating subfields. The relational structure of a module record is as below where the subfields are optional according to the rules of 4.1.3.3.6.

```
<module record> ::= <Primfield>
<Primfield> ::= <Subfield1>,
             [<Subfield2>],
                  .
                  .
             [<Subfieldn>]
```

b) the module record is composed of one primary field and one or more nonrepeating secondary fields. This alternate form is sometimes present to take advantage of predefined shared fields. This structure is expressed as below where the optionality of the fields is according to the specifications of 4.1.3.3.5.

```
<module record> ::= <Primfield>,
                    <Secfield1>,
                    [<Secfield2>],
                         .
                         .
                    [<Secfieldn>]
```

#### 4.1.3.3.4 Subfields within Fields.

A module subfield with a given name may be repeated a variable number of times within a given spatial data transfer if this is so specified within this standard (see 4.2.3.5).

#### 4.1.3.3.5 Optionality of Module Fields.

Module fields may be included or excluded. Both inclusion and exclusion may be either mandatory or optional, depending on the context for the use of the fields. When included, field contents may be null or may not be null. The following rules apply. Unless stated otherwise in a particular field description in the module specification table, module fields may be omitted provided that fields can be properly identified in the decoding process without additional external information not contained in the transfer. This can be satisfied with the current implementation method of part 3 that uses tagged fields. The meaning of missing module fields is specified in 4.1.3.3.9. Mandatory fields must not be null. The mandatory absence of fields must have the meaning of "undefined, not relevant," as specified in 4.1.3.3.9. Mandatory fields in mandatory modules must never be absent or null.

#### 4.1.3.3.6 Optionality of Module Subfields.

Module subfields may be included or excluded. Both inclusion and exclusion may be either mandatory or optional, depending on the context for the use of the subfields. When included, subfield contents may be null or may not be null. The following rules apply. Unless stated otherwise in a particular subfield description in the module specification table, module subfields may be omitted provided that subfields can be properly identified in the decoding process without additional external information not contained in the transfer. This can be satisfied with the current implementation method of part 3 that uses labeled subfields. The meaning of missing module subfields is specified in 4.1.3.3.9. Mandatory subfields must not be null. The mandatory absence of subfields must have the meaning of "undefined, not relevant," as specified in 4.1.3.3.9. Mandatory subfields in mandatory modules must never be absent or null.

#### 4.1.3.3.7 Private Module Fields and Subfields.

Extra module fields and subfields must not be added to nongeneric specifications, except under private agreement. The names and mnemonics used for any additional fields and subfields, under such an agreement, must not duplicate any of those specified in the standard.

#### 4.1.3.3.8 Preservation of Order.

For a repetitive list, the implementation must preserve the order as received from the sender, and on output, preserve order as found on the media.

#### 4.1.3.3.9 Nulls and Defaults.

The definition and the method for implementing null values is implementation dependent, and for the user-defined fields and subfields will be application specific. Null values in fields and subfields may be indicated in two ways:

a) through the structure imposed on a transfer's contents by the implementation, and

b) by setting aside certain values in the domain of the specified field or subfields contents as null values.

Structure indicated null values may be manifest in two ways:

a) through the absence of fields or subfields, and

b) through empty fields or subfields.

For the purposes of this standard, the default method for indicating null values must be through the structure imposed by the implementation. *Empty* fields and subfields must have the meaning of "**missing, relevant but not known**," while *missing* fields and subfields must have the meaning of "**undefined, not relevant**." If this default option for implementing null values is not feasible, the user may define alternative meanings to missing and empty fields or subfields, or may opt to implement a different null scheme by designating domain values as null values. In this case, the user must fully describe the selected method in the data quality Logical Consistency module, and if applicable, must specify the designated null domain values in a Data Dictionary/Domain module.

The fields and subfields that may be omitted, and when omitted have the meaning of "undefined, not relevant," are specified in 4.1.3.3.5 and 4.1.3.3.6.

A subfield may have an associated default value that must be assumed in effect when the subfield is omitted from the transfer. In this specification, subfields with default values are flagged appropriately and the default values are indicated. Values of omitted subfields without a preassigned default value are assumed to be of the null type "undefined, not relevant," unless otherwise specified in the Logical Consistency module.

### 4.1.3.4 Explicit Relationships between Constructs.

The following relationships between constructs are explicitly encoded in the spatial data transfer. The relationships described are not only restricted to relationships between transfer constructs, but also include other elements of the transfer such as spatial addresses and attributes.

#### 4.1.3.4.1 Modules, Records, Files, and Volumes.

As indicated in Table 4 -, Relationships between the transfer logical constructs, implementation constructs, and typical medium constructs., a module record may occur in a part of, in all of, or in more than one media record, file, or volume. Global modules may occur in all of or in more than one media file, but must not share the same media file with other modules. The Catalog/Directory module may be used to specify which records, files, and volumes are associated with a particular module. Each Catalog/Directory module record has a single field with subfields containing identifiers for module, record, file, and volume. More than one catalog module record may be used to express the relationships between a specific module and its associated media records, files, and volumes.

#### 4.1.3.4.2 Module Cross-References.

Certain modules can reference, have bearing on, or relate to other modules. These relationships are specifically expressed in the Catalog/Cross-Reference module. Each module record in this module has one field consisting of subfields which contain module name and type for two modules.

#### 4.1.3.4.3 Modules and Spatial Domain.

Relationships between modules and spatial domain, map, theme and aggregate object (e.g., graph) are expressed through the Catalog/Spatial Domain module.

#### 4.1.3.4.4 Module Record Cross-References.

Explicit relationships between module records are established through module record identifiers and foreign identifiers.

**Module Record Identifiers** - A module record identifier must provide a unique identification for the record in the entire transfer. The identifier has two subfields: (1) Module Name and (2) Record ID. The module record identifier exists as the first two subfields of the primary module field associated with the module record. The record number must be unique within the module.

**Foreign Identifiers** - References to other records from a given record must be made through foreign identifiers. Foreign identifiers consist of three subfields: (1) Module Name, (2) Record ID, and (3) Usage Modifier (See “Foreign Identifier” on page 36.) Module Name and Record ID are mandatory subfields corresponding to the mandatory module record identifier fields with matching names. The Usage Modifier subfield is optional and has no equivalent module record identifier subfield.

#### 4.1.3.4.5 Wildcard Characters in References.

For the purpose of eliminating multiple module reference records and multiple foreign identifiers for those cases where the reference model is one-to-many, the use of wildcard characters is allowed where indicated in a module domain description table in section 5. Wildcard characters are also used in attribute definition relationships. Except for the Record Identifier subfield, the subfield containing wildcard characters must be alphanumeric. When so indicated, the following rules apply:

a) An entire data element may be replaced with a "*", meaning "all."

b) If the data element refers to the Record ID subfield, it may be replaced by a negative integer corresponding to the maximum value in the subfield referenced, e.g., "-9328", meaning "all 9,328 records in the module referenced," or "the maximum number of records referenced in any of the referenced modules is 9,328."

c) Non-contiguous substrings of a data element may be replaced with a "*", meaning that the data element refers to those other data elements where the explicitly specified substrings are matched in their relative order.

d) Single characters of a data element may be replaced with a "?" meaning that the data element refers to those other data elements where the explicitly specified characters match in their relative order.

Whenever wildcard characters are used in data items that are part of a nested index, such as the foreign identifier, the scope of the elements referenced must be restricted by the scope of the previous level of reference. For example, if wildcard characters are used in the same foreign identifier to refer to modules and also to refer to records, then the scope of the records is restricted to the set of modules referenced. For any transfer, the scope of a set of modules referenced must be restricted to the modules in the Catalog/Directory module in which the referring module is cataloged.

The use of wildcard characters in the Module Name subfield of a foreign identifier field is not permitted except in global modules.

#### 4.1.3.5 Spatial Registration.

The standard includes a number of mechanisms by which spatial data contained in the transfer can be related to locations on the Earth's surface. The primary goal of this standard is to promote the transfer of data for which all spatial addresses have a known (and expressed) relationship to latitude and longitude. However, for certain types of applications this might not always be possible or meaningful. The standard therefore recognizes three spatial registration conformance levels. A transfer with conformance levels 1 or 2 must contain data that have a specified relationship to latitude and longitude, while this relationship must remain unspecified for a level 3 transfer.

The known relationship to latitude and longitude is expressed through the use of an external coordinate reference system, of which the three most widely used in the United States are (listed in order of preference): Latitude and Longitude (also termed Geographic), Universal Transverse Mercator/Universal Polar Stereographic (UTM/UPS) Grid Systems, and State Plane Coordinate Systems (metric). These systems are mathematically interconvertible, on a point by point basis, and are also officially recognized by many mapping and surveying agencies of the Federal and State governments. This standard allows the use of any of these preferred systems as the external coordinate reference system for spatial registration conformance level 1, and no other system must be used for this conformance level.

Any other external reference system may be used for registration conformance level 2, in which case the standard requires a full disclosure of the reference system, its projection and parameters. The spatial registration conformance levels are summarized as:

- Level 1: Relationship with latitude and longitude known through the use of one of the preferred external reference systems
- Level 2: Relationship with latitude and longitude known through the specification of an external reference system and its projection and parameters
- Level 3: Unspecified relationship with latitude and longitude

In addition to the latitude-longitude system and the specified external reference system, the standard includes two additional reference systems: the internal reference system and the scan reference system. The four types of spatial referencing systems are defined as follows:

a) The scan reference system is a row-column reference system for use with raster data, further described in 5.7.8 and Annex G.

b) The internal reference system is a Cartesian coordinate system, one that does not assume any particular orientation. For raster data, the system must be right-handed. The internal reference system is used to store the spatial addresses for the vector spatial objects of a transfer, while the scan reference system is used to store spatial addresses for raster data.

c) The external reference system is also a Cartesian coordinate system, without an assumed orientation, but the orientation of the internal and external reference systems must be identical. The external reference system must be either the Latitude-Longitude system, the UTM/UPS System, one of the State Plane Coordinate Systems (metric), or a system for which a transformation to latitude and longitude can be described through a projection and its parameters. The external reference system is not used to transfer the spatial addresses of spatial objects, but is used within a transfer to record registration points and spatial domains.

d) The system of latitude and longitude is the ultimate reference system to which, for conformance levels 1 and 2, all spatial data must be convertible.

The standard provides the necessary information to transform spatial addresses from one reference system to another for the following transformations:

a) Scan reference system to internal reference system. This transformation is for raster data, and is defined through the parameters stored in the Raster Definition module (See 5.7 and Annex G) .

b) Internal reference system to external reference system. This transformation may be accomplished (1) through translation and scaling with parameters provided in the Internal Spatial Reference module, or (2) through a transformation implicitly defined by registration points of the Registration module.

c) External reference system to latitude and longitude. This transformation can be accomplished through the known relationship between the preferred external spatial reference systems to latitude and longitude, or through the explicitly specified projection and parameters of another defined external reference system.

This standard is implemented through the use of recognized horizontal and vertical datums.

The spatial address refers to the geographic point location of an object. It is used to define the position of a point (in a defined coordinate system) that can be on, above, or below the Earth's surface. A point location in any one of the described reference systems is specified by means of a spatial address. The scan reference system for raster data is a special case, because it requires transformation from a row-column position to a spatial address in the internal reference system.

The method of spatial addressing is specified in 4.1.3.5.1. This is followed by the requirements for constructing spatial addresses in any of the three preferred external reference systems. These requirements apply directly to the external spatial addresses of the Registration and Spatial Domain modules only. Otherwise, it is upon transformation of internal reference system spatial addresses to external system addresses that the external addresses must meet the stated requirements.

Further information concerning the preferred external spatial reference systems see Annex D .

#### 4.1.3.5.1 Spatial Address and Coordinate Coding.

This standard allows for geospatial and nongeospatial addressing techniques corresponding to the conventional method of Cartesian coordinates. Within this method, different numbers of subfields (depending on whether or not a Z component and (or) additional non-geospatial dimensions are included) may be needed to form a complete spatial address. The specification for a spatial address is given in 5.1.1. The type of address is identified in 5.2.4.1. Specifications for altitude data are provided in 4.1.3.5.5 Specifications for additional non-geospatial dimensions are provided in 4.1.3.5.6.

Internal to the standard, the components of the spatial address are subfields with the labels X, Y, Z, and nongeospatial labels defined in the Dimension Definition module. The Z component of the spatial address must always correspond to the Z component of the selected external reference system. The X component of the spatial address can be assigned to either one of the horizontal components of the selected external spatial reference system, and similarly the Y component. The selected assignment must be communicated through the Spatial Address Component Label subfields in the Internal Spatial Reference Module. Additional nongeospatial dimensions are added to the spatial address by referencing Dimension Definition records through the Dimension ID field of the Internal Spatial Reference module.

#### 4.1.3.5.2 Latitude and Longitude.

Latitude and longitude are angular quantities and must be expressed as decimal fractions of degrees. Whole degrees of latitude must be represented by a two-digit decimal number ranging from 0 through 90. Whole degrees of longitude must be represented by a three-digit decimal number ranging from 0 through 180. When a decimal fraction of a degree is specified, it must be separated from the whole number of degrees by a decimal point.

Latitudes north of the equator must be specified by a plus sign (+), or by the absence of a minus sign (-), preceding the two digits designating degrees. Latitudes south of the Equator must be designated by a minus sign (-) preceding the two digits designating degrees. A point on the Equator must be assigned to the Northern Hemisphere.

Longitudes east of the prime meridian must be specified by a plus sign (+), or by the absence of a minus sign (-), preceding the three digits designating degrees of longitude. Longitudes west of the meridian must be designated by minus sign (-) preceding the three digits designating degrees. A point on the prime meridian must be assigned to the Eastern Hemisphere. A point on the 180th meridian must be assigned to the Western Hemisphere.

Any spatial address with a latitude of +90 (90) or -90 degrees will specify the position at the North or South Pole, respectively. The component for longitude may have any legal value.

#### 4.1.3.5.3 Universal Transverse Mercator/Universal Polar Stereographic Grid Systems.

##### 4.1.3.5.3.1 Universal Transverse Mercator Grid System.

The Universal Transverse Mercator Grid System must be used for spatial addresses between 84 degrees North and 80 degrees South Latitude. The first graphics character of the Zone Number Subfield in the External Spatial Reference module record must be a code to indicate the hemisphere in which the point is located. A plus sign (+) must be used to indicate the Northern Hemisphere, and a minus sign (-) to indicate the Southern Hemisphere. The remainder of the subfield must contain the zone number indicating the 6 degree longitudinal band in which the point is located (01, 02, ...60). The unit of measurement for both Northing and Easting must be the meter.

##### 4.1.3.5.3.2 Universal Polar Stereographic Grid System.

The Universal Polar Stereographic Grid System must be used in place of the Universal Transverse Mercator Grid System whenever the point is located north of 84 degrees North or south of 80 degrees South Latitudes. The Zone Number Subfield must be filled according to the rules outlined in paragraph 4.1.3.5.3.1, except the grid zone letter designator (A,B,Y, or Z) must be used in place of the 6 degree longitudinal band zone numbers.

#### 4.1.3.5.4 State Plane Coordinate Systems.

Currently, many of the SPCS's are, through legislative mandate, referenced to the North American Datum Adjustment of 1983 and are referred to as SPCS 83 systems. The SPCS 83 systems are required to have their horizontal components expressed in meters to conform to the SPCS specifications. However, several SPCS's remain that are referenced to the North American Datum of 1927 and are referred to as SPCS 27 systems. The SPCS 27 specifications required that the horizontal components be expressed in feet. The horizontal component of SPCS 27 data must be converted to meters.

An X or Y coordinate in an existing SPCS can be expressed by a number of the general magnitude of NNNNNNN.NNN. This will suffice for a range of not less than 0.003 meters and not more than 3,000,000.000 meters and is considered to be appropriate for this standard. For the purposes of coordinate transfer, the following convention applies. Where a decimal fraction is used, it must be one, two or three positions in length, as required (e.g., .1, .15, .125).

Each of the zones or SPCS's in each jurisdiction is uniquely identified by a four-character numeric code as specified in table 4 of FIPSPUB 70-1 (1.4.20). This four character code must be transferred in the Zone Number subfield of the External Spatial Reference module.

#### 4.1.3.5.5 Altitude.

Altitude (1.5.2) of a point, as used in this standard, is defined as the distance in meters either above or below a reference surface. The Vertical Datum and Sounding Datum subfields of the External Spatial Reference module must be used to specify this surface.

All altitude measurements below the reference Vertical Datum must be designated by a minus sign (-) preceding the number. Measurements at or above the reference datum, or at or below the Sounding Datum, may be either without a sign or may be designated by a plus sign (+), however usage must be consistent throughout a set of data.

The unit of measurement must be the meter.

#### 4.1.3.5.6 Nongeospatial Dimensions.

If nongeospatial dimensions are used, the additional dimensions are defined by the user of this standard. The additional dimensions can be labeled, formatted, and described, and units can be applied through the Dimension Definition module. If additional metadata about the dimension needs to be encoded, the metadata can be encoded as attributes, referenced by the Attriubte ID field of the Dimension Definition module.

### 4.1.3.6 Attributes

#### 4.1.3.6.1 Introduction.

Attributes must be transferred as simple relational tables. Each Attribute module record must contain a table row. Two types of attribute tables exist: primary and secondary. Each table row must be stored as one module record of an Attribute Primary or Attribute Secondary module. The attributes must be separate from the spatial objects, but primary attributes must be related to the objects through forward and (or) backward foreign identifiers. While the Attribute Primary module records are linked directly to the spatial objects, the records for the secondary attribute tables are related to primary attributes and (or) other secondary attributes through common attributes of the same name and domain, allowing for a relational join between primary and secondary tables. Secondary attributes can provide additional information for the primary attributes without having to repeat this information for each spatial object. Secondary attributes can also relate to other secondary attributes or to more than one set of primary attributes. The link between spatial object module records and Attribute Primary module records is a one-to-one, one-to-many, many-to-one, or many-to-many link. For each spatial object there may be more than one Attribute Primary module record, and more than one spatial object may refer to the same Attribute Primary module record. The link between Attribute Primary and Attribute Secondary module records may be one-to-one, one-to-many, or many-to-one. Attribute Secondary modules are linked to Attribute Primary modules or other Attribute Secondary modules through possible relational joins on corresponding attributes. The names and types of related modules that can be joined must be transferred in the form of module cross-references expressed in the Catalog/Cross-Reference module. The structure of an Attribute Primary module record is defined as follows where n is a constant for the module.

```
<Attribute Primary module record> ::=
                <module record identifier>
                [<spatial object ID>]
                [<attribute 1>]
                [<attribute 2>]
                    .
                    .
                    .
                [<attribute n>]
<module record identifier> ::=
                    <module name>
                    <record id>
<spatial object ID> ::=
                    <module name>
                    <record id>
```

#### 4.1.3.6.2 Attributes and Schema.

The attribute subfields of both the Attribute Primary and Attribute Secondary modules are generic subfields, to be defined by the user of the standard. Therefore, the information about the attributes is also user defined and must be transferred as well. The Data Dictionary/Definition module carries the definition of attributes and entities. The Data Dictionary/Domain module specifies the attribute domains. Specifications contained in these modules can be applicable to all attribute modules in a transfer. The Data Dictionary/Schema module applies to specific tables, and specifies the composition of these tables with respect to specific attributes used from among the total set defined in the other Data Dictionary modules. The Data Dictionary/Schema module transfers five important types of attribute information:

a) The specific set of attributes in an attribute module

b) The relationship between these attributes and an entity

c) The authorities of the attributes and (or) entity

d) The format, measurement unit, and maximum length of an attribute

e) Whether an attribute is a part of a primary or foreign relational key.

#### 4.1.3.6.3 Attributes and Entity.

Part 2, section 2 defines an attribute as "a defined characteristic of an entity type." Attributes may also be used without reference to an associated entity. The combination of an attribute label and its associated authority is considered unique. Therefore, two attributes with the same label and authority must have the same definition and value domain throughout the transfer.

#### 4.1.3.6.4 Object and Entity.

As described, spatial objects are normally associated with entities through attributes stored in Attribute Primary and Attribute Secondary modules, that have associated Schema modules, in which the entity type may be stored.

#### 4.1.3.6.5 Attributes and the Universe and Void Polygons.

As stated in the definitions of the universe and void polygons (2.3.3.3.1 and 2.3.3.3.2), the attribution of these objects can be substantially different from the attribution of the other polygons of a two-dimensional manifold. This difference in attribution may be implemented in any of the following three ways:

a) Polygons that are not universe or void polygons can have associated attributes referenced through the Attribute ID field of the Polygon module, while the universe or void polygons can lack any attributes, as indicated by the absence of the Attribute ID field.

b) A different schema applies to the universe and (or) void polygons. In this case, the universe and void polygons must be stored in a separate module. This module must be uniquely referenced to a special Data Dictionary/Schema module using a Catalog/Cross-Reference module.

c) The same schema applies to all the polygons of a module, including the universe and (or) void polygons. The difference in attribution is accomplished through the proper application of nulls, as described in 4.1.3.3.9, to the attribute fields that are irrelevant for the universe and void polygons.

#### 4.1.3.6.6 Attribute Definition, Authority, and Domain.

Attribute meaning can only be transferred through the association of an attribute label with an attribute definition. The Data Dictionary/Definition module is used to relate an attribute label to an attribute definition. It also relates the attribute label to the attribute source and attribute authority.

The attribute authority is the organization and (or) document through which a meaning is assigned to the attribute label as it occurs in the transfer. The attribute authority is not responsible for the actual value assigned to the attribute in the transfer, other than the specification of the value domain. The description of the authority responsible for actual value assignment must be transferred through the data quality Lineage module (see 5.3.1).

Attribute and entity authorities must be specified in the Attribute and Entity Authority subfields of the Data Dictionary/Schema module. If the authority subfields are null or contain authorities other than this standard, then the attribute and (or) entity must be fully described through Data Dictionary module entries. Detailed conventions for the use of the authority subfields are found in 5.2.6.

A valid domain for each attribute can be specified through the use of the Data Dictionary/Domain module.

#### 4.1.3.6.7 Foreign Identifiers as Attributes.

A foreign identifier must be composed of either two or three subfields: Module Name, Record ID, and an optional Usage Modifier (see 5.1.2). To facilitate joining attribute relations using foreign identifiers, and to facilitate the implementation of relationships, the following special convention allows the storage of foreign identifiers as single attribute values in a single subfield. The format of the attribute containing the foreign identifier must be specified as "^" in the Format subfield of the applicable Data Dictionary/Schema module (see 5.2.6.3), indicating that the attribute is a "packed" foreign identifier. The corresponding attribute subfield must contain the concatenated subfields of a foreign identifier as follows: Module Name and Record ID separated by the Graphic Character "#" (for example, SOILCHAINS#34). The optional Usage Modifier must follow the Record ID directly (for example, SOILCHAINS#34L). When packed foreign identifiers are used, module names referred must not contain the graphics character "#". The following BNF fully specifies the syntax of a packed foreign identifier:

```
<packed foreign identifier> ::=
                <Module Name>
                '#'<Record ID>
                [<Usage Modifier>]
```

#### 4.1.3.6.8 Attribute Labels.

Attributes labels must conform to the "identifier" specification of the ANSI standard for the data base language SQL (1.4.11 ANSI X3.135-1986, FIPSPUB 127). This standard specifies an identifier as beginning with an uppercase letter (SDTS alphabetic character A-Z) and followed by zero or more "character pairs." A "character pair" consists of an optional underscore (SDTS graphic character "_") and an uppercase letter or digit (SDTS numeric 0-9). Conforming to the SQL standard, the length of an attribute label must not exceed 18 characters. An attribute label must not be identical to an SQL keyword. The BNF for the attribute label is:

<attribute label> ::=

<uppercase alphabetic character>
{ <character pair> }

<uppercase alphabetic character> ::=

A|B|C|D|E|F|G|H|I|J|K|L|M
|N|O|P|Q|R|S|T|U|V|W|X|Y|Z

<character pair> ::= [<underscore> ]
<letter or digit>

<underscore> ::= _

<letter or digit> ::=
<uppercase alphabetic character> |
<digit>

<digit> ::= 0|1|2|3|4|5|6|7|8|9

#### 4.1.3.6.9 Using the Data Dictionary To Describe Raster Layers

The Data Dictionary will be used to describe the layers of a raster data set. The usage of the Data Dictionary modules will be similar to its usage for encoding attributes. For a given layer there will be one entry in the Data Dictionary Schema module, one entry in the Data Dictionary Definition module, and at least two entries in the Data Dictionary Domain module.

The Data Dictionary/Schema contains the format for the layer. The Attribute Label subfield value is a short name for the layer. This value will match the value found in the Layer Label subfield of the Layer Definition record corresponding to this D/D Schema record. This value will be unique between all layers of a transfer. This label will also be used as the subfield mnemonic for the subfield.

The Data Dictionary/Definition contains an english readable description for the layer. The Data Dictionary/Domain module usually contains at least two records for each layer, one for the minimum value and one for the maximum value the layer will contain. Other special purpose values can be coded here as well, like the meaning of categories in a thematic map.

## 4.2 Transfer Module Specification Conventions

The following contains the conventions and notation for the module specification tables of section 5.

### 4.2.1 Specification Layout

Each specification consists of a table describing the composition of records in a module. A module record is composed of module fields consisting of a set of subfields. Each subfield has a specified data type and domain. The columns of the specification table are (1) Field Name, (2) Subfield Name, (3) Field/Subfield Description, and, for subfields, (4) Data Type, (5) Domain, and (6) Domain Description. Column (7) gives a four-character mnemonic tag for each field and subfield specified.

The primary module field name for a module record is also the module type. Subfield names must identify the data content of the module records. The Data Type indicates the manner in which the subfield will be encoded. Each of the codes have the following meaning:

A: graphic, alphanumeric, or alphabetic chars
I: implicit-point (integer)
R: explicit-point unscaled (fixed point real)
S: explicit-point scaled (floating point real)
B: bitfield data (see types listed below)
C: char mode bitfield (zero and one chars)

In some instances, one may select from two or more of the above types, in which case the code letters will be separated by a vertical bar ( | ). The data type used should always be predictable.

The code "B" for bitfield data may have an additional qualification as follows:

| | |
|---|---|
| BI8: | 8-bit signed integer |
| BI16: | 16-bit signed integer |
| BI24: | 24-bit signed integer |
| BI32: | 32-bit signed integer |
| BUI: | unsigned integer, length specified by implementation |
| BUI8: | 8-bit unsigned integer |
| BUI16: | 16-bit unsigned integer |
| BUI24: | 24-bit unsigned integer |
| BUI32: | 32-bit unsigned integer |
| BFP32: | 32-bit floating point real |
| BFP64: | 64-bit floating point real |

B or BUI binary patterns may be used when their extent can be described by the implementation and the bit order is preserved by the implementation. When B is used without qualification, the bit pattern must be interpreted according to a subfield description contained in the Domain Value Definition subfield of the appropriate Data Dictionary/ Domain module. When BUI is used, the bit string must be interpreted as an unsigned integer with the most significant bit first and least significant bit last.

The domain column specifies the set of values that may be encoded within the indicated data type. There are nine major domain specifications:

a) Graphics characters (Gr-chars)

b) Alphanumeric (Alphanum)

c) Aphabetic (Alpha)

d) Integer

e) Real

f) Binary

g) Allowable values (domain enumeration)

h) Standard code sets

i) Standard field where domain is defined in Data Dictionary/Domain module

In the first six cases (a, b, c, d, e, f), the domain column must indicate "Alphanum," "Integer," etc.

In case (g), the permitted values must be listed, and each value must be defined in the domain description column. The domain description column may provide further restrictions on the allowable domain. For example, if an alphanumeric item must begin with an alphabetic character, this will be stated. When the domain column indicates "Integer," a positive, negative, or unsigned whole number is indicated. A "Real" number on the other hand calls for a positive or negative number with a fraction. In either case, there is no difference in meaning between a negative or positive zero. The actual implementation of an integer or real number must be according to the domain Data Type in the Domain Description column and as further specified in ISO 6093 for numeric values in character string format and ANSI X3.122-l986 (FIPSPUB 128) for binary data. For additional information see part 3.

In case (h), in most instances the number of a specific FIPS standard code set will be given, preceded by the characters "cs:" (e.g., cs:FIPSPUB4-1 for calendar dates). The Data Dictionary modules also provide a general capability to use code sets from any other FIPS standard as Attribute Values. (See 5.2.6)

In case (i), a standard field may take on specified values that are defined in the domain description column and (or) additional values defined in a Data Dictionary/Domain module. The notation in the domain column must be preceded by "dd:" followed by any appropriate limitation in the domain. For example, dd:<0 means that negative values are permitted but they must be defined in an associated Data Dictionary/Domain module.

Table 6 contains a complete enumeration of the character sets to be used for the graphics characters, alphabetic, numeric, and alphanumeric domains. All graphics characters must be encoded as specified in ANSI X3.4, extended to an 8-bit environment if required. Note that the set of graphics characters has been expanded slightly to include unprintable characters for carriage return (CR), line feed (LF), backspace (BS), tab, and form feed (FF) commonly found in text strings.

### 4.2.2 Generic Versus Explicit Specification

Various specification elements, such as module names, field names, and subfield names, can be specified generically rather than explicitly. In this case, the user must replace the generic names with names composed by the user or selected by the user from a name substitution table as indicated by the notation and naming conventions in the following.

An explicit specification is one that must appear verbatim as documented in this standard (independent of case). Names may be abbreviated internal to the transfer as long as the meaning of the data are unambiguously transmitted to the user of the standard (also see 4.1.3.1 and part 3, annex B).

**Table 6 - Character sets used to express the Graphics Characters, Alphanumeric, Alphabetic, and Numeric domains[1]**

| Graphics Characters | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Alphanumeric | | | | | | | | | |
| Alphabetic | | | | | Numeric | | | | |
| A | N | a | n | SPACE | 0 | E[2] | ! | \| | _ |
| B | O | b | o | | 1 | . | " | / | { |
| C | P | c | p | | 2 | + | # | : | } |
| D | Q | d | q | | 3 | - | $ | ; | FF |
| E | R | e | r | | 4 | SPACE[3] | % | < | LF |
| F | S | f | s | | 5 | | & | = | CR |
| G | T | g | t | | 6 | | ' | > | BS |
| H | U | h | u | | 7 | | ( | ? | TAB |
| I | V | i | v | | 8 | | ) | @ | |
| J | W | j | w | | 9 | | * | [ | |
| K | X | k | x | | | | ~ | ] | |
| L | Y | l | y | | | | , | \ | |
| M | Z | m | z | | | | | ^ | |

1) The width of the row containing the character set name indicates which characters are included in the set.

2) The "E" in the Numeric set is used for expressing an exponent. Note that the characters ".","+", and "-" are not part of the Alphanumeric set.

3) SPACEs may be used in numeric forms as defined in ISO 6093.

### 4.2.3 Notation and Naming Conventions

This subsection specifies notation conventions for the nature and character of field names and subfield names occurring in the module specification tables. A summary of this section is provided in Table 7.

#### 4.2.3.1 Explicit Specification.

All explicit field names are specified in alphabetic characters, with the first character in uppercase. Subfield names are specified the same as field names. Upper and lowercase expression is only significant for the specification of this standard, not for the content of field and subfield names in a transfer.

#### 4.2.3.2 Generic Specification.

Generic field names and subfield names are specified in lower-case alphabetic characters only, and the entire name is to be replaced, according to the instructions for the particular specification.

After substitution, all specifications appear as though they were explicit specifications.

#### 4.2.3.3 Classes of Fields.

Fields may be grouped into different classes. Some fields may have repeated instances in the transfer, while others are not allowed to repeat. For some fields ordering may be important, while for others it is not. Therefore, to designate the class of a field, each field has one or more characters following its name. The meaning of these designations is as follows.

Primary fields are marked by (P), secondary fields where order of repetition is not significant are marked by (R), and secondary fields where the order is significant are marked by (O). Secondary fields that must not be repeated within a module record are marked by (N).

