DIGITAL CARTOGRAPHIC DATA FEATURE STANDARDS IN THE UNITED STATES

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ABSTRACT

There has been a concerted effort in the U.S., over the past four years, to bring forth a national standard for digital cartographic data. A major portion of the project has been directed toward cartographic features. The assigned Working Group III of the National Committee for Digital Cartographic Data standards at first dealt with the issues and then developed alternatives. In the next stage, an interim proposed standard with a model schema of features, attributes, and attribute values plus definitions was published. The preparation of these definitions and the testing of the standard are both described as are the problems encountered enroute and the work remaining.

INTRODUCTION

Since 1982, the U.S. National Committee for Digital Cartographic Data Standards (NCDCDS) has been engaged in the preparation of a national standard. The part of the effort concerned with cartographic features was assigned to Working Group III (WGP III) of the NCDCDS. That body has studied the issues, prepared alternatives, issued an interim proposed standard, and tested the standard. This paper will briefly review the initial efforts and then discuss the Interim Standard, the feature definitions, testing, and the future. Readers who wish more detail than can be given within these ten short pages are encouraged to read the NCDCDS reports.

<u>Background</u> The U.S. National Bureau of Standards assigned the Geological Survey (USGS) responsibility for Earth Science standards including Digital Cartographic Data. In 1981 the USGS gave a grant to the American Congress on Surveying and Mapping to organize a National Committee for Digital Cartographic Data Standards. This was created in 1982 with a Steering Committee and four working groups: Data Organization, Data Set Quality, Cartographic Features, and Terms and Definitions (later combined with first three). In

August 1982, WGP III began its study of the Canadian Standards and the issues of scale independence, data organization, definition form, and a basic set of features. By 1982, it was decided that features in a national standard should be independent of map symbolization and scale, universal in nature, logically structured, consist of a single class with multiple attributes and attribute values, explicitly defined, and initially derived from topographic maps and hydrographic charts. The second phase extending into 1984, identified and discussed alternatives that included the above goals plus relationships, standard products, minimum attributes, completeness, and maintenance, among others. It was at this point realized that the adopted model of features, attributes, and attribute values must be supplied with defini-tions. This work was undertaken by graduate students at Virginia Commonwealth University with funds from both the original USGS grant and the Defense Mapping Agency. Results of this work were published with the model in the Interim Proposed Standard in March 1985. This standard was tested late in the same year and the findings presented in March 1986. Each of these efforts and future work will be detailed below.

Membership

- Mary Clawson, Naval Oceanographic Research and Development Activity
- Dr. Beth Driver, Technology Service Corporation
- Erich Frey, National Ocean Service
- Dr. Benny Klock, Defense Mapping Agency
- Prof. Mark Monmonier, Syracuse University
- Dr. Joel Morrison, US Geological Survey
- Prof. Robert Rugg, Virginia Commonwealth University, Vice Chairman
- Warren Schmidt, Digital Mapping Unlimited, Chairman
- Fred Tamm-Daniels, Tennessee Valley Authority
- Walt Winn, National Ocean Service

Observers

- Dr. Meredith Burrill, Defense Mapping Agency, Retired
- Prof. David Douglas, University of Ottawa
- William Hess, Central Intelligence Agency
- Roger Payne, US Geological Survey

FEATURE STANDARDS

Model The Working Group examined many classification schemes and initially proposed the following five-part one:

Feature Class	Attribute
Feature	Attribute Value
Attribute Class	

These classes were tested and it was found that, other than location, no common attributes applicable to all features could be identified. Therefore, it was decided to eliminate "Attribute Class". However, broad descriptive categories such as measure, serviceability, structure and composition would be beneficial to cartographic produceers. In the same manner, "Feature Classes" such as culture and transportation, would be useful to some, but not all, users and would introduce redundancy. The original schema was then shortened to the following three categories:

FEATURE - A defined entity of interest that is not further subdivided.
ATTRIBUTE - A defined characteristic of a feature.
ATTRIBUTE VALUE - A specific quality or quantity assigned to an attribute.

