

The Puget Sound Regional Council (PSRC) operates under federal regulations, state planning enabling regulations, and interlocal arrangements that require the agency to maintain transportation system, demographic, economic, and land use information. This information must be maintained in a form that supports cooperative, comprehensive, and, more recently, *integrated* regional land use and transportation planning processes. Regional geographic data development has been a necessity for spatial analysis at the PSRC since the inception of the agency, and is now used to inform demographic, transportation demand, and land development modeling. It has also become necessary to extend data development to prepare to support integrated land use and transportation modeling innovations many years in advance of their implementation.

In response to requirements to maintain increasingly detailed transportation network data, and to support a future integrated modeling environment, PSRC thoroughly evaluated a new geographic information system data architecture called the *geodatabase*. Prior to an incremental transition to the geodatabase architecture, PSRC relied on proprietary spatial data "coverage" layers, with attributes that were accessed from separate database instances, and which were distributed and independently maintained by several divisions of the agency. PSRC and their consultant Cambridge Systematics developed the geodatabase data architecture that is implemented in an object-relational data model, where spatial features and their attributes, as well as additional data interaction controls and qualifiers, are maintained in indexed table records inside a single relational database management system.

Several general objectives have been realized by adopting the geodatabase data architecture to replace coverages:

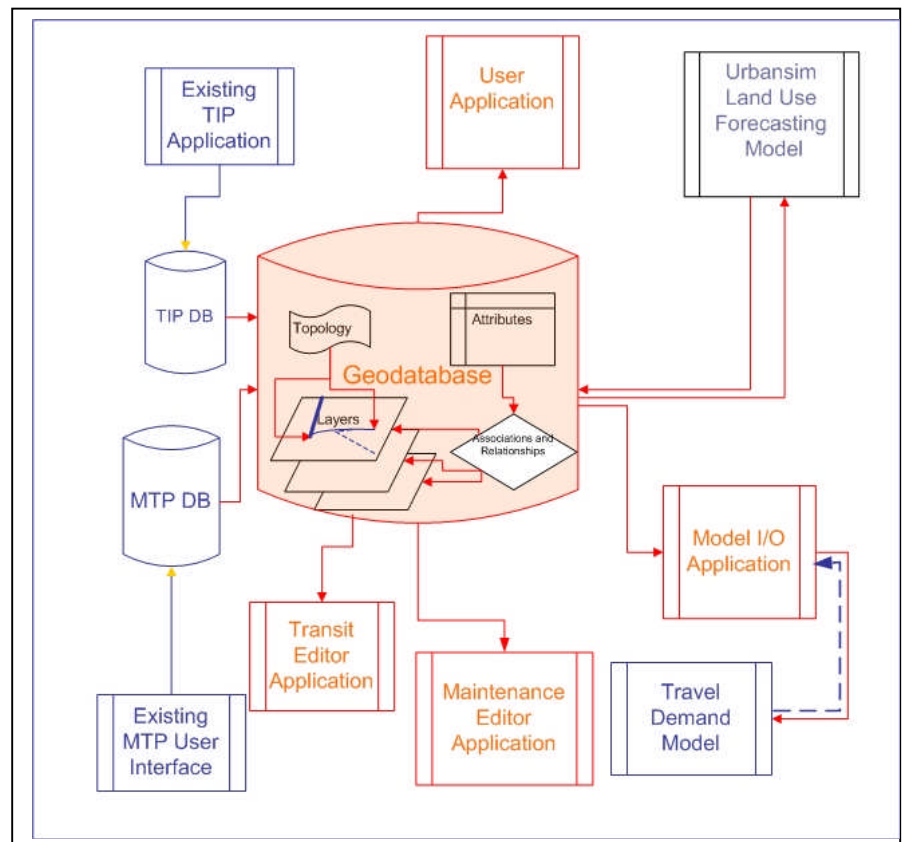
- **Spatial features are integrated with attribute data.** This has enabled the codification of relationships between spatial representations and the attribute data of transportation projects, as well as between transportation and land use features. PSRC business needs for mapping and description of Metropolitan Transportation Plan and Transportation Improvement projects can be achieved in one coherent operation. Relationships between transportation and land use features are convenient and effective at bridging elements to support model integration and incorporating multimodal interactions.
- **Data integrity and accessibility.** As the object-relational model has been implemented, a significant amount of data validation has been automated and incorporated into the geodatabase data architecture. The result has been a reduction in redundant data, a higher level of data security, and a standardization of data versions made available to users within the agency. The current geodatabase, used as a central repository, is a robust platform for integrating agency spatial features and attributes because of enforced internal data integrity.