Secondary fields where order of repetition is significant and is correlated with the repetition of one or more other fields are designated as follows. Each set of fields within a module record where ordering is correlated will be assigned a character. This character is appended to the order symbol (O) for a field, symbolically expressed as (O/x), where x is replaced by an uppercase alphabetic character in the specifications. For example, if two fields named Internal address and External address have an ordering relationship in which there is a one-to-one correspondence between the elements in the list of instances of these fields, then the pair of these fields is designated as set A and the fields are marked:

Internal address (O/A)
External address (O/A)

#### 4.2.3.4 Repeated Subfields in Generic Specifications.

Certain subfields of a field, such as the components of a spatial address, are generically identical and are thus described only once in each generic specification. In the generic specification, the number of these subfields is variable because the number of subfields required depends on the individual application. After user substitution, however, the subfield names will be different, and the number of subfields will be the same for the field throughout the entire module. Subfields of this type are specified only once and are flagged by a "+" in subsequent specifications.

For example, the subfield names for the attributes of an attribute module are not known until the user determines the types of attributes to be used in the transfer. For this reason, the generic specification for the subfield names of the Attributes field in the Attribute Primary module (and similarly for the Attribute Secondary module) is as follows:

| FIELD NAME | SUBFIELD NAME | FIELD/SUBFIELD DESCRIPTION |
|---|---|---|
| Attributes (N) | | |
| | (+) attribute | Primary attributes for the spatial object. |

with the meaning that the user should make substitutions for the "(+) attribute" generic subfield name for his/her specific application so that for the user's purpose the table then reads (for example):

| FIELD NAME | SUBFIELD NAME | FIELD/SUBFIELD DESCRIPTION |
|---|---|---|
| Attributes | | |
| | DEPTH | Depth of soil |
| | TEXTURE | Texture of soil |
| | SLOPE | Slope of soil |

#### 4.2.3.5 Variably Repeating Subfields.

Subfields with a given name and type that may repeat a variable number of times (0 or more repetitions) within a given transfer will have a name flagged by a "#" in subsequent specifications. (Not currently used anywhere in this standard. Subfields only repeat if the entire containing field repeats.)

#### 4.2.3.6 Shared Module Field Types.

Some module fields that occur in a number of modules, and do not change from module to module, are specified only once in 5.1. These fields will thereafter be shown only as a field name; subfield names and descriptions will be omitted from the module specification tables. The entire field will be absent in the domain description table.

For foreign identifiers and spatial addresses the shared field is generic, and these fields may then be assigned a different name in the module descriptions tables. However, to indicate that the contents and structure of these fields are either that of a foreign identifier or a spatial address, foreign identifier fields will be prefixed with the symbol "^" and spatial addresses will be prefixed with the symbol "-".

#### 4.2.3.7 Subfields with Default Values.

Subfields that have a specified default value will be prefixed with the symbol "d". The default values are specified in the standard.

#### 4.2.3.8 Mandatory and Optional Presence and Absence of Fields.

Presence or absence of fields and subfields can be mandatory or optional, depending on the context in which the field or subfield is used. Unless the field is completely optional, one or more status codes may appear in the field or subfield description in the module specification tables indicating the disposition of the field. The status code is enclosed in square brackets and consists of up to three parts. The first part is a key that can be followed by one or more conditions in the second and (or) third part. The key is one of four symbols with the following meaning:

| Key | No condition or true | Condition false |
|---|---|---|
| A | Mandatory absence | Mandatory presence |
| M | Mandatory presence | Optional presence |
| X | Mandatory absence | Optional presence |
| O | Optional presence | Mandatory presence |

The second part is an optional set of one or more Object Representation codes, separated by vertical bars ( | ). The third part is an optional set of field or subfield names with optional values, separated by a "+" or "|", the plus indicating that both fields are present and the vertical bar indicating that either one, but not both, fields are present.

For example, the Domain subfield in the Catalog/ Spatial Domain module is optional if the Map, Theme, Aggregate Object subfield is used: Domain [O/Map|Theme|Aggregate Object]. The Chain Component ID field in the Line module is optional if the Object Representation Codes “LE”, “LL”, “LW” or “LY” is used or the Spatial Address field is used. This is indicated as: Chain Component ID [O/LE|LL|LW|LY/Spatial Address]

The required presence or absence of a field or subfield can also depend on the value of another field or subfield. This will be indicated by the field or subfield name, followed by a "=" and by one or more values separated by vertical bars. For instance, the Vertical Component Format subfield is required when the value of the Spatial Address Type is "3-TUPLE." This is indicated as: Vertical Component Format [M/Spatial Address Type = 3-TUPLE].

The following BNF fully describes the structure of the field and subfield status notation:

status code ::= '[' <status key>
['/' <object representation codes> ]
['/' <field and subfield names > ] ']'

<object representation codes> ::=
<object representation code>
{'|' < object representation code> }

<field and subfield names> ::=
<field or subfield>
{ <separator> <field or subfield>}

<field or subfield> ::=
<field or subfield name>
[ ' = ' value ]

<separator> ::= '|' | '+'

<field or subfield name> ::=
<character string> |
<'character string'>

Each field or subfield can have one or more status codes, indicating the conditions under which the field or subfield should be included, excluded, or optionally included. A field or subfield can have a single status code with an attached condition. If the condition is false, then the disposition of the field or subfield depends on the status code as indicated in the table above. For multiple status codes, the disposition of the field is determined by the intersection of the logical conditions resulting from each status code.

The status codes are relative to the optionality of the module so that when a field or subfield is mandatory, it is mandatory within each SDTS transfer only if the module in which the field or subfield occurs is mandatory.

### 4.2.3.9 Notation Summary.

The notation conventions are as follows:

- Field name that is Generic is lowercase
- Field name that is Explicit is Initial uppercase
- Subfield name that is Generic is lowercase
- Subfield name that is Explicit is Initial uppercase

All fields will have one field class code of (P), (O), (O/x), (R), or (N). Each field or subfield may have zero, one, or more status codes: [A], [M], [X], and [O]. Zero status codes means completely optional. Multiple status codes means the intersection of the interpretations. See Table 7 -, Summary of the special flags used with field names and subfield names.

**Table 7 - Summary of the special flags used with field names and subfield names**

| Flag | Used with | Meaning |
|---|---|---|
| (+) | generic subfield name | User must substitute one or more explicit sub-fields with user-assigned names for the generic subfield in the generic specification. |
| (#) | subfield name | Subfield with given name and type can be repeated an indefinite number of times. (Currently not in use.) |
| (P) | field name | Primary module field. Not allowed to repeat. |
| (O) | field name | Secondary module field where order of repetition is significant and the criteria for order are specified. |
| (O/x) | field name | Secondary module field where order of repetition is significant, and where the order is correlated with the order of one or more other fields belonging to the set x (x to be replaced with an uppercase alphabetic character). |
| (R) | field name | Secondary module field where order of repetition is not significant. |
| (N) | field name | Nonrepeating secondary module field. |
| (-) | field name | Contents and structure of the field is that of a spatial address. (see Table 8) |
| (^) | field name | Contents and structure of the field is that of a foreign identifier. (see Table 9) |
| (d) | subfield | Subfield has a preassigned default value. |
| [A/..] | field, subfield name | Mandatory absence if condition true; otherwise mandatory presence. |
| [M/..] | field, subfield name | Mandatory presence if condition true; otherwise optional. |
| [X/..] | field, subfield name | Mandatory absence if condition true; otherwise optional. |
| [O/..] | field, subfield name | Optional presence if condition true; otherwise mandatory |

# 5 Transfer Module Specification

This section contains field and subfield specifications for each transfer module record type. Each transfer module may contain a number of module records. The general data models and specifications of section 4, combined with the specific details of this section, form the implementation-independent core of the standard.

## 5.1 Spatial Address and Foreign Identifier Fields

Spatial address and foreign identifiers fields are common to a number of modules and are therefore defined only once in this section. They are referenced only by field name in the module specification tables and are not further described in the domain description columns of the tables. The field name used in the module specification table may be different from the field names shown in this section, but the field prefix (-) will indicate that a field is a spatial address field, and the field prefix (^) indicates that a field is a foreign identifier field (see 4.2.3.9, Notation Summary).

### 5.1.1 Spatial Address

Spatial address fields occur in many modules and are fully defined in Table 8 -, Spatial address field specification.

Note that the field name "spatial address" has all lowercase characters, meaning that the field name is generic. Different names may therefore appear in the module description tables (see 4.2.3.2, Generic Specification.)

The fourth subfield nongeospatial component is prefixed with a "+" which indicates a generic specification which must be completed by the data encoder. Zero or more subfields can be defined here to append nongeospatial dimensions to a spatial address. Examples are time, parts per billion, pressure, or any other measurement excluding the x,y, and z spatial dimensions.

The nongeospatial component subfield is not applicable when the spatial address field is substituted for the following fields:

RGIS/EADS

RGIS/IADS

SPDM/DMSA

PNTS/OSAD

PNTS/SSAD

ARC/ARAD

ARC/ELAD

ARC/CADR

The Spatial Address field specification must be used consistent with the configuration of the applicable Internal Spatial Reference System module. If subfield Spatial Address Type is set to 3-tuple, then subfield Z must be present; otherwise absent. For every repetition of the subfield Dimension Id, there must be a user-defined subfield specification substituted for nongeospatial components subfield. The order of the DMID field repetition must match the order of the user-defined subfield specifications of the Spatial Address field. Once the Spatial Address field specification has been completed, it is the same for all modules to which the Internal Spatial Reference module instance applies.

### 5.1.2 Foreign Identifier

Foreign identifiers are also part of a number of module specifications and are specified in Table 9 -, Foreign identifier field specification.

The third subfield is only appropriate to modify references to lines or rings. Hence, it is only appropriate when the Object Representation subfield of the referenced module record contains Lx or Rx.

## Table 8 - Spatial address field specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| (-)spatial address | | The order of the instances of this field is dictated by the particular module in which the field is used. | | | | SADR |
| | X [M] | X Component of the spatial address. | I\|R\|S\|B | Numeric | For INTERNAL, defined in the Horizontal Component Format subfield of the Internal Spatial Reference module and according to the specifications of 4.1.3.5.1. | X |
| | Y [M] | Y Component of the spatial address. | I\|R\|S\|B | Numeric | For INTERNAL, defined in the Horizontal Component Format subfield of the Internal Spatial Reference module and according to the specifications of 4.1.3.5.1. | Y |
| | Z [O] | Z Component of the spatial address. | I\|R\|S\|B | Numeric | For INTERNAL, defined in the Vertical Component Format subfield of the Internal Spatial Reference module and according to the specifications of 4.1.3.5.1. | Z |
| | (+) non-geospatial component | The format and subfield mnemonic are derived by the Dimension Definition records defining the internal coordinate system of the spatial address.  There will be one repetition of the subfield for each additional non-geospatial dimension, the order of repetition will be controlled by the order Dimension ID fields repeat in the Internal Reference record. | I\|R\|S\|C \|B | Alphanum Integer Real Binary | As indicated by the Dimension Component Format subfield in the corresponding Dimension Definition record. | (Derived from the Dimension Label subfield of the Dimension Definition Record) |

## Table 9 - Foreign identifier field specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| (^)foreign id | | | | | | FRID |
| | Module Name [M] | Module name(s) of module(s) referenced. | A | Gr-chars | Module name of module referred. Wildcard characters may be used for reference to multiple module names. Use of wildcards in this subfield is restricted to global modules. | MODN |
| | Record ID [M] | Identifier of record(s) referenced. | I | Integer | The absolute value of this integer represents the Record ID of the record referred to. A negative value is used to reference all records in a module, as specified in 4.1.3.4.5 (b). | RCID |
| | Usage Modifier | Used to modify references to lines or rings. Must only be used when pointing to Line Module records from composites, nodes, rings, or polygons, or to Ring Module records from polygons. | A | S<br>E<br>L<br>R<br>F<br>B<br>I<br>X | Start node of line<br>End node of line<br>Left polygon of a line<br>Right polygon of a line<br>Forward orientation of a line or ring<br>Backward orientation of a line or ring<br>Interior polygon of a ring<br>Exterior polygon of a ring | USAG |

## 5.2 Global Information Modules

The global information modules (see Table 10) define global parameters for interpreting the data transfer.

The Identification, Internal, External Spatial Reference and Catalog/Directory modules are always required. The following modules are recommended: Catalog/Cross-Reference, Catalog/Spatial Domain, and Spatial Domain. Data Dictionary modules are required as defined in 4.1.3.3.1.

**Table 10 - Global module types**

| Global Module type |
|---|
| Identification |
| Catalog/Directory |
| Catalog/Cross-Reference |
| Catalog/Spatial-Domain |
| Security |
| Internal Spatial Reference |
| External Spatial Reference |
| Registration |
| Spatial Domain |
| Data Dictionary/Definition |
| Data Dictionary/Domain |
| Data Dictionary/Schema |
| Transfer Statistics |

### 5.2.1 Identification Module

The Identification module provides identifying information about the content of other data modules in the transfer. At least one Identification module is required for each data transfer. It consists of two mandatory fields: Identification and Conformance (see Table 12).

#### 5.2.1.1 Identification Field.

Except for Module Name, Record ID, Standard Identification, Standard Version, Profile Identification, Profile Version, and Title, all remaining subfields of the Identification field are optional.

#### 5.2.1.2 Conformance Field.

The Conformance field includes object specification subfields, an external spatial reference subfield, a features level subfield, a coding level subfield, and a nongeospatial dimension indicator.

##### 5.2.1.2.1 Object specification subfields.

The object specification subfields specify which object types are included in the transfer and which are not included. Table 11 lists the object types associated with each of the subfields in the Object Specification. The object types are identified by Object Representation Codes. All object specification subfields must be coded either "Y" or "N". A "Y" indicates the presence of one or more of the associated object types. An "N" indicates that none of the associated object types is present, with the following exception. Certain one-dimensional, geometry only vector objects (of type LS, AC, AE, AU, and AB) may be used to construct other objects with topology. An "N" for the geometry subfield indicates that such objects, although present, are used only as building blocks for topologically structured objects. Similarly, an "N" for the with-topology subfield indicates that these objects are not used in topological structures.

##### 5.2.1.2.2 External spatial reference subfield.

The mandatory External Spatial Reference subfield indicates whether one of the three recommended systems, Latitude and Longitude, UTM/UPS, or State Plane Coordinate Systems, has been used in the transfer. The subfield must contain 1 if yes, 2 if no but another projection has been used with a specified relationship to Latitude and Longitude, 3 if the relationship to Latitude and Longitude is unspecified.

##### 5.2.1.2.3 Features level subfield.

The mandatory Features Level subfield indicates the level of conformance to part 2 of this standard. The meaning of each level is as follows:

Level 1 - The transfer consists only of standard entity and attribute terms listed and defined in part 2.

Level 2 - The transfer consists only of standard entity and attribute terms listed and defined in part 2 and other terms not listed in part 2. All nonstandard terms have been converted to standard terms if contained in the cross-reference of included terms contained in part 2. Data Dictionary modules are included in the transfer to define nonstandard entity and attribute terms.

Level 3 - The transfer includes some standard entity and (or) attribute terms listed and defined in part 2 as well as terms for which the authority is not SDTS. The non-SDTS terms may overlap with standard entity and attribute terms and (or) included terms, and any such overlapping terms may be used with non-SDTS definitions. Data Dictionary modules are included in the transfer to define all terms for which SDTS is not the authority.

Level 4 - The authority for all entity and attribute terms is other than SDTS. Data Dictionary modules are used to define all entity and attribute terms.

### 5.2.1.2.4 Coding level subfield.

The Coding Level subfield indicates the level the transfer conforms with respect to data encoding as specified in part 3 (uses ISO 8211 file formats) . The meaning of each level is as follows:

Level 0 - The transfer file set conforms to part 3 (i.e. only ISO 8211 is used to encode module content). (This is the default.)

Level 1 - The transfer contains an adjunct file containing raster cell data. The adjunct file format is described in the transfer.

Level 2-5 - Reserved for future use.

Level 6-9 - May be defined by a profile or within the transfer itself.

### 5.2.1.2.5 Nongeospatial Dimensions subfield.

If a transfer has a Dimension Definition module that extends the Spatial Addresses beyond geospatial dimensions, then the Nongeospatial Dimensions subfield will be valued with “Y”.

**Table 11 - Presence or absence of object types by Object Specification**

| Code | Object Type | Object Specification Subfield | | | |
|---|---|---|---|---|---|
| | | Composite | Vector geometry only | Vector with topology | Image, Grid, Voxel or some other Raster |
| FF | Composite | Y | N | N | N |
| NP | Point | N | Y | N | N |
| NE | Entity point | N | Y | Y | N |
| NL | Label point | N | Y | N | N |
| NA | Area point | N | Y | Y | N |
| NO | Node, planar | N | N | Y | N |
| NN | Node, network | N | N | Y | N |
| LS | String | N | Y | Y | N |
| LQ | Link | N | N | Y | N |
| LE | Complete chain | N | N | Y | N |
| LL | Area chain | N | N | Y | N |
| LW | Network chain | N | N | Y | N |
| LY | Network chain | N | N | Y | N |
| AC | Arc | N | Y | Y | N |
| AE | Arc | N | Y | Y | N |
| AU | Arc | N | Y | Y | N |
| AB | Arc | N | Y | Y | N |
| RM | Ring, mixed | N | Y | N | N |
| RS | Ring, strings | N | Y | N | N |
| RU | Ring, chains | N | N | Y | N |
| RA | Ring, arcs | N | Y | N | N |
| PG | G-polygon | N | Y | N | N |
| PR | GT-polygon | N | N | Y | N |
| PC | GT-polygon | N | N | Y | N |
| PU | Universe polygon | N | N | Y | N |
| PW | Universe polygon | N | N | Y | N |
| PV | Void polygon | N | N | Y | N |
| PX | Void polygon | N | N | Y | N |
| G2 | Raster object | N | N | N | Y |
| G3 | Raster object | N | N | N | Y |
| GV | Raster object | N | N | N | Y |

## Table 12 - Identification module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Identification (P) [M] | | | | | | IDEN |
| | Module Name [M] | A unique name for this Identification module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID[M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Standard Identification [M] | A title for the standard to which this transfer conforms. | A | Alphanum | SPATIAL DATA TRANSFER STANDARD | STID |
| | Standard Version [M] | Version of the standard to which this transfer conforms. | A | Alphanum | Value of version number. | STVS |
| | Standard Documentation Reference | Reference to specific published documentation for the standard. | A | Gr-chars | This standards number and date. | DOCU |
| | Profile Identification [M] | A title for the profile to which this transfer conforms. | A | Alphanum | Alphanumeric title of profile, or "none" if transfer does not conform to a profile. | PRID |
| | Profile Version [M] | Version of the profile to which this transfer conforms. | A | Alphanum | Version, date, and Standard or proposed Standard information; or "none". | PRVS |
| | Profile Documentation Reference | Reference to specific published documentation for the profile, including publisher or source of documentation. | A | Gr-chars | Any combination of graphics characters. | PDOC |
| | Title [M] | An overall title or name applied to all data content of the data transfer. | A | Gr-chars | Any combination of graphics characters. | TITL |
| | Data ID | A user-defined data set identifier, usually unique to the data producer. | A | Gr-chars | Any combination of graphics characters. | DAID |

*(continued)*

## Table 12 - Identification module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Data Structure | A description of the internal data structure, organization, or other properties of the data relating only to the digital representation rather than, and independent of, the actual "analog" data represented. | A | Gr-chars | Any combination of graphics characters. | DAST |
| | Map Date | A date specifying the temporal extent of the data.This date must apply to the actual real-world information represented by the data, and not to data collection or any other processing history. | A | cs: FIPSPUB4 | FIPSPUB 4 specified date (day or month-day may be omitted). | MPDT |
| | Data Set Creation Date | A date specifying when the data were created (a processing history date "stamp" on the data set rather than on the information represented). | A | cs: FIPSPUB4 | FIPSPUB 4 specified date (day or month-day may be omitted). | DCDT |
| | Scale | A scale denominator at which the data may be referenced in a "paper-map" sense. If the data were collected from a graphic map, or meant to be displayed graphically, this subfield would indicate the scale of the map/display. | I | Numeric | A valid numeric scale denominator. | SCAL |
| | Comment | Additional comments. | A | Gr-chars | Any combination of graphics characters. | COMT |
| Conformance (N)[M] | | See 5.2.1.2 for details. | | | | CONF |
| | Composites [M] | Transfer contains at least one composite object. | A | Y<br>N | Yes<br>No | FFYN |
| | Vector Geometry [M] | Transfer contains vector objects used for geometry only operations. | A | Y<br>N | Yes<br>No | VGYN |

*(continued)*

## Table 12 - Identification module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Vector Topology [M] | Transfer contains vector objects with topological relationships included. | A | Y<br>N | Yes<br>No | GTYN |
| | Raster [M] | Transfer contains raster-- image and (or) grid-- objects. | A | Y<br>N | Yes<br>No | RCYN |
| | External Spatial Reference [M] | Specifies whether one of the three recommended coordinate systems (Latitude and Longitude, UTM/UPS, or State Plane Coordinates) has been used as the External Spatial Reference system. | I | 1<br>2<br>3<br>0 := NULL | Yes - one of three.<br>Other projection used.<br>Projection unspecified.<br>Undefined, not relevant. For use only in transfers not containing any spatial data. | EXSP |
| | Features Level [M] | Specifies the level of conformance to the lists and definitions of entity and attribute terms in part 2. | I | 1<br>2<br>3<br>4 | All SDTS<br>Mixed, non-overlapping<br>Mixed, overlapping<br>All non-SDTS | FTLV |
| | (d)Coding Level | Specifies the level of conformance to the part 3 encoding. Default is zero meaning only part 3 encoding used in a transfer file set. | I | 0<br>1<br>2 through 5<br>6 through 9 | The transfer file set encoded using part3<br>The transfer has an adjunct file for raster cell data<br>Reserved for future use<br>Meaning defined by profile or within the transfer. | CDLV |
| | (d)Nongeospatial Dimensions | Transfer contains vector or raster objects whose spatial addresses extend into nongeospatial dimensions. Default is N. | A | Y<br>N | Yes<br>No | NGDM |
| (^)Attribute ID(R) | | Foreign identifier for Attribute Primary module record. Attribute data referenced are global. | | | | ATID |

*(continued)*

### 5.2.2 Catalog Modules

The Catalog module specification describes three types of modules:

a) Catalog/Directory, containing information on the location of modules within the transfer.

b) Catalog/Cross-Reference, indicating pair-wise relationships between modules.

c) Catalog/Spatial Domain, specifying the relationships between modules, spatial domain, maps, themes, and aggregate objects.

The catalog defines the contents of the transfer in terms of the included modules, specifies how to access individual modules, and specifies relationships between modules. It also relates modules to spatial domains. It therefore describes the physical, logical, and spatial organization of the transfer at the module level. The three catalog modules are relational modules with one primary module field per module record. Many-to-one and one-to-many relationships are expressed with multiple module records, in which the single item is repeated from record to record (one to one relationships may also be expressed by limiting the number of Catalog modules used within a given transfer to one, or to one of each of the three types). Wildcard rules as described in 4.1.3.4.5 may be applied for the purpose of eliminating multiple records, as indicated in the module domain description tables. See examples in annex D.

#### 5.2.2.1 Catalog/Directory Module.

This module contains information on where to locate all modules within the transfer (see Table 13). It is also used to locate adjunct files which constiute part of the transfer. An adjunct file contains data that constitues part of the transfer, however, the file format is based on a standard other than Part 3/ISO 8211. (The use of adjunct files is permitted only as defined by an SDTS profile.) In other module records, modules are referenced by module name, and adjunct files are referenced by an adjunct file identifier. In the Catalog/Directory module these logical names are mapped to physical file names.

The Catalog/Directory module is required in a transfer. It must contain records to describe all modules (internal to the transfer and external) and adjunct files that constitute a complete spatial data transfer.

#### 5.2.2.2 Catalog/Cross-Reference Module.

This module contains the linkages for modules in the transfer. These linkages can be many-to-one, one-to-many, or one-to-one. For example, for global modules, the linkage may be one-to-one or one-to-many. For the one-to-many and many-to-one linkages, multiple module records for a given module must be present. Alternatively, one-to-many can in some cases be handled by a single module record with a wildcard reference. (see Table 14).

#### 5.2.2.3 Catalog/Spatial Domain Module.

This module defines the relations between a particular module and a spatial domain, map, theme, or aggregate object (see Table 15).

### 5.2.3 Security Module

The Security module provides information on the security, confidentiality, or copyrights that might effect distribution and use of the data in a transfer. Information on security may be carried at different levels of aggregation. Thus, information on security may refer to a domain, map, theme, or an individual spatial object. (see Table 16).

# Table 13 - Catalog/directory module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Catalog/Directory (P)[M] | | | | | | CATD |
| | Module Name [M] | A unique identifier for this Catalog/ Directory module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Name [M] | The unique value in the Module Name subfield of the module referenced; or an adjunct file identifier. | A | Alphanum | Name must begin with alphabetic character. | NAME |
| | Type [M] | The transfer module primary field name of "Name" above; or type indicating adjunct file. | A | primary field name<br>Gr-chars | Must be a valid module primary module field name.<br>Value identified by profile; must indicate file format. | TYPE |
| | Volume | The volume on which a part or all of the module is to be found. | A | Gr-chars | Valid volume descriptor, wildcard characters may be used. | VOLM |
| | File | The file on which a part or all of the module (or adjunct file) is found. | A | Gr-chars | Valid file name, wildcard characters may be used. | FILE |
| | Record | The record on which a part or all of the module is to be found (implementation record). | I\|A | Integer<br>Gr-chars | Unsigned integer, wildcard characters maybe used. | RECD |
| | (d)External | The module is external to this transfer data set. Default is N. | A | Y<br>N<br>A | Yes - Module not included.<br>No - Module is included.<br>Adjunct File included. | EXTR |
| | Module Version [M/External=Y] | Version of the module referenced by, or included in, this transfer data set. | A | Gr-chars | Valid version designator. | MVER |
| | Comment | Any other information. | A | Gr-chars | Any combination of graphics characters. | COMT |

## Table 14 - Catalog/Cross-Reference module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Catalog/Cross-Reference(P) [M] | | | | | | CATX |
| | Module Name [M] | A unique identifier for this Catalog/ Cross-Reference module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer, with Module Name must form unique ID within file set. | RCID |
| | Name 1 [M] | The unique value in the Module Name subfield of the module referenced. | A | Alphanum | Name must be name of a module in the transfer. | NAM1 |
| | Type 1 | The transfer module primary field name of "Name 1" above. | A | Gr-chars | Must be a valid module primary field name. | TYP1 |
| | Name 2 [M] | The unique value in the Module Name subfield of the module referenced. | A | Gr-chars | Name must be name of a module in the transfer, wildcard characters may be used. | NAM2 |
| | Type 2 | The transfer module primary field name of "Name 2" above. | A | Gr-chars | Must be a valid module primary module field name. | TYP2 |
| | Comment | Any other information. | A | Gr-chars | Any combination of graphics characters. | COMT |

## Table 15 - Catalog/Spatial Domain module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Catalog/Spatial Domain(P) [M] | | | | | | CATS |
| | Module Name [M] | A unique identifier for this Catalog/ Spatial Domain module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer, with Module Name must form unique ID within the file set. | RCID |
| | Name | The unique value in the Module Name subfield of a module referenced. | A | Alphanum | Name must begin with an alphabetic character. | NAME |
| | Type | The transfer module primary field name of "Name" above. | A | Gr-chars | Must be a valid module primary field name. | TYPE |
| | Domain [O/ Map\|Theme\| Aggregate Object] | Area of geographic coverage referenced by this module. | A | Gr-chars | Any combination of graphics characters; wildcard characters may be used and are always taken as wildcards. | DOMN |
| | Map [O/ Domain\|Theme\|Aggregate Object] | Map coverage name within geographic coverage referenced by this module. | A | Gr-chars | Any combination of graphic characters; wildcard characters may be used and are always taken as wildbards. | MAP |
| | Theme [O/ Domain\|Map\| Aggregate Object] | Theme referenced by this module. | A | Gr-chars | Any combination of graphics characters; wildcard characters may be used and are always taken as wildcards. | THEM |

*(continued)*

## Table 15 - Catalog/Spatial Domain module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Aggregate Object [O/Domain\| Map\| Theme] | Aggregate spatial object referenced by this module. | A | Gr-chars | Any combination of graphics characters; wildcard characters may be used and are always taken as wildcards. | AGOB |
| | Aggregate Object Type [M/Aggregate Object] | Type of aggregate spatial object referenced, such as Graph or Raster. | A | GP<br>GT<br>GN<br>G2<br>G3<br>GV<br>Gr- chars | Planar graph<br>2-D manifold<br>Network graph<br>Grid or Image (2-d raster)<br>Voxel Space (3-d raster)<br>Rectangle Variant Grid<br>Other as defined by profile | AGTP |
| | Comment | Any other information. | A | Gr-chars | Any combination of graphics characters. | COMT |

*(continued)*

## Table 16 - Security module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Security (P)[M] | | | | | | SCUR |
| | Module Name [M] | A unique name for this Security module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Security Class [M] | Security classification level. | A | TOPSEC<br>SECRET<br>CONFID<br>RESTRC<br>UNCLAS<br>COPYRI<br>Gr-chars | Top Secret<br>Secret<br>Confidential<br>Restricted<br>Unclassified<br>Copyrighted<br>Other as defined by profile | CLAS |
| | Control | Instructions for distribution and handling of the data concerning security or copyrights. | A | Gr-chars | Any combination of graphics characters. | CTRL |
| | Release Instructions | Instruction on release restrictions. | A | Gr-chars | Any combination of graphic characters. | RLIS |
| | Review Date | Reclassification date | A | cs:FIPSPUB4 | FIPSPUB 4 specified date. | RVDT |
| | Review Instructions | Reclassification instructions. | A | Gr-chars | Any combination of graphics characters. | RVIS |
| | Comment | Additional comments | A | Gr-chars | Any combination of graphics characters. | COMT |
| (^)Foreign ID (R) | | Reference to a specific module record. | | | | FRID |

### 5.2.4 Spatial Reference Modules

The spatial reference in a spatial data transfer is defined through the use of the following transfer modules:

Internal Spatial Reference
External Spatial Reference
Registration
Dimension Definition

The internal (to the transfer) coordinate system can be related to geographic coordinates through the use of the Internal and External Spatial Reference modules. The Internal Spatial Reference module provides a mechanism for the sender to *explicitly* define the translation and scaling of the geospatial dimensions of the internal coordinate system to the system defined in the External Spatial Reference module. The Registration Module provides a mechanism to *implicitly* specify the transformation from the internal to the external system.

Any non-geospatial dimension of the internal coordinate system, defined through the Dimension Definition module, does not have transformation parameters. When the internal reference system is transformed to the external reference system, the values for the nongeospatial dimensions will appear as they are found in the internal reference system.

#### 5.2.4.1 Internal Spatial Reference Module.

The transformation parameters described in the Internal Spatial Reference module record provide for a simple translation and scaling from the internal reference system to the external reference system. Three scale factors and a translation vector that is the origin of the external spatial reference system provide the independent scaling and translation of the geospatial dimensions of the internal coordinates to external coordinates (see Table 17).

The following matrix equation must be specified:

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} SX & 0 & 0 \\ 0 & SY & 0 \\ 0 & 0 & SZ \end{vmatrix} \begin{vmatrix} X' \\ Y' \\ Z' \end{vmatrix} + \begin{vmatrix} Xo \\ Yo \\ Zo \end{vmatrix}$$

where:

- X,Y,Z = geospatial components of spatial address in the external system

- SX,SY,SZ = geospatial scaling factors for scaling to the external system, forming the diagonal elements of a diagonal matrix with off-diagonal zero elements

- X',Y',Z' = geospatial components of spatial address in internal system

- Xo,Yo,Zo = geospatial components of spatial address of origin of internal system in external system

If the external reference system is the State Plane coordinate system and the internal system uses units of feet, the feet to meters conversion factor of 0.3048 must be used in computing scaling factors.

An alternative method for converting from internal to external coordinates is provided by registration points in the Registration module.

The subfields containing the scaling factors and the origin of the external system are optional only if registration points are used. Otherwise, the subfields are mandatory and must not be null. If no transformation is required, then the identity transformation must be indicated by scaling factors of 1.0 and components of the origin of 0.0.

