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OpenMap™ Development

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What is OpenMap™?

- Visualization of data, situational awareness
- Java-based programmer's toolkit and application (JRE v1.4)
- User can develop map layers to display private data or standard data formats
- Runs on any machine with a JVM (Windows, Macintosh, Linux, Solaris, etc.)
- Compliant with Sun's "100% Pure Java" certification

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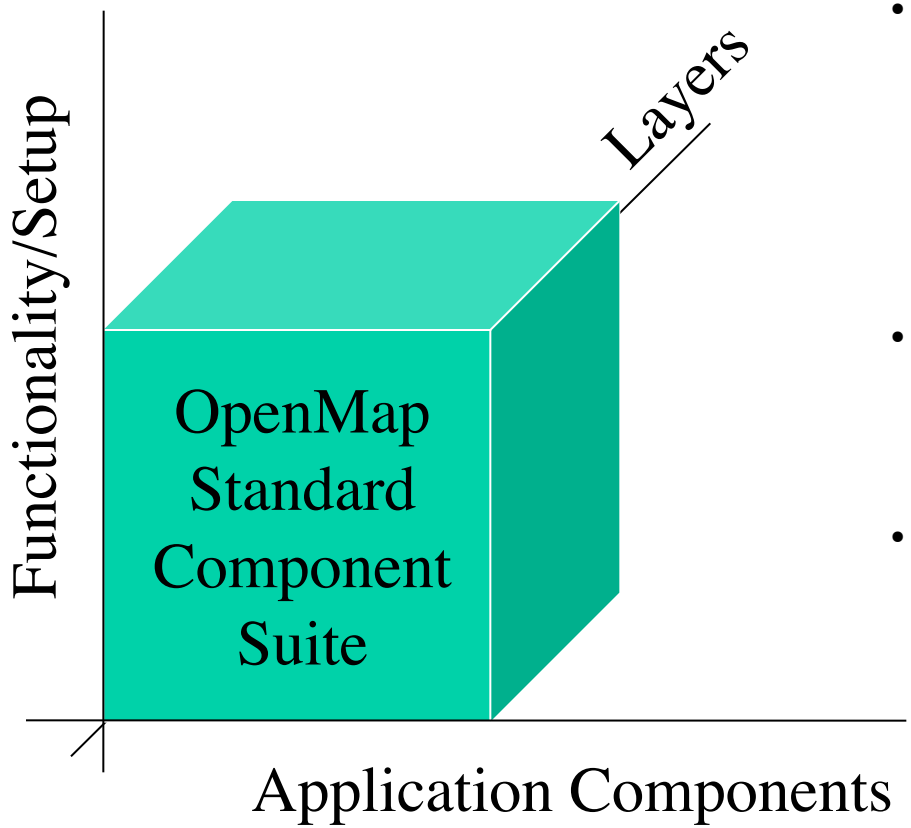
Variable Level of Commitment



- Architecture
  - Application/Applet
  - Embedded Components
  - Image Generation
  - Flexible Layer Configurations
- Ever-growing List of Layers
  - Property File Editing
  - Layer Authoring
- 80/20

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OpenMap's History

- 1995: OpenMap developed as a web-based (Java) client-server tool
- 1998: BBN released Java version of OpenMap as open source under the OpenMap Software License Agreement
- 2009: Version 4.6.5 released March 5

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Basic Goals

- Understand how OpenMap displays and manages map data.
  - Interaction
  - Animation
- Understand the OpenMap package components
  - What is available
  - Integrate them into your application
  - Create a new application

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Section 1

Introduction to OpenMap

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What's in OpenMap™?

- Suite of components, managing
  - Map Objects
  - Projections
  - Data Sources
  - GUI (Swing Components)
  - Application Framework
- Architecture Management
  - Application
  - Applet
  - Web Server Image Support
  - Custom integration

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Component Communication

- OpenMap components use the Java Event Model
- Events are objects that are sent from a source to a listener

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Using OpenMap™ Requires 2 Viewpoints

- Application view
  - Java components with layout concerns
- Data view
  - Create map objects reflecting data source
  - Use Projection to determine which should be displayed

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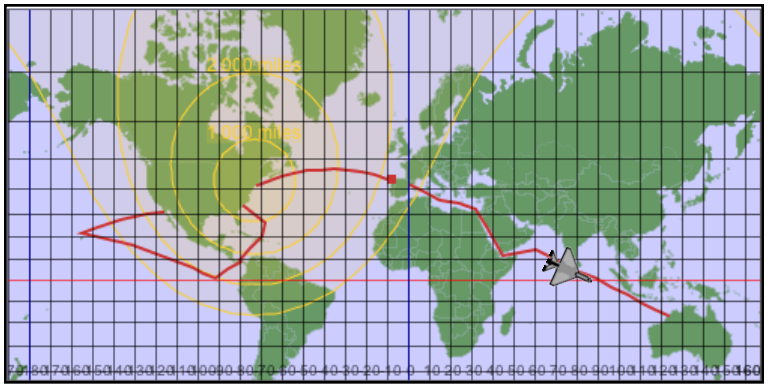
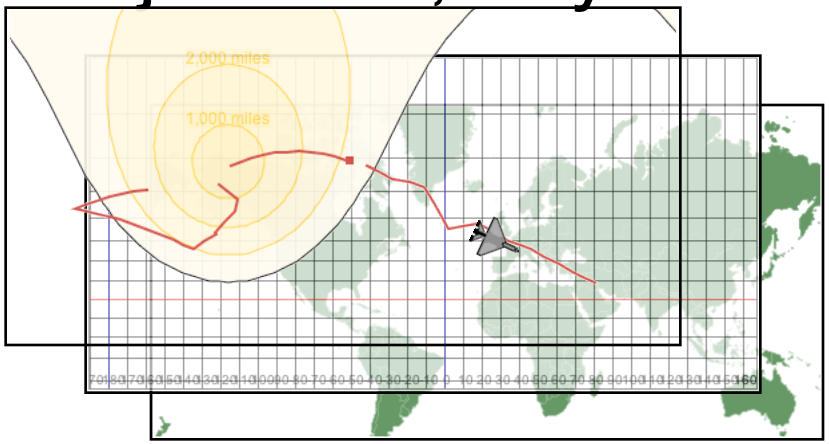
General Architecture

- JavaBeans Swing Components
  - BeanContext handles connections between components.
- MapBean manages Projections, Layers.





- Layers manage display of map data from a source.

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MapBean Component

- Main Map Component, Java Container object
- Manages a projection object
- Layers are children that listen for projection changes
- Layer painting controlled by Java AWT thread.

