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

Aileen Buckley, Ph.D.
and Charlie Frye
Cartographic Researchers, ESRI
Outline of the presentation

- Introduction
  - Differences between GIS and cartographic data
  - DLM - DCM
  - Describing cartographic workflows
- Modeling GIS data to support mapping workflows
- Cartographic data model
- Supporting multi-scale multi-purpose mapping
- Summary
Differences between GIS and cartographic data

- Processing cartographic data is different from processing GIS data
  - Representations of data for graphic display
    - Symbols
    - Labels
  - Geoprocessing for cartography not spatial analysis
    - Classification
    - Selection by attribute
    - Selection by size
- Changing the view on the data as opposed to changing the data in the database
Changing the representation changes the message

- For cartography – dissolve roads so you can use a continuous road symbol
- For analysis – dissolve roads so you can validate connectivity in the network
Modeling GIS data

Cartographic data model

Multi-scale multi-purpose mapping

Summary

GIS vs. cart data

Cartographic workflows
DLM - DCM

Digital Landscape Model or DLM
- GIS database (wire frame model)
- compiled from source information registered to the ground
- several standardized scales
- accuracy and resolution are of primary concern

Digital Cartographic Model or DCM
- stored in a product database (for a map)
- enhanced and modified from DLM
- specific to a map’s purpose
- graphic clarity and visual integrity are of primary concern
Types of maps

- **High**
  - Special Use Maps
    - Trail Map
    - Bike Map
  - Analysis Results
    - Suitability Map
    - Crime Hot Spots
  - Thematic Maps
    - Census Data
    - Atlas Thematic Map

- **Low**
  - Reference Maps
    - Topo Map
    - Atlas Reference Map

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

Number of map features (and the subsequent complexity of relationships among them)
GIS database

GIS vs. cart data
Cartographic workflows
Cartographic data model
Multi-scale multi-purpose mapping
Summary

Multi-scale multi-purpose mapping

GIS database

GIS vs. cart data
Cartographic workflows
Cartographic data model
Multi-scale multi-purpose mapping
Summary
Multiple DCM products

- Terrain analysis
- ‘Traditional’ topographic views
Multiple DCM products

- Town planning
- Infrastructure development
Multiple DCM products

- Land cover analysis
- Site suitability
Describing cartographic workflows

- The workflows are intended to transform information
  - DLM -> DCM -> final map product
- As you go through the transformations, you:
  - move from multi-purpose to targeted use
  - may move across limited scale ranges
- Design the workflow and model the data before you go into production
Fundamental information transformations in cartography

DATA COLLECTION

Transform 1

Geographical environment

Census
Ground survey
GPS
Remote sensing
Digitizing

Geospatial data

Transform 2

Selection
Generalization
Symbolization
Labeling

CARTOGRAPHY

Transform 3

Map

Reading
Analysis
Interpretation

MAP USE

Map image
DLM – DCM data production workflow

- Small → Large
  - Map scale
  - Number of users

- DLM
- DCM
- Derived data model

R3 → R4 → R6 → R7 → R8
Cartographic data modeling for map production

- Geographical environment
- Conceptual data model
- GIS data model
- ArcGIS geodatabase
- Workflow
- Map production process
- Map products
  - 250K Road Map
  - 10K Campus Map
  - 10K OS Topo Map Series
  - 5K OS Base Map
Map production process

Cartographic data model

Map customer and map purpose

Graphic ideation

Graphic plan

Graphic refinement

Map conceptualization process

Final product

MAP

Publication

Workflow

Map production process

Cartographic data model

ArcGIS geodatabase

Conceptual data model

Geographical environment
Modeling GIS data to support cartographic workflows

- What does this all look like in an ArcGIS environment?
- What themes are relevant for the map purpose?
  - What cartographic features?
  - What cartographic attributes?
- How do you modify the DLM to create the DCM?
  - We talked about transforming GIS data to cartographic data
  - This is where the cartographic geoprocessing happens
  - This is what it looks like...
Cultural

