NCDOT

Traffic Survey Unit

An LRS Based Information System Design for Traffic Survey Data

By

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OUTLINE

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1.0 INTRODUCTION

The primary function of the Traffic Survey Unit (TSU) is to collect transportation data and to format it in a meaningful manner. The unit may be viewed as a traffic data warehouse. This data can then be published so that it may be used by other NCDOT units and by outside agencies and interested parties. Approximately 90 percent of the data is specific to traffic volumes, vehicle types, and vehicle weights.

In addition to storing data, the TSU analyzes data to derive traffic and travel statistics that are of use to others. In the future, TSU would like to provide on-line access to as much of its data as possible for all those who might be interested in traffic information. Although the unit undertakes many activities, the one of interest in this report is to define the information system design for a key subset of traffic survey data.

1.1 Background

Handling data is a difficult task as evidenced by the emergence of an entirely new discipline called information technology which was created to formalize this task. Of particular importance in data handling are:

- data collection
- data storage
- data quality maintenance and enhancement
- data delivery

This report focuses on data storage and delivery.

The TSU warehouses a variety of data in multiple formats. These can be simplified into two main categories:

- paper
- electronic

The electronic data encompasses files, disks, tapes, CDs, etc. The paper data includes completed data collection forms, paper printouts, and annotated maps. The future goal of the TSU is to move increasingly toward electronic formats. In particular the Unit seeks to:

- develop a comprehensive database (and to ultimately make its data available via the world wide web). [data storage]
- allow presentation of data using a GIS display. [data delivery]
- allow presentation of data using the world wide web. [data delivery]

These three goals focus on the data storage and data delivery tasks of the Unit.

The NCDOT GIS Unit has embarked on an effort to develop a versatile base location referencing system (LRS) that can be used throughout the Department. Because it deals with many linear objects, including the highway network, that referencing system is referred to as a linear referencing system. In this report the acronym LRS is taken to mean linear referencing system. A design for the NCDOT LRS has now been developed that allows other NCDOT business units to attach their data to this "common" LRS.

Presently, many NCDOT Units have their own location referencing method and most differ to some extent. As a result, department wide data sharing and exchange are significantly inhibited because of the need to write location referencing translation programs. Additionally, data analysis using diverse data sets is inhibited. Thus, multi-disciplinary queries such as "find all accidents where the pavement condition rating is low and the AADT is high (insert some appropriate values here)" are not presently easy to resolve. Such a query would require data from PMU, TSU, and TE. The data sets of these units and branches are not currently well linked. The purpose of the LRS is to make this less difficult.

The new LRS will provide a common, standardized highway network on which any NCDOT Unit may overlay its data. The GIS Unit will maintain the network topology and geometry and each unit will maintain their own attribute data as shown in Figure 1.1. The LRS is the network and TSU data is event data associated with the LRS.