#### 5.2.4.2 External Spatial Reference Module.

This module is used to define the external spatial reference system and its relationship to latitude and longitude (see 4.1.3.5). The external spatial referencing systems supported by the standard and to be used under conformance level 1 are Latitude-Longitude (GEO), Universal Transverse Mercator/Universal Polar Stereographic (UTM/UPS), and State Plane Coordinate Systems--metric (SPCS). The system being used is indicated by one of the codes (GEO, UTM/UPS, or SPCS) in the Reference System Name subfield (see Table 18).

For conformance level 2, the Reference System Name subfield must contain OTHR, meaning that another reference system is used. In this case, the system and its projection must be fully described in the Projection subfield, the associated parameters for conversion to latitude and longitude must be fully defined in Data Dictionary modules, and parameter values must be provided as attributes referenced by the Attribute ID field. A full description of the system used must be provided in the Lineage portion of the Quality Report as well.

For conformance level 3, the Reference System Name subfield must contain UNSP, meaning that the relationship of the spatial addresses to geographic coordinates is not specified, and this fact must also be documented in the Lineage portion of the Quality Report.

Additional dimensions defined in the Internal Spatial Reference module are also implicitly defined in the external spatial reference system. Any metadata, such as units, format, and description, are found in the Dimension Definition module. The external spatial reference system will have one dimension for each geospatial dimension plus one dimension for each Dimension ID field defined in the Internal Spatial Reference module.

Altitude and depth measurements can be encoded as Z-values in spatial addresses or alternatively as attribute values or cell values. The Vertical Attribute field and the Sounding Attribute field should be used when attribute and/or cell values are used for encoding vertical or depth measurements, respectively.

#### 5.2.4.3 Registration Module

Registration points may be used to express the relationship between the internal spatial reference system and the external spatial reference system (see Table 19).

The Registration Module is highly recommended for External Spatial Reference conformance level of 2. (Also, indicated in the External Spatial Reference module by having a Reference System Name of “OTHR”.)

#### 5.2.4.4 Dimension Definition Module

The Dimension Definition module is used for data sets which contain nongeospatial dimensions. This allows N-dimensional data with spatial registration to be encoded in this standard. Each record provides dimension information: data type, resolution, units, etc. Each Dimension Definition record may be referenced by one or more Internal Spatial Reference records.

The main components of the Dimension Definition module are (see Table 20):

a) A primary field which contains a text label, the format of the values used for indexing along the axis, and resolution information.

b) An Attribute ID field used for assigning attributes to the dimension being described.

The records of the Dimension Definition module will modify any Spatial Addresses which happen to fall within the scope of the definition. This scope is defined by the Internal Reference System module record which references one or more records of the Dimension Definition module.

## Table 17 - Internal Spatial Reference module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Internal Spatial Reference (P)[M] | | | | | | IREF |
| | Module Name [M] | Unique name for this Internal Spatial Reference module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Comment | Free-form comment subfield. | A | Gr-chars | Any combination of graphics characters. | COMT |
| Note: the following subfields provide information for the type of spatial address used. | | | | | | |
| | Spatial Address Type [M] | Indicates whether horizontal component only or both horizontal and vertical components are present in the spatial address. | A | 2-TUPLE | Horizontal component only (i.e. x,y). | SATP |
| | | | | 3-TUPLE | Horizontal component and a vertical component. (i.e. x,y,z). | |
| | Spatial Address X Component Label [M] | Indicates the correspondence of internal and external spatial address X components to either one of the horizontal components of the external spatial reference system. | A | LATITUDE LONGITUDE | For use with geographic coordinates. When Latitude is selected for X, then Longitude must be selected for the following Y subfield. | XLBL |
| | | | | EASTING NORTHING | For use with State Plane or UTM/UPS systems. When Easting is selected for X, then Northing must be selected for the following Y subfield. | |
| | | | | Gr-chars | May be used with External Spatial Reference Conformance level 2 or level 3. | |

## Table 17 - Internal Spatial Reference module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Spatial Address Y Component Label [M] | Indicates the correspondence of internal and external spatial address Y components to either one of the horizontal components of the external spatial reference system. | A | LATITUDE<br>LONGITUDE | For use with geographic coordinates. When Latitude is selected for Y, then Longitude must be selected for the previous X subfield. | YLBL |
| | | | | EASTING<br>NORTHING | For use with State Plane or UTM/UPS systems. When Easting is selected for Y, then Northing must be selected for the previous X subfield. | |
| | | | | Gr-chars | May be used with External Spatial Reference Conformance level 2 or level 3. | |
| | Horizontal Component Format [M] | Specific format of the horizontal components of the spatial address. | A | I<br>R<br>S<br>BI8<br>BI16<br>BI24<br>BI32<br>BUI<br>BUI8<br>BUI16<br>BUI24<br>BUI32<br>BFP32<br>BFP64 | Implicit-point integer<br>Explicit-point unscaled<br>Explicit-point scaled<br>8-bit signed integer<br>16-bit signed integer<br>24-bit signed integer<br>32-bit signed integer<br>Unsigned integer<br>8-bit unsigned integer<br>16-bit unsigned integer<br>24-bit unsigned integer<br>32-bit unsigned integer<br>32-bit floating point real<br>64-bit floating point real | HFMT |

## Table 17 - Internal Spatial Reference module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Vertical Component Format [M/Spatial Address Type = 3-TUPLE] | Specific format of the vertical components of the spatial address. | A | I<br>R<br>S<br>BI8<br>BI16<br>BI24<br>BI32<br>BUI<br>BUI8<br>BUI16<br>BUI24<br>BUI32<br>BFP32<br>BFP64 | Implicit-point integer<br>Explicit-point unscaled<br>Explicit-point scaled<br>8-bit signed integer<br>16-bit signed integer<br>24-bit signed integer<br>32-bit signed integer<br>Unsigned integer<br>8-bit unsigned integer<br>16-bit unsigned integer<br>24-bit unsigned integer<br>32-bit unsigned integer<br>32-bit floating point real<br>64-bit floating point real | VFMT |
| Note: the following subfields are used to specify the scaling matrix and translation vector. The off-diagonal elements of the scaling matrix are always zero, and are therefore not transferred. | | | | | | |
| | Scale Factor X [O/Registration] | Scaling factor for the X axis. | R | Real | Any real number. | SFAX |
| | Scale Factor Y [O/Registration] | Scaling factor for the Y axis. | R | Real | Any real number. | SFAY |
| | Scale Factor Z [M/Spatial Address Type = 3-TUPLE] | Scaling factor for the Z axis. | R | Real | Any real number. | SFAZ |
| | X Origin [O/Registration] | X component of origin spatial address in external system. | R | Real | Expressed in degrees for geographics, in meters for State Plane or UTM/UPS. | XORG |
| | Y Origin [O/Registration] | Y component of origin spatial address in external system. | R | Real | Expressed in degrees for geographics, in meters for State Plane or UTM/UPS. | YORG |

## Table 17 - Internal Spatial Reference module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Z Origin [M/Spatial Address Type = 3-TUPLE] | Z component of origin spatial address in external system. | R | Real | Expressed in meters for geographics, State Plane, or UTM/UPS. | ZORG |
| Note: the following subfields specify the resolution components for the spatial address, where resolution is defined as the minimum difference between two independently measured or computed coordinate values that can be distinguished by the measurement or analytical method used. | | | | | | |
| | X Component of Horizontal Resolution | X component of horizontal coordinate resolution. | R | Real | Expressed in meters for geographics, State Plane, or UTM/UPS. | XHRS |
| | Y Component of Horizontal Resolution | Y component of horizontal coordinate resolution. | R | Real | Expressed in meters for geographics, State Plane, or UTM/UPS. | YHRS |
| | Vertical Resolution Component [M/Spatial Address Type = 3-TUPLE] | Vertical component of coordinate resolution. | R | Real | Expressed in meters for geographics, State Plane or UTM/UPS. | VRES |
| (^) Dimension Id (O) | | A pointer to the Dimension Definition records which define the nongeospatial dimensions of the Spatial Address. The order of repetition of this field determines the order subfields are placed in the Spatial Address field. | | | | DMID |

## Table 18 - External spatial reference module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| External Spatial Reference (P)[M] | | | | | | XREF |
| | Module Name [M] | A unique name for this External Spatial Reference module. | A | Alphanum | Names must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Comment | Free-form comment subfield | A | Gr-chars | Any combination of graphics characters. | COMT |
| | Reference Documentation | Reference in which the external system used is documented. | A | Gr-chars | Any combination of graphics characters. | RDOC |
| | Reference System Name [M] | Name for the external system used | A | GEO | Geographics (latitude and longitude). | RSNM |
| | | | | SPCS | State Plane Coordinate System - meters. | |
| | | | | UTM | UTM - meters. | |
| | | | | UPS | UPS - meters. | |
| | | | | OTHR | Other - Described in Projection subfield. | |
| | | | | UNSP | Unspecified. | |
| | Vertical Datum [X/Spatial Address Type = 2-TUPLE\|Sounding Datum] | Reference surface for the third component of the internal spatial addresses (not used for hydrographic depths). | A | NGVD | National Geodetic Vertical Datum of 1929. | VDAT |
| | | | | NAVD | North American Vertical Datum of 1988. | |
| | | | | GEODETIC | All altitudes are referenced to the ellipsoid of the specified datum. | |
| | | | | Gr-Char. | Any other geodetic datum. | |

## Table 18 - External spatial reference module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Sounding Datum [X/Spatial AddressType = 2-TUPLE\|Vertical Datum] | Reference datum for the third component of the internal spatial addresses (for hydrographic depths only). | A | MHW<br>MHWN<br>MHWS<br>MHHW<br>MLW<br>MLWN<br>MLWS<br>MLLW | Mean High Water<br>Mean High Water Neaps<br>Mean High Water Springs<br>Mean Higher High Water<br>Mean Low Water<br>Mean Low Water Neaps<br>Mean Low Water Springs<br>Mean Lower Low Water | SDAT |
| | Horizontal Datum [M/EXSP=1\|2] | Geodetic datum to which the internal spatial addresses have been referenced. | A | NAS<br>NAX<br>WGA<br>WGB<br>WGC<br>WGE<br>Gr-chars | North American 1927<br>North American 1983<br>World Geodetic System 1960<br>World Geodetic System 1966<br>World Geodetic System 1972<br>World Geodetic System 1984<br>Any other geodetic datum | HDAT |
| | Zone Number [M/Reference System Name = SPCS\|UTM\|UPS] | UTM/UPS/State Plane Zone number. | A | Gr-chars | Valid UTM/UPS/State Plane zone number (see 1.3.21 and annex C). | ZONE |
| | Projection [M/Reference System Name = OTHR] | Name and (or) description of the projection and reference system used. | A | Gr-chars | Any combination of graphics characters. | PROJ |
| (^)Attribute ID (N) [M/ReferenceSystemName = OTHR] | | Foreign identifier for Attribute Primary module record containing projection parameters. | | | | ATID |
| Vertical Attributes (R) | | The Vertical Attributes field is used for any attribute or raster layer which require a vertical datum. This field can repeat for each layer or each attribute needing a vertical datum. | | | | VATT |

**Table 18 - External spatial reference module specification *(continued)***

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Vertical Datum [M] | Reference surface for vertical measurements like elevation or altitude. | A | (same as subfield VDAT above) | | VDAT |
| | Vertical Encoding Method [M] | The method used to encode vertical measurements (except for the use of Z-component of spatial address) | A | ATT<br>CELL | As Attribute Values<br>As Cell Values | VEM |
| | Attribute Label [M] | Name of attribute subfield whose values carry vertical measurements. | A | Gr-chars | Attribute subfield name as in the Attribute Primary, Attribute Secondary, or Cell modules. | ATLB |
| | Attribute Authority [M] | Name of the attribute authority for Label field above. | A | Gr-chars | Any combination of at most eight characters. | AUTH |
| Sounding Attributes (R) | | The Sounding Attributes field is used for any attribute or raster layer which require a sounding datum. This field can repeat for each layer or each attribute needing a sounding datum. | | | | SATT |
| | Sounding Datum [M] | Reference datum for hydrographic depths. | A | (same as subfield SDAT above) | | SDAT |
| | Sounding Encoding Method [M] | The method used to encode depth measurements (except for the use of Z-component of spatial addresses) | A | ATT<br>CELL | As Attribute Values<br>As Cell Values | SEM |
| | Attribute Label [M] | Name of attribute subfield whose values carry hydrographic depth measurements. | A | Gr-chars | Attribute subfield name as in the Attribute Primary, Attribute Secondary, or Cell modules. | ATLB |
| | Attribute Authority [M] | Name of the attribute authority for subfield label above. | A | Gr-chars | Any combination of at most eight characters. | AUTH |

## Table 19 - Registration module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
| --- | --- | --- | --- | --- | --- | --- |
| Registration (P) [M] | | | | | | RGIS |
| | Module Name [M] | A unique name for this Registration module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Comment | Free-form comment subfield. | A | Gr-chars | Any combination of graphics characters. | COMT |
| (-)External Reference Spatial Address (O/A) [M] | | | | | . | EADS |
| (-)Internal Reference Spatial Address (O/A) [M] | | | | | | IADS |

## Table 20 - Dimension definition module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Dimension Definition (P)[M] | | One dimension definition record will describe one nongeospatial dimension. | | | | DMDF |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Dimension Label [M] | Label describing this dimension of the space. This label will be found in the SADR as the mnemonic for the subfield containing values along this dimension. | A | Gr-chars | Any combination of graphics characters. | DMLB |
| | Dimension Component Format [M] | Format for this dimension's resolution or for this dimension's index labels. This also provides the format for SADR subfield which corresponds to this record. The format for the values is found along this dimension's axis. The subfield of the Spatial Address which corresponds to this dimension will have the format specified by this subfield. | A | I<br>R<br>S<br>BI8<br>BI16<br>BI24<br>BI32<br>BUI<br>BUI8<br>BUI16<br>BUI24<br>BUI32<br>BFP32<br>BFP64<br>C<br>A | Implicit-point (integer)<br>Explicit-point, unscaled<br>Explicit-point, scaled<br>8-bit signed integer<br>16-bit signed integer<br>24-bit signed integer<br>32-bit signed integer<br>Unsigned integer<br>8-bit unsigned integer<br>16-bit unsigned integer<br>24-bit unsigned integer<br>32-bit unsigned integer<br>32-bit floating point real<br>64-bit floating point real<br>Character mode bitfield<br>Alphanumeric | DFMT |
| | Dimension Component of Resolution [M] | Defines the resolution of data stored along this axis. | I\|R\|S\|C \|B | Integer<br>Real<br>Binary | As defined by the DFMT subfield | DRES |

*(continued)*

**Table 20 - Dimension definition module specification *(continued)***

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Dimension Value Measurement Unit [M] | Measurement unit for the values of this dimension. | A | Gr-chars | Any combination of graphics characters. | DDMU |
| | Dimension Description | A brief description of the dimension. | A | Gr-Chars | Any combination of graphics characters. | DDES |
| (^)Dimension Attribute ID (R) | | Foreign identifier for Attribute Primary module record. Attributes pertain to a specific dimension. | | | | DATP |

*(continued)*

### 5.2.5 Spatial Domain Module

The Spatial Domain module (see Table 21) specifies a geographic areal domain within which the spatial addresses of other modules are contained. Two basic methods of specifying this coverage are allowed in this module:

a) By specifying a spatial address with all minimum value components and a spatial address with all maximum value components (in most cases, the southwest (or lower left) and northeast (or upper right) corners of a coverage rectangle); and (or)

b) By a series of spatial addresses describing a ring delineating the area.

Two types of spatial addresses may be used:

a) "Internal" spatial addresses as fully defined by parameters of the Internal Spatial Reference module; and

b) "External" spatial addresses as fully defined by parameters of the External Spatial Reference module.

Any number of Spatial Domain module records may be used to specify spatial domain for the same set of data (if more than one way of specifying spatial domain is desired).

### 5.2.6 Data Dictionary Modules

The Data Dictionary specification describes three types of modules:

a) Data Dictionary/Definition

b) Data Dictionary/Domain

c) Data Dictionary/Schema

The purpose for the data dictionary is to convey the meaning of entities and attributes, the relationship between entities and attributes, the relationship between attributes and value domains, and the relationship between attributes as they make up relational tables. Cell Values of the Cell module are defined by the data dictionary in the same manner as attributes.

Data Dictionary modules must be used to fully describe attributes and entities for which the attribute and (or) entity authority subfields of the Data Dictionary/Schema primary field are null. In this case, there is no preestablished authority, so that attribute meaning must be defined within the spatial data transfer itself.

The Data Dictionary/Definition module must also provide a full description of the attribute and (or) entity authority, when an authority other than the standard is referenced in the Data Dictionary/Schema subfields. In this case, the referenced definitions must be available in the form of a standard Data Dictionary/Definition module. Wildcard characters may be used in the Entity/Attribute Label field, indicating that the authority applies to a collection of attributes defined in an authority document not included in the transfer. The applicable wildcard rules are those specified in 4.1.3.4.5

Data Dictionary/Domain modules must accompany Data Dictionary/Definition modules except where domain and value definitions are available from the attribute authority as noted above. A separate Data Dictionary/Domain module must also be provided, where necessary, for the purpose of defining values of standard subfields where the domain type "dd:" is specified (case (i) in 4.2.1, Specification Layout). Such a module must (a) contain no corresponding Data Dictionary/Definition or Data Dictionary/Schema module, (b) contain a concatenations, separated by a slash "/", of the field and subfield mnemonics (e.g., AFIL/HIDX for Area Fill Representation/Hatch Index) for which definitions are provided, in the Attribute Label subfield, and (d) be referenced in a corresponding Catalog/Cross Reference module which associates the Data Dictionary/Domain module with the module(s) for which subfield value definitions are provided.

The three data dictionary modules are relational modules with one primary module field per module record. For examples of the use of data dictionary modules, consult Annex C.

If the authority for an attribute is another FIPS standard, the Attribute Domain Type subfield of the Data Dictionary/Domain module must contain the keyword FIPSCODE (see 5.2.6.2) with the number of the applicable FIPSPUB cited in the Attribute Authority Description subfield of Data Dictionary/Definition module (see 5.2.6.1).

#### 5.2.6.1 Data Dictionary/Definition Module.

This module contains definitions for entities and entity attributes and raster layers. It also specifies the name of the relevant authority and provides a full description of this authority. This module is a relational module, thus any one-to-many relationships between entities or attributes and definition, source, and authority must be expressed using multiple module records (see Table 22).

#### 5.2.6.2 . Data Dictionary/Domain Module.

This module is used to specify attributes and their associated value domains. It is also used to provide descriptions and definitions for user-defined attribute values. The module is a relational module with one primary field, so that the one-to-many relationship between an attribute and the values of its associated domain must be expressed through the use of multiple module records (see Table 23). The domain types specified in this module are exactly the same as those specified for use in the transfer module specification layout (see 4.2.1). Special values of a domain, such as may be the case with an enumerated domain or with the specification of user null conventions, must be defined using this module. The module serves to attach domain value definitions to domain values. Values must always be defined, in one of three ways: (a) by specifying a measurement unit in the Attribute Domain Value Measurement Unit subfield, (b) by providing a definition in the Domain Value Definition subfield; or (c) by providing a reference to a published source of definitions of value terms used in the Attribute Authority Description subfield of the corresponding Data Dictionary/Definition module record for the attribute.

This module is also used to specify the complete domain for subfields for which the domain is only partially defined in the standard. These are identified in the module description tables by a notation of dd: in the domain column. See 4.2.1.

#### 5.2.6.3 Data Dictionary/Schema Module.

The primary function of this module is to describe the specific composition of the Attribute Primary, Attribute Secondary and Cell modules, and to relate the attributes in the attribute modules to the corresponding entities according to the entity-attribute model specified in 2.1.1 and in part 2, section 2 (see Table 24). A secondary function is to provide additional information about the entity and attributes, such as authority, format, measurement unit, and subfield length. The module also contains a subfield indicating whether an attribute is a part of a relational primary or foreign key so as to preserve a relational attribute model. For an additional explanation of the relationships between this and the Attribute Primary and Attribute Secondary see 4.1.3.6.1.

### 5.2.7 Transfer Statistics Module

This module is used to provide a transfer recipient with data volume information at various levels. For this purpose, the module consists of a table of module names, total module record counts, and total spatial address counts (see Table 25).

## Table 21 - Spatial domain module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Spatial Domain (P) [M] | | | | | | SPDM |
| | Module Name [M] | Unique name for this Spatial Domain module | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Spatial Domain Type [M] | Method of specifying the domain spatial addresses. | A | MINMAX | Spatial domain is specified by two spatial addresses. The first containing the minimum value associated with each component; the second containing the maximum value associated with each component. | DTYP |
| | | | | RING | Spatial domain is specified by a series of spatial addresses forming a ring boundary. | |
| | Domain Spatial Address Type [M] | System employed to specify the domain spatial addresses. | A | INTERNAL | Internal spatial addresses are used. | DSTP |
| | | | | EXTERNAL | Spatial addresses are in the form defined in the external spatial reference module. | |
| | Comment | Free-form comment subfield. | A | Gr-chars | Any combination of graphics characters. | COMT |
| (-)Domain Spatial Address (O) [M] | | Spatial address of spatial domain boundary vertex. The ordering required for the instances of the field relates to the proper sequence of the vertices for describing the boundary. | | | When the Domain Spatial Address Type is EXTERNAL, the formats of the geospatial subfields, X, Y, and Z, will be (I or R). | DMSA |

## Table 22 - Data dictionary/definitionmodule specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Data Dictionary/ Definition (P) [M] | | | | | | DDDF |
| | Module Name [M] | Unique name for the Data Dictionary/ Definition module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Entity or Attribute [M] | Indicates whether the module record contains an entity or attribute definition. | A | ENT<br>ATT | Definition is for entity.<br>Definition is for attribute or cell value. | EORA |
| | Entity/Attribute Label [M] | Entity or attribute label. | A | Gr-chars | Any combination of graphics characters; wildcard characters may be used and are always taken as wildcards. | EALB |
| | Source | Source for the definition. | A | Gr-chars | Any combination of graphics characters. | SRCE |
| | Definition [M] | Definition of the attribute or entity denoted by the contents of the Entity/Attribute subfield. | A | Gr-chars | Any combination of graphics characters. | DFIN |
| | Attribute Authority [M] | Name of the attribute (or entity) authority. If the authority is another FIPS standard, specify FIPS in this subfield, and give a full reference in the ADSC subfield. | A | FIPS<br>Gr-chars | Authority is a FIPS.<br>Any combination of at most eight graphics characters. | AUTH |
| | Attribute Authority Description [M/ ADSC=FIPS] | Full description of the attribute (or entity) authority. | A | Gr-chars | Any combination of graphics characters. | ADSC |

## Table 23 - Data dictionary/domain module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Data Dictionary/ Domain (P)[M] | | | | | | DDOM |
| | Module Name [M] | Unique name for the Data Dictionary/ Domain module. | A | Alphanum | Name must begin with an alphabetic character other than a SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Attribute Label [M] | Attribute label. | A | Gr-chars | Subfield name as in the Attribute Primary, Secondary and Cell modules must conform to the SQL standard as described in 4.1.3.6.8. The Attribute Label subfield must contain, if necessary, a concatenation of the field and subfield mnemonics for the representation index separated by a slash for domain types dd: for case (i) in section 4.2.1. | ATLB |
| | Attribute Authority [M] | Name of the attribute authority. | A | Gr-chars | Any combination of at most eight graphics characters. | AUTH |
| | Attribute Domain Type [M] | Attribute Domain Type. If the authority is another FIPS standard which contains standard codes for attribute values, specify FIPSCODE in this subfield. | A | GR-CHARS<br>ALPHANUM<br>ALPHABET<br>INTEGER<br>REAL<br>BINARY<br>ENUMERATED<br>FIPSCODE | | ATYP |

## Table 23 - Data dictionary/domain module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Note: the contents of the Attribute Domain Value Format subfield must be the same in all records specifying the same attribute (where the Attribute Label and Attribute Authority subfield contents are equivalent). | | | | | | |
| | Attribute Domain Value Format [M] | Attribute domain value format. | A | A<br>I<br>R<br>S<br>B<br>BI8<br>BI16<br>BI24<br>BI32<br>BUI8<br>BUI16<br>BUI24<br>BUI32<br>BFP32<br>BFP64<br>C | Graphics Characters<br>Implicit-point (integer)<br>Explicit-point unscaled<br>Explicit-point scaled<br>Bitfield data<br>8-bit signed integer<br>16-bit signed integer<br>24-bit signed integer<br>32-bit signed integer<br>8-bit unsigned integer<br>16-bit unsigned integer<br>24-bit unsigned integer<br>32-bit unsigned integer<br>32-bit floating point real<br>64-bit floating point real<br>Character mode bitfield | ADVF |
| | Attribute Domain Value Measurement Unit | Measurement unit of attribute domain value. | A | Gr-chars | Any combination of graphics characters. | ADMU |
| | Range or Value [M] | Indicates whether the value is single value or the maximum or minimum of a range. | A | MIN<br>MAX<br>VALUE | Value is minimum of a range or subrange.<br>Value is maximum of a range or subrange.<br>Value of the specified domain with specific significance described in the Domain Value Definition subfield. | RAVA |

## Table 23 - Data dictionary/domain module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Domain Value [M] | Possible value of lower or upper range limit for the attribute value. Subfield only applies when range, enumerated or code set domain. When a code set is used, contains the name of the code set. | A\|I\|R<br>S\|B\|C | Gr-chars<br>Integer<br>Real<br>Binary<br>NULL | As indicated by Attribute Domain Value Format.Value may be intermittently absent or field or subfield may be intermittently empty. | DVAL |
| | Domain Value Definition | Definition of or description associated with the Domain Value. | A | Gr-chars | Any combination of graphic characters. | DVDF |

## Table 24 - Data dictionary/schema module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Data Dictionary/ Schema (P) [M] | | | | | | DDSH |
| | Module Name [M] | Schema module name. | A | Alphanum | Name must begin with an alphabetic character other than a SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Name [M] | Name of module with data to which the schema applies. | A | Alphanum | Name must begin with an alphabetic character and be the module name of an Attribute or Cell module. | NAME |
| | Type | Type of module with data to which the schema applies. | A | ATPR | Applies to Attribute Primary Module. | TYPE |
| | | | | ATSC | Applies to Attribute Secondary Module. | |
| | | | | CELL | Applies to a Cell Module. | |
| | Entity Label [O/Attribute Label] | Entity label of entity for which the subfield will contain an attribute value. | A | Gr-chars | Any combination of graphics characters. | ETLB |

**Table 24 - Data dictionary/schema module specification *(continued)***

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Entity Authority [O/Attribute Label] | Authority for the definition (including meaning) of the entity. | A | SDTS-USA | Part 2 of this standard is the authority for the definition of the uniquely named entity. | EUTH |
| | | | | SDTS-xxx | A standard register of entities and attributes for a country other than the United States is the authority for the definition of the uniquely named entity. "xxx" is the three-character ISO 3166 country code. | |
| | | | | Gr-chars | Any combination of up to eight graphics characters. The meaning of this code must be explained in a Data Dictionary/Definition module. | |
| | Attribute Label [M/Attribute Primary] | Name of attribute subfield | A | Gr-chars | Attribute subfield name as in the Attribute Primary, Attribute Secondary, and Cell modules. Must conform to the SQL standard as described in 4.1.3.6.8. | ATLB |

## Table 24 - Data dictionary/schema module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Attribute Authority [M/ Attribute Primary] | Authority for the definition (including meaning) of the attribute. | A | SDTS-USA | Part 2 of this standard is the authority for the definition of the uniquely named attribute. | AUTH |
| | | | | SDTS-xxx | A standard register of entities and attributes for a country other than the United States is the authority for the definition of the uniquely named attribute. "xxx" is the three-character ISO 3166 country code. | |
| | | | | Gr-chars | Any combination of up to eight graphics characters. The meaning of this code must be explained in a Data Dictionary/Definition module. | |

## Table 24 - Data dictionary/schema module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Note: The selected code must correspond to the data type and domain for the subfield in the attribute or cell module to which the schema module applies. | | | | | | |
| | Format [M/Attribute Primary] | Format for contents of attribute sub-field. | A | A<br>I<br>R<br>S<br>B<br>BI8<br>BI16<br>BI24<br>BI32<br>BUI<br>BUI8<br>BUI16<br>BUI24<br>BUI32<br>BFP32<br>BFP64<br>C<br>^ | Graphics characters<br>Implicit-point (integer)<br>Explicit-point unscaled<br>Explicit-point scaled<br>Bitfield data<br>8-bit signed integer<br>16-bit signed integer<br>24-bit signed integer<br>32-bit signed integer<br>Unsigned integer<br>8-bit unsigned integer<br>16-bit unsigned integer<br>24-bit unsigned integer<br>32-bit unsigned integer<br>32-bit floating point real<br>64-bit floating point real<br>Character mode bitfield<br>Packed foreign identifier | FMT |
| | Unit | Measurement unit for contents of attribute subfield | A | Gr-chars | Any combination of graphics characters. Any recognizable measurement unit or abbreviation for measurement unit | UNIT |
| | Precision | The minimum difference between consecutive measurements, given in same units as the values. | R | Real | | PREC |
| | Maximum Sub-field Length [M/Attribute Primary] | Maximum length of the subfield for all module records expressed as the maximum number of ASCII characters. | I | Integer | Unsigned Integer >= 1. | MXLN |

**Table 24 - Data dictionary/schema module specification** ***(continued)***

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Key [X/Type=CELL] | Indicates whether attribute is part of primary or foreign relational key. | A | NOKEY | Attribute is not part of key | KEY |
| | | | | PKEY | Attribute is part of primary key | |
| | | | | FKEY | Attribute is part of foreign key | |
| | | | | PFKEY | Attribute is part of both primary and foreign key | |

## Table 25 - Transfer statistics module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Transfer Statistics (P) [M] | | | | | | STAT |
| | Module Name [M] | A unique identifier for this Transfer Statistics module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Module Type Referred | The primary field name of the module to which the total module record count refers. | A | Alphanum | Valid primary field name. | MNTF |
| | Module Name Referred [M] | Module name of module to which the total module record count refers. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MNRF |
| | Module Record Count [O/Spatial Address Count] | Total number of module records in the module with the module name given in the Module Name Referred field. | I | Integer | Unsigned integer >= 1. | NREC |
| | Spatial Address Count [O/Module Record Count] | The total number of spatial address field instances in the module. | I | Integer | Unsigned integer >= 0. | NSAD |

## 5.3 Data Quality Modules

The Data Quality group is composed of the following modules: Lineage, Positional Accuracy, Attribute Accuracy, Logical Consistency, and Completeness. Suggestions and requirements for the Attribute field groups associated with these modules are specified in section 3.

Information on data quality can be carried at different levels of aggregation. Thus, information on quality can refer to a domain, map, theme, or an individual spatial object. The Catalog can be used to make reference to the level of specificity of the information on quality. This can be done through the use of Catalog/Cross Reference or the Catalog/Spatial Domain module subfields. There is also the provision for a data quality overlay relationship where a separate data layer provides the geometric and attribute information that applies to another data layer.

Use of all data quality modules in a data transfer is mandatory, and must include at least a statement to the effect that no data quality description is available at the time of data preparation if such a statement reflects the status of the information available.

### 5.3.1 Lineage Module

The Lineage module transfers the information described in 3.1 (see Table 26). This module may contain elaboration of the information also coded in 5.2.1, Identification. However, the transformation details must be transferred in the Spatial Reference modules (see 5.2.4).

### 5.3.2 Positional Accuracy Module

The Positional Accuracy module transfers the description of testing procedures and related details specified in 3.2 (see Table 27).

### 5.3.3 Attribute Accuracy Module

The Attribute Accuracy module transfers all information required by 3.3 (see Table 28).

### 5.3.4 Logical Consistency Module

The Logical Consistency module transfers all information required by 3.4 (see Table 29).

### 5.3.5 Completeness Module

The Completeness module transfers all information required by 3.5 (see Table 30)

## 5.4 Attribute Modules

Refer to 4.1.3.6 and Annex C for a full discussion and examples of the logical encoding of attribute modules.

