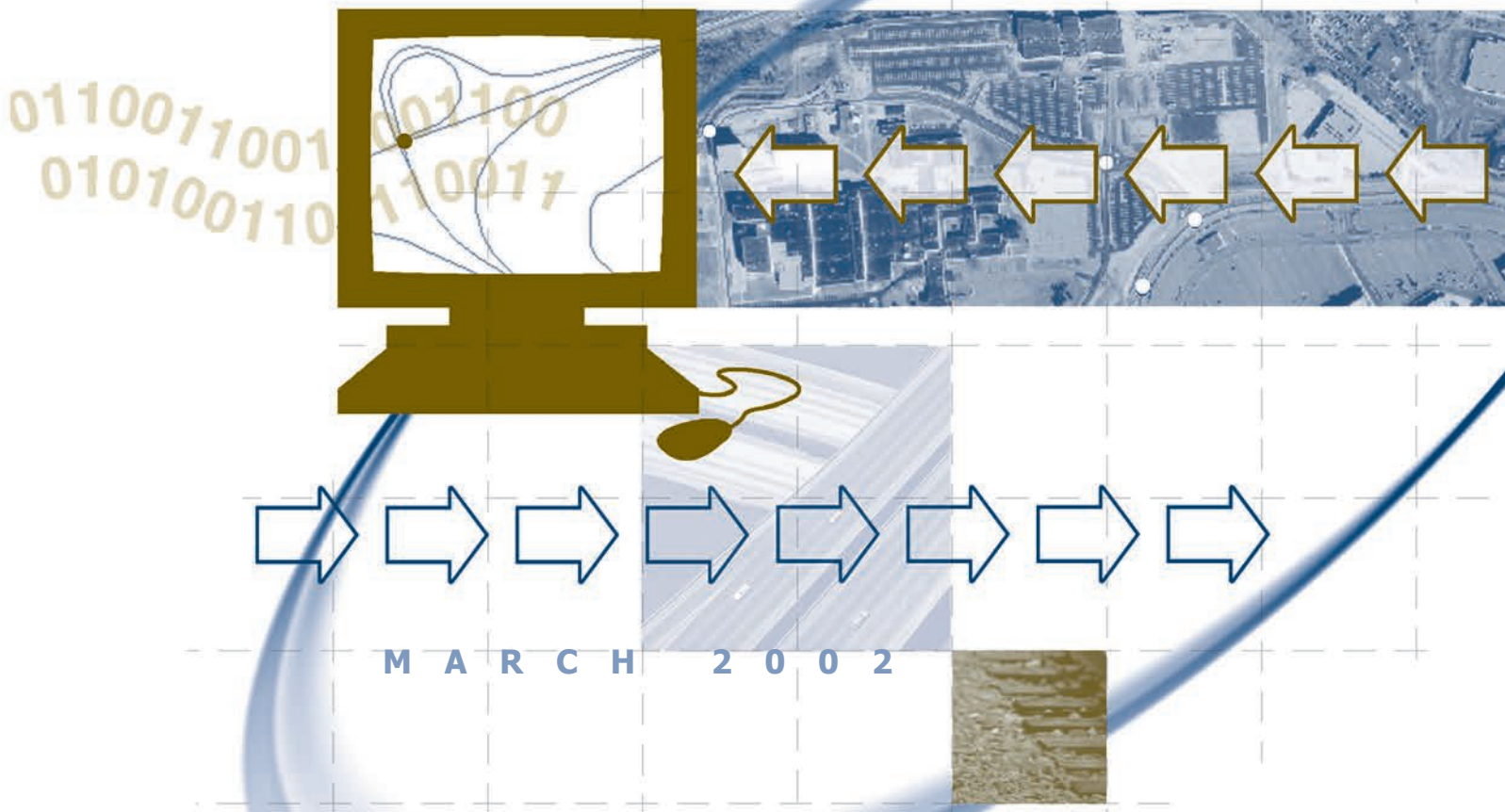
VOLUME IV - IMPLEMENTATION PLANS

Region-wide Transportation GIS Project Design and File Architecture



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Prepared For
The Delaware Valley Regional Planning Commission By:

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A Joint Venture

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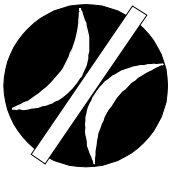
DELAWARE VALLEY REGIONAL PLANNING COMMISSION

Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty and intercity agency that provides continuing, comprehensive and coordinated planning to shape a vision for the future growth of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties, as well as the City of Philadelphia, in Pennsylvania; and Burlington, Camden, Gloucester and Mercer counties in New Jersey. DVRPC provides technical assistance and services; conducts high priority studies that respond to the requests and demands of member state and local governments; fosters cooperation among various constituents to forge a consensus on diverse regional issues; determines and meets the needs of the private sector; and practices public outreach efforts to promote two-way communication and public awareness of regional issues and the Commission.



Our logo is adapted from the official DVRPC seal, and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole, while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The preparation of this document was funded by grants from the Federal Highway Administration and the Pennsylvania Department of Transportation. The authors, however, are solely responsible for its findings and conclusions, which may not represent the official views or policies of the funding agencies.

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Tactical Implementation Plans

I. Background

The final phase of the project consisted of the development of tactical implementation plans for DVRPC, its member organizations, and the regional operating agencies. These plans are tactical in the sense that they provide recommended tactics for each of the participants that can be used to implement the recommendations developed through this project. The characteristics of each plan are reflective of the position of the participant on the scale of the four stages of street centerline development. The purpose of each plan is to facilitate the implementation of the common LRS/street address geocoding approach in developing a GIS database for transportation planning.

The predominant GIS software currently being used by the DVRPC member organizations is the family of products developed and sold by ESRI. For this reason, the technical approaches and the training recommendations described in the following sections are based upon the latest generation of ESRI software, which as a group, is referred to ArcGIS.

These plans outlined in Appendix A address four primary tactical areas: (1.) centerline linework development, (2.) database development, (3.) computer hardware and software and (4.) staffing and training.

I-1 Centerline Linework Development

The first phase of each plan addresses the participant's need for developing appropriate street centerline linework to support the recommended data model. In some cases, adequate centerline geometry exists to support the data model without further modification. In other cases, there exists a need for developing a centerline file from scratch. In the latter cases, specific tactics are described for centerline development by using either in-house resources or by using the services of a contractor or consultant. The basic components of the recommended tactics, described in more detail within each of the plans, include:

1. Developing a project scope of work
2. Acquire DVRPC orthophotography
3. Development of database standards, design and configuration
4. Capture street centerlines from digital orthophotography
5. Add address range information
6. Add unique identifier
7. Implement data maintenance procedures

By employing tactics based upon these fundamental steps, a functional centerline file can be developed by a DVRPC member organization that is in need of such a file to support transportation planning.

I-2 Database Development

The tactical plan recommendations pertaining to database development apply to the feature attribute tables and transportation event data tables that comprise the database portion of the transportation GIS. The feature attributes include the basic elements required for the common LRS model and street address geocoding. These are typically stored as part of the spatial database. The transportation events are the various location-based data items, such as traffic accidents, that are typically mapped to the centerline using common LRS and street address geocoding techniques. The basic components of the recommended tactics, described in more detail within each of the plans, include:

1. Configure attribute and event tables
2. Populate attribute tables
3. Populate event tables

I-3 Computer Hardware and Software

The development of a functional centerline file along with a feature attribute and transportation events database will be of little value without adequate computer hardware and software resources to fully support it's implementation. Each of the tactical implementation plans in this volume contains recommendations for hardware and software resources based upon the information gathered for each organization during the Needs Assessment phase. In some cases, it may be necessary for considerable investments to be made in hardware and software. In other cases, sufficient resources may already be in place. As mentioned above, the predominant GIS software currently being used throughout the region is ESRI's product line. The recommendations that follow are based upon the use of ESRI's ArcGIS software.

I-4 Staffing and Training

The implementation of the common LRS/street address geocoding GIS model to support transportation planning will also require human resources in the form of technicians and analysts with the technical skills and expertise to implement the system and to maintain it once it is operational. The implementation plans include recommendations for addressing staffing and training needs for developing the requisite support staff. Specific information regarding recommended ESRI software training for the various key positions is contained in Section III.

II. Process for Implementing the Common LRS/Street Address Geocoding Approach Using ESRI ArcGIS Software

II-1 Introduction

As the culmination of the process of defining a viable approach to developing regional standards for developing, maintaining and sharing transportation GIS data, DVRPC is providing its member organizations with a suggested technical approach for implementing the technical recommendations established in Volume III. This approach is comprised of a series of steps that can be followed that will facilitate the implementation of the Common LRS/Street Address Geocoding model that has been developed through this project. The procedures described below represent a comprehensive methodology that can be employed by DVRPC members to establish a functional GIS database that will support transportation-planning efforts by:

- Facilitating the integration of the core GIS data with external database tables;
- Establishing a data model that will allow organizations throughout the region to share critical transportation data;
- Creating a framework upon which member organizations can continue to develop transportation GIS resources along a common path towards the implementation of emerging industry standards

The needs assessment interview process revealed that the majority of DVRPC's member organizations are currently using GIS software developed by ESRI. Therefore, all of the functions described in the following procedural steps reflect the use of tools available in ArcGIS 8.1, the current version of ESRI's flagship GIS software. It is assumed that all users are familiar with basic ArcGIS terminology such as feature datasets, feature classes, routes, and so forth.

II-2 ArcGIS Background

In ArcGIS all linear features must be stored in a feature class whose geometry type is polyline. A route is simply one or more linear features on which attributes can be defined. Attributes can be assigned to a route because each route has a unique identifier stored in a field (SRI) and has an associated measurement system. A route's measurements are stored with its geometry. A route's geometry differs from other linear geometry in that instead of being a collection of x, y coordinates; a route's geometry is a collection of x, y, m values. A measure value (m value) is independent of the geometry's coordinate system, since the measure units and x, y coordinate units are different.

A feature class can store routes when its geometry type is polyline and it can store measures. This is defined during feature class creation and is explained in subsequent sections. In our case, a collection of routes with the Common LRS should be stored in a single feature class.

It is important to note that although many applications use measures to represent increasing linear distances along a line, measure values can arbitrarily increase, remain constant, or decrease. In special cases where a feature may not have any known measure value at all, the value should be stored as "not a number" (NaN) instead of an actual measure value. This is important when any

form of analysis is used to determine the measure between an actual measure values and a NaN value. The result should always be NaN.

Step 1 - Create Route Feature Class

First it is recommended to create a new, empty route feature class. When creating the geodatabase feature class, the geometry's field's properties, such as the geometry type and whether measure values can be stored, must be defined. If the feature class is defined as a stand-alone feature class the spatial reference needs to be defined. Adding a new feature class to an existing feature data set will use the existing dataset's spatial reference, which should have been defined when the data was created.

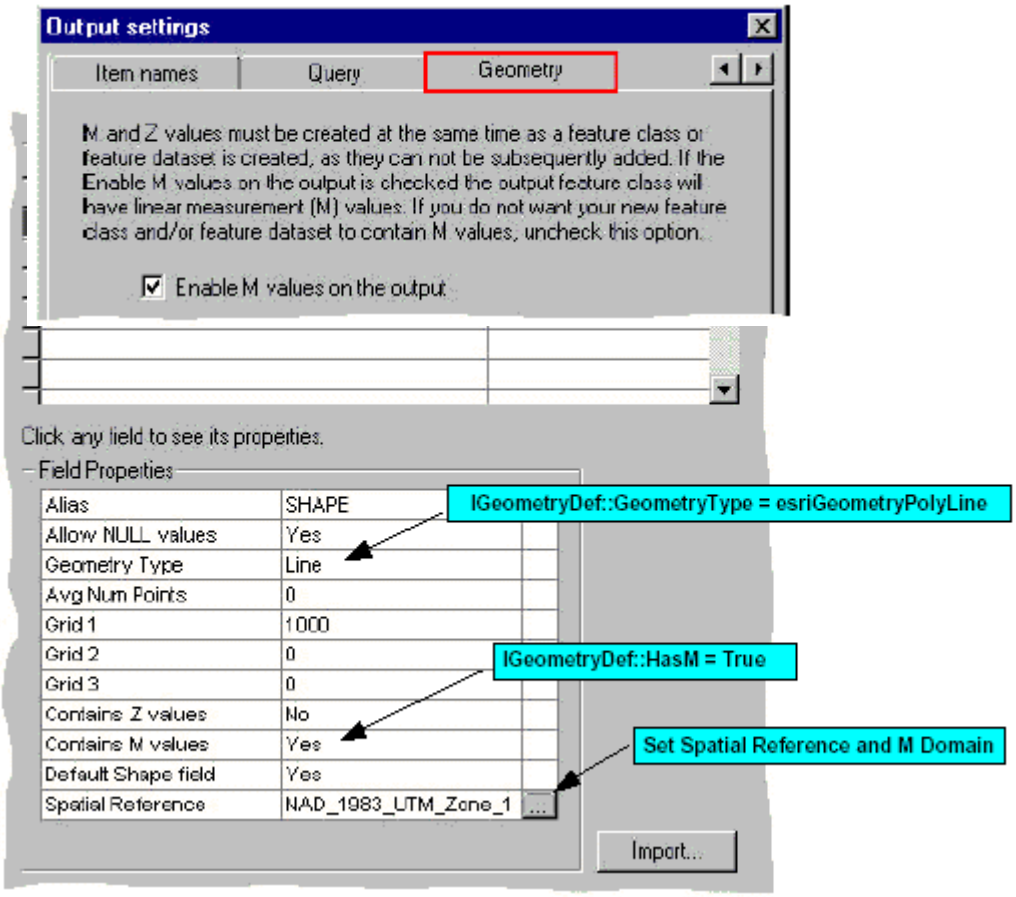

Figure 1 Creating a route feature class

To create a new, empty feature class use either ArcCatalog or ArcToolbox. Data can be loaded into this new feature class through ArcCatalog or ArcToolbox, as well.

Another way to create a new route feature class is to convert existing route data. The ArcToolbax/ArcCatalog data conversion tools can be used to convert existing data between

storage formats including coverages, shapefiles or other geodatabases. These conversions automatically preserve the measure values.

Once a feature class is created, it is not possible to go back and tell it that it will start having the ability to store m values. Therefore, it is very important to enable m values when creating or converting to the feature class. ArcToolbox data conversion tools have the ability to enable m values when creating a new geodatabase feature class.

Step 2 – Capture Centerlines From Orthophotography

In ArcMap, use digital orthophotos and the available digitizing tools to create the new centerlines. This process involves using the "Add new feature" tool and interpreting the aerial photos to determine where to correctly place the centerlines. At a minimum, one rule needs to be enforced during the process. This rule states that, if the road is obviously divided by a large median then two centerline features should be digitized to represent both sides of the road. No attributes are populated during this process. Other rules will definitely be necessary for the complete project, such as: collection of highway ramps, intersections and any other complications. For information regarding the definition of data capture rules, refer to Step 3 of Section II-1, Implementation Approach, above.

Step 3 - Specify Measure Domain Range Extent & the Precision

When converting an existing route feature class to a geodatabase, a default measure domain (m domain) must be explicitly set. This is because there is no way for the tools to know what units the route measures are in or what precision is necessary. It is very important to preserve measure accuracy, whether you are creating a new route feature class or converting an existing non-geodatabase route feature class to a geodatabase.

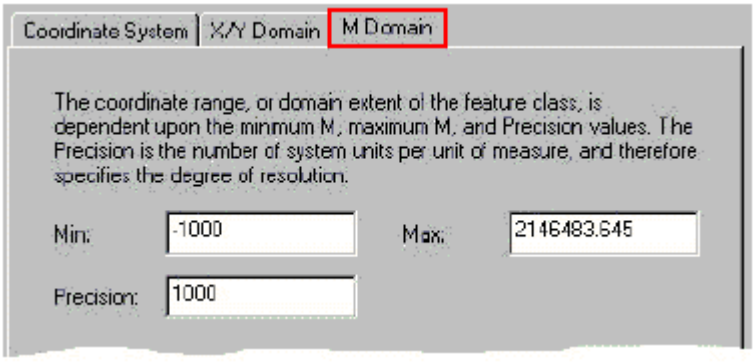

Figure 2 Specifying default measure domain

When setting the m domain, only the minimum value and the precision need to be set. The maximum m value will be automatically calculated by setting these values. The precision value should always be a multiple of 10. An inappropriate m precision will result in a loss of accuracy

during data development and maintenance procedures. The values entered and stored in the geodatabase may not be the same as the values returned by ArcGIS. Events will still be located on the correct spot, meaning positional accuracy will be maintained. However, functions such as calculating the maximum m value on a route will give incorrect results. For this reason, employ a strategy of using a precision value that is both a multiple of 10 and a power of 10.

Specifying the appropriate storage units is another important consideration when setting the m domain. The storage units are based on the actual accuracy of the data. One alternative is to use an order of magnitude greater than the accuracy of the data to allow for the future storage of more accurate data. Routes may be measured in feet, meters, miles and so forth. This has nothing to do with the accuracy at which the data was collected. Precision is the multiplier that scales the measure units into storage units. Precision is the route measurement units divided by the storage units. For example if the route measure units are meters and the data is centimeter accuracy, the precision is 100.

Step 4 – Define Dynamic Segmentation Parameters

To control the behavior of the Dynamic Segmentation dialogues in ArcGIS, it is necessary to install and configure the ArcObjects Developer Kit. There is a folder called ArcObjects Developer Kit under the arcexe81 folder. In the Utilities\VBAdvancedSettingsUtility folder, the ArcMap Advanced Setting Utility is called AdvAMSet.exe.

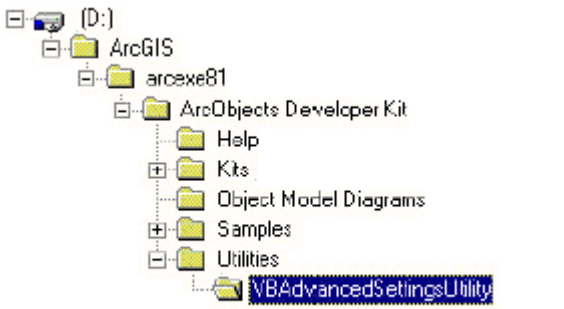

Figure 3 ArcObjects Developer Kit

Start this application and edit the field names as needed to match the field names in the geodatabase. The dynamic segmentation user interface will automatically look for these field names in the data. The end user may specify multiple field names by placing a space character between each field name that is to be used.

Step 5 – Maintenance Considerations

Since routes are simply features that exist in feature classes, they can be edited in ArcMap using normal editing procedures with a few exceptions. There are some different results to keep in mind when various editing operations are performed on polylines with measure values.

There are four basic rules that ArcMap applies when dealing with m values on polylines.

First, ArcMap will never set the m value on a newly created features, it should be set to NaN. Secondly, certain edit operations that insert a vertex between two existing vertices with known m values will interpolate the m value at the new vertex. Third, certain edit operations that create a new vertex outside of the existing vertices will not have the m value at the new vertex extrapolated. Finally, when performing topological operations, the m values from the primary geometry (the one that is selected first) take precedence. Other than these situations, editing the route features is the same as editing any other feature in ArcMap

Step 6 – Locating Events Along/On the Route Feature

Once the foundation has been built for linear referencing, there are several ways of locating events along the centerline. One, fairly straightforward, way to accomplish this is to use the Find tool in ArcMap. This only requires choosing the proper SRI number and the measure(s) along the centerline. The find dialogue relies on the parameters set in the ArcMap Advanced Settings form. This is very helpful in finding individual locations on a case-by-case basis.

If the route events are stored in a table there is a different way of locating them. As described before, the route event table should consist of a least two fields: the unique identifier and the measure value. Route Events are added to ArcMap through the Tools/Add Route Events command dialogue. This command opens a form that allows you to choose all of the pertinent information for displaying route events from a table.

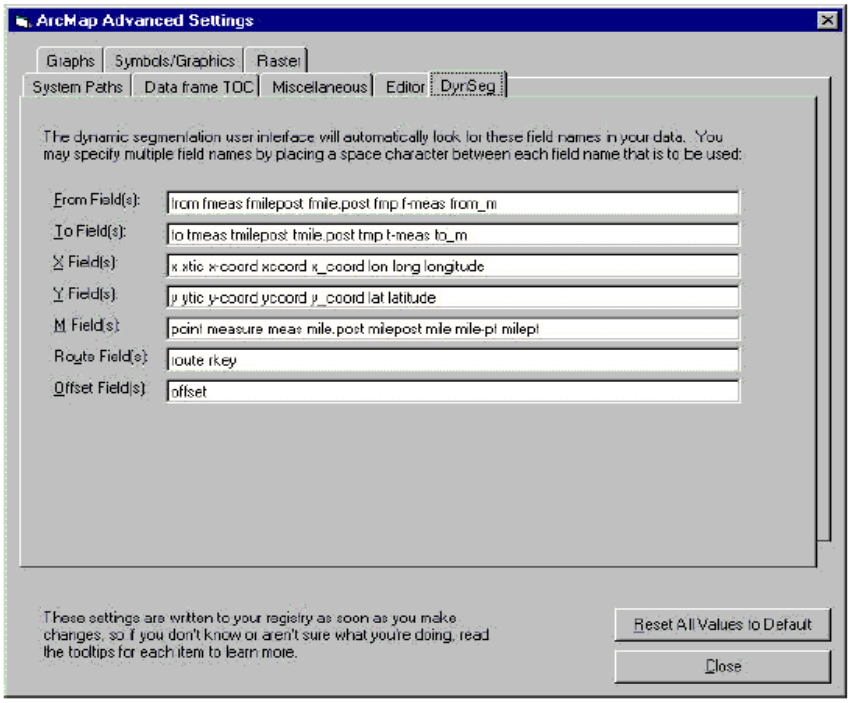

Figure 4 ArcMap Advanced Settings Dialogue

Step 7 – Data Sharing Considerations

Since this type of data will have all of the pertinent information included in the database design, as per Volume III recommendations, sharing this data only requires sending the event data as a data file.

II-3 Process for Street Address Geocoding

At this point it is assumed that all Data Preparation and Conflation procedures described in Section III-2 of Chapter III, Volume III, have been performed enabling Street Address Geocoding operations to be performed on the data. ArcGIS provides tools and a framework for creating, managing, and using geocoding services. In ArcGIS, a geocoding service defines:

- paths to reference data,
- rules for standardizing alphanumeric descriptions of places and matching them to the reference data,
- parameters for reading address data, matching the address data to the reference data, and creating output.

Step 1 – Define the Geocoding Service

ArcGIS comes with several predefined geocoding service styles that can be used to perform geocoding. Based on the recommendations for database design established in Volume III, it will be necessary to utilize the US Streets geocoding service style. This geocoding service style can use feature classes with any type of geometry. Each feature in the reference data represents a street segment with two ranges of addresses that fall along that street segment, one for each side of the street. Additionally, the reference data should have prefix direction, street names, street type, suffix direction and zip code in order to perform the most accurate geocoding. These requirements are consistent with the database design recommendations presented in Volume III. The ArcCatalog module of ArcGIS should be used to define the geocoding services by double-clicking Create New Geocoding Service and selecting the US Streets with Zone style.

Once you have selected the correct Geocoding Service Style, click ok and add a name for the service and browse to the name for the reference data. In order to facilitate data sharing, be sure to select all of the output field options when setting up this service. This should allow others to locate these features as well, through the reference data id and the percent along fields. The remaining parameters in this window are explained in detail through the ArcGIS help.

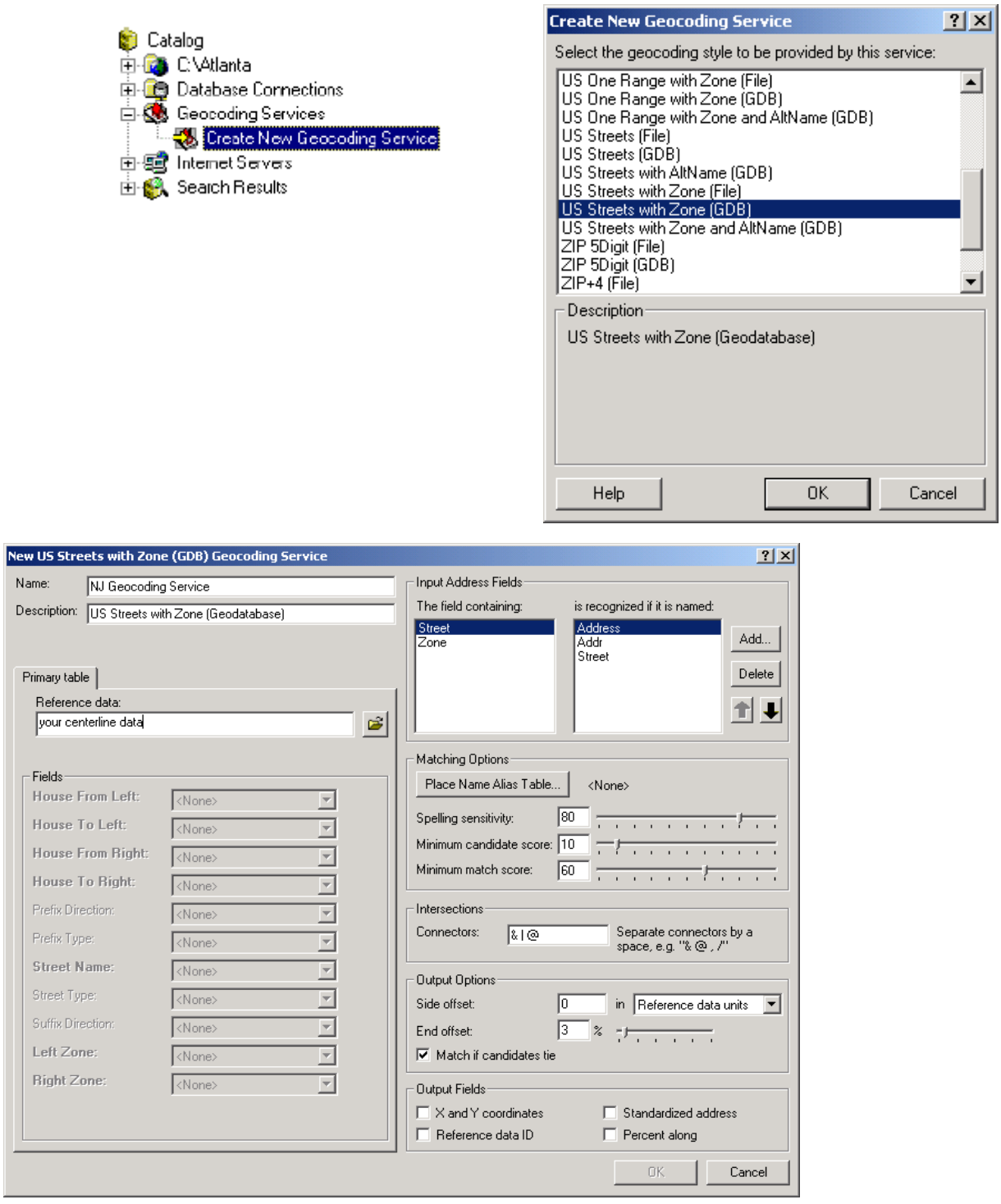

Figure 5 ArcGIS Street Geocoding Service Dialogues

Step 2 –Geocoding

Once the geocoding service has been defined, there are several ways of locating addresses. One, fairly straightforward, way to accomplish this is to use the Find tool in ArcMap. This is very similar to the method described previously. It only requires choosing the proper geocoding service and the typing the address components into the text boxes. This is very helpful in finding individual locations on a case-by-case basis.

If the addresses that you would like to geocode are stored in a table there is a different way of locating them. In this case, you will utilize the geocoding service to create point features that represent locations of the addresses. Using ArcMap, click the Tools menu, point to Geocoding, and then click Geocode Addresses. Select the proper geocoding service, choose the proper column names for the address information of the table you would like to geocode and finally specify where to save the geocoded feature class.

III. ESRI Training

It is the recommendation of the Project Team that if a DVRPC member government is going to implement and deploy an ESRI based system that their personnel have the following ESRI training or similar work experience.