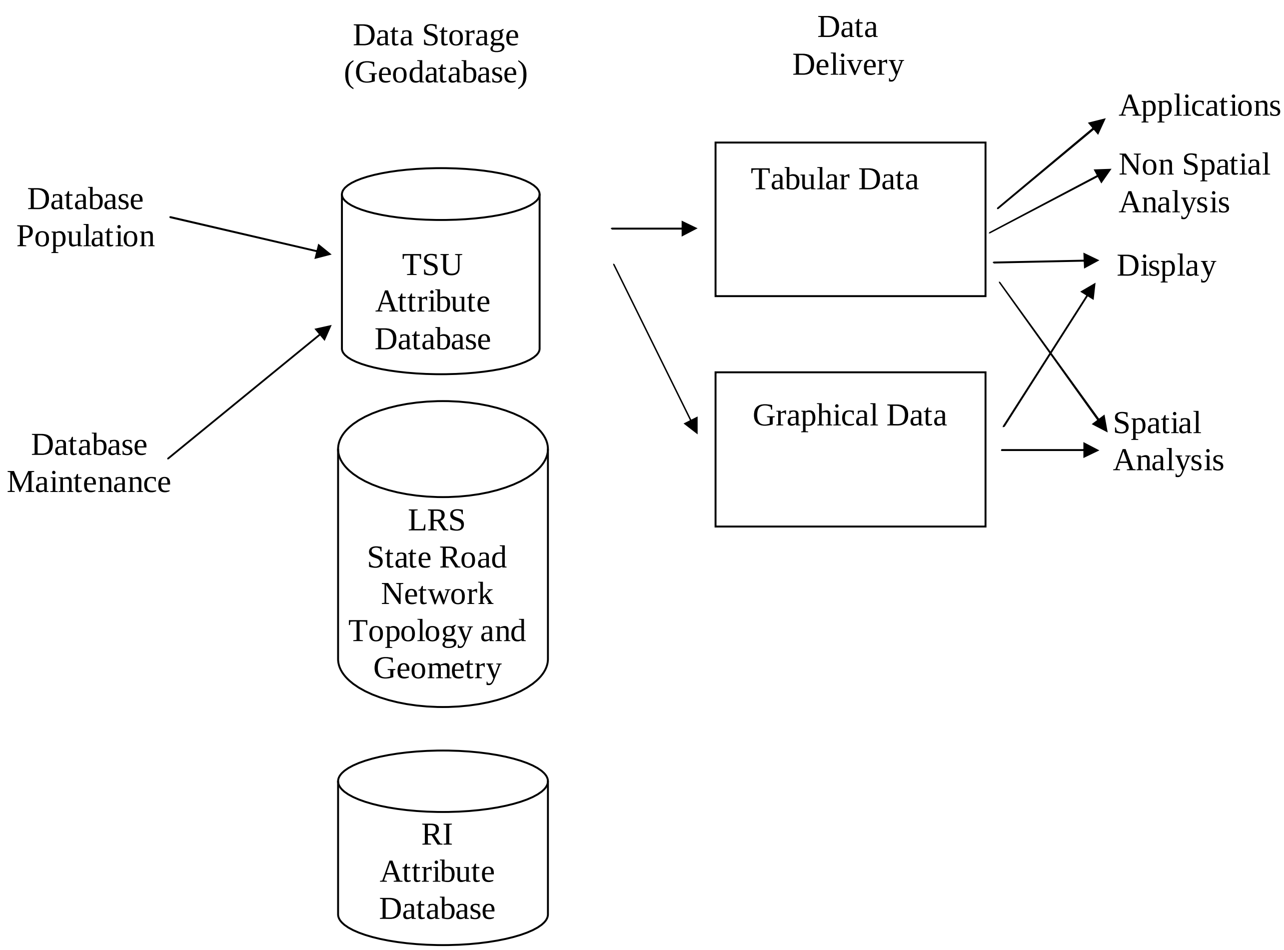

Figure 1.1: LRS Data Storage and Delivery

In Figure 1.1 the GIS Unit maintains the LRS State Road Network Topology and Geometry which constitutes the Geodatabase. The GIS Unit is responsible for the network while others are responsible for their data. This is the preferred approach as no one is as capable of taking care of the data as the Unit from which it originated.

1.2 Context

The LRS itself is now under development and is an ongoing and evolving project. Such development may, over time, cause some of the content of this document to change as the LRS evolves.

This document relates to the 1.X data model and series of releases for the LRS. It is a study intended to show how to integrate TSU with the new LRS. This document represents a recommended design that is to be used as a basis for an implementation. It is not yet a specific project proposal to develop a product. Thus, it serves as an advising resource and best practice document but does not serve as a project charter of the GIS Unit.

The normal business process for the GIS Unit would encompass the development of numerous documents including a Project Request Document, a Project Charter, and a Project Formal Agreement. This report lays the foundation for a Project Request Document which would enable the GIS Unit to assess the needs of TSU and respond with what could be done and how. Thus, this report helps to define the overall vision and goal of TSU.