### 5.4.1 Attribute Primary Module

The Attribute Primary module defines the primary attributes associated with a spatial element or object. All fields for the module record are nonrepeating and the module is therefore a relational module (see Table 31). The forward link, if present, from the spatial object through the Attribute ID field, must match the Module Name and Record ID of the primary field of the module record for this module. The backward link, if present, is provided through the Spatial Object ID field, and the contents of this field must match the module record identifier of the spatial object. The subfields of the Primary Attributes field are generic, user defined, with the description occurring in the Schema module. The number of attributes is selected by the user, but this number must not vary for a given module in a transfer.

### 5.4.2 Attribute Secondary Module

The Attribute Secondary module defines the secondary attributes associated with values of primary attributes (see Table 32). The module is also of the relational type. The Catalog/Cross-Reference module must be used to indicate associations between Attribute Primary and Attribute Secondary modules. Further association between attributes in both modules must then be made through common attributes (same name and authority) to be used in relational joins. The Data Dictionary/Schema module can be used to indicate primary and foreign key relationships between attributes in both types of modules.

## Table 26 - Lineage module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Lineage (P) [M] | | | | | | DQHL |
| | Module Name [M] | A unique module name for a Lineage module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Comment [M] | Any comments | A | Gr-chars | Any combination of graphics characters. | COMT |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module record. Attributes or comments as determined by the supplier organization in accordance with 3.1. | | | | ATID |
| (^)Foreign ID (R) | | Reference to a specific module record. | | | | FRID |

## Table 27 - Positional accuracy module specification

| Field name | Subfield name | Field/subfield d escription | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| PositionalAccu-racy (P) [M] | | | | | | DQPA |
| | Module Name [M] | A unique module name for a Positional Accuracy module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Comment [M] | Any comments. | A | Gr-chars | Any combination of graphic characters. | COMT |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module record. Attributes or comments as determined by the supplier organization in accordance with 3.2. | | | | ATID |
| (^)Foreign ID (R) | | Reference to a specific module record. | | | | FRID |

## Table 28 - Attribute accuracy module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Attribute Accuracy (P) [M] | | | | | | DQAA |
| | Module Name [M] | A unique module name for an Attribute Accuracy module. | A | Alphanum | Name must begin with an alphabetic character other than a SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Comment [M] | Any comments. | A | Gr-chars | Any combination of graphics characters. | COMT |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module record. Attributes or comments as determined by the supplier organization in accordance with 3.3. | | | | ATID |
| (^)Foreign ID (R) | | Reference to a specific module record. | | | | FRID |

## Table 29 - Logical consistency module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Logical Consistency (P) [M] | | | | | | DQLC |
| | Module Name [M] | A unique module name for a Logical Consistency module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Comment [M] | Any comments. | A | Gr-chars | Any combination of graphics characters. | COMT |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module record. Attributes or comments as determined by the supplier organization in accordance with 3.4. | | | | ATID |
| (^)Foreign ID (R) | | Reference to a specific module record. | | | | FRID |

## Table 30 - Completeness module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Completeness (P) [M] | | | | | | DQCG |
| | Module Name [M] | A unique module name for a Completeness module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Comment [M] | Any comments. | A | Gr-chars | Any combination of graphics characters. | COMT |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module record. Attributes or comments as determined by the supplier organization in accordance with 3.5. | | | | ATID |
| (^)Foreign ID (R) | | Reference to a specific module record. | | | | FRID |

## Table 31 - Attribute primary module specification

| Field name | Subfield name | Field/subfield DESCRIPTION | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Attribute Primary<br>(P)<br>[M] | | | | | | ATPR |
| | Module Name<br>[M] | A unique identifier for this Attribute Primary module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID<br>[M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| (^)Spatial Object ID<br>(N) | | Foreign identifier of spatial object with which the attribute record is associated. | | | | OBID |
| Primary Attributes<br>(N)<br>[M] | (+)attribute<br>[M] | Primary attributes for an object. | A\|I\|R<br>S\|B\|C<br>^ | Alphanum<br>Numeric<br>Bitfield | As indicated by Format in the Data Dictionary/ Schema module. Packed foreign identifier (see 4.1.3.6.7) | ATTP |

### Table 32 - Attribute secondary module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Attribute Secondary (P) [M] | | | | | | ATSC |
| | Module Name [M] | A unique identifier for this Attribute Secondary module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| Secondary Attributes (N) [M] | (+)attribute [M] | Secondary attributes associated with primary attribute. | A\|I\|R S\|B\|C ^ | Alphanum Numeric Bitfield | As indicated by Format in the Data Dictionary/ Schema module. Packed foreign identifier (see 4.1.3.6.7) | ATTS |

## 5.5 Composite Module

The Composite module is used to transfer composite objects (see 2.3). It serves to transfer user-defined composite data in ways that cannot be accomplished with the Point-Node, Line, Polygon, Ring, Arc, or Raster modules alone. A composite object is composed of zero, one, or more other spatial objects, either vector or raster, simple or composite. Using this module, spatial objects are aggregated to make a more complex spatial object; therefore, composite objects do not carry any coordinate data within the module record (see Table 33).

Composite objects are given the Object Representation Code "FF".

## 5.6 Vector Modules

The vector modules are designed for the transfer of vector data as objects; that is, each module record defines a vector object including links to its component parts as well as a possible direct link to its attribute data.

The vector objects of 2.3 have been grouped into corresponding modules according to the similarity in data fields required to represent the object.

Aside from attributes, the modules that implement the vector-based spatial objects are: Point-Node, Line, Arc, Ring, Polygon, and Composite.

As more than one type of object can be stored in each type of module, the type of object represented is expressed through an object representation code. Table 34 summarizes the assignment of vector-based objects to modules and lists the object representation code for each.

The vector-based spatial objects may include both the downward "is composed of" definition in the composite module and the upward "composes" definition in the Point-Node, Line, Arc, Ring, and Polygon modules.

### 5.6.1 Point-Node Module

The Point-Node module must be used to transfer points of the following type: generic point, entity point, label point, area point, and node (see Table 35).

### 5.6.2 Line Module

The Line module must be used to transfer spatial objects of the following type: string, link, complete chain, area chain, and network chain (both planar and nonplanar) (see Table 36).

When the object type is that of a chain (LE, LL, LW, or LY), the Chain Component ID field may be used instead of or in addition to the Spatial Address field. The Chain Component ID then refers to records in other Line or Arc modules.

This allows for the transfer of a chain entirely composed of arcs, or a chain made up of a mixture of arcs and strings.

## Table 33 - Composite module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Composite (P) [M] | | | | | | COMP |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | Composite object record identifier. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Object Representation [M] | Representation code for the object. | A | FF | A constant value of "FF" for composite objects. | OBRP |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module record. | | | | ATID |
| (^)Foreign ID (O) | | Foreign identifier of module record for object that is a part of this composite. The order of the instances of this field is significant when referencing linear objects; the order indicates the sequence of construction of the composite object in terms of its component objects. | | | | FRID |
| (^)Composite ID (R) | | Foreign identifier of Composite module record that includes this composite object. | | | | CPID |

**Table 34 - Modules and vector-based object representations**

| Module type | Object representation | Representation Code |
|---|---|---|
| Point-Node | Point | NP |
| | Entity point | NE |
| | Label point | NL |
| | Area point | NA |
| | Node, planar graph | NO |
| | Node, network | NN |
| Line | String | LS |
| | Link | LQ |
| | Complete chain | LE |
| | Area chain | LL |
| | Network chain, planar graph | LW |
| | Network chain, nonplanar graph | LY |
| Arc | Circular arc, three point center | AC |
| | Elliptical arc | AE |
| | Uniform B-spline | AU |
| | Piecewise Bezier | AB |
| Ring | Ring with mixed composition | RM |
| | Ring composed of strings | RS |
| | Ring composed of chains | RU |
| | Ring composed of arcs | RA |
| Polygon | G-polygon | PG |
| | GT-polygon composed of rings | PR |
| | GT-polygon composed of chains | PC |
| | Universe polygon composed of rings | PU |
| | Universe polygon composed of chains | PW |
| | Void polygon composed of rings | PV |
| | Void polygon composed of chains | PX |

## Table 35 - Point-node module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Point-Node (P) [M] | | | | | | PNTS |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | Point object record identifier. | I | Integer | Unsigned integer. With Module Name must form unique ID within the file set. | RCID |
| | Object Representation [M] | Representation code for the object. | A | NP<br>NE<br>NL<br>NA<br>NO<br>NN | Point<br>Entity point<br>Label Point<br>Area Point<br>Node, planar graph<br>Node, network | OBRP |
| (-)Spatial Address (N) [M/NP\|NE\|NL\|NA] | | Spatial address of point (single spatial address). | | | | SADR |
| (^)Attribute ID (R) [M/NL] | | Foreign identifier for Attribute Primary module record. | | | | ATID |
| (^)Line ID (O) [X/NP\|NE\|NL\|NA] | | Contains foreign identifier of line associated with the node. The required ordering for the instances of this field relates to the occurrence of adjacent lines around the node. | | | | LNID |
| (^)Area ID (O) [X/NP\|NN] | | Contains foreign identifier of area or polygon associated with the node, area point, label point, or entity point. The required ordering for the instances of the field relates to the occurrence of adjacent areas around the node. | | | | ARID |

*(continued)*

## Table 35 - Point-node module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| (^)Composite ID (R) | | Contains foreign identifier of Composite module record that includes this Point-Node. | | | | CPID |
| (^)Representation Module ID (O) | | Contains foreign identifier of the Representation module record. | | | | RPID |
| (-)Orientation Spatial Address (O) [X/ NP\|NE\|NA\|NO\|NN] | | Spatial address of orientation point. This point combined with the location point determines the angle of the text string. If omitted, the text string is placed horizontally. If more than one point is provided, then these points combined with the location point define a curve along which the text string is placed. If a total of three points are provided, the location point is the start point of the circular arc. The first orientation point is an intermediate point on the circular arc between the location point and the second orientation point, which lies on the circular arc. If more than three points are provided, the arc is defined as a second order piecewise Bezier arc. | | | | OSAD |
| (^)Attribute Primary Foreign ID (O) [X/ NP\|NE\|NA\|NO\|NN] | | Contains foreign identifier of the Attribute Primary module record that includes the attribute to be annotated. | | | | PAID |

*(continued)*

## Table 35 - Point-node module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | (N)Attribute Label (O) [X/ NP\|NE\|NO\|NN ] | Name of attribute subfield to be annotated. | A | Gr-chars | Attribute subfield name as in the Attribute Primary and Secondary modules. | ATLB |
| (-)Symbol Orientation Spatial Address (N) [X/NL] | | Spatial address of orientation point (single spatial address). This point combined with the location point determines the angle of symbol representing the point. If omitted, the symbol is placed horizontally. | | | | SSAD |

*(continued)*

## Table 36 - Line module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain escription | Mnemonic |
|---|---|---|---|---|---|---|
| Line (P) [M] | | | | | | LINE |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | Line object record identifier. | I | Integer | Unsigned integer. With Module Name must form unique ID within the file set. | RCID |
| | Object Representation [M] | Representation code for the object. | A | LS<br>LQ<br>LE<br>LL<br>LW<br>LY | String<br>Link<br>Complete chain<br>Area chain<br>Network chain, planar grph<br>Network chain, nonplanar | OBRP |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module record. | | | | ATID |
| The following two fields are to be used for complete and area chains (object representation codes LE and LL) and must reference the topologically correct GT-Polygons (see 2.3.4.5.2, Two-dimensional Manifold). | | | | | | |
| (^)Polygon ID Left (N) [M/LE\|LL][X/LS\|LW\|LY\|LQ] | | Foreign identifier of left Polygon or Area Point module record. | | | | PIDL |
| (^)Polygon ID Right (N) [M/LE\|LL][X/LS\|LW\|LY\|LQ] | | Foreign identifier of right Polygon or Area Point module record. | | | | PIDR |

*(continued)*

## Table 36 - Line module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain escription | Mnemonic |
|---|---|---|---|---|---|---|
| The following two fields are to be used for links and for complete and network chains (object representation codes LQ, LE, LW and LY) and must reference the topologically correct nodes (see 2.3.4.5, graph). | | | | | | |
| (^)Startnode ID (N) [M/ LE\|LW\|LY\|LQ][X/ LS\|LL] | | Foreign identifier of start node Point-Node module record. | | | | SNID |
| (^)Endnode ID (N) [M/ LE\|LW\|LY\|LQ][X/ LS\|LL] | | Foreign identifier of end node Point-Node module record. | | | | ENID |
| (^)Chain Component ID (O) [X/LS\|LQ][O/ LE\|LL\|LW\|LY/Spatial Address] | | Foreign identifier of module record of other Arc or Line module. The order of the instances of this field indicates the sequence of construction of the chain composed of arcs, or of strings and arcs. | | | | CCID |
| (-)Spatial Address (O) [M/LS] [X/LQ] [O/LE\|LL\|LW\|LY/ Chain Component ID] | | Spatial address of line point. The order of the instances of this field indicates the construction of the line in terms of vertices. Note that even if the line module record includes foreign identifiers of the nodes (for chains and links), the spatial addresses of the nodes, although redundant, must be included here. | | | | SADR |
| (^)Composite ID (R) | | Foreign identifier of Composite module record which includes this line. | | | | CPID |
| (^)Representation Module ID (O) | | Contains foreign identifier of the Representation module record. | | | | RPID |

*(continued)*

### 5.6.3 Arc Module

An Arc module must be used to transfer the arc object as defined in 2.3.2.3. Arc modules are used to transfer only the geometry of the curved line and rudimentary attributes (see Table 37). If topology is required, then a chain must be used to reference the appropriate Arc module record, and the topology must be associated with the chain object.

An Arc module must be used to transfer arcs of the following types:

AC Circular arc
AE Elliptical arc

and other curves of the following types:

AU Uniform B-Spline
AB Piecewise Bezier

For both circular and elliptical arcs, the start and end addresses must occur in counterclockwise order. Total sweep angle for circular arcs and elliptical arcs must be less than or equal to 360 degrees.

NOTE - For circular arcs, radius and start vector are defined by the start address. Arcs with a sweep angle of 360 degrees have the same start and end addresses.

The Order subfield must not be used with circular arcs or elliptical arcs.

All parametric descriptions must apply only to the horizontal components of the spatial address. All other components may be encoded; however, these components must be ignored in reconstructing objects based on these descriptions.

### 5.6.4 Ring Module

The Ring module must be used to transfer the ring object as described in 2.3.2.6. A ring is defined to consist of either strings, arcs, or chains, which are one-dimensional line objects. However, four types of chains can be represented in the Line module, and arcs can be referenced directly, or indirectly as components of chains (see Table 38). The Object Representation Codes for Rings are "RM" for a ring of mixed composition, "RS" for a ring of strings, "RU" for a ring of chains (any type), and "RA" for rings directly composed of arcs. Because strings, arcs, and chains are all stored in the Line module or can be referenced through the Line module, the composition of a Ring is primarily expressed as a sequence of Line foreign identifiers. But Rings can be expressed in the form of arcs as well, so that the same foreign identifier field may be used to refer to Arc module records. Because rings are parts of polygons that themselves can be linked to attributes, there is no forward attribute link provided in this module.

### 5.6.5 Polygon Module

The Polygon module must be used to transfer polygons as defined in 2.3.3. There are two types of polygons: G-polygons, and GT-polygons. Geometry only polygons (G-polygons) consists of one outer ring, and zero or more inner rings. This module therefore contains a secondary field that is a foreign identifier for its member rings. The order of the rings is significant. The outer ring must occur first, followed by the inner rings, if any (see Table 39).

The geometry-topology polygons (GT-polygons) can also be transferred in terms of constituent rings, but an alternative is to use chains instead of rings. For this purpose the module has a secondary field that is a foreign identifier for its member chains. The order of the chains is significant but is not specified. Either one or the other method may be used, so that in a given module either the Ring ID field or the Chain ID field may be present, but not both. When rings are used for GT-polygons, the ordering requirements are the same as for G-polygons.

.

## Table 37 - Arc module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Arc (P) [M] | | | | | | ARC |
| | Module Name | A unique identifier for this Arc module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID | Arc object record identifier. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Object Representation | Representation code for the object. | A | AC | Circular arc, three point center. | OBRP |
| | | | | AE | Elliptical arc. | |
| | | | | AU | Uniform B-spline. | |
| | | | | AB | Piecewise Bezier. | |
| | Surface | Indicates the type of surface on which the reconstruction must take place. | A | PLAN | PLANAR; reconstruction of arc occurs only on a planar surface. | SRFC |
| | | | | ELIP | ELLIPSOIDAL; reconstruction of arc occurs on an ellipsoidal surface. | |
| | Order [X/AC\|AE] | Value of the largest exponent in the parametric expression. | I | Integer | <9, positive value indicating the value of the largest exponent in the parametric expression. | ORDR |
| (-)Arc Address (N) [M/AC\|AE] [X/AU\|AB] | The following field contains three spatial addresses, either six (if x,y) or nine (if x,y,z) subfields | | | | | ARAD |
| | (-)Center Address | Spatial address of the center point of the arc. | | | | CTAD |
| | (-)Arc Start Address | Spatial address of the start point of the arc and also defining the start vector. | | | | STAD |

*(continued)*

## Table 37 - Arc module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | (-)Arc End Address | Spatial address of the end point of the arc and also defining the end vector. | | | | ENAD |
| Ellipse Address (N) [M/AE] [X/AC\|AU\|AB] | | | | | | ELAD |
| | (-)Conjugate Diameter Point - Major Axis | Spatial address of a point on the major axis and the ellipse. | | | | MJRA |
| | (-)Conjugate Diameter Point - Minor Axis | Spatial address of a point on the minor axis (placed perpendicular to the major axis) and the ellipse. | | | | MNRA |
| (-)Curve Address (O) [M/AU\|AB] [X/AC\|AE] | | Spatial address for control points on curve. | | | | CADR |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module record | | | | ATID |
| (^)Composite ID (R) | | Foreign identifier of composite module record which includes this arc. | | | | CPID |
| (^)Representation Module ID (O) | | Contains foreign identifier of the Representation module record. | | | | RPID |

*(continued)*

**Table 38 - Ring module specification**

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Ring (P) [M] | | | | | | RING |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | Ring object record identifier. | I | Integer | Unsigned integer; with Module Name must form a unique ID within the file set. | RCID |
| | Object Representation [M] | Representation code for the object. | A | RS<br>RU<br>RA<br>RM | Ring of strings.<br>Ring of chains.<br>Ring of arcs.<br>Ring of mixed composition. | OBRP |
| (^)Line or Arc Foreign ID (O) [M] | | Foreign identifier of Line or Arc module record for line or arc object as part of the ring. The order of the instances of this field indicate the sequence of construction of the ring in terms of its line in a clockwise direction with reference to the interior of the ring. | | | | LAID |
| (^)Polygon ID (R) [M] | | Foreign Identifier of a polygon of which the ring is a part. | | | | PLID |

## Table 39 - Polygon module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Polygon (P) [M] | | | | | | POLY |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with alphabetic character other than SPACE. | MODN |
| | Record ID [M] | Polygon object record identifier. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Object Representation [M] | Representation code for the object. | A | PG<br>PR<br>PC<br>PU<br>PW<br>PV<br>PX | G-Polygon.<br>GT-Polygon, rings.<br>GT-Polygon, chains.<br>Universe polygon, rings.<br>Universe polygon, chains.<br>Void polygon, rings.<br>Void polygon, chains. | OBRP |
| (^)Attribute ID (R) | | Foreign identifier for Attribute Primary module Record. | | | | ATID |
| (^)Ring ID (O) [M/PR][X/PC] | | Foreign identifier of Ring module record for ring object as part of the polygon. Order is significant, the outer ring must be referenced first. | | | | RFID |
| (^)Chain ID [X/PR\|PU\|PV] | | Foreign identifier of Line module record for chain object as part of the polygon. Order is significant, but not specified. | | | | CHID |
| (^)Composite ID (R) | | Foreign identifier of Composite module record that includes this polygon. | | | | CPID |
| (^)Representation Module ID (O) | | Foreign identifier of the Representation module record. This representation module refers to the area fill representation. The boundary is represented via the line object. | | | | RPID |

## 5.7 Raster Modules

The raster modules can accommodate image data, digital terrain models, gridded GIS layers, other gridded data, and a voxel space. For the purposes of this specification, raster, grid, voxel space, or image data will all be referred to as raster data. A raster object may consist of different layers, each layer being composed of a number of grid cells, pixels, voxels, or n-dimensional cells (See 2.3.4.3), henceforth to be referred to as cells, arranged in an array.

Many different types of organizational schemes exist for raster data. To distinguish between the main aspects of these schemes, the concept of an object representation code has been carried through to this transfer form. A two-dimensional grid or digital image is object code G2. A three-dimensional voxel space is a G3. A two or three dimensional grid that varies (has discrete labeled axes) is a GV.

A raster object consists of one or more related layers of cells arranged in such a way that corresponding cells between layers are registered to a common scan reference system (to be defined) and overlap, but need not be of the same spatial extent.

There are three different types of raster modules: the Raster Definition module, the Layer Definition module, and the Cell module. A typical transfer of a raster object can require one Raster Definition module, one Layer Definition module, several Cell modules, one Internal Spatial Reference module, one External Spatial Reference module, the Data Dictionary modules, as well as other miscellaneous modules. A Raster Definition module record must reference one or more layers. Each Layer Definition record must reference one Cell Module or equivalent. One Cell Module must only contain cells from one layer, unless the layers are interleaved, in which case it must contain cells from all.

### 5.7.1 Raster Definition Module

The Raster Definition module (see Table 42) is used to define each raster object in the system. One Raster Definition module record corresponds to one raster object. A raster object is defined by one or more layers, as defined in the Layer Definition module. The raster object internal reference system is defined by the Internal Spatial Reference record pointed to by the Raster Definition records Internal Spatial ID field.

Raster objects are usually two dimensional, but this standard also supports additional dimensions as needed. The additional dimensions for a raster object are defined by having the coresponding Internal Spatial Reference record point to each additional dimension through the Dimension ID field. All dimensions, geospatial and nongeospatial, are defined through the Internal Reference module and the Dimension Definition module, respectively.

The registration of a raster object is defined by two categories of information; the location, Spatial Address (SADR), of the origin of the scan reference system, and the size of the raster objects cells. The cell size is derived from the Internal Spatial Reference record and/or Dimension Definitions record(s) pointed to by a raster object. If any of the dimension's cell sizes are zero, that dimension, geospatial or nongeospatial, will be explicitly labeled using the corresponding repeating Label field. The number of repetitions of the Label fields is determined by the value found in the Corresponding Extent subfield, i.e. for each position a cell might reside along the axis an associated registration value will be defined. Labeling is only permitted for the following Object Representation Codes: GV.

The main components of the Raster Definition module are:

a) a primary field consisting of subfields defining the geospatial dimensions of the raster object scan reference system as well as global cell sequencing parameters,

b) an Internal Spatial Id field pointing to the Internal Spatial Reference record defining all dimensions of the raster object,

c) a repeating nongeospatial raster extent field, used to describe the nongeospatial dimensions of the raster object scan reference system,

d) a Spatial Address field used to locate the origin of the raster object scan reference system,

e) a repeating X-Axis label field used when the resolution along the X-Axis is not fixed, each position along the grid will be explicitly labeled here. Similarly for all dimensions.

f) a repeatable Layer ID field; each field points to the Layer Definition module record which define the layers of this raster object.

### 5.7.2 Layer Definition Module

Each Layer Definition module record (see Table 43) describes one layer of a raster. The format, definition and domain of the layer are stored in the respective Data Dictionary modules. The Attribute Label subfield found in the Data Dictionary modules will contain the name of the layer as it appears in the Layer Label subfield of the Layer Definition record, thereby making it possible to relate the Data Dictionary records to the Layer Definition records. Each record in this module will be referenced by only one Layer ID field from the Raster Definition module, thereby making it impossible to reuse the Layer Definition records for multiple raster objects. Each record of the Layer Definition module will be uniquely identified by the name of the layer in conjunction with the name of the cell module into which the cell values for the layer will reside. The information found in this module will define the layer scan reference system.

The main components of the Layer Definition module are:

a) primary field consisting of subfields pertaining to the entire layer,

b) an optionally repeating Layer Extent field used to describe the extents of the layer for nongeospatial dimensions, as described in the corresponding Dimension Definition module. The extents for geospatial dimensions are described in the primary field, separate from the nongeospatial dimensions, and

c) a repeating Layer Attribute ID for attributes of the layer.

### 5.7.3 Cell Module

The Cell module contains the actual data values for the raster (see Table 44).

The module record of the Cell module has been designed so that each module record can hold information on a number of related cells. Designating these related cells as a "stream" to facilitate the following explanation, examples of a stream are a single scan line of an image, a number of layer-interleaved scan lines as a part of an image, a single cell, a block of a quad tree, or even an entire layer of a raster. A stream does not necessarily start at the beginning of a line or row, but can start in the middle of row i, proceed through rows i through n - 1, and terminate somewhere in row n. If the raster object is of three or greater dimensions then the order of cells in the module may be affected by the order Dimension ID fields are found in the corresponding Internal Spatial Reference record for the raster object (see Annex F).

The main components of the Cell module are:

a) a primary field with the number of cells per record and a row, a column and a plane index; the index is used to locate the first cell in the record inside of the layer scan reference system,

b) a repeating Dimension Index field used to locate the first cell in the record inside the layer scan reference system for the dimension,

c) an attribute foreign identifier for the stream, and

d) a Cell Values field with a number of layer subfields, each to be repeated for each cell value. The attribute link can be used, for instance, to store ancillary data with a layer interleaved scan line, or it can be used to associate a full set of attributes with each run encoded cell.

### 5.7.4 Object Representation Codes

Any of the object representation codes may be used, but their use is dependent on the configuration of the Internal Spatial Reference record pointed to by the RSDF/ISID. Table 40 summarizes the rules for each object representation code:

The Internal Spatial Reference module must be consistent with the Object Representation Code selected. The Object Representation Code will be used to configure the Raster modules for encoding the raster data.

### 5.7.5 Default Implementation

The Raster Definition and Layer Definition modules have a strongly recommended default implementation in which a number of subfields have default values. Subfields with a default value are indicated by the symbol "(d)" preceding the field name in the module specification table, as defined in 4.2.3.7. Table 41 - lists the subfields values that must be present when the default implementation is used

### 5.7.6 Tesseral Indexing.

The use of the raster portion of the standard is not restricted to raster transfer using a row-column layout. Rasters can be divided into tiles of regular or irregular size and can be transferred on a tile basis. To fit this type of organization into the SDTS model, each tile is equated with a stream. Each stream (tile) can be preceded by a row-column address, or alternately, a tesseral index can be used. A tesseral index is not the equivalent of a row and column address, because the index can contain the extent of the tile as well through the use of wildcard components. The type of tesseral index must conform to the contents of the Scan Pattern subfield of the Raster Definition module and can, therefore, only be a Linear, Boustro, Morton, or Peano key.

Use of tesseral indexing must be indicated through the Tesseral Indexing Description subfield, and the type of data structure, particular method, and meaning of the index digits must be specified in the Tesseral Index Format subfield.

### 5.7.7 Cell Encoding.

Various methods are possible for assigning a unique attribute value to each cell in a raster. The Cell Encoding Type subfield of the Raster Definition module specifies the method used. The possible values are: "L", indicating that the presence or absence of the attribute is coded for each cell; "D", indicating that the value assigned occupies the greatest area of the cell; "F", indicating that the value assigned is the one that occurs most frequently within the cell; "V", indicating that the value is a continuous numeric variable measured at the center of the cell; or "X", indicating that the value is a code representing a value defined in a corresponding Data Dictionary/Domain module.

### 5.7.8 Registration of Cell Values to the External Reference system.

Spatial referencing for raster data must be governed by parameters transferred in the Spatial Reference modules. For raster data with a known and expressed relationship to latitude and longitude, spatial registration conformance level 2 (See 5.2.4.2) might be the best registration level, allowing the raster data to remain untransformed in a specified projection that is not one of the three preferred systems (GEO, UTM/UPS, or SPCS). Use of one of these three preferred systems might result in a loss of information because of transformation.

For complete details on converting from raster coordinate systems to internal coordinates see Annex F.

### 5.7.9 Radiometric Information.

For remotely sensed images, radiometric infoirmation is of utmost importance for the correct utilization of the imagery. There is no standardized set of radiometric parameters. Therefore producer defined attributes can be used to encode radiometry.

### 5.7.10 Alternate Formats: Compression and Adjunct Files.

This standard permits raster data to be compressed. It also permits file encodings for raster data other than prescribed in Part 3. Compression methods and alternate file formats can be used independently. The method and details for decompressing or reading the alternate format must be specified by a profile document. The use of compression and (or) use of adjunct files is indicated in the Raster Definition module and thus applies to the entire raster. The Layer Definition module references the specific Cell module for part 3 encodings or a file id for adjunct file. The logical id can then be used to look up the physical file name in the Catalog/Directory module.

#### 5.7.10.1 Run Length Encoding

The Run Length Encoding method of compressing cell values is specified in this standard as a permitted (optional) method of compression. The use of Run Length Encoding is indicated by placing the value “RLE” in the Data Compression Method subfield of the Raster Definition Module. Run length encoding is a method where a cell value and a run count is given that indicates the number of consecutive cells with the same value. This method is most applicable to gridded raster data which is not interleaved with other raster layers. The meaning of “consecutive cells” is dependent on the overall cell ordering as described by the subfields of the applicable Raster Definition and Layer Definition module records.

For RLE, the two subfields of the Cell Values field of the Cell Module must be (1) a user-defined cell value subfield (for example, LANDUSE, SOILTYPE, or WETLANDTYPE) and (2) a subfield named RLECOUNT.

## Table 40 - Rules to configure the internal spatial reference record for the various types of raster object representation codes

| | The internal spatial reference record will be configured as: | | | | |
|---|---|---|---|---|---|
| **Object rep. code** | **X** | **Y** | **Z** | **Dimension ID[1]** | **Resolution[2]** |
| G2 | Yes | Yes | No | Optional | Nonzero |
| G3 | Yes | Yes | Yes | Optional | Nonzero |
| GV | Yes | Yes | No | Optional | Some Zero |
| GV | Yes | Yes | Yes | Optional | Some Zero |

1) This use of the Dimension ID field is optional but, if it is used, it will apply to all layers of the raster.

2) Nonzero - All dimensions will have nonzero resolutions.
Some Zero - At least one dimensions resolution will be zero

## Table 41 - Mandatory values for default raster implementation

| Module | Subfield name | Default[1] |
|---|---|---|
| Raster | Scan Origin | TLor TLZN[2] |
| | Scan Pattern | LINEAR |
| | Tesseral Indexing | NOTESS |
| | Number of Lines per | 1 |
| | First Scan Direction | R or RC[2] |
| | Aspect Ratio | 1 |
| | Dimension Scan Origin | NP |
| | Data Compression | NON |
| Layer | Scan Origin Row | 1 |
| | Scan Origin Column | 1 |
| | Scan Origin Plane | 1 |
| | Scan Origin Dimension | 1 |
| | Row Offset Origin | 0 |
| | Column Offset Origin | 0 |
| | Plane Offset Origin | 0 |
| | Dimension Offset Origin | 0 |
| | Intracell Reference | TL or TLF[2] |
| | Dimension Intracell Reference | F |

1) Not all default implementation values are relevant for all Object Representation codes, because not all subfields will not be present for all Object Representation codes.

2) The first value is used when the raster uses the two geospatial dimensions, X and Y. The second value is used when all three geospatial dimensions are used, X, Y, and Z.

