GIS Beyond the Basics: Our System is Mapped, Now What?

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Utility Solutions Business Development
Agenda

• What is GIS?
• Creation of GIS data
• Managing and sharing data
• Coordinate systems and datums
• Insuring quality
  – Metadata
  – Spatial accuracy
  – Topology
  – Attribution
• How to use GIS system
  – Find things
  – Asset inspection
  – Valve isolation
  – Asset relocation
  – Maintenance tracking
  – Generate Reports
  – Leak detection
What is GIS?

• **Geographic Information System**

• Integrated collection of software & data used to view & manage information about geographic places, analyze spatial relationships, & model spatial processes.

• A GIS provides a framework for gathering, managing, analyzing, & visualizing spatial data
Purposes of the GIS

Capture – Survey, GPS, or tabular

Store – raster and vector

Query – parcels 1 acre or more

Analyze – find parcels along river

Display – variety of symbols, elements

Output – maps, graphs, reports
GIS Data Types

• Vector
  – Points (Hydrants, valves, meters, etc)
  – Lines (mains, service lines, etc)
  – Polygons (service areas, reservoirs, etc)

• Raster
  – Grid data/cell based
  – Satellite imagery
GIS data creation is the extraction in digital form of real world data to be used for analysis or visualization.
GIS Software

• Office based
  – ArcGIS Desktop
  – ArcGIS Pro
  – QGIS

• Web based (cloud)
  – ArcGIS Online
  – Trimble Unity
High Accuracy GIS Data Collection

• GNSS receivers used for field data collection
• High accuracy available
  – Meters ➔ Centimeters
• Field software collect location and attributes
GNSS – Global Navigation Satellite System

Combination of regional satellite systems

GPS - USA  GLONASS - Russia  Galileo - Europe  BeiDou - China

US GPS History

- 1958 – US Navy Navigation Satellite System approved and funded
- 1983 – President Reagan opens GPS for civilian use
- 1989 – Launch of first fully operational GPS satellite
- 1989 – Release of first handheld GPS receiver
- 1990 – First production car with built-in GPS navigation system
- 1993 – 24 satellite system becomes fully operational
- 1999 – First commercially available GPS enabled phone
GNSS Today

- Trend toward Bring Your Own Device (BYOD)
- Smaller devices, lower cost, higher accuracy & precision
- Shift toward real-time corrections vs post processing
Digitization

Digitizing is the process by which coordinates from a map, image, or other sources of data are converted into a digital format in a GIS.
Remote Sensing

The use of satellite- or aircraft-based sensor technologies to detect and classify objects on Earth

- Satellite based
- Aircraft based
- Drone based
Data File Types

• **Shapefiles** - Consisting of at least 3 & as many as 9 files
  - filename.shp *shape geometry data*
  - filename.shx *a linking index to attributes*
  - filename.dbf *attribute data*
  - *filename.prj* *projection & coordinate system information*

• **Geodatabases**
  - Personal, File, Enterprise (SDE/RDBMS)

• **Online Data Sources**
  - ArcGIS Online, Open Source, other
<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Easy to share</td>
<td>• Many files=1 layer</td>
</tr>
<tr>
<td>• Non-proprietary</td>
<td>• Field Truncation</td>
</tr>
<tr>
<td>• Works on all GIS/CAD</td>
<td>• No Domains (menus)</td>
</tr>
<tr>
<td></td>
<td>• Data Integrity Loss</td>
</tr>
</tbody>
</table>
Benefits of Data Storage - Geodatabases

• Container of geographic datasets
• Scalable
• Primary format for edits & data management
• Portable
• Domains/Subtypes
• Topology Rules
• Spatial Reference
Types of Geodatabases

• Personal: 2GB max, 1 user
• File: TB/FD, 1 editor, many viewers
• Enterprise: RDBMS, multi-user, performance, archiving
Parts of the Geodatabase

- Tables
- Layers or feature classes
- Groups of feature classes = feature datasets
- Spatial reference
- Raster Datasets
What are features?

