Topology Workshop

Oklahoma State Training

DATAMARK TECHNOLOGIES

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Introductions

- DATAMARK Technologies
- Oklahoma GIS Committee Members
- Class Attendees

Agenda

- Topology Concepts – 3 hours
  - Topology overview
  - NG9-1-1 layer topology requirements
  - Topology in ArcGIS Pro
  - Explanation of Topology Rules
  - Creating a Topology
  - Map topology vs geodatabase topology
- Correcting Topology Errors – 3 hours
- Workflow Discussions and Best Practices – 2 hours
  - Real world workflows
    - Annexations
    - Considerations when adding new features
    - Snap to vertex
  - Best Practices and QA/QC workflows

Topology Concepts

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What is Topology?

Topology is the set of **rules and relationships** that define **spatial relationships between features.**

- These relationships are critical for data accuracy, routing, analysis, and decision-making.
- Instead of only focusing on how features *look* on a map, topology focuses on how they are spatially related.

Why does it matter?

- GIS data is often used for analysis and not just for visualization. Specifically, NG9-1-1 data…it performs a function!
- Poor topology can lead to incorrect results, system errors, or operational failures.
- Topology helps with data integrity, maintain consistency across datasets, and will help identify data errors.

Common Topology Relationships

1. **Connectivity**
   - Describes how features connect to each other
   - Think: Road Networks, Utility Line networks

2. **Adjacency**
   - Describes how features share boundaries
   - Think: Parcels alignment, City limits aligning with county boundary

3. **Containment**
   - Describes where features must exist inside another
   - Think: Address Points completely within a city boundary, zoning areas within city limits

Topology Requirements for NG9-1-1

- NG9-1-1 GIS data must follow strict topology rules to ensure that emergency calls are routed accurately and consistently. These requirements enforce clean, shared geometry and logical spatial relationships between core GIS layers used within the 9-1-1 systems.
- NG9-1-1 systems rely on GIS data for:
  - Call route to correct PSAP
  - Assigning law, fire, and EMS services
  - Validating addresses
  - Routing
- Each required data layer will have its own topology requirements
- Requirements may vary
  - Oklahoma State Standard Requirements
  - NENA NG9-1-1 Data Model Requirements
  - Next Generation Core Services Requirements

Boundary Requirements

- Mandatory Boundary Layers for Oklahoma NG9-1-1
  - PSAP Boundary
  - Discrepancy Agency Boundary
  - Emergency Service Boundaries – Fire, Law, EMS
  - Emergency Service Zones (ESZ) Boundary
- Topology Requirements
  - No gaps or overlaps within boundaries
  - Boundaries are fully contained within Discrepancy Agency Boundary

Address Point Requirements

- Addresses must not touch a road centerline segment
- Address Point to Boundary Topology
  - Addresses must be fully contained within boundaries

Road Centerline Requirements

- Topology Requirements
  - Road intersections – must have intersections represented where there are traversable roads in the real world
  - Self-intersecting – a road intersects itself
  - Road dangles – roads must snap and connect appropriately to adjacent segment
  - Road must be single part – a single record must exist for each individual road segment
  - Roads
  - Roads overlapping – stacked road centerlines

- Road Centerline to Boundary Topology
  - Roads must be fully contained within boundaries
  - Roads must be broken and snapped to boundaries

Topology Requirements for NG9-1-1

NG9-1-1 Topology Requirements verify:

- Every location belongs to exactly one PSAP
- Service boundaries are seamless and non-overlapping
- Roads are fully connected and properly split
- Address locations can be routed and validated correctly
- GIS data can be trusted by emergency systems!

Topology in ArcGIS Pro

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Topology Requirements in ArcGIS Pro

- Software Requirements
  - To create a topology in ArcGIS Pro, you must have a Standard or Advanced license level
- Data Requirements
  - Data must be in **feature class** format
  - Topology can only be created within a **geodatabase** inside of a **feature dataset**
  - All feature classes you want to validate with your topology must be inside the same feature dataset
  - All feature classes must share the same **coordinate system**

Topology Rules

- Rules applied within the Oklahoma NG911.Toolkit.v3.1 are referenced within the **ReadMe Document > Topology Rules** grouping

Let's review some visuals!

- Esri Geodatabase Topology Rules Poster: AGIS-GDB-Topo_94681

Polygon Layer Rules

All polygon feature classes must individually conform to the rule:

- Must Not Overlap (Area)

ESB and PSAP Layer Rules

The ESB_EMS_BOUNDARY, ESB_FIRE_BOUNDARY, ESB_LAW_BOUNDARY, and PSAP_BOUNDARY must individually conform to the rule:

- Must Not Have Gaps (Area)

ROAD_CENTERLINE Layer Rules

The ROAD_CENTERLINE layer must conform to the following rules:

- Must Not Overlap (Line)
- *Must Not Have Dangles (Line)*
- Must Not Self-Overlap (Line)
- Must Not Self-Intersect (Line)
- Must Be Single Part (Line)

NOTE: The rule(s) in italics may be marked as exceptions on a per-feature basis.