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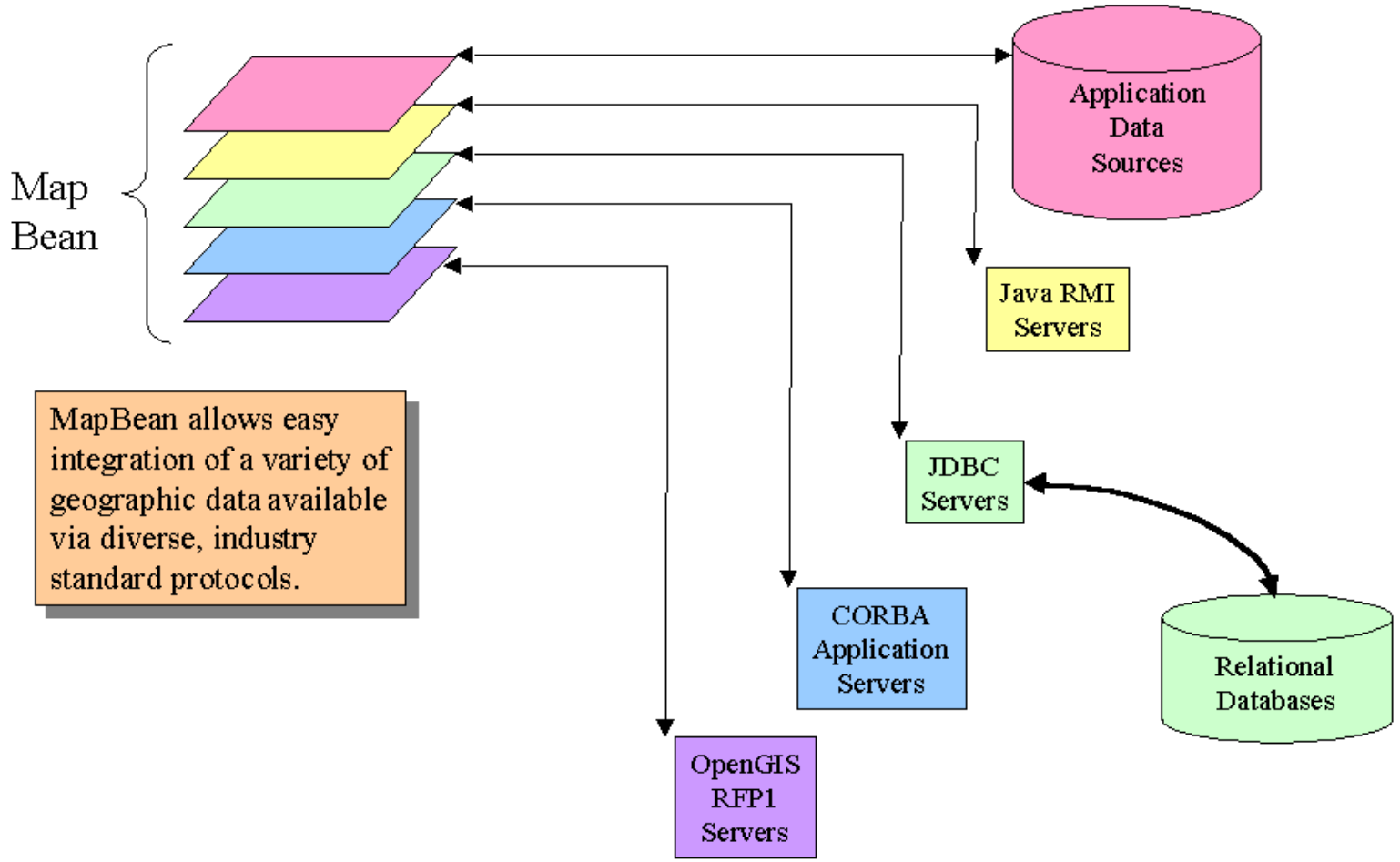
MapBean and Layers



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MapHandler Component

- Java BeanContext object
- Object holder for application components
- Membership Listeners get notified when objects are added and removed
- Conceptual map - knows that map has one version of some components (SoloMapComponent), handles duplicates

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MapPanel GUI Component

- MapPanel holds everything you need
  - JPanel with BeanContext, automatic connections
  - Has MapBean, Menus (as list or MenuBar)
  - Add other components to MapPanel for enhancements

```
Jframe jFrame = new Jframe("Map");

BasicMapPanel basicMapPanel =
          new BasicMapPanel();
// Add MapPanel as Swing Component
jFrame.getContentPane().add(basicMapPanel);
// If you want to set MenuBar for Map controls
jFrame.setJMenuBar(basicMapPanel.getMapMenuBar());

jFrame.pack();
jFrame.show();
```

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Exercise 1

Get the MapApplication up and running.

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Section 2

Using Layers to Display Map Data

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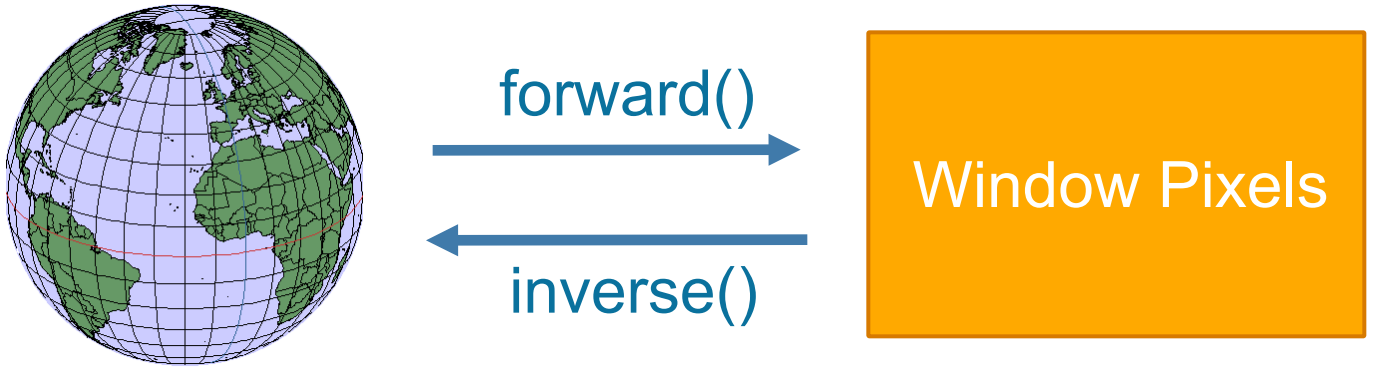
OpenMap™ Projections

- MapBean's Projection objects provide forward and inverse translation methods



- Datums define how coordinates are laid out on the projected grid (WGS 84)
- Projected coordinates are not handled by OpenMap

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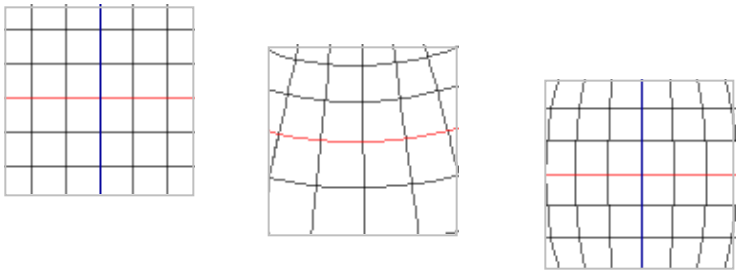
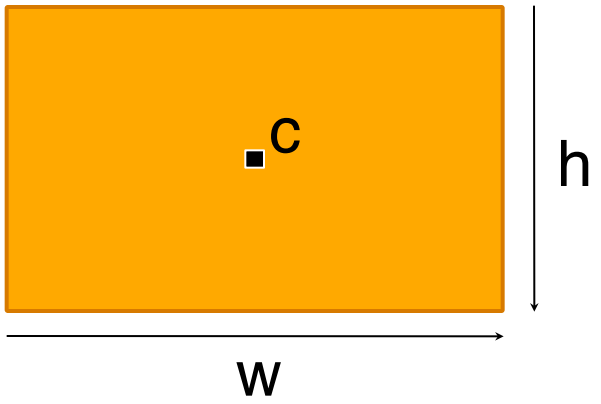
OpenMap™ Projection Parameters