- **Framework standards support.** The field of geospatial data management is rapidly evolving, as are transportation spatial data framework implementations and standards they are built to. Moving to the object-relational data model was necessary in the long term to adhere to the new standards, as they more frequently require object-entity relationships to implement. As the standards become widely accepted, they will enhance data sharing among transportation agencies. Through support of framework standards, the PSRC can potentially reduce data collection costs for member agencies.
- **Customization of data schema, or design.** By closely examining the PSRC business needs through many use cases, and by enumerating future data needs, transition to a geodatabase architecture served as an opportunity to refine the agency data design to fit those needs.
- **Maintenance and update enhancement.** Multi-user editing as implemented through the enterprise geodatabase has been critical to develop the maintenance editor application, and has enforced data integrity.

## Overview

The “geodatabase” now refers to a portion of the PSRC regional integrated modeling system, which consists of multiple aspects of spatial data storage and includes data structure, applications that use the data, and the data model itself. External business databases such as those for TIP (Transportation Improvement Program) and MTP (Metropolitan Transportation Plan) projects can be directly accessed through these applications but are maintained separately. The entire system consists of:

- The “geodatabase,” which contains spatial data layers and feature and layer interaction relationships. The basic transportation network comprises about 250,000 linear features and about 200,000 point features, as well as 8,000+ transit routes for modeling by time of day, and 3,000+ TIP and MTP project features. Additional line and point features overlie the basic network. These are all available agency-wide for mapping, display, and analysis through desktop GIS and database applications.

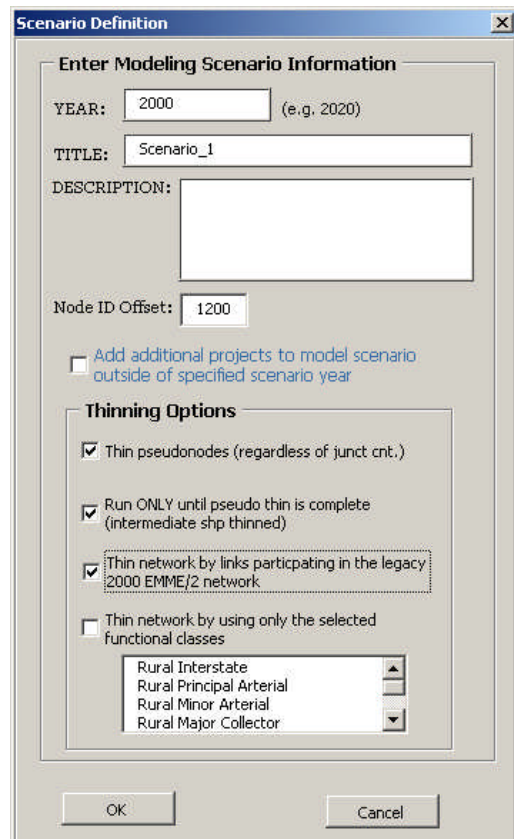


- The MTP database contains metropolitan transportation planning projects that may be included in Transportation 2040 or in previous plans, or are otherwise useful representations for travel demand modeling. MTP database tabular records are associated with their unique spatial feature through a geodatabase relationship. These are available for viewing agency-wide, in conjunction with the geodatabase or separately.
- The TIP database contains transportation improvement project applications competing for federal funding through the PSRC. TIP database tabular records are associated with their unique spatial feature, and stored similarly to MTP projects through a geodatabase relationship. While the TIP and MTP databases are instances outside the geodatabase structure, the geodatabase maintains direct connection to them, accessed as business tables. Portions of the TIP database are available for viewing at the discretion of the TIP database administrator, and the project features are available for viewing through the geodatabase.
- Several applications are informed by the geodatabase, including the maintenance editor, transit editor, and, most notably, the model Input/Output (I/O) application. The model I/O application produces model network files from the geodatabase and user specification for direct integration into a travel demand model run.

The geodatabase is based on a data structure architecture, and should not be considered as a behavior model like the models (land use and travel demand) that it supports at PSRC. Nevertheless, the geodatabase does carry data representations, associations, relationships and rules of inheritance and behavior that can inform a behavior model. The results of this method of combining spatial data with ancillary information has sometimes been referred to as a “smart” database because of the reduction in functional manipulation needed in development of applications.

