

Dynamic Segmentation in ArcGIS

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With the release of ArcGIS 8.1, ArcView, ArcEditor, and ArcInfo users can share a common environment for implementing the dynamic segmentation process in contrast to the different implementations of dynamic segmentation found in ArcInfo 7.x and ArcView 3.x. This article covers dynamic segmentation concepts in ArcGIS and discusses the linear features used to perform dynamic segmentation. In addition to defining a route, it describes the process of migrating existing route data, and provides an overview of working with routes in the ArcMap environment. Familiarity with ArcGIS fundamentals is assumed.

Dynamic segmentation is the process of transforming linearly referenced data (commonly called events) stored in a table into a feature that can be displayed on a map. For example, a stream hydrologist may record the location of stream samples based on how far upstream the samples were collected. A transportation worker may locate potholes by using the milepost location along a street.

There are two data requirements for performing dynamic segmentation. First, each event in an event table must include a unique identifier and its measurement along a linear feature. Second, each linear feature (commonly called a route) must have a unique identifier and a measurement system stored with it.

What Is a Route?

In the ArcGIS geodatabase data model, features are stored in feature classes. A feature class is essentially a table with a special field that can store a shape (i.e., geometry). Each feature in a feature class shares a common geometry type that can be point, multipoint, polyline, or polygon.

For linear features, the geometry type is polyline. A polyline is an ordered collection of paths that can be connected or disjointed. Each path is defined by a series of segments defined by x,y coordinate pairs. Optional measure (m) and elevation (z) values can be stored with any geometry in the geodatabase model so that a feature's geometry may be composed of x,y,m or x,y,z,m values rather than just x and y values.

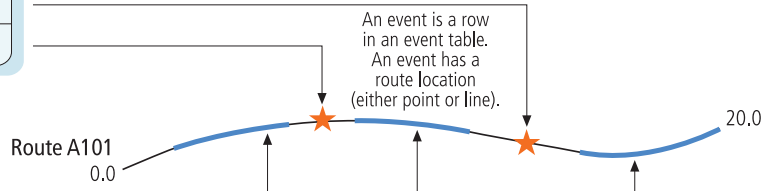
A route is simply any linear feature upon which events can be located. Examples of routes include city streets, highways, rivers, and pipelines. Events can be located along a route because the route feature has an identifier stored in a field and its geometry has a measurement system associated with it. The measurement system is

Figure 1: The dynamic segmentation process

A point event table contains many point events. Each point event has a route location.

OID	RID	Mile
1	A101	12
2	A101	7.5

A route is a polyline feature with m -values.



An event is a row in an event table. An event has a route location (either point or line).

The identifier for each route is stored in any numeric or text field.

OID	RID	From_M	To_M
1	A101	1	5
2	A101	7	9
3	A101	15	20

A line event table contains many line events. Each line event has a route location.

Figure 2: Comparing single part polylines to multipart polylines

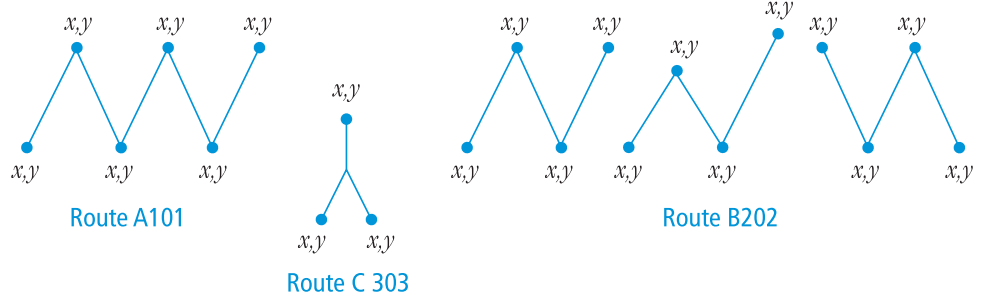
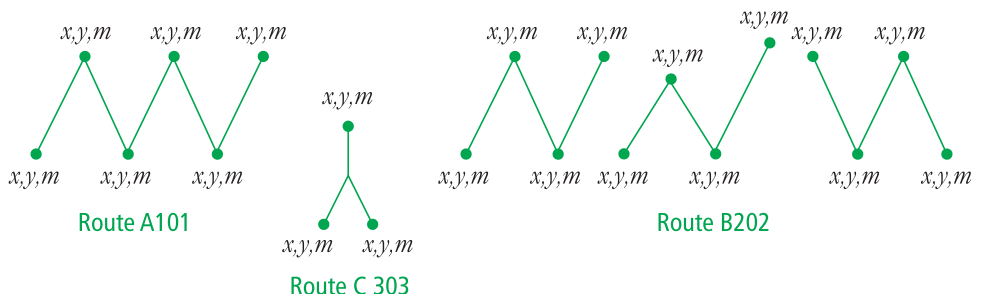
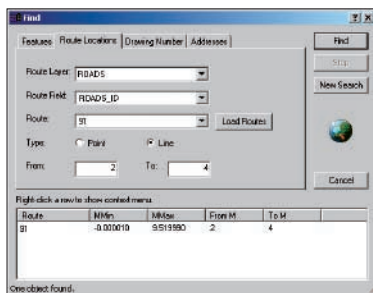