- Projection type
  - Mercator
  - Orthographic
  - LLXY (EPSG 4236)
  - Gnomonic
  - Lambert Conformal Conic
  - CADRG (Equal Arc for RPF data)



- Latitude and longitude of window center
- Scale factor (zoom level)
- Pixel height and width of window

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Creating Projection Objects

- ProjectionFactory singleton class
- ProjectionLoader classes provide information about specific Projections
- Custom Projections can be added

```
ProjectionFactory.makeProjection(
        com.bbn.openmap.proj.Mercator.class,
         latitude,
         longitude,
         scale,
         windowWidth,
         windowHeight);
```

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Layer Basics

- com.bbn.openmap.Layer class
- Layers are primarily responsible for displaying information on the MapBean
- Layers should mainly be concerned with rendering themselves properly for the latest projection received from the MapBean
- The MapBean doesn't care what the Layers are doing

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Layer Basics (con't)

- Layers are PropertyConsumers, easily written to be configurable at startup
- Can provide a GUI palette to remain dynamically configurable
- Can be added to BeanContext to have access to other application components

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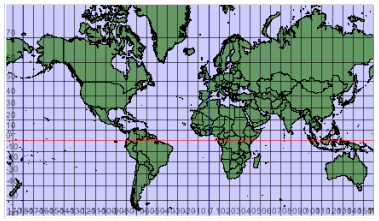
Layer.paint(Graphics)

- Layer extends JComponent
- The paint(java.awt.Graphics) method is where Layers draw the map objects
- Called from JVM AWT Thread
- Try to be a quick as possible
- Force paint() method calls with repaint()

Layers and Projection Events

- When added to the MapBean, a layer will start receiving ProjectionEvents
- Contains current Projection of map, layer should react accordingly
- Significant work should be done in a separate thread (SwingWorker)



Projection changes/
Map resizes

OMGraphics appear
on map

Layer

`projectionChanged()`

`prepare()`

`repaint()`

`paint()`

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Displaying Data on a Layer

- Gather data from data sources by any method allowed by JVM
- Decimal degree lat/lon data or x/y coordinates, WGS84 datum
- BinaryFile/BufferedBinaryFile used to read data files from any location
  - Resource `'datafile'`
  - File `'/home/user/datafile'`
  - URL `'http://localhost/datafile'`

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Displaying Data with OMGraphics

- OMGraphics are the main classes provided in OpenMap to display map objects
- Not mandatory, but convenient
- Contain rendering attributes - colors, stroke
- Map objects are maintained as objects, can contain more than display information if needed.
- OMGraphics know how to use the Projection to locate and render themselves

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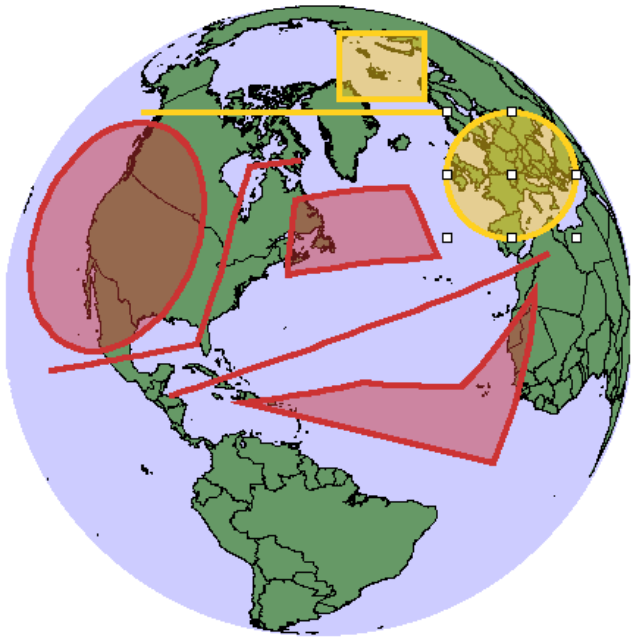
OMGraphics by Type

- OMGraphics represent data objects.
  - Coordinate space (lat/lon)
  - Pixel space (x/y)
- Many Types
  - Polygons, Splines
  - Points
  - Lines
  - Arcs, Circles, Ellipses
  - Rectangles
  - Grids, Rasters, Bitmaps
  - OMGeometryList, OMAreaList
- Manage with OMGraphicList



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OMGraphics and RenderType

- The render type dictates how OMGraphics react when the map projection changes.
  - Lat/Lon render type always positions according to coordinates, size changes with zoom level, location changes with pan `(RENDERTYPE_LATLON)`
  - Offset render type places object at a pixel offset from one lat/lon coordinate. Size doesn't change with zoom, but will move with pan `(RENDERTYPE_OFFSET)`
  - X/Y render type positions object at the same window location regardless of pan or zoom `(RENDERTYPE_XY)`
- OMGraphic RenderType is selected by the choice of constructor used.

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OMGraphics and LineType

The line type specifies how nodes between coordinates on the shape are connected.

- Straight lines are drawn in pixel space directly from one node to another `(LINETYPE_STRAIGHT)`
- Great circle lines are drawn to represent the shortest path from one point to another `(LINETYPE_GREATCIRCLE)`
- Rhumb lines are drawn with a constant directional bearing between nodes `(LINETYPE_RHUMB)`

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OMPoint

- Simple location marker
- Rendered as square or circle, centered over location
- Size is set for pixel space

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OMRasterObjects

- OMRasters place raster images on the map
  - Upper left coordinate is anchor
- OMScalingRaster automatically scales and places images according to corner coordinates
- OMScalingIcon places image centered over a point, with scaling over that point
- OMBitmaps place XBM style images on map
  - 2 bit image, not Windows bitmaps

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OMPoly, OMDistance and OMSplines

- OMPoly can be rendered as polyline (open) or polygon (closed). Polys with fill color are assumed to be closed polygons
- OMDistance objects are lat/lon rendertype OMPoly objects with labels marking ground distance between nodes
- OMSplines are polygons/polylines with natural cubic curved lines between nodes

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OMLine and OMArrowHead

- OMLines are single connection between two nodes
- Can have arrow head at start, end or both, at different points on line
- Can be rendered with arc in x/y space between points

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OMArc, OMCircle and OMEllipse

- OMArcs can be chords, pies or open
- Specified with starting azimuth and angular extent and radius
- OMCircle can be specified by center location and constant distance radius
- OMEllipse can have different major and minor axis distance values

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OMGrid

- OMGrid contains two dimensional array of values, either integers or objects, with equal-arc spacing between values
- Uses OMGridGenerator to interpret values to create another OMGraphic to represent values on map