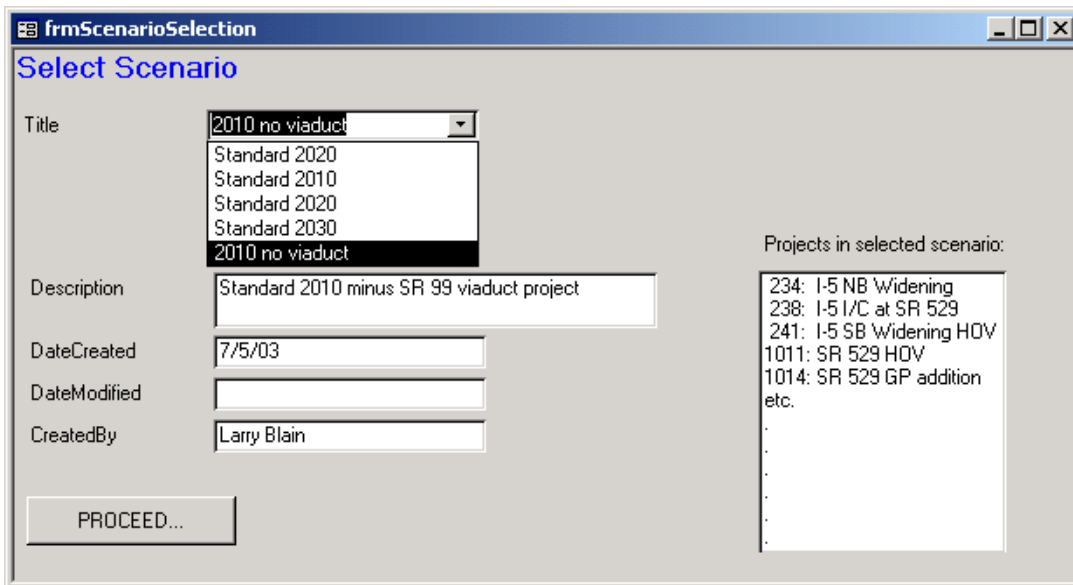
**What is the geodatabase used for?**

The geodatabase at the PSRC is used as a centralized repository of regional transportation network data, but includes most other spatial data sets that are required for business needs. It would be unusual to find a region spatial data set that is not already or will not in the future be represented in geodatabase feature classes. The centralized repository approach is valuable for the purpose of informing the travel demand model and the land use forecasting model because spatial features, attributes, associations and relationship rules within the geodatabase act to standardize data supplied to both models for the effect of integration. For the travel demand model, this integration is channeled through the Model I/O application. Data maintenance and updates are done through maintenance and transit editors. For the land use forecasting model, certain geodatabase layers are accessed to build, re-format and transfer required land use input data layers.



The Model I/O application manages the flow of data from the geodatabase to the regional travel demand forecasting model and back again. The application contains functionality that is central to constructing and managing network files for input to the travel demand model. The travel demand model network files are called *buildfiles*, and consist of consecutive labeled link and node records in a specified format. The model I/O application prepares all model buildfiles needed, including node, link, turn penalty, custom attributes, toll, and transit buildfiles that are based on a scenario defined by a geodatabase user. Buildfiles for one scenario are created for five specific time of day periods to match those used in the travel demand model (AM peak, midday, PM peak, evening, and night) for available general purpose links and transit routes. Currently, transit routes are limited to AM peak and midday time periods. One or more time periods may then be selected for travel demand model assignment.

Scenarios are created by the user by assigning a title, setting a horizon year, entering a text scenario description, defining a filter for the extent of the network, and entering individual projects, a filtered selection of projects, or by selecting a pre-constructed list of projects. Individual projects may be added to or deleted from the pre-constructed lists.



