Using ArcGIS to Develop a Fire Map Book

Or “How I Learned to Love Symbol Levels”

Brian Bradshaw
GIS Project Manager
(858) 636-4880
bbradshaw@sddpc.org
Acknowledgements

- Map Book Editing Team
  - John Urata, Linzy Qi, Lynn Finkel

- One Way Road Symbology, Road Update Program
  - Ron Harris

- Customers & Supervisors
  - Susan Infantino, Laura Brenner, Jody Betry, Marlyn Webb

- Funding
  - Dept of Homeland Security Urban Area Strategic Initiative (UASI) Grant
Overview

- Description - Objectives & Challenges/Issues
- Advanced Road Symbology
  - Cased Roads, Symbol Levels, VBA & ArcObjects
- Other Advanced Symbology
  - One Way Road Arrows – Labels Using a Symbol Font
  - Gates - Symbol Rotations
  - Hydrant Offsets – VBA & ArcObjects
- Map Book Production
  - Map Book Definition & Page Layout
  - Helpful Map Document Settings
  - Production Workflow & Computing Environment
- VBA Code Samples
Objective

• Replace a Hand Drawn Map Book Used by San Diego Fire-Rescue Dept. with a GIS-Based Map Book
  – Hardcopy Book on Vehicles to Backup GPS Navigation System
  – Large Wall Maps at Each Station for Area Overview

• Duplicate Same Features as Hand Drawn Map Book

• Replicate Hand Drawn Symbology

• Use Regional Symbology for Point & Poly Features
Challenges/Issues

- Replicating Road Overpass/Underpass Symbology
  - Solved Using Cased Roads & Symbol Levels
  - Resulted in Unique Version of Road Data for Map Book

- Digital Data Issues
  - No Digital Data for Some Features or Feature Types
  - Some of Available Digital Data Not Complete or Accurate

- Designing Single Layout for Map Book & Wall Maps

- No Multi-User Editing Environment Available
Hand Drawn Map Book vs GIS-Based Map Book
Hand Drawn Map Book vs GIS-Based Map Book
Advanced Road Symbology
Road Symbology

- Basic Road Symbology
  - Cased Roads Using Unique Values with Many Fields

- Symbol Levels Description

- Symbol Levels Issues
  - Roads Data Format - From/To Node Elevations vs Segment Elevations

- Making Symbol Levels Work

- Automate Road Symbology Using VBA & ArcObjects

- Symbol Levels Alternative
Basic Road Symbology

• Cased Road Symbols
  – Cartographic Line Symbol with 2 Layers
    • Wider Bottom Layer Appears as Outline (Casing)
  – Specify Line Join = Round (Smooth Edges Between Segments)
  – Line Cap = Butt Creates Open End
    • Best to “Join” Road Segments to Show Connectivity
  – Line Cap = Round Creates Closed End
    • Best Representation for Cul De Sacs

• Unique Values with Many Fields (3 Fields)
  – Road Type (Freeway vs Major Rd vs Private Rd) Defines Width
  – Route Type (Route of Response or Not) Defines Symbol Color
  – Elevation Used to Define Symbol Level
Basic Road Symbology

- Route of Response
- Major Road
- Private Road
- Open End (Cap=Butt)
- Closed End (Cap=Round)
Symbol Levels - Basic Concept
- Overrides ArcMap Default Drawing Sequence
- Can Specify Drawing Order of Individual Layers for Multilayer Symbols
- Allows Symbology to “Blend” Where Streets Intersect or Not Blend for Overpass/Underpass
- Can Use Elevations to Visually Separate Overlapping Road Segments
- Roads with Same Elevation can be “Blended”
Symbol Levels Options

- Default View
  - Specify Draw Order by Moving Symbols Up/Down List
  - Specify Join to Blend All Features With That Symbol
  - Specify Merge to Blend Symbol With Symbol Above