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OMText

- Add text labels to map
- Uses variety of font types/sized available to JVM
- Justification, baseline alignment

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OMGeometryList and OMAreaList

- OMGeometryList contains OMGeometry objects that should be rendered the same way
- OMGeometry objects only contain location information
- OMAreaList combines all OMGraphics on list into one polygon

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Customized OMGraphics

- You can extend OMGraphic to create new, multi-part geometries
  - generate
  - render
  - distance
- Can use internal OMGraphicList, or manage OMGraphics separately

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OMGraphics and Rendering Attributes

- DrawingAttributes object can be used to transfer rendering information to OMGraphics
  - Edge, selection, fill and matting Paint
  - Stroke settings
  - Fill patterns
  - Masks
- Can be used by Layer, set with PropertyConsumer methods

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OMGraphic Attribute Table

- Allows OMGraphics to hold additional information

```
OMGraphic.put(key, value)
Object value = OMGraphic.get(key)
```

- If OMLabeler added under `OMGraphicConstants.LABEL` key, OMGraphic will have label presented

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OMGraphic Management - OMGraphicList

- Java List wrapper
- OMGraphicList contains OMGraphics, is an OMGraphic
- Order and membership can be controlled
- Can be vague or non-vague

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The Generate and Render Paradigm

- OMGraphics know how to draw themselves on the map
- OMGraphics MUST be generated with the projection of the MapBean they will be rendered upon, to figure out where they go
- If OMGraphic parameters are changed, the OMGraphic will determine if it needs to be re-generated
- OMGraphics that need to be generated will not render themselves

```
OMGraphic.generate(Projection)
OMGraphic.render(java.awt.Graphics)
```

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Exercise 2

Creating a layer to display map objects

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Section 3

Interact with Map Objects

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MouseEvent Handling

- User mouse movements over the map are translated to MouseEvents, which are distributed to listeners
- MouseEvents describe location, keys, type of action
- OpenMap MouseEvent distribution is controlled for predictable application behavior

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MapMouseModes and MouseDelegator

- A MapMouseMode is a MouseEventListener that distributes MouseEvents for a particular purpose
- Limits distribution when event is consumed
- MouseDelegator manages MouseModes, determines which one is active
- MouseDelegator queries Layers for MapMouseListener that handles MouseEvents
  - Specifies which MapMouseModes should send events
  - Can be Layer itself, or proxy object

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OpenMap MapMouseModes

- Abstract CoordMouseMode
  - Super class that handles display of coordinates with InformationDelegator
- NavMouseMode/NavMouseMode2
  - Click to recenter
  - Click and drag to create zoom box
- SelectMouseMode
  - Interaction with map objects
- PanMouseMode
  - Pan map to new location

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Using MouseEvents with OMGraphics

- If OMGraphics have been generated, they can respond to queries using x/y coordinates from MouseEvents

```
OMGraphic.contains(x, y)
OMGraphic.distance(x, y)
```

- OMGraphicList can provide OMGraphic closest to MouseEvent, providing mechanism to respond to user gestures on map

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OMGraphicHandler Interface and FilterSupport

- OMGraphicHandler interface is for any component that manages an OMGraphicList
- FilterSupport is a support component that manages queries on an OMGraphicList, both spatially and parametized

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OMGraphicHandlerLayer

- New Layer super class, implements OMGraphicHandler
- Uses policy objects to set how it handles OMGraphics for projection changes and rendering
- Minimal modifications needed to place data on map
- MouseEvents are Interpreted
  - On/Over OMGraphics or Map
  - How to react?
  - Uses MapMouseInterpreter

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OMGraphicHandlerLayer and MouseEvents

- GestureResponsePolicy
- Guides interpreter on reacting to events over specific OMGraphics
- Provides information about OMGraphics
  - ToolTips
  - InfoLine input
  - Popup Menu options
- Handles Highlight/Selection
  - Default: highlight, no selection

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OMGraphicHandlerLayer Interpretation

- On mouseMoved, mouseDragged over OMGraphic

```
isHighlightable(OMGraphic)
    highlight(OMGraphic) -> unhighlight(OMGraphic)
    getToolTipTextFor(OMGraphic)
    getInfoTextFor(OMGraphic)
```

- On mouseReleased over OMGraphic

```
isSelectable(OMGraphic)
    select(OMGraphicList) -> deselect(OMGraphicList)
```

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OMGraphicHandlerLayer Interpretation

- On mousePressed with right mouse button, do PopupMenu
  - If over an OMGraphic

    `getItemsForOMGraphicMenu(OMGraphic)`
  - If over Map

    `getItemsForMapMenu(MapMouseEvent)`

- Map events

  `receivesMapEvents()`

  `leftClick(MapMouseEvent)`

  `mouseOver(MapMouseEvent)`

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Exercise 3

Conversion of layer to OMGraphicHandlerLayer and Interaction with MouseEvents over the Map Objects

Section 4

Expanding the Functionality of an Application

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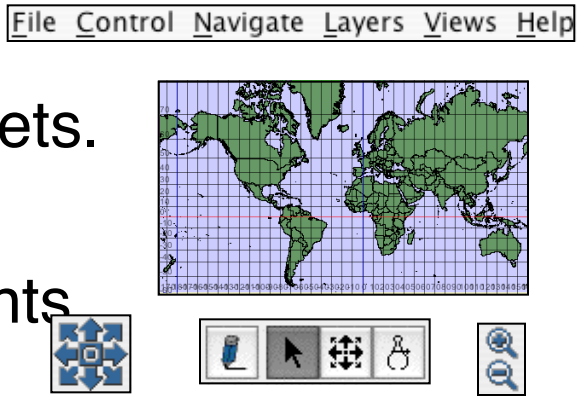
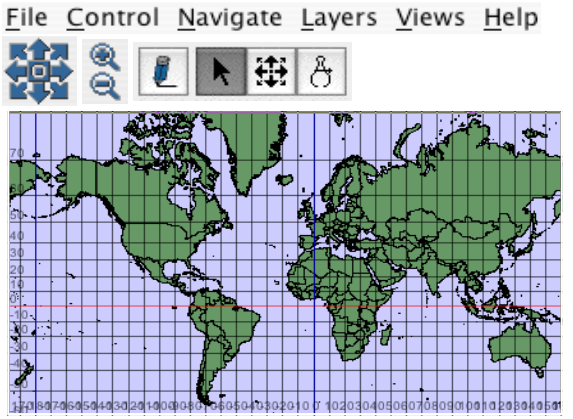
Using OpenMap™ From the Application View

- Set of components for embedding into an application.
  - Programmatic integration of widgets.
  - Map, layer and action controls.
  - BeanContext connects components.



- Application Framework
  - Addition of layers and components through property file editing.
  - No recompilation needed.