Rules Involving the DISCREPANCYAGENCY_BOUNDARY Layer

Layer	Relationship to DISCREPANCYAGENCY_BOUNDARY
ADDRESS_POINT	Must Be Properly Inside (Point-Area)
ROAD_CENTERLINE	*Must Be Inside (Line-Area)*
ESB_EMS_BOUNDARY	Must Cover Each Other (Area-Area)
ESB_FIRE_BOUNDARY	Must Cover Each Other (Area-Area)
ESB_LAW_BOUNDARY	Must Cover Each Other (Area-Area)
ESZ_BOUNDARY	Must Cover Each Other (Area-Area)
PSAP_BOUNDARY	Must Cover Each Other (Area-Area)

NOTE: The rule(s) in italics may be marked as exceptions on a per-feature basis.

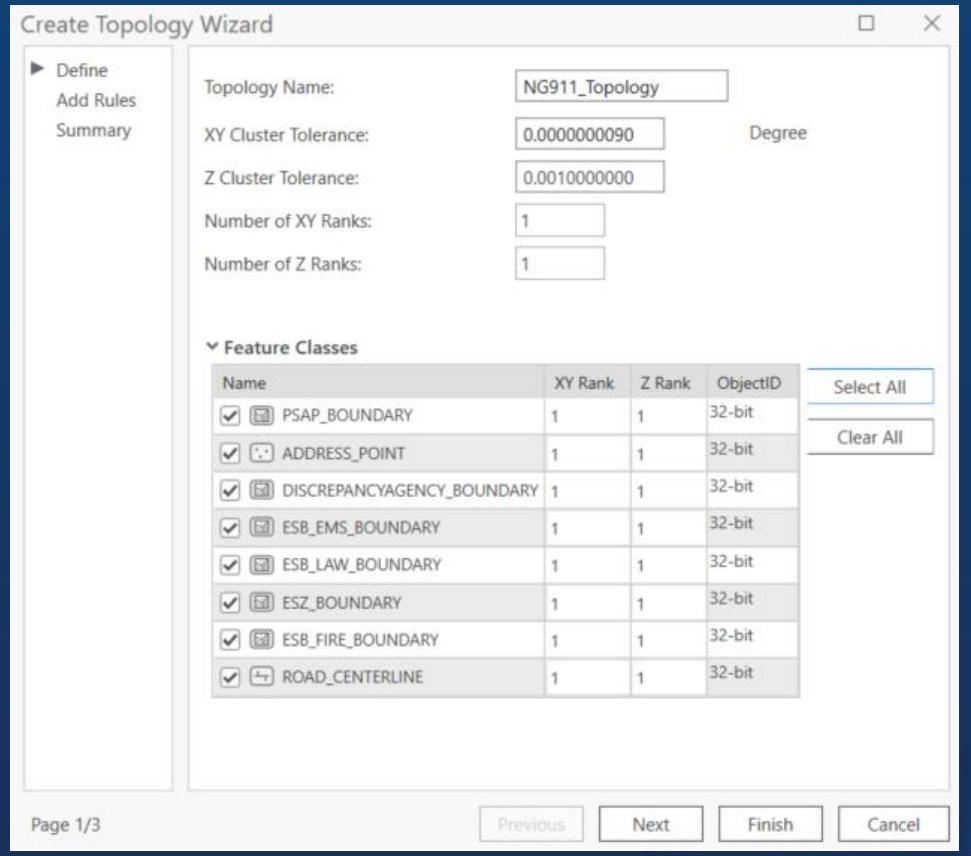
Creating a Topology

Step 1: Prepare Your Data

- Topology works only in a geodatabase within a feature dataset

