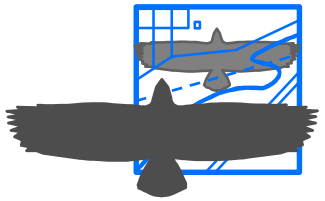

Spatially Enabling PODS

Tracy Thorleifson

Eagle Information Mapping, Inc.

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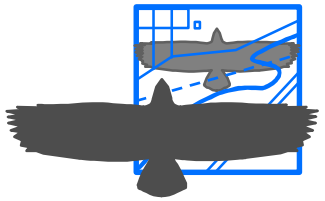

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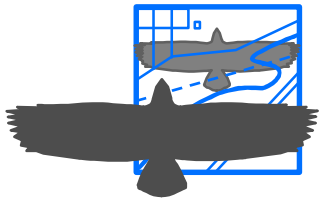

Agenda

- Review PODS core tables, key definitions and concepts
  - Core Tables (Centerline Model)
  - Systems of measurement – Stationing and Measure
  - Coordinates/Geometries
  - Events
- Discuss methods for spatially representing the PODS centerline
- Discuss methods for spatially representing PODS online events:
  - Facilities such as pipe segments, valves, etc.
  - Line crossings, inspection results, etc.

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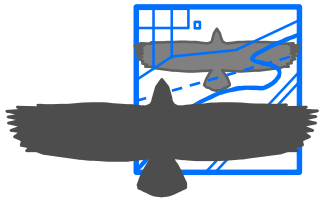

Caveats

- The PODS model is designed for use with relational database systems
  - PODS can be used with all major RDBMS's
- PODS is GIS-neutral
- PODS is well suited for use with GIS systems that support linear referencing
  - Examples are presented in the context of ESRI technology
  - The general principles shown are applicable to any GIS technology
- PODS has not yet defined best practices for spatially enabling the model
  - This presentation represents a view of work in progress, not a final definition

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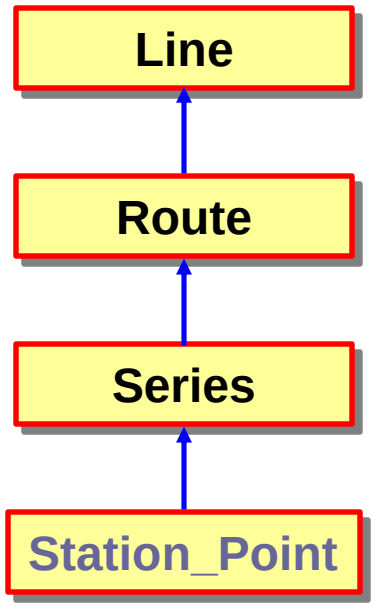
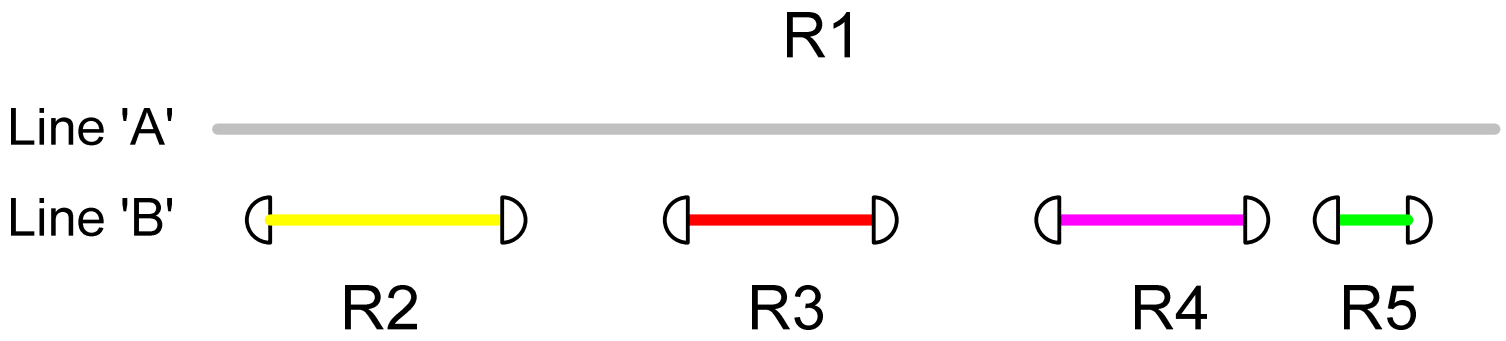
PODS Centerline Tables



