# THE SPATIAL DATA TRANSFER STANDARD

## Handbook for Technical Staff

*A “road map” to the SDTS for technical staff involved in SDTS implementation*

Prepared under direction of the Federal Systems Integration and Management Center (FEDSIM) and the SDTS Task Force

SDTS
Spatial Data Transfer Standard

# Contents

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# Preface: Using This Handbook

## Overview

This handbook provides a technical explanation of the Spatial Data Transfer Standard (SDTS) and offers information of value to technically oriented individuals who will be implementing SDTS. The materials in this handbook and its appendices are designed to summarize important SDTS topics and to augment the SDTS specification itself.

For more effective use of this handbook, please note the following:

- Notations in brackets in the left column provide useful cross-references to the SDTS specification document.
- Italicized words are defined in the Glossary at the end of this handbook.

## Intended Audience

This handbook will be useful to you if you are:

- **Developing translation software** for one or more SDTS profiles.
- A technical person who **is designing or developing new and modified SDTS profiles.**
- A technical staff person in a government agency or private firm involved in **"packaging" data for distribution in SDTS format.**
- A technical manager **directing any of the efforts listed above** who requires a detailed guide to technical aspects of SDTS.

This handbook is meant to give you a solid understanding of the format, content, and requirements for SDTS transfers. It summarizes and serves as a guide to the actual SDTS specification, which must be consulted to examine the details of SDTS. This handbook assumes that readers are knowledgeable about spatial data structures and the details of the specific application software used by their organizations. This guide is not intended to teach programming techniques; its goal is to help technical development personnel understand SDTS so that implementation work can proceed.

If you are interested in a more management-oriented discussion of SDTS, you may wish to refer to the companion documents, *SDTS Guide for Technical Managers* and *SDTS Senior Management Overview.*

# 1. Introduction

## 1.1 What is SDTS?

[SDTS specification* cross reference: Part 1—Introduction]

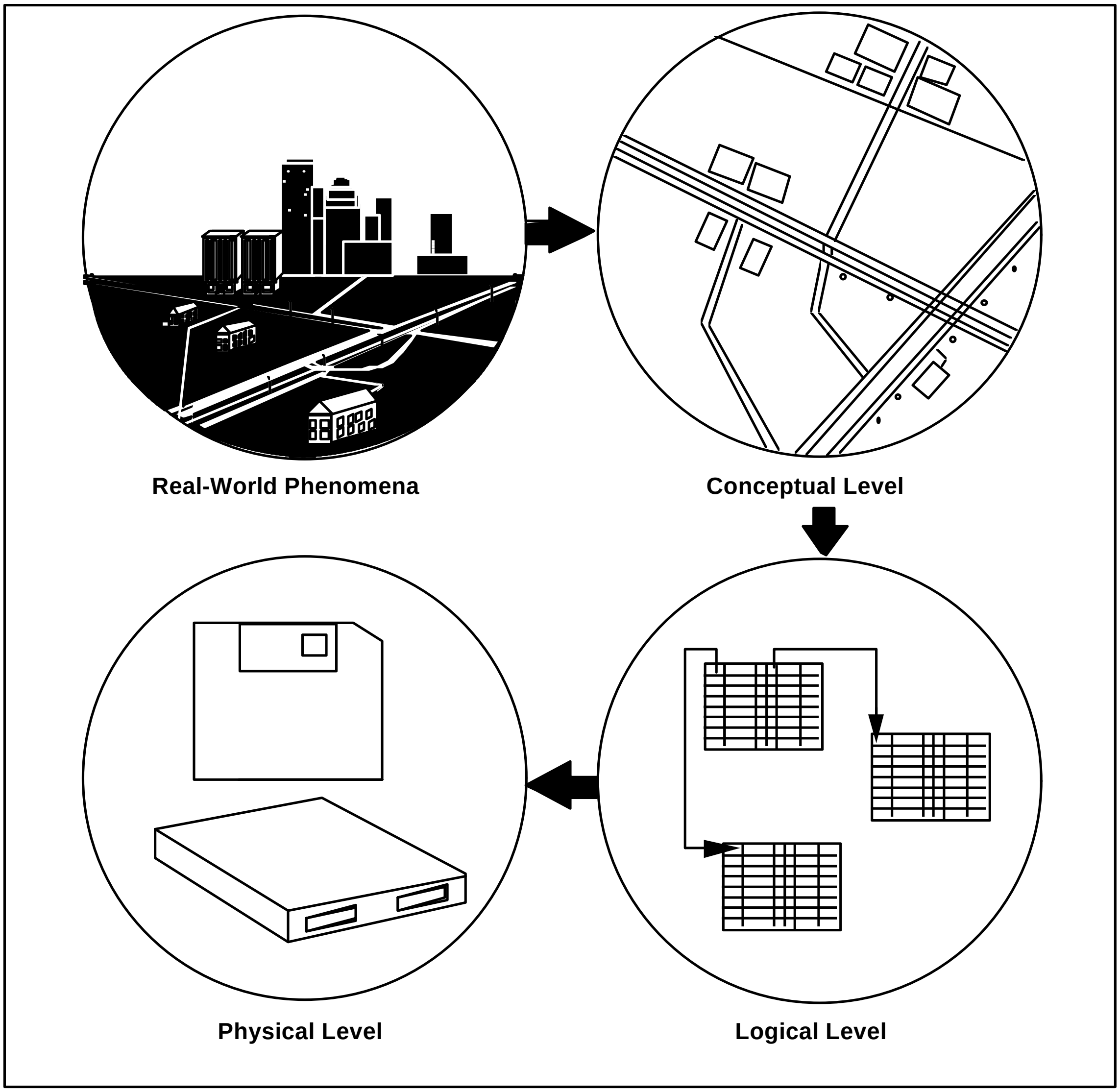
The Spatial Data Transfer Standard (SDTS) provides a practical and effective vehicle for the exchange of spatial data between different computing platforms. It is designed specifically as a format for the **transfer** of spatial data—not for direct use of the data. By addressing all aspects of spatial data, SDTS is comprehensive in nature—effectively avoiding pitfalls of other transfer formats that have been used in the past. After years of development and testing, SDTS is now ready for use.

SDTS was ratified by the National Institute of Standards and Technology (NIST) as a Federal Information Processing Standard (FIPS 173) in 1992. Compliance with FIPS 173 by federal agencies became mandatory in 1994. Many federal agencies, most notably the U.S. Geological Survey (USGS), U.S. Census Bureau, and Army Corps of Engineers, are producing and distributing spatial data in SDTS format.

As described in more detail in this handbook, the full SDTS specification creates a framework for spatial data transfer by defining different "levels," from the real world to the physical encoding of the data (see Figure 1). The **conceptual level** describes a way to represent real-world entities, including their geometric and topological characteristics and relationships. The **logical level** presents a data model for identifying and encoding information for an SDTS transfer. SDTS also defines the **physical level** with rules and specific formats for encoding data on a medium of choice (e.g., magnetic tape).

*National Institute of Standards and Technology, *Federal Information Processing Standards Publication 173: Spatial Data Transfer Standard (SDTS)*, Gaithersburg, MD: U.S. Department of Commerce, 1992.

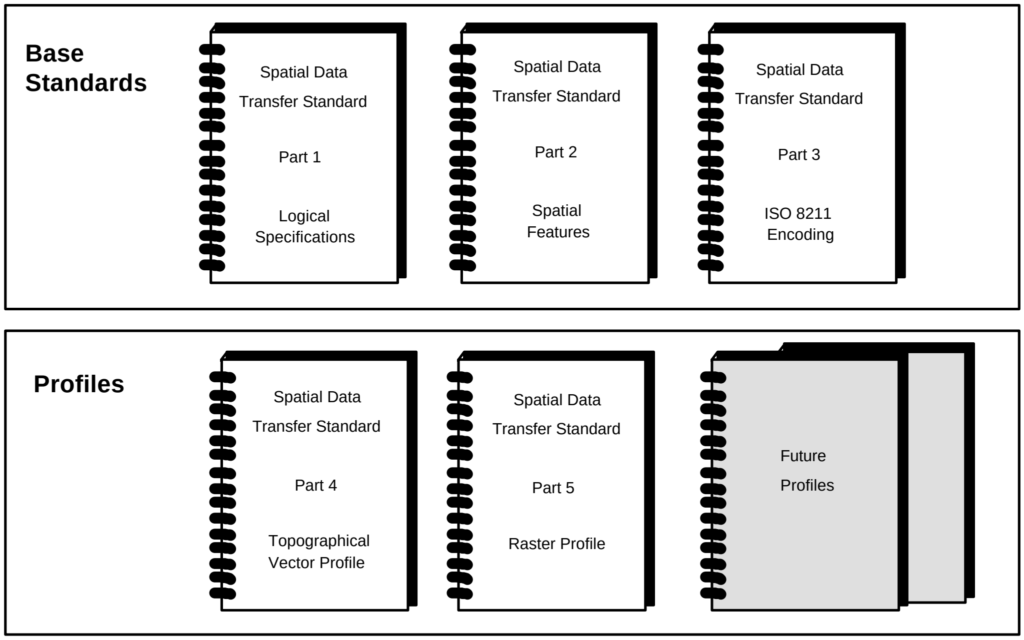
**Figure 1: Foundation for SDTS Transfer**




## 1.2 Overview of the Content and Format of SDTS

The SDTS specification currently consists of five parts that describe the underlying conceptual model explained above and the detailed specifications for the content and structure for exchange of spatial data to and from any system for which translation software has been developed. As shown in Figure 2, the SDTS specification is organized into the base specification and multiple profiles, each of which defines specific rules and formats for applying SDTS for the exchange of particular types of data. The base specification and the current profiles—the *Topological Vector Profile* (TVP) and the *Raster Profile* (RP)—address all elements of spatial data transfer.

**Figure 2: SDTS Specification Format**




Each part is summarized below.

**Part 1—Logical Specifications**
Part 1 consists of three main sections which explain the SDTS conceptual model and SDTS spatial object types, components of a data quality report, and the layout of SDTS modules that contain all needed information for a spatial data transfer compliant with SDTS. This part of SDTS addresses the conceptual and logical levels shown in Figure 1.

**Part 2—Spatial Features**
Part 2 of SDTS further addresses the logical level of Figure 1. It contains a catalogue of spatial features and associated attributes. This part addresses a need for definition of common spatial feature terms to ensure greater compatibility in data transfers. The current version of Part 2 is limited to small-and medium-scale spatial features commonly used on topographic quadrangle maps and hydrographic charts.

**Part 3—ISO 8211 Encoding**
This part of SDTS addresses the physical level of Figure 1. It explains the use of an international standard for physical data encoding (ISO 8211, also known as FIPS 123) to transfer SDTS on a physical medium (e.g., disk) or through communication lines.

**Part 4—Topological Vector Profile**
The *Topological Vector Profile* (TVP) is the first of a potential series of SDTS profiles, each of which defines how the SDTS base specification (Parts 1, 2, and 3) must be implemented for a particular type of data. The TVP limits options and identifies specific

requirements for SDTS transfers of data sets consisting of topologically structured area and linear spatial features.

**Part 5—Raster Profile**

The *Raster Profile* presents requirements for the formatting and transfer of data in raster or gridded form. A final draft of the Raster Profile is complete, but formal approval under FIPS 173 has not yet occurred.

## 1.3 SDTS—Its Past, Present, and Future

A brief timeline of major SDTS milestones is presented in Figure 3. This timeline shows that the development of SDTS dates to the 1982 formation of the National Committee for Digital Cartographic Data Standards (NCDCDS) sponsored by the American Congress on Surveying and Mapping (ACSM). SDTS development received a boost in 1983 with the formation of the Federal Interagency Coordinating Committee on Digital Cartography (FICCDC) with a goal of setting standards and encouraging greater sharing of spatial data among federal agencies.

Since 1982, many experts from government, academic institutions, and the private sector have participated in SDTS development. Detailed preparation began in 1987 with the creation of the Digital Cartographic Data Standards Task Force (DCDSTF). This group, which was led by USGS, included many individuals and organizations. In 1988, a specification, "Proposed Standards on Digital Cartographic Data," was completed by the DCDSTF. This specification was the basis for SDTS. SDTS development and support have been coordinated by the SDTS Task Force in the National Mapping Division of USGS. Many years of work have culminated in a sound and practical vehicle for the transfer of spatial data.

**Figure 3: Important Dates in SDTS Development**

| | Milestone | SDTS Development Phase |
|---|---|---|
| 1982 | NCDCDS Formed | **Building the Foundation** |
| 1983 | FICCDC Formed | |
| 1987 | DCDSTF Formed | |
| 1988 | Proposed Standards on Digital Cartographic Data | **Base Standards Development/ Approval** |
| 1990 | Draft SDTS | |
| 1991 | SDTS Submitted to NIST | |
| 1992 | Base SDTS Approved as FIPS 173 | |
| 1993 | SDTS TVP Approved for FIPS 173 | **Refinement/ Profile Development** |
| 1994 | Mandatory SDTS Compliance by Federal Agencies | |
| 1995 | SDTS Draft Raster Profile Prepared | |
| | • Program Coordination | |
| | • Industry Adoption | |
| | • Certification | |
| | • Continued Refinement/Profile Development | |

## 1.3.1 Relationships with Other Standards Activities

SDTS is one of several formal standards initiatives that are aimed at providing flexible ways to exchange digital spatial data. Bodies at the national and international level are sponsoring standards development programs that affect spatial data content and format. The nature of formal standards setting by these organizations provides for input from a broad community of interested parties and for coordination between different standards organizations. SDTS has been developed in coordination with related standards initiatives of these other national and international bodies.

One important SDTS-related standard is the FGDC-sponsored *Content Standard for Digital Spatial Metadata.* This standard was intended to provide a consistent framework for a comprehensive set of metadata describing a spatial data set. This FGDC standard has metadata elements arranged into the following categories: a) spatial data organization information, b) data quality information, c) spatial reference information, d) entity and attribute information, e) distribution information, and f) metadata reference information. This FGDC Standard defines the content of a metadatabase with recommendations for mandatory and optional items. It is not meant to prescribe a specific format for storage or transfer of metadata. Since it is an approved FGDC standard, federal agencies are required to use it for documenting new spatial data being provided as part of the National Spatial Data Clearinghouse Program.

SDTS was one of the sources used to prepare the FGDC metadata standard, and therefore similarities exist between some of the FGDC modules and fields and the elements in the FGDC Content Standard. However, there is not a direct logical or functional relationship between these standards. Much of the information in a metadatabase that fully complies with the FGDC standard could be used in an SDTS transfer, but there is no direct relationship or formal “logical mapping” between them. The table in Appendix D indicates the general relationship between the components of these two standards.

While a direct functional link between the FGDC standard and SDTS might be desirable for many users, the evolution of these standards has not resulted in such a direct relationship. At this time, organizations, particularly at the Federal level, that produce spatial information may need to establish internal procedures to comply with each of these standards.

# 2. SDTS Base Specification

## 2.1 SDTS Part 1: Logical Specifications

Part 1 of SDTS explains a *conceptual model* that serves as a foundation for SDTS and a logical format for data translation. Part 1 also defines the content and format that are needed to transfer information about the quality of spatial data.

### 2.1.1 SDTS Spatial Data Model (Conceptual Level)

[SDTS specification cross reference: Part 1, Informative Annex A]
[Part 2, Section 2.1]

Data transfer through SDTS is based on a *conceptual model* of spatial data that defines the characteristics of *objects*—the building blocks for a digital representation of a spatial *entity* like a river, building, utility line, or water well. Objects within SDTS may be *simple objects* (the most basic representative elements like points or line segments) or *aggregate objects* (which combine several simple objects into a larger whole, e.g., a data layer).

[Part 2, Section 2.2]

The spatial model defines both the *geometry* (graphic depiction as x,y or x,y,z coordinates) and the *topology* (connectivity and spatial relation-ships) of map features as shown in Figure 4. These map features may be graphically represented as points (zero-dimensional vector objects), as lines (one-dimensional vector objects), as areas (two-dimensional vector objects), or in gridded or raster form. Figure 5 illustrates how spatial entities may be represented as zero-, one-, or two-dimensional.

**Figure 4: Geometry vs. Topology**

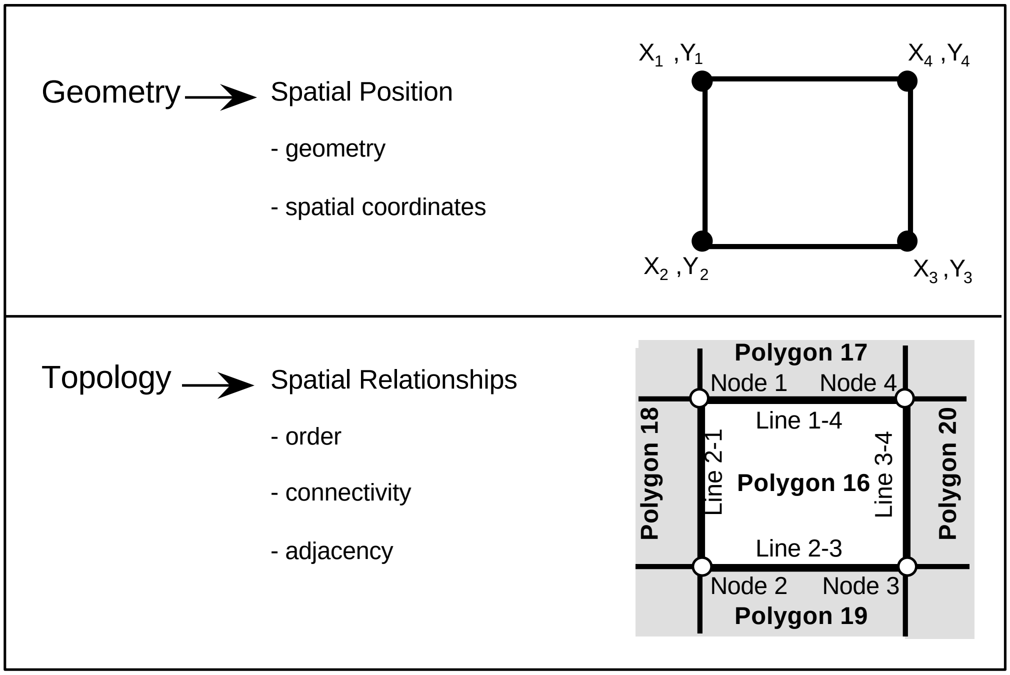



**Figure 5: Map Feature Representations**

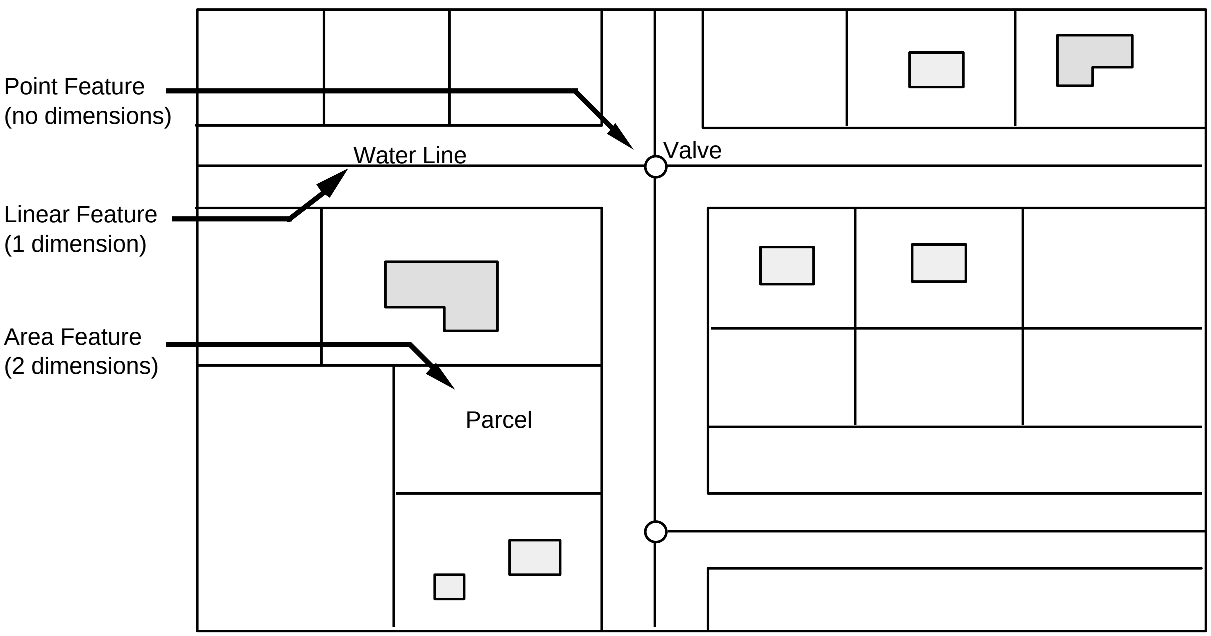



Table 1 identifies the *simple objects* defined in SDTS, categorizing them as "geometry only" and "geometry-topology." Depending upon the particular type of data and requirements of particular users, a map feature could be digitally represented by "geometry only" objects OR by "geometry-topology" objects. Whether or not a map feature is represented with geometry only or with a topological representation is dependent in part upon the software being used and on the specific applications of the user.