Step 2: Create a Topology

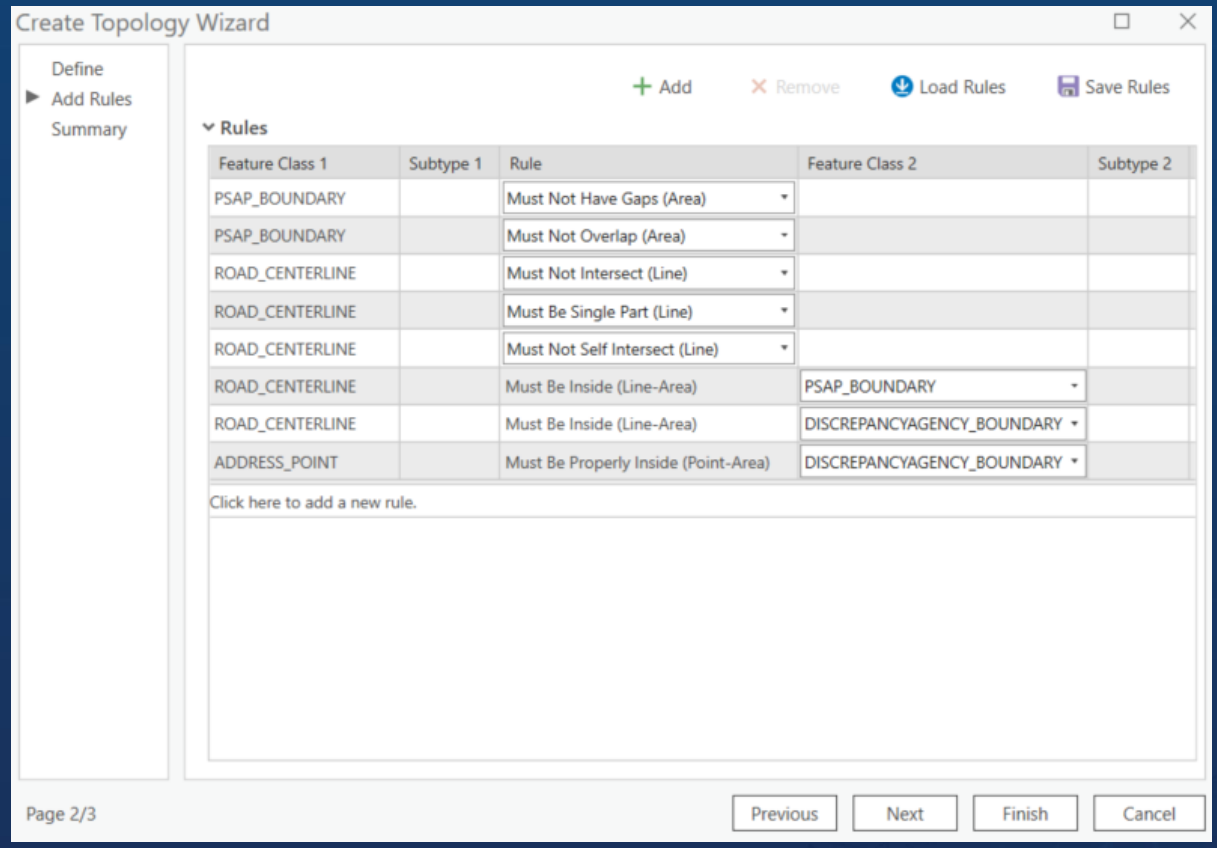
- In the Catalog pane, right-click the feature dataset → New → Topology
- The Create Topology Wizard will pop up
- Name your topology and set the cluster tolerance (default is usually fine)
- Add feature classes that will participate in the topology (Select All!)
- Assign rank (higher rank = less likely to move during validation)



Creating a Topology

Step 3: Add Topology Rules

- Choose rules like:
  - Must Not Overlap (for polygons)
  - Must Not Intersect (for lines)
  - Must Be Covered By Boundary Of (for polygons within polygons)
  - Must be Inside (for all features compared to Discrepancy Agency Boundary)

