How to Prepare Railroad Data For Use with ArcGIS Roads and Highways, Including Building Linear Referencing

Background

The steps below start with a line dataset of rail centerlines and a point dataset of track switches which are where three or more track lines will need to snap to. The point dataset of track switches also needs to contain points that represent bumper stops in situations where the end of a track centerline just stops *(spurs, turnouts, terminals, dead ends)*. The rail centerlines become the edges in this network, and the track switches and bumper stops serve as the junctions in the network. *For more info, contact: Jim Barry, @Esri, jbarry@esri.com, twitter: @JimBarry*

Prepping the data

While ArcGIS Roads and Highways only works when all of the data is stored in enterprise geodatabases, and served as web services from ArcGIS Enterprise, there is a lot of prep work you can do on that data using locally stored file geodatabases. The steps below do as much prep work as possible in file geodatabases, then later in the steps, the FGDBs are imported into EGDBs, for the remaining steps.

Steps

1-- Start with a FGDB containing a FDS. *(quick definitions - FGDB: File Geodatabase, FDS: Feature Dataset, FC: Feature Class)*

*2-- In that FDS there should be a PolylineMZ feature class of tracks to serve as network edges.

*3-- In that FDS there should be a PointMZ feature class of switches and track terminal bumpers to serve as network junctions.

**(Note about Steps 2 and 3: To check to see if a feature class supports M and Z, in Catalog, right click on the feature class, click Properties, then in the Properties popup, on the Source tab, check for "Yes" in the rows labeled "Coordinates have Z value" and "Coordinates have M value". If your feature classes do not support M and Z, you can use the Export Features tool and its Environments tab to ensure that the exported output supports M and Z.)*

4-- Every track polyline should start and end at either a switch point, or at a track end bumper point. Check to ensure this is true. If not, then edit them into the switch points FC.

5-- And of course since both FCs are in the same FDS, they must share the same spatial reference. If you get any errors that mention mismatched spatial reference as you put these two FCs into the same FDS, you'll need to use the *Project* tool on one or both of them to get them into the same spatial reference as the FDS.

6—Next. It's important to ensure that all of the FCs in the FDS have valid network topology. Building a Trace Network, then Enabling, then Validating topology is a great way to do this, and where topology

errors are found, fix them all until you can Validate a clean network topology for all FCs that will be participating in the LRS. For railroads, at a minimum this will be the track FC and the switch FC.

7-- Another tip, is to use an "arrow along" line symbol on the tracks layer in order to visually inspect the digitized direction of the track lines. You'll have smoother results if you can make it so that all track lines flow in the same digitized direction. When it comes to mileposts/kilometerposts, check with the railroad to understand which direction that post measurements are ascending, then fix the data so that digitized directional flow conforms. This is not required of course. It's just best practice for building a tight foundational database. And don't just check the main tracks, but also the crossovers, spurs, loops, and yards. This is not always perfectly possible given some types of track organization like U-curves, lollipops, turntables, and other structures that might pose a challenge, but do your best. The polylines that are misoriented, you can select, then use the *Flip Line* tool to flip their digitized direction to get the track data to flow in the same direction.

8-- What we're going to do below is prepare the data for use with ArcGIS Roads & Highways. To do this will follow several steps, using tools you'll find in the toolboxes: *Linear Referencing* and *Location Referencing.* Here is a list of tools, in order, that you will be using, in case you want to move them into your Favorites list:

Create Routes
Add Field
Calculate Field
Create LRS
Create LRS Network
Append Routes
Generate Calibration Points
Generate Routes
Create LRS Event

9-- Create a new column in the polyline feature class to store the route names. For the purposes of the rest of these instructions, we're going to assume that you give this field the name "*RouteName*". Populate that field with route name values, in a way that all polylines that you want to be in the same route, should get the same route name value. For example, each of the main lines along the way should be its own route from start to finish, but then each crossover, spur, and loop should be their own routes. It helps to use a consistent naming structure.

10-- In the *Linear Referencing* toolbox, run the *Create Routes* tool.