[Part 2, Section 2.3] For each of the *simple objects* identified in Table 1, one or more special implementations or uses of those objects may be determined by user applications or the specific software in use. These specific types of objects are explained in Table 2.

**Table 1: SDTS Simple Objects**

| | SDTS Simple Objects | |
|---|---|---|
| **Feature Types** | **Geometry Only** | **Geometry/Topology** |
| Point Features (Zero-dimensional) | Point (includes subtypes of Entity, Area, and Label Points) | Node (Planar or Network) |
| Linear Features (One-dimensional) | Line String, Arc, G-Ring | Link, Chain, GT-Ring |
| Area Features (Two-dimensional) | G-Ring[1], G-Polygon | GT-Polygon, Universe Polygon, Void Polygon |
| Raster Surfaces (Two-dimensional) | Pixel, Grid Cell, Labeled Grid Cell[2], | N/A |
| Raster Surfaces (Three-dimensional) | Voxel[2], Labeled Voxel[2] | N/A |

[1] The G-Ring does not formally represent the area inside the closed linear boundary, but in non-topologically based graphics software, it can be used to represent area features.

[2] These new object types are not part of the 1992 version of SDTS, but will be included in the next version of the standard, expected to be issued by NIST in late 1996 or 1997.

[Part 1, Section 2.3.4] Several types of aggregate objects are defined by SDTS because they are effective in providing a context for use of simple objects in a data transfer. With simple objects as the building blocks, *aggregate objects* denote collections of simple objects that represent real-world phenomena and, therefore, they provide a basis for defining a specific data transfer. For example, the aggregate object, planar graph, may represent a road network that is concisely defined in terms of its component *simple objects* thereby facilitating a consistent data transfer. Aggregate objects are explained in Table 3.

The *composite object* is a specially-defined object type that is any aggregation of simple objects or other composite objects. This object type is useful because it allows the flexibility to define an object for transfer that consists of any collection of other objects.

**Table 2: Characterization of Simple SDTS Object Types**

| Simple Object Type | Geometry Only | Geometry-Topology | Raster | Object Type Code | Definition | Examples of Use |
|---|---|---|---|---|---|---|
| **Point (0-dimensional) Objects** | | | | | | |
| Point | X | | | NP | Object specified by its point location as a coordinate pair (x,y) or coordinate triplet (x,y,z). | Control point for specifying registration to ground reference system. |
| Entity Point | X | X[1] | | NE | Specific implementation of the point object used to define a point feature or occurrence. | Tower, well, street address, water valve, water monitoring station, utility pole. |
| Label Point | X | | | NL | Specific implementation of the point object used for association and display of a text label for feature identification. | Parcel # label point, street name or highway route label point, label point for boundary of a political or administrative district (e.g., city, county). |
| Area Point | X | X | | NA | Point within a defined area feature used to associate attribute information with that area. | Parcel centroid, centroid point for watershed, centroid for a political or administrative district. |
| Planar Graph Node | | X | | NO | A point object that is the topological junction of link or chain objects or the end point of a link or chain object in a planar graph. | Confluence point on stream network, pipe fitting, or valve in a water utility system. |
| Network Node | | X | | NN | A 0-dimensional object that is the topological junction of link or chain objects or the end point of a link or chain object in a network. | Non-planar road network with overpasses |
| **Linear (1-dimensional) Objects** | | | | | | |
| Line Segment | | | | | General term for direct line segment between two points. This object provides a foundation for defining 1-dimensional objects. | |

[1]The Entity Point does not have topology itself, but it is a valid object for inclusion in the Topological Vector Profile.

[2]Line String and Arc objects have topology only when they are part of a chain.

[3]These new object types are not part of the 1992 version of SDTS, but will be included in the next version of the standard, expected to be issued by NIST in late 1996 or 1997.

**Table 2: Characterization of Simple SDTS Object Types (continued)**

| Simple Object Type | Geometry Only | Geometry-Topology | Raster | Object Type Code | Definition | Examples of Use |
|---|---|---|---|---|---|---|
| **Linear (1-dimensional) Objects (continued)** | | | | | | |
| Line String | X | X[2] | | LS | Ordered sequence of points formed by non-branching series of line segments (may intersect itself). | May be used to represent any linear map feature such as a road centerline segment, section of pipeline or transmission line, or a drainage channel. |
| Link | | X | | LQ | A direct topological connection between two nodes. May have assigned direction by an ordering of its nodes. Component object of graph or manifold. | Segment of topologically structured gas distribution pipeline system, stream network, or road centerline network. |
| Chain | | X | | See LE, LL, LW, and LY | General term meaning an ordered, directed sequence of points formed by non-intersecting series of line segments bounded at each end by nodes. | |
| Complete Chain | | X | | LE | A chain which explicitly references right and left polygons and which has designated start and end nodes. | Segment of road centerline referencing districts on right and left, network, or pipeline system. |
| Area Chain | | X | | LL | A chain which explicitly references right and left polygons and which does not have designated start and end nodes. | Boundary segment of a mapped soil unit or land cover polygon, parcel boundary segment. |
| Network Chain | | X | | LW, LY[1] | A chain with designated start and end nodes which does not reference right and left polygons. Used as component objects for planar and non-planar graphs. | Segment of water or sewer pipeline network, road centerline network without reference to right and left polygons. |
| Arc | X | X[2] | | AC, AE, AU, AB | A curve which is defined by a mathematical expression. Arcs are classified into Circular Arc (AC), Elliptical Arc (AE), Uniform B-spline Curve (AU), Bezier Curve (AB). | Any feature that can be graphically defined mathematically. Typically used for civil engineering structures, including road curves at highway interchanges and cul de sacs. |

[1]The Entity Point does not have topology itself, but it is a valid object for inclusion in the Topological Vector Profile.

[2]Line String and Arc objects have topology only when they are part of a chain.

[3]These new object types are not part of the 1992 version of SDTS, but will be included in the next version of the standard, expected to be issued by NIST in late 1996 or 1997.

**Table 2: Characterization of Simple SDTS Object Types (continued)**

| Simple Object Type | Geometry Only | Geometry-Topology | Raster | Object Type Code | Definition | Examples of Use |
|---|---|---|---|---|---|---|
| **Linear (1-dimensional) Objects (continued)** | | | | | | |
| Ring | X | X | | See RS, RA, RM, and RU | A general term referring to a connected series of non-intersecting strings, arcs, or chains with closure. | While rings are one-dimensional features without defining any interior area, they may be used to graphically represent any area feature or linear feature which has graphic closure. |
| G-Ring | X | | | RS, RA, RM | A ring created from strings and/or arcs. | Any closed boundary in which explicit reference to the interior area is not made (e.g., race track, electrical circuit, transit route). |
| GT-Ring | | X | | RU | A ring created from complete or area chains. | Any closed boundary in which explicit reference to the interior area is not made (e.g., race track, electrical circuit, transit route). |
| **Area or Polygon (2-dimensional) Objects** | | | | | | |
| G-Polygon | X | | | PG | An enclosed area bounded by G-Rings which may include one or more non-nested G-Rings in its interior. | Any closed area feature represented with G-Rings as boundaries (e.g., lake or pond with or without islands, parcel, soil unit, county or state boundary). |
| GT-Polygon (composed of rings) | | X | | PR | An enclosed area whose boundary is formed by a ring (whose component chains explicitly reference the interior polygon). | Any closed area feature with explicit topological reference to the interior area (see G-Polygon for examples). |
| GT-Polygon (composed of chains) | | X | | PC | An enclosed area bounded by chains (which explicitly reference the interior polygon). | Any closed area feature with explicit topological reference to the interior area (see G-Polygon for examples). |

[1]The Entity Point does not have topology itself, but it is a valid object for inclusion in the Topological Vector Profile.

[2]Line String and Arc objects have topology only when they are part of a chain.

[3]These new object types are not part of the 1992 version of SDTS, but will be included in the next version of the standard, expected to be issued by NIST in late 1996 or 1997.

**Table 2: Characterization of Simple SDTS Object Types (continued)**

| Simple Object Type | Geometry Only | Geometry-Topology | Raster | Object Type Code | Definition | Examples of Use |
|---|---|---|---|---|---|---|
| **Area or Polygon (2-dimensional) Objects (continued)** | | | | | | |
| Universe Polygon | | X | | PU, PW | An area formed by Rings (PU) or Chains (PW) that is not enclosed by other GT-polygons. The Universe Polygon completes a two-dimensional manifold. It may or may not have attributes assigned. | Any map area that is within the spatial extent (Universe) of a mapped area but which is not part of a defined study area (e.g., area outside the boundary of a single county map). |
| Void Polygon | | X | | PV, PX | An area that is part of the universe, formed by Rings (PU) or Chains (PW), and is bound by other GT-polygons but which otherwise has the same characteristics as a Universe Polygon. | Any polygon in the interior of a mapped area which is excluded from a study area. Areas of cloud cover excluded from a mapping of land cover using aerial photography as a source. |
| **Raster Objects** | | | | | | |
| Pixel | | | X | | A two-dimensional object (rectangular or non-rectangular) which is the smallest non-divisible component of an image. | One picture element of an orthophoto, raw satellite image, or document image. |
| Grid Cell | | | X | | A two-dimensional object which is the smallest non-divisible component of a grid. Cells may be rectangular, triangular, or other regular geometric shape. | One grid cell in any gridded geographic database (e.g., gridded land cover database). |
| Labeled Grid Cell[3] | | | X | | A two-dimensional rectangular object which is the smallest non-divisible component of a labeled grid (rectangular irregular grid). X and Y labels on grid cells identify the specific cell. | Science data measuring dispersion of a phenomenon over a logarithmic grid. |

[1]The Entity Point does not have topology itself, but it is a valid object for inclusion in the Topological Vector Profile.

[2]Line String and Arc objects have topology only when they are part of a chain.

[3]These new object types are not part of the 1992 version of SDTS, but will be included in the next version of the standard, expected to be issued by NIST in late 1996 or 1997.

**Table 2: Characterization of Simple SDTS Object Types (continued)**

| Simple Object Type | Geometry Only | Geometry-Topology | Raster | Object Type Code | Definition | Examples of Use |
|---|---|---|---|---|---|---|
| **Three-Dimensional Objects** | | | | | | |
| Voxel[3] | | | X | | An abbreviation for "volume defined cell." The Voxel is a unit of volume and is the three-dimensional equivalent of the two-dimensional grid cell. | Science data like atmospheric pressure or pollutant particle per air volume. |
| Labeled Voxel[3] | | | X | | A three-dimensional element, similar to a Voxel, that represents the smallest non-divisible component of a Labeled Voxel space. | Science data over a geographic domain, e.g., a measure of pollutants on a logarithmic grid at various heights above the ground. |

[1]The Entity Point does not have topology itself, but it is a valid object for inclusion in the Topological Vector Profile.

[2]Line String and Arc objects have topology only when they are part of a chain.

[3]These new object types are not part of the 1992 version of SDTS, but will be included in the next version of the standard, expected to be issued by NIST in late 1996 or 1997.

**Table 3: Aggregate Spatial Objects**

| Aggregate Object Type | Geometry Only | Geometry-Topology | Raster | 3- or N-Dimensional | Object Type Code | Definition | Examples of Use |
|---|---|---|---|---|---|---|---|
| Layer | X | X | X | X | N/A | General term describing a collection of geographically-distributed entities comprising a common theme. In context of raster data, a layer is a two, three, or N-dimensional array of raster elements and associated attribute values. | Layers reflect common “themes” of spatial features like hydrology, political boundaries, land ownership, water utility, surficial geology, etc. They are defined, as appropriate, by users. |
| Raster | | | X | X | N/A | General term referring to one or more overlapping layers for the same grid, labeled grid, Voxel space[1] or any other raster data. | |
| Planar Graph | | X | | | GP | Topologically connected linear objects (nodes/links or chains) represented on a planar surface where only one node may exist at any one point and where a node occurs at any intersection of links or chains. | Topologically structured drainage network or road centerline network with nodes at all confluences or intersection/overpass points. |
| Two-Dimensional Manifold | | X | | | GT | A type of planar graph composed of chains and GT-Polygons and the areas that they reference. GT-Polygons are mutually exclusive and completely exhaust the surface. | Any topologically structured data set depicting polygon map features like land use areas, parcels and street rights-of-way, or counties within a state. |
| Network | | X | | | GN | Topologically connected linear objects (nodes/links or chains) where, if represented on a planar surface, multiple nodes may exist at a single point, and links or chains may intersect at a point without a node. | Water or gas pipeline network with nodes placed at pipe fittings, valves, and other points with crossing pipe segments (non-connecting) where no junction occurs. |
| Image | | | X | X | G2 | A 2-dimensional array of regularly spaced pixels (to which a gray tone or color value is assigned) which form a picture. | Digital orthophotography, unclassified satellite image, or document image. |

[1]These new object types are not part of the 1992 version of SDTS, but will be included in the next version of the standard, expected to be issued by NIST in late 1996 or 1997.

**Table 3: Aggregate Spatial Objects (continued)**

| Aggregate Object Type | Geometry Only | Geometry-Topology | Raster | 3- or N-Dimensional | Object Type Code | Definition | Examples of Use |
|---|---|---|---|---|---|---|---|
| Grid | | | X | X | G2 | A matrix of grid cell objects (to which a set of attributes is assigned) forming a repeating pattern. | Any gridded geographic data set such as a digital elevation model or gridded land cover map. |
| Labeled Grid[1] | | | X | | G2L | A two-dimensional set of labeled grid cells forming an irregular rectangular tessellation of a surface. | Any gridded geographic data set such as a digital elevation model or gridded land cover map. |
| Voxel Space[1] | | | | X | G3 | A three-dimensional integer grid of Voxels in which the volumetric data set resides. | Science data like atmospheric pressure or pollutant particle per air volume. |
| Labeled Voxel[1] Space | | | | X | G3L | A three-dimensional labeled integer grid of Labeled Voxels in which the volumetric data set resides. | Science data over a geographic domain, e.g., a measure of pollutants on a logarithmic grid at various heights above the ground. |

[1]These new object types are not part of the 1992 version of SDTS, but will be included in the next version of the standard, expected to be issued by NIST in late 1996 or 1997.

## 2.1.2 Spatial Data Quality

Information about the quality of spatial data provides a basis for decisions on the appropriateness of data for specific applications. Part 1 of SDTS specifies a format for storing information about *data quality* for creating a *data quality report* to accompany a spatial data set when it is transferred via SDTS. This data quality report provides for “truth in labeling” about the data set. When available for a particular data set, the categories of *data quality* described in Table 4 should be included in an SDTS transfer.

**Table 4: Categories of Data Quality**

| Data Quality Category | Explanation | Example |
|---|---|---|
| **Lineage** | Information on sources, update activity with dates, and processing steps that have transformed the data. | A reporting of photogrammetric compilation methods and sources and ancillary sources for topographic quadrangle production. |
| **Positional Accuracy** | Information about how closely the coordinate values of map features match their true location. Based on reference to latitude/longitude or another external coordinate reference system using any of several means to deductively estimate or rigorously test accuracy. | a) Geodetic control report documenting the horizontal and vertical accuracy of control points, or<br>b) Statement of horizontal accuracy (maximum circular margin of error) for a large-scale planimetric map based on independent checks on a selected sample of features. |
| **Attribute Accuracy** | Information on the error in the values of attribute data elements included in a transfer. The error may be based on deductive estimates or actual tests. | a) Error levels expressed as a percentage of primary attributes such as parcel number, owner name, deed reference, etc., associated with parcels on a tax map, or<br>b) Level of misclassification of defined areas on a land cover map. |
| **Logical Consistency** | An indication of the graphic quality and topological integrity of a digital map. | a) Report on problems in graphic connectivity and closure (overshoots, gaps, etc.) for a parcel or soil map, or<br>b) Report on the topological integrity of a water utility map modeling the water network. |
| **Completeness** | Information about selection criteria for inclusion of map features, minimum thresholds in map compilation (minimum area or width), and the exhaustiveness of features mapped. | a) Selection criteria for planimetric mapping indicating inclusion of all buildings and structures above X sq. feet in size, or<br>b) Minimum mapping unit sizes for soil mapping, or<br>c) Expected percentage of manholes mapped from aerial photography relative to the number of manholes that actually exist. |

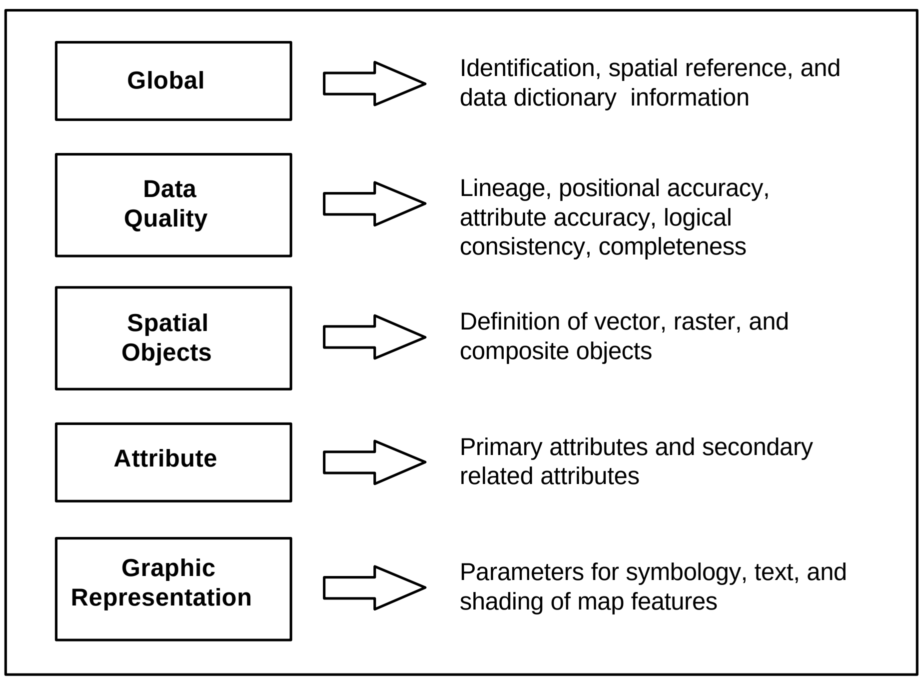
[Part 1, Section 5.3] It should be the responsibility of the organization that collects or manages spatial data to maintain appropriate information on data quality to satisfy the specifications for an SDTS *data quality report*. Comprehensive procedures to record and track this *data quality* information are not in place in many organizations, though they are becoming standard in most federal agencies and other government organizations that have established serious GIS or mapping programs. Although data quality information may not always be available, SDTS encoding and decoding routines must have the capability to capture and extract the data quality report. This is not an extremely complex task since much of the data quality information is in text report form.

Appendix A contains several sample data quality reports.

### 2.1.3 General Transfer Specification

Part 1 also includes the logical data format for an SDTS transfer. This logical format defines the content and basic format of a series of *modules*, each of which contains a specific type of information for the SDTS data transfer. Figure 6 shows the five major areas into which a total of 34 individual SDTS *modules* are grouped.

**Figure 6: Multiple Data Transfer Modules in the Following Categories**



Each *module* is presented in the SDTS document as a table listing the contents of each element of the module with a *field* and *subfield* identification and a description, element type (e.g., alpha, integer, etc.), domain information, and a mnemonic name to be used in the SDTS transfer. Appendix A includes specifications for several of these modules as examples of the content used by SDTS transfers.