- **Line**
  - Root-level centerline entity of PODS
  - Abstract – simply an organizational (arbitrary) grouping of routes
  - A line is composed of one or more Routes
- **Route**
  - A physically continuous run of pipe
    - Typically bounded by major facilities such as pumping or compressor stations
  - A route is composed of one or more Series
- **Series**
  - Lowest level centerline entity in PODS
  - A length of line defined by a continuous, uninterrupted range of engineering stationing
  - Series are bounded by station equations (discontinuities in engineering stationing)
- **StationPoint**
  - Defines a known location on the centerline
    - Location at a station point is defined in terms of Route and measure, and Series and engineering stationing
    - When lat/long or X/Y is known at a station point, the station point may be used as a control point to define the shape of the centerline

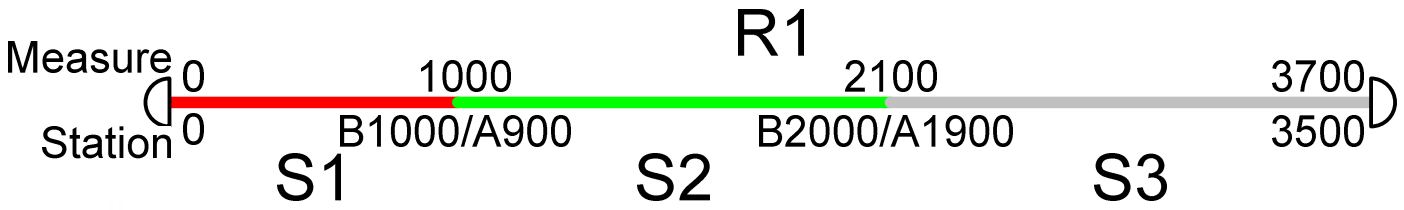
Line Entity

- An arbitrary, organizational grouping of routes
- The routes comprising a line may or may not be physically contiguous
  - Line ‘A’ consists of a single route
  - Line ‘B’ consists of multiple, non-contiguous routes
- The Line entity is abstract and conceptual in nature, and thus poorly suited to defined actual shapes



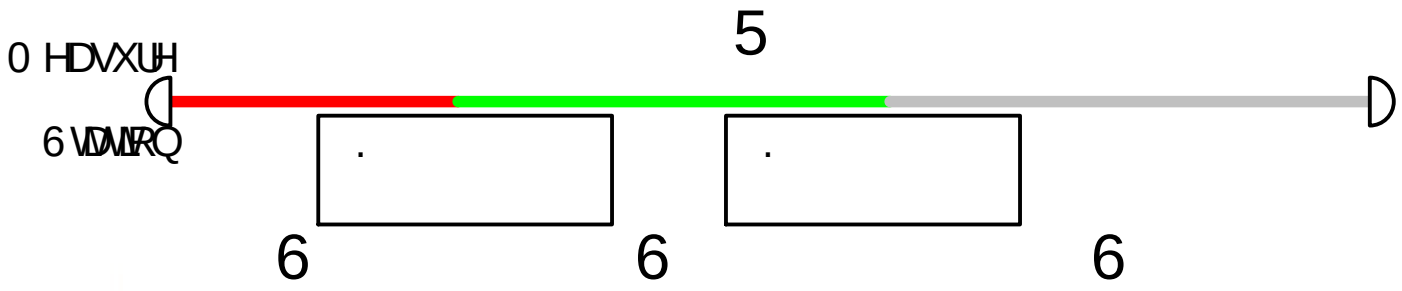
Route Entity

- A physically continuous run of pipe
  - Typically bounded by major facilities such as pumping or compressor stations
- A route is composed of one or more Series
  - Series must be contiguous end-to-end
  - Station equations (boundaries between series) are not explicitly modeled
  - Measure, the primary system of measurement in PODS, is defined at the Route level in the centerline hierarchy
  - Measure is defined by, and is a function of, engineering stationing
    - Measure scale is identical to stationing scale
    - Station equation discontinuities are removed
    - Where stationing represents slack-chain length, the total range in measure on a route defines the length of the route
- The Route entity is an ideal target for spatial enabling