Though not part of the descriptive model, "feature class" and "attribute class" were provided as user options. The appearance of the word, "defined," in the model responds to the general lack of definitions in digital cartography. The definition of feature and attribute terms necessary to the standard is described in the next section. The assignment of codes for terms and attributes was deferred until the definitions were completed. These codes shall not impose a structure upon the features, but are intended only for retrieval and maintenance.

Alternatives Ten following alternatives were considered by the Working Group. Because of space limitations, these can be cited with only minimum explanation.

1. Scale Independence vs. Scale Specific -- the former was chosen.
2. Hierarchal or Relational Data Organization? -- not relevant to feature.
3. Basic Feature Set -- to be universal but begun with those found on topographic maps and hydrographic charts.
4. Feature-Attribute Relations -- each feature to be unique and variations captured in attributes.
5. Relationships Between Features -- accommodated by attributes or data structure but avoids embedding relationships in definitions.
6. "Standard Product" vs. "Shopping List" -- a universal list of features with standard definitions was preferred.
7. Minimum Attributes -- location shall be the only mandatory attribute.
8. Completeness of Feature Set -- may be desirable.

9. "Pure Attributes" -- such as gravity can be handled with location as an attribute or a feature.
10. Uni- or Bi-Directional Interface -- transfer will be from standard to non-standard.

Maintenance This issue occupied much of the WGP's time in 1986. Because both language and technology are dynamic, and because only those features appearing on hydrographic and topographic publications have been defined, there will be future changes and additions. The maintenance of a standard consists of four functions: responding to queries; making decisions relative to changes and additions; keeping the standard current; and publishing and distributing the standard. Conversations were initiated with the Board of Geographic Names, a U.S. Government committee charged with naming conventions, but resolution of future maintenance was unsettled at the time of writing.

FEATURE DEFINITIONS

Within the framework of the proposed standard model, definitions for cartographic features have been developed. Although the proposed model is intended to promote the goals of scale and product independence, the features shown on topographic maps and nautical charts were initially used as the basis for a prototype set of definitions. The resulting lists and definitions appear in NCDCDS Report #7.

Sources of Feature Lists and Definitions Lists of features were originally compiled from publications and working documents of Federal agencies including the USGS, National Ocean Service, Defense Mapping Agency and Defense Intelligence Agency. Additional terms and synonyms were provided by the Geographic Names Information System group within the USGS. From an initial set of 30 features, the list was expanded to include 1,200 hydrographic and topographic feature names.

Some of the Federal sources contained definitions. Others were lists of terms or map legends, without written definitions. To supplement the definitions available from Federal sources, geographic dictionaries by Stamp, Monkhouse, Moore, Snead, and Schmieder et al. were used along with draft standards by the Canadian Council on Surveying and Mapping and several English dictionaries. As a result of the variety of sources used, numerous alternate definitions were available for most of the feature terms considered.

Definition Process Much of the work in preparing the prototype list of standard feature definitions was conducted by a group of graduate students at Virginia Commonwealth University. Each student worked independently on a class of features (for example, water features), and frequent meetings were held with a faculty supervisor present to review progress and discuss relationships among features in different feature classes.

The process of arriving at a proposed standard feature definition included several steps. First, similar feature terms were grouped together (for example: stream, river, brook, creek). Second, of the several terms that might be used to describe the same feature, a selection was made of a single term that could be most broadly applied (e.g. stream). On rare occasions, a new term was invented to describe a general feature with no existing general name. Third, definitions of the proposed standard term were reviewed in order to select the simplest and broadest definition. Definitions were often modified, or new definitions derived, to make the proposed standard definition applicable to all the various feature terms included in the same standard category. Finally, in order to permit distinctions among features in the same category, attributes were listed and defined that could be used to capture the differences among otherwise similar feature terms (for example, using width, depth, or volume of flow to distinguish brook from river).