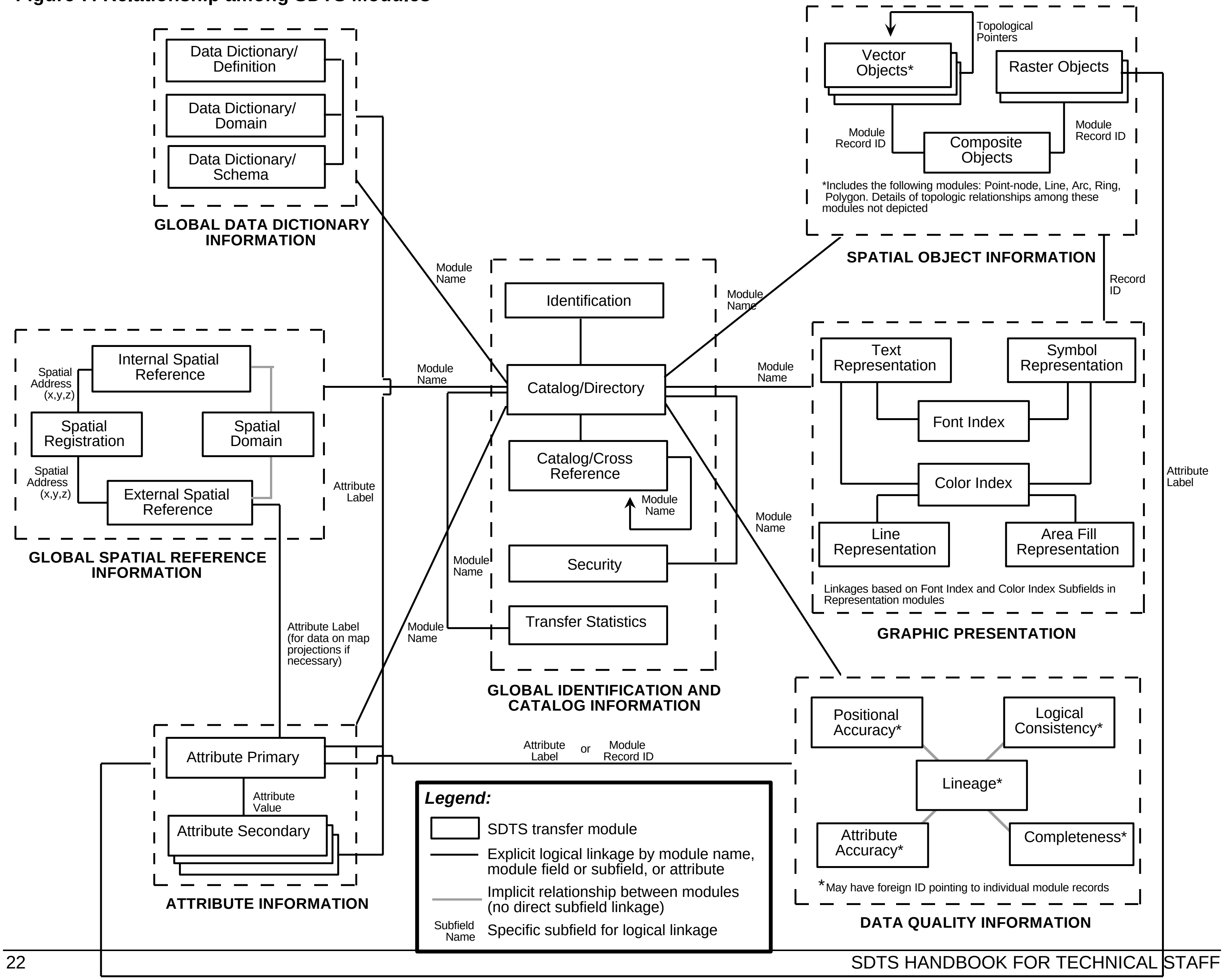
| Module | Description of Contents |
|---|---|
| **Global Modules** | |
| Identification | a) SDTS and Profile versions being used, and<br>b) Descriptive information about data included in a transfer |
| Catalog/Directory | Defines file name, volume label, and record number for each module in a transfer. Functions as overall directory of modules in a transfer |
| Catalog/Cross Reference | Defines specific relationships between modules |
| Catalog/Spatial Domain | Identifies geographic area and particular themes associated with each module in a transfer |
| Security (optional) | Contains security information governing use and release of specific modules and specific module records |
| Internal Spatial Reference | a) Type of coordinates (x,y or x,y,z),<br>b) Format of coordinates (integer, real, etc.), and<br>c) Scaling factors to convert to external spatial reference |
| External Spatial Reference | Specifies ground-based coordinate systems, including datums, map projections |
| Registration | Ties internal to external spatial reference systems. This module provides an alternate way to specify a projection from internal to external. However, the IREF is sufficient to do this, so this module is “optional.” |
| Spatial Domain | Specifies a window as a boundary enclosing all features in a transfer |
| Dimension Definition | Used for data sets which contain non-spatial dimensions allowing encoding and transfer of n-dimensional data sets |

| Module | Description of Contents |
|---|---|
| **Data Quality** | |
| Data Dictionary/Schema | Record layout for each attribute module (primary and secondary) |
| Transfer Statistics (optional) | Information on data volume, number of records, etc. |
| Lineage | Source, compilation methods, transformation steps, and associated dates |
| Positional Accuracy | Horizontal and vertical error of mapped features as compared with true coordinate position |
| Attribute Accuracy | Error in attribute values |
| Logical Consistency | Graphic and topological integrity |
| Completeness | Map feature selection criteria, minimum geometric thresholds, and inclusiveness of mapped features |
| **Attribute** | |
| Attribute Primary | Main data tables containing attributes associated with spatial features or holding spatial reference or quality information |
| Attribute Secondary | Secondary data tables, linked by value or foreign identifiers to attribute primary tables, containing additional attribute data |
| **Spatial Object** | |
| Point-Node | Contains records defining all point (0-dimensional) objects |
| Line | Contains records defining all non-arc line (1-dimensional) objects |
| Arc | Contains records defining all arc objects |
| Ring | Contains records defining all ring objects |
| Polygon | Contains records defining all polygon objects |
| Raster Definition | Defines parameters and format characteristics of raster data sets |
| Layer Definition | Identifies and provides information characterizing individual layers |
| Cell | Contains index information rows and columns and actual values of cells in a raster data set |
| Composite | Contains records defining all composite objects (objects formed from multiple simple objects or other complex objects) |

| Module | Description of Contents |
|---|---|
| **Graphic Representation** | |
| Text Representation | Specifies text character font style, size, color placement, etc. For map annotation attached to a label point |
| Line Representation | Specifies line width, style, color, and scale parameters for map features |
| Symbol Representation | Specifies point symbol types, color, and scale parameters for map features |
| Area Fill | Specifies shading, colors, and patterns for area features |
| Color Index | Index of color values referenced by other graphic representation modules |
| Font Index | Index of font styles referenced by the text representation module |

Figure 7 illustrates the relationships between SDTS *modules*. This figure is quite complex and is intended to be a graphical "reference map" of major module relationships to help in understanding the structure of SDTS.

**Figure 7: Relationship among SDTS Modules**



[Part 1, Sections 4.1 and 4.2]

Major rules and guidelines that apply in any transfer for use and formatting of modules are listed below. In a given data transfer, modules may be included or omitted, except as required by the rules listed below. Specific profiles may define additional limitations or rules governing the use of SDTS modules.

- On a physical medium where order is important (e.g., sequential access tape), the Identification and Catalog Modules shall be the first in the sequence.

[Part 1, Section 5.2.2]

- Unless otherwise specified in the Catalog/Directory Module, the remaining modules will be organized in the order given in Section 5 of SDTS Part 1.
- Modules referred to by foreign identifiers in other modules shall always be present in the transfer.

[Part 1, Section 5.2]

- Three of the Global Modules given in Section 5.2 (Identification, Internal Spatial Reference, and External Spatial Reference) shall always be present. The other modules are recommended.

[Part 1, Section 5.2.6]

- If attribute data is present in a transfer, the Data Dictionary/Definition, Data Dictionary/Domain, Data Dictionary/Schema shall always be present. An exception to this rule is when the transfer has attributes that are all defined by SDTS Part 2. In this case, the Data Dictionary Domain and Definition modules are not included in the transfer.

[Part 1, Section 5.2.6]

- When the Attribute Authority or Entity Authority subfield of any Data Dictionary/Schema module is null or non-standard, appropriate Data Dictionary modules defining the entity or attributes and/or entity or attribute authority shall be used.

[Part 1, Section 5.2.6]
[Part 1, Section 4.1.3]

- 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.

[Part 1, Section 5.3]

- The five Quality Modules (Lineage, Positional Accuracy, Attribute Accuracy, Logical Consistency, Completeness) shall be present.

[Part 1, Section 4.1.3]

- For each Attribute Primary or Attribute Secondary Module, there shall be related Schema Module records.

[Part 1, Section 5.7]
[Part 5—Raster Profile, Section 5.7 (Draft changes to Part 1)]

- For each Raster Cell module, there shall be a related Layer Definition and Raster Definition Module, and for each Raster Definition and Layer Definition Module, there can be more than one related Raster Cell Module.

[Part 1, Section 5.8]

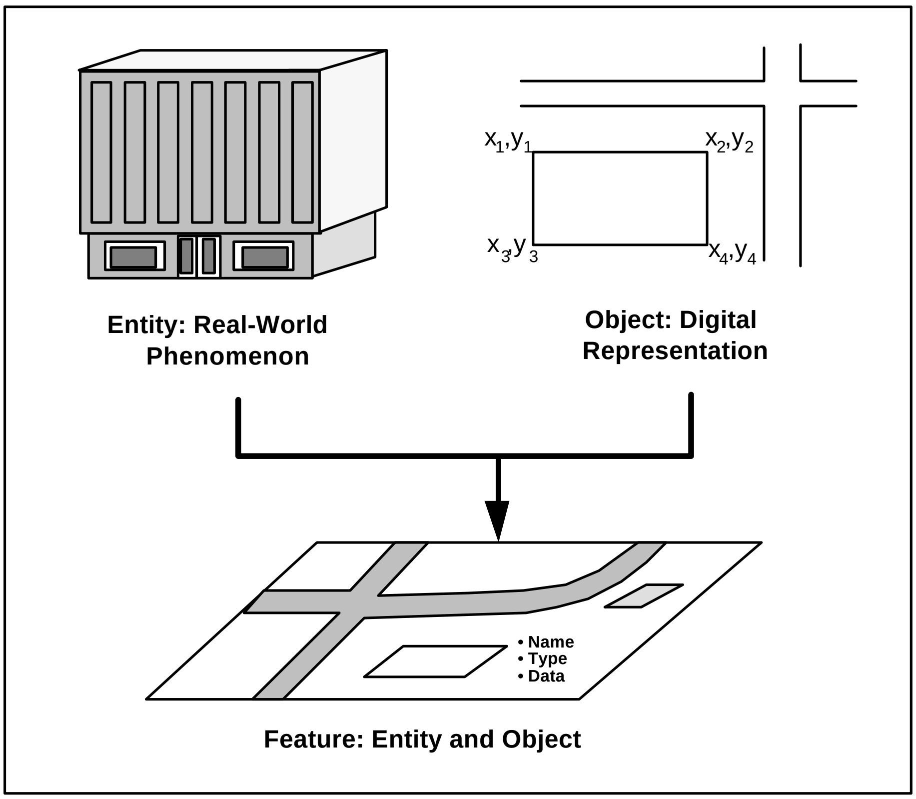
- For the Line Representation, Symbol Representation, and Area Fill Representation modules, a standard field can take on specified values that are defined in the domain description column, or additional values defined in a Data Dictionary Module. If additional values are used, the value and the authority for the values shall be defined in an associated Data Dictionary module, and the Data Dictionary module shall always be present.
- Module records should preferably occur in ascending sorted order, according to the module record identifier field.

## 2.2 SDTS Part 2: Spatial Features

[Part 2, Sections 1 and 2]

The SDTS defines a spatial *entity* as a specific "real world phenomenon," which could be a physical feature or an occurrence that can be located geographically. An *object* in SDTS is used as a digital representation (geometry and/or topology) of the *entity*. SDTS defines the term *spatial feature* as the combination of the concepts of *entity* and *object* (as shown in Figure 8). The terms entity and spatial feature are often used synonymously; but to be totally consistent with the SDTS model, spatial feature should be used to refer to an entity, represented in digital form, with its geometry, topological relationships, and attributes.

**Figure 8: SDTS Conceptual Model Entities, Objects, Features**



Different organizations often apply different names and methods of classification to spatial entities. For instance, does the entity name “road” differ from “street” or “highway,” or does it include these terms as particular types of “roads?” The resulting need for interpretation can inhibit effective sharing of data.

[Part 2, Annex A] Part 2 of the SDTS *base specification* identifies a standard set of spatial *entity types* to provide a consistent basis for transferring spatial information among organizations. Entity types have been designed with the following characteristics:

- Each entity type is mutually exclusive.
- Standard names will be assigned to entity types.
- No specific hierarchy or classification system is pre-defined.

[Part 2, Annex B and C] While SDTS does not define any specific hierarchy or classification scheme for *entity types*, it is understood that some type of hierarchical classification is often required by data users and that these classification schemes may vary from user to user. By defining entities to be independent, users may accept data from SDTS transfers in a consistent manner and apply specific classification schemes that meet their needs.

Table 5 provides some examples of *entity types* in SDTS Part 2. Part 2 includes names and definitions for a finite set of entity types, along with a set of standard attributes and, where applicable, *included terms* that are encompassed by the entity type.

**Table 5: Spatial Entity Examples**

| | Example of Entity Types | |
|---|---|---|
| | **Road** | **Mine** |
| **Attributes** | Name<br>Surface Type<br>Number of Lanes | Name<br>Mineral Content<br>Size |
| **Included Terms** | Highway<br>Street<br>Thoroughfare | Quarry<br>Excavation<br>Gravel Pit |

A specific occurrence of an *entity type* in a data set is referred to as an entity instance. An entity instance may have attributes associated with it. Part 2 also lists common included terms associated with the standard entity types. Included terms are non-standard names by which a standard entity is sometimes referred.

The current version of SDTS Part 2 focuses on types of entities useful in topographic base mapping and hydrographic charting. There is no defined limit to the number of spatial entities that may be included in Part 2 of SDTS. Efforts underway by the Federal Geographic Data Committee (FGDC) and other groups will result in an expansion, in future versions, in the number of entity types included in Part 2. The FGDC is defining formal procedures for making revisions to Part 2.

[Part 1, Section 5.2.1.2] [Part 2, Section 6] In any SDTS transfer, the level of conformance with the Part 2 specifications may be indicated in the Identification Module (Conformance Field, Features Level Subfield). The Identification Module must indicate one of the following levels of conformance in the use of standard Part 2 terms:

- Level 1, when the transfer consists only of standard entity and attribute terms in Part 2.
- Level 2, when the transfer consists of standard entity and attribute terms in Part 2 and other terms not listed in Part 2.
- Level 3, when the transfer includes some standard entity and/or attribute terms in Part 2 as well as terms for which the authority is not SDTS. Non-SDTS terms may overlap with standard terms in Part 2.
- Level 4, when the authority for all entity and attribute terms in the transfer is other than SDTS.

## 2.3 SDTS Part 3: ISO 8211 Data Encoding (Physical Level)

### 2.3.1 Introduction

[Part 3, Sections 1 and 2] *ISO 8211* is a recognized standard for encoding digital information on storage media or for transmitting it electronically. It provides a standard means for arranging information in a transfer so that it can be accepted and decoded easily. ISO 8211 was first defined by the International Organization for standardization. The American National Standards Institute (ANSI) and the National Institute of Standards and Technology have recognized it as a formal standard, known as FIPS 123. ISO 8211 and SDTS are two different standards, but SDTS uses ISO 8211 because it is a general-purpose standard, accepted internationally for the  physical transfer of data.

Part 3 of SDTS describes how *ISO 8211* is used to encode SDTS transfers. Familiarity with ISO 8211 is required before reading Part 3 of SDTS. In brief, Part 3 provides the following:

- Directions for "mapping" the SDTS logical module structure to the ISO 8211 physical format
- Arrangement of records for ISO 8211 compliance
- Record and field naming
- Arrangement of records in the transfer
- Implementation with different types of media.

## 2.3.2 Overview of ISO 8211 Structure

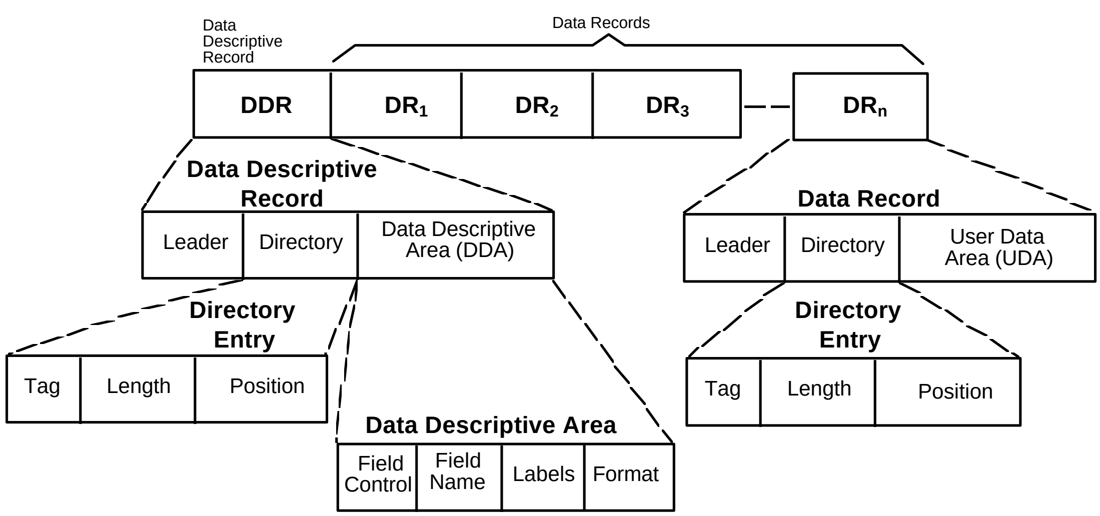
[Part 3, Section 6]

An ISO 8211 file is called a *Data Descriptive File* (DDF) (Figure 9). It consists of two types of records. The Data Descriptive Record (DDR) contains the structure and description of data. The Data Records (DRs) contain the actual data. There is always one DDR in a file, and one or more DRs.

Records consist of one or more fields. A *field* can be thought of as having two components—its description and structure contained in the DDR and its data contained in the DR. Fields consist of one or more subfields.*Subfields* are the basic elements of data.

Figure 9 shows the general structure of DDRs.

**Figure 9: Structure of the ISO 8211 Data Descriptive File**




## 2.3.3 ISO 8211 Structure

[Part 3, Sections 6, 7, 8, 9]

### Record Structure

Both DDRs and DRs are broken into three parts. The first part of both the DDR and DR is called the leader. DDR and DR leader formats differ, but their purposes are the same. The leader is always 24 bytes long and serves to describe the remainder of the record. Information included in the leader includes the length of the record and the lengths of entries in the second part of the DDR and DR, the directory.

The directory specifies the tag, length, and position (relative to the start of the DDR or DR) of each field in the record. Tags are internal field names that are used in the directories of both the DDR and DRs to match the description in the DDR with the data in the DRs.

The third part of a record differs between the DDR and the DR. The third part of DRs contains the User Data Area (UDA), including the actual data fields.

### Data Descriptive Area

The third part of a DDR contains the Data Descriptive Area (DDA), which consists of data descriptive fields that define the structure and description of particular fields. Each field's description has four parts:

1. The field control part (6 bytes describing the field's structure and type)
2. The field name (a descriptive name of the field)
3. Labels (descriptions of the subfields that make up a field; see below)
4. Format (specification of the format of each subfield; see below).

### Field Structure

Fields can be either elementary (containing a single value), a vector (a one-dimensional array), or an array (two or more dimensions). For elementary structures, there are no subfields and the label portion of the data descriptive field is empty. For vector structures, the labels for each subfield are separated by exclamation marks. For example, LABEL1!LABEL2!LABEL3.

Labels that start with an asterisk, called a null vector by ISO 8211, repeat themselves indefinitely to correspond to the data. For example, *X!Y indicates that the vector label X!Y will repeat until the end of the data field is reached. This is how the SDTS implements two-dimensional spatial addresses (coordinates) in the Line module where the actual number of spatial addresses can be variable.

### Format Description

The format portion of the data descriptive field consists of format controls that specify the character-by-character or bit-by-bit structure of the data field. Format controls can be used to specify fixed field lengths. For example, (A(10)) indicates a 10-character field with character data. Format controls are also used to specify user delimiters within the data. For example, (A(,)) indicates character data with a user delimiter of a comma character.

If user delimiters or field lengths are not used, the unit terminator can be used to separate subfields and the field terminator can be used to end fields. In such cases, the format control for a subfield consists only of the character indicating the data type. For example, (A).

Subfield formats can be preceded by a repeat count. For example, (5A(10)). Types of subfields can be mixed in a field. For example, (A(3),I(2),5A(#),A).

### ISO 8211 Special Purpose Fields

ISO 8211 defines several special-purpose fields. The file control field is identified by tag 0..0 (0.. indicates zero fill; the number of zeros will vary based on the tag length). This optional tag is used only in the DDR to specify a title for the entire file. The record identifier field, tag 0..1, is required to assign an identifier to each record.

### ISO 8211 File Levels

There are three levels of ISO 8211 DDFs. An SDTS encoding requires Level 2 DDFs. Level 2 supports any structure and any data type and is the most commonly used.

### Dropping Leaders and Directories

When DRs are fixed length and the leader and directory sections of the record are the same for all records, the leader and directory for all records after the first can be dropped. The leader for the first DR should contain an “R” in offset position 6 to indicate that the same leader and directory should be used for all subsequent DRs. Once the leader and directory are dropped, they cannot be respecified for the remainder of the file. Dropping leaders and directories can significantly reduce file sizes when there are many fixed-length records.

### Binary Data

In addition to ASCII character data, ISO 8211 supports binary data. Binary data have special requirements. Binary data must have format control with the width being specified in bits. For example, the format control for a 16-bit binary value would be (B(16)).

Because the field terminators and unit terminators cannot be used with binary data, the exact length in bits must be specified so that the precise end of the data can be determined. Binary data must start and end on a byte boundary, with binary zero padding if necessary.

ISO 8211 transfers binary data without interpretation; the data are just a series of bit values. The data may be signed or unsigned, integer or real, etc. The interpretation of the data is the responsibility of the user. The SDTS as the user of ISO 8211 provides subfields to transfer information on the type of binary data. For example, when spatial addresses are transferred as binary data, the Horizontal Component Format and Vertical Component Format subfields of the Internal Spatial Reference module contain information on how the binary values are to be interpreted.