Figure 3: A polyline with x , y , and m values





A linear route location uses both a from- and a to-measure value to describe a portion of a route.

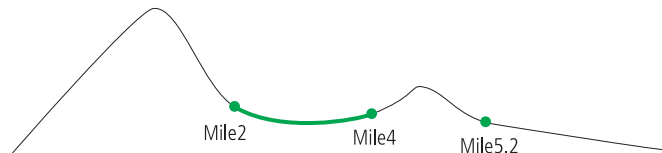


Figure 4: A point location on a route uses a single measure to describe a discrete location.

achieved by storing the optional *m* values with every *x,y* coordinate that makes up the geometry.

Setting up a route's measurement system is called calibration. The measure values can be temporal, absolute, or relative and can be determined by such parameters as geometric length, calculations based on geometric length, or other calculations such as interpolating values between mile posts, reference markers, or time points. ArcGIS provides many methods for calibrating a route's measures.

It is important to note that, even though a route's measure values are stored with the coordinates that make up its geometry, the measure values are independent of the geometry's coordinate system. This means, for example, that a route stored in Universal Transverse Mercator (UTM) in meters might have its measure values stored in feet or miles.

When required, multiple route features can share a common route identifier. In such cases, each route feature still has its own geometry and, consequently, its own measure values. However, the measure values can be set so that contiguous linear features have a monotonic measurement system and many route features can be used to mimic a single route feature for purposes of dynamic segmentation.

Because a route's geometry is simply a polyline with measures, routes can be used wherever a polyline is needed. Route feature classes are not only useful for dynamic segmentation, but can also be used in geometric networks or topological operations.

Routes in ArcGIS

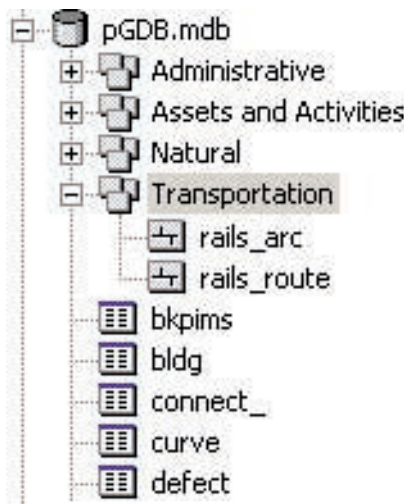
Existing route data, created in ArcInfo 7.x and ArcView 3.x using dynamic segmentation, need not be migrated to a personal or enterprise geodatabase to leverage dynamic segmentation functionality in ArcGIS. ArcGIS supports routes stored in coverages and shapefiles as well as personal and enterprise geodatabases. However, tools available in ArcCatalog, ArcToolbox, and ArcMap help users migrate data between all supported data types. Any calibration scheme that exists on route data will be preserved during the conversion.

Migrating Route Coverages

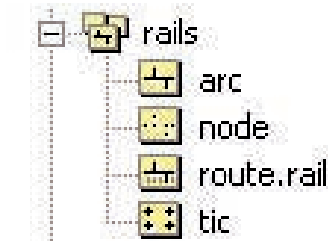
Routes stored in a coverage can easily be exported to a shapefile or a feature class in a personal or enterprise geodatabase. This process transforms each route (i.e., record from the route attribute table or RAT) into a calibrated polyline with measures values. The records from the section table

(SEC) and the arcs that make up the coverage define the geometry of the new polyline and its measures so that both the route structure and measure scheme that existed in the coverage are preserved.