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LayerHandler

- Manages all layers, both on and off the map
- Uses layer visibility settings to determine which layers to provide to the MapBean
- Sends events detailing which layers are available to the application

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InformationDelegator

- Single interface to present information to User
- Can provide multiple information lines, pop-up windows, tooltips on map, additional information and browser content

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ToolPanel

- Main panel that displays Tools, widgets that provide application controls
- Can grab all available Tools from MapHandler, or can be limited to which tools to use or avoid
- Several ToolPanels can be used in an application, but coordination is needed to avoid duplicate parentage

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Various Tools

- OMToolSet (Map Navigation)
  - NavigatePanel
  - ZoomPanel
  - ScaleTextPanel
- OverviewMapHandler (Mini-map)
- ProjectionStackTool (back-forward)
- LayersPanel (control layers)
- OMDrawingToolLauncher (Create OMGraphics)
- MouseModeButtonPanel

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OMDrawingTool

- Tool to create or manipulate OMGraphic's location, shape and rendering parameters
- Can be created programmatically or found in the MapHandler
- Uses EditToolLoaders dynamically to match EditableOMGraphics to requests

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Using the MapHandler

- Add Objects to MapHandler

```
mapHandler.add(Object);
```

- MapHandlerChild describes methods to use the MapHandler to find other components

```
findAndInit(Object);
findAndUndo(Object);
```

- Use instanceof and other tests to locate specific objects

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MapHandlerChildren

- Extend these classes
  - Layer
  - OMComponent
  - OMToolComponent
  - OMComponentPanel
  - AbstractOpenMapMenu
- LightMapHandlerChild interface
  - Has `findAndInit(Object)` and `findAndUndo(Object)`
  - MapHandlerMenuItem

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Exercise 4

Use the MapHandler to find an OMDrawingTool for your Layer

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Section 5

Using Properties

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Properties and the PropertyHandler

- Java Properties object, set of key - value pairs
- Runtime application configuration with PropertyHandler
  - openmap.properties text file
  - Can search CLASSPATH and user home directory

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PropertyConsumer

- Interface for component that can be configured by Properties
- Provides methods for setting and getting properties
- Also provides methods for gathering information about what properties are available to be set (editors)

```
void setProperties(String, Properties);
void setProperties(Properties);
void setPropertyPrefix(String);
String getPropertyPrefix();
Properties getProperties(Properties);
Properties getPropertyInfo(Properties);
```

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PropertyHandler and PropertyConsumers

- Property files loaded into PropertyHandler
- Marker Name list used for scoping

```
openmap.components= mn1 mn2 mn3 …

mn1.class=com.bbn.openmap.LayerHandler
mn2.class=com.bbn.openmap.InformationDelegator

mn3.class=classname
mn3.firstProperty=value
mn3.secondProperty=value
```

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LayerHandler Example

- Given `layerHandler` markername

```
layerHandler.class=com.bbn.openmap.LayerHandler
openmap.layers=shapeLayer
openmap.startupLayers=shapeLayer

shapeLayer.class=com.bbn.openmap.layer.shape.ShapeLayer
shapeLayer.prettyName=Countries
shapeLayer.shapeFile=data/shape/world/cntry02/cntry02.shp
shapeLayer.fillPaint=FFBDDE83
```

Exercise 5

Run the OpenMap application with an openmap.properties file that reflects your current application

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Section 6

Animation Techniques

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Animation Techniques

- Animate by
  - Changing OMGraphic parameters
  - Regenerating OMGraphic with current projection
  - Repaint the layer
- Specific package aimed at making animation easier
  - com.bbn.openmap.graphicLoader
  - AbstractGraphicLoader contains timer to check data sources, modify OMGraphics and push results to map

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Animation Techniques (con't)

- Reduce paint load on MapBean
  - Buffer 'background' layers (BufferedLayerMapBean)
  - BufferedImageRenderPolicy
- Don't do calculations in paint thread
- If updates are rapid and random, queue them up for scheduled repaint() occurring in regular intervals

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GraphicLoaders

- Create OMGraphics from data source and pushes them to OMGraphicHandler receiver
- Can run in own/external thread
- For creating dynamic input to layers
- Can be used with GraphicLoaderPlugIn
- GraphicLoaderConnector provides automatic hookup to layer using MapHandler

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Exercise 6

Add GraphicLoader to your application, use LayerHandler to manage layer buffering

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Section 7

Layers and Data

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Displaying Support Data Formats

- OpenMap has built-in support for various commercial and government data formats
- Layers configured via properties
- Three general types of data
  - Raster (images)
  - Vector (object descriptions)
  - Grid/Coverage

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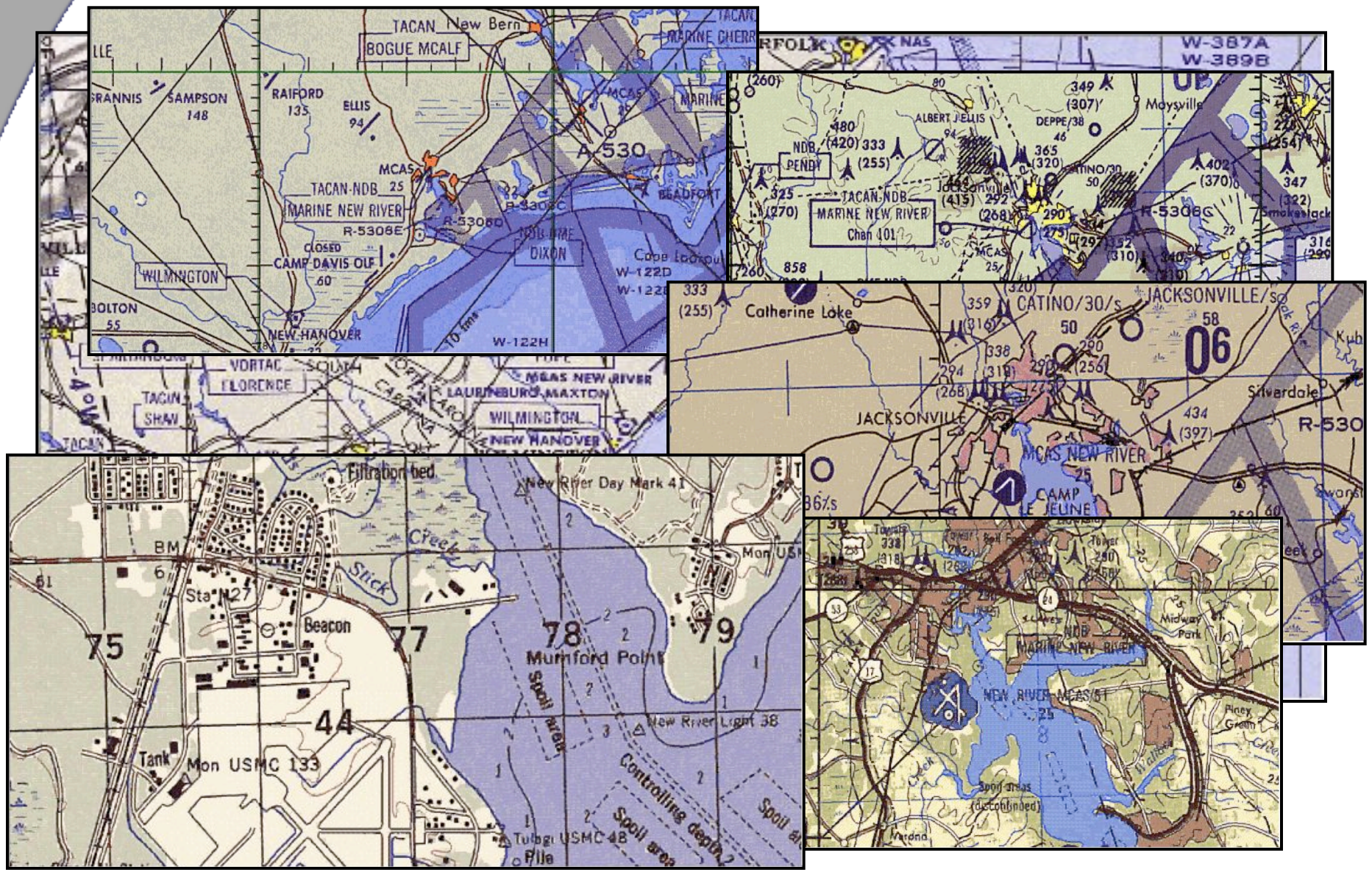
Raster Examples (RPF)