- Cultural Features (Buildings, Areas, Points of Interest)
  - Type (how to symbolize and for some kinds of cultural features, it is the label)
  - Name (for label)
  - Size or Area (used to set threshold for which features are shown)
**Boundaries**

- **Boundary Lines (any level)**
  - Type *(how to symbolize)*
  - L_Name *(left/upper label)*
  - R_Name *(right/lower label)*
  - Annotation must be produced to ensure proper identification

- **Legal Areas (any type)**
  - Type *(how to symbolize and what kind of label)*
  - Name *(for label)*
  - WithinMSA *(Boolean for drawing/labeling)*

- **City Points**
  - Name *(how to label)*
  - Size *(how to symbolize and label)*
  - Special Type *(how to label or symbolize)*
  - WithinMSA *(Boolean for drawing/labeling)*
Transportation

- **Roads**
  - Class *(how to symbolize)*
  - Type *(determine correct kind of label)*
  - Name *(for text labels)*
  - Highway Route Number *(for highway labels)*
  - UrbanRural *(for multipurpose data which may be represented differently within urban areas)*
  - Label String *(store exactly what is to be labeled and then the Name does not need to be edited/compromised)*

- **Railroads**
  - Type *(how to symbolize)*
  - Owner *(how to label)*
Hydrography

- **Area Features**
  - Name *(how to label)*
  - Type *(how to symbolize and which features to label, and sometimes is the label)*
  - Area *(used to set threshold for which features are shown)*

- **Line Features**
  - Name *(how to label)*
  - Type *(how to symbolize)*
  - Size, Discharge, or Level *(how to symbolize or as a filter for which features to show—dendritic branch count and Stream Order are not useful here)*
Surface Overlays

- Land cover/Land use/Zoning/Flood zones/Homeland security (risk), etc.
  - Type *(how to symbolize)*
  - Abbreviated Type *(for labeling, e.g., soils, surface geology, etc.)*
  - Area *(used to set threshold for which features are shown or get labels)*
  - Uncertainty *(used to modify symbology of either features or labels to show reliability, etc.)*
Terrain

- **Contours**
  - Elevation *(for labels)*
  - Units *(for labels or conversion when mix of data is present)*
  - Type *(for symbol, includes index, intermediate, depression, etc.)*
  - LabelYN *(optional: for determining whether to draw a gap or a line, gaps are where labels get placed)*

- **Spot Elevations**
  - Type *(how to symbolize)*
  - Elevation *(part of label)*
  - Units *(part of label)*
DEM

- Elevation Raster
  - Elevation *(how to symbolize)*

- Hillshade Raster
  - Value *(how to symbolize)*
Putting them all together on the map
Cartographic Data Model

- Cartographic Feature Types
- Symbols and Labels
- Cartography Table
  - Links the feature to its representation (symbol + label)
- Construct the Basemap Data Model together
# Cartographic Feature Type

- A type of feature on the map...
- ...that has unique symbology and/or labeling

<table>
<thead>
<tr>
<th></th>
<th>BMDM_Theme</th>
<th>Point</th>
<th>Line</th>
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Cartographic Feature Type (CFT)

- Ties everything together

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<tr>
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Each cartographic feature type has a ... Unique ID Unique description

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# Cartographic Feature Types (CFTs) in the Cartography Table

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<th>Description</th>
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</table>
Label Specifications

- Contain the rules for labeling a specific Cartographic Feature Type

Symbolization

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
<th>Symbol Specs</th>
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<tr>
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Symbol#: SPRING_SEEP_P001
Dimension: 0

Type Specs
- Label, Name, and Water Characteristics:
  - Color: Blue
  - Style: SL1 C/lc
  - Size: 8
  - Spacing: 0

Conflict Detection and Resolution

Conflict detection and resolution rules are being developed. Additions and modifications to the rule set will continue until all features are completed.