1.3 Objectives

One objective of this report is to present the general database design for Traffic Survey Unit data (TSU Attribute Database as shown in Figure 1.1) that will be made available via the NCDOT LRS. This document will support the future integration of the TSU database schema into the LRS database. In addition, this report describes the processes (additional programs and programming) needed to implement the database population and maintenance activities.

This report defines what we refer to as the core data items to be initially implemented. The ultimate LRS database is in no way limited to these data items and, in fact, is expected to expand and evolve over time. However, at present, this report describes material that is broad enough in scope to provide useful and meaningful data, yet it is not as broad as to limit implementation or to require excessive resources. It is a target that can be successfully met in a reasonable time frame with low risk and high payoff.

1.4 Scope

Linear referencing of traffic data will be divided into two categories:

- Collection Elements
- Reporting Elements

Collection refers to the acquisition of data. Reporting refers to the dissemination of data.

Each collection element is specific to the point location at which traffic data is collected. Collection elements are intended for scheduling, collection, processing, and analysis activities.

Reporting elements are a representation of the results of one or more analyses from a collection element translated to a segment on the linear highway system. Where collection elements are primarily point references, reporting elements are primarily segment references. Reporting elements are the initial TSU data items to be made available to the public through the LRS.

1.4.1 *Collection Elements*

Point elements to support data collection activities are as follows:

- PTC (Portable Volume Counts) - Station Identifier.
- PVC (Portable Vehicle Classification Counts) - Station Identifier.
- ATR (Permanent Volume Counts) - Station Identifier.
- AVC (Permanent Vehicle Classification Counts) - Station Identifier.
- WIM (Permanent Vehicle Class and Truck Weight) - Station Identifier.
- MC (Manual Classification - Manual Vehicle Class) - Station/Event Identifier.
- TM (Turning Movement - Intersection movement counts and count data on approaches to the intersection) - Station/Event Identifier.

The first 6 types of counts shown above are collected at points located between intersections. The turning movement count, on the other hand, is always located directly at an intersection. However, some of these intersections are not on the State highway system. This presents a problem in that the LRS presently handles only the state highway network. This problem needs to be addressed in the final design. It does not initially need to be addressed because the evolution of the LRS may be such that the problem is resolved before it becomes a significant problem. For the present this is handled simply by storing the data using the turning pavement count identifier and leaving the intersection identifier blank.

1.4.2 *Reporting Elements*

Segment elements to support data reporting activities are as follows:

- Volume (AADT) - Total Volume (in vehicles per day) - Source Data Identifier.
- Single Unit (AADVT_SU) Trucks - SU Truck Volume (in vehicles per day) - Source Data Identifier.
- Multi Unit (AADVT_MU) Trucks - MU Truck Volume (in vehicles per day) - Source Data Identifier.
- Volume Seasonality - VOLUME Group or Station Identifier.
- Vehicle Class Seasonality - VC Group or Station Identifier.
- Truck Weight Seasonality - TWR Group or Station Identifier.

These are the data items to be made publicly available for access through the LRS. The source data identifier is the corresponding station identifier where the actual data was collected. A group is a logically assembled collection of station identifiers from which data was collected.

1.5 Report Organization

This report contains the following major sections:

- NCDOT LRS Database Design
- TSU Data
- Database Tables
- Programs
- Database Server Organization
- Implementation
- Roles and Responsibilities

This report first addresses and explains the NCDOT LRS database design. It then describes the data that the Traffic Survey Unit handles, collects, stores, and processes. Two issues are addressed in particular: spatial location and attribute values. Traffic Survey data items are then described in detail in the Traffic Survey Database Tables Section. The design of the database tables is also presented.

The next portion of the report addresses various business processes that use the data in the Programs Section. The major programs that need to be written to achieve the database design (previously described) are discussed. The report then focuses on the data that is to be stored using Oracle, including which data is public vs. private, and how that data is organized on the server. Trade-offs between a database (tabular) and a GIS (graphical) approach are discussed.