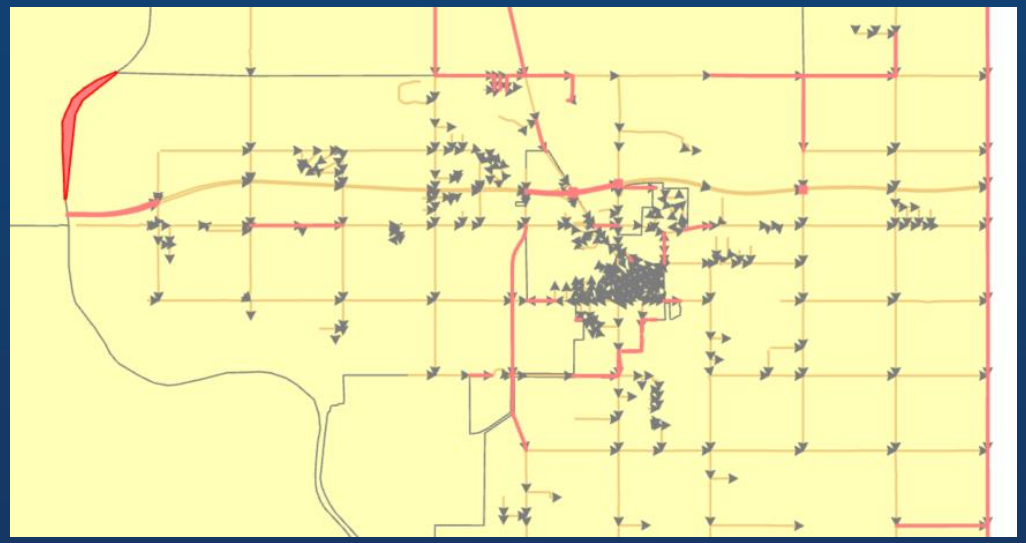


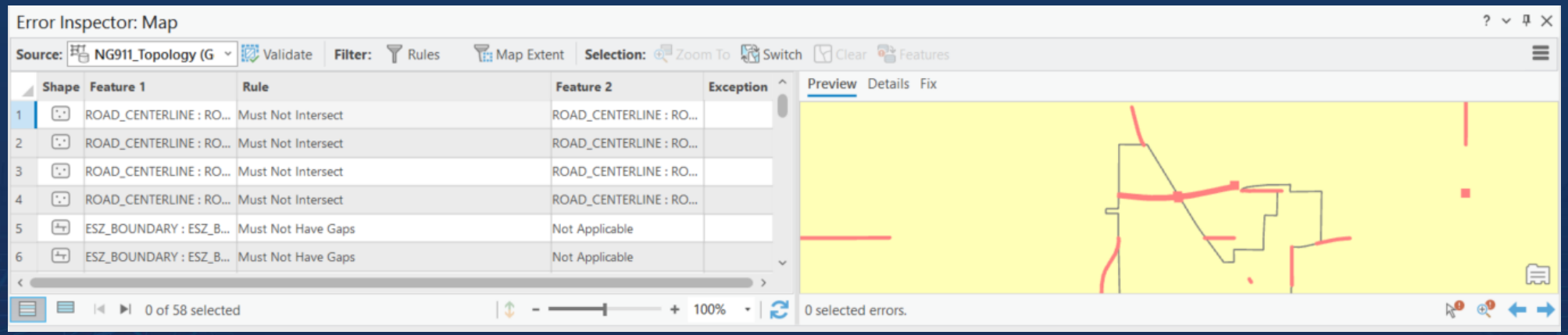
Creating a Topology

Step 4: Validate Topology and Fix Errors

- Go to Edit tab → Select the new Topology
- Open Error Inspector and Validate
- Errors will appear in the Error Inspector pane
- Use Error Inspector to locate and fix errors

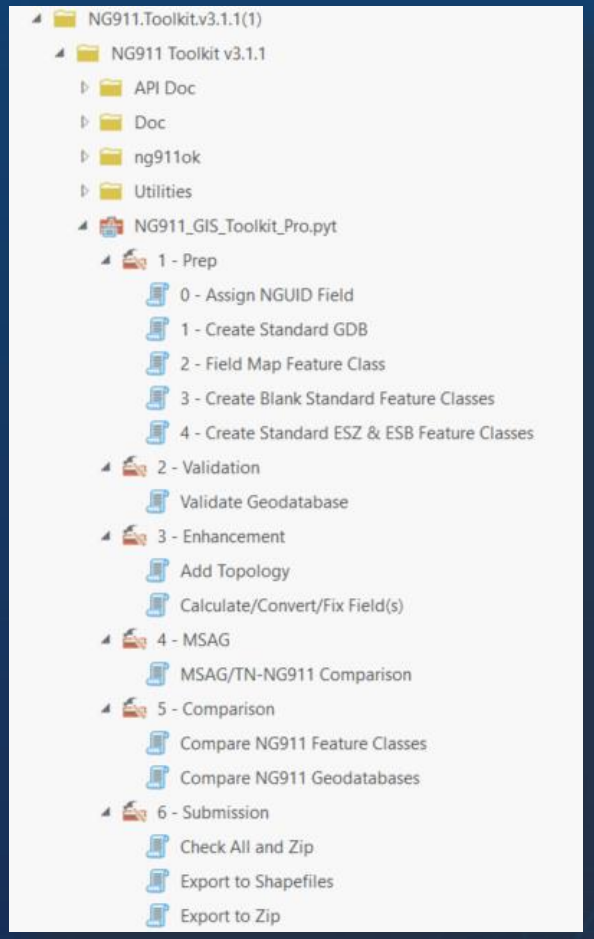
Class Exercises 1





Topology within Toolkit v3.1

- When using the Oklahoma NG911 Toolkit v3.1, a topology will be created.
- Topology rules that the toolkit generates are the rules your data **must** meet to be Oklahoma NG9-1-1 compliant and successfully submitted to repository



Geodatabase vs. Map Topology

Geodatabase Topology

- Persistent, rule based and stored in geodatabase
- Applies to all feature classes participating in the topology, whether or not they are visible in the map
- Uses defined topology rules
- Requires explicit validation
- Produces error features
- Includes tools like Error Inspector and Fix Error for organized cleanup

Map Topology

- Temporary and exists only in current map session
- Not stored with the data
- Updates as you edit features
- Applies only to the visible and editable layers within your map
- Does not use topology rules
- No validation required, no error layers provided
- Can work with layers from different geodatabases and hosted layers