III-1 GIS Technician

This individual should have the instructor led ESRI Introduction to ArcGIS I (for ArcView 8, ArcEditor 8, and ArcInfo8) , which is a two-day course. This course introduces students to ArcGIS and provides the foundation for becoming a successful ArcView, ArcEditor, or ArcInfo user. Participants learn how to use ArcMap, ArcCatalog, and ArcToolbox and explore how these applications work together to provide a complete GIS software solution. The course covers fundamental GIS concepts as well as how to create, edit and work with georeferenced spatial data. Attendees learn how to manipulate tabular data, query a GIS database, and present data clearly and efficiently using maps and charts.

III-2 GIS Analyst

This individual should have the ArcGIS I class as required by the GIS Technician and the following two classes: Introduction to ArcGIS II (for ArcView 8, ArcEditor8, and ArcInfo8) and Creating and Managing Geodatabases. Both of these courses are three-day courses.

III-2.1 Introduction to ArcGIS II

This three-day course follows Introduction to ArcGIS I and continues to present important concepts and functionality for successfully working with ArcGIS. With further exploration of ArcMap, ArcCatalog, and ArcToolbox, students focus on spatial analysis, automation of spatial and attribute data, editing, and advanced options for cartographic display and reports. Hand-on exercises teach ArcGIS procedures in the context of solving real-world problems.

III-2.2 Creating and Managing Geodatabases

This three-day course introduces the capabilities of the geodatabase. Attendees learn how to create, use, edit and manage spatial and attribute data stored in the geodatabase. Discussion topics include loading data into the geodatabase; defining domains, subtypes, and relationship classes; and creating, editing, and performing analysis on geometric networks

III-3 Project Manager

This individual should have at a minimum all three courses outlined above.

III-4 Database Administrator (ArcSDE)

For those entities that will be deploying ArcSDE as part of this project the database administrator should have the following training classes.

III-4.1 Introduction to ArcSDE using ArcInfo8

This two-day course details the architecture and fundamental concepts of ArcSDE software and storage structures. Through lectures and hands-on exercises, participants view and query layers in an ArcSDE database using ArcCatalog and ArcMap. They also create new ArcSDE layers by loading existing, file-based geographic data sources, such as shapefiles, coverages, and images, into an ArcSDE server.

III-4.2 ArcSDE Administration for Oracle

This five-day course prepares Oracle database administrators for implementing ArcSDE by building their own, individual ArcSDE servers. Participants learn how to configure Oracle to support ArcSDE, install and configure ArcSDE, load vector and raster data, monitor and optimize queries, and manage a multiversioned geodatabase.

IV. Conclusion

By applying the tactics presented in the implementation plans presented in Appendix A, it will be feasible for the member organizations to effectively construct GIS databases that will facilitate the exchange of transportation related data to support a variety of applications at and among local, regional and State levels.

Using the recommendations put forth by the implementation plans, the member organizations will be able to define the components of a scope of work to support the development of a transportation GIS database, whether the work is done in-house or contracted out.

Appendix A - Individual Implementation Plans

Plan Number 1 - Delaware Valley Regional Planning Commission (DVRPC)

I Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for DVRPC. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, the DVRPC centerline dataset is considered to be at the Stage 2 Level. DVRPC has road centerlines but with no attribution attached to the centerlines.

I-2 Summary of Needs

Currently DVRPC's most critical needs for implementing GIS for transportation planning are: (1) either update the centerlines based on the new digital orthophotography and add the critical elements for the Common LRS Approach using to the road centerlines or (2) come to an agreement with the participating local governments and generate a new "regional" centerlines for Pennsylvania and New Jersey. This would be accomplished using the centerlines that will be developed by the local governments in order to implement the Common LRS Approach.

I-2.1 Implementation Options

In order to meet these needs, DVRPC has two options. The first option involves using the existing DVRPC CADD centerlines, updating them to the new digital orthophotography, and conflating address ranges and Common LRS information. The principle benefit of this option is that DVRPC can utilize their existing centerlines. The principal disadvantages of this option are (1.) the centerline geometry must be brought up to date and (2.) DVRPC must conflate the address ranges as well as each State's unique road identifier and measure values.

The second option involves establishing data sharing agreements, which will allow for the combination of the completed centerlines from each member agency to create a regional centerline for each State. These centerlines will already be attributed with each State's unique road identifier/measure values and street address information. The advantages of this option are (1.) the requirement for conflation is eliminated and (2.) the centerline dataset is more up-to-date and accurate, which allows removal of the Update

Centerline Geometry sub-task under the Data Preparation task of the conflation process described in Chapter I of Volume III. This option, however, will require the topological cleaning of centerlines along the boundaries between entities and the integration of the centerline tables.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to DVRPC, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II Tactical Implementation Recommendations – Linework –

The implementation of the first option would require the commitment of a vast amount of resource to essentially duplicate the efforts of the member agencies. Therefore, it is recommended that DVRPC implement the second option. Specific steps in the required process are outlined below.

II-1 Implementation Approach

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach on a regional basis for DVRPC.

Step 1 – Establish Data Sharing Agreements

DVRPC needs to put into place a data sharing agreement with each one of the local entities that will contribute their centerlines as part of the two regional files. The data agreements would allow for DVRPC to use the data as well as share it with "sub-regional" organizations like SEPTA/NJ Transit who may need a portion of the data for their service territory.

Step 2 – Integrate Centerline Database Tables

Next DVRPC would need to analyze each centerline table, extract the critical elements for the Common LRS Approach and load them into a unified database table.

Step 3 – Compile Centerline Linework

Finally, DVRPC would merge centerline linework from each of the local government agencies into a single file for each State and then perform topological cleaning of centerlines along the boundaries between entities.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data models from Volume III, Chapter II is reproduced in Figures 1and 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Our suggestion would be that DVRPC have two separate projects each with its own basic database design, one for New Jersey and one for Pennsylvania. This would allow for the addition of mileposts in New Jersey and cumulative offsets in Pennsylvania as well as the unique identification schemes of each state should be able to move ahead

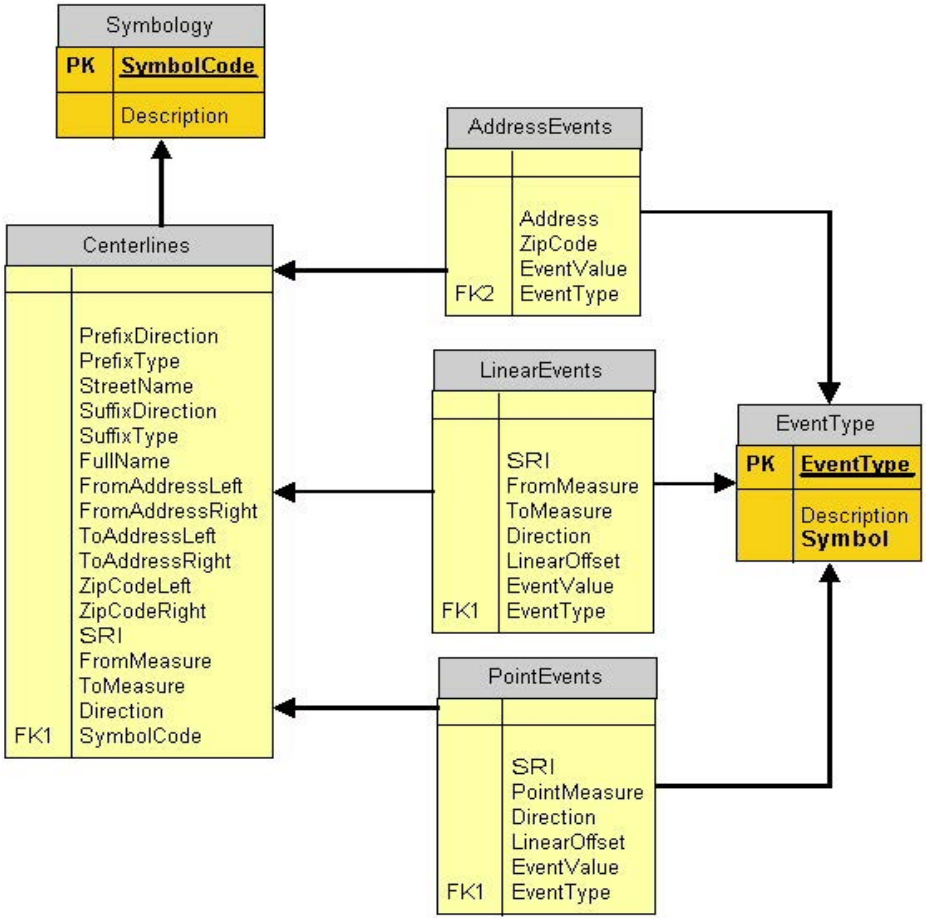

Figure 1 – Recommended New Jersey Common LRS Data Model

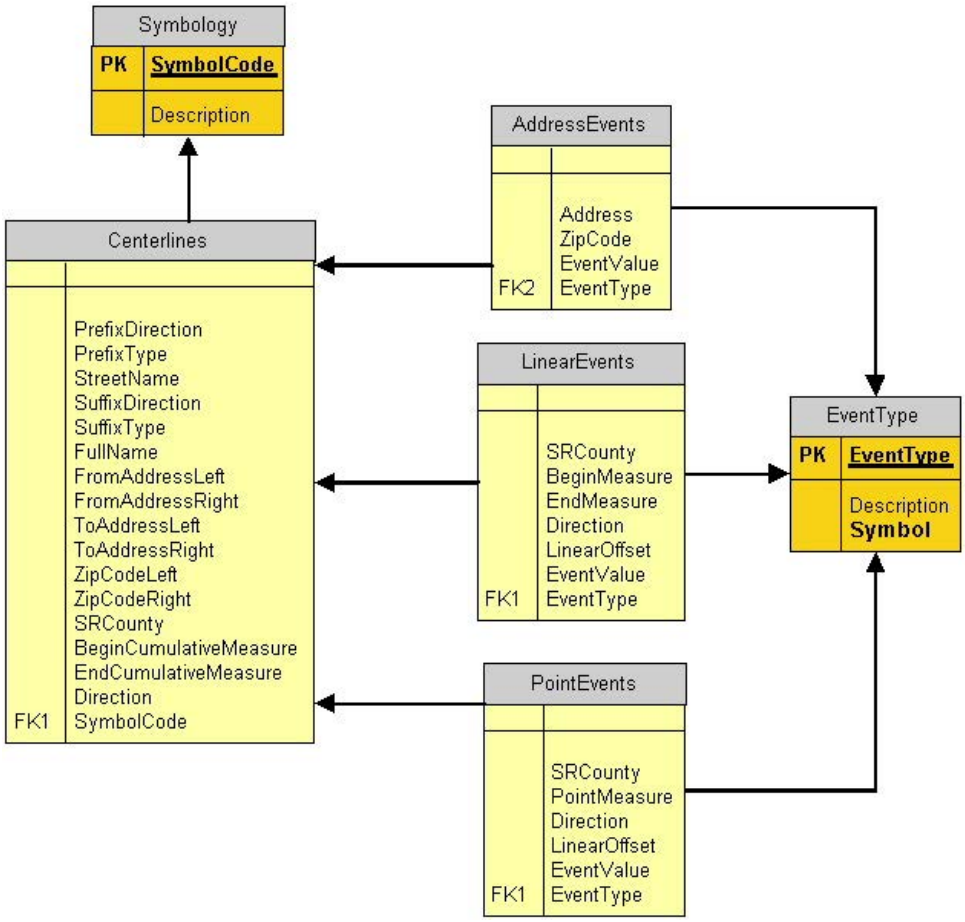

Figure 2 – Recommended Pennsylvania Common LRS Data Model

It is further recommended that DVRPC acquire and implement ESRI's Spatial Database Engine (SDE) software. As the prime user of all of the GIS data that is produced and used throughout the region, it is inevitable that DVRPC will continue to expand its GIS and the resources required to support it. As the regional GIS database expands and becomes more complex, the need for a tool such as SDE will become more acute.

IV. Tactical Implementation Recommendations – Hardware/Software

The successful implementation of the plan that has been presented for DVRPC is clearly dependent upon DVRPC's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

The interview portion of the needs assessment process involving DVRPC revealed that DVRPC currently uses ESRI GIS software products, including ArcInfo 8.1 (ArcGIS). This software provides the requisite tools for performing the various conflation processes and database development procedures described above. At this time, there appears to be no urgent need for DVRPC to procure additional software resources other than ArcSDE as mentioned above.

IV-2 Hardware

The interview portion of the needs assessment process and subsequent discussions with DVRPC staff have revealed that DVRPC currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Training

The implementation of the recommended procedures outlined above and in Section II will require a relatively strong understanding of the use of ArcGIS software and experience in applying the necessary software tools. The DVRPC staff will require additional training in order to develop the requisite skills to perform the work that is required to implement the recommendations presented in this plan and previous volumes.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project Scope of Work	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Integrate Centerline DB				
Extract Critical Elements	8.0	24.0	0.0	**32.0**
Load Elements into Unified Database	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Compile Centerline Linework				
Merge Linework into Unified File	16.0	40.0	40.0	**96.0**
Edgematch at Agency Boundaries	16.0	60.0	320.0	**396.0**
Verify Topologic Integrity	16.0	40.0	80.0	**136.0**
Total Task 4	**48.0**	**140.0**	**440.0**	**628.0**
Task 5 – Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 5	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**152.0**	**340.0**	**520.0**	**1012.0**

Task 1 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach, DVRPC must: (1) establish data sharing agreements, (2.) integrate Centerline Database Tables, and (3.) compile local government centerline linework into a regional centerline file for each State. Although, the steps for accomplishing these three items have been defined above, DVRPC must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow DVRPC to share data with all partner agencies, but it will also allow DVRPC to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 2 - Bucks County, Pennsylvania

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Bucks County, Pennsylvania. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, Bucks County was considered to be at the Stage 1 Level. Since that time, Bucks County has developed a centerline that can be utilized for this implementation and can be considered Stage 2. The County contracted with a mapping firm to have a graphic centerline produced using the DVRPC regional digital orthophotography.

I-2 Summary of Needs

Currently the county's most critical needs are: (1.) add address range information to the centerlines to enable accurate geocoding and (2) add critical elements for the Common LRS approach to enable data sharing and linear referencing.

I-2.1 Implementation Options

Several options for centerline development were evaluated through the street centerline development options demonstration that was performed as part of the prototype phase of the project. This demonstration process and its results are documented in Chapter II of Volume II. After due considerations of all of the options, it is recommended that Bucks County use the centerlines that they have recently developed. This will allow the County to take advantage of a centerline that has a high degree of accuracy and completeness.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to Bucks County, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase I, which will only cover roads maintained in the PennDOT GIS centerline database. This is primarily due to the fact that creating Common LRS attribution for these roads will be most feasible.

The process for implementing the Common LRS Approach is outlined below. Since Bucks County has centerlines that can be used for implementation of the Common LRS Approach, the implementation they should follow starts at the "Obtain Centerlines" block, which is noted by the "Add Address Information" label.

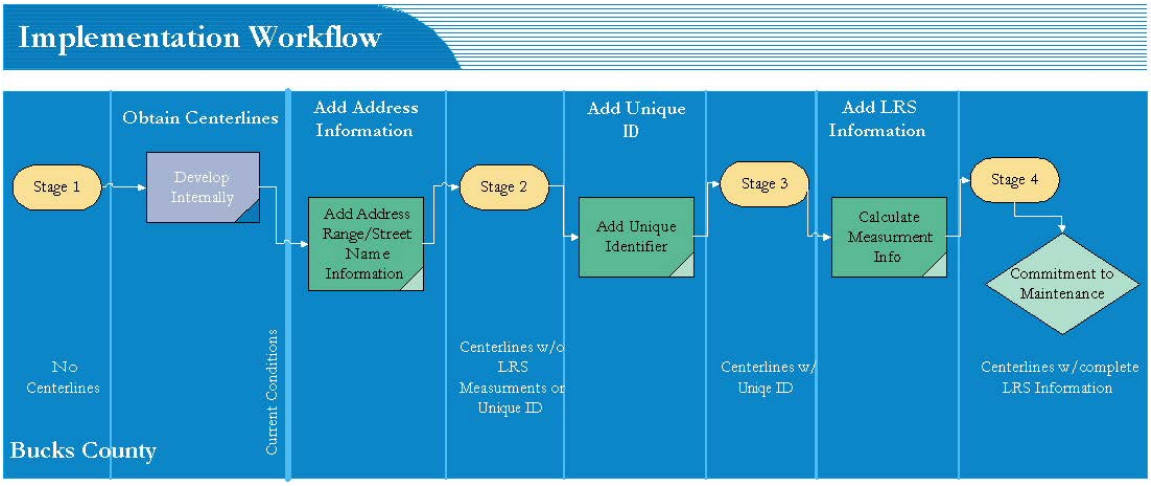

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that Bucks County must make when implementing the Common LRS approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for Bucks County to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach for Bucks County. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline data. They address the two alternative approaches mentioned above: development of centerline data by County staff and development of centerline data through use of an outside contractor.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the County, neither process can commence until the County has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, work flow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata

Step 2 - Add Address Range Information

The next step in implementing the Common LRS Approach is to add the appropriate address range information. This is accomplished through conflation. Depending on the available resources this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the address information, the same procedure must be followed in order to develop accurate and complete address attribution.

Again, in the event that Bucks County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 3 - Add LRS Information (Unique Route Number and Measurement Values)

As described in Volume III, the development of a GIS data model that supports the Common LRS approach requires that each segment in the centerline database have a unique route identification number and measurement attributes. In New Jersey, it has been determined that the Standard Route Identifier (SRI) will serve this purpose. Currently in Pennsylvania, there is no single data element to serve this purpose. However, the use of the State Route Number (SR) and County Code (CO) combination will provide for a unique road identifier. PennDOT is currently

investigating the creation of a unique identifier similar to NJDOT's SRI number. PennDOT will also supply the beginning cumulative measure and end cumulative measure for each segment of road broken by all road intersections. The addition of the SR-CO combination and the begin cumulative measure and end cumulative measure to the Bucks County centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Again, in the event that Bucks County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 4 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Attribute and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. In Bucks County's case, the centerline table could be developed as an Arc Attribute Table (AAT). The various event tables could be developed within an external database system such as Microsoft Access, which the County currently uses.

Step 2 – Populate Attribute Tables

Once the database tables have been properly configured, Bucks County will need to at least populate the centerline AAT with the appropriate LRS and street address data as described in the preceding section.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of Bucks County. The interview process revealed that the County currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through a County data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

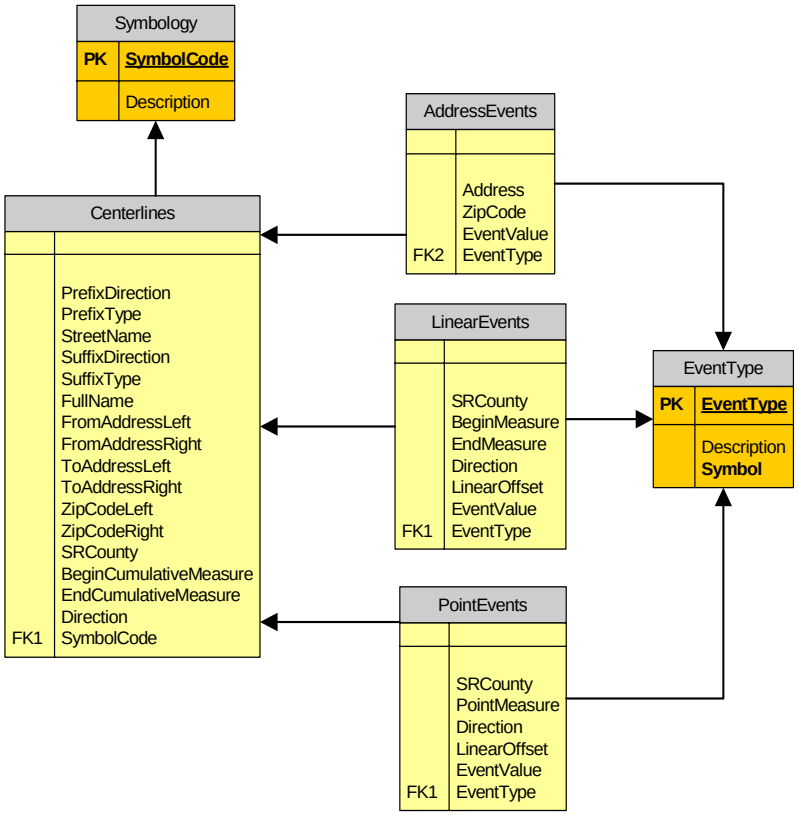

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations Hardware/Software/Staffing and Training

The successful implementation of the plan that has been presented for Bucks County is clearly dependent upon the County's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving Bucks County revealed that the County currently uses ESRI GIS software products, including ArcGIS within the Planning Department. If the County places centerline data maintenance responsibility within the Planning Department, there is no critical need, at this time, for the County to acquire significant additional software resources.

With regard to the database management component of the implementation, it is recommended that Bucks County consider the use of a product other than INFO to manage external event data tables. Interview responses indicated that the County is considering the use of Oracle or SQL Server for this purpose.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for Bucks County will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process and subsequent discussions with Bucks County staff have revealed that the County currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the County opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by County staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

Based on the information collected during the interview phase, it is anticipated that Bucks County may need to hire a GIS Technician or provide additional training to existing staff if the implementation work is to be performed in house. Formal training on ESRI software is available from ESRI both in a traditional classroom setting and through online classes via their website. Costs vary, with classroom training costs ranging from approximately $500 - $2,000 per student depending upon the nature and duration of the course. Online training is significantly less expensive, but is limited in scope and content.

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For Bucks County, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately four to six months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRI software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that Bucks County would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that Bucks County should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project Scope of Work	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Design of data capture rules, work flow and processes				
Develop Data Capture Rules	8.0	24.0	0.0	**32.0**
Design and Develop Work Flows and Processes	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Conflate Address Ranges				
Conflate address ranges from appropriate source	16.0	40.0	40.0	**96.0**
Quality Control	8.0	24.0	24.0	**56.0**
Total Task 4	**24.0**	**64.0**	**64.0**	**152.0**
Task 5 – Add LRS Information				
Add SR-CO and begin and end cumulative distance	8.0	8.0	240.0	**256.0**
Calculate 3D Distance	8.0	16.0	120.0	**144.0**
Quality Control	4.0	16.0	80.0	**100.0**
Total Task 5	**16.0**	**24.0**	**440.0**	**500.0**
Task 6 – Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 6	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**144.0**	**288.0**	**584.0**	**1,016.0**

Task 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in Bucks County the county must: (1) add address range information to the centerlines to enable accurate geocoding, and (2.) add critical elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, Bucks County must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow Bucks County to share data with PennDOT, but it will also allow the county to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 3 – Chester County, Pennsylvania

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Chester County, Pennsylvania. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages if street centerline development were identified. Currently, Chester County is considered to be at the Stage 2 Level. The county has road centerlines but no LRS Measure

I-2 Summary of Needs

Currently the county's most critical need for implementing GIS for transportation planning is: (1) add critical elements for the Common LRS approach to enable data sharing and linear referencing.

I-2.1 Implementation Options

In order to meet these needs, Chester County has a few options. The first option involves manually entering or tagging each road centerline which overlaps with PennDOT's LRS with the Unique Route Identifier and Begin and End Cumulative offset measures. The second option involves the use of conflation to try to automate as much as possible the adding of the PennDOT Unique Road Identifier (SR/CO) and the Begin and End Cumulative offset measures.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to Chester County, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase I, which will only cover roads maintained in the PennDOT GIS centerline database. This is primarily due to the fact that creating Common LRS attribution for these roads will be most feasible.

The process for implementing the Common LRS Approach is outlined below. Since Chester County has centerlines that can be used for implementation of the Common LRS Approach, along with the Street Names and address ranges the implementation they should follow starts at the "Add Unique Identifier" block, which is noted by the "Current Conditions" label.

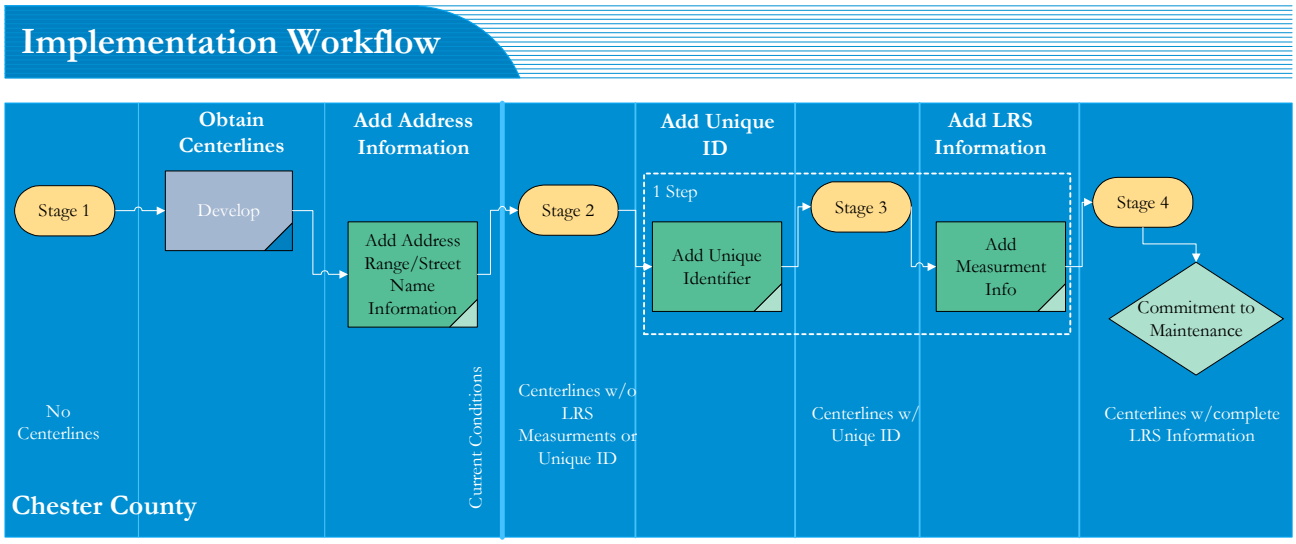

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that Chester County must make when implementing the Common LRS approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for Chester County to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach - Add LRS Information (Unique Route Number and Measurement Values)

As described in Volume III, the development of a GIS data model that supports the Common LRS approach requires that each segment in the centerline database have a unique route identification number and measurement attributes. In New Jersey, it has been determined that the Standard Route Identifier (SRI) will serve this purpose. Currently in Pennsylvania, there is no single data element to serve this purpose. However, the use of the State Route Number (SR) and County Code (CO) combination will provide for a unique road identifier. PennDOT is currently investigating the creation of a unique identifier similar to NJDOT's SRI number. PennDOT will also supply the beginning cumulative measure and end cumulative measure for each segment of road broken by all road intersections. The addition of

the SR-CO combination and the begin cumulative measure and end cumulative measure to the Chester County centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Step 1 – Develop Project Scope of Work

As the first step in the recommended process, the County will need to develop a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, work flow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata.

Step 2 – Development of Standards and Database Design, Configuration, and Implementation

If Chester County opts for capturing the centerline geometry and attribution in-house with County staff, it will be necessary for the County to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables
- Construction of the database within the County's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, Chester County should use the database design recommendations outlined in Volume III.

Step 3 - Add LRS Information (Unique Route Number and Measurement Values)

As described in Volume III, the development of a GIS data model that supports the Common LRS approach requires that each segment in the centerline database have a unique route identification number and measurement attributes. In New Jersey, it has been determined that the Standard Route Identifier (SRI) will serve this purpose. Currently in Pennsylvania, there is no single data element to serve this purpose. However, the use of the State Route Number (SR) and County Code (CO) combination will provide for a unique road identifier. PennDOT is currently investigating the creation of a unique identifier similar to NJDOT's SRI number. PennDOT will also supply the beginning cumulative measure and end cumulative measure for each segment of road broken by all road intersections. The addition of the SR-CO combination and the begin cumulative measure and end cumulative measure to the Chester County centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Again, in the event that Chester County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

In performing theses tasks, Chester County should use the database design recommendations outlined in Volume III.

Step 4 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represented by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Centerline and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. The various event tables could be developed within an external database system such as Microsoft Access and Oracle, which the County currently uses.