- Input line features: use the polyline FC from Step 2
- Route Identifier Field: should be "*RouteName*" *(or the name from Step 9)*
- Output Route Feature Class: if the polyline FC is called "*abc*" then call the output "*abc_routes*". *(IMPORTANT!!: The tool will—by default--try to write this output routes FC into the default project FGDB. Instead, navigate to the same FDS the tracks and switches FCs are stored in, to ensure that the new routes FC output will go into that same FDS.)*
- Measure Source: "*Length of Features*" *(don't worry, we can recalibrate later)*
- Coordinate Priority: *[Whatever makes sense for your data. What helps is if you use arrow symbology to inspect the digitized direction of your lines in order to choose the best orientation setting in this pull-down.]*

- Measure Factor, 1; Measure Offset, 0;
- Ignore spatial gaps, *check on*; Build index, *check on*;
- Click *Run*

11—Add some new columns to this new output routes FC and calculate values into them. One way to do this is to open the attribute table, then using its Add and Save buttons, then for each new field, right clicking the field header to get to the field calculator. Another way to do this is with the *Add Field* and *Calculate Field* tools. Either way:

- add two new Date columns called: `FromDate`, `ToDate`.
- add a new Text(38) column called: `RouteId`
- on the Fields ribbon, click Save, to save these new columns.
- close the Fields panel, returning to the attribute table panel.
- field calc FromDate using Python: `FromDate = datetime.datetime.now()`, or Arcade: `FromDate = Now()`, then click Apply or OK. *(Note that using Python, the time will be pulled off your machine, which is probably local time, but if you use Arcade, the time will be GMT/Zulu/UTM+0 time.)*
- leave `ToDate` *null*
- Now calculate the `RouteID` field with a Guid using Arcade: `RouteId = Guid()`.
- or…
- If you'd rather use Uuid's instead of Guid's, you can use Python instead of Arcade. If so, then write this line into the "`RouteId =`" textbox:
  `'{' + str(uuid.uuid4()) + '}'`
  And write this line into the "Code Block" box, then click Apply or OK:
  `import uuid`

12-- Create a new empty LRS: *Location Referencing tools > Configuration > LRS > Create LRS*

- Input Location: use the FDS from Step 2
- LRS Name: if your FDS is "*abc_fds*", call this new lrs "*abc_lrs*"
- Centerline Feature Class Name: default *Centerline*
- Calibration Point Feature Class Name: default *Calibration_Point*
- Redline Feature Class Name: default *Redline*
- Centerline Sequence Table Name: default *Centerline_Sequence*
- Spatial Reference: *[same as the ~routes FC in the FDS]*
- Tolerances and Resolutions: just take the defaults
- Click *Run*

13-- Back in the map, create a Group Layer called "*base layers*" and put your original polyline, point, and route FCs into it, to sort of get them out of the way.

14-- Create a new LRS Network: *Location Referencing tools > Configuration > LRS Network > Create LRS Network*

- Input Location: use the FDS that contains the routes FC you created in Step 10.
- LRS Name: Should auto-populate with the name of the LRS you had just created, which is stored in that FDS. If it doesn't appear, then you may not have been storing everything into the same

FDS, as you need to be. Important to remember that these tools often try by default to send output to the project's default FGDB. You should always navigate the output away from that, and instead send the output to the FGDB you created above where everything else is being stored

- LRS Network Name: if your FDS is "*abc_fds*" and your LRS is "*abc_lrs*", make it "*abc_lrs_network*"
- Route ID Field: `RouteId`
- Route Name Field: `RouteName`
- From Date Field: `FromDate`
- To Date Field: `ToDate`
- Derive from line network, *unchecked*; Include fields to support lines, *unchecked*; Measure Unit, *Miles (US Survey)*;
- Click *Run*

15-- Append the routes into the LRS Network: *Location Referencing tools > Append Routes*

- Source Routes: use the routes FC you created in Step 10
- LRS Network: use the LRS Network you created in Step 14
- Route ID Field: default, should be "*RouteId*"
- Route Name Field: default, should be "*RouteName*" *(or the name from Step 9)*
- From Date Field: default, should be "*FromDate*"
- To Date Field: default, should be "*ToDate*"
- Field Map section: just leave them all blank by default
- Load Type: default, should be "*Add*"
- Click *Run*