The topological association between a coverage's routes and arcs will not be preserved during migration. Topology, which will be part of a future ArcGIS release, will allow topological relationships to be established in a geodatabase.



Geodatabase features class



Coverage feature class

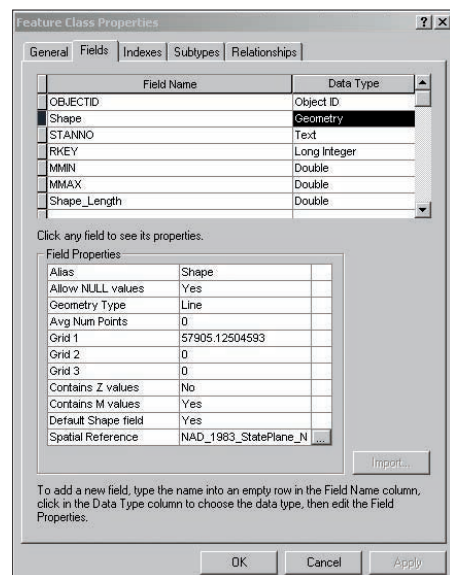
Routes in a Geodatabase

In a geodatabase, the M Domain is the range of allowable measure values a feature can support. The M Domain is attached to the Spatial Reference of a feature class. Since the Spatial Reference of a feature class cannot be changed once it is created, it is important to take the time to validate the M Domain when creating or converting route data.

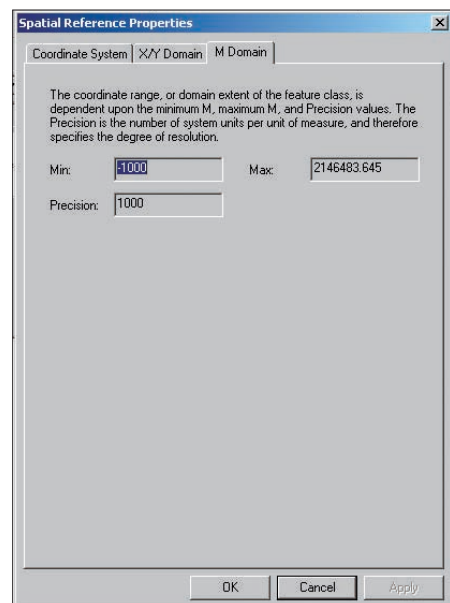
When creating a geodatabase feature class, the ability to store measure values must be defined as part of the geometry field's properties. The ability to store measure values cannot be added to existing data. Therefore, when creating a new route feature class, ensure not only that the geometry

type is linear but also that the field property "Contains M values" is set to Yes. Existing data that requires measure values storage will have to be converted to a feature class that can store measures.

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When creating a new route feature class, ensure not only that the geometry type is linear but also that the field property "Contains M values" is set to Yes.



Set spatial reference properties for the M Domain when creating a feature class.

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Working with Routes in ArcGIS

Route feature classes are created and managed in ArcCatalog and ArcToolbox. Using ArcMap, a route can be displayed, analyzed, and edited using core ArcGIS functionality. ArcInfo 7.x includes advanced route creation and editing tools. Many of these capabilities are available in ArcGIS 8.1 through ArcObjects. Future releases of ArcGIS will expose this functionality through the GUI.

Since a route's geometry is simply a polyline with measures, routes can be created in the ArcMap editing environment and ArcGIS includes a suite of geometry editing tools. When the geometry of a linear feature is modified, ArcMap obeys certain rules for handling measure values that generate predictable behaviors.

- If new vertices are added at either end of a calibrated feature, measure values will not be extrapolated on the new vertices.
- Measure values will be interpolated for any new vertices added between existing vertices with measure values.
- Measure values are not set for newly created features.
- When performing topological operations on two calibrated linear features (e.g., an intersect), the measures of the geometry selected first will be applied to the resulting geometry.

The following scenarios illustrate how these rules would be applied in real-world situations.

Scenario 1: A road feature is extended to a new housing development.

Behavior: Any vertices added to the end of the road will have no measure values. These vertices will have "Not a Number" (NaN) values.

Scenario 2: When more accurate data becomes available, a portion of a road feature was reshaped resulting in new and deleted vertices.

Behavior: The measure values for any vertices that were added or affected by the reshaping will be interpolated.