## 2.3.4 ISO 8211 Files and Media

[Part 3, Section 10]

### Global Modules

For global modules, one ISO 8211 record always contains the fields of exactly one module record. One ISO 8211 file contains the records of exactly one module.

### Other Modules

ISO 8211 files may contain records from one or more modules. The SDTS warns against indiscriminately merging unrelated modules. The Topological Vector Profile is more restrictive than the SDTS—it requires that all ISO 8211 files contain exactly one SDTS module.

If required due to the amount of data, the SDTS allows multivolume files. If the media do not support multivolume files, modules can be transferred as multiple files.

### Media Requirements

ISO 8211 references other standards for specific media—ANSI X3.27 Level 2 for magnetic tapes (the SDTS specifies a block size of 2,048 bytes), ISO 9293 (DOS format) for flexible diskettes, Level 2 of ANSI/ISO 4341 for magnetic tape cartridges and cassettes (the SDTS specifies a block size of 2,048 bytes), and Level 1 of ISO 9660 for compact disk read only memory (CD-ROM).

## 2.3.5 Mapping the SDTS into ISO 8211

Part 3 specifies how SDTS logical constructs defined in Part 1 are mapped into ISO 8211 constructs. Table 6 is a summary of corresponding constructs. Note that the field mnemonic from Part 1 becomes the ISO 8211 field tag and that the subfield name or mnemonic from Part 1 becomes the ISO 8211 label.

### Part 3 Specifications of ISO 8211 Constructs

Part 3 contains a table of ISO 8211 specifications, including tags, field controls, names, labels, and formats reserved by the SDTS for the transfer of modules. It consists of entries for each module field in the following format:

```
Tag        st00fuName&     (Part 1 section reference)
[  ] [n]  [m,n]     Label&
Format;
```

Where:

| | |
|---|---|
| Tag | is the ISO 8211 field tag |
| st00fu | are the field controls (6 bytes) |
| Name& | is the field name, “&” represents its unit terminator delimiter |

| | |
|---|---|
| [ ] | specifies there are no labels |
| [n] | specifies n subfield elements of a vector structure |
| [m,n] | specifies the dimensions of a two-dimensional array |
| | indicates that one of the above three cases will exist |
| Label& | is an ISO 8211 vector or Cartesian label; "&" represents its unit terminator delimiter |
| Format; | is the ISO 8211 format control; ";" represents its field terminator delimiter. Formats may require completion by the user to add field widths, user-defined delimiters, or repeat factors. A value of "z" indicates that the data type must be supplied by the user from a list of allowable types. |

**Table 6: Relationship between SDTS and ISO 8211 Constructs**

| SDTS Part 1 | ISO 8211 |
|---|---|
| Module Subfield | Subfield/Element |
| Subfield Name/Mnemonic | Label |
| Module Field | Field |
| Field Name | Name |
| Field Mnemonic | Tag |
| Domain | Data type/format |

It can be seen that the entries in the specification table contain the field controls, field name, label, and formats required for the ISO 8211 data descriptive field. The ISO 8211 tag required for DDR and DR directories is indicated. The information on field dimensions and the Part 1 section reference are for information. The Part 1 section reference only appears on the first field of each module.

The following is an example entry from the specifications table in Part 3:

IDEN 1600;&IDENTIFICATION&(See Part 1, 5.2.1.1)
[15] MODN!RCID!STID!STVS!DOCU!PRID!PRVS!PDOC!
TITL!DAID!DAST!MPDT!DCDT!SCAL!COMT&
(A,I,11A,I,A);

These are the specifications for the Identification field in the Identification module. The ISO 8211 field tag is "IDEN," field control is "1600;&," the field name is "IDENTIFICATION," the field has a vector structure with 15 subfields, the first subfield label is "MODN," and the format of the first subfield is "A."

# 3. SDTS Profiles

## 3.1 Overview

Actual use of SDTS for transferring spatial data is carried out through its profiles. A *profile* provides specific rules for applying the SDTS *base specification* to a particular type of spatial data. A profile can be considered a subset of the SDTS specification that defines the following:

- Restrictions and requirements for use of specific spatial object types
- Restrictions and requirements for use of SDTS modules, including rules for choosing among options present in the *base specification*
- Module naming and file naming conventions
- Use of the *ISO 8211* encoding specifications, including allowable options to be used.

One profile, the *Topological Vector Profile* (TVP), has been formally approved by NIST as part of FIPS 173. The TVP is Part 4 of the SDTS specification. Another profile, the *Raster Profile* (RP), which is Part 5 of SDTS, has been prepared in draft form by the SDTS Task Force with considerable outside review and comment. It has not been submitted to or formally approved by NIST, so it currently is not part of the FIPS 173 mandate.

These two profiles address a large portion of the spatial information used by organizations today that are operating geographic information systems or image processing systems. These profiles are summarized in Table 7.

**Table 7: Summary of Current SDTS Profiles**

| Profile | Explanation | Example Data Sets |
|---|---|---|
| **Topological Vector Profile** | Designed for transfer of spatial data sets in which vector features are represented with geometry **and** topology. Data sets may contain point, line, and area features that may be defined as a two-dimensional manifold. | • USGS DLG data sets for 1:24K and 1:100K scale topographic maps<br>• U.S. Census Bureau TIGER files |
| **Raster Profile** | Designed for transfer of spatial data sets in which features or images are represented in raster or gridded form. | • USGS DEM and DOQQ |

*Profiles* are designed to allow implementation of SDTS with enough flexibility to take into account some variability in user data formats—thus avoiding a proliferation of profiles for different data models that are similar in structure. This flexibility is made possible through *core options* and *annex options*. Neither core nor annex options are required by a specific profile. Core options address characteristics of data sets that are considered very important for any transfer, while annex options provide additional supporting information that may enhance a transfer but are not necessarily critical. Core options, when they are used in encoding a data set, must be decoded by decoder software in order for them to conform to SDTS. For example, a number of object types (e.g., NP, NE, NL) are optional for the TVP. These are considered core options because when they are included in a transfer, compliant decoding software must be able to translate them. Conforming decoder software is not required to be able to handle annex options in an SDTS transfer.

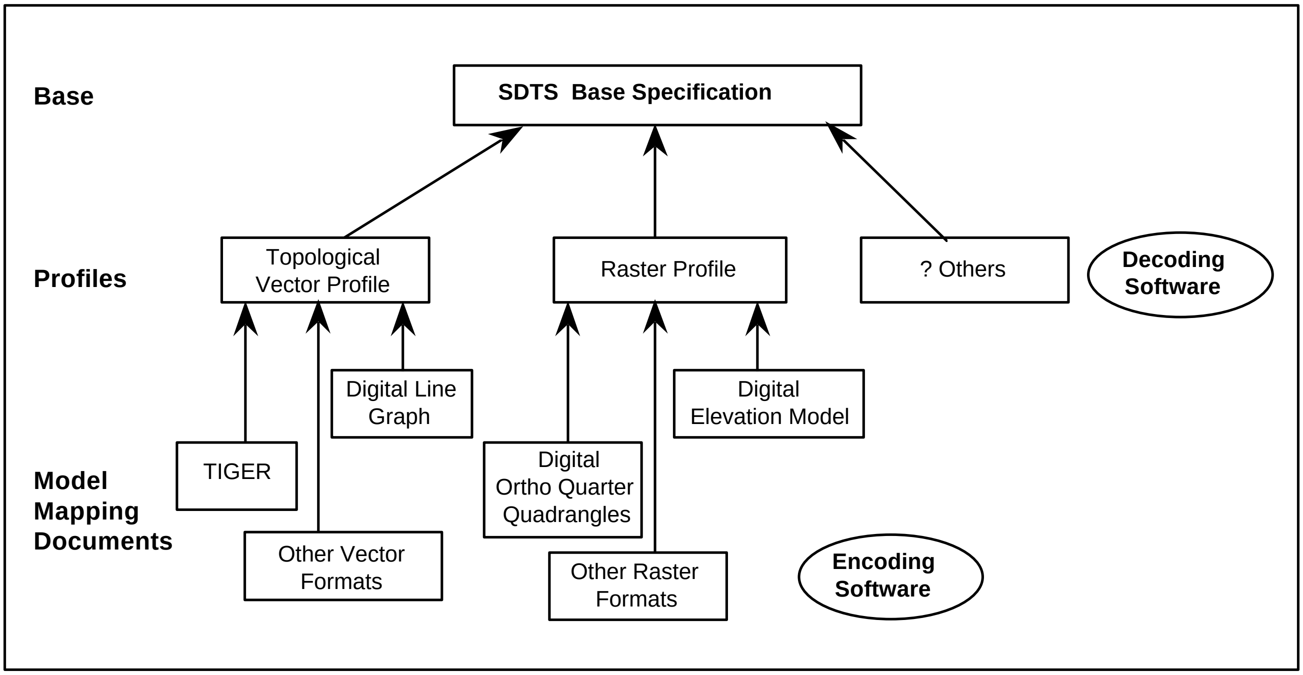
The SDTS program allows for and encourages the development of new profiles or modifications to existing profiles in cases where existing profiles are not entirely suited to the type of data being transferred or where additional options may enhance a transfer. Some possible new profiles or profile modifications that have been discussed are shown in Table 8.

**Table 8: Potential New SDTS Profiles or Modifications to Current Profiles**

| Potential New or Modified Profile | Status |
|---|---|
| **Point Data Profile**<br>**Explanation**: For transfer of data sets consisting of only point features or locations and associated attributes. | The SDTS Task Force and the Hydrographic Surveys Division of the National Ocean Survey prepared a draft in 1994. The National Geodetic Survey is pursuing FIPS ratification of this profile. This profile will facilitate the FGDC framework initiative for geodetic networks. |
| **Non-topological Vector Profile**<br>**Explanation**: For transfer of features as geometry-only objects which do not require topology. Includes features typical of CAD drawings which represent features parametrically (e.g., arcs). | Suggested as possible profile in 1993, but no specific work was carried out. The Tri-Service CADD/GIS Technology Center (administered by the Army Corps of Engineers in Vicksburg, MS) has initiated a development project. With active participation of the Facilities Working Group of the FGDC and in coordination with the SDTS Task Force and private companies (Intergraph and AutoDesk), development work will likely begin in 1996. No projected completion date at this time. |
| **Transportation Network Profile**<br>**Explanation**: For transfer of data sets that define topological linear networks (e.g., road networks) with no area features. | Effort begun in 1993 by Volpe National Transportation Systems Center. Development of profile now in hands of the Transportation Subcommittee of the FGDC. A final draft is complete. This profile provides a model that could be applied to other linear networks. Expected submittal for approval by FGDC Standards Working Group by the end of 1996. |
| **Intelligent Transportation Systems (ITS) Profile**<br>**Explanation**: Network profile that meets requirements of private companies developing products for intelligent transportation systems (e.g., vehicle navigation systems). | The vendor consortium ITS America began investigating development of a profile in 1993. The Database Sub-committee of ITS America is considering SDTS profile development as it reviews the suitability of other standard formats. There has been some discussion of adapting the Transportation Network Profile (FGDC Transportation Subcommittee) for ITS America requirements. |
| **DX-90 Profile**<br>**Explanation**: To allow transfer of data between SDTS and the DX-90 international standard for hydrographic charts. | The National Ocean Service (NOS) sponsored a project to define DX-90 as a profile of SDTS. The requirements for a Hydrographic Vector Profile (HVP) (similar to TVP) which implements the full topological level of DX-90 have been determined. The HVP is currently unimplemented, but the NOS has a pilot project to create HVP data. Plans for full formalization of HVP are not in place at this time. |
| **DIGEST Profile**<br>**Explanation**: To allow transfer of data between SDTS and the Digital Geographic Exchange Standard (DIGEST), the standard for spatial data exchange developed by the Digital Geographic Information Working Group (DGIWG) sponsored by NATO. | In 1993, the Defense Mapping Agency sponsored a study to examine harmonization of SDTS and DIGEST. This resulted in an outline for a DIGEST vector profile (DVP) for DIGEST-A. No formal work for DVP implementation has occurred. |

Encoding software implements the specific mapping of a source data model into SDTS structures. If the mapping uses one option, where a profile may have permitted three, the encoding software only needs to handle the one. For example, the TVP permits geographic, UTM, or SPCS coordinates. An encoder only needs to deal with one of these. A decoder, on the other hand, needs to deal with all three. Decoding software needs to handle the more general case of what is allowed by a profile. See Figure 10 for an illustration of the relationships among types of documents, SDTS profiles, and the base specification.

**Figure 10: Document Relationships**




Neither the SDTS Task Force nor any other organization has a mandated role to develop new SDTS profiles. However, the SDTS Task Force encourages profile development by government or private communities of users. The Task Force will provide information and technical support to any groups interested in profile development. When a new or modified profile is ready for formal approval, the SDTS Task Force will work with the developer and NIST in the FIPS review and approval process.

## 3.2 Topological Vector Profile

### 3.2.1 Object Types

As described above, the *Topological Vector Profile* (TVP) is used for the transfer of topologically structured spatial data containing a mix of point, linear, or area objects. The following types of objects may be used in the TVP:

- Point (NP)
- Entity Point (NE)
- Label Point (NL)
- Area Point (NA)
- Planar Node (NO)

- Complete Chain (LE)
- GT-Polygon (PR*, PC)
- Universe Polygon (PU*, PW)
- Void Polygon (PV*, PW)
- Composite Objects.

Point, entity point, label point, area point, void polygons, and *composite objects* are optional in the TVP, but all other spatial objects are required. In a TVP, data set, these objects make up or are integrated with a two-dimensional *aggregate object*. As depicted in Figure 11, the following rules apply:

- Each chain is bounded by an ordered pair of nodes, not necessarily distinct

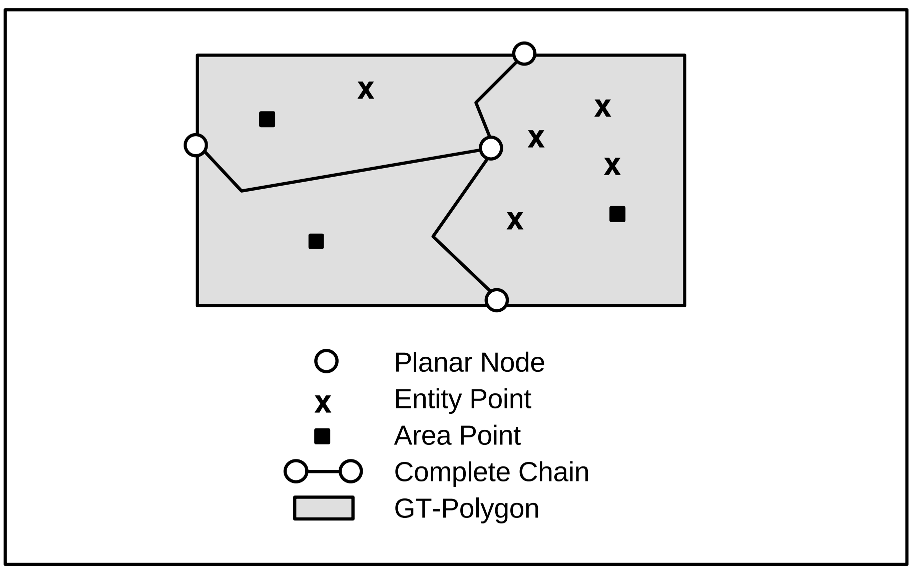
- A node must bound one or more chains

- Not more than one node can exist at any given point

- Each chain is bounded by exactly two, not necessarily distinct, GT-Polygons

- The GT-Polygons are mutually exclusive and completely exhaust the surface.

**Figure 11: Major Objects Handled by the TVP**




In a specific data transfer using the TVP, one *theme* (logically related set of features) or group of themes may be included in a single two-dimensional manifold *Composite objects* are optionally allowed.

*PR, PU, and PV are permitted only in Ring modules from Annex E of the TVP.

### 3.2.2 Module Restrictions for the TVP

The TVP places restrictions on the use of each SDTS *module*. In some cases, the TVP defines certain choices when the SDTS *base specification* allows options. Some modules are not allowed, some are always required, and some are optional. Table 8 identifies module restrictions that apply to the TVP.

In this table, restriction codes are applied as follows:

- M—Mandatory for TVP transfers
- C—*Core option* considered very important for most TVP transfers and which must be handled by decoding software if information cited by the option is included in an SDTS data set
- A—*Annex option* that may enhance a TVP transfer, but is not critical or required for compliant encoding or decoding software
- P—Prohibited for use in TVP transfers.

**Table 8: Module Restrictions for TVP**

| Module | Restrictions |
|---|---|
| **Global Modules** | |
| Identification | M |
| Catalog/Directory | M |
| Catalog/Cross Reference | C |
| Catalog/Spatial Domain | M |
| Security | C |
| Spatial Reference-Internal | M |
| Spatial Reference-External | M |
| Spatial Reference-Registration | C |
| Spatial Reference-Spatial Domain | C |
| Data Dictionary/Definition | M |
| Data Dictionary/Domain | M |
| Data Dictionary/Schema | M |
| Transfer Statistics | M |
| **Data Quality Modules** | |
| Lineage | M |
| Positional Accuracy | M |
| Attribute Accuracy | M |
| Logical Consistency | M |
| Completeness | M |
| **Attribute Modules** | |
| Attribute Primary | M |
| Attribute Secondary | C |
| **Spatial Objects** | |
| Vector-Point-Node (for node objects) [1] | M |
| Vector-Line (for node objects) | M |
| Vector-Arc | A |
| Vector-Ring | A |
| Vector-Polygon (for GT-polygons, universe polygons, and void polygons if present) [2] | M |

M = MANDATORY IN ALL CASES, C = CORE OPTIONS,
A = ANNEX OPTION, P = PROHIBITED

[1]Simple objects NP, NE, NL, and NA are core options; other point objects are mandatory.

[2]Void Polygons (PV, PX) are core options; other polygon objects are mandatory.

**Table 8: Module Restrictions for TVP (continued)**

| Module | Restrictions |
|---|---|
| **Spatial Objects (continued)** | |
| Raster Definition | P |
| Raster Cell | P |
| Composite | C |
| **Graphic Representation Modules** | |
| Text Representation | P |
| Line Representation | P |
| Symbol Representation | P |
| Area Fill | P |
| Color Index | P |
| Font Index | P |

M = MANDATORY IN ALL CASES, C = CORE OPTIONS,
A = ANNEX OPTION, P = PROHIBITED

[1]Simple objects NP, NE, NL, and NA are core options; other point objects are mandatory.

[2]Void Polygons (PV, PX) are core options; other polygon objects are mandatory.

## 3.3 Raster Profile

The raster capabilities are very extensive in the next proposed version of SDTS. However, the first raster profile only uses a small set of these raster options, which suffice for a large number of raster data.

The proposed *Raster Profile* is used for the transfer of two-dimensional regular grid or image raster data (object type G2). This raster profile can accommodate image data, digital terrain models, gridded GIS layers, and other gridded data. This profile does not permit vector objects, raster objects higher than 2-D, or irregular grids.

The pixels or grid cells are referred to as cells in SDTS and are transferred in the Cell Module.

Rasters can be composed of layers. Each layer in a transfer needs to have the same geographic extent. A transfer may also include multiple horizontal spatial extents.

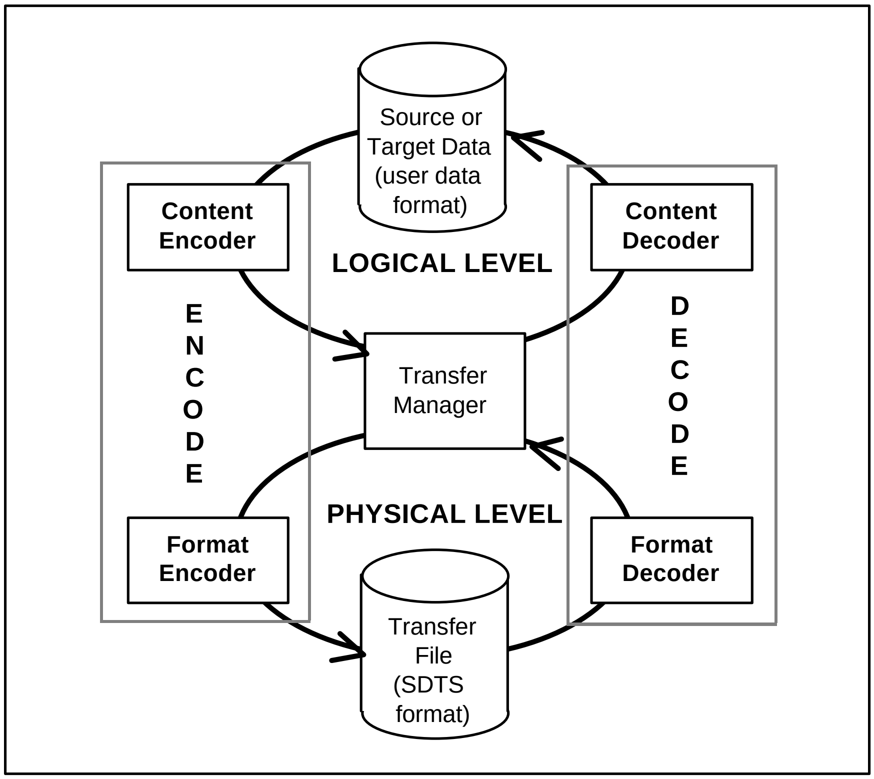
The cell data can be ordered in band sequential (code “GI”) or band interleaved by cell (code “GL”). Other band interleaving options are not permitted.

