An Information Model for Maps:
Towards Cartographic Production from GIS Databases

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Fundamental information transformations in cartography

DATA COLLECTION
- Geographical environment
  - Census
  - Ground survey
  - GPS
  - Remote sensing
  - Digitizing

CARTOGRAPHY
- Geospatial data
  - Selection
  - Generalization
  - Symbolization
  - Labeling

MAP USE
- Map
  - Reading
  - Analysis
  - Interpretation
- Map image

Transform 1: Geographical environment → Geospatial data
Transform 2: Geospatial data → Map
Transform 3: Map → Map image
From geographical environment to map...
Outline of remainder of talk

- Cartographic data modeling
- Map conceptualization
- Proposed information model for maps
- Use of the model for cartographic production
Types of Maps

Number of users and uses (indicates the level of general application)

Number of map features (and the subsequent complexity of relationships between them)

- Bike Map
- Trail Map
- Special Use Maps

- Crime Hot Spots
- Suitability Map
- Analysis Results

- Census Data
- Atlas Thematic Map
- Thematic Maps

- Topo Map
- Atlas Reference Map
- Reference Maps

Low

High
Traditional GIS data modeling

Geographical environment -> Conceptual data model (CDM) -> Logical data model (LDM) -> Physical data model (PDM)

Data model + Functional model (FM) = Workflow or process model = Product e.g., GIS database
Cartographic data modeling

Geographical environment → CCDM → LCDM → PCDM → Map

Cartographic data model

+ FCM

Cartographic workflow model
Process of map conceptualization

Map and graphic design: an intuitive and creative process

Map conceptualization

- Type of map
- Spatial format
- Basic layout
- Data to be represented
- Mapping technique

- Kinds of symbols
- General symbology
- Number of classes and class limits
- Symbol and type relationships
- Typography
- Colors

- Legibility
- Visual contrast
- Organizational hierarchy
- Figure-ground organization

Map user and Map purpose

Graphic ideation

Graphic plan

Graphic refinement

Map conceptualization

Map conceptualization

Graphic plan

Graphic ideation

Map user and Map purpose

Map conceptualization
Map conceptualization

Map user and Map purpose

Map conceptualization

CCDM
LCDM
PCDM

Cartographic data model

Geographical environment

Geographical environment

Cartographic workflow model

Geographical environment

Geographical environment

Geographical environment

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Geographical environment
Hydro Layer

Cartographic Representations

Representation features (multiple representations)

Symbolization
Labeling

Representation Rules

Visual Contrast
Legibility
Figure-Ground Hierarchy

Graphic Rules (for Features)

Symbology conflicts
Labeling conflicts

Graphic Conflict Rules

Hydro Boundaries
Cultural
Transportation
Surface Cover
PLSS
Physiography

Map Production Process

Feature class + Cartography Table + Style = Hydro

Generalization Rules
Selection Classification Simplification

Representation Rules
Symbolization Labeling

Graphic Rules (for Features)
Visual Contrast Legibility Figure-Ground Hierarchy

Map Compilation Rules
Page layout Map elements

Graphic Rules (for the Page)
Visual Balance

Map Frame
Map Surrounds
Page Template
Map

Export Print Email Serve Publish

Data Frame

Map

Cartography Table

Selection Classification Simplification

Symbolization Labeling

Visual Contrast Legibility Figure-Ground Hierarchy

Symbology conflicts Labeling conflicts

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MULTI-SCALE MULTI-PURPOSE BASE MAP
A Data Model, Map Specification, and Methodology for Creating High Quality Maps using Geographic Information Systems

Inside the Geodatabase

Typical Feature Classes

Glossary:

cartographic feature type - a database feature that is used in cartographic abstraction to communicate the properties and characteristics of geographic themes and their relationships.
cartographic feature table - a database table that contains a comprehensive list of the unique cartographic feature types specific to a particular mapping environment, along with the specifications for cartographic abstractions of those features. The cartographic feature table can also be used to add additional content, such as common attributes and attribute code combinations that can be used to hyphenate the data model.
features - a representation of a sample-world's geographic features. Features can be represented in GIS as vector data points, shapes, or clusters, and their features are used to create an efficient model and to represent the geographic features by different geometric types that may be stored in a feature table.
region - a column that stores the values for a single attribute for a region which defines how the region should be displayed and behavior on a map. Region attributes include additional properties, such as region formatting, feature-level formatting, feature-level attributes, and attribute code combinations.
properties - a collection of feature classes stored together that share the same geographic reference. Features that share the same geographic reference, such as common or geographical reference, can be used to streamline the data model. Features must have geometry and information.