## Table 42 - Raster definition module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Raster Definition (P) [M] | | | | | | RSDF |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with alphabetic character other than SPACE | MODN |
| | Record ID [M] | Raster object record identifier. | I | Integer | Unsigned integer; with Module Name must form a unique ID within the file set. | RCID |
| | Object Representation [M] | Representation code for the raster object. (must be the same for all layers referenced) | A | G2<br>G3<br>GV | 2-D geospatial grid or image.<br>3-D voxel space.<br>Rectangle variant grid. | OBRP |
| | Cell Sequencing Code [M] | A code which indicates how cells will be sequenced in the Layers (i.e. between their Cell modules.) | A | GI<br>GJ<br>GL | Layer sequential.<br>Layer interleaved by line.<br>Layer Interleaved by pixel. | CSCD |
| | Acquisition Device/Method | Sensor or acquisition device from which the data originated and method by which the data were acquired/processed. | A | Gr-chars | Any combination of graphics characters. | AQMD |
| | Acquisition Date | Acquisition date for the data. | A | cs:FIPSPUB4 | FIPSPUB 4 specified date. | AQDT |
| | Comments | Any desired comments pertaining to the entire raster. | A | Gr-chars | Any combination of graphics characters. | COMT |
| | Default Implementation [M] | Signifies whether the module version is a default implementation or not. (See 5.7.5) | A | DEF<br>NON | Default Implementation<br>Nondefault Implementation | DEFI |
| Note: The next four subfields describe the data encoding; must be the same for all layers referenced. | | | | | | |
| | (d)Data Compression [M/DEFI=NON] | Signifies whether data compression is in effect or not. | A | COM<br>NON | Compressed raster data.<br>Raster data not compressed. | CMPR |

*(continued)*

# Table 42 - Raster definition module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Data Compression Method [A/ CMPR=NON] | Description of the compression method used; applies to the entire raster being described. | A | RLE<br>Gr-chars | Run length encoding as described in 5.7.10.1.<br>Compression method as identified by a profile. | CMMD |
| | (^)Decompression Parameters | Foreign id to Attribute record containing parameters needed to decompress raster data. (As required by a profile.) | | | | DCOM |
| | (d)Coding Method | Indicates whether raster data is encoded in files according to SDTS Part3 (ISO 8211)--the default, or whether another file format is in use (adjunct file). | A | ISO8211<br>Gr-chars | Raster data in Part3/ISO8211.<br>Raster data in another format as specified by a profile. | METH |
| Note: The following three subfields describe the size of the raster object, within which all raster layers belonging to the raster object reside. | | | | | | |
| | Row Extent [M] | Number of rows in the union of the geospatial extent of all layers, including the origin of the scan reference system. | I | Integer | Unsigned integer >= 1. | RWXT |
| | Column Extent [M] | Number of columns in the union of the geospatial extent of all layers, including the origin of the scan reference system. | I | Integer | Unsigned integer >=1. | CLXT |
| | Plane Extent [A/G2] | Number of planes in the union of the geospatial extent of all layers, including the origin of the scan reference system. | I | Integer | Unsigned integer >= 1. | PLXT |

*(continued)*

## Table 42 - Raster definition module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | (d)Scan Origin [M] | Location of the first cell with respect to the image viewed as a rectangle. Orientation of the raster object scan reference system with respect to the internal reference system. | A | TL | [2-d] Origin top left. | SCOR |
| | | | | TR | [2-d] Origin top right | |
| | | | | BL | [2-d] Origin bottom left | |
| | | | | BR | [2-d] Origin bottom right | |
| | | | | TLZN | [3-d] Top left Z-neg to pos | |
| | | | | TLZP | [3-d] Top left Z-pos to neg | |
| | | | | TRZN | [3-d] Top right Z-neg to pos | |
| | | | | TRZP | [3-d] Top right Z-pos to neg | |
| | | | | BLZN | [3-d] Bottom left Z-neg to pos | |
| | | | | BLZP | [3-d] Bottom left Z-pos to neg | |
| | | | | BRZN | [3-d] Bottom right Z-neg to pos | |
| | | | | BRZP | [3-d] Bottom right Z-pos to neg | |
| | (d)Scan Pattern | Scan pattern for the raster. | A | LINEAR | Scan by row or by column (begin-end-begin-end..). | SCPT |
| | | | | BOUSTRO | Boustrophedonic scan order (begin-end-end-begin..). | |
| | | | | MORTON | Morton or Z order. | |
| | | | | PEANO | Hilbert-Peano order. | |
| | (d)Tesseral Indexing [M] | Signifies whether tesseral indexing is used or not. | A | TESS<br>NOTESS | Tesseral indexing used.<br>No tesseral indexing used. | TIDX |

*(continued)*

## Table 42 - Raster definition module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Tesseral Index Format [A/Tesseral Indexing = NOTESS] | Format for the tesseral index. | A | I<br>B<br>BI8<br>BI16<br>BI24<br>BI32<br>BUI<br>BUI8<br>BUI16<br>BUI24<br>BUI32<br>C | Implicit-point (integer)<br>Binary<br>8-bit signed integer<br>16-bit signed integer<br>24-bit signed integer<br>32-bit signed integer<br>Unsigned integer<br>8-bit unsigned integer<br>16-bit unsigned integer<br>24-bit unsigned integer<br>32-bit unsigned integer<br>Character mode bitfield | TIFT |
| | Tesseral Indexing Description [A/Tesseral Indexing = NOTESS] | Gives further information on data structure, indexing method, and meaning of index components. | A | Gr-chars | Any combination of graphics characters. | TIDS |
| | (d)Number of Lines per Alternation | Number of line per alternation in the scan pattern. | I | Integer | Unsigned integer >= 1 | ALTN |
| | (d)First Scan Direction [M] | Direction (row or column) of the first scan. | A | 2-d geospatial choices: | | FSCN |
| | | | | R | First scan proceeds by row. | |
| | | | | C | First scan proceeds by column. | |
| | | | | 3-d geospatial choices: | | |
| | | | | RC | Expand by Row, Column Plane | |
| | | | | CR | Expand by Column, Row, Plane | |
| | | | | RP | Expand by Row, Plane, Column | |
| | | | | PR | Expand by Plane, Row, Column | |
| | | | | CP | Expand by Column, Plane, Row | |
| | | | | PC | Expand by Plane, Column, Row | |

*(continued)*

## Table 42 - Raster definition module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | (d)Aspect Ratio [A/G3] | Aspect ratio of cells: cell row spacing divided by cell line spacing. Only meaningful for two dimensional rasters. | R | Real | Aspect ratio of cells: cell row spacing divided by cell column spacing. | ASPR |
| | Number of Layers [M] | Number of cell layers (e.g., spectral bands). | I | Integer | Unsigned integer >= 1 | NLAY |
| (^) Internal Spatial ID [M](N) | | A pointer to the Internal Spatial Reference record which defines all dimensions of this raster object. | | | | ISID |
| Raster Dimension Extent (O) [M/Dimension ID][A] | | This field will describe this raster object's extent along the dimension. There should be one field for each Dimension ID Field in the IREF module record referenced above. The order of the fields here must correspond with the order of the DMID field repetition in the IREF module record. | | | | RDXT |
| | Dimension Extent [M] | The Extent for a dimension of this raster. | I | Integer | Unsigned Integer > 0 | DEXT |
| | Dimension Scan Origin [M] | The orientation of the raster object scan reference system with respect to the internal reference system for the dimension. | A | PN<br>NP | Positive to Negative<br>Negative to Positive | DSCO |
| (-) Spatial Address[M] (N) | | The Spatial Address of the origin of the raster object scan reference system. | | | | SADR |
| X-Axis Label(O) [A/G2\|G3\| X Component of Horizontal Resolution != 0] | | The number of repetitions is defined by the Column Extent subfield. The order of repetition must be in ascending order along the axis. | | | | XXLB |

*(continued)*

## Table 42 - Raster definition module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Column Axis Value [M] | Value for a position along the X axis. | I\|R\|S\|B | Integer Real Binary | As defined by the Horizontal Component Format for the corresponding Internal Reference module. | CAVL |
| Y-Axis Label(O) [A/G2\|G3\| Y Component of Horizontal Resolution != 0] | | The number of repetitions is defined by the Row Extent subfield. The order of repetition must be in ascending order along the axis. | | | | YXLB |
| | Row Axis Value [M] | A value for a position along the Y axis. | I\|R\|S\|B | Integer Real Binary | As defined by the Horizontal Component Format for the corresponding Internal Reference module. | RAVL |
| Z-Axis Label(O) [A/G2\|G3\|G2L \| Vertical Resolution Component != 0] | | The number of repetitions is defined by the Plane Extent subfield. The order of repetition must be in ascending order along the axis. | | | | ZXLB |
| | Plane Axis Value [M] | A value for a position along the Z axis. | I\|R\|S\|B | Integer Real Binary | As defined by the Vertical Component Format for the corresponding Internal Reference module. | ZAVL |

*(continued)*

## Table 42 - Raster definition module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Dimension Axis Label [O/Dimension ID] [A/G2\|G3\|Dimension Component of Resolution != 0 \| Dimension Component Format != A] | | The number of repetitions defines the extent for this axis. The order of repetition must be in ascending order along the axis. If more than one non-geospatial dimension has a need to explicitly label the axis, multiple permutations of this field will be necessary, i.e. one permutation per dimension which needs it. The field mnemonic will be altered for each permutation. | | | | DAL1<br>DAL2<br>.<br>.<br>DALn |
| | Dimension Axis Value [M] | A value for a position along this axis | A\|I\|R\|S\|C\|B | Integer<br>Real<br>Alpha<br>Binary | As defined by the Dimension Component Format in the corresponding Dimension Definition Module. | DXVL |
| (^) Layer ID (O) [M] | | Foreign identifier pointing to the layer definition records which constitute this raster. The ordering for the instances of this field is with respect to the layers of the raster data as they occur in the Cell module. | | | | LYID |
| (^)Raster Attribute ID (R) | | Foreign identifier for Attribute Primary module record. Attributes pertain to entire raster object. | | | | RATP |
| (^)Composite ID (R) | | Contains foreign identifier of Composite module record that includes this raster object. | | | | CPID |

*(continued)*

## Table 43 - Layer definition module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Layer Definition (P) [M] | | One Layer Definition record for each data layer. | | | | LDEF |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with alphabetic character other than SPACE | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Cell Module Name or Adjunct File Id [M] (N) | Name of the Cell module to which this Layer Definition record applies; or an identifier for an adjunct file which contains the raster data for this layer. [The filename can be found in the Catalog/directory module.] | A | Alphanum | Logical name of where to find the data for this layer. Name of Cell module to which this Layer Definition record applies; or an identifier for an adjunct file which contains the raster data for this layer. | CMNM |
| | Layer Label [M] | Short name/mnemonic for the layer as defined in the Data Dictionary modules. This value will be unique to all other layer labels in the same logical raster. | A | Gr-chars | Cell value name, used to indicate the type of value stored here. These layers will be described by the Data Dictionary. | LLBL |
| | Cell Code[M] | Cell value encoding method; how to interpret the cell value. | A | L | Presence/absence of theme in cell. | CODE |
| | | | | D | Dominate type of area. | |
| | | | | F | Dominant type by frequency. | |
| | | | | V | Value of a continuum attribute variable. | |
| | | | | X | Assign code, must be defined in Data Dictionary/Domain module. | |

*(continued)*

## Table 43 - Layer definition module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Bitmask | Defines bitfield length and active bits of an individual cell value as a binary string. (Used for example to transfer 3-bit data using 8-bits with a mask of say 00000111.) | C | C | An ordered list corresponding to unused (zero) and active (one) positions of bitfield bits. | BMSK |
| | Number of Rows [M] | Number of rows in the layer | I | Integer | Cannot exceed Row Extent. | NROW |
| | Number of Columns [M] | Number of columns in the layer. | I | Integer | Cannot exceed Column Extent | NCOL |
| | Number of Planes [A/G2] | Number of planes in the layer. | I | Integer | Cannot exceed Plane Extent | NPLA |
| Note: The next group of subfields has information about the scan reference system origin for the layer | | | | | | |
| | (d)Scan Origin Row [M] | Designates whether row index starts at 0 or 1. | I | 0<br>1 | First cell occurs at row 0.<br>First cell occurs at row 1. | SORI |
| | (d)Scan Origin Column [M] | Designates whether column index starts at 0 or 1. | I | 0<br>1 | First cell occurs at column 0.<br>First cell occurs at column 1. | SOCI |
| | (d)Scan Origin Plane[A/G2] | Designates whether plane index starts at 0 or 1. | I | 0<br>1 | First cell occurs at plane 0.<br>First cell occurs at plane 1. | SOPI |
| | (d)Row Offset Origin [M] | Number of Rows to offset the layer scan reference system to place the layer into the raster object scan reference system. | I | Integer | Unsigned integer >= 0. | RWOO |
| | (d)Column Offset Origin [M] | Number of columns to offset the layer scan reference system to place the layer into the raster object scan reference system. | I | Integer | Unsigned integer >= 0. | CLOO |

*(continued)*

**Table 43 - Layer definition module specification *(continued)***

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | (d)Plane Offset Origin [A/G2] | Number of planes to offset the layer scan reference system to place the layer into the raster object scan reference system. | I | Integer | Unsigned integer >= 0. | PLOO |
| | (d)Intracell Reference Location [M] | Relative location of the internal reference system origin within the cell. | A | 2d geospatial choices: | | INTR |
| | | | | TL | Top left of cell | |
| | | | | TR | Top right of cell | |
| | | | | BL | Bottom left of cell | |
| | | | | BR | Bottom right of cell | |
| | | | | CE | Center of cell | |
| | | | | 3d geospatial choices: | | |
| | | | | TLF | Top left front of cell | |
| | | | | TLB | Top left back of cell | |
| | | | | TRF | Top right front of cell | |
| | | | | TRB | Top right back of cell | |
| | | | | BLF | Bottom left front of cell | |
| | | | | BLB | Bottom left back of cell | |
| | | | | BRF | Bottom right front of cell | |
| | | | | BRB | Bottom right back of cell | |
| | | | | CEN | Center of the voxel or cube | |
| | Comment | Comments pertaining to the specific layer. | A | Gr-chars | | COMT |

*(continued)*

## Table 43 - Layer definition module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Layer Dimension Extent (O) [M/Dimension ID][A] | | This field will describe this layer's extent along this dimension. The order this field repeats and the number of repetitions must be correlated with the Dimension ID fields of the IREF record referenced by the RDEF record that includes this LDEF record. | | | | LDXT |
| | Dimension Extent [M] | The Extent for a dimension of this layer | I | Integer | Unsigned Integer > 0 | DEXT |
| | Scan Origin Dimension [M] | Designates whether dimension index starts at 0 or 1. | I | 0<br>1 | First cell occurs at position 0.<br>First cell occurs at position 1. | SODM |
| | Dimension Offset Origin [M] | Number of positions along the dimension to offset the layer scan reference system to place the layer into the raster object scan reference system. | I | Integer | Unsigned Integer >=0. | DTOO |
| | Dimension Intracell Reference Location [M] | Relative location of the internal reference system origin within the cell along this dimension. | A | F<br>C<br>B | Front of cell - toward origin.<br>Center of cell.<br>Back of cell - away from origin. | DINR |
| (^)Layer Attribute ID (O) | | Foreign identifier for Attribute Primary module record. Attribute pertain to a specific layer. | | | | LATP |

*(continued)*

## Table 44 - Cell module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Cell (P) [M] | | | | | | CELL |
| | Module Name [M] | A unique identifier for the module. | A | Alphanum | Name must begin with alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | Unsigned integer; with Module Name must form unique ID within the file set. | RCID |
| | Number of Cells | Number of cell fields in this module record | I | Integer | Unsigned Integer >= 1. | NCEL |
| | Row Index [O/Tesseral Index = TESS] | Row index of first cell in module record. (layer scan reference system) | I | Integer | Unsigned Integer >= 1. | ROWI |
| | Column Index [O/Tesseral Index = TESS] | Column index of first cell in module record. (layer scan reference system) | I | Integer | Unsigned Integer >= 1. | COLI |
| | Plane Index [O/Tesseral Index = TESS] [A/G2] | Plane index of first cell in module record. (layer scan reference system) | I | Integer | Unsigned Integer >= 1. | PLAI |
| | Tesseral Index [A/Tesseral Indexing=NOTESS] | Tesseral index for the tile contained in the module record. (layer scan reference system) | I\|B | Integer Binary | Unsigned Integer. | TIND |
| Dimension Index (O) [O/Tesseral Index = TESS] [M/Dimension ID][A] | | The order this field repeats and the number of repetitions must be correlated with the Dimension ID fields of the IREF record referenced by the RDEF record that references the LDEF record that includes this Cell module record. | | | | DNDX |

*(continued)*

## Table 44 - Cell module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Array Index Value [M] | An integer indicating the index along the dimension of the array corresponding to the appropriate Dimension ID Field. | I | Integer | Unsigned integer >= 0 | ANVL |
| (-)Spatial Address (N) | | Spatial address of the first cell of this module record in the Internal Spatial Reference System (Address if given here must be consistent with all other spatial referencing parameters that apply.) | | | | SADR |
| (^)Attribute ID (R) [O] | | Foreign identifier for Attribute Primary module record which applies to all cell values in this module record. | | | | ATID |
| Cell Values (O) | (+)cell value | Contains cell data values for part or all of a stream, and for part of, all, or one or more layers, depending on the cell sequencing code. The ordering of the fields corresponds to the ordering of the Layer Definition field and the ordering of the Dimension ID field in the coresponding Raster Definition module. | A\|I\|R\|S \|B\|C | Alphanum Integer Real Binary | As indicated by the Format subfield in the corresponding Data Dictionary/ Schema record. | CVLS |

*(continued)*

## 5.8 Graphic Representation Modules

Each vector based object in the SDTS transfer except Ring can include a foreign identifier that references a representation module. The representation module reference determines how the object should be portrayed within fixed product scale ranges (i.e., scale ranges, Small Scale Minimum and Large Scale Maximum, are given in the appropriate subfields for this module).

The parameters associated with the representation module indexed by the foreign identifier determine the values used by graphical devices to produce a display or plot. The Computer Graphics Metafile (CGM) standard provides a device-independent format for the transmission of picture description data. The SDTS standard and the CGM standard (ANSI X3.122-1986) follow the same formats for definition of the graphical representation of an object. To support cartographic spatial applications, several parameters have been modified to present parameters in a standard form used by cartographers. The content is the same and the format differences are clearly noted. CGM must be used as the reference for the modules.

The graphic representation modules include the following:

- Text Representation
- Line Representation
- Symbol Representation
- Area Fill Representation
- Color Index
- Font Index

Table 45 relates the module type with the representation code and lists the types of objects that reference the module type.

> NOTE - The Register of Graphical Items (see 1.3.16) may also be used to support the Line, Symbol, and Area Fill graphical representation modules.

The representation modules use an index into the Color and Font Index modules. These modules reference primitive graphics elements defined by a registration authority, such as the one for CGM or defined explicitly in a Data Dictionary/Domain module. For complex graphic representations, the formats may be transmitted using a separate SDTS transfer that includes a graphic representation for each symbol or line representation option. The authority must then be the associated transfer modules.

### 5.8.1 Text Representation Module

The Text Representation module provides the graphic data necessary to portray the text (see Table 46).

Necessary parameters are included to define the placement of text independently of device functionality. Parameters such as text precision, which is in the CGM standard, must be determined by the product requirements and device capabilities of the receiving system. The CGM standard uses a character orientation vector that encodes character height, skew angle, and orientation in a CGM-defined coordinate system. SDTS specifies the same parameters at a base geographic scale. These parameters can be directly converted to the CGM character orientation vector (see Figure 28).

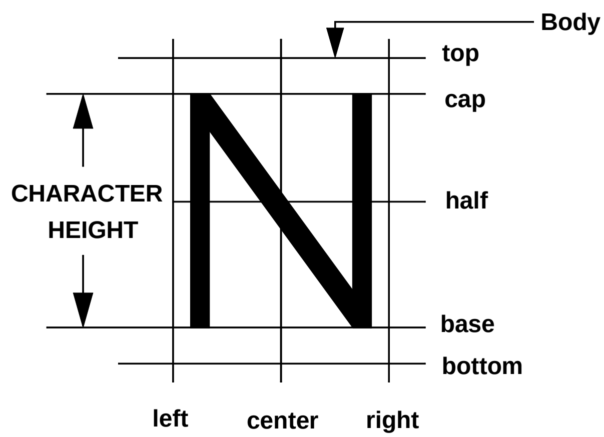


**Figure 28 - Text definition parameters**

The font coordinate system is illustrated in Figure 28 - Text Definition Parameters. The character body encloses all of the drawn parts (kerning excepted) of all characters in the font (that is, no descender extends lower than the bottom and no accent or oversized symbol extends higher than the top). The left and right edges of the character body may be defined on a per character basis to accomodate variable width and proportional spacing. It is expected that some font designers will specify fonts having kerns beyond the character body. The body exceeds the actual character symbol width and height as necessary to provide adequate white space between characters, so that text is readable and adequately separated when the character spacing is zero. The character height is the height of the character at the base scale. For different scale products the character should be scaled inversely with the scale factor. The character expansion factor specifies the deviation of the width to height of the characters from the ratio indicated by the font designer. If the value of the character spacing is positive, additional space is inserted between character bodies. If negative, adjacent character bodies overlap although the charactor symbols themselves might not. The character height is specified as a fraction of the scaled character heigth.

The text path and the horizontal and vertical text alignment parameters specify how the string is aligned relative to the label point and the orientation points. The skew angle is the angle between the base vector and the character up arrow.

### 5.8.2 Line Representation Module

The Line Representation module (see Table 47) provides the graphic data necessary to portray one-dimensional spatial objects (see Figure 28).

The standard line representation repertoire is not sufficient for most cartographic applications. To use a line type outside the defined domain, the SDTS user must identify the application's representation requirements, assign line types to these representations, and fully define the representations in a Data Dictionary/Domain module. The definition must include precise lengths, symbol references, and other requirements.

### 5.8.3 Symbol Representation Module

The Symbol Representation module (see Table 48) provides the graphic data necessary to portray the symbols.

The standard symbol representation repertoire is not sufficient for most cartographic applications. To use a symbol marker outside the defined domain, the SDTS user must identify the application's requirements, assign marker types to these representations, and fully define the representations in the Data Dictionary.

### 5.8.4 Area Fill Representation Module

The Area Fill representation module provides the graphic data necessary to fill polygonal areas (see Table 49).

The representation of the edge of a polygon is defined by its associated linear objects.

### 5.8.5 Color Index Module

The Color Index module (see Table 50) provides the correlation between a color index value and specific normalized values for the red, green, and blue components of the desired color. Color values are a 3-tuple of values providing the normalized weight of red, green, and blue components. Each component of the 3-tuple is normalized to the continuous range of real numbers [0,1]. For any given component, one end of the range indicates that none of that component is included, and the other end indicates the maximum intensity of that component.

For color process printing, magenta, cyan, and yellow values are combined with a black intensity to fully define the color to be printed. The values or magenta, cyan, and yellow may be determined by the following equations:

magenta component =1. - green component;
cyan component =1. - red component; and
yellow component =1. - blue component.

The Color Index module also provides an optional Black Intensity Component to provide the black intensity to complete the process color definition. If the Black Intensity Component is omitted, a default value of zero is assumed.

### 5.8.6 Font Index Module

The Font Index module (see Table 51) provides the correlation between a font index value and a font defined in the Data Dictionary.

**Table 45 - Representation module type and object representations**

| Module type | Object representations | Object type |
|---|---|---|
| Text | NL | Label Point |
| Line | LS | String |
| | LQ | Link |
| | LE | Complete Chain |
| | LL | Area Chain |
| | LW | Network Chain (planar graph) |
| | LY | Network Chain (nonplanar graph) |
| | AC | Circular arc, three point center |
| | AE | Elliptical arc |
| | AU | Uniform B-spline |
| | AB | Piecewise Bezier |
| Symbols (points) | NP | Point |
| | NE | Entity point |
| | NA | Area point |
| | NO | Node, planar graph |
| | NN | Node, network |
| Area fill | PG | G-polygon |
| | PR | GT-polygon composed of rings |
| | PC | GT-polygon composed of chains |
| | PU | Universe polygon composed of rings |
| | PW | Universe polygon composed of chains |
| | PV | Void polygon composed of rings |
| | PX | Void polygon composed of chains |

## Table 46 - Text representation module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Text Representation (P) [M] | | | | | | TEXT |
| | Module Name [M] | A unique identifier for this Text Representation module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | An unsigned integer unique within the representation module. With Module Name must form unique ID within the file set. | RCID |
| | Base Scale [M] | The scale denominator used to translate the scale-independent data transferred in the SDTS transfer to scale-dependent graphic attributes such as text height. | I | Integer | A valid numeric scale denominator. | BSCL |
| | Small Scale Minimum | The smallest appropriate scale denominator for the graphics representation. | I | Integer | A valid numeric scale denominator. | SSCL |
| | Large Scale Maximum | The largest appropriate scale denominator for the graphics representation. | I | Integer | A valid numeric scale denominator. | LSCL |
| | Color Index [M] | Index corresponding to a value of the Record ID subfield in the Color Index module. | I | Integer | Unsigned integer. | CLDX |
| | Character Height [M] | Specifies the distance measured in millimeters between the capline and the baseline of the font for the graphics portrayal of the spatial data at the base scale. | R | Real | Character height measured in millimeters. | CHHT |

*(continued)*

## Table 46 - Text representation module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Font Index [M] | Index corresponding to a value of the Record ID subfield in the Font Index module. | I | Integer | Unsigned integer. | FTDX |
| | (d)Text Path | Specifies the writing direction of the text string. Path directions are right, left, up, or down. Right is assumed if text path is not explicitly included. | A | RIGHT<br>LEFT<br>UP<br>DOWN | Right.<br>Left.<br>Up.<br>Down. | TPTH |
| | (d)Horizontal Text Alignment | Controls the positioning of the text extent rectangle in relation to the text position. The horizontal text alignment has three possible values: "left," "center," and "right." For example, if the horizontal text alignment is "left," the left side of the text extent rectangle passes through the text position. Left is assumed if horizontal text alignment is not explicitly included. | A | LEFT<br>CENTER<br>RIGHT | Left.<br>Center.<br>Right. | UTXA |

*(continued)*

## Table 46 - Text representation module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | (d)Vertical Text Alignment | Controls the positioning of the text extent rectangle in relation to the text position. The vertical text alignment has five possible values: "top," "cap," "half," "base," and "bottom."<br><br>The vertical alignment causes the text to be moved in such a way that the corresponding defining line of the text extent rectangle passes through the text position. Base is assumed if vertical text alignment is not explicitly included. Note that the values specified for the horizontal and vertical text alignment are a subset of those required by the CGM for the CGM text alignment vector. | A | TOP<br>CAP<br>HALF<br>BASE<br>BOTTOM | Top.<br>Cap.<br>Half.<br>Base.<br>Bottom. | VTXA |
| | (d)Character Expansion Factor | Specifies the deviation of the width to height ratio of the characters from the ratio indicated by the font designer. A value of one is assumed if the factor is not explicitly included. | R | Real | The deviation of the width to height ratio of the characters from the ratio indicated by the font designer. | CHEX |
| | (d)Character Spacing | Specifies how much additional space is to be inserted between adjacent character bodies. Character spacing is specified as fraction of character height. Zero is assumed if not explicitly defined. | R | Real | Space to be inserted between adjacent character bodies. | CHSP |

*(continued)*

**Table 46 - Text representation module specification *(continued)***

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | (d)Skew Angle [O] | Specifies the skew angle of the characters. The skew angle is the angle between the character base vector and the character up vector. It represents the slant angle of the characters. The value is measured in decimal degrees with 90 assumed unless otherwise specified. Skew angle values near 0 or 180 should be avoided since the result is likely to be unreadable or not visible. | R | Real | Measured in decimal degrees between 0 and 180. | SANG |

*(continued)*

## Table 47 - Line Representation module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| LineRepresentation (P) [M] | | | | | | LNRP |
| | Module Name [M] | A unique identifier for this Line Representation module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | An unsigned integer unique within the representation module. With Module Name must form unique ID within the file set. | RCID |
| | Base Scale [M] | The scale denominator used to translate the scale independent data transferred in the SDTS transfer to scale dependent graphic attributes such as dash spacing. | I | Integer | A valid numeric scale denominator. | BSCL |
| | Small Scale Minimum | The smallest appropriate scale denominator for the graphics representation. | I | Integer | A valid numeric scale denominator. | SSCL |
| | Large Scale Maximum | The largest appropriate scale denominator for the graphics representation. | I | Integer | A valid numeric scale denominator. | LSCL |
| | Color Index [M] | Index corresponding to a value of the Record ID subfield in the Color Index module. | I | Integer | Unsigned integer. | CLDX |
| | Line Type [M] | The type of line representation. Values above 5 are reserved for extensions and future standardization. Negative values are available for implementation dependent use, with definitions given in corresponding Data Dictionary/Domain module. | I | 1 | Solid line. | LTYP |
| | | | | 2 | Dashed line. | |
| | | | | 3 | Dotted line. | |
| | | | | 4 | Dash-dot line. | |
| | | | | 5 | Dash-dot-dot line. | |
| | | | | dd: >5 | Reserved for extension. | |
| | | | | dd: <=0 | Implementation dependent. | |

**Table 47 - Line Representation module specification *(continued)***

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Line Width | The line width measured in millimeters at the base scale. If not specified, the receiving system should use the smallest visible line width. | R | Real | The line width measured in millimeters. | LWTH |

## Table 48 - Symbol representation module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| SymbolRepresentation (P) [M] | | | | | | SYRP |
| | Module Name [M] | A unique identifier for this Symbol Representation module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | An unsigned integer unique within the representation module. With Module Name must form unique ID within the file set. | RCID |
| | Base Scale [M] | The scale denominator used to translate the scale independent data transferred in the SDTS transfer to scale dependent graphic attributes such as symbol height. | I | Integer | A valid numeric scale denominator. | BSCL |
| | Small Scale Minimum | The smallest appropriate scale denominator for the graphics representation. | I | Integer | A valid numeric scale denominator. | SSCL |
| | Large Scale Maximum | The largest appropriate scale denominator for the graphics representation. | I | Integer | A valid numeric scale denominator. | LSCL |
| | Color Index [M] | Index corresponding to a value of the Record ID subfield in the Color Index module. | I | Integer | Unsigned integer. | CLDX |
| | Symbol Marker Type [M] | The type of symbol representation. Values above 5 are reserved for extensions and future standardization. Negative values are available for implementation dependent use, with definitions given in corresponding Data Dictionary/Domain module. | I | 1 | Dot | SMKR |
| | | | | 2 | Plus | |
| | | | | 3 | Asterick | |
| | | | | 4 | Circle | |
| | | | | 5 | Diagonal cross | |
| | | | | dd:>5 | Reserved for future extensions. | |
| | | | | dd:<=0 | Implementation dependent. | |

**Table 48 - Symbol representation module specification *(continued)***

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Marker Size [M] | The symbol measured in millimeters at the base scale. | R | Real | The symbol height measured in millimeters. | MKSZ |

## Table 49 - Area fill representation module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Area Fill Represen-tation (P) [M] | | | | | | AFIL |
| | Module Name [M] | A unique identifier for this Area Fill Representation module. | A | Alphanum | Name must begin with an alpha-betic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | An unsigned integer unique within the module. With Module Name must form unique ID within the file set. | RCID |
| | Base Scale [M] | The scale denominator used to translate the scale independent data transferred in the SDTS transfer to scale dependent graphic attributes such as symbol height. | I | Integer | A valid numeric scale denomi-nator. | BSCL |
| | Small Scale Minimum | The smallest appropriate scale denominator for the graphics rep-resentation. | I | Integer | A valid numeric scale denomi-nator. | SSCL |
| | Large Scale Maximum | The largest appropriate scale denominator for the graphics rep-resentation. | I | Integer | A valid numeric scale denomi-nator. | LSCL |
| | Color Index [M/Fill Style Type = HOL-LOW\|SOLID\|HATCH\|PAT-TERN] | Index corresponding to a value of the Record ID subfield in the Color Index module. | I | Integer | Unsigned integer. | CLDX |

## Table 49 - Area fill representation module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Fill Style Type [M] | The interior fill style may be "hollow," "solid," "pattern," "hatch," or "empty." Additional index values must be defined in the Data Dictionary/Domain module. | A | HOLLOW | No filling, but the bounding line of the filled area is drawn using the fill color currently selected. The boundary of a HOLLOW filled area is the representation of the interior. The bounding line is distinct from the edge and is drawn only for HOLLOW filled areas. | FTYP |
| | | | | SOLID | Fill the interior using the fill color. | |
| | | | | PATTERN | Fill the interior using the pattern index defined pattern | |
| | | | | HATCH | Fill the interior using the fill color and the hatch index. | |
| | | | | EMPTY | No filling is done and no boundary is drawn, i.e., nothing is done to represent the interior. | |
| | | | | dd: if not listed above | Additional values defined in a Data Dictionary/Domain module. | |

## Table 49 - Area fill representation module specification *(continued)*

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| | Hatch Index [M] | Hatch index value. Values above 6 are reserved for registration and future standardization. Negative values are available for implementation dependent use, with definitions given in corresponding Data Dictionary/Domain module. | I | 1 | Horizontal equally spaced parallel lines. | HIDX |
| | | | | 2 | Vertical equally spaced parallel lines. | |
| | | | | 3 | Positive slope equally spaced parallel lines. | |
| | | | | 4 | Negative slope equally spaced parallel lines. | |
| | | | | 5 | Horizontal/vertical crosshatch. | |
| | | | | 6 | Positive slope/negative slope crosshatch. | |
| | | | | dd:>6 | Reserved for registration. | |
| | | | | dd:<=0 | Implementation dependent. | |
| | Pattern Index [M] | An integer value that defines the type of pattern. Values for this index must be defined in a Data Dictionary/Domain module. | I | Integer | An integer value that defines the type of pattern. | PIDX |

# Table 50 - Color index module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Color Index (P) [M] | | | | | | CLRX |
| | Module Name [M] | A unique identifier for this Color Index module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | An unsigned integer unique within the representation module. With Module Name must form unique ID within the file set. | RCID |
| | Red Component [M] | The red component of the desired color normalized from zero to one. | R | Real | The red component of the desired color normalized from zero to one. | RED |
| | Green Component [M] | The green component of the desired color normalized from zero to one. | R | Real | The green component of the desired color normalized from zero to one. | GREN |
| | Blue Component [M] | The blue component of the desired color normalized from zero to one. | R | Real | The blue component of the desired color normalized from zero to one. | BLUE |
| | Black Intensity Component | The black intensity component normalized from zero to one. | R | Real | The black intensity component normalized from zero to one. | BLCK |

## Table 51 - Font index module specification

| Field name | Subfield name | Field/subfield description | Type | Domain | Domain description | Mnemonic |
|---|---|---|---|---|---|---|
| Font Index (P) [M] | | | | | | FONT |
| | Module Name [M] | A unique identifier for this Font Index module. | A | Alphanum | Name must begin with an alphabetic character other than SPACE. | MODN |
| | Record ID [M] | A number for the module record, unique within the module. | I | Integer | An unsigned integer unique within the representation module.  With Module Name must form unique ID within the file set. | RCID |
| | Font [M] | The name or index of the actual font. | I\|A | Integer Alphanum | Font number or font name Format defined in a Data Dictionary/Domain module. | FNTN |

# Annex A

(Informative)

## Implementation Resources

For this standard to be beneficial to the spatial data community, it must be widely implemented. To assist in this effort, explanatory material, reference software, and sample datasets are available from the secretariat for this standard.