- Advanced View
  - Specify Numeric Values for Each Symbol Layer to Define Blending (Each Symbol Layer Has a Value)
  - Symbol Layers with Same Number (Level) Will Blend
  - Higher Numbers (Levels) Drawn Over Lower Numbers
  - Specify Same Number for Outer Symbol Layer for Roads at Same Elevation
  - Specify Higher Numbers for Roads with Higher Elevations
Symbol Levels – Advanced View

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Layer Name</th>
<th>Label</th>
<th>-1</th>
<th>-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMB_RoadsAllStName</td>
<td>1,1,5</td>
<td>76</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>1,1,4</td>
<td>69</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>2,1,4</td>
<td>69</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>3,1,4</td>
<td>69</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>1,2,4</td>
<td>69</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>8,1,4</td>
<td>69</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>9,1,4</td>
<td>69</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>8,2,4</td>
<td>69</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>1,2,3</td>
<td>57</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>2,2,3</td>
<td>57</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>3,2,3</td>
<td>57</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>1,1,3</td>
<td>57</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>2,1,3</td>
<td>57</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>3,1,3</td>
<td>57</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>8,1,3</td>
<td>57</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>9,1,3</td>
<td>57</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>FMB_RoadsAllStName</td>
<td>8,2,2</td>
<td>57</td>
<td>61</td>
<td></td>
</tr>
</tbody>
</table>
Symbol Levels Issues

- Limited Documentation and Samples

- Data Format - Node Elevations vs Segment Elevation
  - Elevation Defined for From Node & To Node, NOT Segment
  - Symbol Levels Works Best With a Single Elevation per Segment
  - Majority From & To Nodes Have Same Elevation
    - 155875 Road Segments Total
    - 1891 Segments Where From Node Elevation NE To Node Elevation

- Performance Issues
  - Partial Drawing & Then Hangs Up Using Shapefile
  - Slow But Acceptable Performance with File Geodatabase
Making Symbol Levels Work

• Use Open Ends Where Possible
  – Keep Closed End for Local Streets & Roads with Elevation = 1
  – ***Eliminates Lines Between Segments Joined End-to-End, Regardless of Elevation Differences
  – Still Have Lines Between Segments Joined at an Angle

• Define & Adjust Segment Elevations
  – Begin with Segment Elevation = Max of From or To Elevation
  – Change Segments Joined at Angle to Same Elevation
  – Eliminates Most Remaining Lines Between Segments

• Split Roads For “3 Segment Triangle Problem”
  – ***3 Roads Forming Triangle at Overpass Requires 4 Segments
Road Symbology – Initial Results
(Closed Ends, Elevation=Max of From & To Els)
Road Symbology – Road Ends Adjusted
(Open Ends for Elevations NE 1, Not Local Street)
Road Symbology
Elevation Adjustment – Before
Road Symbology
Elevation Adjustment – After
Road Symbology – Elevations Adjusted
Road Symbology – Elevations Adjusted
3 Segment Triangle Problem Remains
3 Segment Triangle – Before Road Split
3 Segment Triangle – After Road Split
(Creating 4 Segment Triangle)
Road Symbology – Final Results
Automate Road Symbology Using VBA & ArcObjects

- 73 Different Road Symbols (Combos of Width, Color, Elevation)

- Issue - Limited Documentation and Sample Code

- Code Summary
  - Define Map Layer to Symbolize
  - ISymbolLevel: Specify to Use Symbol Levels for Map Layer
  - ICartographicLineSymbol: Define Symbol Layers (Color, Width, Cap)
  - IMultiLayerLineSymbol: Group Symbol Layers
  - IUniqueValueRenderer: Assign Attribute Values to Specific Symbol
  - IMapLevel: Define Symbol Levels to Symbol Layers
  - *** Specify MapLevel = -1 for MultiLayer Symbol, Then Specify Actual Symbol Levels for 2 Separate Layers of Cased Road
Symbol Levels Alternative

- ESRI Tech Support Solution
  - “Can’t use Symbol Levels”
  - Use Cartographic Representations
    - Lengthy Multi Step Process
    - Requires Great Deal of Manual Interaction
    - Creates Separate Graphic Over Roads to Simulate Overpass
      - Graphic Does Not Change if Road Data Modified
    - Slows Draw Speed
Other Advanced Symbology
One Way Road Arrows

- Symbolized as Labels Using Symbol Font
  - Wingdings 3 vs Alphabet Font (Arial, Times, etc.)