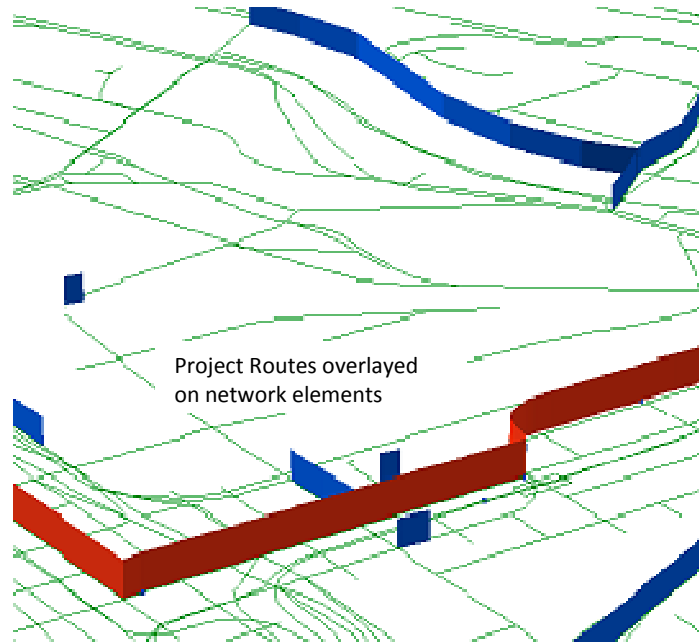
The Model I/O application also contains an entry point for “output retrieval” to manage display of travel demand model output on the network created by model input. After an assignment or a full travel demand model run, the application can import selected model outputs back into the database for visualization and analysis. The user may choose among many model output attributes by link and by time of day. For example, volumes may be displayed by line symbology at a selected scale range.

The Maintenance Editor application manages multimodal, multiuser network edge and junction structure to add, delete, modify, or reshape the basic network, as well as project features and transit routes that overlay the network. It tailors GIS staff network editing and data management to take advantage of built-in geodatabase data integrity and validation features.

The Transit Editor application manages the TransitRoutes and TransitPoints feature classes to add, delete, modify or re-route them coincident to base network edges of the proper subtype.

## How does the geodatabase operate?

The geodatabase is implemented within the ArcGIS geographic information system (GIS) in an enterprise form, where individual or combinations of layers can be accessed through a rich geographic user interface for display, query, or geospatial analysis. The enterprise form at the PSRC employs the SQL Server relational database management system to house the geodatabase itself, and a database connection is used for correspondence and control between the GIS user and database. Use of the relational database management system enables the full scale of geodatabase functionality, including versioning for a temporal dimension, and multiuser editing. MTP and TIP project records are also housed within a SQL Server database, convenient to connect to project spatial features through the geodatabase.