The most complex part of the definition process followed. Each proposed standard term and definition had to be reviewed in relation to all other proposed standard features to make sure that the definitions did not overlap. This might require altering the proposed standard definition, or perhaps altering other definitions, sometimes with a domino effect through the entire list. Only in this way was it possible to arrive at standard definitions that could be unambiguously applied in various operational settings. For future reference, it should be noted that this final stage of the definition process becomes geometrically more complex as more standard feature terms are added to the list.

Review Procedure Recommended standard feature and attribute definitions were continually reviewed over a two-year period by members of WGP III. Initially, the WGP was composed of representatives of major Federal mapping agencies, the private sector and academia. Later, as the definitions work became more technical, observers were added with expertise in toponymy. While not official members of the WGP, they participated fully and provided invaluable assistance in the work.

During the winter of 1985-86, the WGP undertook a test of the proposed standard set of feature terms and definitions. The results of this test will be used to improve the proposed standard in regards to its completeness, consistency of application, and ease of use.

The Defense Mapping Agency (DMA) has simultaneously prepared a set of feature definitions and codes for its internal use, following the model developed by WGP III. The Group is in the process of reviewing the non-military portion of the DMA feature terms and definitions as well.

TESTING AND RESULTS

The test of the Interim Proposed Standard for feature definitions sought to determine the general validity of the model developed by WGP III and the specific application of the model to topographic map and nautical chart features. Three broad questions were posed as the basis for the test. How complete is the set of definitions? Are the definitions understandable and specific enough to assure consistency of interpretation in a variety of operational settings? How easy or difficult to use is the proposed scheme? These questions were addressed in a test of the September 1985 version of the proposed definitions. The test was administered in four Federal agencies and four external organizations during the period November 1985 through February 1986.

To meet the objectives of the test, three sections were devised. Section 1, the "consistency test," involved the identification and coding of 51 selected features on the Port Royal, Virginia quadrangle of the USGS 7.5 minute series topographic map. Section 2, the "completeness test," involved identification and coding of selected features shown in the legends for nautical charts and topographic maps. The sources used for the test were Section G -- Ports and Harbors -- of NOAA/DMA Chart No. 1, <u>Nautical Chart Symbols and Abbreviations</u>, November 1984 edition, and page 11 -- Blue Plate -- of USGS <u>Standards for 1:24,000 and 1:25,000-Scale Quadrangle Maps</u>, part 6, December 1981 edition. Sec-tion 3 on "ease of use" consisted of a series of open-ended questions. Each participating organization was asked to select three testers (see Table 1).

Table 1
Tests Returned by Organization

Organization	Tests Completed: Consistency Test	Tests Completed: Completeness Test
External		
Bell South	3	3
Perkin-Elmer	3	3
Synectics	1	1
U. of Minnesota Geog. Dept.	3	3
Federal		
Defense Mapping Agency	3	3
Federal Emergency Mgt. Agency	1	1
National Ocean Service	4	0
Tennessee Valley Authority	3	3
All organizations	21	17

Consistency The results of the consistency test were measured in terms of the percentage of testers who coded the same map features the same way. For the 51 features identified on the quadrangle, an average "consistency score" of 85% was achieved. This result did not vary significantly between named features (such as Rappahannock River) versus unnamed features (such as fence rows or marshes) (see Table 2). Over three-fifths of the test features were coded consistently by 90% or more of the testers. Features with low consistency scores included one where name placement on the map caused confusion, one to which no standard definitions could be applied, a few to which more than one definition might apply, and a few for which analytical distinctions made in the definitions were apparently misunderstood by the test participants.

Table 2
Consistency Scores for USGS Quadrangle Features

	N	Mean	Standard Error
Named Features	34	84.5%	3.27%
Unnamed Features	17	87.1%	5.01%
All Features	51	85.4%	2.72%

Completeness In the "completeness test," testers were simply asked to give a standard feature code for each item appearing on the legends. Completeness was measured in terms of whether or not a standard code could be found for each item attempted. About 90% of the items were successfully coded to the standard. There was a difference between the results for Chart No. 1 and for the USGS legend as shown in Table 3.