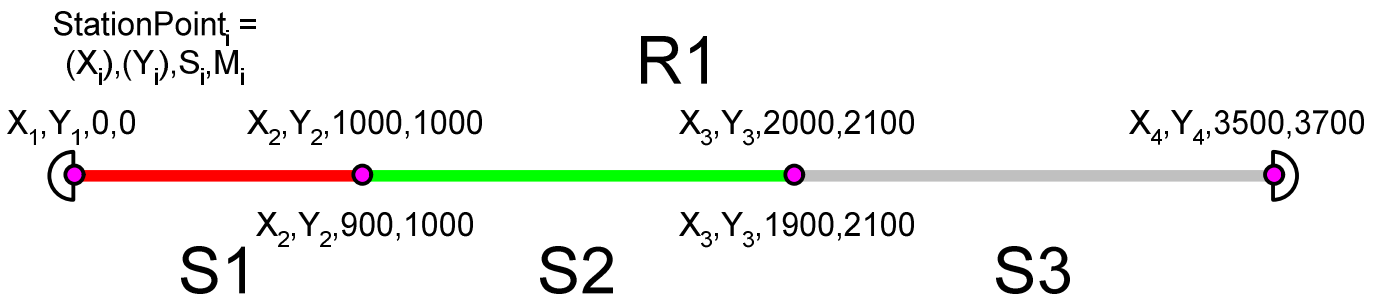
Series Entity

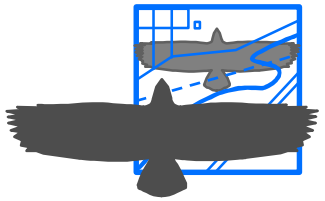
- Lowest level centerline entity in PODS
- A length of line defined by a continuous, uninterrupted range of engineering stationing
- Series are bounded by station equations (discontinuities in engineering stationing)
  - Station equations typically results from reroutes that add or remove length to the centerline
  - Stationing values downstream from a reroute are unaffected by the reroute
- The Series entity can be spatially enabled, but:
  - PODS linear events can span series
  - ESRI linear events cannot span the features they are built on



Station_Point Entity

- Defines a known location on the centerline
- Location at a station point is defined in terms of Route and measure, and Series and engineering stationing
  - (Series, Station)
  - (Route, Measure)
- When lat/long or X/Y is known at a station point, the station point may be used as a control point to define the shape of the centerline
  - Lat/Long, X/Y are not required to define a station point
  - Lat/Long, X/Y are not stored in the StationPoint table, but rather the Coordinate table
- PODS point and linear events are located on the centerline via station points
- The Station_Point entity is not suitable for spatial enabling, but:
  - Station points are used to 'calibrate' measures for M-Aware centerline features