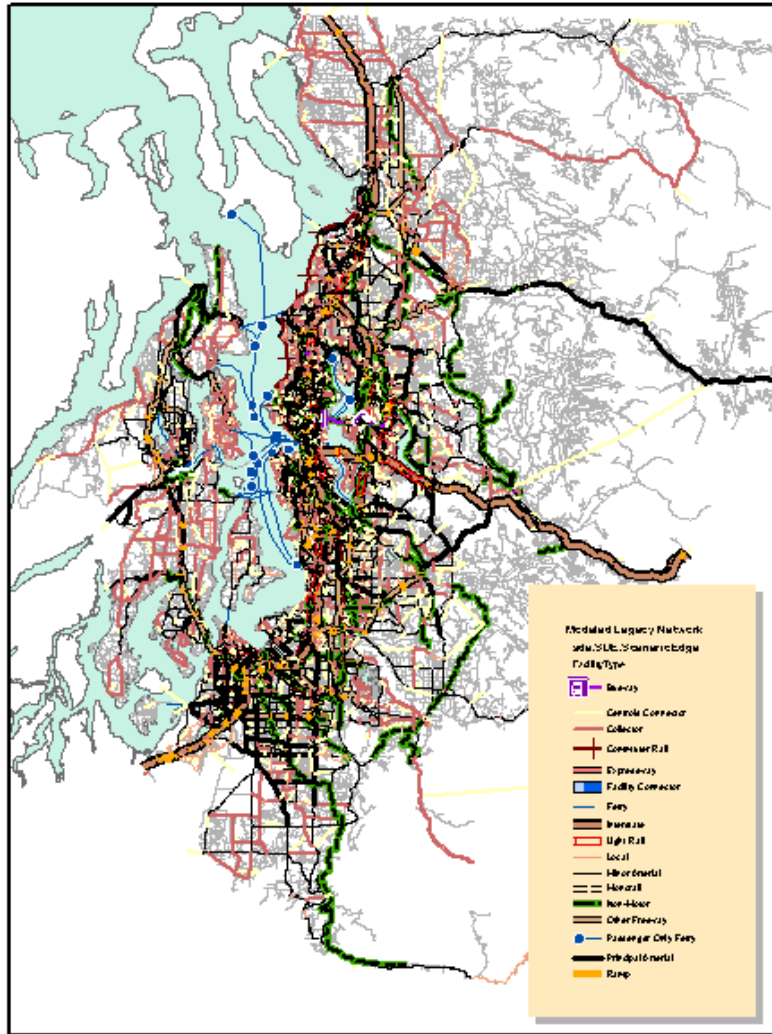


There are two important basic data elements that make up the transportation network; *edges* and *junctions*. Edges are curvilinear chains of vertices, or coordinate pairs, and they are generally the smallest vector element that can be attributed. Junctions are, in the PSRC schema, the endpoints of edges. Together, edges and junctions define the network and intersections of modes in the regional transportation system. The geodatabase enables collections of edges and junctions to be defined as layers, or *feature classes*. Multiple feature classes between which many data associations are expected, such as between edges and junctions, can be grouped together into a *feature dataset*. At the PSRC two layers named TransRefEdges and TransRefJunctions contain features comprising a planar representation of the entire regional transportation network. These are combined with several layers that are coincident with edges and junctions into the "Transportation" feature dataset. One of these layers represents spatial locations of existing or proposed transportation projects, called ProjectRoutes.

ProjectRoutes are limited to the spatial feature representations of records from the MTP and TIP databases that can be mapped. A core concept of the PSRC transportation reference network design is that "all ProjectRoutes must Start and Stop at Junctions," meaning that there are no fractions of underlying network edges associated with projects. This concept is carried through all layers in the transportation feature dataset and all maintenance operations as well, avoiding the need for measuring features by linear referencing. Through this design, ProjectRoutes associated with the underlying network enable the user to gain transportation attribute summations by an inclusive overlay of combinations of projects.

Edges and junctions are classified by the transportation mode or network component they represent, the classifications called *subtypes* within their feature class. In the PSRC geodatabase there are currently 16 linear subtypes operating to accomplish multimodal connectivity:

- Interstate
- Other Freeway
- Expressway
- Ramp
- Principal Arterial
- Minor Arterial
- Collector
- Local
- Passenger Only Ferry
- Ferry
- Non-Motorized
- Monorail
- Light Rail
- Commuter Rail
- Facility Connector
- Centroid Connector



These subtypes are designed specifically for use at the PSRC to address model integration. Most are a hybrid combining aspects of Federal Functional Classification, travel demand model facility types, and physical or capacity characteristics. Centroid

connectors and facility connectors are special subtypes used to support data associations that may not depend on physical network features, but are needed for integration with the travel demand model. Centroid connectors are a model abstract subtype to carry underlying travel demand model area characteristics of Transportation Analysis Zones (TAZ). Facility connectors link transportation point locations such as stations, transit centers, and park and rides to the network. Facility connectors may represent road or walkway geometry if it is available.

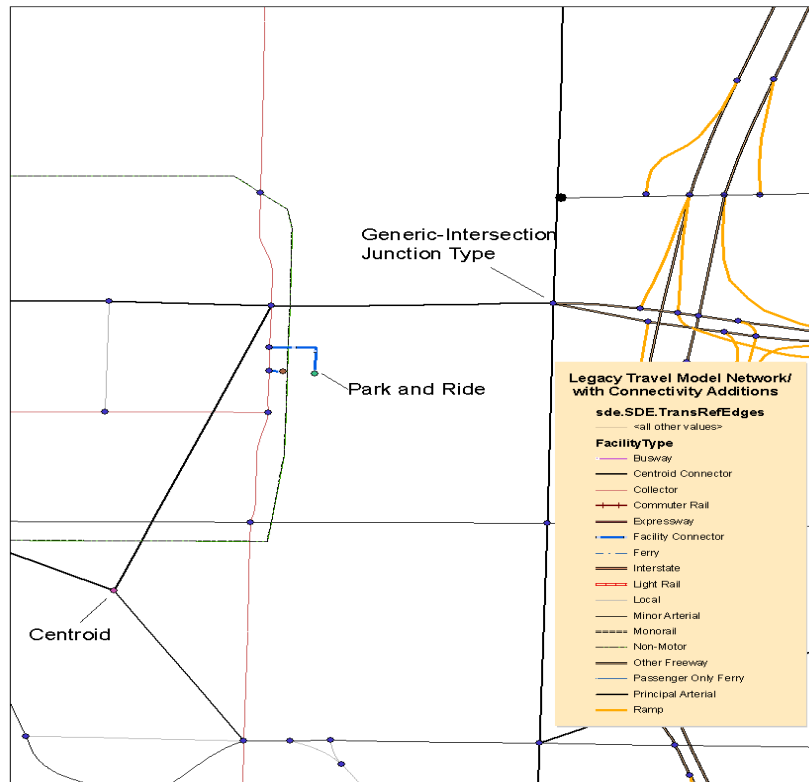
Junction subtypes are used to identify and attribute point/node locations required in the travel demand model, particularly those that represent travel attractions and productions through centroid connectors and facility connectors. These include (TAZ) centroids and park and ride facilities. Transit station subtypes are also implemented but are not currently used directly in the travel demand model.