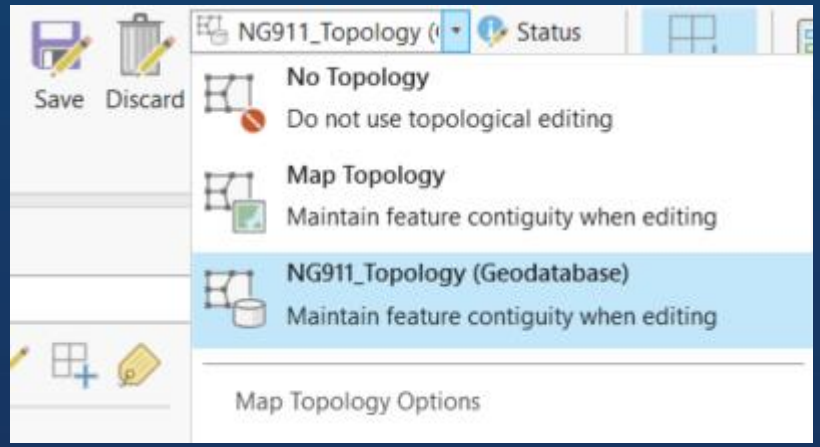
Geodatabase vs. Map Topology – Use Cases

Use **Map Topology** when:

- You need quick alignment between layers
- Data comes from different sources or databases
- You don’t control the schema
- You’re doing short-term editing or cleanup

Use **Geodatabase Topology** when:

- Data quality must be enforced long-term
- Using rule-based validations
- Multiple editors work on shared datasets
- You manage authoritative datasets



Correcting Topology Errors

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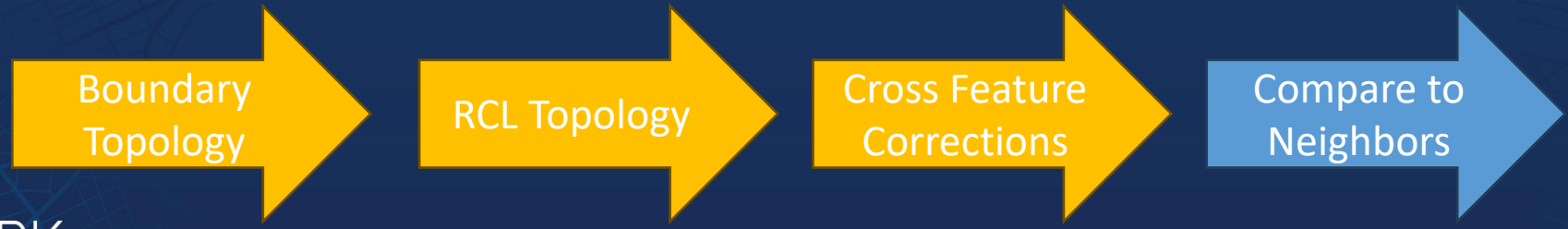
Suggested Order of Corrections

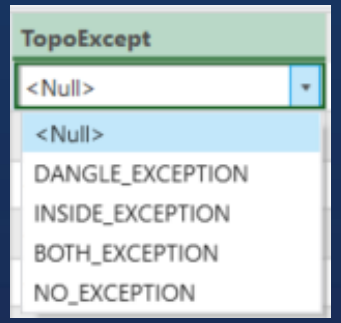
Order of corrections in applying topology through an entire feature dataset

1. Start with correcting Boundary gaps and overlaps
   - PSAP Boundary gaps and overlaps – must coordinate with State and neighboring PSAPs for external edges
   - Fire, Law, EMS, and ESZ Boundaries – correct internal gaps and overlaps locally
2. Correct Road Centerline topology
   - Intersecting/self-intersecting segments
   - Multipart segments
   - Dangles
3. Correct topology of Roads and Address Points against Boundaries
   - Roads properly snapped and split on boundary edges
   - Roads and Addresses fully contained within boundaries