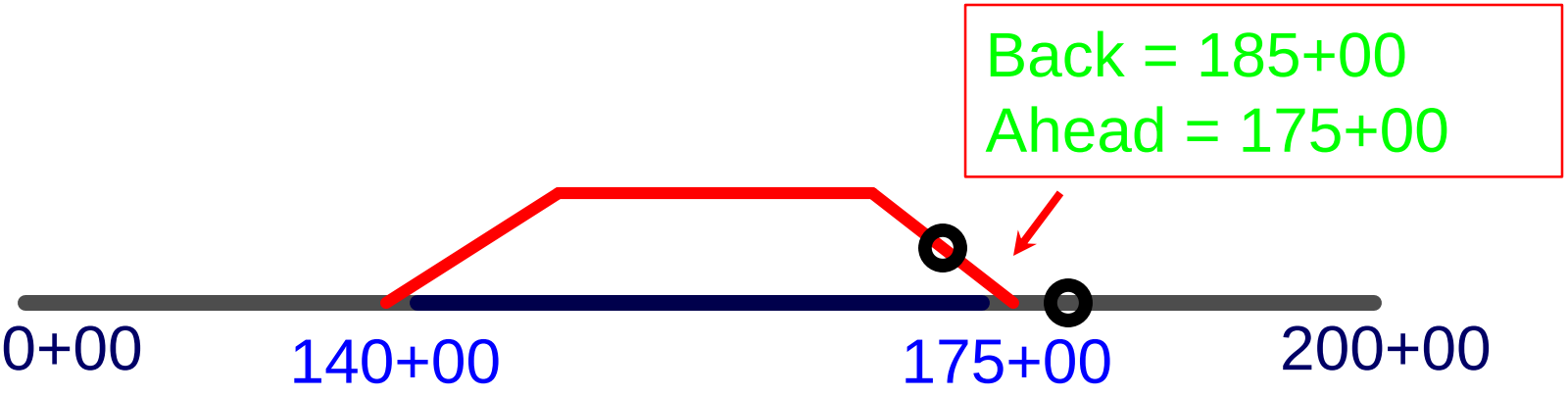
Station_Point Entity

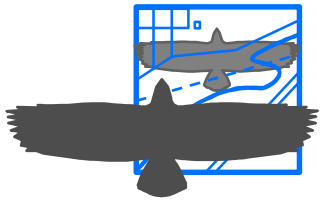
- **Station Points always capture Route,Measure and Series,Station information**
  - **In some cases, additional systems of measurement may be defined**

Series	Station	Milepost	Measure
100	0+00	0	0
100	1+23	0.0232	123
100	2+00	0.0378	200
100	3+45	0.0653	345
100	10+02	0.1897	1002
100	20+76 (BK)	0.3931	2076
200	20+26 (AH)	0.3931	2076
200	24+84	0.4799	2534
200	30+00	0.5776	3050

Pipeline Stationing - Example

- Survey stationing measures linear distances along the pipeline
- "Station equations" are used to equate stationing between two adjacent pipeline surveys





Understanding Measure

- Measure uniquely identify positions on a route
  - Engineering stationing may not uniquely identify a location along a route because of overlaps in station values between series
- Measures are “Continuous Stationing”
  - Measure removes discontinuities in engineering stationing
- Begin at Zero at the beginning of a Route
- The measure at the end of a route shows the total length of the route
- Measure is ideal for defining a linear referencing system

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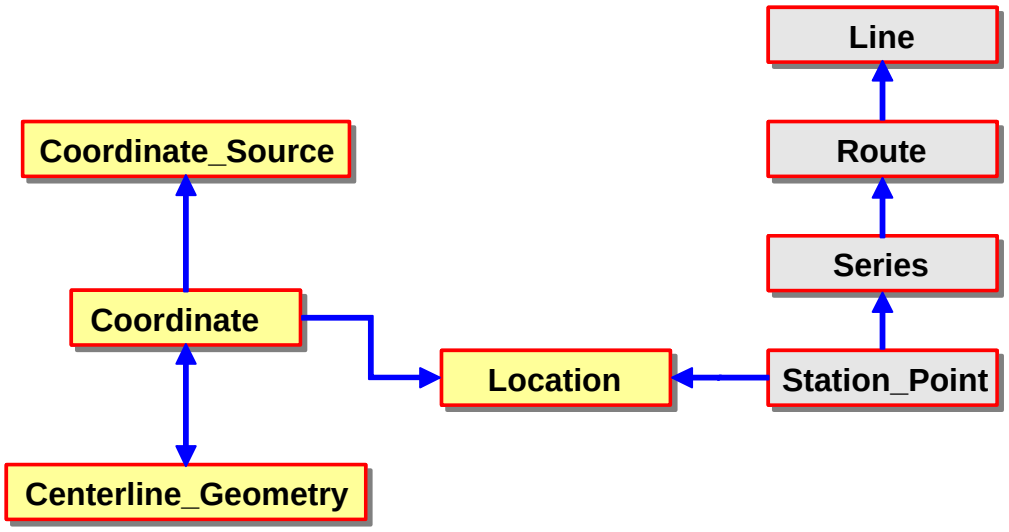
PODS Coordinate Entities