The report continues with an implementation discussion that addresses unresolved issues in the design and the resources needed to implement it. The report concludes with a roles and responsibilities section that addresses participant activities in the delivery of the database.

2.0 NCDOT LRS DATABASE DESIGN

The purpose of the LRS is to robustly and accurately model the state's highway network.

2.1 Network Model

Figure 2.1 presents a graphical model of a highway network using the graphical elements of lines and circles. We refer to the circles as nodes and the linear elements between them as FTSegments. The linear elements are not straight but may be of any shape. Thus, in Figure 2.1 AB, BC, CD, EB, BF, GC, and CH are FTSegments and A, B, C, D, E, F, G, and H are nodes. These are the components of the LRS network *model*.

The components of the LRS model are entirely different from the *graphical display* elements shown in Figure 2.1. A, B, C, D, E, F, G, and H are circles and AD, EF, and GH are lines. These are graphical display elements whether they be in black and white or in color. The graphical display corresponds to the underlying LRS database model.

In this report we are concerned with the highway network model. Graphical display is of secondary interest. Thus, our focus is on the database and the network model it uses to achieve the spatial representation of the linear data associated with the highway network. Topology and geometry are two essential components of the network model.

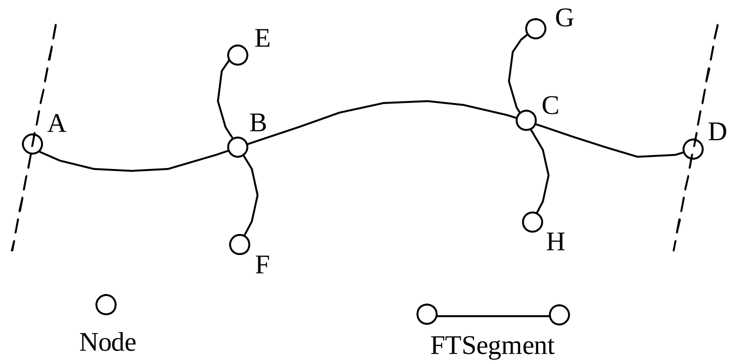

Figure 2.1: Graphical Highway Network Model

2.1.1 Topology

Topology embodies the connectivity of the network. The Topology of the state road network is captured in the LRS through the use of nodes and FTSegments. A node occurs where two lines intersect (B, C), at a dead end of a line (E, F, G, H), or at a state or county boundary (A, D). An FTSegment is the segment between two nodes (AB, BC, CD, BE, BF, CG, CH). We "connect" nodes and FTSegments through references to each other using an identifier. We can then answer queries related to the connectivity of the network.

2.1.2 Geometry

The geometry of the state road network is captured in the LRS by storing the length of the FTSegments. In a linear system position in space is determined by length, or position along a portion of the network, rather than by absolute position on the earth. Thus, GPS coordinates are of limited value to the network itself (although they are useful in other ways). Rather, actual length measurements of the network elements are stored and distances can be determined using these. The length of the FESegments in Figure 2.1 are shown in Figure 2.2.

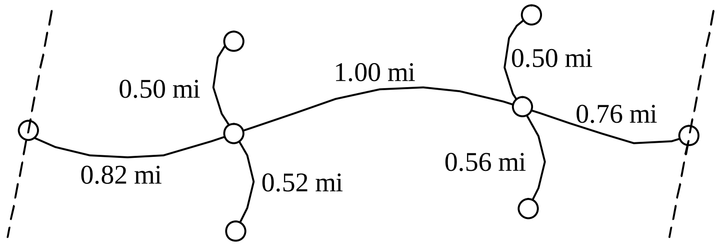

Figure 2.2 Geometry of the Network Model

It should be noted that here we are discussing the modeling of geometry in a relational database rather than in a GIS. While length is the item stored in the relational database to specify geometry, shape is what is stored in a graphical model of geometry in a GIS.