Step 2 – Populate Centerline Table

Once the database tables have been properly configured, Chester County will need to at least populate the centerline with the appropriate LRS which will go along with its current street address data.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of Chester County. The interview process revealed that the County currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through a County data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

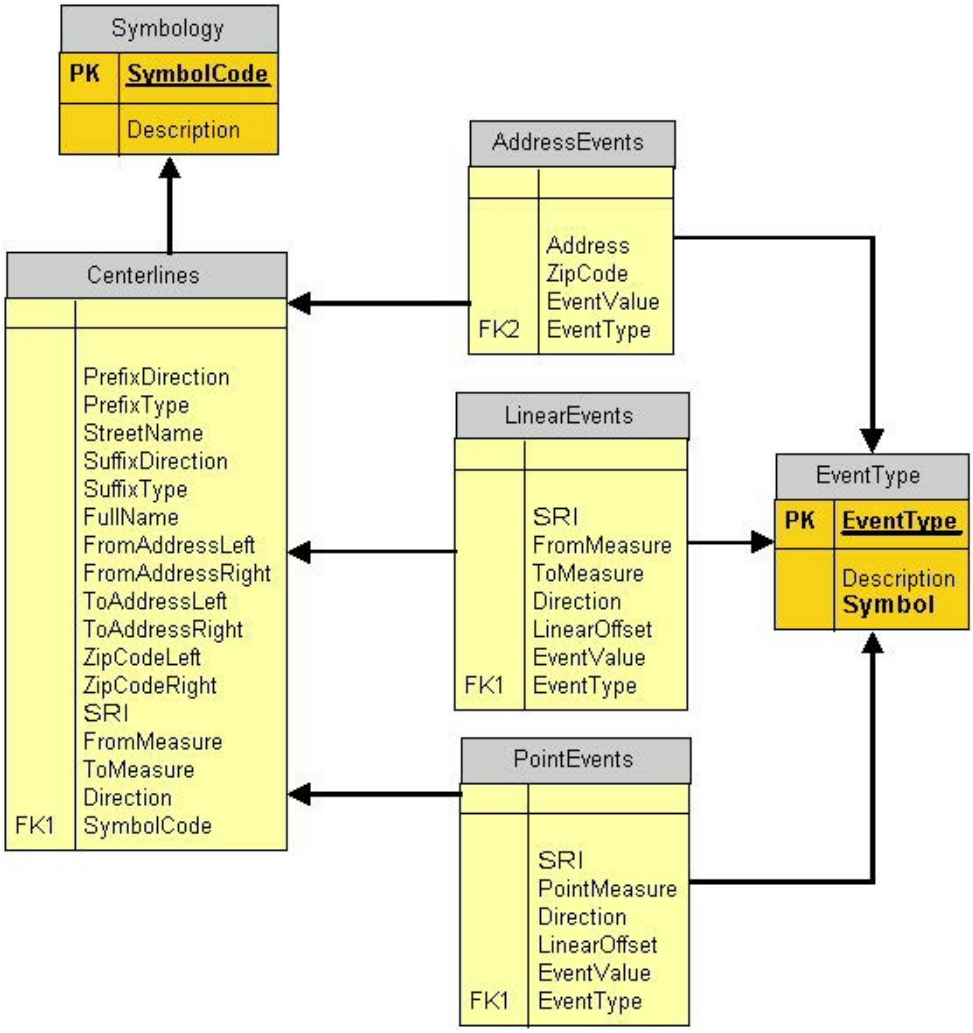

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Training

The successful implementation of the plan that has been presented for Chester County is clearly dependent upon the County's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

The interview portion of the needs assessment process involving Chester County revealed that the County currently uses ESRI GIS software products, including ArcInfo 8.1 (ArcGIS) and associated products. This software provides the requisite tools for performing the various conflation processes, database development procedures, and data maintenance requirements described above. At this time, there appears to be no urgent need for Chester County to procure additional software resources.

IV-2 Hardware

The interview portion of the needs assessment process and subsequent discussions with Chester County staff have revealed that the County currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Training

The implementation of the recommended procedures outlined above and in Section II will require a relatively strong understanding of the use of ArcGIS software and experience in applying the necessary software tools. Recent conversations with Chester County have revealed that staff within the Planning Department are currently receiving ArcGIS training and will possess the requisite skills to perform the work that is required to implement the recommendations presented in this plan and previous volumes.

V. Time and Cost Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	Total Hours
Tasks			
Task 1 – Develop Scope of Work			
Develop Project Scope of Work	40.0	16.0	**56.0**
Total Task 1	**40.0**	**16.0**	**56.0**
Task 2 – Conflate SR-CO and Measures			
Automatic Conflation	16.0	40.0	**56.0**
Manual Conflation	40.0	400.0	**440.0**
Total Task 3	**56.0**	**440.0**	**496.0**
Task 4 – QA/QC			
Find & Correct Null Values	8.0	120.0	**128.0**
Find & Correct LRS Errors	8.0	120.0	**128.0**
Total Task 4	**16.0**	**240.0**	**256.0**
Task 6 – Data Model			
Define Domain Tables	24.0	80.0	**104.0**
Define Standard Symbology	24.0	80.0	**104.0**
Total Task 6	**48.0**	**160.0**	**208.0**
Task 7 - Maintenance			
Establish Maintenance Procedures	8.0	80.0	**88.0**
Total Task 7	**8.0**	**80.0**	**88.0**
SUB-TOTAL	**168.0**	**936.0**	**1,104.0**

Figure 3 – Implementation Strategy Hours Estimate

VI. Summary and Conclusions

In order to implement the Common LRS Approach in Chester County the county must: (1.) add critical elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the process for accomplishing this step has been defined above, Chester County must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow Chester County to share data with PennDOT, but it will also allow the county to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 4 – Delaware County, Pennsylvania

I Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Delaware County, Pennsylvania. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, Delaware County is considered to be at the Stage 1 Level. The county has no centerline data.

I-2 Summary of Needs

Currently the county's most critical needs for implementing GIS for transportation planning are: (1) create a centerline file that will support the use of GIS for transportation planning, (2.) add address range information to the centerlines to enable accurate geocoding and (3.) add critical elements for the Common LRS approach to enable data sharing and linear referencing.

I-2.1 Implementation Options

In order to meet these needs, Delaware County has a few options. The first option involves capturing centerline geometry using the digital orthophotography currently being developed by DVRPC as a base. Centerline geometry could be captured through a process of "heads-up" digitizing with the ESRI GIS software that the County currently uses. This data capture effort could be done by County personnel or contracted out. A second option would include the purchase of centerline data from a third-party commercial vendor. A final option might include the borrowing of existing centerline data from a source such as PennDOT or DVRPC. The principle benefit of this option is that Delaware County can utilize those existing centerlines.

Each of these options was evaluated through the street centerline development options demonstration that was performed as part of the prototype phase of the project. This demonstration process and its results are documented in Chapter II of Volume II. After consideration of all of the options, it is recommended that Delaware County adopt the first option, creating its centerline base from the DVRPC orthophotography. This will allow the County to develop a centerline that has a high degree of accuracy

and completeness. As stated above, this option presents two alternative approaches: centerline data capture and attribution by County staff or centerline data capture and attribution by a contractor.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to Delaware County, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase I, which will only cover roads maintained in the PennDOT GIS centerline database. This is primarily due to the fact that creating Common LRS attribution for these roads will be most feasible.

The process for implementing the Common LRS Approach is outlined below. Since Delaware County has no centerlines that can be used for implementation of the Common LRS Approach, the implementation they should follow starts at the "Obtain Centerlines" block, which is noted by the "Current Conditions" label.

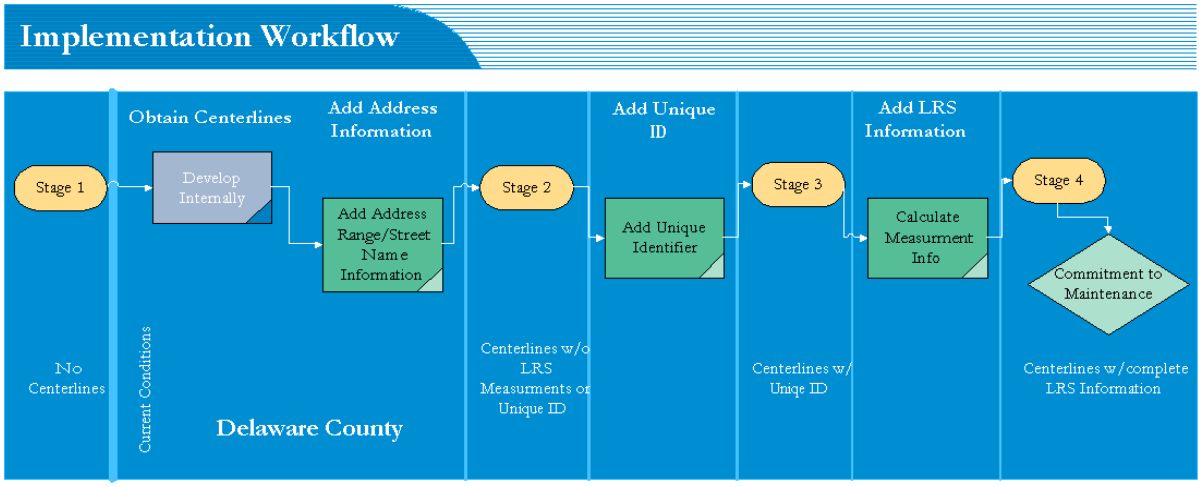

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that Delaware County must make when implementing the Common LRS approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for Delaware County to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach (Option 1 – Develop Centerline From DVRPC Orthophotography)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach for Delaware County. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline data. They address the two alternative approaches mentioned above: development of centerline data by County staff and development of centerline data through use of an outside contractor.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the County, neither process can commence until the County has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Acquisition of orthophotography from DVRPC* – This component includes the acquisition of digital orthophotography from DVRPC with complete coverage of Delaware County.
- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, work flow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Capture of centerline geometry from orthophotography* – This component includes the work effort required to capture centerline geometry from the orthophotography.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata.

Step 2 – Acquisition of Orthophotography

Before data capture can begin, it will be necessary for Delaware County to obtain the digital orthophotography files from DVRPC. The extent of coverage must include the entire County. This step is required regardless of the alternative approach that is selected by the County.

Step 3 – Development of Standards and Database Design, Configuration, and Implementation

If Delaware County opts for capturing the centerline geometry and attribution in-house with County staff, it will be necessary for the County to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables

- Construction of the database within the County's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, Delaware County should use the database design recommendations outlined in Volume III.

Step 4 - Add Address Range Information

The final step in implementing the Common LRS Approach is to add the appropriate address range information. This is accomplished through conflation. Depending on the available resources this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the address information, the same procedure must be followed in order to develop accurate and complete address attribution. Chapter I and Chapter III of Volume III contains technical information regarding the options for acquiring address range information and the conflation process, respectively.

Again, in the event that Delaware County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 5 – Capture Street Centerline Geometry from Digital Orthophotography

Should Delaware County decide to perform the data capture functions in-house, the next step in the process will include the actual processes and procedures through which the data capture staff interacts with the GIS software. Standard "heads-up" digitizing tools are available with the ESRI software that the County currently uses to maintain its GIS databases. There will most likely be some "up-front" configuration work required to facilitate an efficient and streamline data capture methodology. It is recommended that Delaware County follow the steps outlined in Section II for capturing the street centerline geometry from the digital orthophotography. Specifically, steps 1 and 2 of this process are recommended.

In the event that Delaware County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 6 - Add LRS Information (Unique Route Number and Measurement Values)

As described in Volume III, the development of a GIS data model that supports the Common LRS approach requires that each segment in the centerline database have a unique route identification number and measurement attributes. In New Jersey, it has been determined that the Standard Route Identifier (SRI) will serve this purpose. Currently in Pennsylvania, there is no single data element to serve this purpose. However, the use of the State Route Number (SR) and County Code (CO) combination will provide for a unique road identifier. PennDOT is currently investigating the creation of a unique identifier similar to NJDOT's SRI number. PennDOT will also supply the beginning cumulative measure and end cumulative measure for each segment of road broken by all road intersections. The addition of the SR-CO combination and the begin cumulative measure and end cumulative measure to the Delaware County centerline database can

be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Again, in the event that Delaware County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 7 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Centerline and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. The various event tables could be developed within an external database system such as Microsoft Access and Oracle, which the County currently uses.

Step 2 – Populate Centerline Table

Once the database tables have been properly configured, Delaware County will need to at least populate the centerline with the appropriate LRS and street address data as described in the preceding section.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of Delaware County. The interview process revealed that the County currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through a County data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

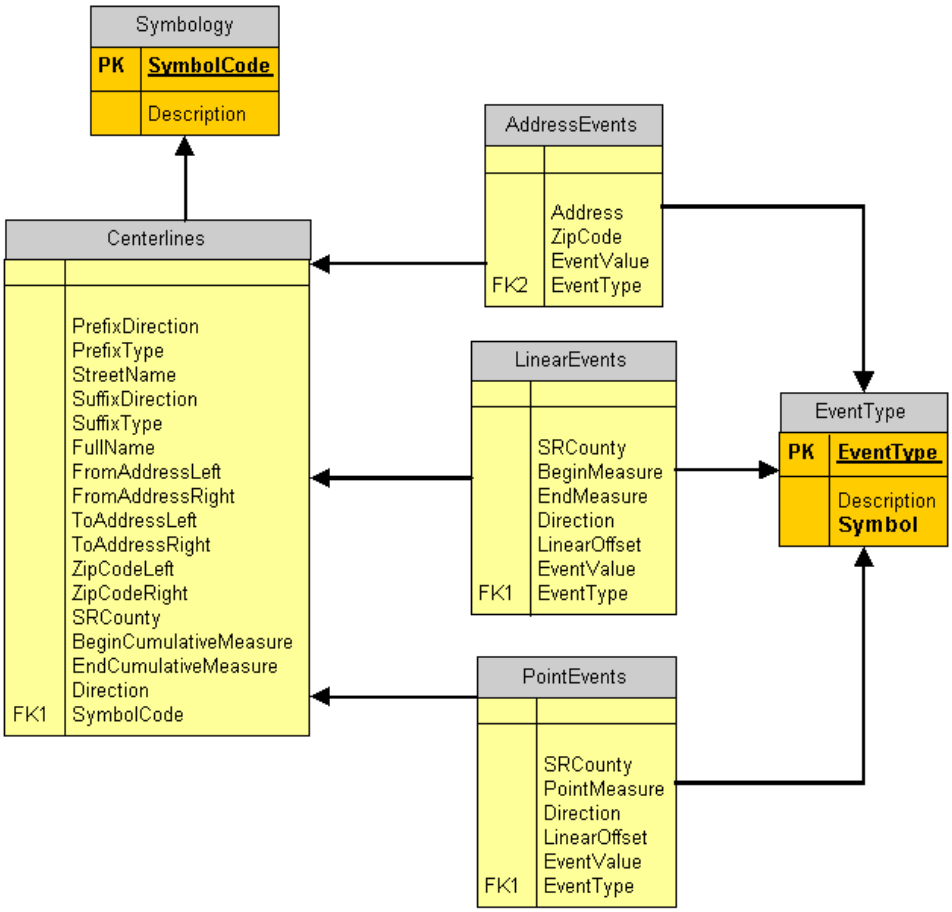

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Training

The successful implementation of the plan that has been presented for Delaware County is clearly dependent upon the County's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving Delaware County revealed that the County currently uses ESRI GIS software products, including ArcInfo 8.1 (ArcGIS) and associated products. This software provides the requisite tools for performing the various conflation processes, database development procedures, and data maintenance requirements described above. At this time, there appears to be no urgent need for Delaware County to procure additional software resources.

With regard to the database management component of the implementation, it is recommended that Delaware County consider the use of a product other than INFO to manage external event data tables. Interview responses indicated that the County is considering the use of Oracle or SQL Server for this purpose.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for Delaware County will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process and subsequent discussions with Delaware County staff have revealed that the County currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the County opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by County staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

The implementation of the recommended procedures outlined above and in Section II will require a relatively strong understanding of the use of ArcGIS software and experience in applying the necessary software tools. Recent conversations with Delaware County have revealed that staff within the Planning Department are currently receiving ArcGIS training and will possess the requisite skills to perform the work that is required to implement the recommendations presented in this plan and previous volumes.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRI software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Based on the information collected during the interview phase, it is anticipated that Delaware County will not need to hire additional staff if the implementation work is to be performed in house. Existing staff are well versed in the use of ArcGIS and are receiving formal training on ESRI software.

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For Delaware County, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately six months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that Delaware County would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that Delaware County should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project Scope of Work	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Design of data capture rules, work flow and processes				
Develop Data Capture Rules	8.0	24.0	0.0	**32.0**
Design and Develop Work Flows and Processes	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Obtain Orthophotography				
Acquire orthophotography	2.0	0.0	0.0	**2.0**
Load orthophotography	1.0	2.0	4.0	**7.0**
Total Task 4	**3.0**	**2.0**	**4.0**	**9.0**
Task 5 – Create Centerlines from Orthophotography				
System set-up	2.0	24.0	0.0	**26.0**
Create route feature class	2.0	16.0	0.0	**18.0**
Capture centerlines from orthophotography	8.0	20.0	240.0	**268.0**
Quality control	16.0	40.0	120.0	**176.0**
Total Task 4	**28.0**	**100.0**	**360.0**	**488.0**
Task 6 – Conflate Address Ranges				
Conflate address ranges from appropriate source	16.0	40.0	160.0	**216.0**
Quality control	8.0	24.0	80.0	112.0
Total Task 4	**24.0**	**64.0**	**240.0**	**328.0**

Task 6 – Add LRS Information				
Add SR-CO	8.0	8.0	200.0	**216.0**
Add begin and end cumulative distance	8.0	16.0	120.0	**144.0**
Quality control	8.0	12.0	80.0	**100.0**
Total Task 5	**24.0**	**36.0**	**400.0**	**460.0**
Task 7 - Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 6	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**183.0**	**402.0**	**1,084.0**	**1,669.0**

Table 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in Delaware County the county must: (1) create a centerline database, (2.) add address range information to the centerlines to enable accurate geocoding, and (3.) add critical elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, Delaware County must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow Delaware County to share data with PennDOT, but it will also allow the county to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 5 – Montgomery County, Pennsylvania

I Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Montgomery County, Pennsylvania. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, Montgomery County is considered to be at the Stage 1 Level. The county has no centerline data.

I-2 Summary of Needs

Currently the county's most critical needs are: (1) create a centerline file that will support the use of GIS for transportation planning, (2.) add address range information to the centerlines to enable accurate geocoding and (2) add critical elements for the Common LRS approach to enable data sharing and linear referencing.

I-2.1 Implementation Options

In order to meet these needs, Montgomery County has a few options. The first option involves capturing centerline geometry using the digital orthophotography currently being developed by DVRPC as a base. Centerline geometry could be captured through a process of "heads-up" digitizing with the ESRI GIS software that the County currently uses. This data capture effort could be done by County personnel or contracted out. A second option would include the purchase of centerline data from a third-party commercial vendor. A final option might include the borrowing of existing centerline data from a source such as PennDOT or DVRPC. The principle benefit of this option is that Montgomery County can utilize their existing centerlines.

Each of these options was evaluated through the street centerline development options demonstration that was performed as part of the prototype phase of the project. This demonstration process and its results are documented in Chapter II of Volume II. After due considerations of all of the options, it is recommended that Montgomery County adopt the first option, creating its centerline base from the DVRPC orthophotography. This will allow the County to develop a centerline that has a high degree of accuracy and completeness. As stated above, this option presents two alternative approaches: centerline data capture and attribution by County staff or centerline data capture and attribution by a contractor.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to Montgomery County, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase I, which will only cover roads maintained in the PennDOT GIS centerline database. This is primarily due to the fact that creating Common LRS attribution for these roads will be most feasible.

The process for implementing the Common LRS Approach is outlined below. Since Montgomery County has no centerlines that can be used for implementation of the Common LRS Approach, the implementation they should follow starts at the "Obtain Centerlines" block, which is noted by the "Current Conditions" label.

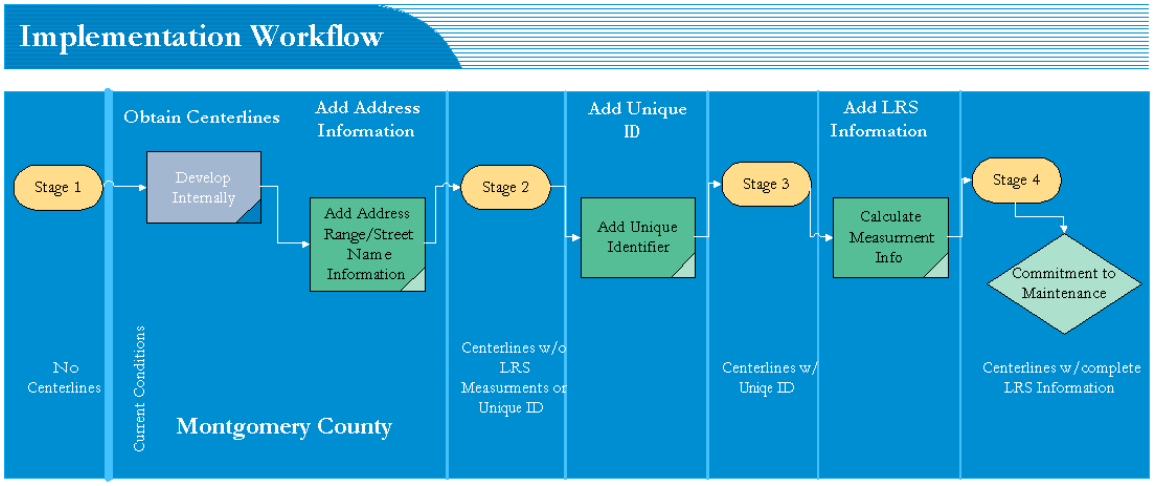

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that Montgomery County must make when implementing the Common LRS approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for Montgomery County to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach (Option 1 – Develop Centerline From DVRPC Orthophotography)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach for Montgomery County. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline data. They address the two alternative approaches mentioned above: development of centerline data by County staff and development of centerline data through use of an outside contractor.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the County, neither process can commence until the County has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Acquisition of orthophotography from DVRPC* – This component includes the acquisition of digital orthophotography from DVRPC with complete coverage of Montgomery County.
- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, workflow and processes* – This component includes the design and documentation of workflow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Capture of centerline geometry from orthophotography* – This component includes the work effort required to capture centerline geometry from the orthophotography.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata.

Step 2 – Acquisition of Orthophotography

Before data capture can begin, it will be necessary for Montgomery County to obtain the digital orthophotography files from DVRPC. The extent of coverage must include the entire County. This step is required regardless of the alternative approach that is selected by the County.

Step 3 – Development of Standards and Database Design, Configuration, and Implementation

If Montgomery County opts for capturing the centerline geometry and attribution in-house with County staff, it will be necessary for the County to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables
- Construction of the database within the County's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, Montgomery County should use the database design recommendations outlined in Volume III.

Step 4 – Capture Street Centerline Geometry from Digital Orthophotography

Should Montgomery County decide to perform the data capture functions in-house, the next step in the process will include the actual processes and procedures through which the data capture staff interacts with the GIS software. Standard "heads-up" digitizing tools are available with the ESRI software that the County currently uses to maintain its GIS databases. There will most likely be some "up-front" configuration work required to facilitate an efficient and streamline data capture methodology. It is recommended that Montgomery County follow the steps outlined in Section II for capturing the street centerline geometry from the digital orthophotography. Specifically, steps 1 and 2 of this process are recommended.

In the event that Montgomery County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 5 - Add Address Range Information

The initial step in implementing the Common LRS Approach is to add the appropriate address range information. This is accomplished through conflation. Depending on the available resources this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the address information, the same procedure must be followed in order to develop accurate and complete address attribution.

Again, in the event that Montgomery County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 6 - Add LRS Information (Unique Route Number and Measurement Values)

As described in Volume III, the development of a GIS data model that supports the Common LRS approach requires that each segment in the centerline database have a unique route identification number and measurement attributes. In New Jersey, it has been determined that the Standard Route Identifier (SRI) will serve this purpose. Currently in Pennsylvania, there is no single data element to serve this purpose. However, the use of the State Route Number (SR) and County Code (CO) combination will provide for a unique road identifier. PennDOT is currently investigating the creation of a unique identifier similar to NJDOT's SRI number. PennDOT will also supply the beginning cumulative measure and end cumulative measure for each segment of

road broken by all road intersections. The addition of the SR-CO combination and the begin cumulative measure and end cumulative measure to the Montgomery County centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Again, in the event that Montgomery County opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 7 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Attribute and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. In Montgomery County's case, the centerline table could be developed as an Arc Attribute Table (AAT). The various event tables could be developed within an external database system such as Microsoft Access, which the County currently uses.

Step 2 – Populate Attribute Tables

Once the database tables have been properly configured, Montgomery County will need to at least populate the centerline AAT with the appropriate LRS and street address data as described in the preceding section.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of Montgomery County. The interview process revealed that the County currently maintains no event tables specifically concerned with transportation related events. However, as this type of data becomes available, either through a County data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

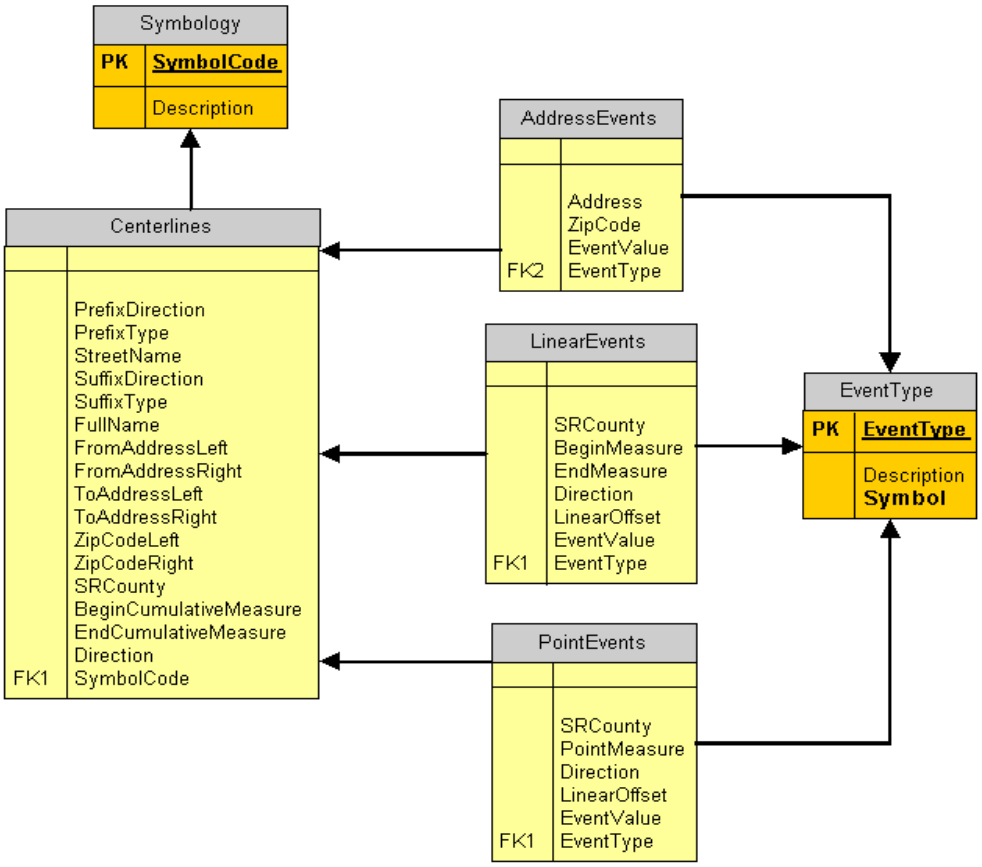

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Training

The successful implementation of the plan that has been presented for Montgomery County is clearly dependent upon the County's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving Montgomery County revealed that the County currently uses ESRI GIS software products, including ArcView version 3.2 and ArcCAD. This software does not provide the requisite tools for performing the various conflation processes, database development procedures, and data maintenance requirements described above. Prior to initiating any in-house efforts to create a centerline database, the County will need to acquire additional software, including ArcGIS 8.1.

With regard to the database management component of the implementation, it is recommended that Montgomery County consider the use of a product other than INFO to manage external event data tables. Interview responses indicated that the County is considering the use of Oracle or SQL Server for this purpose.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

The interview portion of the needs assessment process and subsequent discussions with Montgomery County staff have revealed that the County currently lacks sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common

LRS/Street Address Geocoding approach. Therefore, it is recommended that the County give consideration to procuring additional hardware, sufficient to support the use of ArcGIS 8.1 software and a relational database management system, (RDBMS).