16-- Generate the calibration points: *Location Referencing Tools > Generate Calibration Points*

- Input Polyline Features: use the routes FC you created in Step 10
- Route ID Field: use the `RouteId` field from Step 11
- FromDate, ToDate: use the `FromDate` and `ToDate` fields from Step 11
- Calibration Point Feature Class: use the *Calibration_Point* layer created in Step 14
- LRS Network: use the LRS network you created in Step 14
- Calibration Direction: use *Digitized direction*
- Calibration Method: use *Geometry length*
- .
- *Note: After the tool runs, it may return a warning, despite completing successfully, with a note about M-resolutions being different between the routes FC and the LRS network. I've found most of the time that the difference is at a decimal precision far smaller and insignificant than the accuracy of any dataset you'll be using. Ultimately, that's up to you, but for most purposes, we can just keep going.*

17—Generate routes: *Location Referencing Tools > Generate Routes*

- Input Route Features: use the LRS Network you created in Step 14
- Record calibration changes…: leave *unchecked*

18—Create a LINE event layer to store linear events that record and display max speed limits along the rail line: *Location Referencing Tools > Configuration > Create LRS Event*

- Parent LRS Network: use the LRS network you created in Step 14
- Event Name: name it "*MaxSpeed*"
- Geometry Type: *Line*
- Event ID Field: *Eventid*
- Route ID Field: *FromRouteId*
- From Date Field: *FromDate*
- To Date Field: *ToDate*
- Location Error Field: *LocError*
- MeasureField: *FromMeasure*
- To Measure Field: *ToMeasure*
- Store Route Name: check on *(the default is 'off', but it doesn't hurt to turn it on)*
- Route Name Field: *RouteName*

19-- Create a POINT event layer to store point events that record and display crossings *(grade, overpass, underpass)* along the rail line: *Location Referencing Tools > Configuration > Create LRS Event*

- Parent LRS Network: use the LRS network you created in Step 14
- Event Name: name it "*Crossings*"
- Geometry Type: *Point*
- Event ID Field: *Eventid*
- Route ID Field: *FromRouteId*
- From Date Field: *FromDate*
- To Date Field: *ToDate*
- Location Error Field: *LocError*
- MeasureField: *Measure*
- Store Route Name: *checked off (default)*

20-- Ensure the FDS components hava global IDs and have editor tracking enabled

- In Catalog, navigate to the FDS you've been working with since Step 1
- Right-click the FDS, then click "*Manage*"
- In the *Properties* popup dialog, in the *Manage* tab, ensure the *Global IDs* and *Editor tracking* are both *checked on*
- When you check on *Editor tracking*, it will drop down a few field names and pull downs, just accept all the defaults.
- Click OK. And watch the process run until two green check boxes appear. When successful, the dialog will vanish.

21—Ensure the Centerline_Sequence table has global IDs and editing tracking enabled

- In Catalog, navigate to the FGDB you've been working with since Step 1
- Right click the *Centerline_Sequence* table, then click "*Manage*"

- In the *Properties* popup dialog, in the *Manage* tab, ensure that *Global IDs* and *Editor tracking* are checked on. You can check *Attachments* on or off, your choice.
- When you check on *Editing tracking*, it will drop down a few field names and pull downs, just accept all the defaults.
- Click OK. And watch the process run until two green check boxes appear. When successful, the dialog will vanish.

Maybe put all the GlobalIDs into all the tables and FCs first

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Move the data to ArcGIS Enterprise

Now you have gotten as far as you can go with FGDBs. The next set of steps involve moving all of your prepared data into Enterprise Geodatabases so that you can begin working with your data using ArcGIS Roads & Highways Server, which is an extension of ArcGIS Enterprise.