2.1.3 State Maintained System

The purpose of the network model is to create an accurate representation of the physical roadway system. In particular, the focus of the LRS is on modeling the State Maintained Roadway System. As a result, only state maintained roads are initially planned to be incorporated in the database. Thus, FTSegments represent segments on the State Road System and FTRPs represent intersections of roads on the System.

This presents what appears to be a problem for TSU. Often, Turning Movement counts occur at the intersection of a state road with a non-state road or at the intersection of two non-state maintained roads. If such roads are not represented in the system then it is not the case that TM counts are taken at an FTRP. However, it is expected that the LRS will evolve so that FTRPs can be inserted at these pointes because it is a future desire to have non-state maintained roads added to the system.

At the present time this problem can be handled in the database simply by providing a turning movement count identifier and not specifying an FTRP. This results in an incomplete record but it still enables the system to record all the data.

2.2 Attributes

The items placed onto the network are referred to as attributes. Attributes are characteristic of an object that describe it. Attributes of different components of the highway network include speed limit, traffic volume, number of lanes, etc.

2.2.1 Point Attributes

One attribute type is a point attribute. A point may represent a physical entity such as a count station, a sign, a culvert, a railroad crossing, etc. A point attribute may also represent a conceptual entity such as a county boundary or other political entity. Both physical and conceptual entities retain a position on the network. Figure 2.3 illustrates points A and D as representing county boundaries, point 1 as representing a rail road crossing, and point 2 as representing a culvert, for example.

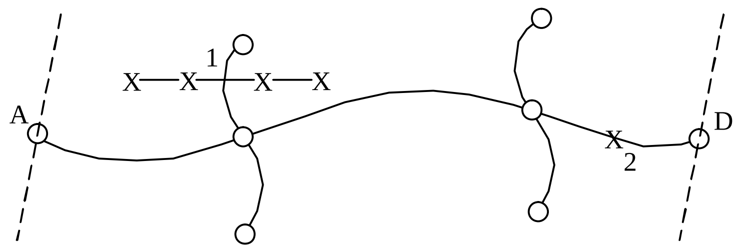

Figure 2.3 Points on the Network Model

Point attribute position in the LRS is determined relative to FTSegments. To identify a position requires the specification of an FTSegment identifier, an end node (of the FTSegment) identifier, and an offset distance from the specified end node to the point attribute under consideration. That location may in fact be directly on the reference point itself and this is indicated by having an offset distance of zero. Offset referencing is further discussed in Section 2.7 below. The collection points of the TSU data set are point attributes.

2.2.2 Segment Attributes

A second attribute type of interest in a transportation network is a segment attribute. A segment attribute may represent a physical entity such as pavement, a guard rail, a shoulder, a median, etc. A segment attribute may also represent a non physical item such as speed limit, AADT, name, etc. Each of these extends along a length of the network at some linear location. Thus, like point attributes, a segment attribute also retains a position on the network, although it is a linear position rather than a point position.

Figure 2.4 illustrates the concept of segment attributes. The segment identified as X extends from node A to node B and encompases the entire FTSegment AB. The segment identified as Y extends from some point on FTSegment BC to some other point on FTSegment BC, neither of which lies at either end of the segment. Finally, the segment identified as Z has one end that corresponds to node D, but its other end lies at some point along FTSegment CD.

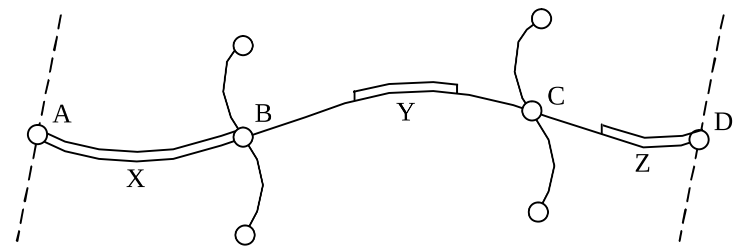

Figure 2.4: Segments on the Network Model

Linear position is also determined relative to FTSegments. In fact, it is determined in exactly the same way as for point attributes because the boundary of each segment consists simply of two points delineating each of its ends.