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the County opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by County staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

Based on the information collected during the interview phase, it is anticipated that Montgomery County may need to hire a GIS Analyst or provide additional training to existing staff if the implementation work is to be performed in house. Formal training on ESRI software is available from ESRI both in a traditional classroom setting and through online classes via their website. Costs vary, with classroom training costs ranging from approximately $500 - $2,000 per student depending upon the nature and duration of the course. Online training is significantly less expensive, but is limited in scope and content.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRO software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For Montgomery County, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately six to eight months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that Montgomery County would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that Montgomery County should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project Scope of Work	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Design of data capture rules, work flow and processes				
Develop Data Capture Rules	8.0	24.0	0.0	**32.0**
Design and Develop Work Flows and Processes	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Obtain Orthophotography				
Acquire orthophotography	2.0	0.0	0.0	**2.0**
Load orthophotography	1.0	2.0	4.0	**7.0**
Total Task 4	**3.0**	**2.0**	**4.0**	**9.0**
Task 5 – Create Centerlines from Orthophotography				
System set-up	2.0	24.0	0.0	**26.0**
Create route feature class	2.0	16.0	0.0	**18.0**
Capture centerlines from orthophotography	8.0	32.0	360.0	**400.0**
Quality control	16.0	40.0	160.0	**216.0**
Total Task 4	**28.0**	**112.0**	**520.0**	**660.0**
Task 6 – Conflate Address Ranges				
Conflate address ranges from appropriate source	16.0	40.0	240.0	**296.0**
Quality control	8.0	24.0	120.0	**152.0**
Total Task 4	**24.0**	**64.0**	**360.0**	**448.0**

Task 6 – Add LRS Information				
Add SR-CO	8.0	16.0	280.0	**324.0**
Add begin and end cumulative distance	8.0	16.0	160.0	**184.0**
Quality control	8.0	40.0	120.0	**168.0**
Total Task 5	**24.0**	**72.0**	**560.0**	**676.0**
Task 7 - Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 6	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**183.0**	**450.0**	**1,524.0**	**2,157.0**

Table 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in Montgomery County the county must: (1) create a centerline database, (2.) add address range information to the centerlines to enable accurate geocoding, and (3.) add critical elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, Montgomery County must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow Montgomery County to share data with PennDOT, but it will also allow the county to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 6 – City of Philadelphia, Pennsylvania

I Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for the City of Philadelphia. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, The City of Philadelphia is considered to be at the Stage 2 Level. The city has road centerlines but no LRS Measure

I-2 Summary of Needs

Currently the city's most critical need for implementing GIS for transportation planning is: (1) add critical elements for the Common LRS approach to enable data sharing and linear referencing.

I-2.1 Implementation Options

In order to meet these needs, the City of Philadelphia has a few options. The first option involves manually entering or tagging each road centerline which overlaps with PennDOT's LRS with the Unique Route Identifier and Begin and End Cumulative offset measures. The second option involves the use of conflation to try to automate as much as possible the adding of the PennDOT Unique Road Identifier (SR/CO) and the Begin and End Cumulative offset measures.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to the City of Philadelphia, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase I, which will only cover roads maintained in the PennDOT GIS centerline database. This is primarily due to the fact that creating Common LRS attribution for these roads will be most feasible.

The process for implementing the Common LRS Approach is outlined below. Since the City of Philadelphia has centerlines that can be used for implementation of the Common LRS Approach, along with the Street Names and address ranges the implementation they should follow starts at the "Add Unique Identifier" block, which is noted by the "Current Conditions" label.

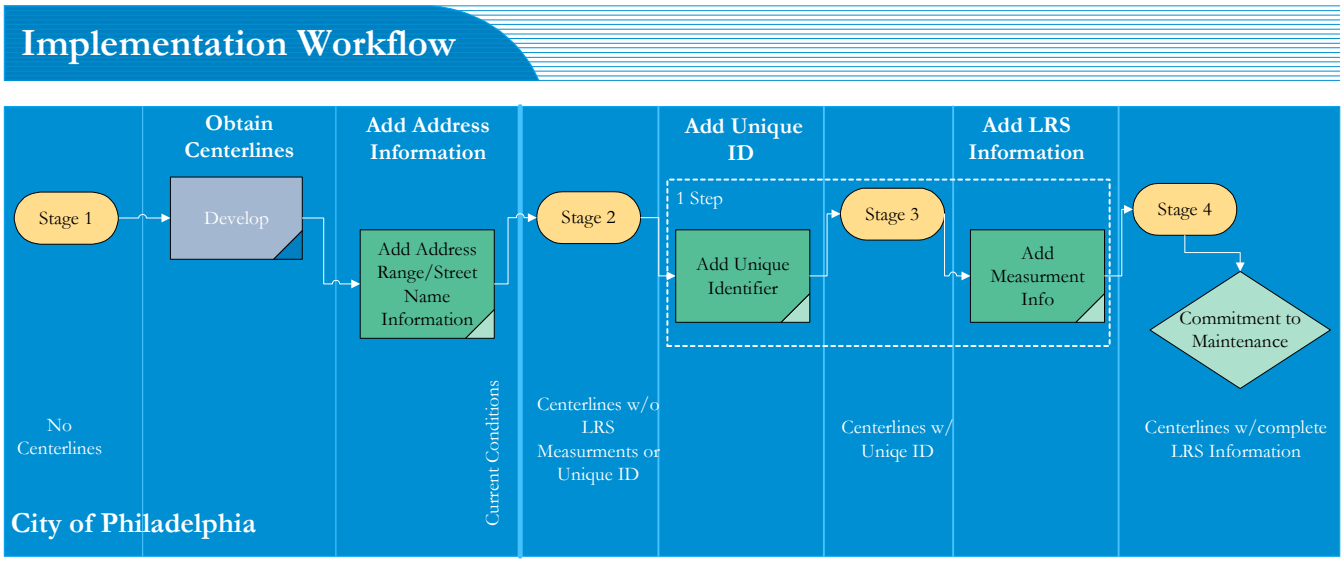

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that the City of Philadelphia must make when implementing the Common LRS approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for the City of Philadelphia to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach - Add LRS Information (Unique Route Number and Measurement Values)

As described in Volume III, the development of a GIS data model that supports the Common LRS approach requires that each segment in the centerline database have a unique route identification number and measurement attributes. In New Jersey, it has been determined that the Standard Route Identifier (SRI) will serve this purpose. Currently in Pennsylvania, there is no single data element to serve this purpose. However, the use of the State Route Number (SR) and County Code (CO) combination will provide for a unique road identifier. PennDOT is currently investigating the creation of a unique identifier similar to NJDOT's SRI number. PennDOT will also supply the beginning cumulative measure and end cumulative measure for each segment of road broken by all road intersections. The addition of

the SR-CO combination and the begin cumulative measure and end cumulative measure to the City of Philadelphia centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Step 1 – Develop Project Scope of Work

As the first step in the recommended process, the City will need to develop a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, work flow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata.

Step 2 – Development of Standards and Database Design, Configuration, and Implementation

If the City of Philadelphia opts for capturing the centerline attribution in-house with County staff, it will be necessary for the County to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables
- Construction of the database within the City's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, the City of Philadelphia should use the database design recommendations outlined in Volume III.

Step 3 - Add LRS Information (Unique Route Number and Measurement Values)

As described in Volume III, the development of a GIS data model that supports the Common LRS approach requires that each segment in the centerline database have a unique route identification number and measurement attributes. In New Jersey, it has been determined that the Standard Route Identifier (SRI) will serve this purpose. Currently in Pennsylvania, there is no single data element to serve this purpose. However, the use of the State Route Number (SR) and County Code (CO) combination will provide for a unique road identifier. PennDOT is currently investigating the creation of a unique identifier similar to NJDOT's SRI number. PennDOT will also supply the beginning cumulative measure and end cumulative measure for each segment of road broken by all road intersections. The addition of the SR-CO combination and the begin cumulative measure and end cumulative measure to the City of Philadelphia centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Again, in the event that City of Philadelphia opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

In performing theses tasks, City of Philadelphia should use the database design recommendations outlined in Volume III.

Step 4 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Centerline and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. The various event tables could be developed within an external database system such as Microsoft Access and Oracle, which the City of Philadelphia currently uses.

Step 2 – Populate Centerline Table

Once the database tables have been properly configured, the City of Philadelphia will need to at least populate the centerline with the appropriate LRS that will go along with its current street address data.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of the City of Philadelphia. The interview process revealed that the City currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through a City data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

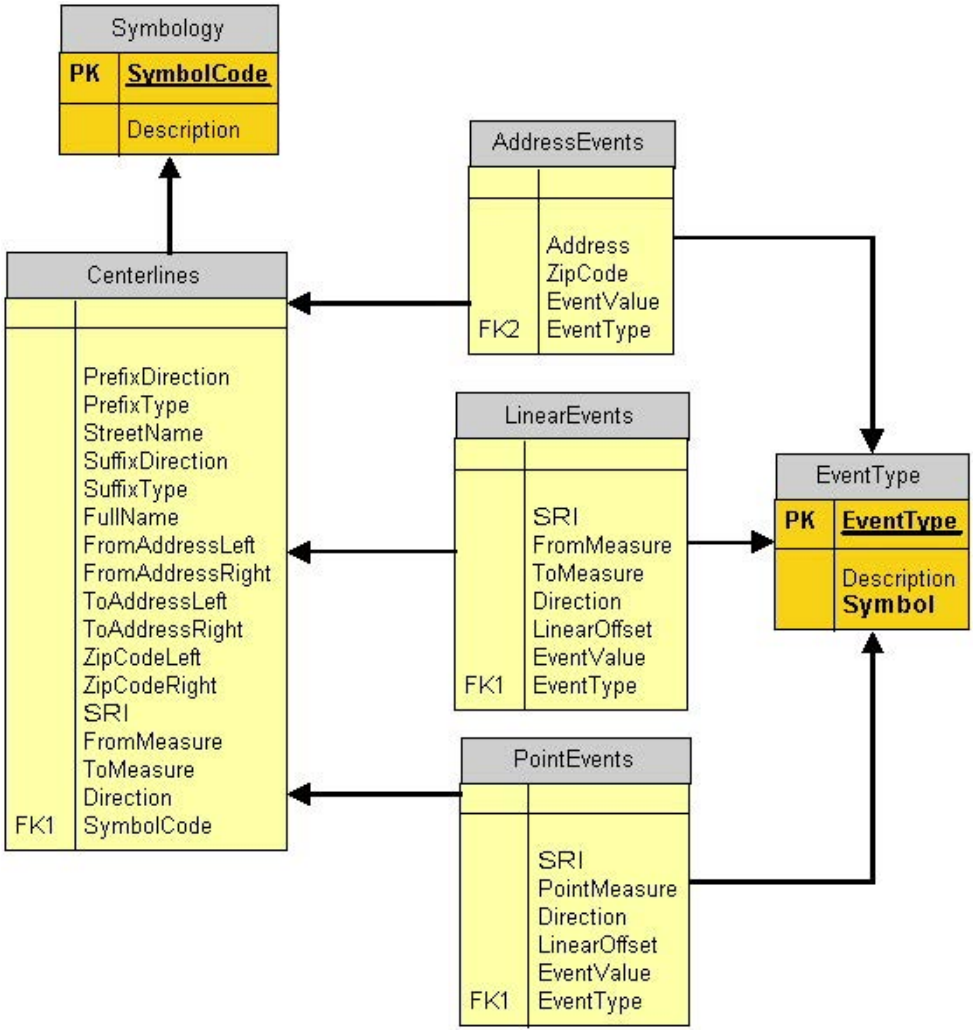

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Training

The successful implementation of the plan that has been presented for the City of Philadelphia is clearly dependent upon the City's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

The interview portion of the needs assessment process involving the City of Philadelphia revealed that the City currently uses ESRI GIS software products, including ArcInfo 8.1 (ArcGIS) and associated products. This software provides the requisite tools for performing the various conflation processes, database development procedures, and data maintenance requirements described above. At this time, there appears to be no urgent need for the City of Philadelphia to procure additional software resources.

IV-2 Hardware

The interview portion of the needs assessment process and subsequent discussions with the City of Philadelphia staff have revealed that the City currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Training

The implementation of the recommended procedures outlined above and in Section II will require a relatively strong understanding of the use of ArcGIS software and experience in applying the necessary software tools. Recent conversations with the City of Philadelphia have revealed that staff are currently receiving ArcGIS training and will possess the requisite skills to perform the work that is required to implement the recommendations presented in this plan and previous volumes.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	Total Hours
Tasks			
Task 1 – Develop Scope of Work			
Develop Project Scope of Work	40.0	16.0	**56.0**
Total Task 1	**40.0**	**16.0**	**56.0**
Task 2 – Conflate SR-CO and Measures			
Automatic Conflation	24.0	80.0	**104.0**
Manual Conflation	80.0	800.0	**880.0**
Total Task 3	**104.0**	**880.0**	**984.0**
Task 3 – QA/QC			
Find & Correct Null Values	24.0	240.0	**264.0**
Find & Correct LRS Errors	24.0	240.0	**264.0**
Total Task 4	**48.0**	**480.0**	**528.0**
Task 4 – Data Model			
Define Domain Tables	24.0	80.0	**104.0**
Define Standard Symbology	24.0	80.0	**104.0**
Total Task 6	**48.0**	**160.0**	**208.0**
Task 5 - Maintenance			
Establish Maintenance Procedures	8.0	80.0	**88.0**
Total Task 7	**8.0**	**80.0**	**88.0**
SUB-TOTAL	**248.0**	**1,616.0**	**1,644.0**

Figure 3 – Implementation Strategy Hours Estimate

VI. Summary and Conclusions

In order to implement the Common LRS Approach in the City of Philadelphia the City must: (1.) add critical elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the process for accomplishing this step has been defined above, the City of Philadelphia must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow the City of Philadelphia to share data with PennDOT, but it will also allow the City to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 7 – Pennsylvania Department of Transportation (PennDOT)

I Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for the Pennsylvania Department of Transportation (PennDOT). It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, PennDOT centerline dataset is considered to be at the Stage 4 Level. PennDOT has road centerlines with full attribution including a unique road identifier. The centerlines are mostly single centerlines but they have centerline representation for each direction on multiple lane state maintained roads. The centerlines are nominally 1:24,000 scale as the original road centerlines were digitized approximately ten years ago off of USGS Quad Sheets. There are some efforts underway to visually adjust the linework to existing digital orthophotos in selected parts of the state. The maps are stored in Polyconic projection - 1983 meters. A complete maintenance procedure is in place as new roads are added, modified or deleted within the state maintained highway network.

I-2 Summary of Needs

Through the Needs Assessment phase, it has been established that PennDOT currently has a GIS system that fits the needs of a State DOT. PennDOT does have a limited need for local road information.

I-3 Phased Approach

In the initial phase of this DVRPC project it has been agreed to that for the first phase that only the State maintained road network would be dealt with. This phased approach will make PennDOT strictly a supplier of information and will not affect their current GIS business process. The consultant has added some additional considerations that PennDOT could start to put into place that could allow for a more comprehensive State/Local sharing of data at a future point in time. We have decided to list those steps as low-impact to PennDOT, Medium Impact to PennDOT and High Impact to PennDOT.

I-4 Low Impact Approach

PennDOT will supply the state maintained road network to the local Pennsylvania entities in an ArcView Shape file in PA State Plane 1983 projections with the roads broken at all intersections with the following attribution on each road segment

A. County
B. State Route Number
C. Begin Cumulative Offset for that Segment
D. End Cumulative Offset for that Segment

PennDOT will then also make available to the local Pennsylvania government entities extracts (selected columns of data) of some of their main business tables in County/State Route and Cumulative Offset format. Examples could be PMS, CRASH, Construction Project Data etc.

I-5 Medium Impact Approach

PennDOT performs all of the steps required in the Low Impact Approach but also would perform two additional tasks.

The first task is to have PennDOT modify its GIS road centerlines so that they fit over the new digital orthophotography being acquired by DVRPC. This increased geometric accuracy would enhance further the conflation process that the local Pennsylvania agencies would face.

The second task would be to have PennDOT work with the local governments in Pennsylvania to postulate and actively participate on generating unique road identifiers for ALL roads in Pennsylvania

I-6 High Impact Approach

PennDOT performs all of the steps required in the Low and Medium Impact Approaches but also starts and completes the process assigning unique road identifies on all roads within Pennsylvania on their current CAD files.

Plan Number 8 – Burlington County, New Jersey

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Burlington County, New Jersey. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. As of the time of the interviews, the County was maintaining two centerline files. The GIS Section of the Department of Data Processing has developed road centerlines collected using Trimble GPS units with the antenna mounted in the center of the survey vehicle roof. Each road centerline was collected by logging GPS positions at one-second intervals while driving the road from the beginning to end. Centerline locations are estimated to be accurate to within +/- 3 feet. These road centerlines have a unique identifier along with various degrees of database attribution. The County Engineering Department also maintains a centerline file that it has developed from orthophotography. The attribution related to these centerlines primarily serves engineering applications.

Currently, Burlington County's centerline dataset is considered to be at the Stage 3 Level. The centerlines are mostly single centerlines, but they do maintain a dual centerline where appropriate (divided highways). The road centerlines include the NJDOT SRI number for road where NJDOT had the values in their Straight Line Diagram (SLD) application. The centerlines also have the beginning milepost and ending milepost for Interstate, US Routes, and NJ State 500/600 Series County roads. The milepost values are for the entire road and do not correspond to the beginning/end of an individual segment. Non-populated database fields exist for the county to add address range and street name information but they are currently not populated. Burlington County is currently working with GDT in order to get those database fields populated correctly.

I-2 Summary of Needs

Currently the county's most critical needs for implementing GIS for transportation planning are: (1.) working with GDT, complete the addition of address range information to the centerlines to enable accurate geocoding, (2.) ensuring that all critical elements for the Common LRS Approach are included in the database to enable data sharing and linear referencing and (3.) working together to identify a single, multi-functional centerline file that will meet the needs of all GIS users within the County government.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to Burlington County, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase 1, which will only cover roads maintained in the New Jersey DOT GIS centerline database. During Phase 2, the same processes and procedures can be applied to local roads that are currently not part of the NJDOT centerline database. This second phase will require the establishment of unique SRI numbers for these local roads.

The process for implementing the Common LRS Approach is outlined below. Since Burlington County already has centerlines with SRI numbers that can be used for implementation of the Common LRS Approach, the implementation they should follow starts at the "Add Address Information" block, which is noted by the "Current Conditions" label skip over the Add Unique ID block and then perform modifications to the Add LRS Information block.

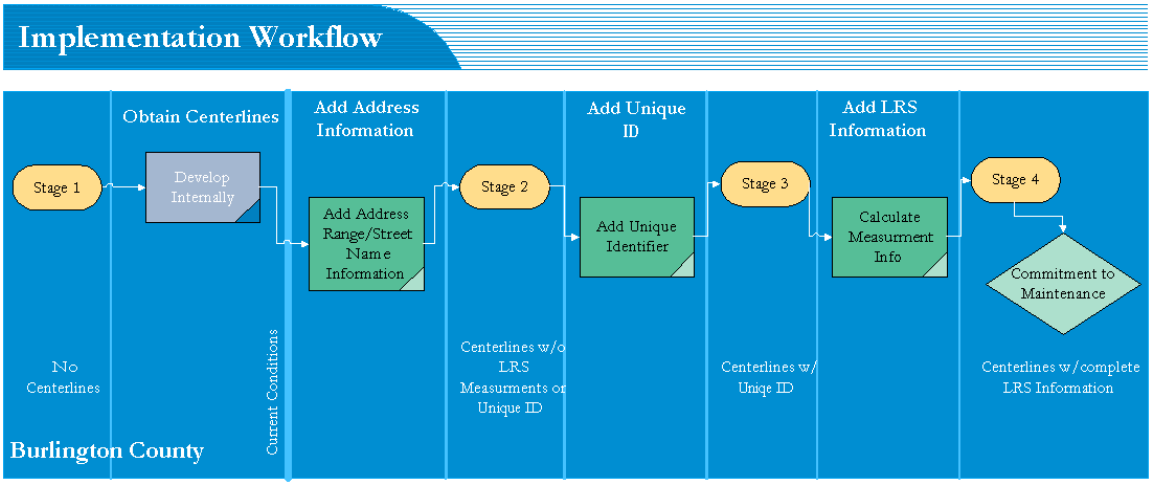

Figure 1 – Implementation Workflow

II-1 Implementation Approach (Option 1 – Maintain Current Centerline)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach with Burlington County's existing street centerlines. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline. In should be noted here that these recommendations assume that Burlington County has identified a common centerline file that meets the needs of all end users. It is further assumed that this common centerline is the file that is currently used by the GIS Section of the Department of Data Processing.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the County, neither process can commence until the County has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, work flow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata

Step 2 – Development of Standards and Database Design, Configuration, and Implementation

If Burlington County opts for capturing the centerline attribution in-house with County staff, it will be necessary for the County to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables
- Construction of the database within the County's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, Burlington County should use the database design recommendations outlined in Volume III.

Step 3 - Add Address Range Information

The first step in implementing the Common LRS Approach is to add the appropriate address range – street name information. This is accomplished through conflation. Depending on the available resources this portion of implementation can be accomplished through internal or external means. It is the current understanding at time of data collection for this project that Burlington County was already engaged with GDT Corporation to add this required information and no additional action is required.

Step 4 - Add LRS Information (Measurement Values)

An LRS has, as its foundation, has a distance measurement along the centerline, from some beginning reference point to some ending reference point. The distance can be any unit of measure. The reference points can be at intersections, mileposts, stations, county boundaries or some other arbitrary location. Currently Burlington County has Begin_MP (beginning milepost) and End_MP (ending milepost) fields in the database. The problem lies in the fact that the milepost value is an attribute of the entire road segment and does not correspond to the beginning/end of individual segments. This needs to be corrected. The process is well documented step by step in Volume III Technical Recommendations.

Step 5 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

With the correction of the milepost values and the addition of the street addressing information via GDT, Burlington County should be able to move ahead with little impact to the current database design.

It is recommended, however, that Burlington County consider the removal of the following fields from the road centerline database table: Lanes, Shoulder, Ditch, Type, Posted_Speed, Dom_Landuse, Surface_Mat, and Striping. These are really dynamic attributes (events) that change over time. New event tables can be generated by the county for each of these pieces of information.

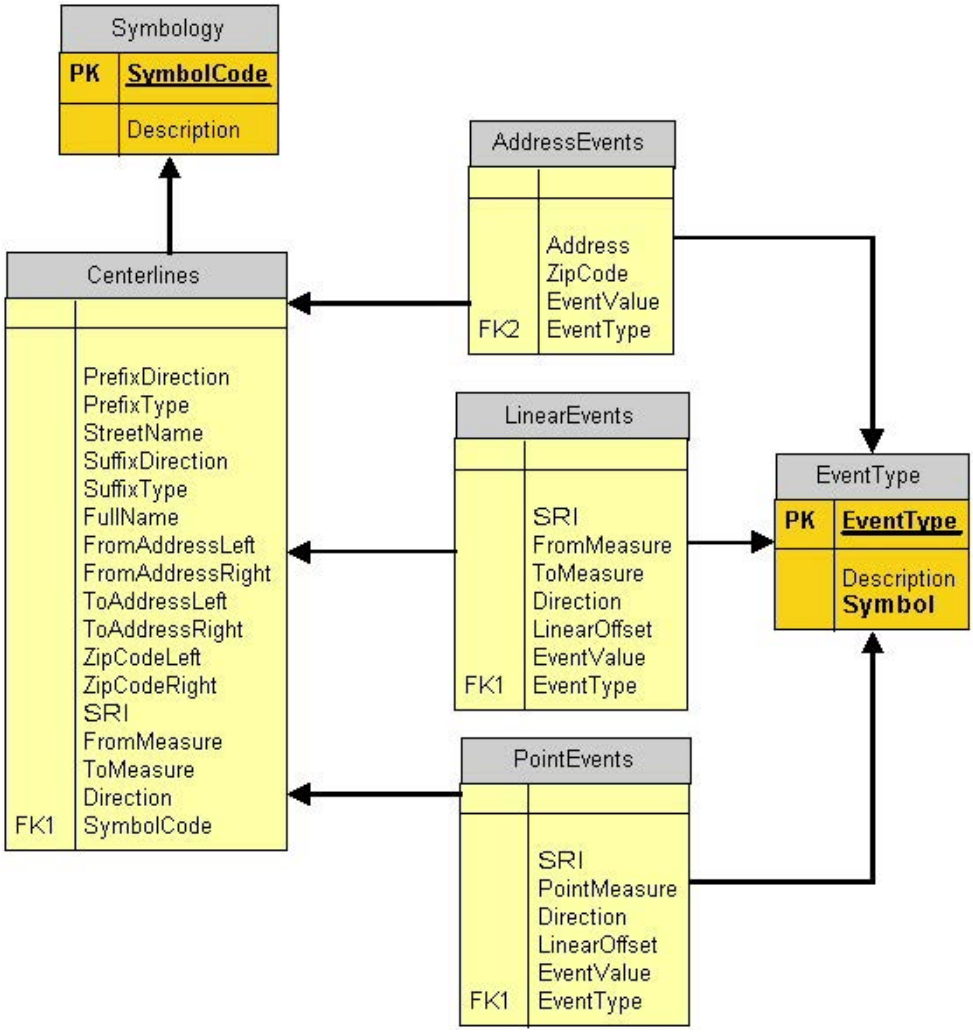

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Staffing and Training

The successful implementation of the plan that has been presented for Burlington County is clearly dependent upon the County's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving Burlington County revealed that the County currently uses ESRI GIS software products, including ArcGIS within the Department of Data Processing. The Engineering Department, the County's other major user of GIS currently has no GIS software resources. If the County places centerline data maintenance responsibility within the Data Processing Department as recommended, there is no critical need, at this time, for the County to acquire significant additional software resources. However, it is highly recommended that the Engineering Department acquire GIS software, such as ESRI ArcView 8.1 so that they can begin to develop productive applications of the County's GIS data.

With regard to the database management component of the implementation, it is recommended that Burlington County consider the use of a product other than INFO to manage external event data tables. Interview responses indicated that the County is considering the use of Oracle or SQL Server for this purpose.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for Burlington County will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process and subsequent discussions with Burlington County staff have revealed that the County currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the County opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by County staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

Based on the information collected during the interview phase, it is anticipated that Burlington County may need to hire a GIS Technician or provide additional training to existing staff if the implementation work is to be performed in house. Formal training on ESRI software is available from ESRI both in a traditional classroom setting and through online classes via their website. Costs vary, with classroom training costs ranging from approximately $500 - $2,000 per student depending upon the nature and duration of the course. Online training is significantly less expensive, but is limited in scope and content.

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For Burlington County, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately three months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRO software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that Burlington County would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that Burlington County should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project Scope of Work	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Design of data capture rules, work flow and processes				
Develop Data Capture Rules	8.0	24.0	0.0	**32.0**
Design and Develop Work Flows and Processes	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Conflate Address Ranges				
Continue GDT Addressing Process	16.0	40.0	40.0	**96.0**
Total Task 4	**16.0**	**40.0**	**40.0**	**96.0**
Task 5 – Add LRS Information				
Correct Mileposting on Road Segments	8.0	8.0	240.0	**256.0**
Calculate 3D Distance	8.0	16.0	120.0	**144.0**
Total Task 5	**16.0**	**24.0**	**360.0**	**400.0**
Task 6 – Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 6	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**136.0**	**264.0**	**424.0**	**824.0**

Task 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in Burlington County the county must: (1) Add Address Range Information to the centerlines to enable accurate geocoding. (2) Add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, Burlington County must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow Burlington County to share data with NJDOT, but it will also allow the county to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 9 – City of Camden, New Jersey

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for the City of Camden, New Jersey. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, the City of Camden is considered to be at the Stage 2 Level. The City has centerline data that could be used to support GIS applications for transportation planning and the sharing of transportation data with other organizations within the region. The City's current centerline file was created originally from aerial photography in 1992 and has been maintained on an ad hoc basis.

I-2 Summary of Needs

Currently, the City's most critical needs are to update it's current centerline file to meet the technical recommendations described in Volume III and then develop and implement long range plans for maintaining and updating the database.