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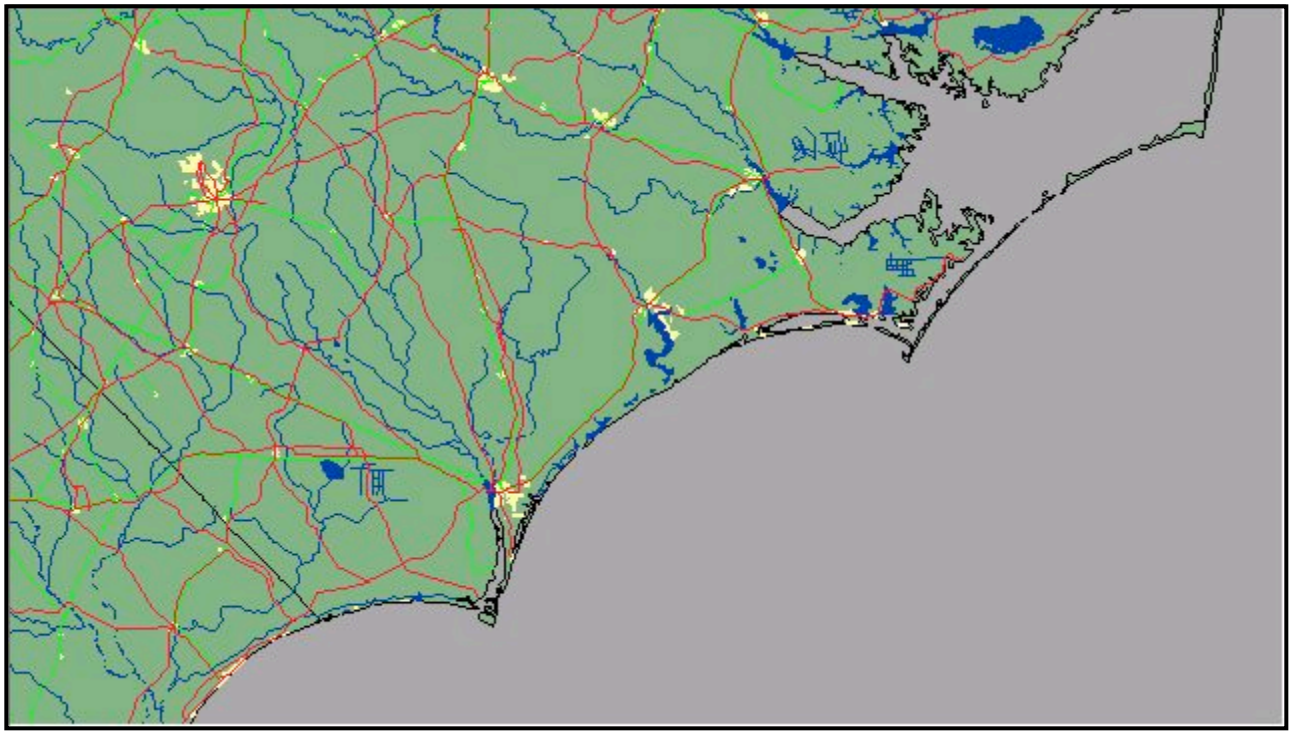
Vector Features (Shape and VPF)



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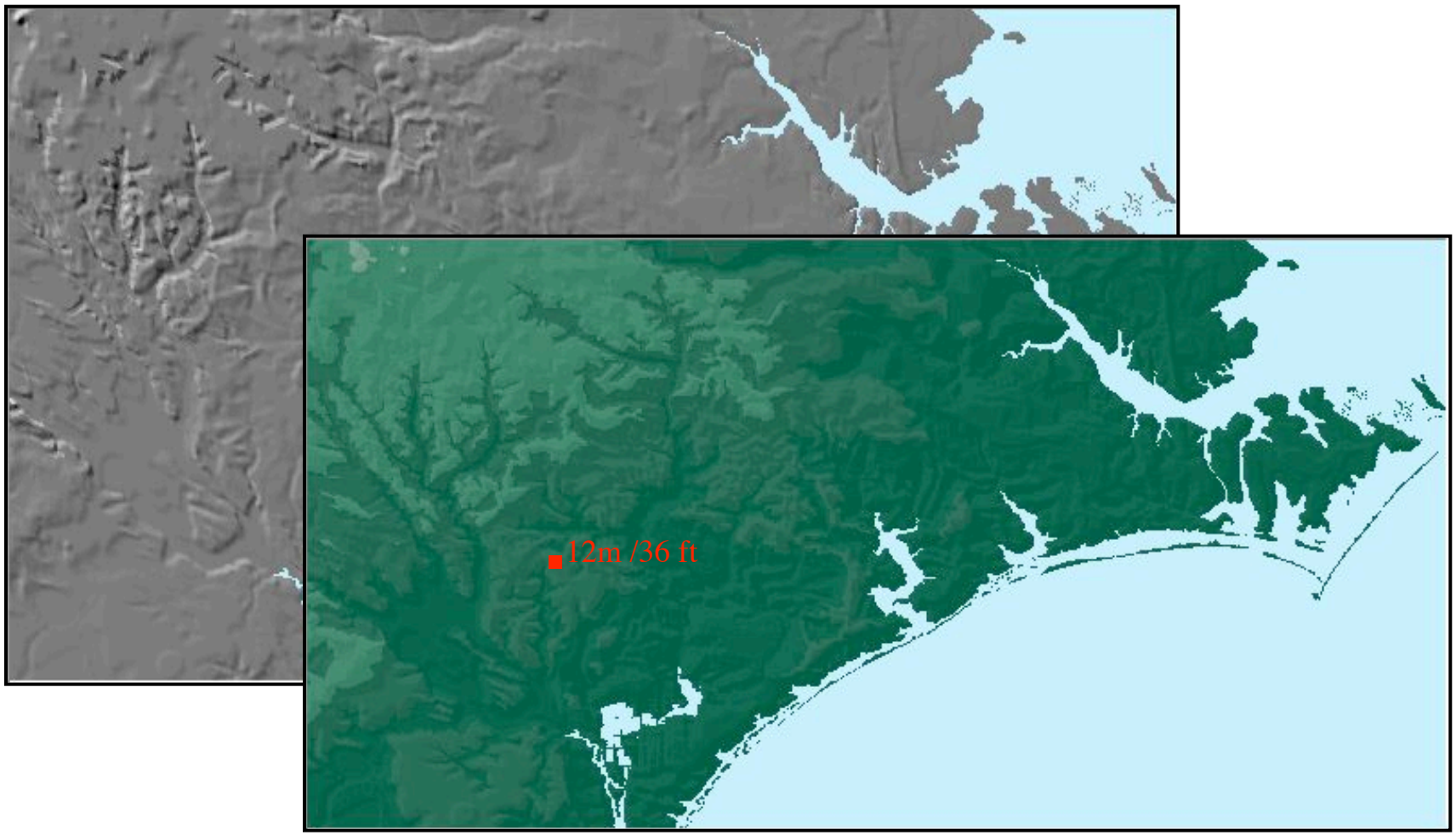
Visualization of Grid Data (DTED)