- Code Road Segment as Letter Position that Matches One Way Arrow Symbol/Direction
  - ← is 6th Symbol (code as f)
  - → is 7th Symbol (code as g)
  - ↔ is 14th Symbol (code as n)

- Requires Maplex
  - *** “Align Label to Direction of Line”
    - Placement Properties → Label Position → Orientation → Label Alignment
Wingdings 3 (OpenType)

OpenType Font, Digitally Signed, TrueType Outlines
Typeface name: Wingdings 3
File size: 35 KB
Version: Version 1.55
Wingdings 3 designed by Bigelow & Holmes Inc. for Microsoft Corporation. Copyright © Reserved.
Gates – Symbol Rotations

- Advanced Symbol Option in ArcMap
- Specify Field to Define Angle
- Specify Angle for Each Feature in Attribute Table
- Visually Verify Angle During Editing
Hydrant Offsets

• Description
  – Road Symbology Makes Some Hydrants Appear In Street
  – Older Version of Hydrant Data Manually Offset To Address This
  – Take Advantage of Offsets from Older Data While Using New Data Set

• Calculate Offset Values for Each Individual Hydrant
  – Calculate X, Y Position of Each Feature in Old & New Datasets
    • Use Calculate Geometry Function from Attribute Table Options
  – Join Tables & Calculate Difference in X,Y Position to Identify X,Y Offset

• ArcMap Symbol Settings Only Enables Single Offset Value for Entire Feature Class/Map Layer vs Each Feature Like Symbol Rotation

• Use VBA Code to Apply Calculated Offsets to Each Feature
Map Book Production
Map Book Definition & Page Layout

- ESRI Developer Sample – DSMapBook
  - Specify Grid File to Define Individual Pages
  - Adds Map Book Tab to Table of Contents with List of Pages in Grid
    - Provides Quick Access to Each Page
  - Allows Layout Customization Used for All Pages
    - Page Specific Items (Page #) Use Attribute in Grid File
  - Built In Functionality with ArcGIS 10

- Layout Issues
  - Map Page & Subgrid Labels on Outside of Map Data for Map Book
  - Need Map Page Label on Map Data for Wall Maps
    - Used Large Outline Font with Light Gray Color to Simulate Transparency
  - Single Data Extent for 8.5x11 Book Page and 15x20 Wall Maps
Helpful Map Document Settings

• Definition Queries
  – Subset Data Without Editing Source Data
  – Easily Modified During Map Production As Needed

• Label Expressions
  – Eliminate Undesired Labels without Editing Source Data
  – Replace Incorrect Labels/Typos without Editing Source Data

• Maplex Label Settings
  – Superior Control over Label Placement
  – Helps Minimize Annotation Adjustment

• Feature Linked Annotation
  – Helpful During Annotation Editing to “Follow Feature”
Production Workflow

- Production Concept
  - Finalize Data Creation & Editing Before Individual Page Production
  - Master File Geodatabase & Map Document with Duplicate GDB’s & MXD’s for Each Editor, 4 Editors
  - Editors Create Feature Linked Annotation One Page At a Time
    - Converted All Labels to Annotation
  - Each Editors GDB Same Except Annotation Created for Their Pages

- Production Issues
  - Errors in Road & Other Data Required Editing During Page Production
    - Significantly Impacted Schedule
    - Required Iterative Editing of Master GDB & Manual Updates to Editor GDBs
    - Changes in Symbology, Label Settings Required Editing MXDs During Production
Computing Environment

- Editing on Desktop Computers
  - ArcMap 9.3 SP1 & Maplex Extension
  - Windows XP SP3
  - 1.6GHz Intel Pentium Dual Processor
  - 2 GB RAM