Example Layer and Label Class

The cartographic table contains a comprehensive set of cartographic feature types (CFTs) in the sample base maps produced by an organization. For example, there are 3.12 out of 15 unique cartographic feature types in the United States Geologic Survey's geographic mapping specifications for map scales ranging from 1:5,000 to 1:2,000,000. The fields in the cartographic table contain all of the sample base maps for each feature type, including label symbols and other information that contribute to high quality cartographic products. The cartographic table can be used to create a base map layer.

ArcGIS Style File

A style is a container for many layers of cartographic elements, including color, line and area symbols, gradients, shadows, and scale bars. It's possible to create and edit a new style, but there's a limit to how many layers a style can include. The cartographic table is used to create a base map layer.

The ArcGIS Style File

Style contain named cartographic data objects

110002 110003 110004

110005 110006 110007

110008 110009 110010

Glossary:

map data model - a specification for the organization of map data, as well as the processes associated to manage, analyze, and produce the mapping process.
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Model generalization:
• Selection
• Classification

computational process
graphic refinements

GIS data

CDM

Generalization Rules
Selection
Classification
Simplification

Representation Rules
Symbolization
Labeling

Graphic Rules (for Features)
Visual Contrast
Legibility
Figure-Ground
Hierarchy

Graphic Conflict Rules
Symbology conflicts
Labeling conflicts

Map compilation

graphic refinement

Map
Cartographic Generalization

- Simplification (reduction of detail or modification that reduces clutter)
  - Elimination (e.g., nth point removal algorithms)
  - Selection (e.g., Douglas routine)
  - Displacement or Repositioning
- Classification (modification of the taxonomy or map legend categories)
  - Aggregation (typification, collapsing, merging, resampling)
  - Partitioning (using metric or non-metric class breaks)
  - Overlay (in vector space and in raster space)
- Enhancement (systematic introduction of detail)
  - Smoothing (e.g., high- or low-pass filter, or DEM pit-pass fill-in)
  - Exaggeration (e.g., retaining features even if they might not maintain visibility "at scale")
  - Refinement (e.g., adding road casing to symbology to highlight highways)
  - Generation (e.g., adding detail through fractal models)
  - Interpolation (e.g., generating a terrain grid or contour lines from individual elevation points)
Model generalization:
- Selection
- Classification

computational process
graphic refinements

CDM

Generalization Rules
Selection Classification Simplification

Representation Rules
Symbolization Labeling

Graphic Rules (for Features)
Visual Contrast Legibility Figure-Ground Hierarchy

Graphic Conflict Rules
Symbology conflicts Labeling conflicts

Map compilation
graphic refinement

GIS data

Map
Feature by feature

Cultural Information + Generalization + Symbolization + Labeling = Cultural features

Cultural features = Carto Cultural + Carto Boundaries + Carto Cultural + Carto Hydro + Carto Transportation + Carto Surface Cover + Carto PLSS + Carto Physiography

Graphic Rules + Graphic Conflicts = Map Document
Generalization Rules

- Feature class
- Cartography Table

1. Select based on attributes
2. Selection of features
3. Simplify lines
4. Simplified features
5. Classify
6. Classified features
7. Save to layer
8. Layer file
Graphic Rules

- Legibility – ability to be seen AND recognized
- Visual Contrast – extent to which a symbol contrasts with its background and adjacent symbols
- Figure-Ground – spontaneous visual organization of the graphic display into two contrasting perceptual impressions
- Organizational Hierarchy – internal graphic structuring that portrays levels of relative importance; visual distance between layers
- Visual Balance – how to draw a reader’s eye and how the data are distributed and the layout of the geography
Example of Graphic Rules

- Legibility
  - ability to be seen AND recognized
- Visual Contrast
- Figure-Ground
- Organizational Hierarchy
- Visual Balance
Graphic Rules / Graphic Conflicts

Layer

Add to data frame → Layers on map → Change order → Ordered layers

Order file

Check feature size for legibility → Modified features

Check color conflicts → Modified features

Check colors for visual contrast → Modified features

Check density of features → Modified features
Compilation Elements

- Map
- Legend
- Slope Guide
- North Arrow
- Conversion Graph
- Adjoining Sheet Guide
- Elevation Guide
- Boundary Guide
- Notes
- Coordinate notes
- Scale Bar
- Glossary
- Title / Subtitle
- Locator Map
- Trim Guide
- Map Specifications
- Meter Reference Guide
Example of Compilation Rules

1. Data frame
2. Map template
3. Map surround elements
4. Add to page
5. Page map
6. Change placement of elements
7. Modified page map
8. Check for discrepancies
9. Highlighted problems
10. Modify positions
11. Final page map

Relative placement relationships
Future Directions

“What we want to do is to put the power back in the hands of the cartographers – allowing them the freedom to override the decisions that the computer made in order to provide absolute clarity. It’s about letting the cartographer put the art back into cartography where it’s needed.”

- Paul Hardy, Cartography Product Manager, ESRI