22. Create a new empty Enterprise GDB for each of the FGDBs that you want to port over.

23. run *Create Enterprise GDB* tool
- database platform - SQL Server *(for example, but whatever yours is)*
- instance – mydb *(for example, or whatever your database instance is)*
- database - *[what i want the db to be called]*
- database administrator – gdb *(for example, or whatever your dba name is)*
- database administrator password - *[your database administrator password]*
- geodatabase administrator password - sde
- sde owned schema - uncheck it
- tablespace name – *[left blank]*
- authorization file - *[Server_Ent_Adv.ecp file]*
- spatial type – ST_Geometry

23b. Create a connection to this new EGDB that you created

- Go to Catalog, in the *Project* tab, click to expand the "*Databases*" section to see if the new Geodatabase you created in Step 23 appears. If it does, move on to 24, but if not, then do these additional steps here:
    - Right click on *Databases*, and click "*New Database Connection*" from the popup menu
    - Fill out these entries on the popup dialog:
        - Database Platform: PostgreSQL
        - Instance: your db instance
        - Authentication Type: Database authentication
        - Username: your username
        - Password: your pwd
        - Save User/Password: check on
        - Database: your db name

24. once the EGDB is created, then work on permissions

- Go to Catalog, in the *Project* tab, in the *Databases* section, right click on the connection that contains your new EGDB
- In the popup menu, click on *Connection Properties*
- In the *Database Connection* dialog, in the *Database* dropdown, select your new EGDB
- Click *OK*

25. Copy the database connection into the *Folders* section of the Catalog

- Go to Catalog, in the *Project* tab, in the *Databases* section, right click your new database
- In the popup menu, click *Copy*
- In the *Folders* part of the Catalog, right click your project folder *(the one that has the icon of the yellow folder with a white house on it)* and then click *Paste*
- At that point it still has the name of the database, but rename that connection using the old sde naming convention. For example, if the database is called "*my.sde*", then if your dataset is for LA Metro, perhaps call it "*lametro@gdb@my.sde"*
- Then right click that database, then click on "*Connection Properties*" in the popup menu to open the "*Database Connection"* dialog box, to check to ensure that the database connection is pointing to the right database.

26. Ok, now that you've got all the right database connections you want, under the Folders part of Catalog, then you can start copying over everything from your FGDB into the EGDB.

27. go to the FGDB, open it up, and copy its contents to the EGDB connection

- Inside your FGDB, but not inside the FDS, find the set of 3 flat tables *(Centerline_Sequence, Lrs_Edit_Log, Lrs_Locks)*
- Copy those three tables into the root of your new EGDB
- Next, if you have a table called "*Centerline_Sequence_ATTACH*" and a relationship called "*Centerline_Sequence_ATTACHREL*", copy those over too.
- Next, if you have any feature classes that are not in the FDS, copy those over as well
- Finally, copy the entire FDS at once, and paste it into your new EGDB.
- *(Note: It's important to copy these components over separately and in the order listed above.)*
- Open the EGDB connection and refresh it to see that everything made it over.

28. run Change Privileges tool

- Input Dataset: navigate to the EGDB, then select one of the FCs
- *(If that doesn't work, then you may need to fully qualify it as '[your_server]/arcgis'. To verify that, go into Control Panel > Administrative Tools > Computer Management > Local Users and Groups > Users > find the "ArcGIS user account")*
- View: select *Grant view privileges*
- Edit: *Grant edit privileges*
- *Click Run*
- If that works, then go back to the *Input Dataset* pulldown and run the tool on the other root level FCs, and then finally the FDS itself.

29. check to see if the privileges of the layers took correctly

- Go to Catalog, and find the FDS that's in your new EGDB.
- Right click on one of the FCs inside the FDS.
- From the popup menu, click *Privileges…*
- In the Privileges popup, "*[your_server]*\arcgis" should be listed with all checks on

30. Ensure that the layers have a *Global ID* column with GUIDs in them *(both a Global ID and enabling editor tracking is a requirement for supporting branch versioning)*

- Drag one of the FDS's FCs into the map, then open its attribute table, looking for a *Global ID* column. If there isn't one, continue…
- Remove all layers from the map
- In Catalog, right click on the FDS, then select *Manage > Add Global IDs*
- In Catalog, right click on the FDS, then select *Manage > Enable Editor Tracking*
- In Catalog, right click on the *Centerline_Sequence* table, and add the Global IDs, and enable editor tracking, same as above
- Do this for any other FCs that are in your EGDB, if any