Secretariat Point of Contact:

USGS
Standards Team [Attn: SDTS Facilitator]
1400 Independence Road
Rolla, MO 65401
Earth Sciences Information Center: 573-308-3500
SDTS Web site: http://mcmcweb.er.usgs.gov/sdts
SDTS e-mail: sdts@usgs.gov [General inquiries]

## A.1 Online Resources

The secretariat for this standard, U.S. Geological Survey, maintains a set of Internet World Wide Web pages which provide information about the Spatial Data Transfer Standard. The USGS also maintains a File Transfer Protocol (FTP) site which contains many SDTS related documents, sample datasets, and software available for download. The Web pages and FTP site are integrated so that all information available through FTP is referenced on a Web page.

The SDTS Web Pages are located at Uniform Resource Locator (URL) **http://mcmcweb.er.usgs.gov/sdts**. This site is managed by the USGS Mid-Continent Mapping Center, 1400 Independence Road, Rolla, Missouri, 65401. The USGS Earth Sciences Information Center in Rolla can be reached at 573-308-3500 or 573-341-2716. [Contact information as of November 1, 1997.]

The SDTS FTP site is reachable through anonymous login at **sdts.er.usgs.gov**. Once connected, change directory to “sdts” (that is **cd sdts**) to find the SDTS related files. This FTP site contains articles, software, sample datasets, presentation materials, etc. which are all available at no cost.

## A.2 Reference Software

The USGS has coordinated the developement of software libraries that will aid programmers in building SDTS applications such as importers, exporters, viewing utilities, and other various utilities. Use of these libraries can greatly reduce developement time because much of the file formatting details (involving Part 3 and ISO 8211) are encapsulated, hence, taken care of automatically. For information about these software libraries, consult the SDTS Web pages, and follow the links pertaining to software.

## A.3 SDTS Transfer Data Sets

Sample datasets are available from the SDTS Web pages. They can be located by following the links to sample datasets. The National Mapping Division of the USGS has performed mass conversions of many of their products to SDTS profiles. (For example, full country coverage at a scale of 1:100,000 for categories of transportation and hydrography is available as SDTS/Topological Vector Profile (TVP) transfer data sets.) From the SDTS Web Pages, follow the links to USGS data in SDTS to find online locations and availability of data sets.

## A.4 Case Studies

The USGS has made extensive use of SDTS as a Federal Information Processing Standard Publication (FIPSPUB) 173-1. The product mappings from native structures and internal environments to SDTS structures and files are available to others to use as examples and case studies. From the SDTS Web Pages, follow the links to training materials, and then product mappings or case studies. From the FTP site directly, look under the /pub/sdts/datasets directory tree to find product mapping documentation and sample datasets.

Any agency or individual wishing to contribute materials to be used as self-guiding examples and case studies is encouraged to contact the secretariat.

# Annex B

(informative)

# The SDTS Model of Spatial Data

The basis of SDTS is a model of spatial data sufficiently general so that any user data can be accepted, but at the same time sufficiently structured to provide an adequate basis for the organization of spatial phenomena. This model encompasses the spatial objects in section 2 and also the attributes associated with these objects (which are of equal importance), and the ways in which objects and attributes are organized and bound into other more comprehensive forms. The SDTS model of spatial data incorporates the model concepts of part 2 (Spatial Features), including the entity type and attribute concepts used to organize the definitions in part 2.

This spatial data model is presented as an informative annex, because the model may be considered an aid to understanding the normative concepts of part 1, rather than an absolute requirement for spatial data transfer.

The SDTS conceptual model has three parts: a model of spatial phenomena; a model of the spatial objects used to represent phenomena; and a model of spatial features, which explains how spatial objects and spatial phenomena are related.

Terms from the Object Oriented Programming System literature are used to define the parts of the model. These terms are given specific definitions in this standard as a way of distinguishing the various criteria for grouping elements into sets that are meaningful as spatial data abstractions. The terms are:

a) *Phenomenon*. A fact, occurrence or circumstance. Route 10, George Washington National Forest, and Chesterfield County are all phenomena.

b) *Classification*. The assignment of similar phenomena to a common class. An individual phenomenon is an instance of its class. Route 10 is an instance of the class road.

c) *Generalization*. A process in which classes are assigned to other classes. The general class includes all the instances of the constituent classes. Sewers are included in the more general class of utilities.

d) *Aggregation*. The operation of constructing more complex phenomena out of component phenomena. A lock is an aggregation of walls, gates, and a reservoir.

e) *Association*. The assignment of phenomena to sets, using criteria different from those used for classification. Concrete roads may be associated with concrete sewers, concrete locks, and other phenomena constructed of concrete.

## B.1 Model of Spatial Phenomena

SDTS transfers information about phenomena that are defined in space and time, and so are described using a fixed location-- spatial phenomena. All phenomena are defined as belonging to a class of phenomena. (Smith's Farm belongs to Farm.) A characteristic of such a class is called an attribute. (Acreage is an attribute for Farm.) An attribute value is a specific quantity or quality of the attribute assigned to a phenomenon in that class. (Smith's Farm has an Acreage of 160 acres.)

Whether a given phenomenon belongs to a class is determined by the definition of the class. The definition consists of a statement about characteristics all members of the class have in common. It also includes characteristics which distinguish the class from other classes. These definitional characteristics are necessary and sufficient conditions for classifying some phenomena into the class and excluding others. The data collector defines which classes of phenomena are of interest. Those classes of phenomena are called entity types, and the individual phenomena are called entity instances.

Certain attributes are identified with each class. The attributes of a class include key attributes. The key attributes are the set of attributes of a class such that the combination of values of the key attributes forms a unique identifier for each entity instance.

Conceptually, an entity instance is a spatial phenomenon of a defined type that is embedded in one or more phenomena of a different type, or that has at least one key attribute value different from the corresponding attribute values of the surrounding phenomena. Such an entity instance is not further subdivided into phenomena of the same type. Examples of entity instances include obvious physical structures (such as a bridge), fuzzy physical regions (such as a soil polygon), cultural artifacts (such as a political boundary), and modeling constructs (such as an economic region).

The distinction between class and instance of entities can be shown as:

| | Class | Instance |
|---|---|---|
| Class or instance | Entity Type | Entity Instance |
| Characteristic | attribute | attribute value |

An example of an entity type is Bridge with attributes Name and Composition. An instance of this type might be the "10th Street Bridge" composed of "steel." "10th Street Bridge" and "steel" are attribute values of Name and Composition. Another example is the entity type Farm with key attribute Owner and non-key attribute Crop_cultivated. Smith's Farm is adjacent to Jones' Farm. Both cultivate corn and soybeans. The two farms can be distinguished as entity instances because of the change in the value of the key attribute Owner. Across the road from the two farms is a shopping mall. The instances of the entity type Farm are bounded by other farms with different key attribute values, but also by instances of other types of entity such as Shopping Center and Road.

Entity instances may be aggregated into instances of a different type of entity. For example, although a lock is partly composed of walls, it is not itself a wall.

Entity types can be generalized into themes based on the definitional characteristics shared by more than one class. A theme can also have its own attributes, including Name. An example of a theme is "transportation" which is by definition a function of both Railway and Road.

The distinction between class and instance of themes can be shown as:

| | Class | Instance |
|---|---|---|
| Class or instance | Theme | Entity Type |
| Characteristics | Theme Name | Entity Label |

Associations of entity instances are defined in terms of characteristics other than those used to define an entity type. A common association is the spatial domain, which groups all entity instances having coordinates within a specified range. Another useful association is temporal domain. SDTS represents entity instances as static, without temporal dimension. However, values of a temporal attribute such as Age may be assigned to entity instances, and used to associate them into sets with a common extent in time.

A relationship is a special case of an association. A relationship exists between entity types. A relationship instance is an association between entity instances with a unique relationship value.

The distinction between class and instance of relationships can be shown as:

| | Class | Instance |
|---|---|---|
| Class or instance | Relationship | Relationship instance |
| Characteristics | Relationship type | Relationship value |

## B.2 Model of Spatial Objects

Entity instances have a digital representation. That digital representation consists of one or more spatial objects. A spatial object may be an aggregation of other spatial objects, not all of which necessarily represent an entity instance. A spatial object that represents all of a single entity instance is an entity object. It may be classified into an entity object class. Entity objects have generalizations and associations as well:

the representation of an entity theme is an object theme, and an entity spatial domain, an object spatial domain.

In general, the correspondence between entity instance and entity object is paralleled by all characteristics of entities and objects. Rather than creating a whole new set of terms, the characteristics' names are generally the same whether referring to phenomena **or** their digital representation. In this standard, whether phenomena or their digital representations are being referred to is indicated by the context. The following table gives examples:

| | Phenomena | Digital Representation |
|---|---|---|
| Class | Entity Type | Entity Object Class |
| Characteristic | Attribute | Attribute |
| Instance | Entity Instance | Entity Object |
| Characteristic | Attribute Value | Attribute Value |
| Generalization | Theme | Theme |
| Association | Spatial Domain | Spatial Domain |

Entity objects have locational attributes (spatial address), non-locational attributes, and relationships (topology). The attributes and relationships of entity objects need not be as extensive as those of their corresponding entity instances. The key attributes used to distinguish a particular entity instance may not be present in the actual transfer; instead, the entity object record identifier may be the only way to distinguish between instances.

Spatial objects may have attributes independently of whether they are entity objects or not. All objects may be classified, aggregated and associated in the same general manner that entity instances may be.

This standard defines a set of simple spatial objects. These simple spatial objects are either primitive objects (not aggregated from any other objects), or are aggregated only from spatial objects belonging to different classes (polygons are not aggregated from polygons, only from rings, chains or strings). The only exception is the composite object. Composite spatial objects may be aggregated from simple objects or from other composites.

Spatial objects are classified into module types, one of the basic building blocks of the standard. Once defined, modules may be associated into sets by spatial domain, temporal domain, data quality, security requirements, topological relationships, or any other criteria.

## B.3 Model of Spatial Features

A feature type consists of an entity type and the entity object class that represents it. If a class is viewed as a set, whose members are the instances of the class, then a particular feature type is the intersection of the entity type and the entity object class. The feature type represents those entity instances that have representative entity objects.

The term feature is defined in the standard for completeness. A spatial data transfer contains entity objects and other spatial objects. Entity instances are not transferred; they exist in the real world.

# Annex C

(Informative)

## Attribute Encoding

This annex presents a further explanation of the attribute encoding methods specified in the normative portion of the standard. Encoding examples, at the logical level, of the Attribute Primary and Attribute Secondary modules are given, together with examples of the Data Dictionary modules that describe the attribute data.

This annex also presents examples of valid attribute labels, and further describes the use of code sets. It presents a suggested list of code sets for use in a transfer.

### C.1 Attribute Primary and Attribute Secondary Modules

The structure of an Attribute Primary module record is defined in 4.1.3.6.1, using BNF, as:

<Attribute Primary module record>::= <module record identifier>
[<spatial object ID>]
[<attribute 1>]
[<attribute 2>]
.
.
.
[<attribute n>]

<module record identifier>::= <module name> <record id>

<spatial object ID>::= <module name> <object id>

The spatial object ID field is optional. If used, it constitutes a backward link from the attributes to the spatial object. Forward links from the spatial object are made through the use of a foreign identifier in the spatial object module record named Attribute ID. This field is also optional, but the minimum requirement is that there be at least either a forward or a backward link.

The structure of the secondary attribute module record is nearly identical to the structure of the primary module record: the difference is the absence of the spatial object link field.

The following schematic example shows some spatial objects with primary and secondary attributes and their potential links. In the first example ("Bridges"), the Attribute Secondary module is used to handle values of the standard attribute 'Composition' with a one-to-many link between 'Composition' and the attribute 'Material' (i.e., each bridge is composed of more than one material). In the second example, primary attributes such as 'State', 'County', and 'Land Type' are given FIPS and DLG code equivalents.

**Table 52 - Point-node module "Bridges"**

| Point-Node | | | Attribute ID | | Spatial Address | |
|---|---|---|---|---|---|---|
| **MODN** | **RCID** | **OBRP** | **MODN** | **RCID** | **X** | **Y** |
| Bridges | 1 | NP | BridgeAtts | 81 | etc. | |
| Bridges | 2 | NP | BridgeAtts | 82 | | |
| Bridges | 3 | NP | BridgeAtts | 83 | | |

### Table 53 - Attribute primary module "BridgeAtts"

| Attribute primary | | Spatial object ID | | Attributes | |
|---|---|---|---|---|---|
| **MODN** | **RCID** | **MODN** | **RCID** | **COMPOSITION** | **SPAN LENGTH** |
| BridgeAtts | 81 | Bridges | 1 | A | 300 |
| BridgeAtts | 82 | Bridges | 2 | B | 1200 |
| BridgeAtts | 83 | Bridges | 3 | A | 500 |

### Table 54 - Attribute secondary module "BridgeComp"

| Attribute Secondary | | Attributes | |
|---|---|---|---|
| **MODN** | **RCID** | **COMPOSITION** | **MATERIAL** |
| Bridge-Comp | 27 | A | Wood |
| Bridge-Comp | 28 | A | Concrete |
| Bridge-Comp | 29 | A | Steel |
| Bridge-Comp | 30 | B | Concrete |
| Bridge-Comp | 31 | B | Wood |

In the above example, the link between the Point-Node and Attribute Primary module records is one-to-one, while the link between Attribute Primary and Attribute Secondary records is one-to-many.

The DLG example shows attributes for a set of polygons, with one Attribute Primary Module and three Attribute Secondary modules:

### Table 55 - Polygon module "GlenEllen"

| Polygon | | | Attribute ID | | Ring ID | |
|---|---|---|---|---|---|---|
| **MODN** | **RCID** | **OBRP** | **MODN** | **RCID** | **MODN** | **RCID** |
| GlenEllen | 1 | PR | GlenEllenAtts | 11 | etc. | |
| GlenEllen | 2 | PR | GlenEllenAtts | 12 | | |
| GlenEllen | 3 | PR | GlenEllenAtts | 13 | | |
| GlenEllen | 4 | PR | GlenEllenAtts | 14 | | |

### Table 56 - Attribute primary module "GlenEllenAtts"

| Attribute Primary | | Spatial Object ID | | Attributes | | |
|---|---|---|---|---|---|---|
| **MODN** | **RCID** | **MODN** | **RCID** | **STATE** | **COUNTY** | **LANDTYPE** |
| GlenEllenAtts | 11 | GlenEllen | 1 | California | Sonoma | Park |
| GlenEllenAtts | 12 | GlenEllen | 2 | California | Sonoma | null |

**Table 56 - Attribute primary module "GlenEllenAtts"**

| Attribute Primary | | Spatial Object ID | | Attributes | | |
|---|---|---|---|---|---|---|
| MODN | RCID | MODN | RCID | STATE | COUNTY | LANDTYPE |
| GlenEllenAtts | 13 | GlenEllen | 3 | California | Sonoma | Land Grant |

**Table 57 - Attribute Secondary Module "States"**

| Attribute Secondary | | Attributes | | |
|---|---|---|---|---|
| MODN | RCID | STATE | DLGCODE | STATEFIPSCODE |
| States | 37 | California | 091.0006 | 06 |
| States | 38 | Nevada | etc. | |

**Table 58 - Attribute secondary module "Counties"**

| Attribute Secondary | | Attributes | | |
|---|---|---|---|---|
| MODN | RCID | COUNTY | DLGCODE | COUNTYFIPSCODE |
| Counties | 92 | Sonoma | 092.0097 | 097 |
| Counties | 93 | Napa | etc. | |
| Counties | 94 | Mendocino | | |

**Table 59 - Attribute secondary module "LandTypes"**

| Attribute Secondary | | Attributes | |
|---|---|---|---|
| MODN | RCID | LANDTYPE | DLGCODE |
| LandTypes | 6 | Land Grant | 090.0113 |
| LandTypes | 7 | Park | 090.0130 |

## C.2 Data Dictionary/Schema Module

Each Attribute Primary or Attribute Secondary module shall have an associated Data Dictionary/Schema module. The following is an example of the Data Dictionary/Schema module for the BridgeAtts and BridgeComp modules of the Bridge example (the sequence of the subfield mnemonics in the table corresponds to the sequence of the subfields in the module description table). The entity for this example is "Bridge," a standard SDTS entity.

**Table 60 - Data dictionary/schema field**

| Module record number | Subfield mnemonic | Subfield contents |
|---|---|---|
| 1 | MODN | BridgesSchema |
| | RCID | 1 |
| | NAME | BridgeAtts |
| | TYPE | ATPR |
| | ETLB | BRIDGE |
| | EUTH | SDTS |
| | ATLB | SPAN_LENGTH |
| | AUTH | NCHA |
| | FMT | I |
| | UNIT | METERS |
| | MXLN | 5 |
| | KEY | NOKEY |
| 2 | MODN | BridgesSchema |
| | RCID | 2 |
| | NAME | BridgeAtts |
| | TYPE | ATPR |
| | ETLB | BRIDGE |
| | EUTH | SDTS |
| | ATLB | COMPOSITION |
| | AUTH | NCHA |
| | FMT | A |
| | UNIT | null |
| | MXLN | 1 |
| | KEY | FKEY[1] |
| 3 | MODN | BridgesSchema |
| | RCID | 3 |
| | NAME | BridgeComp |
| | TYPE | ATSC |
| | ETLB | BRIDGE |
| | EUTH | SDTS |
| | ATLB | COMPOSITION |
| | AUTH | NCHA |
| | FMT | A |
| | UNIT | null |
| | MXLN | 1 |
| | KEY | PKEY |

*(Continued)*

**Table 60 - Data dictionary/schema field**

| Module record number | Subfield mnemonic | Subfield contents |
|---|---|---|
| 4 | MODN | BridgesSchema |
| | RCID | 4 |
| | NAME | BridgeComp |
| | TYPE | ATSC |
| | ETLB | BRIDGE |
| | EUTH | SDTS |
| | ATLB | MATERIAL |
| | AUTH | ASTM |
| | FMT | A |
| | UNIT | null |
| | MXLN | 1 |
| | KEY | PKEY |

*(Continued)*

[1] COMPOSITION in BridgeAtts is only part of a foreign key.

Note that in the above example there is one Data Dictionary/Schema module for two attribute modules, confirming that there need not be a one-to-one correspondence between Data Dictionary/Schema modules and attribute modules. Also note that there are two records for the attribute Composition, because it occurs in both the Attribute Primary and Attribute Secondary modules.

## C.3 Data Dictionary/Definition Module

The Data Dictionary/Definition module defines the entities and attributes used in the Attribute Primary, Attribute Secondary and Data Dictionary/Schema modules.

The use of the Data Dictionary/Definition module is demonstrated with the following example:

**Table 61 - Data dictionary/definition field**

| Module record number | Subfield mnemonic | Subfield vontents |
|---|---|---|
| 1 | MODN | DDDEF |
| | RCID | 1 |
| | EORA | ENT |
| | EALB | Lagoon |
| | SRCE | A dictionary of geography, Monkhouse |
| | DFIN | A sheet of salt water separated from .... |
| | AUTH | FDMA |
| | ADSC | Federal Mapping Authority |

*(continued)*

## Table 61 - Data dictionary/definition field

| Module record number | Subfield mnemonic | Subfield vontents |
|---|---|---|
| 2 | MODN | DDDEF |
| | RCID | 2 |
| | EORA | ENT |
| | EALB | Bridge |
| | SRCE | Canadian Council on Surveying and Mapping |
| | DFIN | A structure erected over a depression... |
| | AUTH | NCHA |
| | ADSC | National Charting Board, Report Q17-F... |
| 3 | MODN | DDDEF |
| | RCID | 3 |
| | EORA | ATT |
| | EALB | SPAN_LENGTH |
| | SRCE | Bridge Engineering Associates Inc. |
| | DFIN | Distance between bridge abutments... |
| | AUTH | SDTB |
| | ADSC | Spatial Data Transfer Board, publication... |

*(continued)*

In this example the first two records contain entity definitions; the last record defines an attribute of the entity "Bridge." The four-character Attribute Authority codes such SDTB, FDMA, NCHA, would also be used in the Attribute and Entity authority subfields of the Data Dictionary/Schema module for the example transfer.

## Table 62 - An example of wildcard character use in this module

| Module record number | Subfield mnemonic | Subfieldcontents |
|---|---|---|
| 1 | MODN | DDDEF |
| | RCID | 1 |
| | EALB | * |
| | AUTH | FDMA |
| | ADSC | Federal Mapping Authority |

meaning that the code FDMA as used in each Attribute Definition or Schema field refers to "Federal Mapping Authority" for all attributes ("*" meaning all).

## C.4 Data Dictionary/Domain Module

The Data Dictionary/Domain module describes the valid domains for the attributes stored with the Attribute Primary and Attribute Secondary modules.

**Table 63 - Data dictionary/domain module example**

| MODN | RCID | ATLB | AUTH | ATYP | ADVF | ADMU | RAVA | DVAL | DVDF |
|---|---|---|---|---|---|---|---|---|---|
| DDDOMAIN | 1 | COMPOSITION | SDTS | ALPHABET | A | null | VALUE | Steel | iron & car- bon |
| DDDOMAIN | 2 | COMPOSITION | SDTS | ALPHABET | A | null | VALUE | Wood | xylem |
| DDDOMAIN | 3 | SPAN_LENGT H | FDMA | INTEGER | I | Meters | MIN | 5 | |
| DDDOMAIN | 4 | SPAN_LENGT H | FDMA | INTEGER | I | Meters | MAX | 300 | |

The first two records contain the domain type of ALPHABET for the attribute "composition" of the entity "bridge"; the last two contain the upper and lower limits of the range for the attribute "Span_length" of the entity bridge. Note that "Steel" and "Wood" are not part of an enumerated domain, other alphabetic values are legal. With an ENUMERATED domain type, no other values would have been allowed.

## C.5 Attribute Labels and SQL Keywords

The standard specifies that an attribute label shall not be identical to an SQL keyword.

**Table 64 - The SQL keywords**

| | | |
|---|---|---|
| ALL | FETCH | PASCAL |
| AND | FLOAT | PLI |
| ANY | FOR | PRECISION |
| AS | FORTRAN | PRIVILEGES |
| ASC | FOUND | PROCEDURE |
| AUTHORIZATION | FROM | PUBLIC |
| AVG | GO | REAL |
| BEGIN | GOTO | ROLLBACK |
| BETWEEN | GRANT | SCHEMA |
| BY | GROUP | SECTION |
| CHAR | HAVING | SELECT |
| CHARACTER | IN | SET |
| CHECK | INDICATOR | SMALLINT |
| CLOSE | INSERT | SOME |
| COBOL | INT | SQL |
| COMMIT | INTEGER | SQLCODE |
| CONTINUE | INTO | SQLERROR |
| COUNT | IS | SUM |
| CREATE | LANGUAGE | TABLE |
| CURRENT | LIKE | TO |
| CURSOR | MAX | UNION |
| DEC | MIN | UNIQUE |
| DECIMAL | MODULE | UPDATE |
| DECLARE | NOT | USER |
| DELETE | NULL | VALUES |
| DESC | NUMERIC | VIEW |

*(continued)*

**Table 64 - The SQL keywords (Continued)**

| | | |
|---|---|---|
| DISTINCT | OF | WHENEVER |
| DOUBLE | ON | WHERE |
| END | OPEN | WITH |
| ESCAPE | OPTION | WORK |
| EXEC | OR | |
| EXISTS | ORDER | |

*(continued)*

Examples of valid attribute labels are:

TYPE, Z_09, VEGETATIONCODING, B, Q_A_1, ATTRIBUTE000000001.

Example of labels that are not valid are:

type, 1ATTRIBUTE, _SECONDATTRIBUTE, VALIDATTRIBUTELABEL, Q__ABC, VEGETATION CODE, soiltype, SQLERROR and COUNT.

## C.6 Suggested Code Sets

The encoding of data content by the sender, based upon the following widely used code sets, will facilitate a more efficient transfer of meaning. It is not the intent of this standard to recommend the coding of all data content, but simply to employ existing code sets where applicable. These sets may be used with the "cs:" convention and the appropriate FIPSPUB number as a domain specification in the Data Dictionary/ Domain module.

Each document in the list is preceded by a short subject for reference purposes only.

CODE SETS
Catalog of Widely Used Code Sets, FIPSPUB 19-1, 7 Jan 85.

CONGRESSIONAL DISTRICTS
Congressional Districts of the United States, FIPSPUB 9, 14 Nov 69.

COUNTIES
Counties, and County Equivalents of the States of the United States and District of Columbia, FIPSPUB 6-4, 31 Aug 1990.

COUNTRIES
Countries, Dependencies, Areas of Special Sovereignty and their Principal Administrative Divisions, FIPSPUB 10-3, 9 Feb 84. Guideline for Implementation of ANSI Codes for the Implementation of Names of Countries, Dependencies and Areas of Special Sovereignty, FIPSPUB 104, 19 Sep 83.

CURRENCY
Codes for Representation of Currencies and Funds, ISO 4217, 15 Jun 78.

DATES
Calendar Date, FIPSPUB 4, 1 Nov 68.

HYDROLOGIC UNITS
Codes for the Identification of Hydrologic Units in the United States and Caribbean Outlying Areas, FIPSPUB 103, 15 Nov 83.

LOCATIONS
Representation of Geographic Position Location for Information Interchange, FIPSPUB 70-1, 14

Nov 86.

ORGANIZATIONS

Codes for Identification of Federal and Federally Assisted Organization, FIPSPUB 95, 23 Dec 82.

PLACES

Metropolitan Statistical Areas, FIPSPUB 8-5, 31 Oct 1984. Guideline: Codes for Names of Populated Places, Primary County Divisions, Other Locational Entities in the United States, FIPSPUB 55-1, 30 Dec 83. Power Plant Identification: Recommended Practice, IEEE 803-1983 &IEEE 803A-1983. Standard Point Location Code (SPLC) Continental Directory, National Motor Freight 102-E, 1 May 1984. National Zip Code and Post Office Directory, U.S.#Postal Service Publication 65.

STATES

States and Outlying Areas of the United States, FIPSPUB 5-1, 15 Jun 70.

TIME

Representations of Local Time of the Day for Information Interchange, FIPSPUB 58, 01 Feb 79. Representations of Universal Time, Local Time Differentials, and United States Time Zone References for Information Interchange, FIPSPUB 59, 1 Feb 79.

# Annex D

(Informative)

## Spatial Address Encoding

This annex is intended for use as a guide to spatial address encoding within SDTS.

Spatial address refers to the geographic point location of an object, and is used to define the position of a point (in a defined coordinate system) that may be on, above, or below the Earth's surface. There are many systems available for indicating point locations. This standard allows for the use of any of the three most widely used in the United States (listed in order of preference): Latitude and Longitude, Universal Transverse Mercator/Universal Polar Stereographic (UTM/UPS) Grid Systems, and State Plane Coordinate Systems (metric). These systems are mathematically interconvertible, on a point by point basis, and are also officially recognized by many mapping and surveying agencies of the Federal and state governments.

Use of altitude data is not required; however, specifications for altitude data are provided in 4.1.3.5.5, Altitude.

References for more detailed information on the methodology, techniques and applications of the three systems are provided in 1.3.

When transforming the coordinates of linear objects (for the purposes of using this standard or otherwise), great care must be taken. A line segment (the most simple component of most of the linear objects) is defined as "a direct line between two points." For the purposes of this standard, a direct line shall be defined as a line of constant slope (the change in Y or latitude divided by the change in X or longitude). When the points of a line segment are specified by coordinates within a given coordinate system, the direct line between them is a function of only that coordinate system. This means that when a line segment is transformed, there will always be two direct lines defined by that line segment: one line before transformation and the second line after transformation. If the distance between the two points of a line segment is great enough, the two direct lines could be significantly different. If this is the case, a data encoder using this standard should break the line segment into two or more segments (by adding intermediate points) to ensure that the resultant before and after sets of direct lines are not significantly different.

The problem of transforming arc objects is conceptually even greater than that of line segments. Just as with line segments, points provide the basis for positioning the arc, and these points can be transformed just as line segment points. But whereas "direct line" has a well defined meaning in both a before and after transformation reference surface, a "curve that is defined by a mathematical function" might not. It can be said that there are no general solutions available for transforming curves.

However, from a practical standpoint, the problem might not be so great. When dealing with large scale data (within a relatively small area), where arc objects are most likely to be used (e.g., highway construction and land parcel maps), and rectangular coordinate projection systems are used, the before and after transformation differences are usually not significant. Where this is not the case (differences are significant), this standard requires that a data encoder convert the arc to a string (or chain if appropriate) with enough line segments to ensure proper relative positional accuracy is retained. The fact that this conversion has been done should also be available to a user of the encoded data.

## D.1 Latitude and Longitude

Latitude and longitude are ellipsoidal coordinate representations that show locations on the surface of the earth using the earth's equator and the prime meridian (Greenwich, England) as the respective latitudinal and longitudinal origins.

### D.1.1 Representation of Degrees

Latitude and longitude are angular quantities, and according to the standard, should be expressed as decimal fractions of degrees.

Degrees of latitude, according to the standard, should be represented by a two-digit decimal number ranging from 0 through 90.

Degrees of longitude, according to the standard, should be represented by a three-digit decimal number ranging from 0 through 180.

When a decimal fraction of a degree is specified it, according to the standard, should be separated from the whole number of degrees by a decimal point.

### D.1.2 Hemisphere Representation

Latitude north of the equator, according to the standard, should be specified by a plus sign (+) or by the absence of a minus sign (-), preceding the two digits designating degrees. A point on the equator, according to the standard, should be assigned to the northern hemisphere. Latitude south of the equator shall be designated by a minus sign (-) preceding the two digits designating degrees.