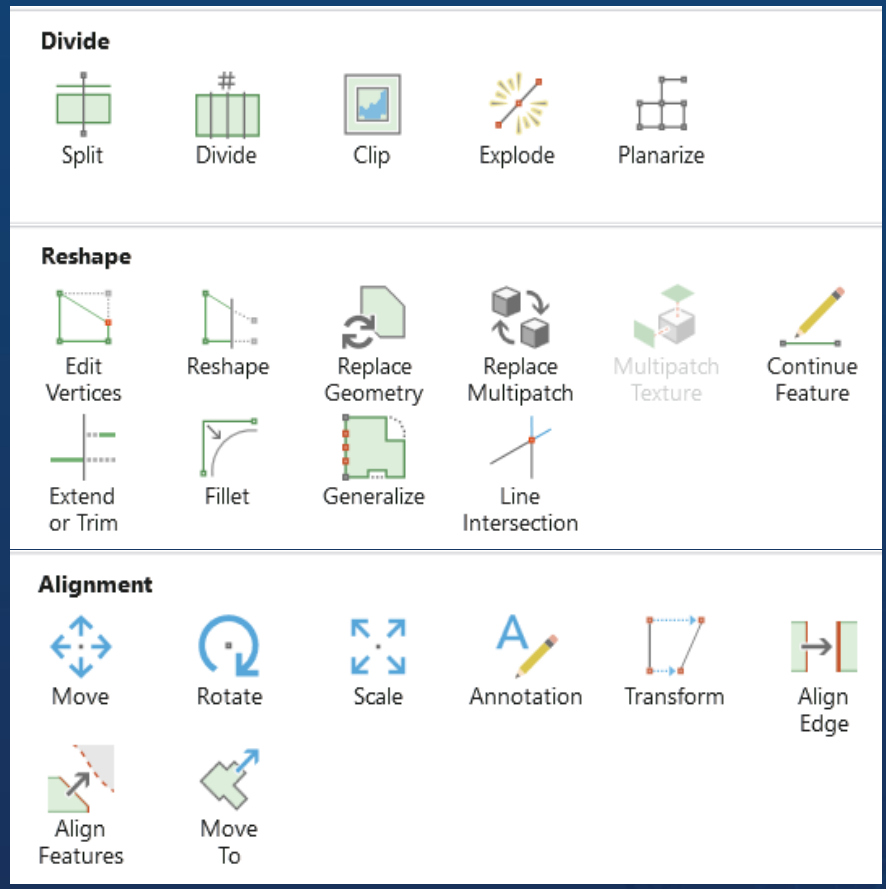
Exceptions

- An **exception** means that the data reflects the real world and no change is required
- Certain topology errors can be marked as exceptions within the standard
  - Note, *TopoExcept* is a **mandatory** field which must be populated. For features that are not exceptions, NO_EXCEPTION will be populated.
  - Within new OK Standard, there is now a *TopoExcept* field within the Address Points layer in addition to Road Centerlines
- Approved exceptions within the standard:
  - ROAD_CENTERLINE *Must Not Have Dangles*
  - ROAD_CENTERLINE *Must Be Inside (DISCREPANCYAGENCY_BOUNDARY)*



Common Editing Tools

- *Split* – use to correct intersecting roads or boundary issues
- *Explode* – use to correct multipart features
- *Edit Vertices and Reshape* – Use when adjusting road or boundary geometry
- *Align Edge* – use to align topological edge to nearest face. Can be within same feature class or across feature classes.
  - Note: Uses Map Topology
- *Align Features* – use to align multiple boundary edges or road centerlines to another feature



Class Exercises 2-10

Workflow Discussions

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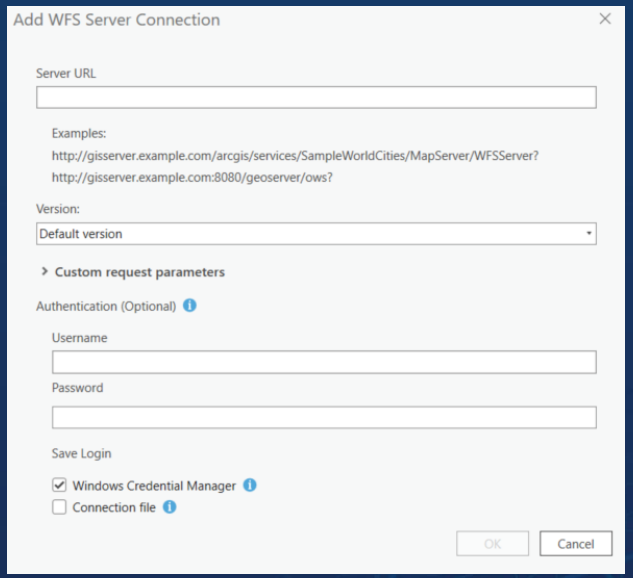
Downloading Statewide Data

OKMAPS Download

- Will allow you to pull down the last uploaded file from your neighboring PSAPs
- Statewide PSAP Boundary
  - https://okmaps.org/OGI/NG911/PSAP/OKMaps/current_okpsapboundary.gdb.zip
- Statewide Address Points & Road Centerline
  - https://okmaps.org/OGI/Downloads/address_point.zip

OKMAPS Direct Link – WFS

- The WFS connection will allow real time updates to be visible within your map, as data is refreshed in OKMAPS it will show through the service
- To add a direct connect link from the OKMAPS site, you will need to use the Esri tool “Add WFS Server Connection”
- Input the server URL and the connection will be added into your current project



Annexations

- Documentation is critical
- Do not make any changes until updates are approved
- Communicate, communicate, communicate!