Table 3
Completeness Test Results

Source	Coded		Uncoded	
	number	%	number	%
NOS/HTC Chart No. 1	898	85.04	158	14.96
USGS Legend	575	97.62	14	2.38
Both Sources	1,473	89.54	172	10.46

To some extent, the difference in coding success can be attributed to the familiarity of testers with the source material. For example, testers from Bell South originally asked to be excused from coding Chart No. 1 since their work entirely concerns topographic features. They participated fully in the test, however, and their results were 100% complete for the USGS legend while only 74% complete for Chart No. 1.

Ease of Use Responses to the open-ended questions were mixed. Many testers found the testing process cumbersome (see Table 4). It took between 4 and 40 hours to complete the test. In large part, this problem may be explained by the form of test materials. In addition to the test instructions, map, and copies of Chart No. 1 and the USGS Legend, the test materials included four print-outs. One print-out contained definitions for 145 standard feature terms and over 1,100 "included terms." A second print-out contained definitions for 197 attributes. The third and fourth print-outs consisted of 3-character alphanumeric codes for each standard feature and attribute. To complete parts 1 and 2 of the rest required leafing through the definitions print-outs, finding a suitable definition and appropriate attributes for each feature to be coded, then scanning the separate code print-outs in order to enter the proper code on the test form. This amount of effort would be greatly reduced in a production environment by providing an on-line system to speed up the search process, and eventually would be minimized as coders begin to memorize the standard definitions.

Conclusions The quantitative results of the test were positive, leading WGP to adopt the following resolution on March 16, 1986: "Working Group III accepts the test as sufficient evidence of the viability of the proposed model." While the results affirm the viability of the proposed model, they also indicate problems remaining to be addressed for the proposed standard. Among these are a need to refine current feature definitions to eliminate remaining ambiguities, a need to extend the basic set of definitions to include all hydrographic and topographic features and their attributes, and a need to simplify the presentational form of the standard to promote greater ease of use.

FUTURE WORK

The groundwork has been laid for a standard for cartographic features that responds to the criteria of scale independence, product independence, and data structure independence. The proposed standard needs improvement in the areas identified by the test procedure. In addition, more thorough testing is needed using a broader variety of cartographic products, including photographic images and existing digital data.

The proposed standard is being developed under the authority of the USGS and is intended to be issued as a Federal Information Processing Standard (FIPS). Once adopted as a FIPS, the standard will be disseminated by the U.S. Bureau of Standards.

Table 4
Responses to Selected Open-ended Questions

Q. 3. In both Part 1 and Part 2, were you able to separate different features adequately with the attributes provided? Please describe any problems in this respect.	
yes	5
no	10
inadequate or incomplete attribute list	7
too many features groups together	2
lack of values	2
no response	1
Q. 4. Overall, would you say that the proposed standard and attribute scheme was easy to use, or difficult to use? Please comment.	
easy	4
somewhat easy	4
difficult	8
time consuming	3
confusing	1
flipping around too much	6
inadequate attribute list	2
Q. 5. Are you satisfied that the results of such a coding scheme could provide a sound basis for exchanging digital cartographic data?	
yes	6
no	4
mixed	4
attribute coding difficult	1
no response	2
Q. 7. Please indicate your professional training or background in the area of cartography and computer mapping.	
cartography	12
<u>geography</u>	5
undergraduate	3
graduate	6
<u>professional training</u>	2
1-3 years experience	3
3+ years experience	7
<u>no experience</u>	1
no response	4

Note: Tabulations for each question include multiple answers.

As the proposed standard for cartographic features is implemented, extensions and modifications will be needed to incorporate features other than those appearing on topographic maps and the nautical charts. A review mechanism for proposed changes and extensions will be needed, requiring expertise in such areas as geography, cartography, toponomy, and the scientific disciplines concerned with particular classes of features.

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