Annex options provide for the transfer of color palette and compressed raster data.

# 4. Technical Approach for SDTS Implementation

The SDTS data transfer process and the components of any translation software for SDTS encoding or decoding are depicted in Figure 12.

**Figure 12: SDTS Data Transfer Process**




This figure shows spatial data in a *user data format* (e.g., a format supported by the user's automated mapping or GIS software package) that is the source or target data format in an SDTS transfer. Encoding of the *source data format* to SDTS format is depicted on the left side of the figure, and decoding of SDTS to a *target data format* is shown on the right. As shown at the top of the figure, data being encoded or decoded must pass through the logical level which involves a logical "mapping" of SDTS modules to or from the user data format. The bottom of the figure addresses the physical formatting process in which *ISO 8211* structured files are created or decoded. The "transfer manager" box in the middle may be considered a set of rules and supporting software that direct the logical and physical encoding and decoding process to comply with SDTS requirements. The suggested approach for the development of an SDTS translation process is to break it into two major parts, one dealing with encoding or decoding at the logical level and the other addressing the physical level. For more discussion of an SDTS processor design, readers are referred to Altheide (1992), p. 311-314 (see Bibliography).

Technical development activities for implementation and use of the SDTS focuses on the following major areas:

1. **Development of translation software** for **encoding** user data, the source data model (SDM), into SDTS format and **decoding** SDTS into the "target data model" (TDM)

2. Development of technical procedures for **encoding and decoding of spatial data** to and from SDTS format, for acceptance from or distribution to outside parties

3. Design and **development of new or modified profiles** for SDTS.

This section presents suggested steps and guidelines for any technical person or team to follow in organizing and executing one of the implementation initiatives listed above.

## 4.1 Development of Translation Software

Some general guidelines for the design and development of translation software for the encoding or decoding of SDTS data are provided in this sub-section. The encoding and decoding software should properly handle the required "mapping" and formatting of data structures compliant with a particular profile. Developers of translation software will find it useful to consult Appendix A of this handbook, which summarizes a particular case in the encoding of a user data format, DLG-3 files maintained by the USGS, to SDTS-TVP format. Procedures and actual work in developing encoding and decoding software for DLG and Census Bureau TIGER files are further explained in the following references listed in the bibliography—Altheide (1992), pp. 306-310; Greenlee (1992); Lazar (1992), pp. 296-299; Lazar (1992), pp. 303-305; Stigberg (1994); and Williams (1992).

Users of any GIS or *automated mapping* (AM) package will benefit from SDTS translation software that is user-friendly and flexible. This is the philosophy under which most developers have proceeded. A major goal of any translation software is to make the translation process (encoding or decoding) as automatic as possible and to limit the need for operator intervention. SDTS translation can be made automatic to an extent; but since specific profiles, like the TVP, may require data that may not already be stored in the *user data format* (the specific GIS or automated mapping software), some intervention by the user may be required. The amount of user intervention will be governed by the data content of the user's GIS or automated mapping software and the specific options (as allowed by a particular profile) exercised by the translation software and the user of the software.

Translation software should be built using methodologies for system design and development with which the developer is comfortable. Detailed design and development should be preceded by an adequate level of scoping and planning to define objectives and parameters for the translation process. General steps in the planning, design, and development of SDTS translation software follow:

1. **Decide whether translation software is to be written for SDTS encoding, decoding, or both.**

   Different sets of software will be required for encoding and decoding.

2. **Identify and characterize the specific user data format (the GIS or automated mapping data) for which encoding or decoding must be performed.**

   Detailed documentation about the underlying conceptual model, logical file format, and physical file layout of the target GIS or *automated mapping* software must be obtained and examined.

3. **Carry out a "conceptual mapping" between SDTS and the specific GIS or automated mapping data format.**

   The effort concentrates on making a correspondence between object types in the GIS or the *automated mapping* system and SDTS. It may also involve defining the correspondence between standard spatial feature types (SDTS Part 2) and the user's definition of*spatial features*.

4. **Determine the appropriate SDTS profile for which translation software must be written.**

   Encoding or decoding software will be specific to a given *profile* and must comply with the requirements of that profile.

5. **Identify and define data elements (as required by SDTS modules) that are inherently stored as part of the GIS or automated mapping system.**

   This step will largely determine what parts of the translation process can be made automatic and which might require user intervention. It will also influence a decision on what profile options are exercised in the design of encoding or decoding software. Table 9 provides some additional explanation of the correspondence between SDTS modules and the source of the information in a typical GIS or automated mapping system.

**Table 9: SDTS Modules and General Relationship with User's GIS or Automated Mapping System**

| SDTS Module | Data Availability in GIS or Automated Mapping (AM) System and SDTS Translation Approach |
|---|---|
| Identification Module | Descriptive information that must be uniquely entered for a specific transfer. |
| Catalog/Directory and Catalog/ Cross Reference Modules | Includes information specific to a certain type of data set and can be largely automated (for that data set) by the translation software. |
| Catalog/Spatial Domain Modules | May be available from coordinate extent information in AM or GIS or stored as metadata in user-maintained attribute tables. Otherwise, would require user entry. |
| Security Module | Optional module. Information is specific to a particular transfer and would require user entry (perhaps with defaults) for each transfer. |
| Spatial Reference Modules | GIS often stores information on coordinate systems, datum, map projections, etc., which could be automatically extracted by translation software. |
| Data Dictionary Modules | Most information on attribute data schema and dictionary is stored as an inherent part of the system's database management environment. Some information on attribute definition and domain may be stored by users in separate metadata tables. Translation software should handle this automatically. |
| Transfer Statistics Module | Information on data volume, etc., called for by this optional module should be automatically derived by translation software. |
| Data Quality Modules | May or may not be stored by user-maintained attribute tables or text files. When available, it could exist as a textual data quality report or as metadata elements in data tables. Translation software for SDTS encoding should accommodate user entry of data quality information. Automatic creation of a data quality report will not be practical under most user environments. |
| Attribute Modules | Translation software should automatically handle the encoding and decoding of all attribute tables. |
| Spatial Object Modules | Based on a conceptual "mapping" of SDTS objects with object definitions in the GIS or AM, translation software should accomplish this automatically and should comply with limitations established by a specific profile. |
| Graphic Representation Module | Representation specifications will be inherently stored in GIS or AM. Translation software should automatically handle these parameters making a best possible "mapping" to or from SDTS. |

6. **Determine which options to implement.**

   As discussed in this handbook, the SDTS *base specification* and each *profile* allow specific options and levels of conformance that will impact the design and development of both encoding and decoding software. These options must be examined, within the context of the specific types of data sets that the translation software must handle, and decisions must be made as a precursor to software design.

7. **Design the "logical mapping" to and from SDTS modules.**

   Following the requirements of the specific SDTS profile, translation software design must include a specific identification of the SDTS modules and their *fields* and *subfields* into or out of which data from the user's GIS or CAD system must be encoded or decoded. This step must also define other issues necessary for proper assignment of logical data element types and domains compliant with SDTS.

8. **Design the "physical mapping" to and from ISO 8211 compliant files.**

   This step involves defining the relationship between the logical and physical formats as called for by the particular profile. Specifically, it involves a "mapping" of SDTS *module fields* and *subfields* to *ISO 8211* files to establish the basis for the physical encoding and decoding process. The SDTS Task Force has sponsored the development of software to assist in the ISO 8211 encoding process. This software, the "FIPS 123 Function Library," is described in Lazar (1992), p. 303-305.

9. **Build and test translation software.**

   This major step, carried out as an interactive development and testing process using standard data sets, will culminate in the completion of translation software for SDTS encoding and/or decoding.

10. **Get formal conformance certification.**

    While it is acceptable to make translation software available for use as soon as it is completed and fully tested by the developer, it is recommended that formal *conformance testing* and certification be carried out as soon as possible. Conformance testing procedures are discussed in Section 4.4 of this handbook.

## 4.2 Encoding or Decoding of SDTS Data

Any generators or users of spatial data who will be distributing data in SDTS format or accepting SDTS data for use with their own GIS or automated system will need to set up procedures and put in place the technical tools to perform file translation for the encoding and/or decoding of SDTS data. For the purposes of this discussion, it is assumed that the appropriate translation software already exists as pre-developed, off-the-shelf software. Such off-the-shelf software is becoming increasingly available as automated mapping and GIS software companies and several federal agencies provide software tools to perform the necessary translation, for the *Topological Vector Profile* and the *Raster Profile*. Where off-the-shelf software is not available for a particular *user data format*, it will be necessary, of course, to design and develop it to support the transfer.

Ideally, users of off-the-shelf SDTS translation software do not need to know a great deal about the technical constructs underlying SDTS or the physical encoding of data in an ISO 8211 file. Some guidelines for establishing a process for routine SDTS encoding and decoding follow:

- Characterize the environment for spatial data exchange

  This includes identifying the particular type of data sets for which SDTS transfers will be applicable, whether the transfer(s) involve encoding of data to be distributed or decoding of SDTS data from an outside source, the frequency of the transfer(s), and the *user data formats* involved (i.e., the source or target data models). It will also be necessary to identify the specific SDTS *profile* that applies.

- Identify and evaluate applicable off-the-shelf translation software

  If it exists, this software will be available from a government source, private GIS or *automated mapping* software vendor, or another private company. Many GIS firms are beginning to package SDTS translation software with current versions of their software packages. The SDTS "Guide for Technical Managers," a companion to this handbook, includes a table which summarizes the status of off-the-shelf SDTS translation software. Existing software will be accompanied by documentation and sometimes sample data sets. Users should become familiar with the software by examining the documentation and performing encoding and decoding with sample data sets.

- Become familiar with options implemented by the translation software

As discussed in Section 3 of this handbook, each SDTS profile has *core options* and *annex options* that may or may not be addressed by a particular translation software. The user of encoding or decoding software should be familiar with these options, which are important for the particular data sets in use, and how the translation software addresses these options.

- Identify and set up procedures for user input necessary for SDTS encoding

  Subsection 4.2 discusses the fact that not all parts of the SDTS encoding process can be automatic. Some data in SDTS modules that are required or optional for an SDTS transfer may or may not reside in the original *user data format* (i.e., source data model), or it may not exist in a format that allows for efficient SDTS encoding. Therefore, SDTS encoding software may allow for or require user input (e.g., for *data quality* information) by the user or through reference to external files. Users of encoding software will need to set up and document procedures for input of such information.

- Identify and set up a process for acceptance of “extra” data in SDTS decoding

  Just as the user’s *source data model* may not hold all information deemed necessary for SDTS encoding (see bullet point above), data may be provided to users in SDTS format which is not required or not currently part of the user’s *target data model*. For instance, information may be contained in Global Modules which is not needed or not currently maintained by the user accepting data in a transfer. In this case, the user will need to decide how to deal with this incoming data. “Extra” SDTS data may be discarded, it may be archived in external data files, or it may be made part of the data tables (e.g., relational database tables) which are a part of the user’s GIS database. Having made decisions about the disposition of this data, procedures should be documented and possibly some custom software should be developed to automate the process.

- Acceptance checking after decoding

  Compliant decoding software should ideally yield files in the *user data format* which are error-free. Still, it is suggested that a decoded data set be checked for format, graphic integrity, and data consistency. In most cases, users of a particular software package have automated validation routines available that check for such characteristics as assignment or tagging of features (e.g., assign-ment to proper coverage, levels, category, layer, etc.), graphic integrity and topological consistency, attribute accuracy (e.g., range and domain checks), and other data validation checks.

- Critique and suggestions for improvements

  Spatial data users drive the demand for improved software. Particularly in the case of commercial software, users influence private software developers since they buy software licenses and pay software support fees for ongoing use. Users of SDTS translation software should continually document problems or cite suggestions for improvements in translation software and communicate with developers to encourage continual software enhancement.

## 4.3 Profile Development and Modification

As summarized in Sub-section 3.1, currently there are two mature profiles (the *Topological Vector Profile* and the *Raster Profile*). Several others are being planned or developed. The SDTS Task Force encourages the development of new profiles or the modification of existing profiles that may better suit the needs of users and the data sets that they are using. While the SDTS Task Force does not assume lead responsibility for new profile development, it is committed to playing a support role to provide technical advice and to help organize the review of drafts, and to coordinate formal review and approval with NIST.

Some general guidelines for profile development or modification are provided below:

1. **Organize a technical development team.**

   The profile development process should begin by assembling a technical team of developers, knowledgeable about SDTS and the particular data and user environment the profile will address. A fairly small development team (three to ten members) should be augmented by a larger group of reviewers who provide comments on profile drafts.

2. **Develop a clear conceptual model of the data to be handled by the profile.**

   Profile definition should be preceded by appropriate investigations and planning that clearly define the user environments the profile addresses and the nature of the data that will be handled by the profile.

3. **Design a "conceptual mapping" between SDTS and the specific GIS or automated mapping data format.**

   The effort concentrates on making a correspondence between *object types* in the GIS or automated mapping system and SDTS. This establishes the mandatory, optional, and prohibited SDTS objects that are handled by the profile. It is possible, although unlikely, that new profile development may require the definition of new objects not already included in the SDTS *base specification*. If this is necessary, the new objects must be defined and submitted as a revision to Part 1 of SDTS.

4. **Identify specific spatial features (entity types) that are a required or optional part of the profile.**

   A profile may define mandatory or optional use of standard *entity types* or attribute names (the subject of SDTS Part 2). These must be explicitly defined. If the profile development results in the definition of new entity type or attribute names, these must be submitted as a change to SDTS Part 2.

5. **Define requirements for inclusion and content of data quality modules.**

   This includes any specific rules or requirements of the profile for complying with spatial *data quality* modules (from Part 1, Section 3).

6. **Define general specifications for the profile.**

   The general specifications for the profile contain specific rules for organization and content of SDTS modules. This may include information on order and naming of modules, *module fields*, and *subfields*; relationships between modules; information on spatial address formats, and other general specification information specific to the profile.

7. **Design "logical mapping" and define module require-ments and restrictions.**

   This step results in a full definition about requirements for the format and content of SDTS modules. It describes the status of each module (required, optional, prohibited), *core* and *annex options*, and particular requirements or restrictions that apply to each module or their *fields* and *subfields*.

8. **Define ISO 8211"physical mapping" requirements.**

   Any requirements, specific to the profile, impacting the writing and format of ISO 8211 compliant files will be defined.

Currently mature profiles (i.e., TVP and RP) and any that are available in an advanced draft form (e.g., the Transportation Network Profile) serve as excellent "templates" for new profile development. It is suggested that these be consulted as a starting point. The assistance of the SDTS Task Force should be enlisted early in the development process, and other appropriate experts who can assist in profile development should be included in the effort.

# 4.4 Conformance Testing for SDTS

## 4.4.1 Overview of Conformance Testing

Practical use of SDTS necessitates that a conformance testing process be established to check SDTS products (translation software or data sets) for proper compliance with SDTS requirements. *Conformance testing* for SDTS is carried out under procedures established by the National Institute of Standards and Technology (NIST). The NIST conformance testing components, collectively referred to as a "test suite," consist of software, procedures, test data sets, and documentation. SDTS conformance testing procedures will use a process called "falsification testing" in which as many SDTS requirements as are feasible are examined to identify any errors.

SDTS conformance testing evaluates conformance to a specific SDTS profile. Three types of SDTS products may be tested for conformance:

- SDTS encoding software
- SDTS decoding software
- SDTS transfers (data inan SDTS profile format being exchanged).

Conformance testing relies on both automated and manual checks. Conformance testing for SDTS data transfers is the most straight-forward. It involves evaluation of the content and format of a standard SDTS data set complying with a specific profile allowing the testing to be almost entirely automated. Testing of encoding and decoding software is much more complex since it involves examining and comparing SDTS data sets with the original or resulting source or target data models. Much of the conformance testing for encoding and decoding software involves manual procedures since automating the process would require unique software for each different *user data model*. This is considered to be infeasible. In order to test for conformance of encoding and decoding software, a developer will be required to complete a questionnaire (specific to a source or target data model) which provides information necessary to evaluate test points.

*Conformance testing* is dependent on the definition of *test points* which are specific requirements to be examined in the conformance test. Test points for the three types of products listed above may be reviewed in detail in the following publications:

- "Test Points for Conformance Testing of TVP Transfers"

- “Test Points for Conformance Testing of TVP Encoders”
- “Test Points for Conformance Testing of TVP Decoders.”

These are unpublished documents, which may be obtained from the SDTS ftp site sdts.er.usgs.gov, pub/sdts/conform, directory.

### 4.4.2 Arranging for and Conducting Conformance Testing

USGS has developed a conformance test suite to test SDTS/TVP data sets, encoders, and decoders. Included in this test suite is software to test SDTS/TVP data sets. It has been decided that SDTS certification will not be issued to SDTS data sets. Issuing certification to data sets alone would require that each time a data set was generated, a new certification test would need to be run. It is seen as a more feasible approach to issue certification to SDTS encoders. The SDTS certification would then convey to data sets created by a certified encoder. Although the SDTS/TVP conformance testing software tests only data sets, it will be used to play a role in the certification of SDTS/TVP encoders. A representative group of data sets will be created by the encoder. The SDTS/TVP conformance testing software will be used to test this group. Any problems found in the output data sets will be corrected as modifications to the encoder. The beta testing cycle of the SDTS/TVP conformance test suite began in April 1996. Once the beta testing cycle is complete, the SDTS/TVP conformance test suite will be handed off to NIST.

Conformance testing at NIST is generally overseen by a group called the Test Method Control Executive Committee (TMCEC). This committee is only a model for the process and has yet to be assembled. It will consist of certification bodies, technical authority, and a maintenance organization for the test suite. The technical authority has yet to be identified, and the testing laboratory role will probably be filled by NIST since the SDTS/TVP certification requests are expected to be light. The duties of the TMCEC will be test method maintenance, resolution of requests for interpretations of standard languages and challenges to the test method, and technical assistance for problems encountered in running the certification tests. The beginning of certification testing for SDTS/TVP encoders and decoders is tentatively projected to begin in early October 1996. NIST and USGS will make a joint announcement of the start of this cycle. Mailings will be sent to all organizations on USGS mailing lists. Also announcements will be posted on NIST and USGS World Wide Web pages.

# Appendices

# A: Example of Logical Encoding of SDTS Modules for the Topological Vector Profile

# DLG-3 SDTS Transfer Description

DRAFT April 22, 1996

**The following is an excerpt of a larger document, which is available from the USGS via the Internet at ftp site sdts.er.usgs.gov, directorypub/sdts/datasets/tvp/dlg3 (the name of the document is dlg3sdts.wp). It is a description of SDTS encoding for DLG3 and sample SDTS modules.**

## Purpose of this Document

This document describes how U.S. Geological Survey (USGS) digital line graph 3 (DLG-3) files are transferred using the Topological Vector Profile (TVP) of the Spatial Data Transfer Standard (SDTS).

The document is divided into four sections:

1.) **Transfer Overview -** overviews the structure of the DLG-3 SDTS transfer including an summary of the modules included and description of equivalent DLG-3 and SDTS spatial concepts.

2.) **SDTS Module Contents -** This section enumerates the fields and subfields of each SDTS module used in the transfer, showing each subfield's contents and where this information was obtained.

3.) **Master Data Dictionary Transfer Module Contents-** Instead of being included with each transfer of DLG-3 data, the Data Dictionary/Definition and Data Dictionary/Domain modules are transferred in a separate master data dictionary transfer. This section describes the modules in the master data dictionary transfer.

4.) **Attribute Modules -** This describes the Attribute Primary modules and how DLG-3 attribute codes are converted into attributes in the SDTS.

# Table of Contents

# 1. Transfer Overview

A DLG-3 SDTS transfer is created from one or more DLG-3 files. Each DLG-3 file is converted to one SDTS two-dimensional manifold, the SDTS's term for a topologically structured planar graph with two-dimensional objects. One or multiple 2-D manifolds may be included in one transfer. Multiple 2-D manifolds are included in a transfer for (1) DLG-3 Roads and Trails, Railroads, and Pipelines which are combined into a "transportation" transfer or (2) 1:100,000-scale DLGs where a transfer consists of 7.5 or 15 minute partitions of a 30 minute by 30 minute area (transportation themes are also combined into one transfer in this situation.) In other cases, a transfer will consist of one 2-D manifold (one DLG-3 file.)

A DLG-3 SDTS transfer consists of a group of SDTS modules, each in a separate ISO 8211 file. On media which have directory structures, each transfer is placed in a separate directory. On media with a sequential structure, such as ANSI-labeled tapes, the files for a transfer are grouped on the media with the Identification module placed first.