- **Features** are the records within a layer or feature class. (hydrants, valves, etc)
- **Feature classes** contain features and store information other than geometry (hydrant ID, type, date, etc)
  - Attributes: answer questions about features
- **Feature datasets** store FC’s that share similar functions and spatial references
Coordinate Systems and Datums

- **Geographic coordinate systems** (lat/long) are based on a spheroidal surface that approximates the surface of the earth.
- **Datums** typically define the surface and the position of the surface relative to the center of the earth.
- A **Projection** is a series of transformations which convert the location of points on a curved surface (the reference surface or datum) to locations on flat plane.
Coordinate Systems and Datums

• GPS is *Geographic Coordinate System* WGS84
• Local data in South Carolina is typically *Projected Coordinate System* NAD 83 South Carolina State Plane
Coordinate Systems and Datums

• Transformations occur to change data from one coordinate system to another
• An improper transformation or improperly defined coordinate systems can cause data to be off by many feet to hundreds of miles
Data quality refers to the relative accuracy and precision of a particular GIS database.
Accuracy vs Precision

- **Accuracy** is how close a measurement is to true.
- **Precision** is how close measurements of the same object are to each other.
Importance of Accuracy

• Data in GIS must match real-world values
• Relates to quality of data and number of errors
• Spatial Accuracy
  – Horizontal
  – Vertical
• Attribute
Importance of Precision

• Reproducibility or repeatability
• Level of measurement and exactness of description in a GIS database
• Measure position to a fraction of a unit
• Attribution characteristics of features in great detail
• Precise data may be inaccurate
Attributes

• Tabular data appended to spatial data
• Attributes are characteristics about spatial data
• Character (string), numeric, date
Attribute Types

- Date Installed (Date)
- Size (menu or number, 0 decimals?)
  - Always use number type (float, double, integer) when things will be cumulated mathematically
- Comments (text, NOT TOO LONG)

*Use logic to best “describe” the information*
Metadata

• Information about data
• Metadata records who, what, when, where, how and why GIS data was created
• Important when sharing data

- Spatial Reference
- Lineage
- Temporal
- Entity and Attribute
- Legal
- Reference
- Metadata Standard
A **GIS topology** is a set of rules and behaviors that model how points, lines, and polygons share coincident geometry.

<table>
<thead>
<tr>
<th>Points</th>
<th>Points on points</th>
<th>Points on lines</th>
<th>Points on polygons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must be a single point</td>
<td>Must be covered by endpoint of line</td>
<td>Must be covered by endpoint of line</td>
<td>Must be properly enclosed by polygons</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lines</th>
<th>Lines on points</th>
<th>Lines on lines</th>
<th>Lines on polygons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must not have dangling line segments</td>
<td>Must not have coincident line segments</td>
<td>Must not overlap</td>
<td>Must be covered by boundary of polygons</td>
</tr>
<tr>
<td>Must not overlap</td>
<td>Must not self-overlap</td>
<td>Must not intersect</td>
<td>Must not intersect or touch interior</td>
</tr>
<tr>
<td>Must not intersect or touch interior</td>
<td>Must be single point</td>
<td></td>
<td>Must be covered by boundary of polygons</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Polygons</th>
<th>Polygons on points</th>
<th>Polygons on lines</th>
<th>Polygons on polygons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must not overlap</td>
<td>Must not have gaps</td>
<td>Boundary must be covered by</td>
<td>Must be covered by feature class of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Must be covered by</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Must not overlap with</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Must cover each other</td>
</tr>
</tbody>
</table>
Using GIS Data

– Find things
– Asset inspection
– Valve isolation
– Asset relocation
– Maintenance tracking
– Generate Reports
– Leak detection
– GIS data sharing
Map Where Things Are

Find where things are that have the features you’re looking for, and see where to take action.

• Find a feature—Use maps to see what and where an individual feature is.
• Finding patterns—Patterns emerge when you look at the distribution of features on a map instead of just an individual feature.
Asset Inspection

• Use mobile GIS tools, attribute tables, joined tables, and spatial location to complete inspection
Valve Isolation

• Because of topology we can use GIS to isolate valves
• Connectivity of system shows how turning one valve effects other assets
• GIS tools built to perform isolation
Asset Relocation

- Improve spatial accuracy of legacy data in GIS
- As-builts are typically not accurate
- Use mobile GIS and GNSS receivers to adjust spatial accuracy
Maintenance Tracking

- Create GIS layer or joined table to track maintenance on mapped assets
- Any work performed should be linked to GIS feature
Report Generation

- Hard copy maps
- Maintenance history
- Outage reports/maps
- Pressure zones
- Billing integration
- Infrastructure replacement
Leak Detection
GIS Data Sharing

• Share data outside of your organization
  – Geodatabase
  – Shapefile
  – Feature Service
  – Hard copy map

• Consume data from other organizations
  – Parcel data
  – Adjoining system data
  – Sewer or stormwater system
Conclusion

GIS is a powerful tool and everyone should be using it!

Questions?