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Location Data

- Locations represent a place and a name
- Can be read from Comma-Separated Value (CSV) file or database
- LocationLayer deals with Locations, regardless of source
- LocationHandler handles coverting data source to Location map objects

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ESRI Shape files

- Shape file format consist of 3 files
  - shp contains geometries
  - shx contains index into geometry file
  - dbf contains attributes about geometries
- For OpenMap 4.6.3, data must be in decimal degree lat/lons
- Several layer options for display

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Displaying Shape Data

- ShapeLayer
  - All geometries rendered alike
  - Only holds what is on map in memory
- BufferedShapeLayer
  - All geometries rendered alike
  - All geometries held in memory
- MultiShapeLayer
  - Renders many shape layers in one layer
  - Each shape file contents rendered independently
- AreaShapeLayer
  - All geometries held in memory
  - Individual geometries rendered with custom attributes set in properties

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Displaying Shape Data (con't)

- EsriPlugIn
  - All geometries held in memory
  - DBF file contents displayed
  - Gestures highlight table entries and map shapes
- EsriLayer
  - Simple, generic
  - All geometries held in memory

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NGA Databases

- Raster Product Format (RPF)
  - Compressed Arc Digital Raster Graphics (CADRG)
  - Compressed Image Base (CIB)
- Vector Product Format (VPF)
  - VMAP Levels 0, 1, 2
  - Digital Chart of the World (DCW)
  - Digital Nautical Chart (DNC)
- Digital Terrain Elevation Data (DTED)
  - Levels 0, 1, 2

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Raster Product Format

- Data created from scanned paper maps and digital imagery
- Contained in file hierarchy
  - RPF directory
  - A.TOC file describes contents, sits right inside RPF
- RPFLayer requires path to RPF directory
- RpfLayer can handle multiple RPF directories, but better to create new A.TOC file for many directories

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Raster Product Format (continued)

- Requires CADRG projection for display
- RpfLayer can scale charts, likes to pick chart type most closely associated with projection scale
- Map has to be centered over map data and set to zoom level of data
- Coverage Tool in RpfLayer to assist in finding location of data on map
- All capital letters, ChangeCase class can modify
- Recently used images are cached

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Vector Product Format

- Diverse map object database organized into
  - Coverages: boundaries, transportation, vegetation
  - Coverage types: area, line, point
  - Features: roads, political boundaries
- Utilities for finding out available features
  - VPFConfig is new version with GUI
  - DescribeDB is command line version

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Vector Product Format

- VPFLayer requires path to top-level directory that contains lat/.lat file
- Can display in any projection type
- 1:30,000,000 scale restriction to avoid long delays in gathering data
- VPFLayer gathers new OMGraphics every projection change

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Digital Terrain Elevation Data

- Data is represented by 2 dimensional array of elevation values
- Level defines spacing between posts:
  - Level 0: 30 arcsecond spacing (~300 meters)
  - Level 1: 3 arcsecond spacing (~100 meters)
  - Level 2: 1 arcsecond spacing (~30 meters)
- Thinned data extracted from level 1 (where available), plus VMAP level 0's elevation data

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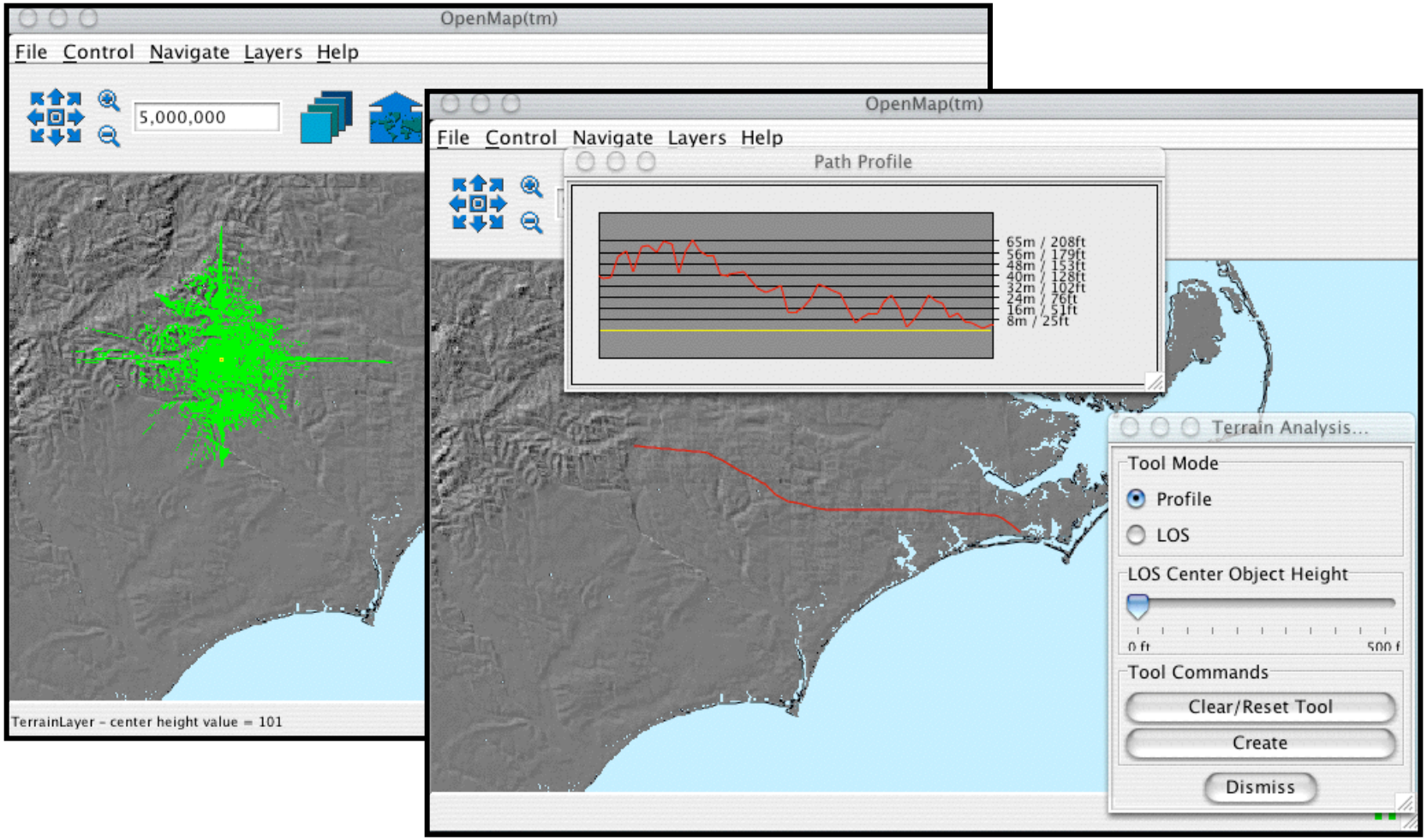
Digital Terrain Elevation Data