## Modules Which Apply to an Entire Transfer

Except for Attribute Primary modules, there will be exactly one of each of the following modules.

| Module Name | Module Type | Description |
|---|---|---|
| A--- | Attribute Primary | Contains attributes of spatial objects. The structure, number, and name of modules will vary with the DLG-3 theme being transferred. Attribute Primary modules are described in detail in section 4. |
| AHDR | Attribute Primary | DLG-3 "header" information which does not have a predefined location within the SDTS |
| CATD | Catalog/ Directory | Directory of each module included in or referenced by the transfer |
| CATS | Catalog/ Spatial Domain | Catalog of the relationships of modules to 2-D manifolds, themes, and maps |
| CATX | Catalog/ Cross Reference | Catalogs relationships between modules |
| DDSH | Data Dictionary/ Schema | Describes the structure of attributes in Attribute Primary modules |
| DQAA | Attribute Accuracy | Contains the data quality report for Attribute Accuracy |
| DQCG | Completeness | Contains the data quality report for Completeness |
| DQHL | Lineage | Contains the data quality report for Lineage |
| DQLC | Logical Consistency | Contains the data quality report for Logical Consistency |
| DQPA | Positional Accuracy | Contains the data quality report for Positional Accuracy |
| FF01 | Composite | Contains composite objects for each 2-D manifold "surface." |
| IDEN | Identification | Contains global identification information for the transfer |
| IREF | Internal Spatial Reference | Describes the internal spatial reference system and its relationship to the external spatial reference system |
| SPDM (Used only for 1:2,000,000-scale DLG's) | Spatial Domain | Defines the minimum and maximum limits of a geographic areal domain within which the spatial addresses of the transfer are contained (Not used for 1:100,000 and 1:24,000-scale DLG's) |
| STAT | Statistics | Contains statistics on each module in the transfer |
| XREF | External Spatial Reference | Describes the external spatial reference system |

## Modules Which Apply to a Particular 2-D Manifold

These modules will be repeated for each 2-D manifold (corresponding to one DLG-3 file):

| Module Name | Module Type | Description |
|---|---|---|
| LE-- | Line (Complete Chains) | Contains complete chain spatial objects |
| NA-- | Point-Node (Area Points) | Contains area point spatial objects |
| NE-- | Point-Node (Entity Points) | Contains entity point spatial objects (this module is omitted if the transfer does not contain entity points) |
| NO-- | Point-Node (Nodes) | Contains node spatial objects |
| NP-- (Not used for 1:2,000,000-scale DLG's) | Point-Node (Generic Points) | Contains point spatial objects for the four registration points used in DLG-3 files (registration points correspond to map quadrangle corners for 1:24,000 and 1:100,000-scale DLG-3's) |
| PC-- | Polygon | Contains GT-Polygon spatial objects (including Universe Polygon and Void Polygons) |

The last two characters of the module name will be the same for a particular 2-D manifold and will correspond to the Aggregate Object subfield value in the Catalog/Spatial Domain module. The first 2-D manifold will be "01"; all digits 0-9 and all upper-case letters A-Z are possible in these two characters.

## Modules Included in Master Data Dictionary Transfer

To avoid duplication, the data dictionary is transferred in a master data dictionary transfer as described in Section 3.

| Name | Module Type | Description |
|---|---|---|
| MDEF | Data Dictionary/ Definition | Contains definitions of entities and attributes |
| MDIR | Catalog/ Directory | Directory of each module included in the transfer |
| MDOM | Data Dictionary/ Domain | Contains the domain of values for attributes |
| MIDE | Identification | Contains global identification information for the transfer |
| MQCG | Data Quality/ Completeness | Completeness data quality report for the master data dictionary |
| MQHL | Data Quality/ Lineage | Lineage data quality report for the master data dictionary |

## Module and File Names

Module names are shown in the previous tables. These are standardized by the TVP. In cases where there is a potential for multiple instances of a module type within a transfer, some characters of the module name will vary. These are indicated by dashes in the names.

The TVP standardizes file names to be a 4-character transfer base name followed by the module name. The extension will always be DDF.

For 1:24,000 & 1:100,000-scale DLG-3's, the transfer base name is an abbreviation for the theme contained in a transfer followed by an arbitrary two characters. For example, in a transfer of the hydrography theme, the Identification module file might be named HY01IDEN.DDF.

For 1:2,000,000-scale DLG-3's, the transfer base name is the two letter state abbreviation followed by the theme abbreviation. For example, in a transfer of the hydrography theme of the state of Virginia, the Identification module will be named VAHYIDEN.DDF.

## File Order

DLG-3 SDTS transfers use 9-track magnetic tape conforming to ANSI X3.27 (commonly known as "ANSI-labeled tapes.") A tape may contain multiple transfers; each transfer begins with an Identification module. The first file on a tape is a README file which is an ASCII text file, not an ISO 8211 file. Next are the files for the master data dictionary transfer. Finally are the files for one or more SDTS transfers containing DLG-3 data. The following table illustrates the order of files.

| File Name | Module Type | Comments |
|---|---|---|
| README | | ASCII text file, not an SDTS module |
| DLG3MIDE.DDF | Identification | Part of master data dictionary transfer |
| DLG3CATD.DDF | Catalog/ Directory | Part of master data dictionary transfer |
| DLG3MDEF.DDF | Data Dictionary/ Definition | Part of master data dictionary transfer |
| DLG3MDOM.DDF | Data Dictionary/ Domain | Part of master data dictionary transfer |
| DLG3MQHL.DDF | Data Quality/ Lineage | Part of master data dictionary transfer |
| DLG3MQCG.DDF | Data Quality/ Completeness | Part of master data dictionary transfer |
| The following files are repeated for each transfer (bbbb indicates a file name base which is common to all files in a transfer, --- or -- indicates part of a file name which is variable) | | |
| bbbbIDEN.DDF | Identification | Indicates the beginning of a transfer |
| bbbbCATD.DDF | Catalog/ Directory | Catalog of all modules in a transfer |
| bbbbCATX.DDF | Catalog/ Cross-Reference | |
| bbbbCATS.DDF | Catalog/ Spatial Domain | |
| bbbbIREF.DDF | Internal Spatial Reference | |
| bbbbXREF.DDF | External Spatial Reference | |
| bbbbSPDM.DDF | Spatial Domain | Only used for 1;2,000,000-scale DLG-3's |
| bbbbDDSH.DDF | Data Dictionary/ Schema | |
| bbbbDQHL.DDF | Data Quality/ Lineage | |
| bbbbDQPA.DDF | Data Quality/ Positional Accuracy | |
| bbbbDQAA.DDF | Data Quality/ Attribute Accuracy | |
| bbbbDQLC.DDF | Data Quality/ Logical Consistency | |
| bbbbDQCG.DDF | Data Quality/ Completeness | |
| bbbbA---.DDF | Attribute Primary | Number of and names of Attribute Primary modules will vary with theme (see section 4) |
| bbbbB---.DDF | Attribute Secondary | Number of and names of Attribute Secondary modules will vary with theme and scale (they are only used with 1:2,000,000-scale DLG-3's; see section 4) |
| bbbbFF01.DDF | Composite | |
| bbbbNA--.DDF | Point-Node | Contains area point objects; one module per 2-D manifold |
| bbbbNE--.DDF | Point-Node | Contains entity point objects; one module per 2-D manifold (omitted if a 2-D manifold does not contain entity points) |
| bbbbNO--.DDF | Point-Node | Contains planar node objects; one module per 2-D manifold |
| bbbbNP--.DDF | Point-Node | Contains point objects for the four quadrangle corners of a DLG in 1:24,000 and 1:100,000-scale only; one module per 2-D manifold |
| bbbbLE--.DDF | Line | Contains complete chain objects; one module per 2-D manifold |
| bbbbPC--.DDF | Polygon | Contains GT-polygon objects; one module per 2-D manifold |

## Spatial Reference Systems

As required by the TVP, spatial addresses (coordinates) are stored internally as 32-bit signed binary integers. This coordinate system is known as the internal spatial reference system. The external spatial reference system is a ground-based coordinate system; the Universal Transverse Mercator (UTM) grid system is used for 1:24,000 and 1:100,000-scale DLG-3's. Geographic coordinates are used as the external spatial reference system for 1:2,000,000-scale DLG-3's. The Z coordinate is not used in DLG-3's.

## Spatial Objects

DLG-3 spatial objects are converted to corresponding SDTS spatial objects as shown in the following table:

| DLG-3 Spatial Object | SDTS Spatial Object | Object Representation Code | Module Name |
|---|---|---|---|
| Node | Planar Node | NO | NO-- |
| Line | Complete Chain | LE | LE-- |
| Degenerate Line | Entity Point | NE | NE-- |
| Area<br>(Maps to one of the three according to attribution) | GT-Polygon Universe Polygon<br>or Void Polygon | PC<br>PW<br>PX | PC-- |
| *and* -> | Area Point | NA | NA-- |
| Registration Point<br>(Not applicable to 1:2,000,000-scale DLG-3's) | Point | NP | NP-- |

## Surface Composite Module (FF01)

Each DLG-3 transfer contains a Composite module, named FF01, which contains objects representing each surface in the transfer. Surface is a DLG term which is equivalent to the SDTS 2-D manifold term. One DLG-3 file (one theme for one partition) is equivalent to one surface. The composite objects for each surface contain pointers to the spatial object modules and header attributes which make up the surface. This module is used in addition to the Catalog/Spatial Domain module to determine which modules contain spatial objects of a particular surface. The added benefit to using a composite module to identify a surface is that attribute records can be pointed to by the composite records thereby attributing the whole surface.

# 2. Transfer Module Content

The following tables describe the fields and subfields contained in selected modules in SDTS transfers created from DLG-3 files. These are examples; for the complete set of tables, refer to the publication of which this is an excerpt/ Modules are ordered alphabetically by module name. Attribute Primary modules for attributes of spatial objects and modules in the master data dictionary transfer are described in separate sections.

Sources

Under the column heading "Source" the following terms are used:

Profile the data are defined within SDTS as implemented by the TVP

Generated there is a simple generation or counting involved which is normally done within a computer program

External data must be obtained from sources other than the SDTS/Vector Profile and normally requires significant human intervention

DLG-3 implies that the data can be extracted from a DLG-3

## CATD (Catalog / Directory)

The Catalog/Directory module contains a directory of modules, identifying the file in which each module is contained.

| **Catalog/Directory (CATD)** Primary Field | **Contents** | **Source** |
|---|---|---|
| Module Name | "CATD" | Profile |
| Record ID | Defined by order in this module | Generated |
| Name | Name of module referenced | Profile |
| Type | Primary field name from module referenced | Profile |
| File | File of the module referenced | DLG-3, profile |
| External | Module is external to the transfer "Y/N" | External |
| Module Version | Version of the module referenced by, or included in the transfer (used to indicate the version of the master data dictionary) | External |

## CATS (Catalog / Spatial Domain)

The Catalog/Spatial Domain module is used to specify the aggregate object, map, or theme to which a module applies.

| **Catalog/Spatial Domain (CATS)** Primary Field | **Contents** | **Source** |
|---|---|---|
| Module Name | "CATS" | Profile |
| Record ID | Defined by order in this module | Generated |
| Name | Name of module referenced | Profile |
| Type | Primary field name of module referenced | Profile |
| Map | Name of digital cartographic unit | DLG-3 |
| Theme | Category name | DLG-3 |
| Aggregate Object | Arbitrary identifier which uniquely identifies a particular aggregate object (2-D manifold); the * wildcard is used for a module which applies to all 2-D manifolds; a null value is used if there is only one 2-D manifold in a transfer | Generated |
| Aggregate Object Type | "GT" indicating that the object is a 2-D manifold | Profile |

## CATX (Catalog / Cross-Reference

The Catalog/Cross-Reference module is used to describe relationships between modules.

| **Catalog/Cross-Reference (CATX)** Primary Field | **Contents** | **Source** |
| --- | --- | --- |
| Module Name | "CATX" | Profile |
| Record ID | Defined by order in this module | Generated |
| Name 1 | Name of module referenced | Profile |
| Type 1 | Primary field name of module referenced by Name 1 | Profile |
| Name 2 | Name of module referenced | Profile |
| Type 2 | Primary field name of module referenced by Name 2 | Profile |
| Comment | Text stating the meaning of the cross-reference | External |

## DDSH (Data Dictionary / Schema)

The Data Dictionary / Schema Module describes structure of the Attribute Primary and Secondary modules (DLG-3 does not use Attribute Secondary modules.)

| **Data Dictionary / Schema (DDSH)** Primary Field | **Contents** | **Source** |
|---|---|---|
| Module Name | "DDSH" | Profile |
| Record ID | Defined by order in this module | Generated |
| Name | Name of module with data to which the schema applies | Profile |
| Type | "ATPR"<br>for Attribute Primary modules &<br>“ATSC”<br>for Attribute Secondary modules<br>(type of module with data to which the schema applies) | Profile |
| Attribute Label | Name of attribute label | External |
| Attribute Authority | "USGS/NMD" | External |
| Format | Format of the attributes subfield | External |
| Unit | Measurement unit for attribute subfield | External |
| Maximum Subfield Length | Maximum length of the subfield (maximum number of characters) | Generated |
| Key | NOKEY, PKEY, FKEY, PFKEY (indicates whether attribute is part of primary or foreign relational key) | External |

## Data Quality Modules

The Data Quality modules (Attribute Accuracy, Completeness, Lineage, Logical Consistency, and Positional Accuracy) are encoded according to the following format.

| **Data Quality/Attribute Accuracy (DQAA)**<br>Primary Field | **Contents** | **Source** |
|---|---|---|
| Module Name | "DQAA" or "DQCG" or "DQHL" or "DQLC" or "DQPA" | Profile |
| Record ID | "1" (only one DQAA record in our application) | Generated |
| Comment | Narrative describing the data quality information | External |

## IDEN (Identification)

The Identification module contains global information which serves to identify the transfer.

| Identification (IDEN) Field | Subfield | Content | Source |
|---|---|---|---|
| Primary Field | Module Name | "IDEN" | Profile |
| | Record ID | "1" (only one IDEN record in our application) | Profile |
| | Standard ID | "SPATIAL DATA TRANSFER STANDARD" | Profile |
| | Standard Version | "1992 AUGUST 28" | Profile |
| | Standard Documentation Reference | "FIPS PUB 173" | Profile |
| | Profile Identification | "SDTS TOPOLOGICAL VECTOR PROFILE" | Profile |
| | Profile Version | "VERSION 1 DECEMBER 20, 1993" | Profile |
| | Profile Documentation Reference | "FIPS 173 PART 4" | Profile |
| | Title | Name of digital cartographic unit | DLG-3 File ID & Description Records (concatenation of name of digital cartographic unit and category name) |
| | Data ID | Map number from National Digital Cartographic Data Base | External |
| | Data Structure | "DLG-3" | Deduced from the data source |
| | Map Date | Date of original source material or revision date, whichever is later | DLG-3 File ID & Description Records |
| | Data Set Creation Date | Date from computer system's clock | Generated |
| | Scale | Scale | DLG-3 File ID & Description Records |
| Conformance | Composites | "Y" | Profile |
| | Vector Geometry | "Y" for 1:24,000 & 1:100,000-scale DLG-3's<br>"N" for 1:2,000,000-scale DLG-3's | Profile |
| | Vector Topology | "Y" | Profile |
| | Raster | "N" | Profile |
| | External Spatial Reference | "1" | Profile |
| | Features Level | "4" | Profile |

## IREF (Internal Spatial Reference)

The Internal Spatial Reference module is used to describe the internal spatial reference system and its relationship to the external spatial reference system.

| Internal Spatial Reference (IREF) | | Contents | Source |
|---|---|---|---|
| Field | Subfield | | |
| Primary Field | Module Name | "IREF" | Profile |
| | Record ID | Defined by order in this module | Generated |
| | Spatial Address Type | "2-TUPLE" | Profile |
| | Spatial Address X Component Label | "EASTING" for 1:24,000 & 1:100,000-scale DLG-3's "LONGITUDE" for 1:2,000,000-scale DLG-3's | Profile |
| | Spatial Address Y Component Label | "NORTHING" for 1:24,000 & 1:100,000-scale DLG-3's "LATITUDE" for 1:2,000,000-scale DLG-3's | Profile |
| | Horizontal Component Format | "BI32" | Profile |
| | Scale Factor X | 0.01 for 1:24,000 & 1:100,000-scale DLG-3's 0.000001 for 1:2,000,000-scale DLG-3's | Profile |
| | Scale Factor Y | 0.01 for 1:24,000 & 1:100,000-scale DLG-3's 0.000001 for 1:2,000,000-scale DLG-3's | Profile |
| | X Origin | 0.0 | Profile |
| | Y Origin | 0.0 | Profile |
| | X Component of Horizontal Resolution | Resolution | DLG-3 File Identification Record |
| | Y Component of Horizontal Resolution | Resolution | DLG-3 File Identification Record |

## LE-- (Line)

The Line module is used to transfer complete chains for a particular 2-D manifold.

| Line (LE--) Field | Subfield | Contents | Source |
|---|---|---|---|
| Primary Field | Module Name | Module name beginning with "LE" | Profile, generated |
| | Record ID | Element internal ID number | DLG-3 Line ID record element ID |
| | Object Representation Code | "LE" | Profile |
| ^Attribute ID Foreign ID Fields | Module Name | Module name of the Attribute Primary record referenced | Profile, generated |
| | Record ID | ID of the Attribute Primary module record referenced | Generated sequentially as DLG-3 is processed |
| ^Polygon ID Left Foreign ID Field | Module Name | Name of the Polygon Module referenced | Profile, generated |
| | Record ID | Element ID of the area at the left of the line | DLG-3 Line ID record, left area internal element ID |
| ^Polygon ID Right Foreign ID Field | Module Name | Name of the Polygon Module referenced | Profile, generated |
| | Record ID | Element ID of the area at the right of the line | DLG-3 Line ID record, right area internal element ID |
| ^Start Node ID Foreign ID Field | Module Name | Name of planar node module referenced | Profile, generated |
| | Record ID | Element ID of the node at the start of the line | DLG-3 Line ID record, start node internal element ID |
| ^End Node ID Foreign ID Field | Module Name | Name of planar node module referenced | Profile, generated |
| | Record ID | Element ID of the node at the end of the line | DLG-3 Line ID record, end node internal element ID |
| -Spatial Address Fields | X component | The easting value of each of the coordinates for the DLG-3 line | DLG-3 line coordinate string records |
| | Y component | The northing value of each of the coordinates for the DLG-3 line | DLG-3 line coordinate string records |

## NA-- (Point-Node for Area Points)

The NA Point-Node module transfers area points for a particular 2-D manifold.

| Point-Node (Area Points) (NA--) Field | Subfield | Contents | Source |
|---|---|---|---|
| Primary Field | Module Name | Module name beginning with "NA" | Profile, Generated |
| | Record ID | Element internal ID number | DLG-3 |
| | Object Representation | "NA" | Profile |
| -Spatial Address Field | X Component | The easting coordinate value of the representative point for the area | DLG-3 Area Identification Record |
| | Y Component | The northing coordinate value of the representative point for the area | DLG-3 Area Identification Record |
| ^Area ID Foreign ID Field | Module Name | Name of the polygon module referenced | Profile |
| | Record ID | DLG-3 internal element ID of the area mapped | DLG-3 Area Identification Record |

## NE-- (Point-Node for Entity Points)

The NE Point-Node module transfers entity points for a particular 2-D manifold.

| Point-Node (Entity Points) (NE--) | | Contents | Source |
|---|---|---|---|
| Field | Subfield | | |
| Primary Field | Module Name | Module name beginning with "NE" | Profile, generated |
| | Record ID | DLG-3 element internal ID number | DLG-3 Line ID Record |
| | Object Representation | "NE" | Profile |
| -Spatial Address Field | X Component | The easting value of the first coordinate pair listed with a DLG-3 degenerate line | DLG-3 Coordinate String records |
| | Y Component | The northing value of the first coordinate pair listed with a DLG-3 degenerate line | DLG-3 Coordinate String records |
| ^Attribute ID Foreign ID Field | Module Name | Name of the Attribute Primary Module referenced | Profile |
| | Record ID | Represents Record ID of Attribute Primary record referenced | Generated |
| ^Area ID Foreign ID | Module Name | Module name of the polygon module referenced | Profile |
| | Record ID | DLG-3 Internal Element ID of either the left or right area of a degenerate line | DLG-3 Line ID Record |

## NO-- (Point-Node for Planar Nodes)

The NO Point-Node module transfers planar nodes for a particular 2-D manifold.

| Point-Node (Planar Nodes) (NO--) | | Contents | Source |
|---|---|---|---|
| Field | Subfield | | |
| Primary Field | Module Name | Module name beginning with "NO" | Profile, generated |
| | Record ID | Element internal ID number | DLG-3 Node Identification Record |
| | Object Representation | "NO" | DLG-3, profile |
| -Spatial Address Field | X Component | The easting value of the spatial address of the node | DLG-3 Node Identification Record |
| | Y Component | The northing value of the spatial address of the node | DLG-3 Node Identification Record |
| ^Attribute ID Foreign ID Field | Module Name | Name of the Attribute Primary module referenced | Profile |
| | Record ID | Represents Record ID of Attribute Primary record referenced | Generated sequentially as DLG-3 is processed |

## NP-- (Point-Node)

This module contains point spatial objects which are used to transfer the four registration points contained in DLG-3 files (typically corresponding to quadrangle corners.) This module is not included for 1:2,000,000-scale DLG-3's.

| Point-Node (NP--) | | Contents | Source |
|---|---|---|---|
| **Field** | **Subfield** | | |
| Primary Field | Module Name | Module name beginning with "NP" | Profile, generated |
| | Record ID | where control-point label = SW then "1" NW then "2" NE then "3" SE then "4" | Value determined from control-point label from the DLG-3 Control-Point Identification Record |
| | Object Representation | "NP" | DLG-3, profile |
| -Spatial Address Field | X Component | The easting value of the "SW", "NW", "NE", or "SE" DLG-3 control point addresses | DLG-3 Control Point Identification Record |
| | Y Component | The northing value of the "SW", "NW", "NE", or "SE" DLG-3 control point addresses | DLG-3 Control Point Identification Record |

## PC-- (Polygon)

The Polygon module is used to transfer GT-polygons, universe polygons, and void polygons for a particular 2-D manifold.

| Polygon (PC--) | | Contents | Source |
|---|---|---|---|
| Field | Subfield | | |
| Primary Field | Module Name | Module name beginning with "PC" | Profile, generated |
| | Record ID | Element internal ID number | DLG-3 Area Identification Record element ID |
| | Object Representation Code | "PC" (GT-polygon), "PW" (universe polygon), or "PX" (void polygon); choice made according to attribution | DLG-3, profile |
| ^Attribute ID Foreign ID Field | Module Name | Name Attribute Primary Module referenced | Profile |
| | Record ID | Record ID of Attribute Primary record referenced | Generated sequentially as DLG-3 is processed |

## SPDM (Spatial Domain)

The Spatial domain module specifies a geographic areal domain  within which the spatial addresses of the transfer are contained.

| Spatial Domain (SPDM) | | Contents | Source |
|---|---|---|---|
| Field | Subfield | | |
| Primary Field | Module Name | "SPDM" | Profile |
| | Record ID | "1" (only one record in this application) | Generated |
| | Spatial Domain Type | "MINMAX" | Profile, external |
| | Domain Spatial Address Type | "INTERNAL" | Profile, external |
| Domain Spatial Address MIN value | X component | Minimum longitude value of the spatial domain | DLG-3 Control-Point Identification Record Southwest corner |
| | Y component | Minimum latitude value of the spatial domain | DLG-3 Control-Point Identification Record Southwest corner |
| Domain Spatial Address MAX value | X component | Maximum longitude value of the spatial domain | DLG-3 Control-Point Identification Record Northeast corner |
| | Y component | Maximum latitude value of the spatial domain | DLG-3 Control-Point Identification Record Northeast corner |

# 3. Master Data Dictionary Transfer Modules

The Data Dictionary/Definition and Data Dictionary/Domain modules are transferred separately in a master data dictionary which conforms to the requirements of Annex A of the TVP. This master data dictionary transfer is included with each order of DLG-3 SDTS data.