- **Location – a known location on the earth**
  - A location may have 0 → many coordinates
  - A location may have 0 → many station points
  - A location that has both coordinates and a station point can be used as a 'control point' to define the centerline
- **Coordinate – stores X/Y or Long/Lat data**
  - Global coordinate warehouse for PODS
- **Centerline_Geometry – collection of coordinates for a specific spatial representation (geometry)**
  - Multiple spatial representations of a single feature are possible
- **Coordinate_Source – metadata for coordinates**

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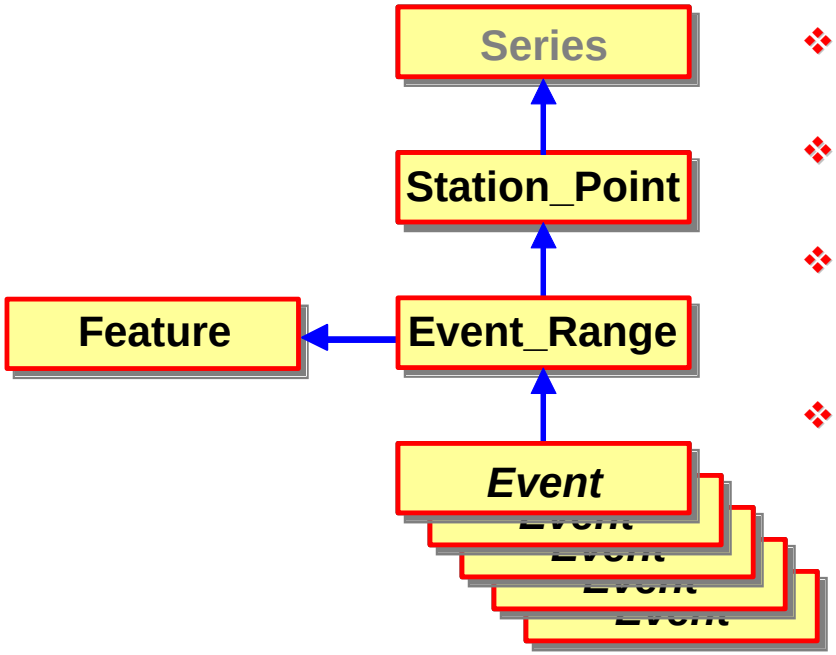
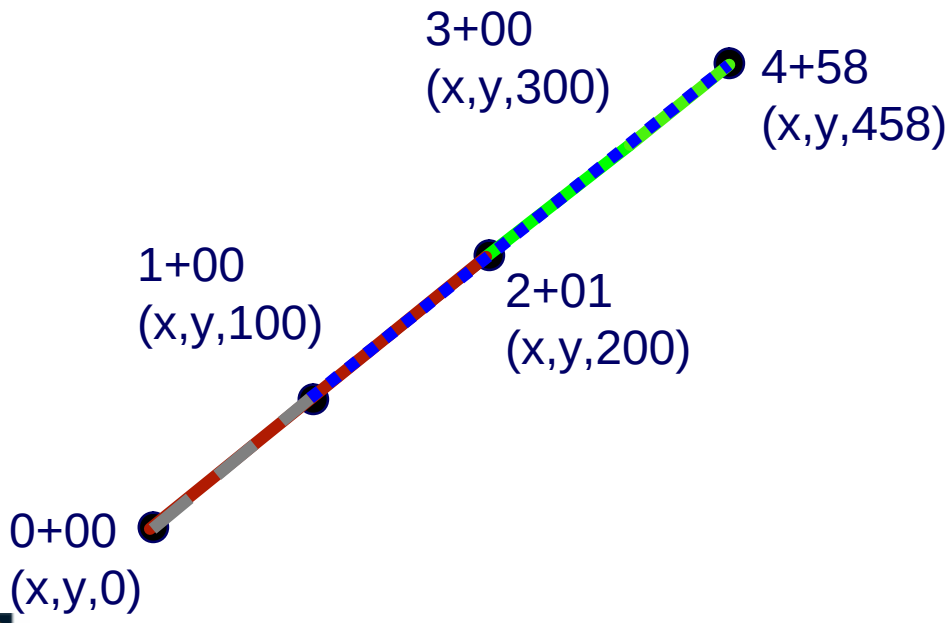
PODS Events