Every edge is managed with an association with one record in a table *modeAttributes*, where key travel model attributes are maintained. These attributes were originally transferred from the travel model for edges that participated in a sub-network that represented the “legacy” model links; subsequently the entire geodatabase transportation network was populated. In the geodatabase schema, high occupancy vehicle lanes (HOV) are captured not as a subtype but as an attribute value in *modeAttributes*.

The park and ride junction is the only junction subtype managed in association with records in the table *PRAssets*, where both current and future travel model attributes and current park and ride facility inventory values are maintained.

*TransitLines* make up a major linear transportation feature class within the Transportation feature dataset. The *TransitLines* feature class was originally designed to represent a travel demand model generalization of bus, rail, and other transit routes, but has since been expanded to include additional route detail. *TransitPoints* now are situated at junctions along a transit route to mark an attribute change on the next *TransitRoute* segment. In conjunction with *TransitPoints*, segments of *TransitLines* trace individual existing or proposed transit routes for travel demand model assignment of mode split.

A construct for *Turn Movements* is included to emulate the travel demand model turn penalty behavior. Restrictions for one turn direction are represented by a route with two roadway edges and their one shared roadway junction, along with an impedance value. Where many turn directions are possible at an intersection, there is one turn movement route for each direction. Turn movements are used only where there is a restriction or penalty imposed; most network intersections are not limited or are limited through other mechanisms such as topology rules.



Over time major changes to the transportation feature dataset, as well as changes to the geodatabase schema have affected the way it operates.

- Divided highways and ramps were added to the network, and support for divided highway use in the travel demand model was developed. Handling of directional attributes improved in model I/O application. (2008)
- *TransitPoints* added. (2007)
- Transit routes were altered to use divided highways and ramps. (2008)
- Schema changes included additional subtypes/modes for passenger only ferry and others. (2008)
- Topology replaced the original dependence on connectivity. Connectivity between network mode subtypes was exhaustively charted, to be used to create and maintain a "geometric network" for the purpose of network tracing. Initial testing revealed incompatibility between use of a geometric network and the application of some needed rules within the transportation feature dataset. (2006)
- Non-Motorized Facilities (trails) linked for access to roadway network (2008)

- Travel Demand Model base year link attributes and transit routes updated from base year 2000 to 2006 (2006-7)
- Park and Ride locations and model characteristics updated subsequent to travel demand model updates. (2000-2009)
- Turn movements eliminated or re-configured where divided highways and ramps were added. (2008)

### ***What data are used in the geodatabase?***

The current geodatabase layers were acquired from various sources, the most extensive of which are pre-existing GIS coverages and, for the transportation feature dataset, travel demand model link attributes and tables. Additionally, the PSRC GIS staff contributed substantial updates and corrections during the multi-year transition from coverages to geodatabase layers, when required maintenance and review of both data structures revealed inaccuracies. The original transportation network, prior to use in the geodatabase, was derived from four GIS coverages acquired from Pierce, Snohomish, King and Kitsap counties, and merged for the region. This was used as the initial network to fit travel demand model base year 2000 “legacy” links using a 2000 base year. Edges and junctions were added to represent the entire 2030 link set. Centroid connectors were created by programmatically forming edges between centroids and load point coordinate pairs.

As the travel model network was updated to the present 2006 base year and including a 2040 horizon, the updates were incorporated into the geodatabase through manual editing in conjunction with validation of topology rules.

### **Additional Information**

- Enterprise Geodatabase for Local Government. ESRI White paper March 2009:  
<http://www.esri.com/library/whitepapers/pdfs/enterprise-gis-localgov.pdf>