I-2.1 Implementation Options

In order to meet these needs, the City of Camden has a few options. The first option involves updating the City's current centerline data by capturing centerline geometry using the digital orthophotography currently being developed by DVRPC as a base. Centerline geometry could be captured through a process of "heads-up" digitizing with GIS software. This data capture effort could be done by City personnel or contracted out. A second option would include the purchase of centerline data from a third-party commercial vendor. A final option might include the borrowing of existing centerline data from a source such as New Jersey DOT or DVRPC.

Each of these options was evaluated through the street centerline development options demonstration that was performed as part of the prototype phase of the project. This demonstration process and its results are documented in Chapter II of Volume II. After due considerations of all of the options, it is recommended that the City of Camden adopt the first option, updating its centerline base from the DVRPC orthophotography. This will allow the City to develop a centerline that has a high degree of accuracy and completeness. As stated above, this option presents two alternative approaches: centerline data capture and attribution by City staff or centerline data capture and attribution by a contractor.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to the City of Camden, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase I, which will only cover roads maintained in the PennDOT GIS centerline database. This is primarily due to the fact that creating Common LRS attribution for these roads will be most feasible.

The process for implementing the Common LRS Approach is outlined below. Since the City of Camden has no centerlines that can be used for implementation of the Common LRS Approach, the implementation they should follow starts at the "Obtain Centerlines" block, which is noted by the "Current Conditions" label.

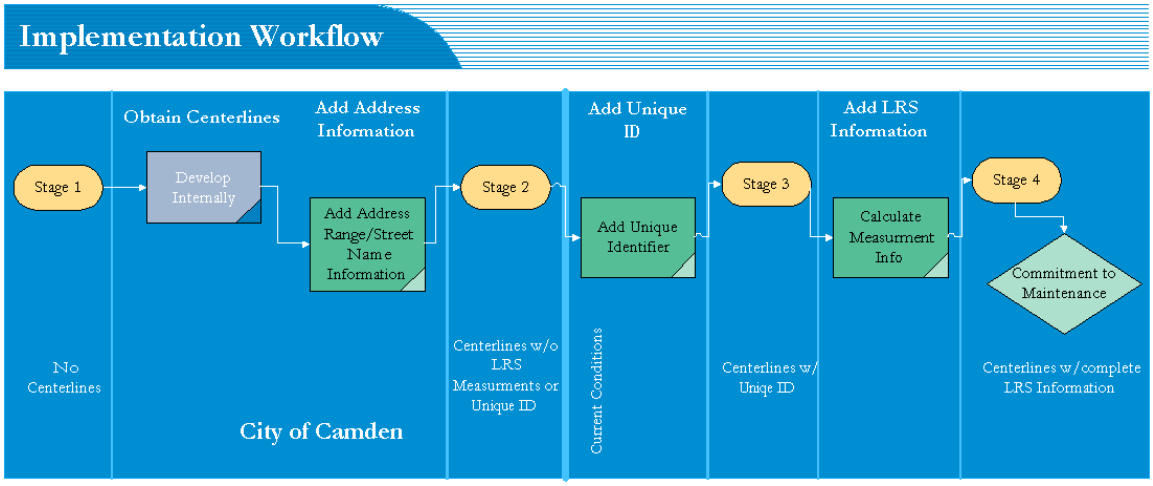

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that The City of Camden must make when implementing the Common LRS approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for The City of Camden to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach (Option 1 – Update Centerline From DVRPC Orthophotography)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach for The City of Camden. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline data. They address the two alternative approaches mentioned above: development of centerline data by City staff and development of centerline data through use of an outside contractor.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the City, neither process can commence until the City has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Acquisition of orthophotography from DVRPC* – This component includes the acquisition of digital orthophotography from DVRPC with complete coverage of The City of Camden.
- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, work flow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included are the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Update of centerline geometry from orthophotography* – This component includes the work effort required to update centerline geometry through data capture from the orthophotography.
- *Attribution of all centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of updated centerlines with street address information* – This component includes the work effort required to update street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata.

Step 2 – Acquisition of Orthophotography

Before data capture can begin, it will be necessary for The City of Camden to obtain the digital orthophotography files from DVRPC. The extent of coverage must include the entire City. This step is required regardless of the alternative approach that is selected by the City.

Step 3 – Development of Standards and Database Design, Configuration, and Implementation

If the City of Camden opts for updating the centerline geometry and attribution in-house with City staff, it will be necessary for the City to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables
- Construction of the database within the City's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, The City of Camden should use the database design recommendations outlined in Volume III.

Step 4 – Capture Street Centerline Geometry from Digital Orthophotography

Should the City of Camden decide to perform the data capture functions in-house, the next step in the process will include the actual processes and procedures through which the data capture staff interacts with the GIS software. Standard "heads-up" digitizing tools are available with ESRI software is compatible with the software that the City currently uses to maintain its GIS databases. However, it will be necessary for the City to acquire additional GIS software in the form of ArcGIS 8.1 in order to fully implement this plan. There will most likely be some "up-front" configuration work required to facilitate an efficient and streamline data capture methodology. It is recommended that The City of Camden follow the steps outlined in Section II for capturing the street centerline geometry from the digital orthophotography. Specifically, steps 1 and 2 of this process are recommended.

In the event that The City of Camden opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 3 - Add Address Range Information

The final step in implementing the Common LRS Approach is to add the appropriate address range information to support street address geocoding of event data. The addition of this data to the centerline databases is typically accomplished through conflation. In the case of the City of Camden, this process need only be applied to new, updated centerlines that are captured from orthophotography. Depending on the available resources, this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the address information, the same procedure must be followed in order to develop accurate and complete address attribution.

Again, in the event that the City of Camden opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 4 - Add Unique Identification (SRI Number) and NJDOT 3-D Measures

The next step in implementing the Common LRS Approach is to add the appropriate unique identification number and the NJDOT 3-D measures to the street centerline database. In the case of the City of Camden, this unique identification number is the Standard Route Identifier (SRI)

utilized by the New Jersey Department of Transportation (NJDOT). A description of the NJDOT SRI number can be found in Chapter II of Volume I. The addition of the SRI number to the City of Camden centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Depending on the available resources, this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the unique identification numbers, the same procedure must be followed in order to develop accurate and complete address attribution. In this case the source data are centerlines obtained from New Jersey DOT. These centerlines must contain the SRI number as an attribute. It is important to note that there will be numerous cases of the None-To-One scenario. This is due to the fact that SRI numbers are only down to the 700 level roads in most areas.

Again, in the event that The City of Camden opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 3 process, above.

Step 5 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Attribute and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. In The City of Camden's case, the centerline table could be developed as an Arc Attribute Table (AAT). The various event tables could be developed within an external database system.

Step 2 – Populate Attribute Tables

Once the database tables have been properly configured, the City of Camden will need to at least populate the centerline AAT with the appropriate LRS and street address data as described in the preceding section.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of the City of Camden. The interview process revealed that the City currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through a City data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

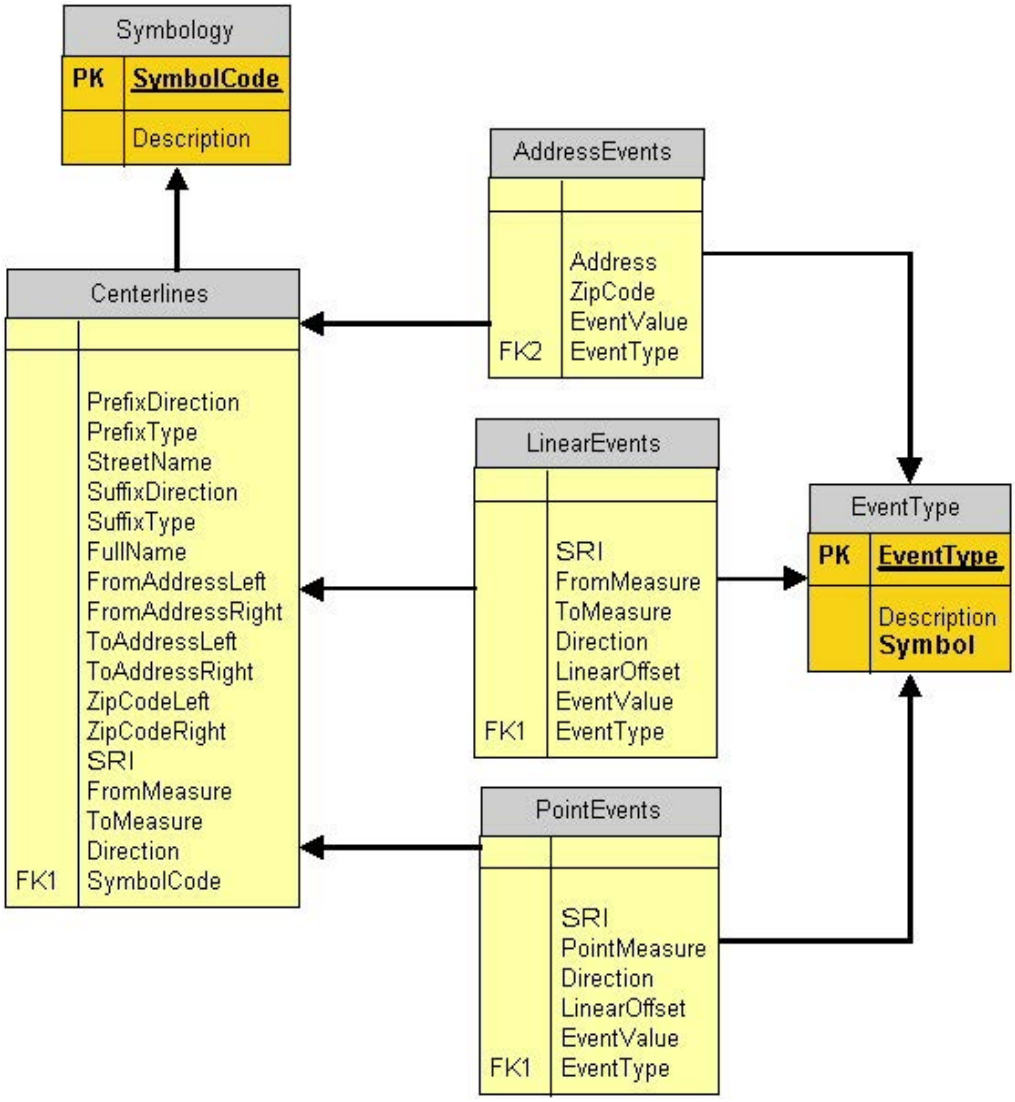

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Staffing and Training

The successful implementation of the plan that has been presented for City of Camden is clearly dependent upon the City's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving City of Camden revealed that the City currently uses ESRI GIS software products, including ArcView 3x within the Department of Development and Planning. If the City places centerline data maintenance responsibility within the Department of Development and Planning as recommended, it is highly recommended that the City ESRI's ArcGIS software, so that they can perform the necessary data capture and maintenance functions and operations.

With regard to the database management component of the implementation, it is recommended that City of Camden consider the use of a product other than INFO or DBF tables to manage external event data tables. Interview responses indicated that the City is considering the use of Oracle or SQL Server for this purpose.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for City of Camden will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process and subsequent discussions with City of Camden staff have revealed that the City currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the City opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by City staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

Based on the information collected during the interview phase, it is anticipated that City of Camden may need to hire a GIS Analyst and a GIS Technician or provide additional training to existing staff if the implementation work is to be performed in house. Formal training on ESRI software is available from ESRI both in a traditional classroom setting and through online classes via their website. Costs vary, with classroom training costs ranging from approximately $500 - $2,000 per student depending upon the nature and duration of the course. Online training is significantly less expensive, but is limited in scope and content.

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For City of Camden, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately three months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRO software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that City of Camden would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that City of Camden should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project Scope of Work	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Design of data capture rules, work flow and processes				
Develop Data Capture Rules	8.0	24.0	0.0	**32.0**
Design and Develop Work Flows and Processes	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Obtain Orthophotography				
Acquire orthophotography	2.0	0.0	0.0	**2.0**
Load orthophotography	1.0	2.0	4.0	**7.0**
Total Task 4	**3.0**	**2.0**	**4.0**	**9.0**
Task 5 – Update Centerlines from Orthophotography				
System set-up	2.0	24.0	0.0	**26.0**
Create route feature class	2.0	16.0	0.0	**18.0**
Capture centerlines from orthophotography	8.0	20.0	120.0	**148.0**
Quality control	4.0	16.0	60.0	**80.0**
Total Task 4	**16.0**	**76.0**	**180.0**	**272.0**
Task 6 – Conflate Address Ranges				
Conflate address ranges from appropriate source	16.0	40.0	40.0	**96.0**
Quality control	8.0	24.0	32.0	**64.0**
Total Task 4	**16.0**	**40.0**	**40.0**	**160.0**

Task 7 – Add LRS Information				
Correct Mileposting on Road Segments	8.0	8.0	160.0	**176.0**
Calculate 3D Distance	8.0	16.0	120.0	**144.0**
Quality control	4.0	8.0	40.0	**52.0**
Total Task 5	**20.0**	**32.0**	**320.0**	**372.0**
Task 8 - Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 6	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**159.0**	**380.0**	**624.0**	**1,163.0**

Table 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in The City of Camden the City must: (1) create a centerline database, (2.) add address range information to the centerlines to enable accurate geocoding, and (3.) add critical elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these items have been defined above, The City of Camden must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow The City of Camden to share data with PennDOT, but it will also allow the City to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 10 – Camden County, New Jersey

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Camden County, New Jersey. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, Camden County's centerline dataset is considered to be at the Stage 2 Level. The county has centerlines but do not carry any attribution on these centerlines. The centerlines are all single centerlines. A contractor created the centerline dataset with GPS for the Department of Public Works. There is no plan or staff for maintenance procedures.

The Improvement Authority utilizes GDT and TIGER data for geocoding. TIGER would function as a viable source for address ranges but there may be copyright restrictions on the GDT data.

I-2 Summary of Needs

Currently the county's most critical needs for implementing GIS for transportation planning are: (1) add Address Range Information to the centerlines to enable accurate geocoding and (2) add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing. On an organizational level, it is also critical that the County establish a responsible agency for managing and maintaining its GIS data and operations.

I-2.1 Implementation Options

In order to meet these needs, Camden County has two options. The first option involves using the existing centerlines and proceeding through the implementation process as it is written. The principle benefit of this option is that Camden County can utilize their existing centerlines. The principal disadvantages of this option are (1.) the centerline geometry must be brought up to date and (2.) Camden County must conflate the address ranges as well as the Standard Route Identifier.

The second option involves using the centerlines from or NJDOT. These centerlines are already attributed with the Standard Route Identifier, potentially allowing Camden County to remove Step 2 (Task 3 in the Statement of Work) from the Implementation Plan. The advantages to this option are (1.) the requirement for the second conflation procedure could be eliminated, or, at least, minimized and (2.)

the centerline dataset is more up-to-date and accurate, which allows removal of the Update Centerline Geometry sub-task under the Data Preparation task of the conflation process described in Chapter III of Volume III.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to Camden County, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase 1, which will only cover roads maintained in the New Jersey DOT GIS centerline database. During Phase 2, the same processes and procedures can be applied to local roads that are currently not part of the NJDOT centerline database. This second phase will require the addition of the unique SRI numbers for these local roads.

The process for implementing the Common LRS Approach is outlined below. Since Camden County already has centerlines that can be used for implementation of the Common LRS Approach, the implementation they should follow starts at the "Add Address Information" block, which is noted by the "Current Conditions" label.

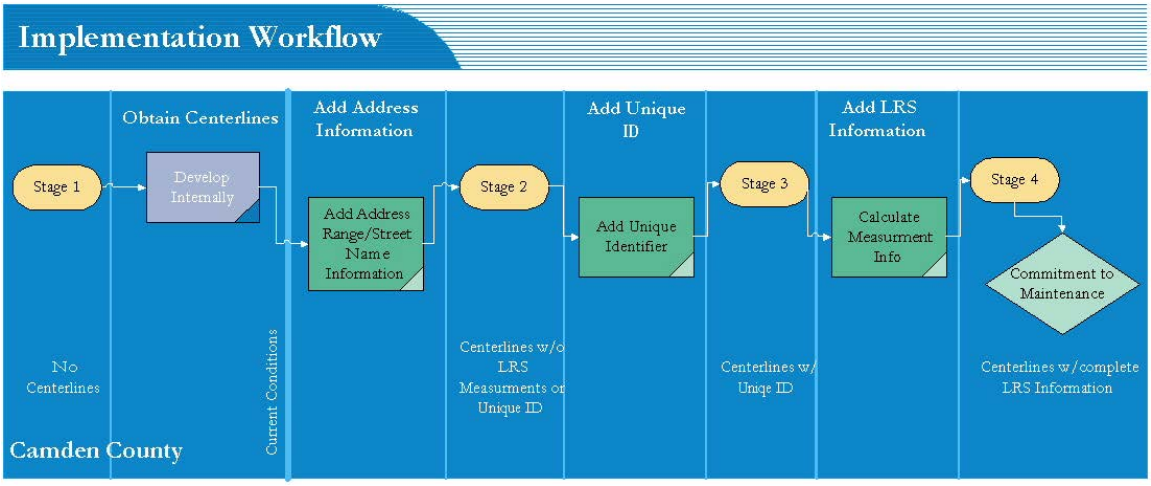

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that Camden County must make when implementing the Common LRS Approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for Camden County to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach (Option 1 – Update Current Centerline)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach with Camden County's existing street centerlines. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline data.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the County, neither process can commence until the County has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, work flow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata

Step 2 – Development of Standards and Database Design, Configuration, and Implementation

If Camden County opts for capturing the centerline attribution in-house with County staff, it will be necessary for the County to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables
- Construction of the database within the County's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, Camden County should use the database design recommendations outlined in Volume III.

Step 3 - Add Address Range Information

The first step in implementing the Common LRS Approach is to add the appropriate address range information. This is accomplished through conflation. Depending on the available resources this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the address information, the same procedure must be followed in order to develop accurate and complete address attribution. Chapter I and Chapter III of Volume III contains technical information regarding the options for acquiring address range information and the conflation process, respectively.

Step 4 - Add Unique Identification (SRI Number) and NJDOT 3-D Measures

The next step in implementing the Common LRS Approach is to add the appropriate unique identification number and the NJDOT 3-D measures to the street centerline database. In the case of Camden County, this unique identification number is the Standard Route Identifier (SRI) utilized by the New Jersey Department of Transportation (NJDOT). A description of the NJDOT SRI number can be found in Chapter II of Volume I. The addition of the SRI number to the Camden County centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Depending on the available resources, this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the unique identification numbers, the same procedure must be followed in order to develop accurate and complete address attribution. In this case the source data are centerlines obtained from New Jersey DOT. These centerlines must contain the SRI number as an attribute. It is important to note that there will be numerous cases of the None-To-One scenario. This is due to the fact that SRI numbers are only down to the 700 level roads in most areas.

Step 5 - Modify LRS Information (Measurement Values)

The final step in implementing the Common LRS Approach is recalculating the LRS measurement values. Since NJDOT does not break the measure values (3-dimensional distances) at intersections of local roads, there needs to be a work around for determining the 3D distances between intersections. However, NJDOT does break the measure values at county boundaries, which can be used in the work around solution. Inherent in the centerline dataset is the 2-dimensional distance measured by the GIS software. The 3D distances can be estimated through a ratio. This process requires the calculation of a 2D/3D ratio in order to automate the addition of the measure values. Refer to Volume III, Chapter III, Section III-3 for a detailed description of this process.

Step 6 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

II-2 Implementation Approach (Option 2 – Obtain Centerline Data From NJDOT)

The following implementation plan reflects the technical requirements for implementing the Common LRS approach with centerline data obtained from NJDOT (see Centerline Borrowing under Centerline Development Options in Volume II, Chapter II). The most significant difference between this plan and the County centerline based plan describes above lies in the diminished importance of Step 4. Since the NJDOT centerline data includes the SRI number and initial 3-D measures as existing attributes, Camden County would not need to put forth any effort towards capturing this attribute through conflation, or a similar process.

The recalculation of the LRS measure values described as Step 5 of the Option 1 plan must still be accomplished by using the process described in Section III-3 of Volume III, Chapter III. Step 3, the addition of address range information, is required, as well.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Centerline and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. The various event tables could be developed within an external database system such as Microsoft Access, which the County currently uses.

Step 2 – Populate Centerline Table

Once the database tables have been properly configured, Camden County will need to at least populate the centerline table with the appropriate LRS and street address data. Under the Option 1 approach, where the County continues to utilize its existing centerline file, this requirement can be fulfilled by using the conflation processes under steps 1 and 3 under the linework implementation plan above.

Step 3 – Populate Event Tables

Population of the event tables such as those described in Volume III, Chapter II, Section II-1, can be accomplished at the option and discretion of Camden County. The interview process revealed that the County currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through a County data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

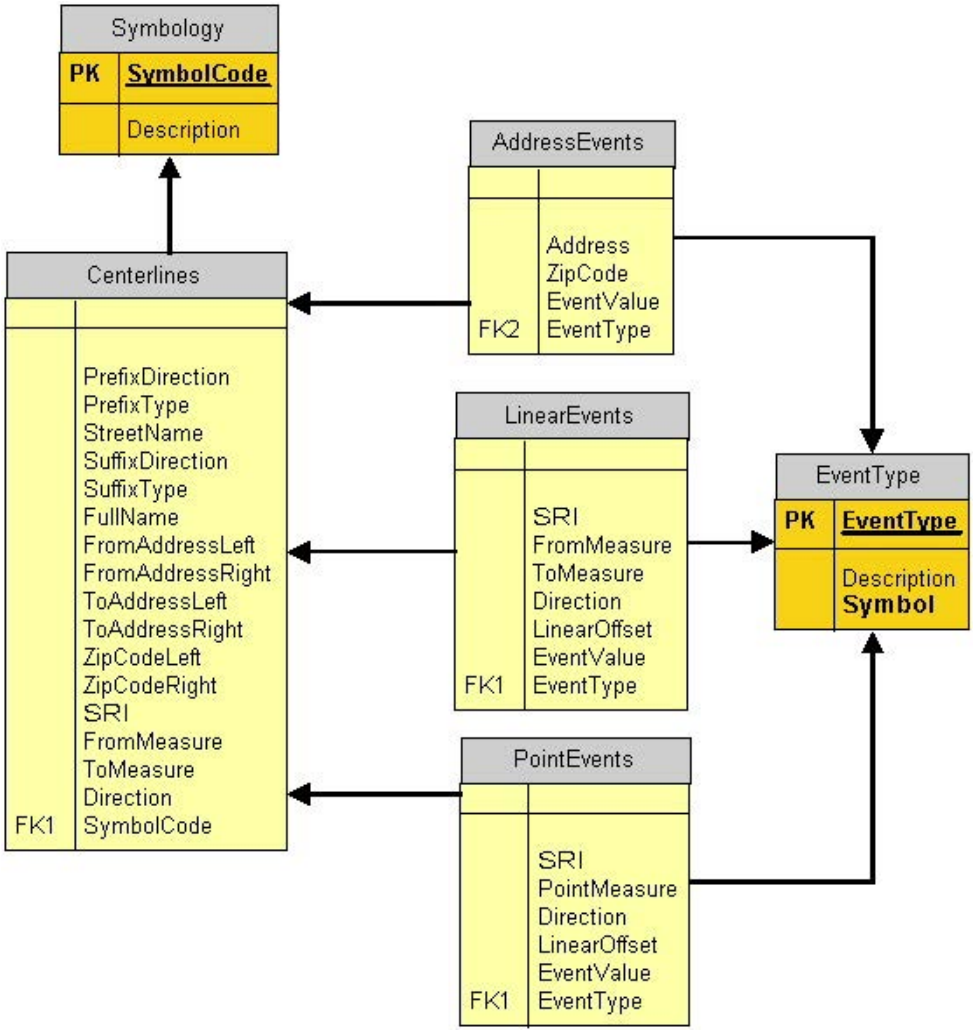

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Staffing and Training

The successful implementation of the plan that has been presented for Camden County is clearly dependent upon the County's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving Camden County revealed that the County currently uses ESRI GIS software products. There is no critical need, at this time, for the County to acquire significant additional software resources. However, it is highly recommended that the County identify a lead agency to coordinate GIS implementation efforts.

With regard to the database management component of the implementation, it is recommended that Camden County consider the use of a product other than INFO to manage external event data tables. While Microsoft Access could be used for this purpose, it is recommended that the County consider a solution such as Oracle or SQL Server to more readily support the enterprise-wide use if the databases.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for Camden County will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process and subsequent discussions with Camden County staff have revealed that the County currently possesses sufficient desktop hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach However, the lack of a local area network to serve the GIS data to end users is an issue that needs to be addressed by the County.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the County opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by County staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

Based on the information collected during the interview phase, it is anticipated that Camden County may need to hire a GIS Technician or provide additional training to existing staff if the implementation work is to be performed in house. Formal training on ESRI software is available from ESRI both in a traditional classroom setting and through online classes via their website. Costs vary, with classroom training costs ranging from approximately $500 - $2,000 per student depending upon the nature and duration of the course. Online training is significantly less expensive, but is limited in scope and content.

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For Camden County, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately three months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRO software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that Camden County would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that Camden County should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
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Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Design of data capture rules, work flow and processes				
Develop Data Capture Rules	8.0	24.0	0.0	**32.0**
Design and Develop Work Flows and Processes	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Conflate Address Ranges				
Conflate address ranges from appropriate source	16.0	40.0	40.0	**96.0**
Total Task 4	**16.0**	**40.0**	**40.0**	**96.0**
Task 5 – Add LRS Information				
Correct Mileposting on Road Segments	8.0	8.0	240.0	**256.0**
Calculate 3D Distance	8.0	16.0	120.0	**144.0**
Total Task 5	**16.0**	**24.0**	**360.0**	**400.0**
Task 6 - Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 6	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**136.0**	**264.0**	**424.0**	**824.0**

Task 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in Camden County the county must: (1) Add Address Range Information to the centerlines to enable accurate geocoding. (2) Add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, Camden County must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow Camden County to share data with NJDOT, but it will also allow the county to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 11 – Gloucester County, New Jersey

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Gloucester County, New Jersey. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, Gloucester County's centerline dataset is considered to be at the Stage 2 Level. The county has centerlines but do not carry any attribution on these centerlines. The centerlines are mostly single centerlines, but they do maintain a dual centerline where appropriate (divided highways). The centerline dataset was digitized from 1992 aerial photography and is at 1" = 2000' scale. Maintenance is performed on a five-year cycle based on receipt of new aerial photography.

The county also has centerlines that were purchased from ETAK. These centerlines have address ranges but are dated and probably not useful as a source for address range information.

I-2 Summary of Needs

Currently the county's most glaring needs are: (1) add Address Range Information to the centerlines to enable accurate geocoding and (2) Add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing.

I-2.1 Implementation Options

In order to meet these needs, Gloucester County has two options. The first option involves using the existing centerlines and proceeding through the implementation process as it is written. The principle benefit of this option is that Gloucester County can utilize their existing centerlines. The principal disadvantages of this option are (1.) the centerline geometry must be brought up to date and (2.) Gloucester County must conflate the address ranges as well as the Standard Route Identifier.

The second option involves using the centerlines from or NJDOT. These centerlines are already attributed with the Standard Route Identifier, potentially allowing Gloucester County to remove Step 2

(Task 3 in the Statement of Work) from the Implementation Plan. The advantages to this option are (1.) the requirement for the second conflation procedure could be eliminated, or, at least, minimized and (2.) the centerline dataset is more up-to-date and accurate, which allows removal of the Update Centerline Geometry sub-task under the Data Preparation task of the conflation process described in Chapter I of Volume III.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to Gloucester County, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase 1, which will only cover roads maintained in the New Jersey DOT GIS centerline database. During Phase 2, the same processes and procedures can be applied to local roads that are currently not part of the NJDOT centerline database. This second phase will require the establishment of unique SRI numbers for these local roads.

The process for implementing the Common LRS Approach is outlined below. Since Gloucester County already has centerlines that can be used for implementation of the Common LRS Approach, the implementation they should follow starts at the "Add Address Information" block, which is noted by the "Current Conditions" label.