- A collection of attributes that are known about the pipe or its surroundings
- Data for each 'Event' is stored a separate table
- Common event attributes are defined via Event_Range
- Event location is defined in Event_Range defined via relationships to Station_Point
- Feature identifies the specific target database table in which event data is stored
- Major event categories
  - Physical Pipeline Assets (pipe, coating, valves, bends, tees, drips, branches, meters)
  - Structures
  - Regulatory & Operating (MAOP, Class Location, Test history, Leak History, Gas Temp.)
  - Crossings
  - CP (rectifers, test points, CIS, readings)
  - Inline inspection
  - Soils, excavations and repairs

Attaching Events to the Core Tables



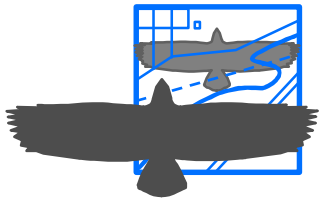
Pipe Segments

Begin	End	Attributes
0+00	2+01	30″x.281″
2+01	3+00	30″x.325″
3+00	4+58	30″x.312″

Coatings

Begin	End	Attributes
0+00	1+00	Coal Tar
1+00	4+58	Enamel

Special Considerations when Spatially Enabling PODS



- **PODS provides history capability**
  - A single 'entity' (feature) may have many historical versions
  - PODS history storage mechanisms are not thoroughly defined
    - PODS is designed for 'inline' history storage, but:
      - Some implementation use 'inline' history storage
      - Some implementations use 'offline' history storage
      - PODS 3.2 is incomplete with respect to 'inline' history storage
        - Audit attributes are missing from the Route table (and others)
- **PODS allows multiple representations of the centerline**
  - A single 'entity' (feature) may have multiple shapes
  - No commercial GIS currently facilitates multiple shapes for a single entity

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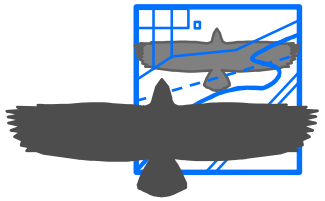

PODS-GIS Coupling Strategies

- **Tight coupling**
  - **Directly spatially enable PODS entities**
    - **If using SDE layers, make PODS tables SDE 'business' tables**
    - **If using Geodatabase feature classes, convert PODS tables directly to feature classes**
  - **Pros**
    - **Simple approach**
    - **May provide better performance in the GIS**
      - **Fewer database joins are required**
  - **Cons**
    - **'Inline' history storage for some features (e.g., Routes) is not possible**
    - **Storage of multiple shapes per feature is not possible**
    - **PODS becomes 'GIS-dependent'**
      - **Enterprise integration becomes much more complicated**
        - **Particularly when a versioned geodatabase is implemented**
        - **Existing enterprise integration software may have to be rewritten**

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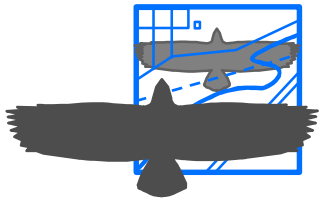

PODS-GIS Coupling Strategies

- **Loose coupling**
  - **Create standalone GIS feature classes/layers**
    - **Link to PODS tables via foreign key relationships**
  - **Pros**
    - **'Inline' history storage is possible for all entities**
      - **Audit attributes can be added to the GIS feature classes/layers if necessary (i.e., for the Route feature class/layer)**
    - **Multiple shapes per PODS entity can be accommodated**
    - **PODS linear events can be stored both as point and linear GIS features**
      - **Extremely useful for short linear events such as Casings**
    - **Existing enterprise integration software is unaffected**
  - **Cons**
    - **A little more complicated conceptually**
    - **Achieving desired performance may require competent database tuning, or better hardware**
      - **Joins are required to access PODS attribute data**