Municipal_PSAPMtcGuidelines.pdf

Adding New Features – APs and RCLs

Address Point Considerations

- Placing address points on current locations
  - Not touching road segments
  - Not touching boundary edges
  - Completely within boundries
- Attributes of addresses match boundaries they exist within
  - PSAP, Incorporated Municipality, County, ESBs

Road Centerline Considerations

- Digitizing road network segments to show proper traversable intersections
- Digitizing road segments in direction of increasing addresses
- Roads are properly broken, snapped, and contained within the boundaries
- Attributes of segments match boundaries they exist within
  - PSAP, Incorporated Municipality, County, ESBs

Adding New Features - Boundaries

Boundaries within same Feature Class

- Boundaries do not contain gaps and overlaps
- It's a best practice that boundaries do not share edges with road centerlines
  - Pull roads away from boundary edges and utilize pinch points to offset road segments

Boundaries across Feature Classes

- Where boundaries should follow same edge, they are aligned properly
- Boundaries should be fully contained within the Discrepancy Agency boundary
- Boundaries should be edge-matched

Boundaries across PSAP Borders

- Must be edge matched to eliminate gaps and overlaps across borders
- Road centerlines must be properly snapped to neighboring road network for seamless connectivity

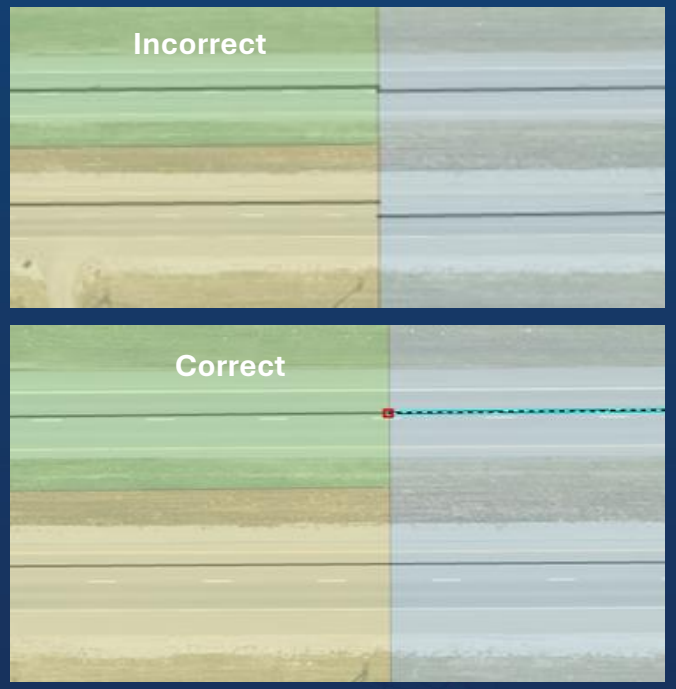
Snap to Vertex

Coordination across PSAPs

- It is **critical** that there is communication and coordination across PSAPs to collaborate
- PSAP or Discrepancy Agency boundary adjustments must be communication and submitted through the State process

PSAP Boundary Snap-to-Vertices

- Road Centerline transitions across PSAP Boundaries are required for a seamless, statewide, routable network
- Workflow:
  - Download OKMAPS data and pull into local environment to compare your PSAP data to neighboring data
  - Always verify projection prior to comparison and correction