Longitudes east of the prime meridian, according to the standard, should be specified by a plus sign (+) or by the absence of a minus sign (-), preceding the three digits designating degrees of longitude. Longitudes west of the meridian, according to the standard, should be designated by a minus sign preceding the three digits designating degrees. A point on the prime meridian, according to the standard, should be assigned to the eastern hemisphere. A point on the 180th meridian shall be assigned to the western hemisphere.

Any spatial address with a latitude of +90 or -90 degrees specifies the location of the North or South pole, respectively. The longitude component may have any legal value.

## D.2 Universal Transverse Mercator/Universal Polar Stereographic Grid Systems

### D.2.1 Universal Transverse Mercator Grid System

The Universal Transverse Mercator Grid System (UTM) provides rectangular coordinates that may be used to indicate locations of points on the surface of the Earth. UTM involves linear measurements, and the unit of measure is the meter. A point is located by specifying a hemispheric indicator, a zone number, an easting value, and a northing value.

UTM is designed for world use between 80 degrees south latitude and 84 degrees north latitude. The globe is divided into narrow zones, 6 degrees of longitude in width, starting at the 180 degree meridian of longitude and progressing eastward. The zones are numbered 1 through 60. Each zone has, as its east and west limits, a meridian of longitude. Each zone also has a central meridian passing through the center of the zone. The location of any point within a zone is given in relation to the central meridian within that zone and the equator. The system zone yields positive values for the identification of a point on the earth's surface by first assigning numeric values to the equator and the central meridian. Then, a point's north-south location is obtained by either adding or subtracting the point's distance north or south of the equator. Similarly, a point's east-west location is obtained by either adding or subtracting the point's distance east or west of the central meridian.

A value of 500,000 meters is assigned to the central meridian of each zone in order to avoid negative numbers at the west edge of the zone. The values increase from west to east. For north-south values in the northern hemisphere, the equator is assigned 0 meters, and the numbers increase toward the north pole. In the southern hemisphere, the equator is assigned 10,000,000 meters, and the numbers decrease toward the south pole.

On a map, appropriate values for the easting and northing of a point are determined relative to labeled grid lines. A point on the equator is assigned a value of zero for its northing and is treated as if it were in the northern hemisphere. A point on a boundary meridian is assigned the zone number for the zone to the east of the point.

### D.2.2 Universal Polar Stereographic Grid System

The Universal Polar Stereographic Grid System (UPS) is used in place of UTM in the polar regions of greater than 84 degrees north latitude and 80 degrees south latitude. Characteristics of UTM (paragraph C.2.1) also apply to UPS, with some important modifications. The 0 degree and 180 degree meridians divides each polar region into an eastern and western half. At the north pole, the western grid zone is labeled "Y" and the eastern grid zone "Z". The corresponding south polar grid zones are labeled "A" and "B". The location of any point within either of the polar regions is given in relation to the 180 degree meridian and 90 degree meridian. A value of 2,000,000 meters north and 2,000,000 meters east is added in order to avoid negative numbers.

### D.2.3 Hemisphere and Zone Representation

The first graphics character of the Zone Number subfield in the External Spatial Reference module record shall be a code to indicate the hemisphere in which the point is located. A plus sign (+), according to the standard, should be used to indicate the northern hemisphere, and a minus sign (-) to indicate the southern hemisphere. The remainder of the subfield, according to the standard, should contain the zone number indicating the 6 degree longitudinal band in which the point is located (01, 02, ... 60) for UTM or grid zone letter designator (A,B,Y or Z) for UPS.

### D.2.4 Unit of Measurement

The unit of measurement for both Northing and Easting, according to the standard, should be the meter.

### D.2.5 State Plane Coordinate Systems

The State Plane Coordinate Systems (SPCS's) are designed to define the location of points within a geographic grid system. They were used first in the nineteenth century; the first formal use was in 1932. There are now one or more State Plane Coordinate Systems in use in each of the 50 United States, as well as in the Commonwealth of Puerto Rico, the U.S. Virgin Islands, American Samoa, and Guam. The District of Columbia is included with the State of Maryland. State Plane Coordinate Systems represent separate, distinct systems for the 54 political jurisdictions involved, as opposed to the universally applicable Latitude and Longitude and Universal Transverse Mercator/Universal Polar Stereographic (UTM/UPS) Grid Systems.

Nine States, Puerto Rico, American Samoa, and Guam are covered individually by one State Plane Coordinate System or zone. The nine States are: Connecticut; Delaware; Maryland; New Hampshire; New Jersey; North Carolina; Rhode Island; Tennessee; and Vermont. The remaining 41 States and the Virgin Islands are covered individually by from two to ten SPCS's. These systems fall into four general categories, based upon the conformal mapping projection methods utilized in the political jurisdiction:

a) The Lambert Conformal Conic Projection.

b) The Transverse Mercator (TM) Projection (not to be confused with the UTM).

c) A combination of Lambert and TM Projections in New York and Florida.

d) A combination of Lambert, TM and an (unique) Oblique Mercator Projection in Alaska.

A zone may extend to the State boundaries of a political jurisdiction and to county boundaries where these are contiguous with State boundaries.

Further, a zone may be defined in one of three ways. In each of these three methods, an arbitrary point of origin in latitude and longitude is one element of the definition of the zone. The other element of definition varies with the conformal mapping projection system used in the zone:

a) Lambert Conformal Conic Projection - two "standard parallels" of latitude bounding the zone.

b) Transverse Mercator Projection - one central north-south (longitudinal) meridian bisecting the zone at an arbitrary east-west point, and a constant signifying the scale reduction along this meridian.

c) Alaskan Oblique Mercator Projection - as defined in detail in the Alaska State Plane Coordinate System specifications.

The arbitrary point of origin for each zone is typically located outside the geographic area it covers. This is designed to meet the objective that no coordinate may have a negative value.

### D.2.6 Zone Representation

Each of the zones or SPCS's in each jurisdiction is uniquely identified by a four-character numeric code as specified in Table 4 of FIPSPUB 70-1. This four character code, according to the standard, should be transferred in the Zone Number subfield of the External Spatial Reference module.

### D.2.7 Coordinate Representation

Three methods are available for the designation of the east-west (X or E(easting) coordinate) and north-south (Y or N(northing) coordinate) location indicators: (1) the Lambert Conformal Conic Projection, (2) the Transverse Mercator Projection, and (3) the Oblique Mercator Projection used in Alaska.

An X or Y coordinate in an existing SPCS may be expressed by a number of the general magnitude of NNNNNNN.NNN. This will suffice for a range of not less than .003 meters and not more than 3,000,000.000 meters, and is considered to be appropriate for this standard. For the purposes of coordinate transfer the following conventions apply. Where a decimal fraction is used, according to the standard, it should be one, two or three positions in length, as required (for example, .1, .15., .125).

### D.2.8 Unit of Measurement

The unit of measurement of both the X and Y coordinate, according to the standard, should be the meter, as required by the SPCS '83 specification.

Currently, many of the SPCS's are, through legislative mandate, referenced to the North American Datum Adjustment of 1983 and are referred to as SPCS 83 systems. The SPCS systems must have their horizontal components expressed in meters to conform to the SPCS specifications. However, there remain several SPCS's which are referenced to the North American Datum of 1927 and are referred to as SPCS 27 systems. The SPCS 27 specifications required that the horizontal components be expressed in feet. The horizontal component of SPCS 27 data must be converted to meters.

## D.3 Altitude

Altitude of a point, as used in this standard, is defined as the distance in meters either above or below a reference surface. The Vertical Datum and Sounding Datum subfields of the External Spatial Reference module, according to the standard, shall be used to specify this surface.

All altitude measurements below the reference Vertical Datum, according to the standard, should be designated by a minus sign (-) preceding the number. Measurements at or above the Vertical Datum, and at or below the Sounding Datum, may be either without a sign or may be designated by a plus sign (+); however usage, according to the standard, should be consistent throughout a set of data.

The use of meters as the unit of vertical measurement is required.

## D.4 Using nongeospatial dimensions

The spatial address field can accommodate additional dimensions. For each added dimension, the Spatial Address field will have one subfield added. The label for the new SADR subfield will match the Dimension Label subfield in the corresponding Internal Spatial Reference record. The format for the new SADR subfield shall match the Format subfield defined in the corresponding Dimension Definition record. The units for the new SADR subfield will be described by the Dimension Value Measurement Unit subfield of the corresponding Dimension Definition record. The number of subfields in the Spatial Address field will be equal to the number of geospatial dimensions defined in the Internal Spatial Reference module plus the number of nongeospatial dimensions defined by the Dimension ID fields of the Internal Spatial Reference module record. The order subfields will appear in the Spatial Address is determined by the order of repetition of the Dimension ID fields.

## Annex E
(Informative)

## Catalog Module Examples

This annex is a companion to 5.2, to provide user assistance in the preparation of Global Information modules. The examples in this annex demonstrate the logical encoding of the Catalog global modules.

## E.1 Catalog/Directory

The following table demonstrates the use of the Catalog/Directory module (module types have been abbreviated to fit the table):

**Table 65 - Usage of the catalog/directory**

| Module Name | Record ID | Name | Type | Volume | File | Record | Comment |
|---|---|---|---|---|---|---|---|
| CD | 1 | CD | Cat/Dir | FloppyA | C.DAT | 1 | 86/6/13 |
| CD | 2 | CX | Cat/Cross | FloppyA | C.DAT | 2 | null |
| CD | 3 | CS | Cat/Spatial | FloppyA | C.DAT | 3 | Alaska data |
| CD | 4 | ID | Identification | FloppyA | I.DAT | 1 | Read pls. |
| CD | 5 | IR | Internal Ref | FloppyA | IR.DAT | * | null |
| CD | 6 | ER | External Ref | FloppyA | ER.DAT | * | null |
| CD | 7 | P1 | Point-Node | FloppyA | P1.DAT | * | Points |
| CD | 8 | P2 | Point-Node | FloppyA | P2.DAT | * | Nodes |
| CD | 9 | L1 | Line | FloppyA | L1.DAT | * | Lines |
| CD | 10 | L2 | Line | FloppyA | L2.DAT | * | Chains |
| CD | 11 | PR | Polygon | FloppyA | PR.DAT | * | Polygons |
| CD | 12 | PR | Polygon | FloppyB | PR.DAT | * | |

Note that Module Name is by definition the same throughout the entire module.

## E.2 Catalog/Cross-Reference

The following example demonstrates the use of the Catalog/Cross-Reference module:

**Table 66 - Use of the catalog/cross-reference**

| Module Name | Record ID | Name 1 | Type 1 | Name 2 | Type 2 | Comment |
|---|---|---|---|---|---|---|
| CX | 1 | CD | Cat/Dir | * | * | All modules are cataloged. |
| CX | 2 | ER | External Ref | P1 | Point-Node | null |
| CX | 3 | ER | External Ref | P2 | Point-Node | null |
| CX | 4 | ER | External Ref | L1 | Line | null |
| CX | 5 | ER | External Ref | L2 | Line | null |
| CX | 6 | ER | External Ref | PR | Polygon | null |
| CX | 7 | PR | Polygon | L2 | Line | PR pols consist of L2 chains. |

## E.3 Catalog/Spatial Domain

The use of the Catalog/Spatial Domain module is demonstrated with the following example (the comment subfield is not shown):

**Table 67 - Use of the catalog/spatial domain**

| Module name | Record ID | Name | Type | Domain | Map | Aggregate theme | Object type |
|---|---|---|---|---|---|---|---|
| CS | 1 | CD | Cat/Direct | * | * | * | null |
| CS | 2 | P1 | Point-Node | Alaska | Mount Drum | null | null |
| CS | 3 | P2 | Point-Node | Alaska | Gulkana | null | null |
| CS | 4 | L1 | Line | Alaska | Copper River | Transport | network |
| CS | 5 | L2 | Line | Alaska | Gulkana | null | null |
| CS | 6 | PR | Polygon | Alaska | Gulkana | null | null |
| CS | 7 | PS | Polygon | Alaska | Kenai | Soils | null |

# Annex F

(Informative)

# Raster Examples

## F.1 Intermodule References

The figures below indicate the intermodule references of some global information and spatial object modules used in raster data transfers. These figures do not display all SDTS mandatory modules that must be transferred in accordance to SDTS.

Figure 29, Intermodule References with two or three Spatial Dimensions, displays a fairly typical raster data transfer. The External Spatial Reference module contains the external coordinate frame of reference for the entire transfer. The Raster Definition (RSDF) module has two records indicating that two raster objects are being transferred. The Internal Reference Foreign ID (IRID) links a IREF record and a RSDF record. Therefore each record of the RSDF module may have a different internal reference system, this allows each raster object to have a different resolution from the other raster objects. One raster object, described in the first record of the RSDF module, has three layers. The other raster object, described in the second record of the RSDF module has one layer. This is indicated by the foreign identifiers pointing to the four records of the Layer Definition (LDEF) module. There are two Cell modules containing all the cell values for each of the four raster layers. The LDEF module indicates which Cell module contains the cell values for that particular raster layer. The Cell modules could have one or more records (RCIDs) depending upon how the encoder chooses to format this module. There are three raster layers encoded in the Cell module named CEL1 and one layer in CEL2.

Figure 30 displays the intermodule references of a raster transfer having two or three geospatial dimensions and 5 non-geospatial dimensions. The XREF module contains the external coordinate frame of reference for the entire transfer. There can only be one XREF module in a transfer. The RSDF module has two records indicating that two raster objects are being transferred. Again, the Internal Reference Foreign ID field links the RSDF record to the IREF record. In addition the Dimension Definition (DMDF) records used by the Internal Reference record are linked by the Dimension Foreign ID fields (DMID). One raster object, described in the first record of the RSDF module, has three layers. The other raster object, described in the second record of the RSDF module has one layer. This is indicated by the foreign identifiers pointing to the four records of the LDEF module. The LDEF module indicates which Cell module contains the cell values for that particular raster layer. The Cell modules could have one or more records (RCIDs) depending upon how the encoder chooses to format this module.

## F.2 SDTS Raster Objects

A raster object contains all raster data layers which have been collected and/or processed together, have similar geographic extents, and have the same resolution. A raster object is defined in one Raster Definition (RSDF) module record. Data layers within a raster object must share the same cell size (resolution). The cell size is defined in the Internal Spatial Reference (IREF) module record referenced by the ISID field of the RSDF module. One LDEF module record defines one layer of the raster object. A raster object could be composed of a single layer (Figure 31) or multiple layers (Figure 32). Both of these rasters have an Object Representation Code of G2, a 2-dimensional gridded raster.

Raster object A (Figure 31) has one data layer (or band). The geographic extent of raster object A is similar to raster object B (Figure 32). However, the data for each raster object was collected by different means. (example: scanned areal photography vs. satellite)

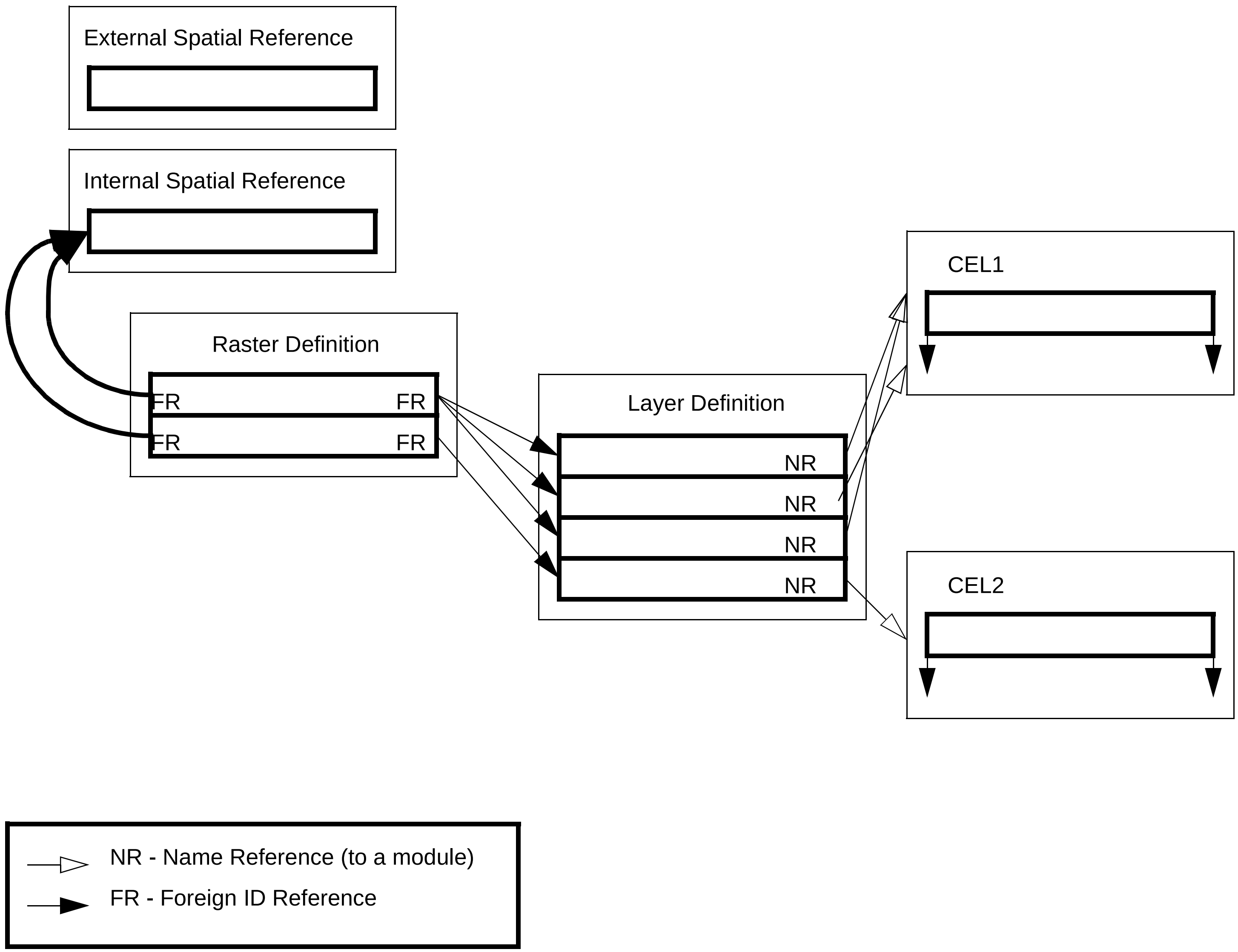


**Figure 29 - Intermodule references for a raster with geospatial**

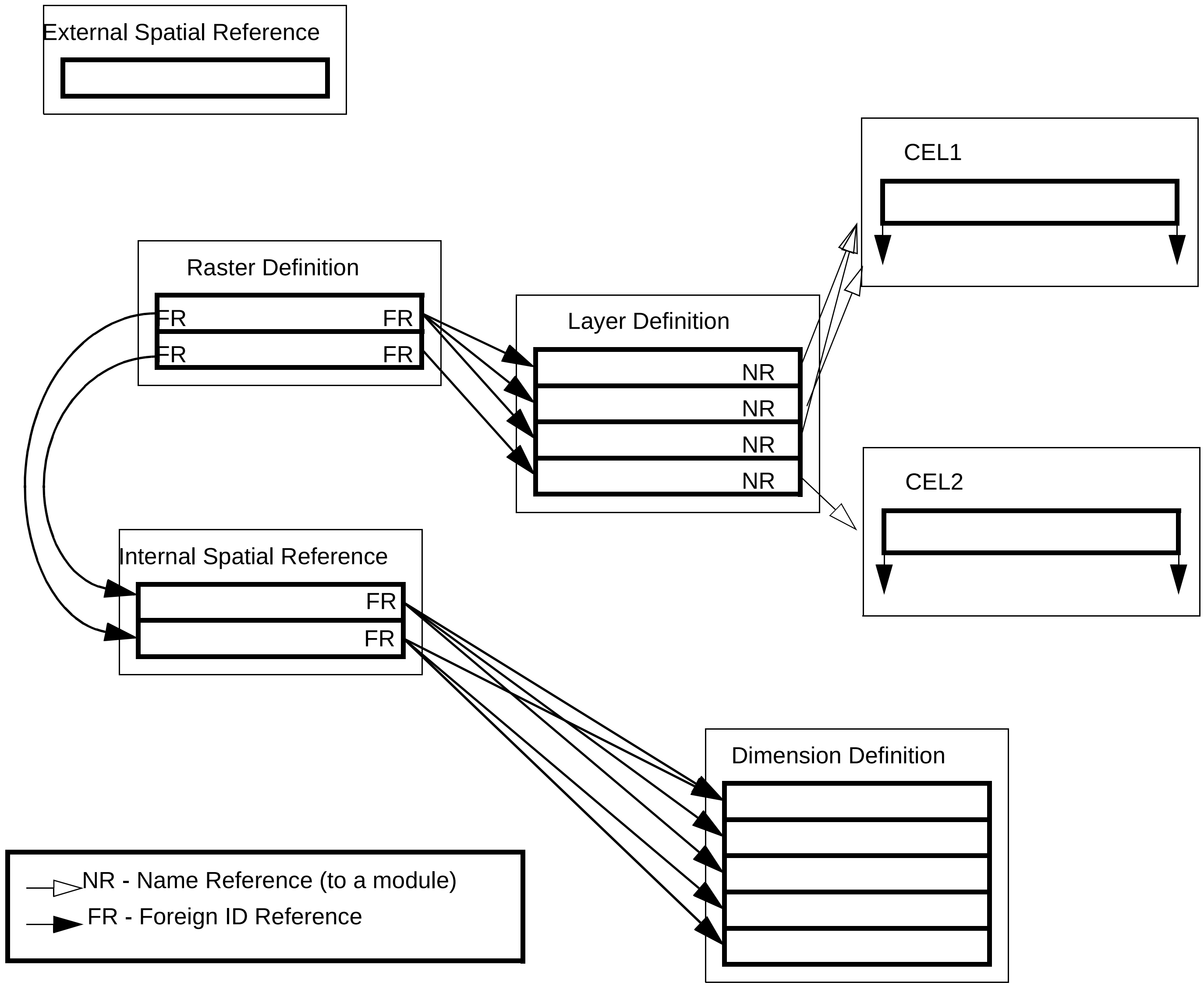


**Figure 30 - Intermodule references for a raster with non-geospatial**

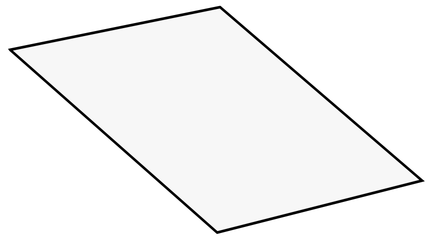

**Figure 31 - Raster object A**

Raster object B has three data layers (or bands). For this example, all cell values of each data layer are interleaved in one Cell module. Thus, a Cell Sequence Code GJ, band interleaved by cell (pixel), would be indicated in the RSDF module when defining raster object B. Interleaving is not a requirement for raster objects with multiple layers.

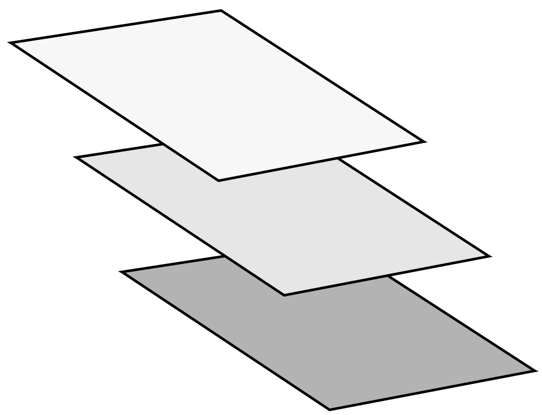

**Figure 32 - Raster object B**

These raster objects will be transferred in one SDTS transfer file set. Each raster object is defined in its own record of the Raster Definition (RSDF) module.

Raster Definition module record (RCID) 2 defines raster object A and contains the foreign identifier reference to the Layer Definition (LDEF) module record. The Layer Definition module record defines its one data layer. RCID 4 of the Layer Definition module also indicates the Cell module name where the cell values are found.

Raster Definition module RCID 1 defines raster object B and contains the foreign identifier references to the Layer Definition module records. There are three records in the Layer Definition module defining the three separate data layers. Each Layer Definition module record identifies the Cell module name where the cell values are found.

A separate Cell module could be created for each data layer of raster object B and thus, cell sequencing code GI would have been used. Having separate Cell modules for each raster layer is the most straightforward type of SDTS - ISO 8211 encoding. The cell sequencing codes GI (band sequential), GJ (band interleaved by cell), and GL (band interleaved by pixel) determine whether raster layers are in separate Cell modules or interleaved within one Cell module.

# Annex G

(Normative)

## Registration of Cell Values to Internal Reference System

### G.1 Overview of Reference Systems

There are two reference systems defined by section 5.2.4: an Internal Spatial Reference System and an External Spatial Reference System. The Raster Modules provide two additional reference systems: the Raster Object Scan Reference system and the Layer Scan Reference system. The following definitions summarize these four reference systems:

- External Reference system - As defined by the External Spatial Reference and the Dimension Definition modules, if the Dimension Definition module is used. This reference system defines the space in which the data set lies. A coordinate for this reference system is called an External Coordinate.

- Internal Reference system - As defined by the Internal Spatial Reference and the Dimension Definition modules. The Internal Coordinate, also called the Spatial Address, is used to locate points in the Internal Reference system. The Spatial Address can be transformed into a External Coordinate by applying the transformation parameters defined in the Internal Reference record. The Internal Reference record transformation parameters are only used to transform the three geospatial dimensions. Nongeospatial dimensions will not be transformed, therefore, the values for these dimensions will appears as they are found in the Spatial Address (See 5.2.4, Spatial Reference Modules).

- Raster Object Scan Reference system - As defined by the Raster Definition module. The Raster Object Coordinate is used to locate points in the Raster Object Scan Reference system. The Raster Object Coordinate can be reflected, translated, and scaled into a Spatial Address by parameters found in the Raster Definition module.

- Layer Scan Reference System - As defined by the Layer Definition module. The Layer Coordinate is used to locate points in the Layer Scan Reference System. A Layer Coordinate, also called an index, is explicitly coded for the first Cell Value of each Cell Record. Subsequent Cell Value indexes of a record are derived by this first index plus parameters defined in the Internal Spatial Reference, Dimension Definition, Raster Definition and Layer Definition modules (See G.2). These indexes can be translated to a Raster Object Coordinate by parameters found in the Layer Definition module.

The remainder of this annex discusses the parameters necessary to perform the transformations of layer coordinates to raster object coordinates, and subsequently to internal coordinates.

### G.2 Rules for Assigning Layer Coordinates to Cell Values.

The definitions in section G.1 require that each Cell Value be assigned a Layer Coordinate before the Cell Value can be registered to the Internal Reference system. To assign a Layer Coordinate to every cell of the layer requires knowledge about the sequence in which Cell Values will occur within the Cell Record. Basically, an n-dimensional array space must be mapped into a linear sequence. The method used by this standard to specify this order uses a conceptual structure called a cartesian label. The cartesian label is derived from parameters found in the Internal Spatial Reference, Dimension Definition, Raster Definition and Layer Definition modules. When the Cartesian product is performed on a cartesian label, an ordered list, composed of unique indexes, will be generated (see Part 3, 6.1.4, Order of Data Items in Arrays). The indexes generated in this fashion can be directly mapped to Layer Coordinates.

The two ordered sets, the sequence of Cell Values in a module record and the list of indexes (labels) from the cartesian product, can be matched up item for item---thus assigning an n-dimensional coordinate to every Cell value. The Layer Coordinate for the first Cell Value of the Cell Record is encoded in the Cell Record. The Layer Coordinate for the first Cell Value can be mapped to an index located in the list of indexes, called the Primary Index. All Cell Values following the first Cell Value can be matched to indexes following the Primary Index. Each Cell record will need a separate Primary Index to locate the first Cell Value of the record. Mapping indexes to Layer Coordinates and back is discussed in section G.3.

## G.3 Generating a Cartesian Label for a Raster Object.

The Cell Values of an n-dimensional array are stored linearly in the repeating Cell Values field of the Cell module. The collection of Cell Values for a layer may be encoded in one record or in multiple records, but the order Cell Values are encoded within the Cell record is defined by the cartesian label. The cartesian label defines the cartesian coordinate system called the Layer Scan Reference system.

The cartesian label defines the Cartesian coordinate system by specifying the number of dimensions, the extent of each dimension and the order of expansion when the cartesian product is taken. Changing the order of repetition for the Dimension ID fields will change the cartesian label generated. The X, Y, and, if needed, Z dimensions will always be the last dimensions of the cartesian label.

The cartesian label is composed of multiple vector labels. Each vector label essentially labels one dimension of the Layer Scan Reference System, thus a four dimensional raster will have a cartesian label composed of four vector labels. The vector label is composed of simple labels. Each simple label provides a value for a position along the dimension. To clarify we will use the following notation:

**m** = total dimensions geospatial and nongeospatial. This count is derived from the Internal Spatial Reference record referenced by RSDF/ISID. The number of dimensions will be two or greater. The Internal Spatial Reference record can be used to find the number of dimensions as follows:

**m** = *2* + (1 *if Z used*) + (*# of repetitions of the IREF/DMID field*)

***n*** = a unique value used to identify a specific dimension of the raster. NOTE: the first two dimensions will always be the geospatial dimensions X and Y respectively and if the geospatial dimension Z is used then the Z dimension will be the third dimension. If the Z dimension is not used, then the third dimension will be the first nongeospatial dimension. All nongeospatial dimensions will appear after the geospatial dimensions, and the order the nongeospatial dimensions appear will be dependent on the order Dimension ID fields repeat in the Internal Reference Record for the raster object in question.

X dimension or Column of the raster - ***n*** = 1

Y dimension or Row of the raster - ***n*** = 2

Z dimension or Plane of the raster - ***n*** = 3 (when the Z dimension is used)

the first IREF/DMID - ***n*** = 3 (when Z is not used) or 4 (when Z is used)

the second IREF/DMID - ***n*** = 4 (when Z is not used) or 5 (when Z is used)

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the last IREF/DMID - ***n*** = **m**

$\mathbf{e_n}$ = extent of the layer along dimension ***n***.

$\mathbf{e_1}$ - LDEF/LDEF/NCOL

$\mathbf{e_2}$ - LDEF/LDEF/NROW

$\mathbf{e_3}$ - LDEF/LDEF/NPLA (if the Z dimension is used)

$\mathbf{e_4}$ - The first repetition of LDEF/LDXT/DEXT

$\mathbf{e_5}$ - The second repetition of LDEF/LDXT/DEXT

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$\mathbf{e_m}$ - The last repetition of LDEF/LDXT/DEXT

$\boldsymbol{v}$ = an index value used to identify a specific position along the dimension; legal values will be integers from 1 to $\mathbf{e}_{\boldsymbol{n}}$ for a given dimension $\boldsymbol{n}$.

$\mathbf{sl}_{\boldsymbol{v}\,\boldsymbol{n}}$ = simple label located at index $\boldsymbol{v}$ along dimension $\boldsymbol{n}$.

if LDEF/LDEF/SORI is 0 then $\mathbf{sl}_{\boldsymbol{vn}} = \boldsymbol{v}-1$

if LDEF/LDEF/SORI is 1 then $\mathbf{sl}_{\boldsymbol{vn}} = \boldsymbol{v}$

$\mathbf{vl}_{\boldsymbol{n}}$ = vector label for the ***nth*** dimension, composed of $\mathbf{e_n}$ index values.

$= \mathbf{sl}_{1\,n}!\mathbf{sl}_{2\,n}!\ \ldots\ !\mathbf{sl}_{(en-1)\,n}!\mathbf{sl}_{e2\,n}$

**cl** = cartesian label for the Layer Scan Reference System, composed of **m** vector labels, one for each dimension. The order vector labels are placed in the cartesian label is defined as follows:

Right most three vector labels will be for the geospatial dimension X, Y and Z. The order the X, Y and Z vector labels will appear in the Cartesian label will be dependent on the value of the RSDF/RSDF/FSCN subfield. The FSCN subfield indicates which of the three dimension proceeds first, which proceeds second and which last. The dimension to proceed first will be the last vector label to appear in the cartesian label. The dimension to proceed second will be the second from last vector label in the cartesian label. And the dimension to proceed last will be the third from the last vector label in the cartesian label. If the Z dimension is not used, then no vector label will be present in the cartesian label for the Z dimension. NOTE: The raster modules uses the term *column* for the X dimension, *row* for the Y dimension, and *plane* for the Z dimension, all other dimensions are termed as they appear in the Dimension Definition record.