- Data Stored on Network Server
  - 1 GB Ethernet Connection
  - Master & Editor Geodatabases
VBA Code Samples
Public Sub Symbolize_Roads()

' define layer
Dim pMxDoc As IMxDocument
Set pMxDoc = ThisDocument
Dim pMap As IMap
Set pMap = pMxDoc.FocusMap
Dim pLayer As ILayer
Set pLayer = pMap.Layer(0)
Dim pFLayer As IFeatureLayer
Set pFLayer = pLayer
Dim pGFLayer As IGeoFeatureLayer
Set pGFLayer = pFLayer
Dim pFClass As IFeatureClass
Set pFClass = pGFLayer.FeatureClass

' define unique value renderer
Dim pUVRen As IUniqueValueRenderer
Set pUVRen = New UniqueValueRenderer
Set pGFLayer.Renderer = pUVRen

' specify fields to render unique values with
pUVRen.FieldCount = 3
pUVRen.Field(0) = "SEGCLASS" ' Road type attribute
pUVRen.Field(1) = "RteType" ' Route of Response attribute
pUVRen.Field(2) = "FMB_ELEV" ' Elevation attribute
pUVRen.FieldDelimiter = ","
pUVRen.UseDefaultSymbol = False
• `set up symbol levels`
  Dim pSymLevels As ISymbolLevels
  Set pSymLevels = pGFLayer
  pSymLevels.UseSymbolLevels = True

• `define colors`
  Dim pYlwColor As RgbColor
  Set pYlwColor = New RgbColor
  pYlwColor.RGB = RGB(255, 255, 0)
  Dim pGrnColor As RgbColor
  Set pGrnColor = New RgbColor
  pGrnColor.RGB = RGB(56, 168, 0)
  Dim pWhtColor As RgbColor
  Set pWhtColor = New RgbColor
  pWhtColor.RGB = RGB(255, 255, 255)

• `define widths`
  Dim d32Width As Double
  d32Width = 3.2
  Dim d42Width As Double
  d42Width = 4.2
Road Symbology
Sample VBA Code

- 'Define symbols for Symbol 400
  Dim pWht400CLSym As ICartographicLineSymbol
  Set pWht400CLSym = New CartographicLineSymbol
  Dim pGrn400CLSym As ICartographicLineSymbol
  Set pGrn400CLSym = New CartographicLineSymbol

- 'Define layer 1
  pWht400CLSym.Color = pWhtColor
  pWht400CLSym.Width = d32Width
  pWht400CLSym.Cap = esriLCSButt
  pWht400CLSym.Join = esriLJSRound

- 'Define Layer 2
  pGrn400CLSym.Color = pGrnColor
  pGrn400CLSym.Width = d42Width
  pGrn400CLSym.Cap = esriLCSButt
  pGrn400CLSym.Join = esriLJSRound

- 'Add layers to MultiLayer Symbol - level 0
  Dim p400MLSym As IMultiLayerLineSymbol
  Set p400MLSym = New MultiLayerLineSymbol
  p400MLSym.AddLayer pGrn400CLSym
  p400MLSym.AddLayer pWht400CLSym

- 'add the unique symbols to the renderer - level 0
  pUVRen.AddValue "4,2,0", "", p400MLSym
  pUVRen.AddValue "5,2,0", "", p400MLSym