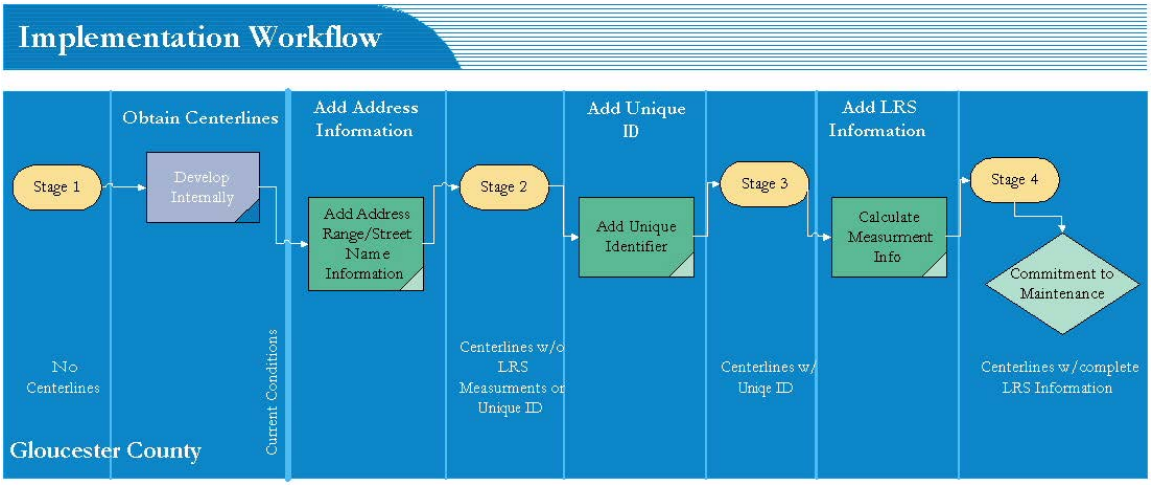

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that Gloucester County must make when implementing the Common LRS Approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for Gloucester County to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach (Option 1 – Maintain Current Centerline)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach with Gloucester County's existing street centerlines. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline data.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the County, neither process can commence until the County has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.
- *Design of data capture rules, work flow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata

Step 2 – Development of Standards and Database Design, Configuration, and Implementation

If Gloucester County opts for capturing the centerline attribution in-house with County staff, it will be necessary for the County to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables
- Construction of the database within the County's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, Gloucester County should use the database design recommendations outlined in Volume III.

Step 3 - Add Address Range Information

The first step in implementing the Common LRS Approach is to add the appropriate address range information. This is accomplished through conflation. Depending on the available resources this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the address information, the same procedure must be followed in order to develop accurate and complete address attribution.

Step 4 - Add Unique Identification (SRI Number)

The next step in implementing the Common LRS Approach is to add the appropriate unique identification number to the street centerline database. In the case of Gloucester County, this unique identification number is the Standard Route Identifier (SRI) utilized by the New Jersey Department of Transportation (NJDOT). A description of the NJDOT SRI number can be found in Chapter II of Volume I. The addition of the SRI number to the Gloucester County centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Depending on the available resources, this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the unique identification numbers, the same procedure must be followed in order to develop accurate and complete address attribution. In this case the source data are centerlines obtained from New Jersey DOT. These centerlines must contain the SRI number as an attribute. It is important to note that there will be numerous cases of the None-To-One scenario. This is due to the fact that SRI numbers are only down to the 700 level roads in most areas.

Step 5 - Add LRS Information (Measurement Values)

An LRS has, as its foundation, has a distance measurement along the centerline, from some beginning reference point to some ending reference point. The distance can be any unit of measure, including an address. The reference points can be at intersections, mileposts, stations, county boundaries or some other arbitrary location.

Step 6 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

II-2 Implementation Approach (Option 2 – Obtain Centerline Data From NJDOT)

The following implementation plan reflects the technical requirements for implementing the Common LRS approach with centerline data obtained from NJDOT (see Centerline Borrowing under Centerline Development Options in Volume II, Chapter II). The most significant difference between this plan and the County centerline based plan describes above lies in the diminished importance of Steps 1 and 2. Since the NJDOT centerline data includes the SRI

number as an existing attribute, Gloucester County would most likely not need to put forth significant effort towards capturing this attribute through conflation, or similar process.

The addition of the LRS measure values described as Step 2 of the Option 1 plan can be accomplished by using the process described in Section III-3 of Volume III, Chapter III.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Attribute and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. In Gloucester County's case, the centerline table could be developed as an Arc Attribute Table (AAT). The various event tables could be developed within an external database system such as Microsoft Access, which the County currently uses.

Step 2 – Populate Attribute Tables

Once the database tables have been properly configured, Gloucester County will need to at least populate the centerline AAT with the appropriate LRS and street address data. Under the Option 1 approach, where the County continues to utilize its existing centerline file, this requirement can be fulfilled by using the conflation processes under steps 1 and 3 under the linework implementation plan above.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of Gloucester County. The interview process revealed that the County currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through a County data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

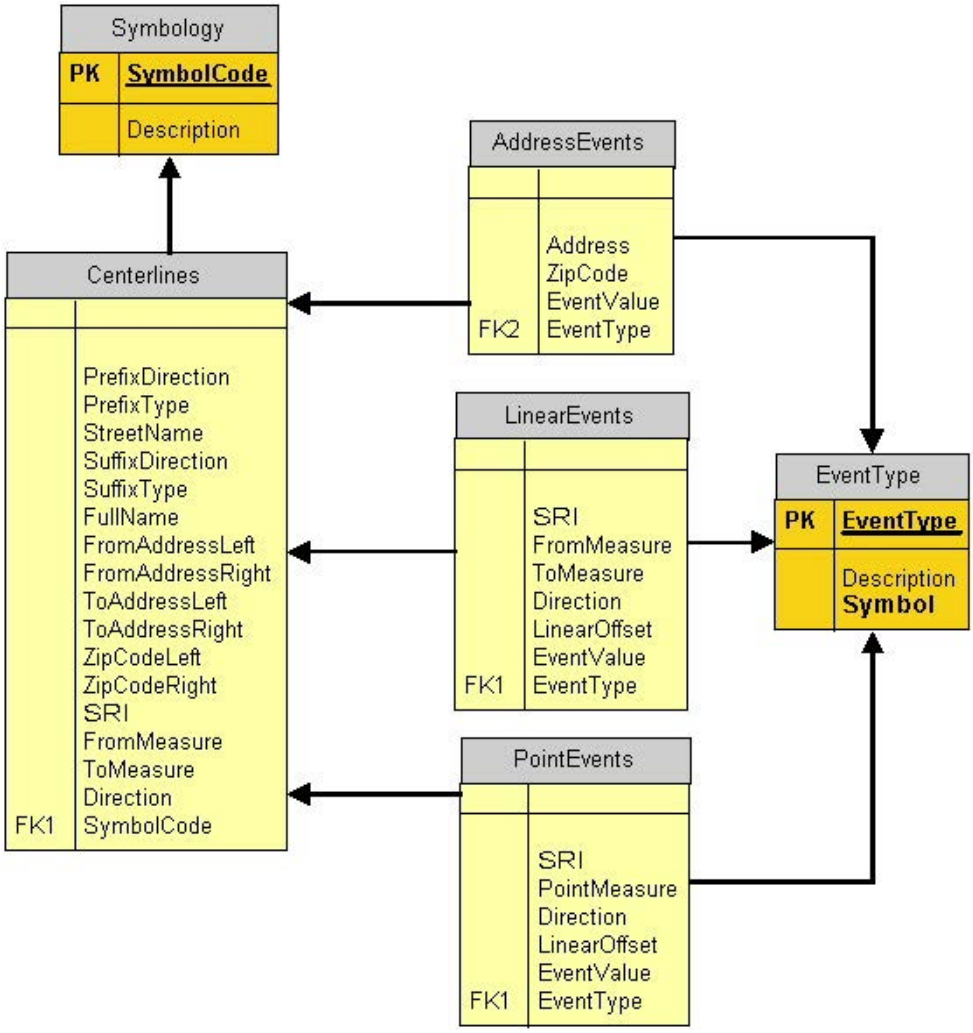

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Staffing and Training

The successful implementation of the plan that has been presented for Gloucester County is clearly dependent upon the County's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving Gloucester County revealed that the County currently uses ESRI GIS software products, including ArcInfo 8.1 (ArcGIS). This software provides the requisite tools for performing the various conflation processes and database development procedures described above. At this time, there appears to be no urgent need for Gloucester County to procure additional software resources.

With regard to the database management component of the implementation, it is recommended that Gloucester County consider the use of a product other than INFO to manage external event data tables. Interview responses indicated that the County is currently using Microsoft Access for this purpose. Consideration should be given to upgrading to Oracle or SQL Server or some equivalent product.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for Gloucester County will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process and subsequent discussions with Gloucester County staff have revealed that the County currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the County opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by County staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

Based on the information collected during the interview phase, it is anticipated that Gloucester County may need to hire a GIS Technician or provide additional training to existing staff if the implementation work is to be performed in house. Formal training on ESRI software is available from ESRI both in a traditional classroom setting and through online classes via their website. Costs vary, with classroom training costs ranging from approximately $500 - $2,000 per student depending upon the nature and duration of the course. Online training is significantly less expensive, but is limited in scope and content.

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For Gloucester County, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately three months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRO software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that Gloucester County would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that Gloucester County should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project Scope of Work	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Design of data capture rules, work flow and processes				
Develop Data Capture Rules	8.0	24.0	0.0	**32.0**
Design and Develop Work Flows and Processes	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Obtain Orthophotography				
Acquire orthophotography	2.0	0.0	0.0	**2.0**
Load orthophotography	1.0	2.0	4.0	**7.0**
Total Task 4	**3.0**	**2.0**	**4.0**	**9.0**
Task 5 – Update Centerlines from Orthophotography				
System set-up	2.0	24.0	0.0	**26.0**
Create route feature class	2.0	16.0	0.0	**18.0**
Capture centerlines from orthophotography	8.0	20.0	120.0	**148.0**
Quality control	4.0	16.0	60.0	**80.0**
Total Task 4	**16.0**	**76.0**	**180.0**	**272.0**
Task 6 – Conflate Address Ranges				
Conflate address ranges from appropriate source	16.0	40.0	40.0	**96.0**
Quality control	8.0	24.0	32.0	**64.0**
Total Task 4	**16.0**	**40.0**	**40.0**	**160.0**

Task 7 – Add LRS Information				
Correct Mileposting on Road Segments	8.0	8.0	160.0	**176.0**
Calculate 3D Distance	8.0	16.0	120.0	**144.0**
Quality control	4.0	8.0	40.0	**52.0**
Total Task 5	**20.0**	**32.0**	**320.0**	**372.0**
Task 8 - Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 6	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**159.0**	**380.0**	**624.0**	**1,163.0**

Table 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in Gloucester County the county must: (1) Add Address Range Information to the centerlines to enable accurate geocoding. (2) Add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, Gloucester County must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow Gloucester County to share data with NJDOT, but it will also allow the county to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 12 – Mercer County, New Jersey

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Mercer County, New Jersey. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. As of the time of the interviews, the County was not maintaining a centerline file. The Etak file that the Planning Department has been using was obtained through the County Prosecutor's Office. The acquisition of this file was a "one time" process circa 1995. Updates were done through manual digitizing "in house". NJDEP orthophotos were used as source data for new roads. Recent information obtained from the Planning Department has revealed that the County is currently participating in Geographic Data Technology's (GDT) Community Update program. Through this program, the County has received an updated GDT centerline file that they are able to maintain online with their own updates. This provides the County with an attribute-rich centerline database that can be maintained by the County. A few disadvantages include the fact that the spatial accuracy of the centerline is inconsistent with other data such as the DVRPC digital orthophotography and GDT licensing restrictions limit the County's ability to share this data with other entities.

Currently, Mercer County's centerline dataset is considered to be at the Stage 2 Level. Both the ETAK and GDT data provide a centerline file that can serve a variety of functions within the County's GIS, including Street Address geocoding. However, the centerline lacks the route number, unique identifier, and distance measures that are required to support the Common LRS Approach.

The County has released a Request for Proposals (RFP) for data conversion services. The primary goal of this project will be to create a tax parcel database, using the DVRPC orthophotography as a base. If sufficient funds are available, the County wishes to include the capture of a graphic street centerline along with the parcels. This centerline file will have only minimal attribution and will not include the critical elements of the Common LRS model.

I-2 Summary of Needs

Currently the county's most critical needs for implementing GIS for transportation planning are: (1.) including the capture of a graphic centerline as a task of the upcoming tax parcel conversion project, and

(2.) ensuring that all critical elements for the Common LRS/Street Address geocoding are added to the centerline database to enable data sharing and linear referencing.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to Mercer County, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase 1, which will only cover roads maintained in the New Jersey DOT GIS centerline database. During Phase 2, the same processes and procedures can be applied to local roads that are currently not part of the NJDOT centerline database. This second phase will require the establishment of unique SRI numbers for these local roads.

The process for implementing the Common LRS Approach is outlined below. Since Mercer County will have accurate graphic centerlines, the implementation they should follow starts at the "Add Address Information" block, which is noted by the "Current Conditions" label. The County will need to conflate the Street Address information from their GDT database to their newly captured graphic centerline.

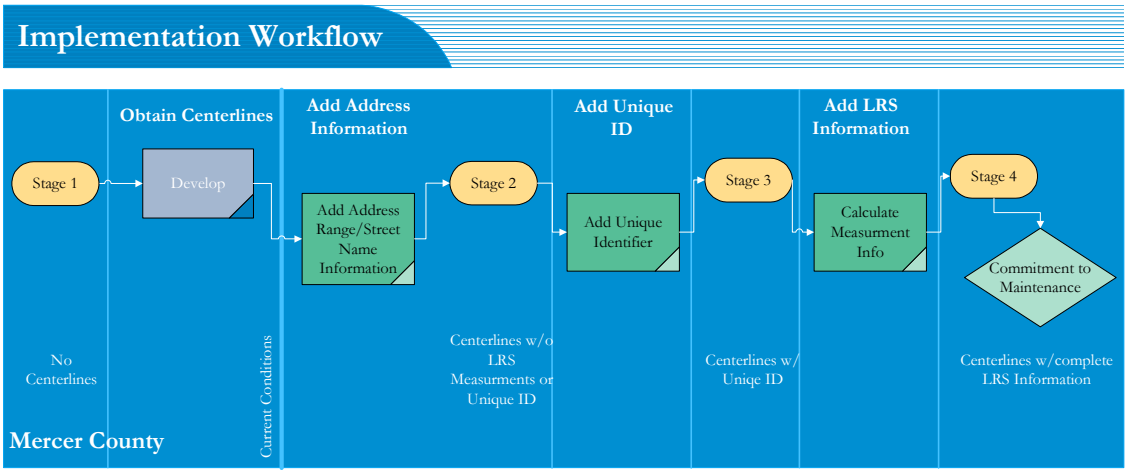

Figure 1 – Implementation Workflow

II-1 Implementation Approach (Option 1 – Add Critical Data Elements To New Centerlines

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach with Mercer County's new street centerlines. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline.

Step 1 – Develop Project Scope of Work

Regardless of whether Mercer County performs the attribute capture in-house or hires a contractor to do the work, neither process can commence until the County has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.

- *Design of data capture rules, workflow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata

Step 2 – Development of Standards and Database Design, Configuration, and Implementation

If Mercer County opts for capturing the centerline attribution in-house with County staff, it will be necessary for the County to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process
- Design of all feature attribute and event tables
- Construction of the database within the County's GIS software environment (ESRI)
- Provision of access to the database by end users through the various software tools that are available.

In performing theses tasks, Mercer County should use the database design recommendations outlined in Volume III.

Step 3 - Add Address Range Information

The first step in implementing the Common LRS Approach is to add the appropriate address range – street name information. This is accomplished through conflation. Depending on the available resources this portion of implementation can be accomplished through internal or external means. It is the current understanding at time of data collection for this project that Mercer County was already engaged with GDT Corporation to add this required information and no additional action is required.

Step 4 - Add LRS Information (Measurement Values)

An LRS has, as its foundation, has a distance measurement along the centerline, from some beginning reference point to some ending reference point. The distance can be any unit of

measure. The reference points can be at intersections, mileposts, stations, county boundaries or some other arbitrary location. Currently Mercer County has Begin_MP (beginning milepost) and End_MP (ending milepost) fields in the database. The problem lies in the fact that the milepost value is an attribute of the entire road segment and does not correspond to the beginning/end of individual segments. This needs to be corrected. The process is well-documented step by step in Volume III Technical Recommendations.

Step 5 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Attribute and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. In Mercer County's case, the centerline table could be developed as a personal geodatabase or an Arc Attribute Table (AAT). The various event tables could be developed within an external database system such as Microsoft Access, which the County currently uses.

Step 2 – Populate Attribute Tables

Once the database tables have been properly configured, Mercer County will need to at least populate the centerline AAT with the appropriate LRS and street address data. Under the Option 1 approach, where the County will utilize a new centerline file, this requirement can be fulfilled by using the conflation processes under steps 1 and 3 under the linework implementation plan above.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of the Mercer County. The interview process revealed that the County currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through an internal data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

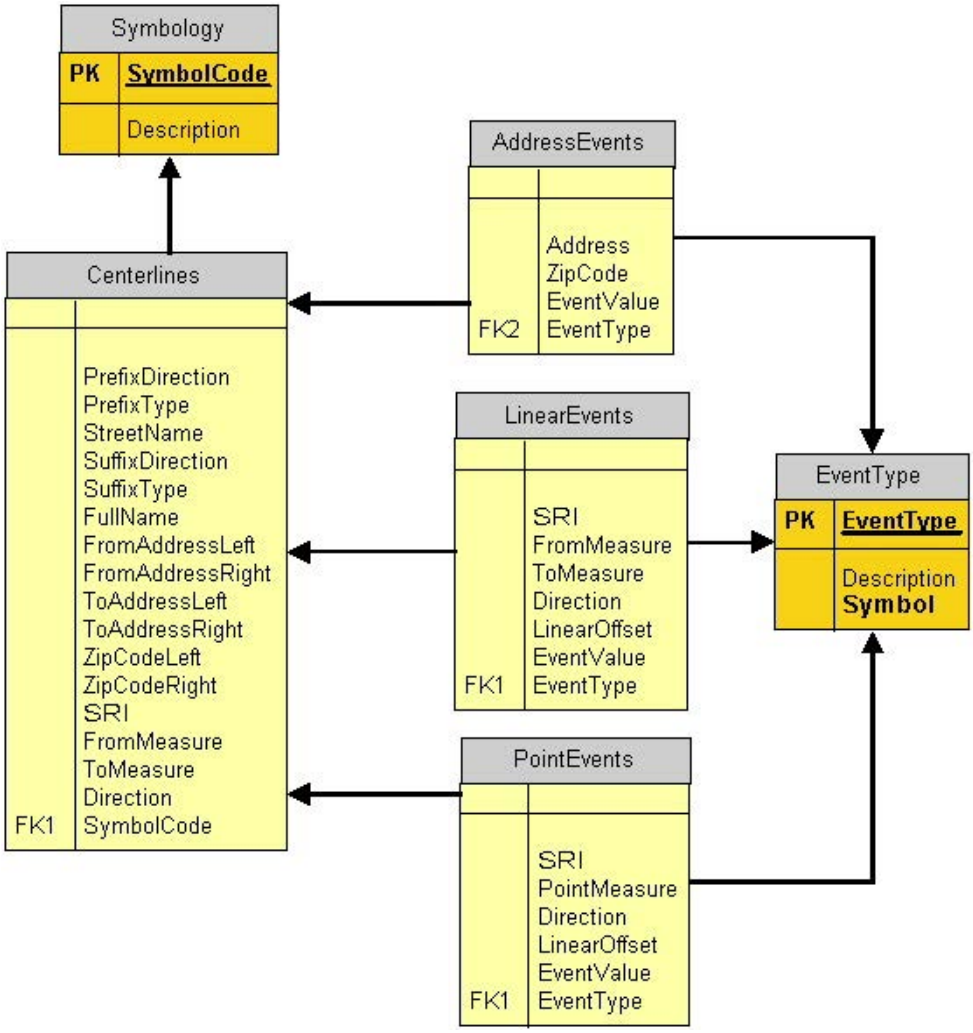

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software/Staffing and Training

The successful implementation of the plan that has been presented for Mercer County is clearly dependent upon the County's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving Mercer County revealed that the County currently uses ESRI GIS software products, including ArcGIS within the Department of Planning. There is no critical need, at this time, for the County to acquire significant additional software resources.

With regard to the database management component of the implementation, it is recommended that Mercer County consider the use of a product other than INFO to manage external event data tables. The County currently does not use an enterprise database management system to manage its GIS data. In order to fully develop the Common LRS/Street Address geocoding model, the County will need to consider the purchase and configuration of an enterprise database management system such as Oracle or SQL Server.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for Mercer County will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process and subsequent discussions with Mercer County staff have revealed that the County currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the County opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by County staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

Based on the information collected during the interview phase, it is anticipated that Mercer County may need to hire a GIS Technician or provide additional training to existing staff if the implementation work is to be performed in house. Formal training on ESRI software is available from ESRI both in a traditional classroom setting and through online classes via their website. Costs vary, with classroom training costs ranging from approximately $500 - $2,000 per student depending upon the nature and duration of the course. Online training is significantly less expensive, but is limited in scope and content.

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For Mercer County, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately three months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRO software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that Mercer County would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that Mercer County should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project Scope of Work	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Database Design				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Design of data capture rules, work flow and processes				
Develop Data Capture Rules	8.0	24.0	0.0	**32.0**
Design and Develop Work Flows and Processes	16.0	40.0	0.0	**56.0**
Total Task 3	**24.0**	**64.0**	**0.0**	**88.0**
Task 4 – Conflate Address Ranges				
Conflate address ranges from GDT centerline	16.0	40.0	40.0	**96.0**
Quality control	8.0	16.0	24.0	**48.0**
Total Task 4	**24.0**	**56.0**	**64.0**	**144.0**
Task 5 – Add LRS Information				
Correct Mileposting on Road Segments	8.0	8.0	240.0	**256.0**
Calculate 3D Distance	8.0	16.0	120.0	**144.0**
Quality control	4.0	6.0	80.0	**90.0**
Total Task 5	**20.0**	**30.0**	**440.0**	**490.0**
Task 6 - Maintenance				
Establish Maintenance Procedures	8.0	40.0	80.0	**128.0**
Total Task 6	**8.0**	**40.0**	**80.0**	**128.0**
TOTAL	**172.0**	**286.0**	**584.0**	**1,042.0**

Task 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in Mercer County the county must: (1) Add Address Range Information to the new centerlines to enable accurate geocoding. (2) Add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, Mercer County must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow Mercer County to share data with NJDOT, but it will also allow the county to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 13 – City of Trenton, New Jersey

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for Trenton, New Jersey. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, the City of Trenton is considered to be at the Stage 2 Level. The City has centerlines but do not carry any attribution on these centerlines.

I-2 Summary of Needs

Currently the City's most critical needs for implementing GIS for transportation planning are: (1) add address range information to the centerlines to enable accurate geocoding and (2.) add critical elements for the Common LRS approach to enable data sharing and linear referencing.

I-2.1 Implementation Options

Several options for centerline development were evaluated through the street centerline development options demonstration that was performed as part of the prototype phase of the project. This demonstration process and its results are documented in Chapter II of Volume II. After due considerations of all of the options, it is recommended that the City of Trenton use the centerlines that they have recently developed. This will allow the City to take advantage of a centerline that has a high degree of accuracy and completeness.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to the City of Trenton, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase 1, which will only cover roads maintained in the New Jersey DOT GIS centerline database. During Phase 2, the same processes and procedures can be applied to local roads that are currently not part of the NJDOT centerline database. This second phase will require the establishment of unique SRI numbers for these local roads.

The process for implementing the Common LRS Approach is outlined below. Since the City of Trenton already has centerlines that can be used for implementation of the Common LRS Approach, the implementation they should follow starts at the "Add Address Information" block, which is noted by the "Current Conditions" label.

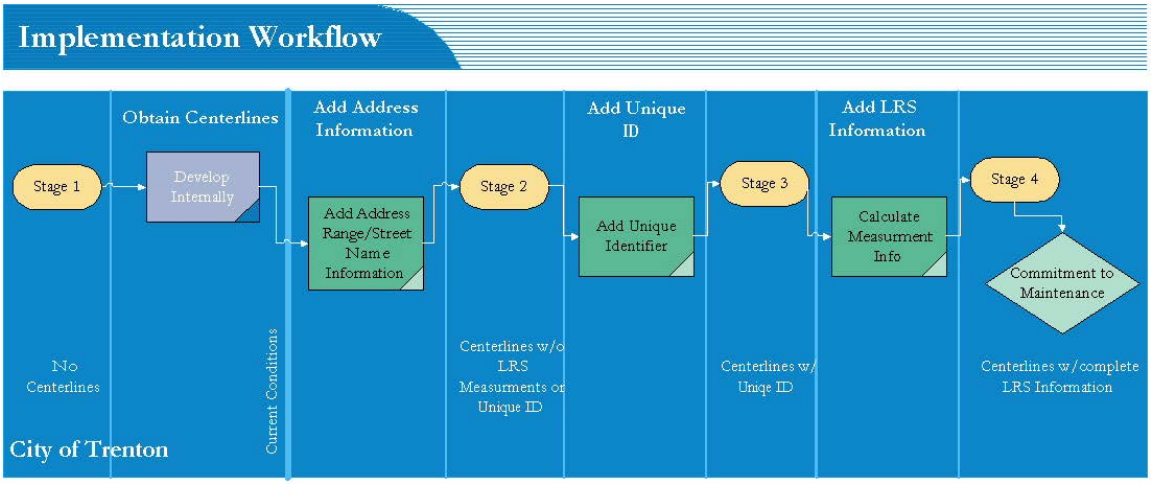

Figure 1 – Implementation Workflow

II-1 Implementation Approach (Option 1 – Maintain Current Centerline)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach with the City's existing street centerlines. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the City, neither process can commence until the City has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.

- *Design of data capture rules, workflow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata.

Step 2 – Development of Standards and Database Design, Configuration, and Implementation

If the City of Trenton opts for capturing centerline attribution in-house with City staff, it will be necessary for the City to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process.
- Design all feature attribute and event tables.
- Construction of the database within the City's GIS software environment (ESRI).
- Provision of access to the database by end users through the various software tools that are available.

In performing these tasks, the City of Trenton should use the database design recommendations outlined in Volume III.

Step 3 - Add Address Range Information

The next step in implementing the Common LRS Approach is to add the appropriate address range information to support street address geocoding of the event data. The addition of this data is typically accomplished through conflation. In the case of the City of Trenton, this process needs to be accomplished for all centerlines. Depending on the available resources this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the address information, the same procedure must be followed in order to develop accurate and complete address attribution.

Again, in the event that the City of Trenton opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 2 process above.

Step 4 - Add Unique Identification (SRI Number) and NJDOT 3-D Measures

The next step in implementing the Common LRS Approach is to add the appropriate unique identification number to the street centerline database. In the case of the City of Trenton, this unique identification number is the Standard Route Identifier (SRI) utilized by the New Jersey Department of Transportation (NJDOT). A description of the NJDOT SRI number can be found in Chapter II of Volume I. The addition of the SRI number to the City of Trenton's centerline database can be accomplished through the process of conflation. Chapter I of Volume III contains technical information regarding the conflation process.

Depending on the available resources, this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the unique identification numbers, the same procedure must be followed in order to develop accurate and complete address attribution. In this case the source data are centerlines obtained from New Jersey DOT. These centerlines must contain the SRI number as an attribute. It is important to note that there will be numerous cases of the None-To-One scenario. This is due to the fact that SRI numbers are only down to the 700 level roads in most areas.

Again, in the event that the City of Trenton opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 2 process above.

Step 5 – Modify LRS Information (Measurement Values)

The next step in implementing the Common LRS Approach is recalculating the LRS measurement values. Since NJDOT does not break the measure values (3-dimensional distances) at intersections of local roads, there needs to be a work around for determining the 3D distances between intersections. However, NJDOT does break the measure values at City boundaries, which can be used in the work around solution. Inherent in the centerline dataset is the 2-dimensional distance measured by the GIS software. The 3D distances can be estimated through the ratio. This process requires the calculation of a 2D/3D ratio in order to automate the addition of the measure values. Refer to Volume III, Chapter III, Section III-3 for a detailed description of this process.