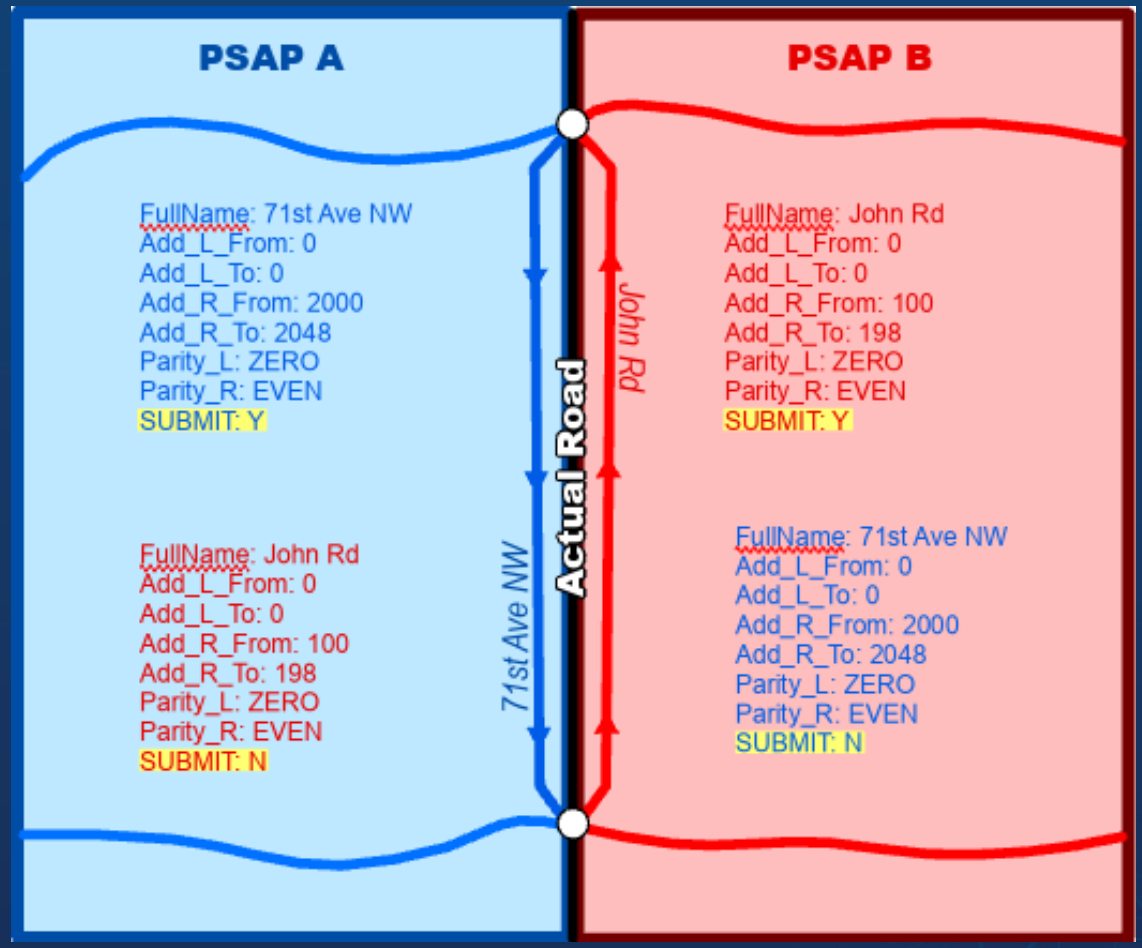


Snap to Vertex

Coordination across PSAPs

- Pinch point intersections
  - In certain cases where PSAP's are unable to resolve PSAP boundary Road Centerline conflicts it may be advisable to implement pinch intersections to allow each PSAP's Road Centerline to retain their respective data independent of their neighbor and not create a topology error within the statewide Road Centerline dataset.
  - Utilize the Submit field within the data to indicate which segment should be validated through the NG9-1-1 Toolkit validation process

Class Exercises 11 and 12



Best Practices

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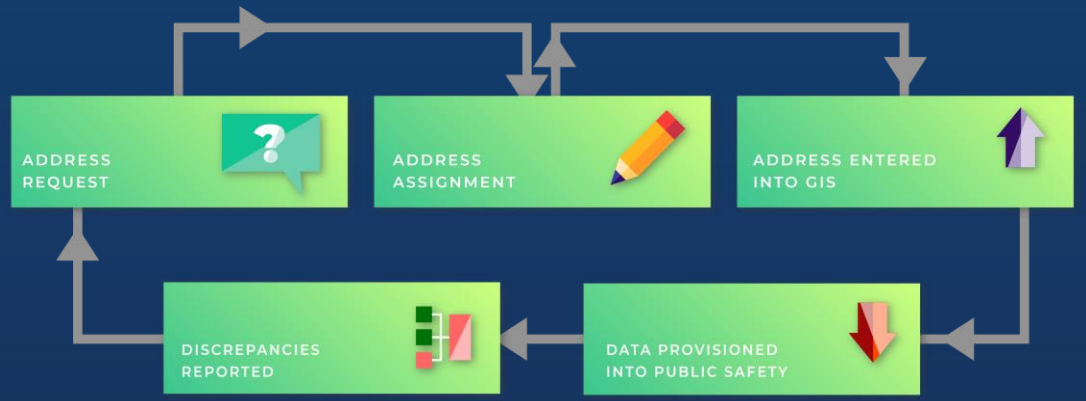
Best Practices

- Geodatabase must not be within a folder with a .gdb extension or topology will not work
- Be mindful of how other features impact data attributes
  - When splitting roads or adjusting features, update attributes to reflect the changes
- Snap to vertices of features – for road snapping and boundary snapping
- Always confirm projection of layers when editing between feature classes
- Turn off visibility or disable editing on any layers you are NOT currently modifying
- Use symbology to help you display discrepancies more effectively
- When editing vertices, press the keyboard space bar to temporarily turn off snapping while editing
- Press the “t” key to temporarily show vertices while editing

Creating a Quality Assurance (QA) Culture

- QA enforces those best practices
- Stakeholder engagement
- Business needs for data - who manages
- NG9-1-1 Education
- Improving existing workflows
- Iterative validations on NG9-1-1 data
- NOT a one and done
- Scheduled - may need more frequently if increased editing and adding data



Oklahoma NG9-1-1 GIS Toolkit v3

- Newest version of the OK Toolkit has been released and can be downloaded from the GIC site: https://www.okmaps.onenet.net/address_standards.htm
- OK Toolkit v3 is built for ArcGIS Pro and uses the newest NG9-1-1 and Address Standard Schema
- Layout of the toolkit categories and tools have been condensed and simplified from previous versions
- The OK toolkit must be incorporated in your QA/QC process and data will be required to be submitted to the OK Repository on a quarterly basis

The State will release more information regarding upcoming trainings!