Scenario 3: A new pipeline feature is copied from a CAD construction drawing to the geodatabase.

Behavior: All vertices will have NaN measure values.

Scenario 4: Two drainages are merged into one drainage with one identifier.

Behavior: Any measure value from the input geometries will be preserved.

Scenario 5: A polyline is smoothed, resulting in deleted vertices.

Behavior: The measures on the remaining vertices will not change.

Scenario 6: Vertices are moved to align them with a more accurate dataset, resulting in a longer line.

Behavior: The measure values will not change.

Enhancing Functionality

Most of the functionality for explicitly setting measure values is currently available only through ArcObjects. Future releases of ArcGIS will include a rich suite of route editing tools. However, some additional functionality is currently available through the GUI using the Editor toolbar and Field Calculator in ArcMap or with minimal coding by using the developer sample code available from the ArcOnline Web site (arconline.esri.com).

When editing in ArcMap, the vertices of any feature, including measure values, can be viewed and edited using the Edit Sketch Properties dialog box. To access this dialog, start an editing session from the Editor toolbar, select a feature, set the edit task to Modify Feature, right-click the feature, and select Properties.

The Field Calculator performs mathematical operations and sets field values on all or a selected set of records. The calculator can also be used to set the measure values on route features. The Field Calculator facilitates advanced calculations using Visual Basic for Applications statements that process the data before calculations are made on a selected field.

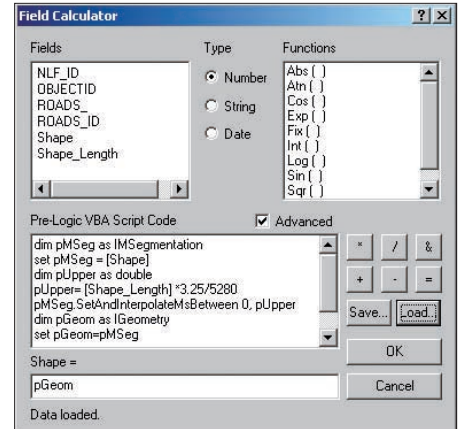
The following developer samples, available from the ArcOnline Web site, contain code that can be used to extend ArcGIS functionality. Locate these samples by selecting ArcGIS > For Developers > Samples from the main ArcOnline page. These samples include

- Identify Ms—Adds the ability to click on a route and return the route identifier and measure
- Digitize Events—Interactively create new events
- Route Editing Extension—Provides tools for performing editing operations on routes and a sample Route Editing toolbar
- Hatch Renderer—Creates a custom renderer to hatch routes

Note: The functionality provided by these and other developer samples will be available as core functionality in future releases of ArcGIS, although the GUI and implementation will be different.

Route Locations


A route location describes a portion of a route (i.e., a line) or a discrete location along a route (i.e., a point). A linear route location uses both a from- and a to-measure value to describe a portion of a route. "Mile two to mile four on Interstate 91" is an example of a linear route location. A point route location uses a single measure value to describe a discrete location along a route such as "mile 5.2 on Interstate 91." Route locations can be identified in ArcMap using the Find tool. A thematic collection of route locations stored within a database table is called an event table.



The Field Calculator performs mathematical operations and sets field values on all or a selected set of records and can set the measure values on route features.

Conclusion

Using the information in this article, users familiar with dynamic segmentation in ArcInfo 7.x and ArcView 3.x and users who have never used dynamic segmentation, can take advantage of this functionality. An accompanying tutorial, available from the *ArcUser Online* Web site (www.esri.com/arcuser), covers migrating route coverage data to a geodatabase, accessing the properties of a polyline with an M feature class, finding a route location, creating a new route feature, and calibrating Ms with the Field Calculator.

For more information on the topics covered in this article, see the white paper, *Linear Referencing and Dynamic Segmentation in ArcGIS 8.1*, available from the ArcOnline Web site at ArcOnline > ArcGIS Desktop > Technical Papers. In addition, reference documents for the Transportation data model include information on implementing dynamic segmentation within a geodatabase. 

About the Authors

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Patrick Brennan received a geography degree from Queen's University in Kingston, Ontario, and an advanced diploma in geographic information systems from the College of Geographic Sciences in Bridgetown, Nova Scotia. Brennan, who started at ESRI seven years ago in technical support, now works in product development on the Geodatabase team designing and implementing linear referencing software.

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