- ' define maplevels - level 0
  Dim pMapLevel As IMapLevel
  Set pMapLevel = p400MLSym
  pMapLevel.MapLevel = -1
  Set pMapLevel = p400MLSym.Layer(0)
  pMapLevel.MapLevel = 2
  Set pMapLevel = p400MLSym.Layer(1)
  pMapLevel.MapLevel = 1
'Define symbols for Symbol 401
Dim pWht401CLSym As ICartographicLineSymbol
Set pWht401CLSym = New CartographicLineSymbol
Dim pGrn401CLSym As ICartographicLineSymbol
Set pGrn401CLSym = New CartographicLineSymbol
'Define layer 1
pWht401CLSym.Color = pWhtColor
pWht401CLSym.Width = d32Width
pWht401CLSym.Cap = esriLCSRound
pWht401CLSym.Join = esriLJSRound
'Define Layer 2
pGrn401CLSym.Color = pGrnColor
pGrn401CLSym.Width = d42Width
pGrn401CLSym.Cap = esriLCSRound
pGrn401CLSym.Join = esriLJSRound
'Add layers to MultiLayer Symbol - level 1
Dim p401MLSym As IMultiLayerLineSymbol
Set p401MLSym = New MultiLayerLineSymbol
p401MLSym.AddLayer pGrn401CLSym
p401MLSym.AddLayer pWht401CLSym
'add the unique symbols to the renderer - level 1
pUVRen.AddValue "4,2,1", "", p401MLSym
pUVRen.AddValue "5,2,1", "", p401MLSym
'define maplevels - level 1
Set pMapLevel = p401MLSym
pMapLevel.MapLevel = -1
Set pMapLevel = p401MLSym.Layer(0)
pMapLevel.MapLevel = 24
Set pMapLevel = p401MLSym.Layer(1)
pMapLevel.MapLevel = 14
'refresh map
pMxDoc.ActiveView.Refresh
pMxDoc.UpdateContents
End Sub
Public Sub SymbolizeHydrants()

Dim pMxDoc As IMxDocument
Set pMxDoc = ThisDocument
Dim pMap As IMap
Set pMap = pMxDoc.FocusMap

' define layer
Dim sLayer As String
sLayer = "wtr_hydrant_FMB"
Dim pLayer As IDataLayer
Set pLayer = FindLayerInTOC(sLayer)
Dim pFLayer As IFeatureLayer
Set pFLayer = pLayer
Dim pGFLayer As IGeoFeatureLayer
Set pGFLayer = pFLayer
Dim pFClass As IFeatureClass
Set pFClass = pGFLayer.DisplayFeatureClass

' define unique value renderer
Dim pUVRen As IUniqueValueRenderer
Set pUVRen = New UniqueValueRenderer

'specify field to render unique values with
pUVRen.FieldCount = 2
pUVRen.Field(0) = "OFFSET_X" ' for use without joins
pUVRen.Field(1) = "OFFSET_Y" ' for use without joins
pUVRen.FieldDelimiter = ","

pUVRen.UseDefaultSymbol = False
'Create the Simple Marker
Dim pCharMarker As ICharacterMarkerSymbol
' define the character font set
Dim pFont As IFontDisp
Set pFont = New StdFont
pFont.Name = "ESRI Default Marker"
' Create a red RGB color for the symbol
Dim pRGBClr As IRgbColor
Set pRGBClr = New RgbColor
pRGBClr.Red = 255

'retrieve x & y offset values and cycle thru each feature
Dim pFCursor As IFeatureCursor
Dim pFeat As IFeature
Set pFCursor = pFClass.Search(Nothing, False)
Set pFeat = pFCursor.NextFeature
Do Until pFeat Is Nothing
  ' define the marker symbol
  Set pCharMarker = New CharacterMarkerSymbol
  pCharMarker.size = 7
  pCharMarker.Color = pRGBClr
  pCharMarker.Font = pFont
  pCharMarker.CharacterIndex = 33
  pCharMarker.XOffset = pFeat.Value (pFClass.FindField ("OFFSET_X")) / 12
  pCharMarker.YOffset = pFeat.Value (pFClass.FindField ("OFFSET_Y")) / 12
  'add the unique symbol to the renderer
  pUVRen.AddValue pFeat.Value (pFClass.FindField ("OFFSET_X")) & "," & pFeat.Value (pFClass.FindField ("OFFSET_Y")), ",", pCharMarker 'for use without joins
  Set pFeat = pFCursor.NextFeature
Loop
' assign the renderer to the layer
Set pGFLayer.Renderer = pUVRen

' refresh map
pMxDoc.UpdateContents
pMxDoc.ActiveView.Refresh

End Sub