This excerpt contains selected Master Data Dictionary modules. Each master data dictionary contains a version number, indicated in the Identification module and the Catalog / Directory module. Transfers which reference this master data dictionary must also include the version number in these modules. The version number should be checked to verify that the master data dictionary is the correct version for the DLG-3 transfer. New versions of the data dictionary may be created to correct errors, add entities, add attributes, and modify definitions. The data dictionary is designed to include DLG-3 entities and attribute which are not collected currently but may exist in older DLG-3; therefore, it is unlikely that entities and attributes will be deleted from new versions of the data dictionary.

In addition to the Data Dictionary/Definition and Data Dictionary/Domain modules, the master data dictionary transfer includes Identification, Catalog/Directory, Data Quality/Completeness, and Data Quality/Lineage modules.

## MDEF (Data Dictionary / Definition)

This module contains the definitions and authorities for entities and attributes.

| **Data Dictionary / Definition (MDEF)** Primary Field | **Contents** | **Source** |
|---|---|---|
| Module Name | "MDEF" | Profile |
| Record ID | Defined by order in this module | Generated |
| Entity or Attribute | "ENT" - entity<br>"ATT" - attribute | Profile |
| Entity/Attribute Label | Name of attribute or entity label | External |
| Source | Source of the definition (not used for most definitions in DLG-3) | External |
| Definition | Text | External |
| Attribute Authority | "USGS/NMD" | Profile |
| Attribute Authority Description | "United States Geological Survey, National Mapping Division" | Profile |

## MDIR (Catalog / Directory)

The Catalog/Directory module contains a directory of modules, identifying the file in which each module is contained.

| **Catalog/Directory (MDIR)** Primary Field | **Contents** | **Source** |
|---|---|---|
| Module Name | "MDIR" | Profile |
| Record ID | Defined by order in this module | Generated |
| Name | Name of module referenced | Profile |
| Type | Primary field name from module referenced | Profile |
| File | File name of the module referenced | DLG-3, profile |
| External | Module is not external to the transfer "N" | External |
| Module Version | Version of the module included in the transfer (used to indicate the version of the master data dictionary) | External |

## MDOM (Data Dictionary / Domain)

This module describes the domain of values for attributes.

| **Data Dictionary / Domain (MDOM)**<br>Primary Field | **Contents** | **Source** |
|---|---|---|
| Module Name | "MDOM" | Profile |
| Record ID | Defined by order in this module | Generated |
| Attribute Label | Name of attribute label | External |
| Attribute Authority | "USGS/NMD"<br>"FIPS" | Profile |
| Attribute Domain Type | "ALPHANUM"<br>"ENUMERATED"<br>"FIPSCODE"<br>"GR_CHARS"<br>"INTEGER"<br>"REAL" | Profile |
| Attribute Domain Value Format | "A"<br>"I"<br>"R" | Profile |
| Attribute Domain Value Measurement Unit | Measurement unit of attribute value, if applicable | External |
| Range or Value | Describes the use of the value in Domain Value:<br>"MIN" - value is minimum of range<br>"MAX" - value is maximum of range<br>"VALUE" - enumerated value | External |
| Domain Value | Valid value for this attribute | External |
| Domain Value Definition | Definition of value in Domain Value subfield | External |

# 4. Attribute Modules

## Introduction

The SDTS model of spatial phenomena describes the real world as consisting of entities which are characterized by attributes which have attribute values.

DLG-3 does not explicitly use this entity-attribute-attribute value model. Instead it assigns any number of "attribute codes" to spatial objects. Looking more closely at these DLG-3 attribute codes, it can be seen that there are codes which identify real world entities and codes which represent attributes of those entities. The SDTS implementation of DLG-3 identifies which DLG-3 attribute codes identify entities and which identify attributes of those entities.

There are two ways in the SDTS of identifying the entity type for a particular object in an SDTS transfer. One method is to create a separate Attribute Primary module for each entity type; in this method the entity type is assigned to a particular attribute and Attribute Primary module through the Data Dictionary/Schema module. The second method is specified in the TVP: a generic ENTITY_LABEL attribute is specified by the TVP, its value identifies the entity type. This method does not require separate Attribute Primary modules for each entity type. It is this second method which is used in DLG-3 transfers.

## Attribute Primary Modules

There will always be at least one **Feature** Attribute Primary module (transfers of transportation will include a separate Feature Attribute Primary module for each of the three transportation themes). The Feature Attribute Primary module contains the ENTITY_LABEL attribute which contains the 7-digit DLG-3 attribute code which identifies the real world entity. Additional attributes provide additional descriptive and parameter information about the entity. These additional attributes will differ with theme.

The name of the Feature Attribute Primary module will vary with theme:

AHPF - Hypsography
AHYF - Hydrography
ASCF - Vegetative Surface Cover
ANVF - Non-vegetative Features
ABDF - Boundaries
ASMF - Survey Control and Markers
ARDF - Roads and Trails
ARRF - Railroads
AMTF - Pipelines, Transmission Lines, and Miscellaneous Transportation Features
AMSF - Manmade Features
APLF - U.S. Public Land Survey System

## Attribute Secondary Modules

Attribute Secondary modules are only included in transfers created from 1:2,000,000-scale DLG-3's. These DLG's store information in companion text files which serve as input to the conversion process. The information in these text files serve to further describe attribute major minor pairs contained in the DLG file. As mapped into SDTS, this additional information is placed in Attribute Secondary modules. Each record of these Attribute Secondary modules is linked to records in other attribute modules by relational key.

## Attribute Modules by Theme

The following table summarizes which Attribute modules are used for transfers of each theme.

| DLG-3 Theme | Attribute Primary Modules | |
|---|---|---|
| | Module Name | Module Description |
| Hypsography | ACOI *<br>AHPF<br>AHPR *<br>AHPT * | Coincidence<br>Feature<br>Elevation - Feet<br>Elevation - Meters |
| Hydrography | ACOI *<br>AHYF | Coincidence<br>Feature |
| Vegetative Surface Cover | ACOI *<br>ASCF | Coincidence<br>Feature |
| Non-vegetative Features | ACOI *<br>ANVF | Coincidence<br>Feature |
| Boundaries | ACOI *<br>ABDF<br>ABDM<br>BFPC **<br>BFPS ** | Coincidence<br>Feature<br>Agency<br>County Names<br>State Name |
| Survey Control and Markers | ACOI *<br>ABDF | Coincidence<br>Feature |
| Transportation | ACOI *<br>AMTF<br>ARDF<br>ARDM<br>ARRF<br>BMTA **<br>BFPS ** | Coincidence<br>Feature - Miscellaneous Transportation<br>Feature - Roads and Trails<br>Route - Roads and Trails<br>Feature - Railroads<br>Airport Names<br>State Name |
| Manmade Features | ACOI *<br>AMSF<br>BMSP **<br>BFPC **<br>BFPS ** | Coincidence<br>Feature<br>Populated Place Names<br>County Names<br>State Name |
| U.S. Public Land Survey System | ACOI *<br>APLF<br>BGRL *** | Coincidence<br>Feature<br>Land Grant Names |

* -- Indicated modules may be absent
** -- Indicated modules are only used for 1:2,000,000-scale DLG-3's
*** -- Indicated modules may be absent and are only used for 1:2,000,000-scale DLG-3's

## Feature Attribute Primary Modules

There will be one Feature Attribute Primary module for each DLG-3 theme in a transfer. The attributes in the module will vary with the DLG-3 theme. The following table is an example of encoding for the Roads and Trails Theme. A similar format is followed for encoding of other themes.

| ARDF Feature Attribute Primary Module | | | | | (Roads and Trails) |
|---|---|---|---|---|---|
| **Attribute Label** | **DLG Code** | **Format** | **Units** | **Length** | **Value Domain** |
| ENTITY_LABEL | | A | N/A | 7 | 7-digit DLG-3 code or blanks |
| ARBITRARY_EXT | 1700216 | A | N/A | 1 | "Y" (applied) or blank |
| RELATION_TO_GROUND | 1700601<br>1700606<br>1700612<br>1700614<br>1700618 | A | N/A | 1 | "T" (tunnel)<br>"S" (submerged)<br>"D" (double-decked)<br>"E" (elevated)<br>"R" (on drawbridge)<br>" " (not applied) |
| VERTICAL_RELATION | 1700602<br>1700607 | A | N/A | 1 | "O" (overpassing)<br>"U" (under passing)<br>" " (not applied) |
| OPERATIONAL_STATUS | 1700603<br>1700604<br>1700611 | A | N/A | 1 | "U" (under construction, classification known)<br>"X" (under construction, classification unknown)<br>"P" (proposed)<br>" " (not applied) |
| ACCESS_RESTRICTION | 1700609<br>1700610 | A | N/A | 1 | "T" (toll road)<br>"P" (private)<br>" " (not applied) |
| OLD_RAILROAD_GRADE | 1700605 | A | N/A | 1 | "Y" (applied) or blank |
| WITH_RAILROAD | 1700623 | A | N/A | 1 | "Y" (applied) or blank |
| COVERED | 1700624 | A | N/A | 1 | "Y" (applied) or blank |
| HISTORICAL | 1700600* | A | N/A | 1 | "Y" (applied) or blank |
| LIMITED_ACCESS | 1700608* | A | N/A | 1 | "Y" (applied) or blank |
| PHOTOREVISED | 1700000 | A | N/A | 1 | "Y" (applied) or blank |
| LANES | 171____ | I | LANES | 2 | "Y" (applied) or blank |
| ROAD_WIDTH | 1700650-<br>1700659 | I | FEET | 3 | Rounded to nearest multiple of 10; -99 indicates not applied |
| BEST_ESTIMATE | 1780000 | A | N/A | 1 | "Y" (applied) or blank |

Notes:

The following are examples of selected DLG entity codes of the Roads and Trails theme which are identified by the ENTITY_LABEL attribute:

ENTITY_LABEL
(DLG-3 code)    Definition

| | |
|---|---|
| 1700005 | Cul-de-sac |
| 1700006 | Dead end |
| 1700201 | Class 1, undivided |
| 1700202 | Class 1, divided by centerline |
| 1700205 | Class 2, undivided |
| 1700206 | Class 2, divided by centerline |
| 1700213 | Footbridge |
| 1700215 | Perimeter of parking area |
| 1700222 | Road in transition |
| 1700402 | Cloverleaf or interchange |
| 1700403 | Tollgate |

# B: ISO 8211 Encoding

## Example of Encoding

Tables B-1 and B-2, and Figures B-1 and B-2, present an example of encoding user data into ISO 8211 using the SDTS. This example encodes data into an SDTS Line Module as used by the Topological Vector Profile. The source of the data for this example is a Digital Line Graph 3 (DLG-3) file produced by the USGS. Many other topological vector data models could be similarly encoded.

**Table B-1: SDTS Line Module Fields and Subfields**

| Field name | Subfield name | Mnemonic | Contents |
|---|---|---|---|
| Line | | LINE | |
| | Module Name | MODN | Profile: “LE01” |
| | Record ID | RCID | DLG-3 file line number |
| | Object Representation | OBRP | Profile: “LE” (complete chain) |
| Attribute ID | | ATID | |
| | Module Name | MODN | Foreign identifier to attribute |
| | Record ID | RCID | primary module record |
| Polygon ID Left | | PIDL | |
| | Module Name | MODN | Profile: “PC01” |
| | Record ID | RCID | DLG-3 file area number |
| Polygon ID Right | | PIDL | |
| | Module Name | MODN | Profile: “PC01” |
| | Record ID | RCID | DLG-3 file area number |
| Startnode ID | | SNID | |
| | Module Name | MODN | Profile: “NO01” |
| | Record ID | RCID | DLG-3 file area number |
| Endnode ID | | ENID | |
| | Module Name | MODN | Profile: “PC01” |
| | Record ID | RCID | DLG-3 file area number |
| Chain component ID | | CCID | |
| | Module Name | MODN | Not applicable |
| | Record ID | RCID | Not applicable |
| Spatial address | | SADR | |
| | X coordinate | X | DLG-3 X coordinate |
| | Y coordinate | Y | DLG-3 Y coordinate |
| | Z coordinate | Z | Not applicable |
| Composite ID | | CPID | |
| | Module Name | MODN | Not applicable |
| | Record ID | RCID | Not applicable |
| Representation Module ID | | RPID | |
| | Module Name | MODN | Not applicable |
| | Record ID | RCID | Not applicable |

**Table B-2: ISO 8211 Specifications for SDTS Line Module**

| | |
|---|---|
| LINE<br>[3] | 1600;&LINE& (See Part 1, 5.62)<br>MODN!RCUD!IBRP&<br>(A,IA); |
| ATID<br>[m,2] | 2600;&ATTRIBUTE ID&<br>*MODN!RCID&<br>(A,I); |
| PIDL<br>[2] | 1600;&POLYGON ID LEFT&<br>MODN!RCID&<br>(A,I); |
| PIDR<br>[2] | 1600;&POLYGON ID RIGHT&<br>MODN!RCID&<br>(A,I); |
| SNID<br>[2] | 1600;&STARTNODE ID&<br>MODN!RCID&<br>(A,I); |
| ENID<br>[2] | 1600&STARTNODE ID&<br>*MODN!RCID!USAG&<br>(A,I,A(1)); |
| CCID<br>[m,3] | 2600;&CHAIN COMPONENT ID&<br>*MODN!RCID!YSAG&<br>(A,I,A(1)); |
| SADR<br>[m,3] | 2600;&SPATIAL ADDRESS&<br>*X!Y!Z& |
| CPID<br>[m,2] | 2600;&COMPOSIT ID&<br>*MODN!RCID&<br>(A,I); |
| RPID<br>[m,2] | 2600;&REPRESENTATION MODULE ID&<br>*MODN!RCID&<br>(A,I); |

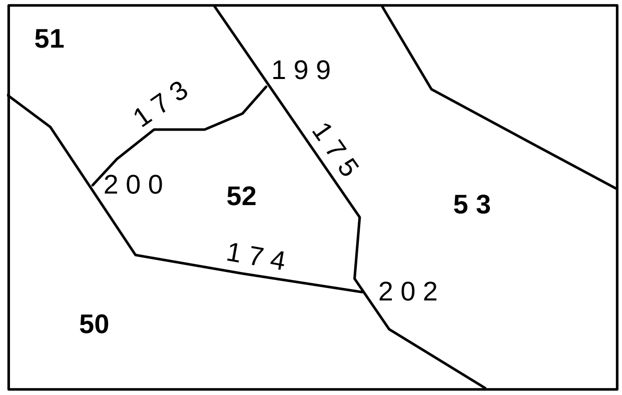
## Part 1 Transfer Specification

Table B-1 lists the fields and subfields for the Line module as described in the logical transfer module specification of Part 1 of the SDTS. The table includes the subfield DR contents and their sources when mapping DLG-3 data into the SDTS using the Topological Vector Profile. Some fields or subfields are not applicable because they are not used in this particular SDTS profile or are not applicable to the DLG-3 data model. For example, because the Topological Vector Profile does not include representation modules, the Representation Module ID field cannot be used. The Z subfield of the spatial address field is not applicable, because DLG-3 data have only two-dimensional coordinates.

**Figure B-1: SDTS Line Module Encoded in ISO 8211**


```
003972L^^^0600106^^^2304
000015000000128015LINE34043ATID36077
PIDL38113PIDR39151SNID35190ENID33225
SADR33258;
0000;&WMHYLE01;
0100;&DDF^RECORD^IDENTIFIER;
1600;&LINE&MODN!RCID!OBRP&(A,I,A);
2600;&ATTRIBUTE^ID&*MODN!RCID&(A,I);
1600;&POLYGON^ID^LEFT&MODN!RCID&(A,I);
1600;&POLYGON^ID^RIGHT&MODN!RCID&(A,I);
1600;&STARTNODE^ID&MODN!RCID&(A,I);
1600;&ENDNODE^ID&MODN!RCID&(A,I);
2600;&SPATIAL^ADDRESS&*X!Y&(I,I);
00358^D^^^^^00151^^^2304
000106000LINE14006ATID10020PIDL11030
PIDR11041SNID11052ENID11063SADR19074
SADR19093SADR19112SADR19131SADR19150
SADR19169SADR19188;
^^159;
LE01&^^173&LE;
AP01&1077;
PC01&^^^52;
PC01&^^380;
NO01&^^199;
NO01&^^200;
-75515776&39628741;-75515862&39628648;
-75515933&39628631;-75515982&39628593;
-75515997&39628500;-75516089&39628406;
-75516110&39628346;
00386^D^^^^^00160^^^2304
000106000LINE14006ATID10020PIDL11030
PIDR11041SNID11052ENID11603SADR19074
SADR19093SADR19112SADR19131SADR19150
SADR19169SADR19188SADR19207;
^^160;
LE01&^^174&LE;
AP01&1078;
PC01&^^^52;
PC01&^^452;
NO01&^^200;
NO01&^^202;
-75516110&39628346;-75515940&39628165;
-75515841&39628099;-75515621&39627785;
-75515571&39627676;-75515465&39627571;
-75515394&39627533;-75515166&39627533;
00302^D^^^^^00133^^^2304
000106000LINE14006ATID10020PIDL11030
PIDR11041SNID11052ENID11063SADR19074
SADR19093SADR19112SADR19131SADR19150;
^^161;
LE01&^^175&LE;
AP01&1079;
PC01&^^^53;
PC01&^^^52;
NO01&^^199;
NO01&^^202;
-75515776&39628741;-75515351&39628137;
-75515344&39627912;-75515237&39627604;
-75515166&39627533;
```

**Figure B-2: Plot of data shown in Figure B-1. (Chain, polygon, and node IDs can be compared to Figure B-1.)**




5 2 - Polygon ID
1 7 4 - Chain ID
2 0 0 - Node ID

Many fields in the Line module are foreign identifiers—pointers to records in other modules; these consist of module name and record ID subfields. Module names, standardized by the Topological Vector Profile, consist of a standard two-character object representation code followed by two digits.

The foreign identifier that links this line record to its corresponding attribute primary module would have to be generated by the encoding software since there is no corresponding record identifier in the DLG-3 file (the identifier would be eliminated if there were no corresponding attribute module record). All other subfield contents can be obtained directly from the input DLG-3 data set. DLG area, node, and line numbers become SDTS record IDs.

## Part 3 Specifications

Table B-2 is an extract from the specifications table of SDTS Part 3 where the ISO 8211 tags, control fields, names, labels, and formats for each field in the Line module are listed.