31. Enable branch versioning

- In Catalog, in the Folders section, right click on your new EGDB
- Click *Geodatabase Connection Properties*
- In the *Geodatabase Connection Properties* dialog box, change *Versioning Type* from *Traditional* to *Branch*, then Click *OK*

32. Register the EGDB contents as versioned
- In Catalog, in your new EGDB, right click the FDS, then "*Manage > Register as Versioned...*"
- Then right click the *Centerline_Sequence* table, then "*Manage > Register as Versioned...*"
- Then right click any other FCs, then "*Manage > Register as Versioned...*"

33. Create and symbolize your map

- Start a new project in ArcGIS Pro with one new Map
- Create a new database connection to where your EGDB is
- Add the FDS to the map, and make it look the way you want.
- Adding them to a group layer can help organize your map better.
- Save the project

34. Publish web services

- Ensure in Pro that you are logged into an Enterprise portal that has ArcGIS Roads & Highways installed and running (actually log into enterprise-ent with railadmin, because the transportation server is federated to it.

- Ensure that your Map Pro project contains only one LRS. If you have multiple LRSs to publish, ensure they are each in their own Pro project. Also, edit the layer names to remove the fully qualified database prefix. Just leave what you want the layer to be called.

- In the Map, on the Share ribbon: click *Web Layer > Publish Web Layer*
- In the *Share as Web Layer* dialog box
    - *General* tab:
        - Give it a name, summary, tags
        - Reference registered data: Map Image radio button *on*, Feature check box *on*
        - Copy all data: leave off, so that the data stays in the DBMS, rather than copied to the relational data store
        - Portal folder: whatever folder you want this to be in
        - Server and Folder: *https://[your_server_domain]/arcgis*, then whatever folder you want it to be in
            - In my case, we use the utilities-transportation server, because that just happens to be at this point the only server with LRS/R&H on it
            - This should be the from dropdown
        - Share with: for now, just the *Portal, private just the railadmin user*
    - Configuration tab – Left most icon
        - Layers: should show as *Map Image* and *Feature*
        - Additional layers: no need for WMS or WFS
        - Capabilities: check *on Linear Referencing* and *Version Management*
    - Configuration tab – Right most icon
        - Instance Type: change to *Dedicated instance, Min 2, Max 4*
    - Content tab:
        - Under "*My Content*", should show the portal folder your stuff is in
        - Under that should be a Map service with your layers underneath
        - Under that should be a Feature service with your layers underneath
    - Click "*Analyze*"

35. If during "*Analyze*", you get errors about data sources not being registered with the server, then right click, *Register with the Server*, then an "*Add data store*" dialog opens up. Give it Title, Tags, Portal Folder, then *Validate*, then *Create*. Also errors about sequential IDs, set that up as a property of the Map. Some of the LRS object that were not registered as versioned (the locks tables)

After that's done, click on "Manage the web layer" to go directly to the hosting server portal. Ensure that the map image layer and feature layer are published, along with the data store

https://*[your_server_domain]*/server/manager/#
--do this from any machine, even your own machine

Go into your server folder to ensure it's running

Click on Capabilities to get the REST endpoints for LRSServer and the FeatureServer

36. Now let's create an *Event Editor* web app

- The steps below are all covered thru this page here

https://enterprise.arcgis.com/en/roads-highways/latest/event-editor/configuring-the-event-editor-web-application.htm

- Use File Explorer and go to your web server root. If you're using MS-IIS, then it's usually *inetpub**wwwroot*
- Create a folder that will be your website
- Go to C:\Program Files\ArcGIS\LocationReferencing*Server11.1*\Web\RoadsandHighways\RoadwayCharacteristics Editor
- Select all contents and copy
- Go back in your *inetpub**wwwroot**[your_website]* folder, paste it all in

37. Create a Web Map

- In a browser, go to you Enterprise portal and log in
- In the *Contents* tab, in the folder you put the published web layers into, find the Map Service *(not the feature service)* and open its portal Item page.
- Click the blue "*Open in Map Viewer*" button
- Save your web map, giving it a title, tags, summary, then Save.