Step 6 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

II-2 Implementation Approach (Option 2 – Obtain Centerline Data From NJDOT)

The following implementation plan reflects the technical requirements for implementing the Common LRS approach with centerline data obtained from NJDOT (see Centerline Borrowing in under Centerline Development Options in Volume II, Chapter II). The most significant difference between this plan and the city's centerline based plan describes above lies in the diminished importance of Steps 1 and 2. Since the NJDOT centerline data includes the SRI number as an existing attribute, the City of Trenton would most likely not need to put forth significant effort towards capturing this attribute through conflation, or similar process.

The addition of the LRS measure values described as Step 2 of the Option 1 plan can be accomplished by using the process described in Section III-3 of Volume III, Chapter III.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

Step 1 – Configure Attribute and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. In the City of Trenton's case, the centerline table could be developed as a personal geodatabase or an Arc Attribute Table (AAT). The various event tables could be developed within an external database system such as Microsoft Access, which the City currently uses.

Step 2 – Populate Attribute Tables

Once the database tables have been properly configured, the City of Trenton will need to at least populate the centerline AAT with the appropriate LRS and street address data. Under the Option 1 approach, where the City continues to utilize its existing centerline file, this requirement can be fulfilled by using the conflation processes under steps 1 and 3 under the linework implementation plan above.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of the City of Trenton. The interview process revealed that the City currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through an internal data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

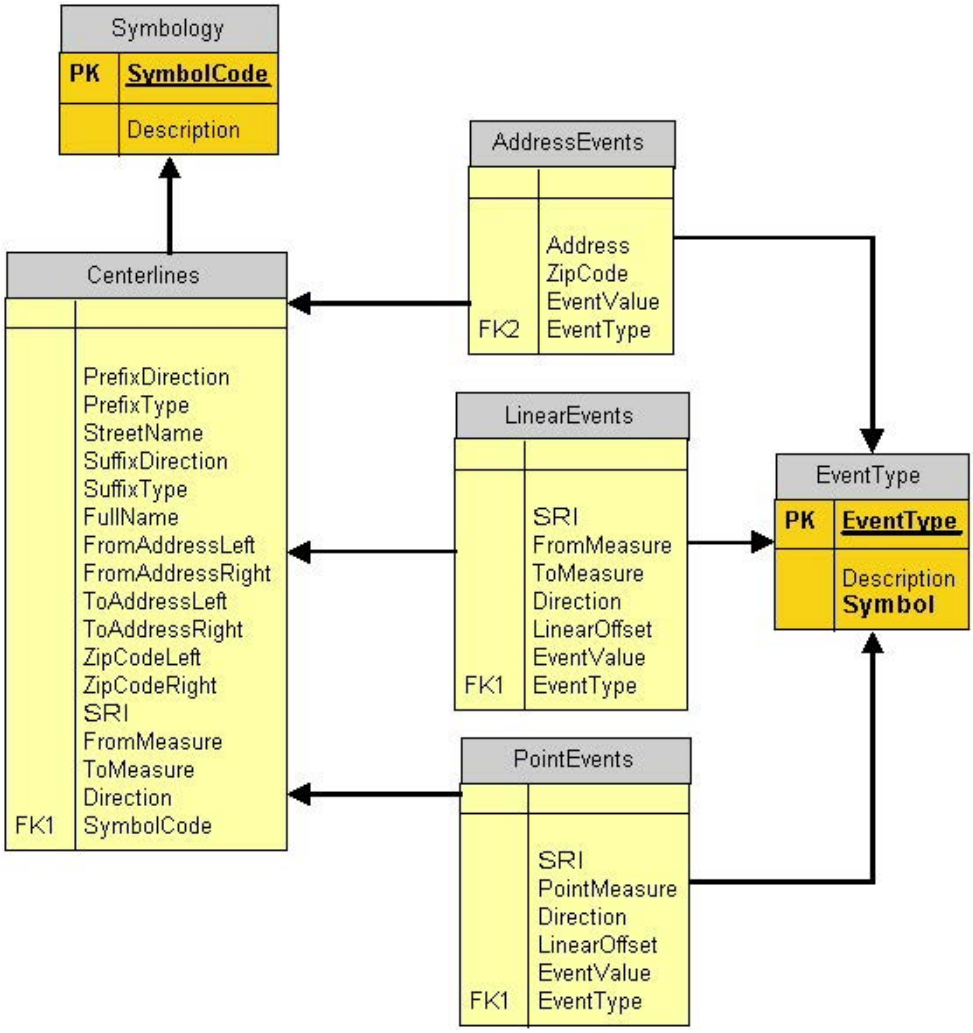

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software

The successful implementation of the plan that has been presented for the City of Trenton is clearly dependent upon the City's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information and street address ranges.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving the City of Trenton revealed that the City currently uses ESRI GIS software products, including ArcInfo 8.1 (ArcGIS). This software provides the requisite tools for performing the various conflation processes and database development procedures described above. At this time, there appears to be no urgent need for the City of Trenton to procure additional software resources.

With regard to the database management component of the implementation, it is recommended that the City of Trenton consider the use of a product other than INFO to manage external event data tables. The database management component could include software such as Oracle or SQL Server 2000, or the personal geodatabase (MS Access 2000).

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for the City of Trenton will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process with the City of Trenton staff have revealed that the City currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the City opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by City staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

The implementation of the recommended procedures outlined above and in Section II will require a relatively strong understanding of the use of ArcGIS software and experience in applying the necessary software tools.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive “hands on” use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production	This individual should possess at

	role: responsible for performing editing and conflation processes and procedures with ESRI software;	least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For the City of Trenton, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately six months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that the City of Trenton would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that the City of Trenton should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Develop Project Scope of Work				
Develop Project SOW	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Table 2 – Design Database				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Data Preparation				
Update Centerline Geometry	16.0	24.0	40.0	**80.0**
Verify Topology	8.0	16.0	40.0	**64.0**
Remove Pseudonodes	8.0	16.0	40.0	**64.0**
Develop/Edit Manual Conflation Tool	0.0	40.0	0.0	**40.0**
Total Task 1	**32.0**	**96.0**	**120.0**	**248.0**
Task 4 – Conflate Address Ranges				
Conflate Address Ranges	40.0	40.0	400.0	**480.0**
Quality Control	24.0	40.0	200.0	**264.0**
Total Task 4	**64.0**	**80.0**	**600.0**	**744.0**
Task 5 – Conflate SRI				
Conflate SRI	24.0	40.0	200.0	**264.0**
Quality Control	16.0	40.0	100.0	**156.0**
Total Task 5	**40.0**	**80.0**	**300.0**	**420.0**
Task 6 – Add LRS Information				
Calculate 3D Distance	8.0	24.0	120.0	**152.0**
Total Task 6	**8.0**	**24.0**	**120.0**	**152.0**
Task 7 - Maintenance				
Establish Maintenance Procedures	16.0	40.0	0.0	**56.0**
Total Task 7	**16.0**	**40.0**	**0.0**	**56.0**
TOTAL	**232.0**	**416.0**	**1,140.0**	**1,788.0**

Table 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in the City of Trenton the city must: (1) Add Address Range Information to the centerlines to enable accurate geocoding. (2) Add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, the City of Trenton must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow the City of Trenton to share data with NJDOT, but it will also allow the city to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 14 – New Jersey Department of Transportation (NJDOT)

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for the New Jersey Department of Transportation (NJDOT). It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, the NJDOT centerline dataset is considered to be at the Stage 4 Level. NJDOT has road centerlines with full attribution including a unique road identifier (SRI). The centerlines are mostly single centerlines but they have centerline information for each direction on multiple lane state maintained roads. The centerlines were originally 1:24,000 scale as they were digitized about ten years ago off of USGS Quad Sheets. However, NJDOT has over the last number of years updated the accuracy of the centerlines using digital orthophotography.

I-2 Summary of Needs

Through the Needs Assessment phase, it has been established that NJDOT currently has a GIS system that fits the needs of a State DOT. NJDOT also has a major task underway which includes adding SRI and measure values down to 700 series roads. NJDOT's unique road identifier (SRI) is in place and is currently being utilized within the Department.

I-3 Phased Approach

In the initial phase of this DVRPC project it has been established that the first phase of full centerline development for New Jersey member agencies will include only the NJDOT GIS maintained road network. This phased approach will make NJDOT strictly a supplier of information and will not affect their current GIS business process in a significant manner.

II. NJDOT's Role

As one of the two major state transportation agencies operating in the region, NJDOT has traditionally filled the role of information provider to local government entities. The Department has developed and continues to maintain a substantial database of transportation information that has value to local government officials. One of the key goals of this project has been to establish a foundation for making this exchange of information more effective and to introduce new tools, such as GIS, that will ultimately enable a "two-way" information flow: from NJDOT to the local governments and from the local governments to NJDOT. As local government becomes more sophisticated in the types of data it collects and the technology that is employed in the collection of the data, NJDOT will most likely begin to recognize the benefits of the data and will become more interested in obtaining it.

During the initial implementation phases of a regional transportation GIS data model, at least, NJDOT will continue in its more traditional role of data provider. NJDOT will supply the GIS road network down to the 700 series roads to the local New Jersey entities in an ArcView Shape file in NJ State Plane 1983 projection. Each graphic centerline will have the following information:

1. SRI Number
2. Begin Milepost
3. End Milepost
4. Direction (if necessary)

Subsequently, NJDOT will also make available to the local New Jersey government entities extracts (selected columns of data) of some of their main business tables in SRI/Milepost format. Examples might include Pavement, Crash, and Construction Project Data etc. The manner in which this information is provided to a particular local entity will depend primarily on the capabilities of the local recipient to receive and utilize the data. In many cases, the process will initially involve the preparation and transfer of ASCII files from NJDOT to the local entity. As NJDOT and local governments move forward with the implementation of the regional model, more sophisticated and efficient means will become feasible.

Plan Number 15 – Delaware River Port Authority of Pennsylvania and New Jersey and Port Authority Transit Corporation (DRPA/PATCO)

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for the Delaware River Port Authority of Pennsylvania and New Jersey and Port Authority Transit Corporation (DRPA/PATCO). It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, the DRPA/PATCO centerline dataset is considered to be at the Stage 1 Level. DRPA/PATCO has no road centerlines that are being used on a regular basis. The limited GIS activity that has occurred with DRPA and PATCO is coordinated for both agencies through a single entity, the DRPA Engineering Division. Based on the information provided through the Needs Assessment process, it is apparent that while DRPA does use GIS technology, this utilization is focused more on land management applications associated with specific projects such as “The Gateway to New Jersey” along Admiral Wilson Boulevard, than on agency-wide transportation applications. The primary database is composed of vector polygons of land parcels located within the project area with attributes relating primarily to various characteristics of those parcels. There is no road centerline file being used either for the special project or the agencies’ overall operations and no apparent requirement for one.

I-2 Summary of Needs

Currently DRPA/PATCO’s most critical need for implementing GIS for transportation planning is to come to an agreement with DVRPC to acquire the new Pennsylvania and New Jersey “regional” centerline file.

I-2.1 Implementation Options

In order to meet these needs, DRPA/PATCO will need to establish a data sharing agreement with DVRPC, which will allow for the use of the completed Pennsylvania and New Jersey regional centerline files. These centerlines will already be attributed with the DOT’s unique road identifier/measure values and additional street address information. The advantage of this option is that it will provide DRPA/PATCO with a readily available centerline file that will more than meet the needs of transportation planning within their operating environment.

II. Tactical Implementation Recommendations – Linework

The implementation of this option would not require the commitment of a vast amount of resource to essentially duplicate the efforts of the member agencies. The only required step in the process is outlined below.

II-1 Implementation Approach

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach on a regional basis for DRPA/PATCO.

Step 1 – Establish Data Sharing Agreement

DRPA/PATCO needs to put into place a data sharing agreement with DVRPC that will allow DRPA/PATCO to use of the completed Pennsylvania and New Jersey regional centerline files.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 1 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

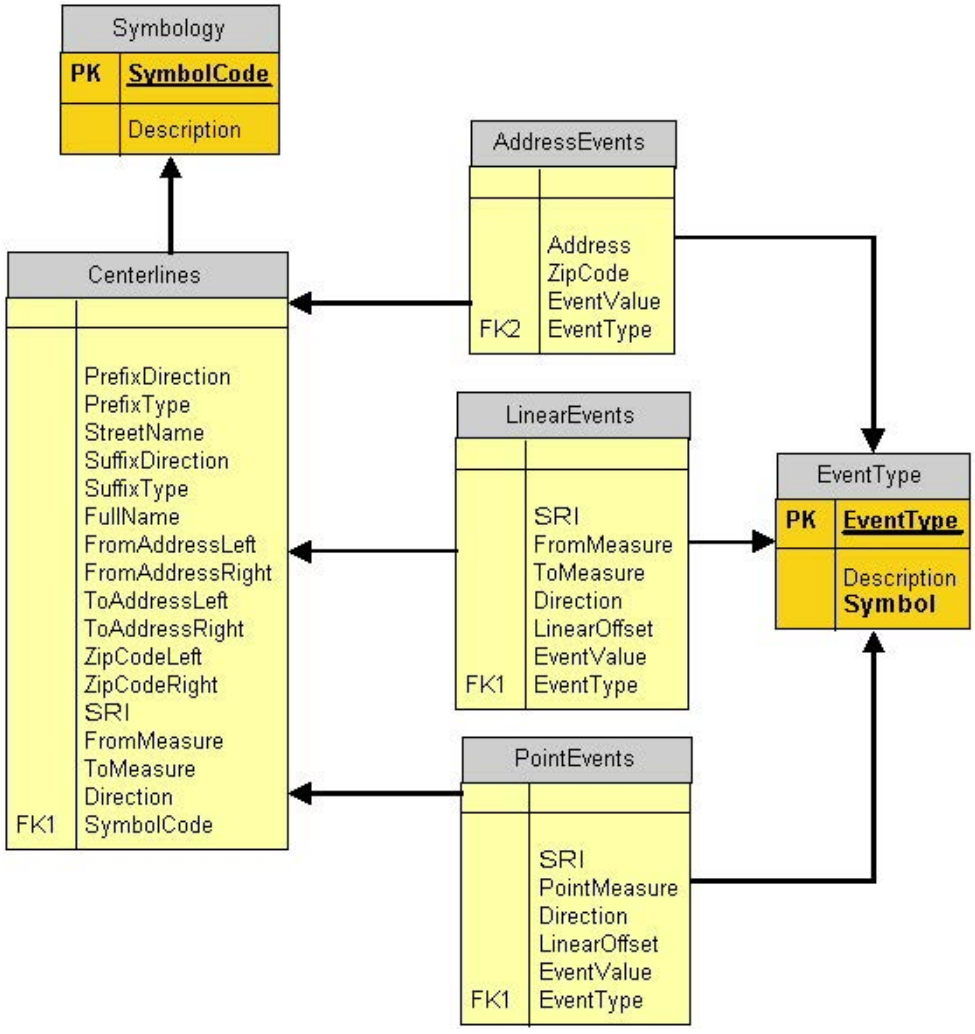

Figure 1 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software

The successful implementation of the plan that has been presented for DRPA/PATCO is clearly dependent upon DRPA/PATCO's ability to utilize sufficient resources to acquire and load the regional centerline file to be provided by DVRPC.

IV-1 Software

The interview portion of the needs assessment process involving DRPA/PATCO revealed that DRPA/PATCO currently uses ESRI GIS software products, including ArcView 3.2. Since the recommended solution for DRPA/PATCO requires no significant database creation and maintenance capabilities, a significant investment in additional software will not be required. It is recommended that DRPA/PATCO consider upgrading to the latest version of ArcView and give future consideration to the acquisition of at least one full license of ArcGIS.

IV-2 Hardware

The interview portion of the needs assessment process and subsequent discussions with DRPA/PATCO staff have revealed that DRPA/PATCO currently possesses sufficient hardware resources to support the recommended procedures for acquiring and using a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Training

The implementation of the recommended procedures outlined above will not require extensive levels of training for DRPA/PATCO staff. Training needs will be an evolving issue with future needs being identified as the agency progresses with its implementation of GIS.

V. Summary and Conclusions

In order to implement the Common LRS Approach, DRPA/PATCO must establish a data sharing agreement with DVRPC. The results of this approach will not only allow DRPA/PATCO to share data with all partner agencies, but it will also allow DRPA/PATCO to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 16 – New Jersey Transit Corporation

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for New Jersey Transit Corporation. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, New Jersey Transit Corporation is considered to be at the Stage 3 Level. New Jersey Transit has road centerlines purchased from NavTech with various degrees of database attribution attached to the centerline but also has established a unique Centerline ID to facilitate the association of agency-wide information to the centerline. Centerline locations are estimated to be accurate to within +/- 3 feet. NavTech roads have all of the required information for standard address geocoding including street names and appropriate address ranges. Data is updated quarterly as part of the maintenance program provided by NavTech.

I-2 Summary of Needs

Currently New Jersey Transit's most critical need for implementing GIS for transportation planning is to add critical elements for the Common LRS approach to enable data sharing and linear referencing.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to New Jersey Transit, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

As discussed in the "Linework Recommendations" section, the implementation process will be a phased approach. This document will discuss Phase 1, which will only cover roads maintained in the New Jersey DOT GIS centerline database. During Phase 2, the same processes and procedures can be applied to local roads that are currently not part of the NJDOT centerline database. This second phase will require the establishment of unique SRI numbers for these local roads.

The process for implementing the Common LRS Approach is outlined below. Since New Jersey Transit already has complete address range and street name information the task New Jersey Transit is faced with is adding the information required with the Common LRS Approach. New Jersey Transit should start at the Add Unique ID block and then perform modifications to the Add LRS Information block.

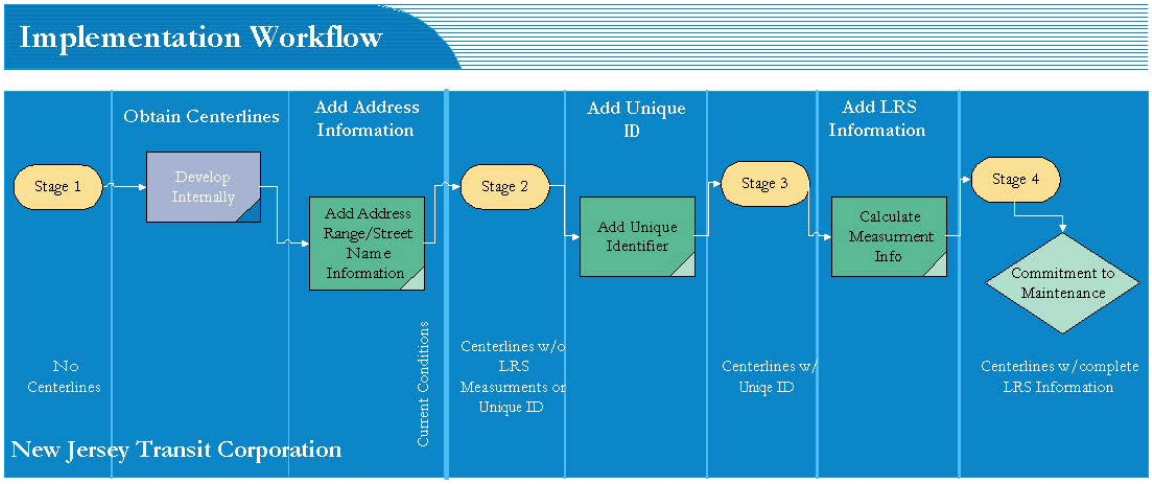

Figure 1 – Implementation Workflow

II-1 Implementation Approach (Option 1 – Maintain Current Centerline)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach with New Jersey Transit's existing street centerlines. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline data.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by New Jersey Transit, neither process can commence until they have developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure using the database management software. One end product of this process is a data dictionary.

- *Design of data capture rules, workflow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata.

Step 2 - Add Unique Identification (SRI Number) and NJDOT 3-D Measures

The next step in implementing the Common LRS Approach is to add the appropriate unique identification number to the street centerline database. In the case of New Jersey Transit, this unique identification number is the Standard Route Identifier (SRI) utilized by the New Jersey Department of Transportation (NJDOT). A description of the NJDOT SRI number can be found in Chapter II of Volume I. The addition of the SRI number to the New Jersey Transit centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Depending on the available resources, this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the unique identification numbers, the same procedure must be followed in order to develop accurate and complete address attribution. In this case the source data are centerlines obtained from New Jersey DOT. These centerlines must contain the SRI number as an attribute. It is important to note that there will be numerous cases of the None-To-One scenario. This is due to the fact that SRI numbers are only down to the 700 level roads in most areas.

Step 3 – Modify LRS Information (Measurement Values)

The next step in implementing the Common LRS Approach is recalculating the LRS measurement values. Since NJDOT does not break the measure values (3-dimensional distances) at intersections of local roads, there needs to be a work around for determining the 3D distances between intersections. However, NJDOT does break the measure values at county boundaries, which can be used in the work around solution. Inherent in the centerline dataset is the 2-dimensional distance measured by the GIS software. The 3D distances can be estimated through the ratio. This process requires the calculation of a 2D/3D ratio in order to automate the addition of the measure values. Refer to Volume III, Chapter III, Section III-3 for a detailed description of this process.

Step 4- Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

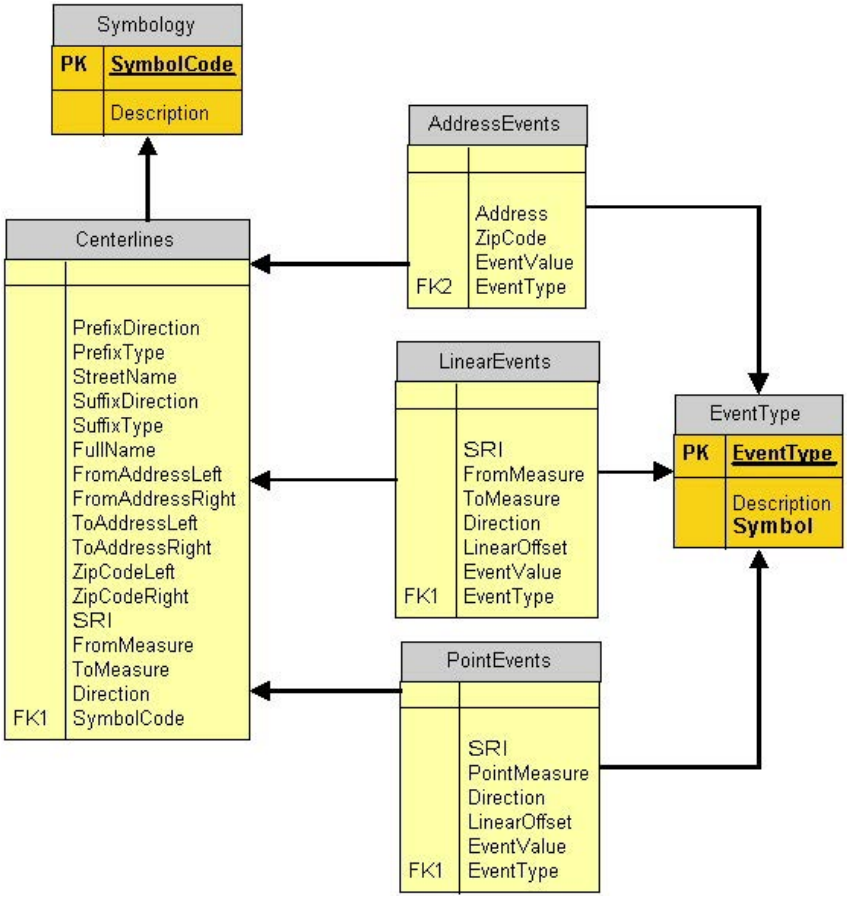

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software

The successful implementation of the plan that has been presented for New Jersey Transit is clearly dependent upon New Jersey Transit's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

The interview portion of the needs assessment process involving New Jersey Transit revealed that the they currently use Intergraph GIS software products, including MGE and GeoMedia. This software provides the requisite tools for performing the various processes and database development procedures described above. At this time, there appears to be no urgent need for New Jersey Transit to procure additional software resources.

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing Intergraph software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for New Jersey Transit will most likely require the use of a single desktop system running Intergraph Software.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above will require a moderate understanding of the use of Intergraph GIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by New Jersey Transit staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of GIS software.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures.	This individual should possess at least one year of "hands on" experience using GIS software performing data editing function.

Table 1 – Recommended Staffing Descriptions

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For New Jersey Transit, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately six months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that New Jersey Transit would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that New Jersey Transit should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 – Conflate SRI				
Conflate SRI	24.0	40.0	200.0	**264.0**
Quality Control	16.0	40.0	100.0	**156.0**
Total Task 3	**40.0**	**80.0**	**300.0**	**420.0**
Task 2 – Add LRS Information				
Calculate 3D Distance	8.0	24.0	120.0	**156.0**
Total Task 4	**8.0**	**24.0**	**120.0**	**156.0**
Task 3 - Maintenance				
Establish Maintenance Procedures	16.0	40	0.0	**56.0**
Total Task 7	**16.0**	**40.0**	**0.0**	**56.0**
TOTAL	**64.0**	**144.0**	**420.0**	**628.0**

Table 2 – Labor Requirements per Task

VI. Summary and Conclusions

In order to implement the Common LRS Approach in New Jersey Transit the agency must: (1) Add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing these two items have been defined above, New Jersey Transit must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow New Jersey Transit to share data with NJDOT, but it will also allow New Jersey Transit to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 17 – New Jersey Turnpike Authority

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for the New Jersey Turnpike Authority. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, New Jersey Turnpike Authority's centerline dataset is considered to be at the Stage 2 Level. The Authority has centerlines but do not carry any attribution on these centerlines. The Authority only covers road centerlines for the New Jersey Turnpike and this is a dual centerline. The centerline dataset was developed by a consultant through the use of GPS. Currently, there are no real maintenance procedures in place.

I-2 Summary of Needs

Since there are no address ranges on the New Jersey Turnpike the authority's only critical need is to add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing.

I-2.1 Implementation Options

In order to meet these needs, New Jersey Turnpike Authority has two options. The first option involves using the existing centerlines and proceeding through the implementation process as it is written. The principle benefit of this option is that the Turnpike Authority can utilize their existing centerlines. The principal disadvantages of this option are (1.) the centerline geometry must be brought up to date and (2.) New Jersey Turnpike must conflate the Standard Route Identifier.

The second option involves using the centerlines from or NJDOT. These centerlines are already attributed with the Standard Route Identifier, allowing New Jersey Turnpike to remove Step 2 (Task 2 in the Statement of Work) from the Implementation Plan. The advantage to this option is the centerline dataset is more up-to-date and accurate, which allows removal of the Update Centerline Geometry sub-task under the Data Preparation task of the conflation process described in Chapter I of Volume III.

I-3 References to Prior Volumes

Although this Implementation Plan is specific to the New Jersey Turnpike Authority, it is based on information from the recommendations formed in Volume III. Those recommendations will be mentioned throughout this document.

II. Tactical Implementation Recommendations – Linework

The process for implementing the Common LRS Approach is outlined below. Since New Jersey Turnpike Authority already has centerlines that can be used for implementation of the Common LRS Approach and they do not have a need for address ranges on their centerlines, the implementation they should follow, starts at the "Add Unique Identifier" block, which is noted by the "Current Conditions" label.