- DTEDLayer requires path to dted directory
- Lower case directory and files
- File path format: dted/[wle]XXX/[nls]YY.dtL
- DTEDLayer creates images from post data
  - Shading
  - Colored Shading
  - Meter and feet greyscale banding
- Recently used frames are cached
- Mouse clicks create elevation location
- Map must be positioned over data
- 1:20,000,000 scale limit
- DTEDFrameCache can be added to MapHandler and used by other components for elevation retrieval

Data for Analysis



- com.bbn.openmap.layer.terrain.TerrainLayer
  - Profile, LOS Generators

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e00 and mif

- ArcInfo Export Files (e00)
  - e00 extension
  - com.bbn.openmap.layer.e00.E00Layer
- MapInfo
  - mif extension
  - com.bbn.openmap.layer.mif.MIFLayer
- Vector format
- Both contain rendering information
- Simply note data file path for layer to display

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Client-Server Layers

- OpenMap package includes several client-server components and packages to use for transfer of map data to MapBean over network
- Object transfer
  - Link package: BBN developed, simple socket, xml/binary protocol
  - Specialist package: CORBA client layer and servers
- Image transfer
  - WebImagePlugIn clients (SHIS and WMS)
  - SimpleHttpImageServer/SHISPlugIn

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PlugIns

- Component that provides data access and OMGraphic creation
- Can be used by layer (PlugInLayer) or server
- Can respond to MouseEvents
- Can provide GUI

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ScaleFilterLayer

- A parent layer that switches between child layers, depending on the map scale
- Need to have one less transition scale than layer count

```
scaledRoads.class=com.bbn.openmap.layer.ScaleFilterLayer
scaledRoads.prettyName=Northeast Roads
scaledRoads.layers=neroads neroadsDetailed
scaledRoads.transitionScales=150000

neroads.class=com.bbn.openmap.layer.shape.ShapeLayer
…

neroadsDetailed.class=com.bbn.openmap.layer.shape.ShapeLayer
…
```

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DrawingToolLayer

- Receives OMGraphics from OMDrawingTool added to application
- Save/Load OMGraphics stored as Serialized Objects saved in file
- Save OMGraphics to Shape file, with restrictions

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EditorLayer

- Generally used for specific data set representations (creation/editing)
- Extension of DrawingToolLayer
- Contains configurable OMDrawingTool
  - Gestures MapMouseMode acts as a proxy for editing
  - DrawingAttributes access optional

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Exporting OMGraphics

- Serialized OMGraphics provide best duplicate representation
- Shape files don't contain rendering information
  - EsriShapeExport class
  - OMGraphics -> Shape files
  - Points, lines, poly files

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Exercise 7

Working with Layers

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Section 8

OpenMap as an Applet

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Applets

- Runtime governed by Java sandbox, imposes operational restrictions
- No access to local system
- Network access restricted to original server
- Certificates can open access to local system

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OpenMap Applet HTML

```
<HTML><BODY bgcolor="FFFFFF">
<center>
<OBJECT classid="clsid:8AD9C840-044E-11D1-B3E9-00805F499D93" WIDTH = "750" HEIGHT = "500" >
<PARAM NAME = ”CODE" VALUE = "com.bbn.openmap.app.OpenMapApplet">
<PARAM NAME = "CODEBASE" VALUE = "." >
<PARAM NAME = "CACHE_OPTION" VALUE = "Plugin" >
<PARAM NAME = "CACHE_ARCHIVE" VALUE = "openmap.jar,data.jar" >

<EMBED type  = "application/x-java-applet;version=1.4”
        java_CODE       = "com.bbn.openmap.app.OpenMapApplet"
       java_CODEBASE   = "."
       WIDTH           = 750
       HEIGHT          = 500
       cache_option    = "Plugin"
       cache_archive   = "openmap.jar,data.jar" >

       <NOEMBED>
                No Java support for applet!
       </NOEMBED>
</EMBED>
```

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Applet Classpath

- CODEBASE parameter, usually parent directory of html file
- openmap.properties file loaded from there, configuring applet
- Data can be loaded from jar files or from directories in CODEBASE

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OpenMap Contact Information:

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More Info

- OMAreaList, including uses for creating OMGraphics with holes
- Using OMScalingRaster for dynamic image scaling
- How to use the EarthImagePlugin - image created from pixel information from data source for lat, lon
- Specific DrawingAttributes examples, including fill pattern example, masks
- Why is there a 180 degree limit on the size of an OMGraphic?

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OMAreaList

- Used to connect OMGraphics to make a continuous shape.
- Works like OMGraphicList, add OMGraphics in the order they should be connected.
- DrawingAttributes set on the parts are ignored, the DrawingAttributes of OMAreaList are used.

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Using the OMScalingRaster

- OMRasterObject that is anchored at the upper left and lower right corners.
- Only scales, doesn't warp.
- Create java.awt.Image in Java, then hand to OMScalingRaster.
  - ImageIcon to read image file

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EarthImagePlugIn

- Displays images that are assumed cover the entire planet with Mercator projection.
- Assumption about image projection allows it to determine color for any lat/lon.
- Creates image in pixel space by using projection to get lat/lon value for each pixel of image.
- Performance directly related to size of image.

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DrawingAttributes

- Line paint (default edge color)
- Select paint (edge color when OMGraphic selected)
- Fill paint
- Fill pattern (from URL file)
- Matting paint
- Stroke (line width, dashes, end and caps)

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DrawingAttributes Properties

```
drawingattributes.selectColor=ffcccc00
drawingattributes.mattingColor=ff330033
drawingattributes.pointRadius=2
drawingattributes.lineWidth=2.0
drawingattributes.matted=true
drawingattributes.dashPattern=10 0
drawingattributes.lineColor=ff006600
drawingattributes.pointOval=true
drawingattributes.fillColor=3d33ff33
```

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DrawingAttributes (cont.)

- PropertyConsumer, can be set from and provide Properties
- Can push and pull values from OMGraphics
  - `drawingAttributes.setTo(OMGraphic);`
  - `drawingAttributes.setFrom(OMGraphic);`

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DrawingAttributes Fill Pattern

- Fill pattern is provided by image file.
- Needs path to image file, as resource, file path or URL.
- Pattern image will be repeated to fill shape.
- Pattern images with transparency will allow fill paint to show through.

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PropUtils Class

- Essential for dealing with Properties in code.
- Conversion methods with defaults
- File URL location
  - `getResourceOrFileOrURL(String path);`