If SPRING/SEEP coincides 2-dimensional LAKE/POND or STREAM/RIVER.
<table>
<thead>
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<td>Name</td>
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Symbol Specifications

Contain the rules for symbolizing a specific Cartographic Feature Type

### Symbolization

- **NAM**
  - Spring
  - \( \text{(WAC)} \)

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<tr>
<th>Attribute</th>
<th>Value</th>
<th>Symbol Specs</th>
<th>Type Specs</th>
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**Conflict Detection and Resolution**

Conflict detection and resolution rules are being developed. Additions and modifications to the rule set will continue until all features are completed.

If SPRING/SEEP coincides 2-dimensional LAKE/POND or STREAM/RIVER,
Symbols

- Contained in a Microsoft Access database
- Named for each Cartographic Feature Type (CFT)
### Symbol Specs in the Cartography Table

<table>
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<td>230010</td>
<td>Archeological Site Area</td>
<td>Archeological Site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Cultural_Areas</td>
<td>X</td>
<td>230011</td>
<td>Archeological Site Area, Ruins</td>
<td>Ruins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Cultural_Areas</td>
<td>X</td>
<td>230012</td>
<td>Archeological Site Area, Indian Mound</td>
<td>Indian Mound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Cultural_Areas</td>
<td>X</td>
<td>230013</td>
<td>Building Area</td>
<td>Area Building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Cultural_Areas</td>
<td>X</td>
<td>230014</td>
<td>Building Area, Amphitheater</td>
<td>Building Area, Amphitheater</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Completed Cartography Table in the Basemap Data Model

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

Example Layer and Label Class

Cartography Table

The cartography table contains the completed cartography data, which provides the relationship between the feature types and the map symbols.

The ArcGIS Style File

Styles contain named cartographic data objects:

110002 110003 110004
110005 110006 110007
110008 110009 110010
Supporting Multi-purpose Multi-scale Mapping

- Cartography Table content can be extended across scales and across purposes
- Add rows and columns to Cartography Table
  - Rows – Add new cartographic feature types
  - Columns – Alternate symbology and labeling – multi-scale & multi-purpose
- SQL query strings for filtering and labeling
Summary - 1

- is different from processing GIS data
- Purpose of processing cartographic data is to change the *view on the data* as opposed to change the *data in the database*
- DLM = GIS database; DCM = map product database
- Many maps and their DCMs can come from one DLM
Summary - 2

- Workflows are intended to transform information
  - DLM -> DCM -> map
- As you go through the transformations, you:
  - move from multi-purpose to targeted use
  - may move across limited scale ranges
- Design the workflow and model the data before you go into production
- Model the GIS data to support cartographic workflows
Summary of the Cartographic Data Model

- Identify the cartographic features
- Assign a unique CFTID and description
- Assign symbology & labeling
- Compile the info into the Cartography Table
- Use the Cartography Table to drive the workflows
Cartographic Attributes

For any Feature Class...

<table>
<thead>
<tr>
<th>Geom</th>
<th>ID</th>
<th>Attributes...</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Coded Value Domain

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Prison</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Park</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Cemetery</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Mall</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Strip Mall</td>
<td></td>
</tr>
</tbody>
</table>

Each type of Cartographic Feature has a number and a description in the Coded Value domain. Integer values allow for faster display.
Example: Cultural
Hydrography

Scales

Features

Labels/Anno

Notes

Reduce this to something that they can see the text
Cultural

Transportation

Hypsography

Reference

Boundaries

Surface Cover

Buildings could be a separate feature class.

Use Transportation_LaneType domain with this feature.

This feature should be an area at 24K.

This feature should be a line at 24K.

This feature is captured in the type of transportation.

Note that there is a "Gate, Highway" feature in the Transportation theme.

How is this different from the simple "Gate" point symbol?

This feature should be a label only.

Note that this classification does not include Shrubland, Tree or Trees as in the old USGS docs.

What about missing categories like grassland?