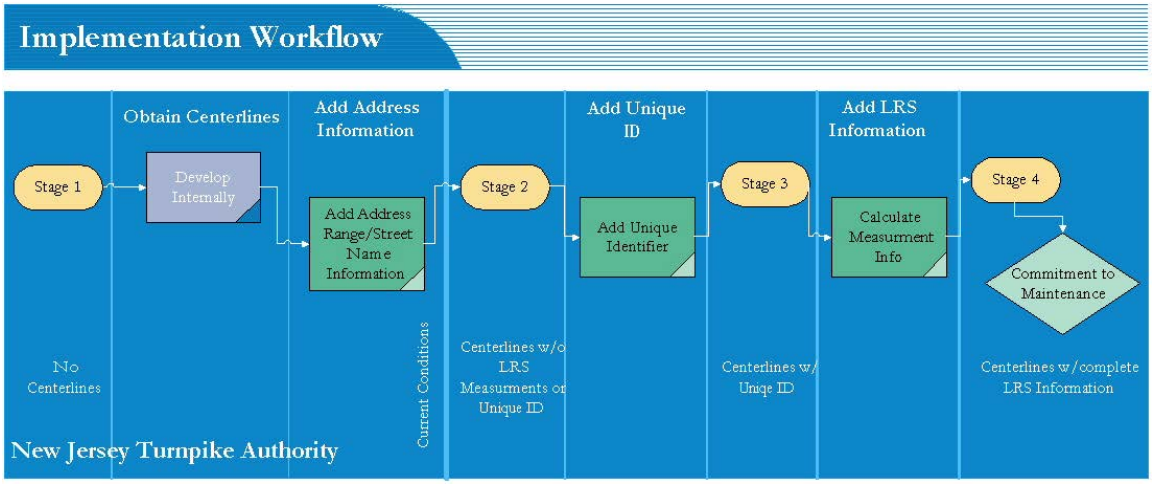

Figure 1 – Implementation Workflow

With the experience gained during the Street Centerline Development Options demonstration described in Volume II, the following methodology for implementation is recommended. There are a number of decisions that New Jersey Turnpike Authority must make when implementing the Common LRS Approach. Associated with these decisions, are benefits and consequences, which are discussed in the following section. Although we recommend a defined plan, there is room for New Jersey Turnpike Authority to modify the plan to better suit their needs, where necessary.

II-1 Implementation Approach (Option 1 – Maintain Current Centerline)

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach with New Jersey Turnpike Authority 's existing street centerlines. These recommendations offer solutions for designing, creating and maintaining the topological structure and associated attributes of the centerline data.

Step 1 – Develop Project Scope of Work

Regardless of the alternative approach that is chosen by the Authority, neither process can commence until the Authority has developed a detailed scope of work. This scope of work will not vary much between the two alternatives. In each case, the primary components will be:

- *Database design, configuration and implementation* – This component includes the formulation of the database design in accordance with the standards presented in Volume III. It also includes the procedures required to physically construct the database structure

using the database management software. One end product of this process is a data dictionary.

- *Design of data capture rules, workflow and processes* – This component includes the design and documentation of work flow that will be required to capture the spatial and attribute data. Included is the identification of all staffing, hardware and software resources that will be required. End products include a data capture work plan and a list of data capture rules.
- *Attribution of centerlines with Common LRS attributes* – This component includes the work effort required to add Common LRS attributes to the centerline geometry.
- *Attribution of centerlines with street address information* – This component includes the work effort required to add street address information to the centerline geometry.
- *Quality assurance and control* – This component includes the development and implementation of all standards, processes, procedures and methods required to ensure data consistency and quality. The primary end product is a data quality assurance and control plan that documents the process and the standards that are to be applied for assuring data quality.
- *Ongoing data maintenance and update plan* – This component includes the development and implementation of a plan for long-term data maintenance and updating. Also included is the development and implementation of metadata.

Step 2 – Development of Standards and Database Design, Configuration, and Implementation

If the New Jersey Turnpike Authority opts for capturing centerline attribution in-house with Authority staff, it will be necessary for the Authority to first perform all necessary activities to set up the appropriate GIS database. This includes:

- Development of all project design standards and specifications, including the rules for data capture that are to be followed throughout the database development process.
- Design all feature attribute and event tables.
- Construction of the database within the Authority's GIS software environment (ESRI).
- Provision of access to the database by end users through the various software tools that are available.

In performing these tasks, the New Jersey Turnpike Authority should use the database design recommendations outlined in Volume III.

Step 3 - Add Unique Identification (SRI Number) and NJDOT 3-D Measures

The first step in implementing the Common LRS Approach is to add the appropriate unique identification number to the street centerline database. In the case of New Jersey Turnpike Authority, this unique identification number is the Standard Route Identifier (SRI) utilized by the New Jersey Department of Transportation (NJDOT). A description of the NJDOT SRI number can be found in Chapter II of Volume I. The addition of the SRI number to the New Jersey Turnpike Authority's centerline database can be accomplished through the process of conflation. Chapter III of Volume III contains technical information regarding the conflation process.

Depending on the available resources, this portion of implementation can be accomplished through internal or external means. Regardless of who conflates the unique identification numbers, the same procedure must be followed in order to develop accurate and complete

attribution. In this case the source data are centerlines obtained from New Jersey DOT. These centerlines must contain the SRI number as an attribute. I

Again, in the event that the New Jersey Turnpike Authority opts to use the services of a data conversion contractor, this work will be performed by the contractor in conformance with specifications developed through the step 2 process above.

Step 4 - Modify LRS Information (Measurement Values)

The next step in implementing the Common LRS Approach is recalculating the LRS measurement values. Since NJDOT does not break the measure values (3-dimensional distances) at intersections of local roads, there needs to be a work around for determining the 3D distances between intersections. However, NJDOT does break the measure values at county boundaries, which can be used in the work around solution. Inherent in the centerline dataset is the 2-dimensional distance measured by the GIS software. The 3D distances can be estimated through the ratio. This process requires the calculation of a 2D/3D ratio in order to automate the addition of the measure values. Refer to Volume III, Chapter III, Section III-3 for a detailed description of this process.

Step 5 - Implement Maintenance Procedure

There are requirements for maintaining the data that will be shared throughout the region. These maintenance requirements go above and beyond the normal maintenance procedures for centerline datasets. These additional procedures require careful coordination between the agencies to ensure that the agencies are always on the same page. Although this sounds technically difficult, it is not. The data that needs to be maintained for effective data sharing is the attribute data only, and more specifically the attribute data that define the Linear Referencing System. Route identifications or measure values are the items that need to be maintained across agencies. Alignments, and other geometric changes are not necessary for the effective sharing of data. In the scenario we have recommended the data that will be transferred is the event data, and as long as the underlying LRS information is up to date, the event data will be placed in the appropriate location. Chapter III of Volume III contains specific recommendations for facilitating these data exchange processes.

II-2 Implementation Approach (Option 2 – Obtain Centerline Data From NJDOT)

The following implementation plan reflects the technical requirements for implementing the Common LRS approach with centerline data obtained from NJDOT (see Centerline Borrowing in under Centerline Development Options in Volume II, Chapter II). The most significant difference between this plan and the Authority's centerline based plan describes above lies in the diminished importance of Steps 1 and 2. Since the NJDOT centerline data includes the SRI number as an existing attribute, New Jersey Turnpike Authority would most likely not need to put forth significant effort towards capturing this attribute through conflation, or similar process. In this scenario, the New Jersey Turnpike Authority should only need to obtain the data from NJDOT in order to immediately take advantage of the Common LRS Approach.

The addition of the LRS measure values described as Step 2 of the Option 1 plan can be accomplished by using the process described in Section III-3 of Volume III, Chapter III.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III; Chapter II is reproduced in Figure 2 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

Step 1 – Configure Attribute and Event Tables

The first step in implementing the Common LRS database is to configure the database using the design proposed in Volume III and depicted in Figure 1. In New Jersey Turnpike Authority 's case, the centerline table could be developed as an Arc Attribute Table (AAT). The various event tables could be developed within an external database system such as Microsoft Access, which the Authority currently uses.

Step 2 – Populate Attribute Tables

Once the database tables have been properly configured, New Jersey Turnpike Authority will need to at least populate the centerline AAT with the appropriate LRS data. Under the Option 1 approach, where the Authority continues to utilize its existing centerline file, using the conflation processes under step 1 under the linework implementation plan above can fulfill this requirement.

Step 3 – Populate Event Tables

Population of the event tables can be accomplished at the option and discretion of New Jersey Turnpike Authority. The interview process revealed that the Authority currently maintains no event tables specifically concerned with to transportation related events. However, as this type of data becomes available, either through an internal data collection effort or through an exchange of data with other entities, standard data entry or electronic transfer techniques may be applied to populate these tables.

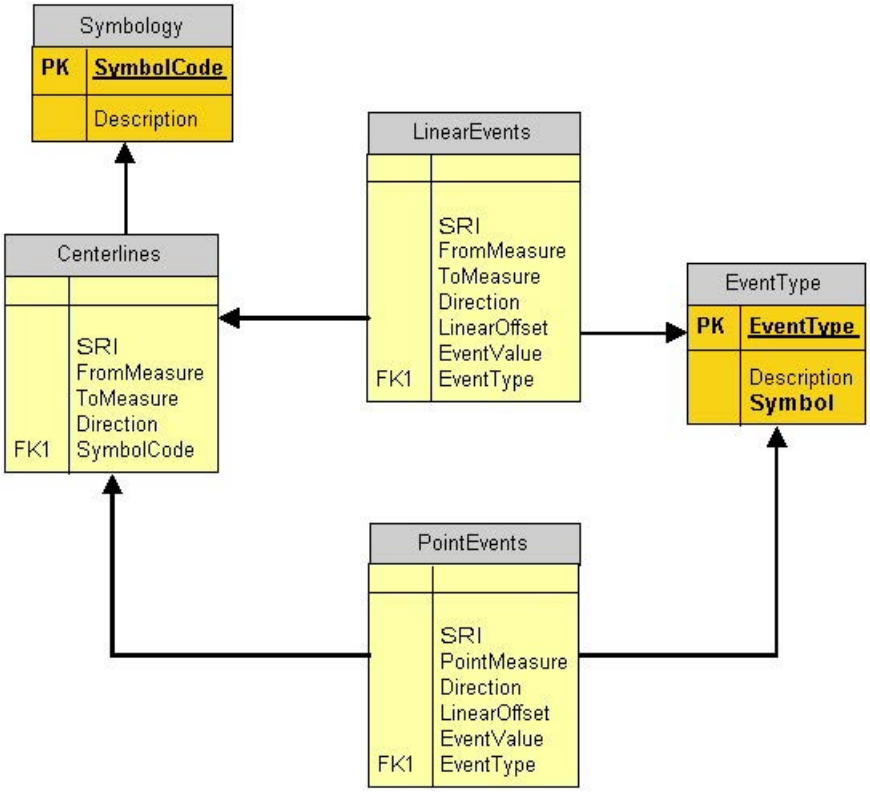

Figure 2 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software

The successful implementation of the plan that has been presented for New Jersey Turnpike Authority is clearly dependent upon the Authority's ability to utilize sufficient resources to perform the various steps in the process. These resources include both computer software and hardware.

IV-1 Software

During the Needs Assessment process documented in Volume I, it became readily apparent that the prevailing GIS software being used by the DVRPC member agencies are the various products developed by ESRI. For this reason, the tactical recommendations for GIS software include the use of ESRI's ArcINFO 8.1 (ArcGIS) for performing the required data editing and updating tasks. This particular software product provides the necessary tools for adding and updating centerlines and database table records and conflating LRS information.

ArcGIS supports the use of a variety of database management software for the storage and maintenance of external database tables. Among these are Microsoft Access and SQL Server, Oracle, and Sybase. Proper use of this software with ArcGIS spatial data requires a relatively advanced level of knowledge and expertise.

The interview portion of the needs assessment process involving New Jersey Turnpike Authority revealed that the Authority currently uses ESRI ArcView GIS. Although this software offers functionality to visualize and analyze data it does not include the tools necessary for performing the various conflation processes and database development procedures described above. To accomplish this the Authority will need to purchase ArcInfo 8.1 (ArcGIS). This software provides the requisite tools for necessary for completing the aforementioned procedures and offers far greater functionality for spatial analysis.

With regard to the database management component of the implementation, it is recommended that the New Jersey Turnpike Authority consider the use of a product other than INFO to manage external event data tables. The database management component could include software such as Oracle or SQL Server 2000, or the personal geodatabase (MS Access 2000).

IV-2 Hardware

The hardware requirements for implementing the Common LRS/Street Address Geocoding approach are fairly typical of any GIS application utilizing ESRI software. Desktop computers with following, or similar, specifications are typically sufficient:

- Pentium III or IV processor
- Windows NT/2000 operating system
- 500 Megahertz processor speed (minimum)
- 20 gigabyte local disk storage (minimum)
- Connection to local area network (LAN) or intranet

Storage of attribute data in event tables can be accommodated through the use of a server. It is not necessary to store this information on local disk drives, as long as the desktop system provides access to the server through a LAN or Intranet connection.

The work effort that is required to carry out the recommended implementation plan for the New Jersey Turnpike Authority will most likely require the use of a single desktop system running ArcGIS software.

The interview portion of the needs assessment process with the New Jersey Turnpike staff have revealed that the Authority currently possesses sufficient hardware resources to support the recommended procedures for developing a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Staffing and Training

The implementation of the recommended procedures outlined above and in Section II will require a moderate understanding of the use of ArcGIS software and experience in applying the necessary software tools. At a minimum, the individual performing the work will need to be experienced in working with standard editing tools for both spatial features and related database records. In the event that the Authority opts to migrate to the ArcGIS Geodatabase data model, additional training will most likely be required to bring staff understanding and capabilities to an acceptable level.

Table 1 lists the staff positions that are typically required for a project of this nature. These staffing requirements apply in both cases: implementation by Authority staff and implementation through the use of a consultant or contractor. The table lists the title of each position, a general description of the duties required for the position specific to the tasks at hand, and information regarding the recommended skill set and level of ESRI software training for an individual filling each position.

The implementation of the recommended procedures outlined above and in Section II will require a relatively strong understanding of the use of ArcGIS software and experience in applying the necessary software tools.

Position Title	Duties	Recommended Skill Set
Project Manager	Oversees all project activities; responsible for developing scope of work and schedule; responsible for monitoring project performance for compliance with scope of work and schedule.	This individual should be a member of senior management of the agency responsible for maintaining the GIS database. Previous experience in managing similar database development projects is highly recommended.
GIS Analyst	Serves as primary technical lead on project team; responsible for defining technical approach to project and managing day-to-day production activities; has overall responsibility for quality control	This individual should possess 2-5 years of experience in using GIS software in a data production environment. Experience should include fairly comprehensive "hands on" use of ESRI GIS software. Formal training at an advanced user level in the use of ESRI software is desirable.
GIS Technician	Serves in primary production role: responsible for performing editing and conflation processes and procedures with ESRI software;	This individual should possess at least one year of "hands on" experience using ESRI GIS software performing data editing function. Formal training at least at an introductory user level in the use of ESRI software is desirable

Table 1 – Recommended Staffing Descriptions

Resource requirements for implementing these types of technology plans, in terms of labor time and costs, can vary widely, depending upon the level of effort required and the resources available to meet the demands posed by that effort. For the New Jersey Turnpike Authority, it is anticipated that the level of effort required to successfully perform the required work would be one GIS technician working full time for approximately three months. A Project Manager would be required to oversee the work and a GIS Analyst would be required on a part-time basis to perform the higher-level technical work.

Table 2 lists the estimated time requirements for each task in the process, listed by position. It is assumed that the New Jersey Turnpike Authority would assign a Project Manager to oversee the work effort, one GIS Analyst to be responsible for higher-level technical work, and one GIS Technician to perform the actual work on the GIS data. In the event that the New Jersey Turnpike Authority should decide to hire a consultant or contractor, it is estimated that the labor requirements on the part of the contractor would be similar.

V. Time and Cost Estimates

	Project Manager (Hours)	GIS Analyst (Hours)	GIS Technician (Hours)	Total Hours
Tasks				
Task 1 - Develop Project Scope of Work				
Develop Project SOW	40.0	16.0	0.0	**56.0**
Total Task 1	**40.0**	**16.0**	**0.0**	**56.0**
Task 2 – Design Database				
Design Database	16.0	40.0	0.0	**56.0**
Configure Database	8.0	24.0	0.0	**32.0**
Implement Database	8.0	16.0	0.0	**24.0**
Total Task 2	**32.0**	**80.0**	**0.0**	**112.0**
Task 3 – Data Preparation				
Update Centerline Geometry	16.0	24.0	24.0	**64.0**
Verify Topology	8.0	16.0	24.0	**48.0**
Remove Pseudonodes	8.0	16.0	24.0	**48.0**
Develop/Edit Manual Conflation Tool	0.0	40.0	0.0	**40.0**
Total Task 3	**32.0**	**96.0**	**72.0**	**200.0**
Task 4 – Conflate SRI				
Conflate SRI	8.0	24.0	100.0	**132.0**
Quality Control	16.0	24.0	60.0	**100.0**
Total Task 4	**24.0**	**48.0**	**160.0**	**232.0**
Task 5 – Add LRS Information				
Calculate 3D Distance	8.0	24.0	80.0	**112.0**
Total Task 5	**8.0**	**24.0**	**80.0**	**112.0**
Task 6 - Maintenance				
Establish Maintenance Procedures	16.0	40.0	0.0	**56.0**
Total Task 7	**16.0**	**40.0**	**0.0**	**56.0**
SUB-TOTAL	**152.0**	**304.0**	**312.0**	**768.0**

Table 2 – Labor Requirements per Task

V. Summary and Conclusions

In order to implement the Common LRS Approach, the New Jersey Turnpike Authority must add Critical Elements for the Common LRS Approach to enable data sharing and linear referencing. Although, the steps for accomplishing this item have been defined above, New Jersey Turnpike Authority must make the commitment to the approach in order for a successful implementation. The results of this approach will not only allow New Jersey Turnpike Authority to share data with NJDOT, but it will also allow the authority to locate events along their centerlines. The events can take the form of linear or point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Plan Number 18 – Pennsylvania Turnpike Commission

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for the Pennsylvania Turnpike Commission. It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, the Pennsylvania Turnpike Commission centerline dataset is considered to be at the Stage 4 Level. Pennsylvania Turnpike Commission has road centerlines with full attribution including a unique road identifier. They have centerline representation for each direction for the turnpike only. Since the Commission is basically using the same data model as PennDOT, the Commission will not have to alter the model. The current model should effectively allow the Turnpike Commission to share data with all agencies that participate in the Common LRS Approach.

I-2 Summary of Needs

Through the Needs Assessment phase, it has been established that the Pennsylvania Turnpike Commission currently has a GIS system that fits its needs. The Turnpike Commission only needs to sign a data sharing agreement to allow transfer of event data. Since the Turnpike Commission does have a limited need for event data from adjacent jurisdictions.

I-3 Phased Approach

In the initial phase of this DVRPC project it has been agreed to that for the first phase that only the State maintained road network would be dealt with. This phased approach will allow the Turnpike Commission to receive event data along those roads in relation to their turnpike. This approach will not affect their current GIS business process.

II. Tactical Implementation Recommendations

The implementation of the Common LRS Approach only requires the establishment of a data sharing agreement. The specific step is outlined below.

II-1 Implementation Approach

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach on a regional basis for the Pennsylvania Turnpike Commission.

Step 1 – Establish Data Sharing Agreements

The Commission needs to put into place a data sharing agreement with each one of the entities that will contribute their event data. The data agreements would allow for the Pennsylvania Turnpike Commission to use the data as part of their normal operating procedures.

IV. Tactical Implementation Recommendations – Hardware/Software

The successful implementation of the plan that has been presented for the Pennsylvania Turnpike Commission is clearly dependent upon the Turnpike Commission's ability to process the shared data. This ability is reliant upon both computer software and hardware.

IV-1 Software

The interview portion of the needs assessment process involving the Pennsylvania Turnpike Commission revealed that the Commission currently uses ESRI GIS software products, including ArcInfo 8.1 (ArcGIS). Based on this fact, there appears to be no urgent need for the Commission to procure additional software resources.

IV-2 Hardware

The interview portion of the needs assessment process and subsequent discussions with the Pennsylvania Turnpike Commission staff have revealed that the Commission currently possesses sufficient hardware resources to support the use of the Common LRS approach.

IV-3 Training

The implementation of the recommended procedures outlined above will require a relatively strong understanding of the use of ArcGIS software and experience in applying the necessary software tools. Since the Commission's staff are already performing tasks similar to those necessary to implement the Common LRS Approach, they should not require additional training.

Plan Number 19 – Southeastern Pennsylvania Transportation Authority (SEPTA)

I. Introduction

The previous volumes that have been produced for this project have provided the technical background and guidelines that are required for DVRPC to accomplish the goals and objectives that were set forth for the project. The information contained in these volumes is of little value unless the various participants develop plans for implementing the recommendations. The purpose of the information that follows is to provide such a plan. By following the recommended processes and procedures, each member agency will be able to develop a functional GIS that supports transportation planning and facilitates the exchange of critical transportation data with other member organizations and operating agencies throughout the region.

This plan has been custom designed for the Southeastern Pennsylvania Transportation Authority (SEPTA). It reflects information that was collected and analyzed through the needs assessment phase and is based upon the technical recommendations put forth through Volume III.

I-1 Overview of Needs Assessment Results

In Volume I, Needs Assessment Overview, four stages of street centerline development were identified. Currently, the SEPTA centerline dataset is considered to be at the Stage 2 Level. SEPTA has road centerlines that were developed from both ETAK and TransCAD. Neither data set is considered to be up to date.

I-2 Summary of Needs

Currently SEPTA's most critical needs for implementing GIS for transportation planning are:
(1) either update the centerlines based on the new digital orthophotography and add the critical elements for the Common LRS Approach using to the road centerlines or (2) come to an agreement with DVRPC to acquire the new Pennsylvania "regional" centerline file.

I-2.1 Implementation Options

In order to meet these needs, SEPTA has two options. The first option involves using the existing SEPTA centerlines, updating them to the new digital orthophotography, and conflating address ranges and Common LRS information. The principle benefit of this option is that SEPTA can utilize their existing centerlines. The principal disadvantages of this option are (1.) the centerline geometry must be brought up to date and (2.) SEPTA must conflate the address ranges as well as each State's unique road identifier and measure values.

The second option involves establishing a data sharing agreement with DVRPC, which will allow for the use of the completed Pennsylvania regional centerline file. These centerlines will already be attributed with PennDOT's unique road identifier/measure values and street address information. The advantages of this option are (1.) the requirement for conflation is eliminated and (2.) the centerline dataset is more up-to-date and accurate, which allows removal of the Update Centerline Geometry sub-task under the Data Preparation task of the conflation process described in Chapter III of Volume III.

II. Tactical Implementation Recommendations – Linework

The implementation of the first option would require the commitment of a vast amount of resource to essentially duplicate the efforts of the member agencies. Therefore, it is recommended that SEPTA implement the second option. The only required step in the process is outlined below.

II-1 Implementation Approach

The following implementation plan reflects the technical requirements for implementing the Common LRS Approach on a regional basis for SEPTA.

Step 1 – Establish Data Sharing Agreement

SEPTA needs to put into place a data sharing agreement with DVRPC that will allow SEPTA to use of the completed Pennsylvania regional centerline file.

III. Tactical Implementation Recommendations – Database

The data model is central to every Implementation Plan; therefore it was included in Volume III as part of the Database Design Recommendations. Specific technical details can be found in Chapter II of Volume III.

The data model from Volume III, Chapter II is reproduced in Figure 1 for reference purposes. As stated in Volume III, this model needs to be structured such that it will support the Unique Identifier, Address Information and Linear Referencing System information on all of the centerlines.

In order to perform accurate geocoding and linear referencing on the same centerline dataset, the data must contain the aforementioned attributes. Although Address Information and LRS information is represent by the same entity on this data model for ease of understanding, they could be represented as separate entities

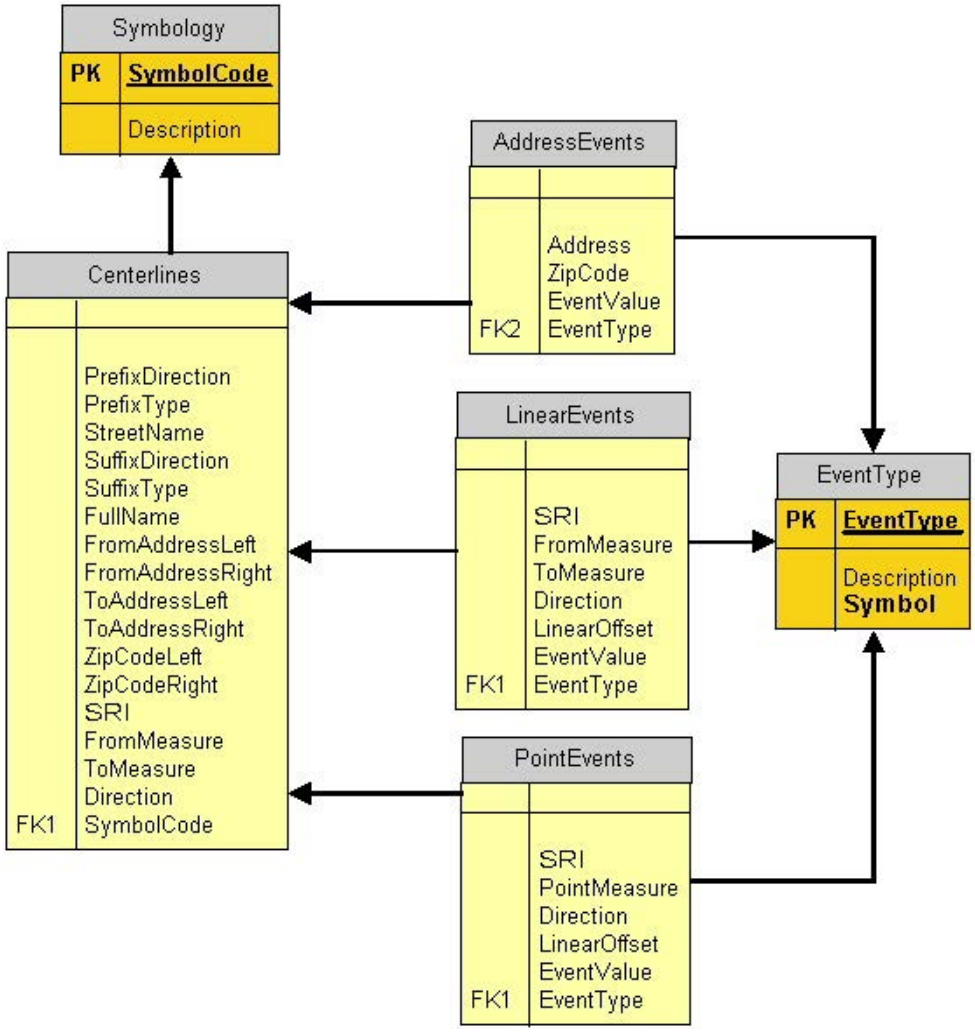

Figure 1 – Recommended Common LRS Data Model

IV. Tactical Implementation Recommendations – Hardware/Software

The successful implementation of the plan that has been presented for SEPTA is clearly dependent upon SEPTA's ability to utilize sufficient resources to acquire and load the regional centerline file to be provided by DVRPC.

IV-1 Software

The interview portion of the needs assessment process involving SEPTA revealed that SEPTA currently uses ESRI GIS software products, including ArcView 3.2. Since the recommended solution for SEPTA requires no significant database creation and maintenance capabilities, a significant investment in additional software will not be required. It is recommended that SEPTA consider upgrading to the latest version of ArcView and give future consideration to the acquisition of at least one full license of ArcGIS.

IV-2 Hardware

The interview portion of the needs assessment process and subsequent discussions with SEPTA staff have revealed that SEPTA currently possesses sufficient hardware resources to support the recommended procedures for acquiring and using a street centerline with attribution to support the Common LRS/Street Address Geocoding approach.

IV-3 Training

The implementation of the recommended procedures outlined above will not require extensive levels of training for SEPTA staff. Training needs will be an evolving issue with future needs being identified as the agency progresses with its implementation of GIS.

VI. Summary and Conclusions

In order to implement the Common LRS Approach, SEPTA must establish a data sharing agreement with DVRPC. The results of this approach will not only allow SEPTA to share data with all partner agencies, but it will also allow SEPTA to locate events along their centerlines. The events can take the form of address locations through geocoding or linear/point events located through dynamic segmentation. The benefits of having this functionality should far outweigh the costs for implementing it.

Region-wide Transportation GIS Project Design and File Architecture
Volume IV – Implementation Plans

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ABSTRACT
The primary purpose of this project is to assure that DVRPC, it's member city and county governments, and transportation operating agencies have a GIS and data files that can be developed and shared with each other to facilitate better transportation planning analysis and decision-making. This report, divided into five volumes, serves as the foundation to establish the operational framework for these efforts.

Volume IV – Implementation Plans presents the process for implementing the Common LRS/Street Address Geocoding Approach. This approach is comprised of a series of steps that represent a comprehensive methodology to establish a functional GIS database that will support transportation-planning efforts. An appendix contains detailed implementation plans, individually tailored for each of the 19 participating agencies. Specifically, they address centerline linework development, database development, computer hardware and software, staffing and training.

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