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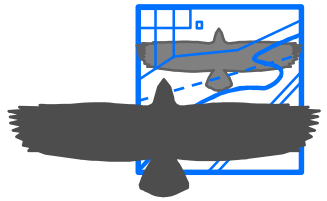
Spatially Enabling the PODS Centerline



- **The PODS centerline should be represented with an M-Z-Aware polyline in the GIS**
  - **Facilitates ad hoc posting of point and line route event layers in ArcMap**
  - **Facilitates use of route hatching and labeling and other linear referencing tools**
- **Potential candidates**
  - **Line table – not possible**
    - **Neither Measure nor Station are unique at the Line level, making creation of route events impossible**
  - **Route table – recommended – *M = Measure***
    - **Measure is unique at the route level, making it simple to post route events (and build features from PODS event tables**
    - **Drawback – linear reference measurement system is PODS measure**
      - **Most users want to see Station values, not Measure values, so custom tools to convert from measure to station may be in order**
  - **Series table – possible, but not recommended for event posting – *M = Station***
    - **PODS linear events span series**
      - **PODS events would have to broken into multiple GIS features at series boundaries**

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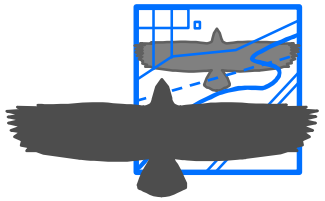
Strategies for Spatially Enabling PODS Event Tables



- **Spatially enable each PODS event table**
  - **Pros**
    - **Fewer joins are required to access event attributes**
  - **Cons**
    - ***Lots* of feature classes/layers must be set up and maintained**
- **Spatially enable the PODS Event_Range table**
  - **Pros**
    - **Only two feature classes/layers need be created and maintained**
      - **Linear Events feature class/layer**
      - **Point Events feature class/layer**
    - **Simple to maintain**
  - **Cons**
    - **An additional join is required to access event data from specific PODS event tables**

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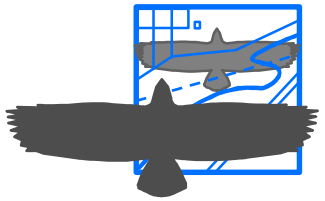

Eagle Implementation Choices

- Standalone SDE layers/geodatabase feature classes are utilized
  - Minimal impact on existing enterprise integration software
- Spatially enable the PODS Route table
  - RouteMZ layer maintains audit attributes, foreign key references to Route and Centerline_Geometry
    - Route history is maintained in the GIS
      - Multiple historical versions of each PODS route can be stored
    - Multiple spatial representations of each PODS route can be stored
- Spatially enable the PODS Event_Range table
  - LinearEvent and PointEvent layers maintain foreign key references to Event_Range and Centerline_Geometry
    - Event history is maintained in PODS
      - Multiple historical versions of each PODS event can be stored
    - Multiple spatial representations of each PODS event can be stored
    - PODS Linear events can be stored as GIS polyline or point features, or both
- Optimal performance has been achieved in all implementations to date
  - Extended stored procedures automate GIS maintenance
  - Custom tools convert Measure to Station in ArcMap

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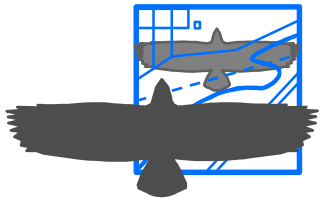

Conclusions

- PODS is ideally suited for integration with GIS systems that support linear referencing
- Multiple strategies for spatially enabling PODS are feasible
- The PODS Association has not yet defined one or more best practice strategies for spatially enabling PODS

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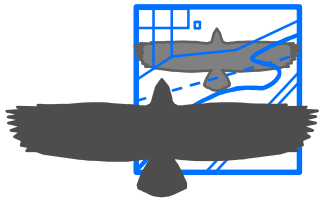

Questions and Discussion...

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