The remaining vector labels will be ordered based on the order of repetition of the IREF/DMID field. The dimension referenced by the last DMID field will have the first vector label in the cartesian label. The next to last DMID field will have the second vector label in the cartesian label. etc...

$= \mathbf{vl_m}*\mathbf{vl_{(m-1)}}*\ \ldots\ *\mathbf{vl_1}*\mathbf{vl_2}$ (This cartesian label shows an order where the RSDF/RSDF/FSCN is equal to 'R') If RSDF/RSDF/FSCN is equal to 'C' then the last two vector labels would have been switched. For an example, see Part 3, 6.1.4, Order of Data Items in Arrays.

After performing the substitutions, the syntax for the cartesian label is as follows:

$\mathbf{cl} = \mathbf{sl}_{1\,m}!\mathbf{sl}_{2\,m}!\ \ldots\ !\mathbf{sl}_{em\,m}*\mathbf{sl}_{1\,m-1}!\mathbf{sl}_{2\,m-1}!\ \ldots\ !\mathbf{sl}_{em-1\,m-1}*\ \ldots..\ *\mathbf{sl}_{1\,1}!\mathbf{sl}_{2\,1}!\ \ldots\ !\mathbf{sl}_{e1\,1}*\mathbf{sl}_{1\,2}!\mathbf{sl}_{2\,2}!\ \ldots\ !\mathbf{sl}_{e2\,2}$

Expanding the cartesian label will yield an ordered list of indexes found in Table 68.

The indexes generated in the table above are not in the correct order to be used as a Layer Coordinate. The indexes must be mapped as follows to generate a Layer Coordinate:

$\mathbf{d}_{\boldsymbol{n}}$ = an integer index along dimension $\boldsymbol{n}$, an element of the Layer coordinate.

Layer Coordinate elements, when derived from a cartesian label index:

$\mathbf{d_1}$ - $\mathbf{sl}_{\boldsymbol{v}\,1}$
$\mathbf{d_2}$ - $\mathbf{sl}_{\boldsymbol{v}\,2}$
$\mathbf{d_3}$ - $\mathbf{sl}_{\boldsymbol{v}\,3}$
$\mathbf{d_4}$ - $\mathbf{sl}_{\boldsymbol{v}\,4}$
$\mathbf{d_5}$ - $\mathbf{sl}_{\boldsymbol{v}\,5}$

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.
.
$\mathbf{d_m}$ - $\mathbf{sl_{v\,m}}$

Layer Coordinate elements, when deriving the Primary Index.
$\mathbf{d_1}$ - CELL/CELL/COLI
$\mathbf{d_2}$ - CELL/CELL/ROWI
$\mathbf{d_3}$ - CELL/CELL/PLAI ( if the Z axis is used)
$\mathbf{d_4}$ - the first repetition of CELL/DNDX/ANVL.
$\mathbf{d_5}$ - the second repetition of CELL/DNDX/ANVL
.
.
.
$\mathbf{d_m}$ - the last repetition of CELL/DNDX/ANVL

**Table 68 - List of indexes generated by taking the cartesian product**

| Repetition No. | Index |
|---|---|
| 1 | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{1\,1}!sl_{1\,2}$ |
| 2 | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{1\,1}!sl_{2\,2}$ |
| 3 | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{1\,1}!sl_{3\,2}$ |
| . | . |
| . | . |
| . | . |
| $e_2 - 1$ | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{1\,1}!sl_{e2-1\,2}$ |
| $e_2$ | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{1\,1}!sl_{e2\,2}$ |
| $e_2 + 1$ | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{2\,1}!sl_{1\,2}$ |
| $e_2 + 2$ | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{2\,1}!sl_{2\,2}$ |
| . | . |
| . | . |
| . | . |
| $e_1 * e_2 - 1$ | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{e1\,1}!sl_{e2-1\,2}$ |
| $e_1 * e_2$ | $sl_{1\,m}!sl_{1\,m-1}!\ldots!sl_{e1\,1}!sl_{e2\,2}$ |
| $e_1 * e_2 + 1$ | $sl_{1\,m}!sl_{2\,m-1}!\ldots!sl_{1\,1}!sl_{1\,2}$ |
| $e_1 * e_2 + 2$ | $sl_{1\,m}!sl_{2\,m-1}!\ldots!sl_{1\,1}!sl_{2\,2}$ |
| . | . |
| . | . |
| . | . |
| $e_1 * e_2 * \ldots * e_{m-1} - 1$ | $sl_{1\,m}!sl_{em-1\,m-1}!\ldots!sl_{e2\,1}!sl_{e2-1\,2}$ |
| $e_1 * e_2 * \ldots * e_{m-1}$ | $sl_{1\,m}!sl_{em-1\,m-1}!\ldots!sl_{e2\,1}!sl_{e2\,2}$ |
| $e_1 * e_2 * \ldots * e_{m-1} + 1$ | $sl_{2\,m}!sl_{1\,m-1}!\ldots!sl_{1\,1}!sl_{1\,2}$ |
| $e_1 * e_2 * \ldots * e_{m-1} + 2$ | $sl_{2\,m}!sl_{1\,m-1}!\ldots!sl_{1\,1}!sl_{2\,2}$ |
| . | . |
| . | . |
| . | . |
| $e_1 * e_2 * \ldots * e_{m-1} * e_m - 2$ | $sl_{em\,m}!sl_{em-1\,m-1}!\ldots!sl_{e1\,1}!sl_{e2-2\,2}$ |
| $e_1 * e_2 * \ldots * e_{m-1} * e_m - 1$ | $sl_{em\,m}!sl_{em-1\,m-1}!\ldots!sl_{e1\,1}!sl_{e2-1\,2}$ |
| $e_1 * e_2 * \ldots * e_{m-1} * e_m$ | $sl_{em\,m}!sl_{em-1\,m-1}!\ldots!sl_{e1\,1}!sl_{e2\,2}$ |

## G.4 Assigning a Layer Coordinate with Multiple Layers per Cell Module.

When more than one layer is encoded into the same Cell Module, assignment of Layer Coordinates will be effected by the Cell Sequencing Code, RSDF/RSDF/CSCD, and sometimes by the order of repetition of the Layer ID fields, RSDF/LYID. For multiple layers to occupy the same cell module four rules must be followed:

- Rule number one, all layers must be part of the same raster object, i.e. the Raster Definition record must have a Layer Foreign ID pointer to each of the Layer records to be coded in the same Cell module.

- Rule number two, only one Layer coordinate will be assigned for each CVLS field. Although, it is possible for the same Layer Coordinate to be assigned to more than one CVLS field, thus the Cell Values with the same Layer Coordinate are coincident.

- Rule number three, all layers must have Cell Values for the same Raster Object Coordinate, i.e. if a layer has missing values then all layers will have missing values in the same locations.

- Rule number four, to allow all layers to be interleaved in the same Cell module, the following subfields must contain the same values for each layer. If the subfield or field is missing from one layer, then subfield or field will be missing from the other layer(s) as well.

LDEF/LDEF/CMNM - Cell Module Name
LDEF/LDEF/NROW - Number of Rows
LDEF/LDEF/NCOL - Number of Columns
LDEF/LDEF/NPLA - Number of Planes
LDEF/LDEF/SORI - Scan Origin Row
LDEF/LDEF/SOCI - Scan Origin Column
LDEF/LDEF/SOPI - Scan Origin Plane
LDEF/LDEF/RWOO - Row Offset Origin
LDEF/LDEF/CLOO - Column Offset Origin
LDEF/LDEF/PLOO - Plane Offset Origin
LDEF/LDEF/INTR - Intracell Reference Location
LDEF/LDXT - Layer Dimension Extent Field
(All repetitions of the repeating LDXT field must be the same for all layers.)

When these conditions are met, the cartesian label will be identical for all interleaved layers. Assigning a Layer Coordinate to the CVLS field, is the same as assigning a Layer Coordinate to all Cell Values of the CVLS field. The process for assigning a Layer Coordinate to the CVLS field is defined in section G.3. Additional restrictions are imposed depending on the Cell Sequencing Code used.

### G.4.1 Assigning a Layer Coordinate to a Cell Value when the GI Sequence is used.

When the layer sequential, GI, sequence code is specified, the Cell Values for each layer will be encoded in separate records. Regardless of how the records are interleaved, each record will have a separate Primary Index, as defined in section G.3. The Primary Index is used with the layers cartesian label to assign Layer Coordinates to each Cell Value.

### G.4.2 Assigning a Layer Coordinate to a Cell Value when the GJ Sequence is used.

When the layer interleaved by line, GJ, sequence code is specified, the Cell Values for each layer will be encoded in the same record. All Cell Values for the first layer will be encoded in the first consecutive set of CVLS fields. The Cell Values for each layer will be encoded in consecutive sets of CVLS fields. There is no restriction on how much of the layer is coded in the record, but there must be equal numbers of Cell Values coded in the Cell Record for each layer. This encoding scheme requires the layers to have the same dimensions and they must be coincident with each other.

### G.4.3 Assigning a Layer Coordinate to a Cell Value when the GL Sequence is used.

When the layer interleave by pixel, GL, sequence code is specified, each Cell Values field will contain one cell value from each layer. This encoding scheme requires the layers to have the same dimensions and they must be coincident with each other.

### G.4.4 Assigning Layer Coordinates to Cell Values Utilizing Tesseral Indexing.

This standard provides the ability to transfer tesserally indexed raster data, but it does not provide the necessary rules for assigning Layer Coordinates to cell values. The responsibility for providing the tesseral indexing rules is left for the data encoder to define. Any data encoder using tesseral indexing will need to consider the parameters used in section G.2 while defining these rules. Once these rules have been established, the Layer Coordinates assigned by the new rules can be used as defined in section G.5. When tesseral indexing is used, the Row Index, Column Index and Plane Index subfields as well as the Dimension Index field of the Cell module can not be used; the Tesseral Index subfield of the Cell module will be used instead.

## G.5 How to Transform a Layer Coordinate into a Spatial Address

To give an accurate description of how spatial addresses are assigned to cells the following definitions can be used to transform a layer coordinate from the layer scan reference system to the internal reference system (see Figure 33)

**m** = as defined in section G.3

***n*** = as defined in section G.3

$\mathbf{e_n}$ = as defined in section G.3

$\mathbf{d}_{\boldsymbol{n}}$ = as defined in section G.3.

$\mathbf{p_n}$ = extent of the raster along dimension ***n***.
$\mathbf{p_1}$ - RSDF/RSDF/CLXT
$\mathbf{p_2}$ - RSDF/RSDF/RWXT
$\mathbf{p_3}$ - RSDF/RSDF/PLXT
$\mathbf{p_4}$ - The first repetition of RSDF/RDXT/DEXT
$\mathbf{p_5}$ - The second repetition of RSDF/RDXT/DEXT
.
.
.
$\mathbf{p_m}$ - The last repetition of RSDF/RDXT/DEXT

$\mathbf{r}_{\boldsymbol{n}}$ = the cell size, in Internal Coordinates, along dimension ***n*** of the raster. The resolution for the X, Y and Z dimension, found in the Internal Spatial Reference record, will be divided by the Scaling factor, SFAX, SFAY and SFAZ, to transform the resolution from External scale to Internal scale. This assumes the cell size along a dimension is constant. For variable cell size along a dimension see section G.6.
$\mathbf{r_1}$ - IREF/IREF/XHRS divided by IREF/IREF/SFAX
$\mathbf{r_2}$ - IREF/IREF/YHRS divided by IREF/IREF/SFAY
$\mathbf{r_3}$ - IREF/IREF/ZHRS divided by IREF/IREF/SFAZ (if Z axis is used)
$\mathbf{r_4}$ - the DMDF/DMDF/DRES pointed to by the first repetition of IREF/DMID
$\mathbf{r_5}$ - the DMDF/DMDF/DRES pointed to by the second repetition of IREF/DMID
.
.
.
$\mathbf{r_m}$ - the DMDF/DMDF/DRES pointed to by the last repetition of IREF/DMID

$\mathbf{s}_{\boldsymbol{n}}$ = indicates if the Layer Scan Reference origin for dimension ***n*** starts at zero or one. If the value is zero then the dimensions Layer Scan Reference system starts at zero. If the value is one then the dimensions layer scan reference system starts at one. These values are derived from the following locations:

**$s_1$** - LDEF/LDEF/SOCI
**$s_2$** - LDEF/LDEF/SORI
**$s_3$** - LDEF/LDEF/SOPI (if Z axis is used)
**$s_4$** - the first repetition of LDEF/LDXT/SODM
**$s_5$** - the second repetition of LDEF/LDXT/SODM
.
.
.
**$s_m$** - the last repetition of LDEF/LDXT/SODM

**$o_n$** = an Internal Coordinate value which locates the origin of the Raster Object Reference system along dimension ***n***.
**$o_1$** - RSDF/SADR/X
**$o_2$** - RSDF/SADR/Y
**$o_3$** - RSDF/SADR/Z (if the Z axis is used)
**$o_4$** - RSDF/SADR/<subfield for first nongeospatial dimension>
**$o_5$** - RSDF/SADR/<subfield for second nongeospatial dimension>
.

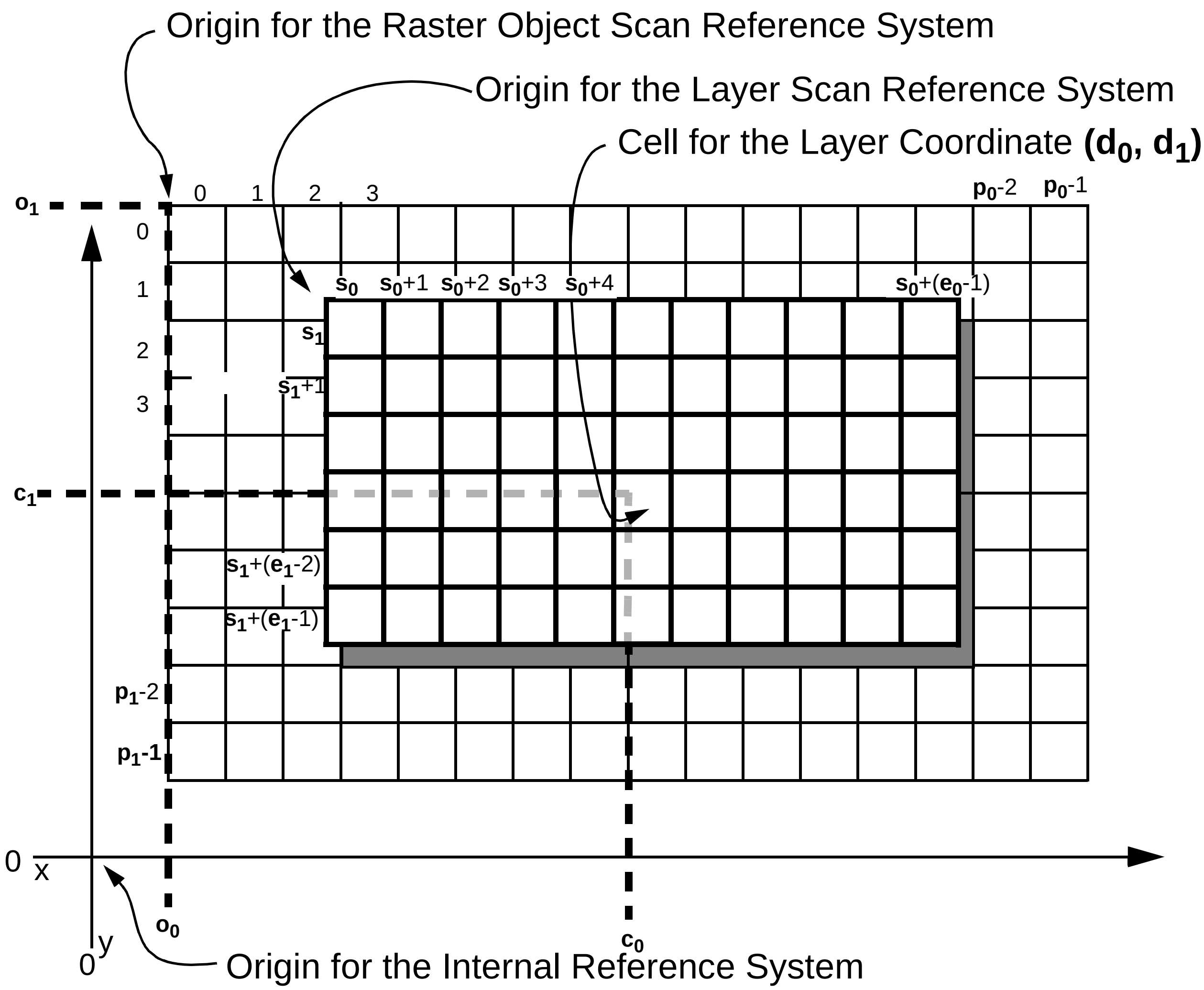


**Figure 33 - Relationship between coordinate systems in two dimensions**

.
.
.
**$o_m$** - RSDF/SADR/<subfield for last nongeospatial dimension>

**$t_n$** = integer translation value to move dimension ***n*** of the Layer Scan Reference system origin to the Raster Object Scan Reference system.
**$t_1$** - LDEF/LDEF/CLOO
**$t_2$** - LDEF/LDEF/RWOO
**$t_3$** - LDEF/LDEF/PLOO (if the Z axis is used)
**$t_4$** - the first repetition of LDEF/LDXT/DTOO
**$t_5$** - the second repetition of LDEF/LDXT/DTOO
.
.
.
**$t_m$** - the last repetition of LDEF/LDXT/DTOO

**$c_n$** = the Internal Coordinate value which locates index **$d_n$** along dimension ***n***

**$a_n$** = a value, +1 or -1, indicating the orientation of the Raster Object Scan Reference origin with respect to the Internal Reference Origin for the dimension ***n***. A positive one indicates the raster object scan reference axis and the internal reference axis are oriented the same way. A minus one indicates the two axes are oriented opposite ways.
if RSDF/RSDF/SCOR indicates Left, **$a_1$** = +1
if RSDF/RSDF/SCOR indicates Right, **$a_1$** = -1
if RSDF/RSDF/SCOR indicates Top, **$a_2$** = -1
if RSDF/RSDF/SCOR indicates Bottom, **$a_2$**= +1
if RSDF/RSDF/SCOR indicates Z runs negative to positive, **$a_3$** = +1
if RSDF/RSDF/SCOR indicates Z runs positive to negative, **$a_3$** = -1
the first repetition of RSDF/RDXT
if DSCO = PN, value for dimension 4, **$a_4$** = -1
if DSCO = NP, value for dimension 4, **$a_4$** = +1
the second repetition of RSDF/RDXT
if DSCO = PN, value for dimension 5, **$a_5$** = -1
if DSCO = NP, value for dimension 5, **$a_5$** = +1
.
.
.
the last repetition of RSDF/RDXT
if DSCO = PN, value for dimension m, **$a_m$** = -1
if DSCO = NP, value for dimension m, **$a_m$** = +1

**R** = a vector representing the Internal Reference system cell sizes for all dimensions, derived from the records pointed to by the Internal Spatial ID field of the Raster Definition module.
$[r_1\ r_2\ r_3\ r_4\ r_5\ \ldots\ldots\ r_m]$

**S** = a vector where each value is zero or one.
$[s_1\ s_2\ s_3\ s_4\ s_5\ \ldots\ldots\ s_m]$

**D** = a vector representing a integer index into the Layer Scan Reference system, usually derived when a Cell Value's index is needed. Every Cell record has a Layer Coordinate, **D**, to locate the first cell of the record.
$[d_1\ d_2\ d_3\ d_4\ d_5\ \ldots\ldots\ d_m]$

**O** = a vector representing the Internal Coordinate of the Raster Object Scan reference system origin, derived from the SADR field in the Raster Definition module.
$[o_1\ o_2\ o_3\ o_4\ o_5\ \ldots\ldots\ o_m]$

**T** = a vector used to translate the Layer Scan Reference system to the Raster Object Scan Reference system.

$[t_1\ t_2\ t_3\ t_4\ t_5\ \ .....\ t_m\ ]$

**A** = a vector representing the location of the Raster Object Scan Reference system origin with respect to the World Coordinate origin.

$[a_1\ a_2\ a_3\ a_4\ a_5\ \ .....\ a_m\ ]$

$\mathbf{R_d}$ = **m**x**m** diagonal matrix where the values of the vector **R** are along the diagonal.

$\mathbf{A_d}$ = **m**x**m** diagonal matrix where the values of the vector **A** are along the diagonal.

**C** = the resultant vector for the Layer Coordinate **D**. This vector is also known as the Spatial Address for the Layer Coordinate **D**. The vector **C** is defined by the following matrix formula:

$= \mathbf{O} + (\ \mathbf{D} - \mathbf{S} + \mathbf{T}\ ) * \mathbf{R_d} * \mathbf{A_d}$

When the default implementation is used for the Object Representation Code, G2, the formula for **C** is defined as follows (See 5.7.5, Default Implementation):

**m** = 2

**O** = derived as indicated above.

$[\ o_1\ \ o_2\ ]$

**T** = [ 0 0 ]

**D** = derived as indicated above.

$[\ d_1\ \ d_2\ ]$

**S** = [ 0 0 ]

**R** = derived as indicated above

$[\ r_1\ \ r_2\ ]$

**A** = [ +1 -1 ]

$\mathbf{R_d}$ = derived as indicated above

$\mathbf{A_d}$ = derived as indicated above

**C** = the same as above, but we can simplify it because of the default values:

$= \mathbf{O} + \mathbf{D} * \mathbf{R_d} * \mathbf{A_d}$

## G.6 Transforming a Layer Coordinate to a Spatial Address using Labels.

This standard allows one or more dimensions of a raster to be labeled, when the resolution for the dimension is not constant. When an axis is labeled each position of the axis in the Raster Object Scan Reference system will have one label indicating where the corresponding position lies in the Internal Reference system. If a dimension requires labeling, then the resolution for the labeled dimension will be set to zero. The geospatial dimensions, X, Y and Z, can be labeled, but the labels must match the format defined by the raster's Internal Reference record. The nongeospatial dimensions can be labeled, but the labels must match the format defined by the dimension's Dimension Definition record. The labels will be stored in the repeating fields, each dimension will be labeled in a specific field (see Table 69).

If the Z dimension were labeled, the IREF/IREF/ZRES would be zero and there would be RSDF/RSDF/PLXT repetitions of the RSDF/ZXLB field. Each ZXLB field would contain a label for the corresponding position along the Z dimension of the Raster Object Scan Reference system.

To use the labels, perform the calculations as defined in section G.3 and then for the dimensions with a zero resolution, a label will have to be placed in the corresponding dimension of the **C** vector. The following formula can be used.

$c_n = \mathbf{LBL}_n\ (dn=0n)$

If the ***n****th* dimension's resolution is zero, the value for $c_n$th element of the **C** vector will be the $(d_n+o_n)$th label of the ***n****th* dimension's list of labels.

**Table 69 - Location of labels when a dimension is labeled.**

| Dimen sion | Field with labels located in it | Subfield containing the Label Field's Number of Repetitions | Notation used when referencing the label. |
|---|---|---|---|
| 1 | RSDF/XXLB | RSDF/RSDF/CLXT | $\mathbf{LBL_1}$ |
| 2 | RSDF/YXLB | RSDF/RSDF/RWXT | $\mathbf{LBL_2}$ |
| 3 | RSDF/ZXLB[1] | RSDF/RSDF/PLXT | $\mathbf{LBL_3}$ |
| 4 | RSDF/DAL0 | RSDF/RDXT/DEXT (1st rep.) | $\mathbf{LBL_4}$ |
| 5 | RSDF/DAL1 | RSDF/RDXT/DEXT (2nd rep.) | $\mathbf{LBL_5}$ |
| 6 | RSDF/DLA2 | RSDF/RDXT/DEXT (3rd rep.) | $\mathbf{LBL_6}$ |
| . | . | | |
| . | . | | |
| . | . | | |
| m | RSDF/DAL(**m**-4) | RSDF/RDXT/DEXT (last rep.) | $\mathbf{LBL_m}$ |

1) if the Z dimension is used

# Annex H
(Informative)

# Glossary

This glossary assembles terms defined in parts 1, 2 and 3 of this standard, in addition to selected terms used in these definitions.

**Accuracy**

The closeness of results of observations, computations or estimates to the true values or the values accepted as being true.

**Aggregation**

The operation of constructing more complex phenomena out of component phenomena. A lock is an aggregation of walls, gates, and a reservoir.

**Altitude**

Elevation above or below a reference datum, as defined in FIPSPUB 70-1; the z-value in a spatial address. See also elevation.

**Association**

The assignment of phenomena to sets, using criteria different from those used for classification. Concrete roads may be associated with concrete sewers, concrete locks, and other phenomena constructed of concrete.

**Attribute**

A defined characteristic of an entity type (e.g. composition).

**Attribute Value**

A specific quality or quantity assigned to an attribute (e.g., steel), for a specific entity instance.

**Check Plot**

A graphic product produced from a digital system to verify the positional data by direct superimposition on the graphic original used to create the digital record. Typically the check plot is produced on stable-base transparent or translucent material. Procedures to register the check plots should be considered carefully.

**Classification**

The assignment of similar phenomena to a common class. An individual phenomenon is an instance of its class. Route 10 is an instance of the class road.

**Composite Object**

An object constructed from a set (i.e. one or more) of either the same kind or a mix of different kinds of simple objects.

**Control (mapping)**

A system of points with established horizontal and vertical positions which are used as fixed references in positioning and relating map features.

**Coordinates**

See Spatial Address.

**Cycle**

In the context of topological testing, a closed ring of adjacencies between graph duals (constructed according to Euler's Law).

**Data Base**

Related subject information stored as a volume set, volume, file set, or file.

**Data Element**

A logically primitive item of data.

**Elevation**

Conforming to FIPSPUB 70-1, the term "altitude" is used in this standard, rather than the common term elevation, for the z-value in a spatial address.

**Entity Instance**

A spatial phenomenon of a defined type that is embedded in one or more phenomena of a different type, or that has at least one key attribute value different from the corresponding attribute values of the surrounding phenomena (e.g., the 10th Street Bridge).

**Entity Type**

The definition and description of a set into which similar entity instances are classified (e.g., bridge).

**Feature Instance**

An instance of a defined entity and its object representation.

**Field**

Consists of one or more related subfields. It may contain part or all of a module field. It does not contain parts of two or more module fields.

**Field Group**

A set of related module fields with special ordering and/or logical relationships between module fields in the group.

**Field Name**

A name associated with a field.

**File**

An identifiable collection of zero or more related records. It may contain part of, or all of one or many modules.

**File Set**

An identifiable collection of zero or more related files.

**Foreign Identifier**

A reference to a unique module record other than the record containing the foreign identifier; has the same domain and structure as the module record identifier to which it refers.

**Foreign Key**

Attributes in one table that match the primary key in another table.

**Generalization**

A process in which classes are assigned to other classes. The general class includes all the instances of the constituent classes. Sewers are included in the more general class of utilities.

**Geocodes**

A system of abbreviation used to represent an exhaustive list of a class of geographic features (usually applied to political units).

**Geospatial dimensions**

The dimensions used for specifying geographic data, longitude, latitude, and altitude; also called spatial dimensions, the terms spatial and geospatial are equivalent. See also Nongeospatial dimensions.

**Implementation Method**

A method of encoding data content and data structure to accomplish a transfer without loss of content, meaning, or structure.

**Included Term**

Non-standard label of an entity type or attribute that is cross-referenced to a standard term of an entity type or attribute.

**Key Attributes**

A set of attributes such that the combination of the attribute values forms a unique identifier for each entity instance.

**Layer**

An integrated, areally distributed, set of spatial data usually representing entity instances within one theme, or having one common attribute or attribute value in an association of spatial objects. In the context of raster data, a layer is specifically a two-dimensional array of scaler values associated with all of part of a grid or image.

**Map**

A spatial representation, usually graphic on a flat surface, of spatial phenomena.

**Media**

The physical devices used to record, store, and (or) transmit data.

**Media Record**

A physical unit of data. The characteristics of a record and its means of delimitation are defined by standards specific to each given medium.

**Misclassification Matrix**

Results of an attribute accuracy test given in the form of a row by column (RxC) contingency table (cross-tabulation) sometimes called a classification error matrix. Usually the rows represent the interpretation tested and the columns represent the verification assumed to be correct. The diagonal elements represent the correct classifications when the matrix is square and the rows and columns are strictly comparable. The remaining elements can be treated row-wise as errors of commission, and column-wise as errors of omission.

**Module**

A logical collection of module records.

**Module Field**

A defined set of one or more module subfields in a Spatial Data Transfer.

**Module Record**

A defined set of one or more module fields in a Spatial Data Transfer.

**Module Record Identifier**

First two subfields of a primary module field of a module record containing an unique identification for that record in the volume set.

**Module Specification**

The meaning, identification, order requirements and data structure requirements for data belonging to the module.

**Module Subfield**

A logical construct defining a single data element in a Spatial Data Transfer.

**Nongeospatial dimensions**

Dimensions used for giving data nongeographic location in space, such as the time dimension. See also Geospatial dimensions.

**Object**

A digital representation of all or part of an entity instance.

**Phenomenon**

A fact, occurrence or circumstance. Route 10, George Washington National Forest, and Chesterfield County are all phenomena.

**Primary key**

The set of key attributes chosen to identify uniquely the rows in a table.

**Primitive**

The quality of not being subdivided; atomic.

**Quality**

An essential or distinguishing characteristic necessary for cartographic data to be fit for use.

**Quality Overlay**

A collection of points, lines, and areas organized to represent quality information for another set of map information. An overlay describing lineage can be termed a source data index; a positional accuracy overlay can be termed a reliability diagram.

**Raster object**

One or more images and/or grids, each grid or image representing a layer, such that corresponding grid cells and/or pixels between layers are congruent and registered.

**Record**

An implementation-dependent construct that consists of an identifiable collection of one or more related fields. It may contain part of, or all of, one or more module records. It may be written as part of or all of one or more media records.

**Representation**

Graphical symbolization of a spatial object.

**Representation Module**

Collection of representation codes that define the way an object will be symbolized or portrayed.

**Resolution**

The minimum difference between two independently measured or computed values which can be distinguished by the measurement or analytical method being considered or used.

**Spatial**

Synonymous with *geospatial*.

**Scales Of Measurement**

A system of classification of measurements depending on the mathematical operations permitted: the simplest scale is nominal scale which only permits a test of equivalence (same value), ordinal scale adds the property of order and the operations greater than and less than, interval scale defines addition and subtraction, and ratio scale subsumes the earlier ones with the inclusion of multiplication and division.

**Spatial Address**

Pairs of numbers expressing horizontal distances along orthogonal axes; alternatively, triplets of numbers measuring horizontal and vertical distances. Can be generalized to refer to an n-tuple with the first 2 or 3 dimensions being geospatial and the higher dimensions being nongeospatial.

**Spatial Data Transfer**

A collection of related modules.

**Standard Term**

Primary label of an entity type or attribute.

**Subfield**

A physical area containing, or logical construct defining, a single data element.

**Subfield Name**

A name associated with a subfield.

**Theme**

A generalization of entity classes (e.g., culture, hydrography, transportation).

**Transfer Construct**

A volume set, volume, file set, file, module, module record, module field, module subfield, field, subfield, record, or media record.

**Transformation**

A computational process of converting a position from one coordinate system to another.

**Volume**

A media-dependent construct consisting of an identifiable collection of part of or all of one or more files. A volume is a discrete interchange construct such as a unit of dismountable media or a single on-line session.

**Volume Set**

A media-dependent construct consisting of an identifiable collection of one or more volumes containing a single file set.

## Annex I
(informative)

## Bibliography

This annex includes normative references to other standards contained in 1.3 and in part 3, in addition to selected works used in the preparation of this standard.


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