## Example File

Figure B-1 contains an ISO 8211 file for a Line module created from a DLG-3 data set using the SDTS Topological Vector Profile. It has been reformatted for greater legibility—field terminators are replaced with ";" characters, unit terminators are replaced with "&" characters, space characters are replaced with "^" characters, and carriage returns are added to improve legibility. This file originally had more DRs; only three have been included in this example.

### An Example of One Field

As an example, the Polygon ID Left field can be examined in more detail. As shown in Figure B-1, the Polygon ID Left field consists of a foreign identifier that identifies the polygon module record of the polygon to the left of the line. The field consists of two subfields. The module name subfield is standardized by the Topological Vector Profile; it consists of the letters “PC” followed by two digits. The record ID corresponds to the record ID pointed to in the polygon module; in this case, it corresponds exactly to the DLG left area ID>.

Using Part 3, as shown in Table B-2, it can be seen that the ISO 8211 field tag is “PIDL,” the field controls are “1600;&,” the field name is “POLYGON ID LEFT,” the subfield labels are “MODN” and “RCID,” and the format is “(A,I).” These ISO 8211 specifications can then be used in the DDR, as highlighted in the ISO 8211 file illustrated in Figure B-1. The data for this field in the three DRs shown are also highlighted. Since the format does not specify subfield lengths or user delimiters, the unit and field terminators indicate the end of each subfield’s data. Note that MODN and RCID are both the corresponding ISO 8211 labels and the SDTS subfield mnemonics, and that PIDL is both the ISO 8211 tag and the SDTS field mnemonic. Figure B-2 contains a plot of the data contained in Figure B-1. The record IDs of the chains, polygons, and nodes are shown in Figure B-2.

## Special Situations

### Tag Conflicts

Generally, Part 3 specifies the ISO 8211 tags for each field. However, ISO 8211 does not allow a tag to be repeated in the same DDR, and situations my arise where the user may need to specify multiple descriptive fields for the same tag. These are situations where there are user-selected data types, and the user needs to use different data types in different instances of a subfield. For example, the Data Dictionary Domain field has a Domain Value subfield that has a data type selected by the user. The data type of the field is likely to vary from record to record depending upon the data type of the attribute being referred to.

There are three possible solutions to tag conflicts. Multiple DDFs could be used to separate the conflicting tags into different DDFs. This may not be practical in many cases, including the example of the Data Dictionary Domain (above). Another would be to convert all data and descriptions to be compatible. For example, all data could be converted to ASCII character data. This would work but would require more work when translating to ISO 8211 to convert the data, and this would eliminate the data description capability of ISO 8211.

Part 3 offers a third solution to tag conflicts; this solution will always work and may be the most practical to use. The user can add an optional fifth character to the tag. For example, instead of DDOM, the Tag specified in Part 3, the user could create tags DDOM1 and DDOM2. All tags within a file must be the same length, therefore, if some tags must be made five characters long, all tags must also be five characters long.

## Missing Data

Part 3 specifies procedures for handling missing data. If a data field is missing from all DRs in a file, the tag and data descriptive field may be omitted from the DDR. If a field is missing from a specific DR, the tag for the field is eliminated from the directory of the specific DR.

If a particular subfield is missing from all DRs in a file, then the subfield label may be omitted from the list of labels. For example, when spatial addresses do not have an elevation coordinate, the “Z” subfield label can be omitted. If a subfield is intermittently missing, its format should use a delimiter, and missing data should be represented by zero bytes followed by the delimiter.

## User-defined Labels

Labels are defined in Part 3 except for attribute modules, in which users can specify labels that correspond to attribute names. Users also modify the data type and format control to correspond to the data type of the attribute.

# C: SDTS Resources

This appendix provides a summary of SDTS resources (people, organizations, on-line access). Table C-1 categorizes various types of SDTS assistance and support.

**Table C-1: SDTS Assistance and Support**

| | Types of Resources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | General Education/ Information about SDTS | Interpretation/ Compliance with FIPS 173 | Development/ Modification of Profiles | Development of SDTS Translation Software | Obtaining FIPS Publications | Spatial Features | SDTS Conformance Testing | SDTS Data Distribution | SDTS-Related Standards | |
| **Government Organizations** | | | | | | | | | | **Comments** |
| SDTS Task Force, MS821<br>U.S. Geological Survey<br>Mid Continent Mapping Center<br>1400 Independence Road<br>Rolla, MO 65401<br>Phone: (573) 308-3543<br>E-mail: sdts@usgs.gov | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | | Designated headquarters of the SDTS Task Force and SDTS support |
| National Technical Information Service<br>Computer Products Office<br>5285 Port Royal Road<br>Springfield, VA 22161<br>Phone: (703) 487-4600 | | | | | ✓ | | | | | |
| National Institute of Standards and Technology<br>Computer Systems Laboratory<br>Gaithersburg, MD 20899<br>Phone: (301) 975-2490 | | ✓ | | | | | ✓ | | ✓ | |
| Federal Geographic Data Committee<br>Office of Secretariat<br>590 National Center<br>Reston, VA 22092<br>Phone: (703) 648-5514<br>Fax: (703) 648-5755<br>gdc@usgs.gov | | | | | | | | | ✓ | |

**Table C-1: SDTS Assistance and Support**

| | Types of Resources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | General Education/ Information about SDTS | Interpretation/ Compliance with FIPS 173 | Development/ Modification of Profiles | Development of SDTS Translation Software | Obtaining FIPS Publications | Spatial Features | SDTS Conformance Testing | SDTS Data Distribution | SDTS-Related Standards | |
| **Government Organizations (con't.)** | | | | | | | | | | **Comments** |
| U.S. Bureau of the Census<br>Geography Division<br>Washington, D.C. 20233-7400<br>Phone: (301) 457-1066<br>Fax: (301) 457-4710<br>bfrey@census.gov<br>Contact: Barbara Frey | | | | ✓ | | | | ✓ | | SDTS implementation for TIGER data |
| U.S. Army Corps of Engineers<br>Construction Engineering<br>Research Laboratories<br>2902 Newmark Drive<br>Champaign, IL 61826<br>Contact: David Stigberg<br>Phone: (217) 352-6511,<br>ext. 7631<br>stigberg@diego.cecer.army.<br>mil | | | | ✓ | | | | | | SDTS implementation for GRASS software and data sets |
| U.S. Department of<br>Transportation<br>Volpe National Transportation<br>Systems Center<br>Cambridge, MA 02142<br>Contact: Kip Brown<br>Phone: (617) 494-2664<br>Fax: (617) 494-3260<br>brownk@volpe1.dot.gov | | | ✓ | ✓ | | | | | | Development of the SDTS Encoding Program and development of the Transportation Network Profile |

### Table C-1: SDTS Assistance and Support

| | Types of Resources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | General Education/ Information about SDTS | Interpretation/ Compliance with FIPS 173 | Development/ Modification of Profiles | Development of SDTS Translation Software | Obtaining FIPS Publications | Spatial Features | SDTS Conformance Testing | SDTS Data Distribution | SDTS-Related Standards | |
| **Private Companies/ System Vendors** | | | | | | | | | | **Comments** |
| American Digital Cartography, Inc.<br>3003 W. College Avenue<br>Appleton, WI 54914<br>Phone: (414) 733-6678<br>Fax: (414) 734-3375<br>mfb@adci.com<br>Contact: Michael Bauer | | | | ✓ | | | | ✓ | | |
| Applied Geographics<br>Bob Lazar<br>Phone: (617) 367-8626<br>Fax: (617) 367-8581<br>lazar@appgeo.com | | | | ✓ | | | | | | |
| Environmental Systems Research Institute<br>380 New York Street<br>Redlands, CA 92373<br>Phone: (909) 793-2853<br>Fax: (909) 307-3067<br>Contact: Deb Anderson<br>danderson@esri.com | | | | ✓ | | | | | | |
| Intergraph Corporation<br>Lacey Sharpe<br>One Madison<br>Phone: (205) 732-6743<br>Fax: (205) 730-6750<br>ltsharpe@ingr.com | | | | ✓ | | | | | | |

**Table C-1: SDTS Assistance and Support**

| | Types of Resources: General Education/ Information about SDTS | Interpretation/ Compliance with FIPS 173 | Development/ Modification of Profiles | Development of SDTS Translation Software | Obtaining FIPS Publications | Spatial Features | SDTS Conformance Testing | SDTS Data Distribution | SDTS-Related Standards | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| **Private Companies/<br>System Vendors** | | | | | | | | | | **Comments** |
| PlanGraphics, Inc.<br>112 East Main Street<br>Frankfort, KY 40601<br>Phone: (502) 223-1501<br>Fax: (502) 223-1235<br>plang@ix.netcom.com | ✓ | | | | | | | | | |
| UNISYS Canada, Inc.<br>Mark Ashworth<br>mark@spatial.unisys.com<br>Trevor Wong<br>trevor@spatial.unisys.com<br>Phone: (416) 297-2500<br>Fax: (416) 297-2520 | | | | ✓ | | | | | | |
| **Individuals** | | | | | | | | | | |
| Bruce Rosen<br>NIST Information Systems<br>Engineering Division<br>Gaithersburg, MD 20899<br>Phone: (301) 975-3246<br>Fax: (301) 948-6213<br>brosen@nist.gov | | ✓ | ✓ | | | | | | | SDTS program oversight |
| Arnold Johnson<br>NIST Computer Sys. Laboratory<br>Gaithersburg, MD 20899<br>Phone: (301) 975-3247<br>Fax: (301) 948-6213<br>johnson@ecf.ncsl.nist.gov | | | | | | | ✓ | | | Manager of standards validation group |

**Table C-1: SDTS Assistance and Support**

| | Types of Resources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | General Education/ Information about SDTS | Interpretation/ Compliance with FIPS 173 | Development/ Modification of Profiles | Development of SDTS Translation Software | Obtaining FIPS Publications | Spatial Features | SDTS Conformance Testing | SDTS Data Distribution | SDTS-Related Standards | **Comments** |
| **Individuals (cont.)** | | | | | | | | | | |
| John Cugin<br>NIST Graphics Software Group<br>Gaithersburg, MD 20899<br>Phone: (301) 975-3264<br>Fax: (301) 948-6213<br>cugin@speckle.ncsl.nist.gov | ✓ | ✓ | | | | | ✓ | | | |
| **Internet Resources** | | | | | | | | | | |
| USGS National Mapping Center<br>WWW Home Page:<br>http://www-nmd.usgs.gov/ | ✓ | | | | | | | ✓ | ✓ | Information on spatial data with links to FTP sites for data download |
| USGS Mid Continent Mapping Center<br>WWW Home Page:<br>http://mcmcweb.cr.usgs.gov/ | ✓ | | | | | | | ✓ | ✓ | Information about SDTS status with links to other sites |
| U.S. Census Bureau<br>WWW Home Page:<br>http://www.usgs.gov/ | | | | | | | | ✓ | | Status information and access to TIGER files in SDTS format |
| FGDC FTP Site:<br>isdres.er.usgs.gov | ✓ | | | | | | | | ✓ | Information and documents of the Federal Geographic Data Committee |

**Table C-1: SDTS Assistance and Support**

| | Types of Resources | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | General Education/ Information about SDTS | Interpretation/ Compliance with FIPS 173 | Development/ Modification of Profiles | Development of SDTS Translation Software | Obtaining FIPS Publications | Spatial Features | SDTS Conformance Testing | SDTS Data Distribution | SDTS-Related Standards | |
| **Internet Resources (cont.)** | | | | | | | | | | **Comments** |
| Federal Geographic Data Committee WWW Home Page: address: http://fgdc.er.usgs.gov | ✓ | | | | | | | | ✓ | Information and documents about FGDC sponsored activities and standards |
| SDTS FTP Site address: ftp://sdts.er.usgs.gov/pub/sdts | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | Contains subdirectories on SDTS information and resources, including articles, news, data sets, conformance testing, software, and more; all available for downloading |
| SDTS WWW Home Page http://mcmcweb.cr.usgs.gov/ ~sdts | ✓ | ✓ | | | ✓ | | | | | Overview of SDTS and status information with links to other sites |

# D: General Comparison between the FGDC Content Standards for Geospatial Metadata and SDTS

**Table D-1: General Comparison between the FGDC Content Standards for Geospatial Metadata and SDTS**

| FGDC Content Standard Elements | SDTS Modules |
|---|---|
| **Identification Information** | |
| Citation | Identification |
| Description | Identification |
| Time Period of Content | Identification |
| Status | Data Quality-Lineage |
| Spatial Domain | Spatial Domain |
| Keyword | Catalog/Spatial Domain |
| Access Constraints | Security |
| Use Constraints | Security |
| Point of Contact | READ ME File |
| Browse Graphic | Raster |
| Security Information | Security |
| Native Data Set Information | Data Quality-Lineage |
| Cross Reference | Identification and Data Quality -Lineage |
| **Data Quality and Information** | |
| Attribute Accuracy | Data Quality-Attribute Accuracy |
| Logical Consistency Report | Data Quality-Logical Consistency |
| Completeness Report | Data Quality-Completeness |
| Positional Accuracy | Data Quality-Positional Accuracy |
| Lineage | Data Quality-Lineage |
| Cloud Cover | Completeness |
| **Spatial Data Organization Information** | |
| Indirect Spatial Reference | N/A |
| Direct Spatial Reference Method | Identification |
| Point and Vector Object Information | Vector Modules |
| Raster Object Information | Raster Definition |

**Table D-1: General Comparison between the FGDC Content Standards for Geospatial Metadata and SDTS (continued)**

| FGDC Content Standard Elements | SDTS Modules |
|---|---|
| **Spatial Reference Information** | |
| Horizontal Coordinate System Definition | External Spatial Reference |
| Vertical Coordinate System Definition | External Spatial Reference |
| **Entity and Attribute Information** | |
| Detailed Description | Data Dictionary Modules |
| Overview Description | Identification |
| **Distribution Information** | |
| Distributor | N/A |
| Resource Description | N/A |
| Distribution Liability | N/A |
| Standard Order Process | N/A |
| Custom Order Process | N/A |
| Technical Prerequisites | N/A |
| Available Time Period | N/A |
| **Metadata Reference Information** | |
| Metadata Date | N/A |
| Metadata Review Date | N/A |
| Metadata Future Review Date | N/A |
| Metadata Contact | N/A |
| Metadata Standard Name | N/A |
| Metadata Standard Version | N/A |
| Metadata Time Convention | N/A |
| Metadata Access Constraints | N/A |
| Metadata Use Constraints | N/A |
| Metadata Security Information | N/A |

# Glossary

# Glossary

## A

**aggregate objects** • Specifically defined collections of simple objects that may be used to represent or model real-world spatial entities. For instance, while a simple object (e.g., Chain) may be used to represent a road centerline segment, an aggregate object such as a Planar Graph can be used to represent an entire road network and, thereby, establish a basis for the transfer of a large data set.

**annex option** • An option for inclusion of information in an SDTS transfer that may or may not be exercised in a transfer in order for it to be compliant with a specific SDTS profile. An annex option is always one which may be omitted from encoding or decoding software. This differs from a core option which **must** be addressed by compliant decoding software **if** the information referenced by the option has been included in a transfer.

**automated mapping** • A general class of software or application that concentrates on graphic operations for the entry, update, display, and hard copy production of maps with little capability for the storage or processing of attribute data or for spatial analysis. Some automated mapping system users have applied the capabilities of computer-aided drafting packages for mapping purposes. GIS software packages also include capabilities for automated mapping as well as more advanced functions for attribute processing and analysis.

## B

**base specification** • Parts 1, 2, and 3 of the SDTS specification. This includes the Logical Specifications, Spatial Features, and ISO 8211 Encoding but does not include any SDTS profiles.

## C

**composite object** • A special type of spatial object (SDTS object code FF) which is any aggregation of simple objects or other composite objects. This object type is useful because it allows the flexibility to define an object for transfer that consists of any collection of other objects.

**conformance testing** • The process of formal testing, managed by The National Institute of Standards and Technology, to verify compliance with SDTS. Conformance testing examines defined test points to check for compliance of SDTS transfers (data sets), encoding software, and decoding software.

**core option** • An option for inclusion of information in an SDTS transfer that may or may not be exercised in a transfer in order for it to be compliant with a specific SDTS *profile*. Information referenced by core options is considered very important for a specific data transfer. **If** a core option is exercised in the **encoding** of SDTS data, compliant decoding software must be capable of **decoding** the data addressed by the option.

## D

**data descriptive file (DDF)** • A data file whose format adheres to ISO 8211 standards containing data descriptive information and data records. The DDF is the physical file format used for SDTS transfers.

**data quality** • Characteristics of a spatial data set and its individual elements and attributes that are important for its proper use. SDTS defines several modules for transferring such data quality information as lineage, positional accuracy, attribute accuracy, logical consistency, and completeness. In an SDTS transfer, this data quality information may be conveyed through a data quality report.

**DCDSTF** • Digital Cartographic Data Standards Task Force.

## E

**entity** • A real-world physical object, incident, or phenomenon that can be described locationally or geographically.

**entity instance** • An actual occurrence of a specific entity type in a transfer that is differentiated from other occurrences of that entity type (e.g., a specific tower or road).

**entity type** • A named set of spatial entities that are formally defined in Part 2 of SDTS. Each entity type (e.g., “road,” “lake,” “tower”) may be considered a spatial feature when it is represented using an SDTS object or objects. Part 2 attempts to define a standard list of entity types for use in an SDTS transfer.

## F

**FGDC** • Federal Geographic Data Committee.

**FICCDC** • Federal Interagency Coordinating Committee on Digital Cartography.

**FIPS** • Federal Information Processing Standards. This refers to the set of information processing standards defined and maintained by NIST which are mandated for use by U.S. federal agencies.

## G

**geographic information system (GIS)** • A computer system that stores and links nongraphic attributes or other spatially referenced information to graphic map features. A GIS goes beyond automated mapping by allowing many different information processing and analysis functions.

**geometry** • The graphical qualities of an object as defined by its coordinates in two or three dimensions.

## I

**included term** • A non-standard name by which a defined entity type in SDTS Part 2 may be referred.

**ISO 8211** • A standard approved by the International Organization for Standardization (ISO) and the American National Standards Institute (ANSI) defining rules for the physical formatting, labeling, and organization of data on storage media or for electronic transmission.

## M

**module** • A defined category of information to be contained in an SDTS transfer. SDTS defines a total of 34 modules covering global information about a transfer, data quality information, definition of spatial objects in a transfer, attribute information, and parameters of graphic representation of the data. Each has a set of related data fields and subfields (with specific logical formats and domains) that hold data in a transfer. The modules, therefore, establish the logical structure for information encoding and decoding in an SDTS transfer.

**module field** • A defined set that includes one or more subfields in an SDTS module.

**module subfield** • A logical breakdown, identified as part of a module field, that defines a single data element in an SDTS transfer.

## N

**NIST** • National Institute of Standards and Technology. The U.S. federal government agency charged with establishing standards of all types for use by federal agencies.

**NCDCDS** • National Committee for Digital Cartographic Data Standards.

## O

**object** • The basic building block for modeling or representing a real-world geographic entity. The definition for a particular object describes the basic geometry (graphics) and topological relationships of the object. SDTS defines simple objects (e.g., Entity Point, Line String, GT-Polygon) and aggregate objects (e.g., Planar Graph, Grid) which are composed of simple objects.

## P

**profile** • A set of rules for actual implementation of SDTS in a specific data transfer. The SDTS Base Specification in Parts 1, 2, and 3, defines the overall model, content, and structure for the transfer of spatial data. A profile defines specifically how SDTS is to be used in a particular case by limiting options and choices that are present in the base specification, thereby, providing a structure for encoding and decoding of data in an SDTS transfer.

## R

**raster profile** • A formal SDTS profile which is in the final stages of development by the SDTS Task Force. It is designed for the transfer of any grid or image data.

## S

**simple object** • A basic element defining certain geometrical and topological qualities that is used as a building block to model or represent a real-world spatial entity.

**Source Data Model**• See “user data format.”

**spatial feature**• See “feature.”

## T

**Target Data Model**• See “user data model.”

**test points** • Specific requirements established for evaluation in a conformance test for an SDTS transfer (data set) or for encoding or decoding software.

**theme** • A general term describing a related set of spatial entities (e.g., transportation, utility, hydrography, etc.). The theme is not a defined object type in SDTS, but a theme may be defined as equivalent to the aggregate object, “layer.”

**topological vector profile (TVP)** • The first formally defined SDTS profile approved as Part 4 of FIPS 173. The TVP is designed for the transfer of topologically structured point, line, and area features, and associated attributes. As a formal profile, the TVP defines a specific way in which SDTS specifications are to be applied by limiting options and identifying specific modules required and how they shall be treated in a data transfer.

**topology** • A characteristic of a spatial data format in which spatial relationships of features such as order, connectivity, and adjacency are explicitly defined.

## U

**user data model** • The format for storage of spatial data (map features and attributes) which is supported by the GIS, Computer-Aided Drafting (CAD), or Automated Mapping (AM) software in use. This may be a public domain data format like the DLG or TIGER formats, or it may be the format supported by a particular commercial software package. This user data format may be considered the “source data model”—from which spatial data is encoded into SDTS or the “target data model” into which SDTS is decoded.

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