The reporting elements of the TSU data set are segment attributes.

2.3 Network Position Identification

Network position identification means to identify where on the network an attribute is positioned. This report describes four ways that is commonly done. These are:

- Mile Post Referencing
- Offset Referencing
- LRS Referencing
- Coordinate Referencing

2.3.1 Mile Post Referencing

Mile post referencing is a common method of specifying and identifying locations within and among DOTs. Figure 2.5 illustrates the use of mile post referencing to refer to a point X on the example network of Figure 2.1.

Mile posting is a conceptual measurement system where distance is measured from the start of a road within a county. For interstate roads, however, mile posting is measured from the start of a road within the entire state. If a road does not cross a state or county boundary, mile posting begins at the point at which the road starts. Increasing mileage generally occurs in easterly and northerly directions. In Figure 2.5 the milepost of point X is 1.30 miles on NC 42. In this case, the mile posting begins at point A which is a county boundary.

Mile post referencing requires only two data items as follows:

- A Route NC 42
- An Offset from Origin 1.30

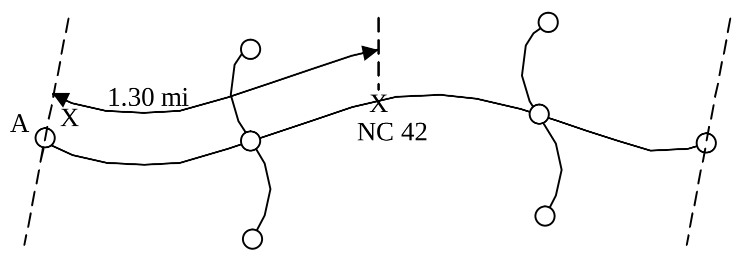

Figure 2.5: Specifying a Point Location Using Mile Post Referencing

Mile post referencing presents severe challenges for location referencing. In actuality it is a form of referencing that is not intuitive and is not referenced to anything predictable or expected. Furthermore, when a section of a road is relocated, the mileposts of all of the features north and east of it will change. It is difficult to develop database systems when the locations of attributes appear to change. Thus, this form of referencing has significant shortcomings.

2.3.2 Offset Referencing

Offset referencing is the primary method of specifying and identifying location in the field. It is also an effective way to specify location in a database and is well suited to the LRS. That is, it can easily be implemented in the LRS. Offset referencing ties the location of a point to the location of some other known point. Refer to Figure 2.6 for an example.

To precisely specify a point location on a network using offsets one must specify four items:

A Route	NC 42
An Intersecting Route	US 1
An Offset Distance	0.48
A Direction	East

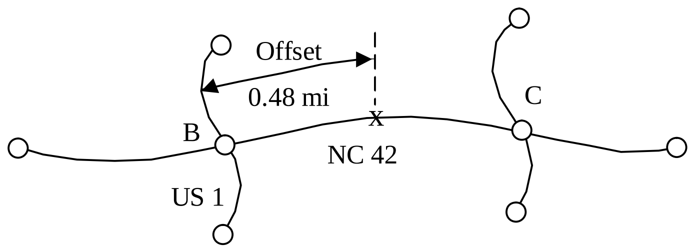

Figure 2.6: Specifying a Point Location Using Offset Distance

The route number is the identifier of the route on which the point lies. The intersecting route is a route that crosses the route on which the data point lies. This crossing defines the intersection that is used as the reference point for the measurement. The offset then is the mileage distance from the identified intersection to the location in question (along the route), given to hundredths of a mile, in the specified direction.

Note that the example shown in Figure 2.6 is that of locating a point. A segment would be identified similarly using two end points. The segment end points may be measured from the same end intersection or they may be measured from a different intersection.

2.3.3 <u>LRS Referencing</u>

LRS referencing is a specialized form of offset referencing. It is the method used in the new NCDOT LRS database. The reader is referred to Figure 2.7 for an example.

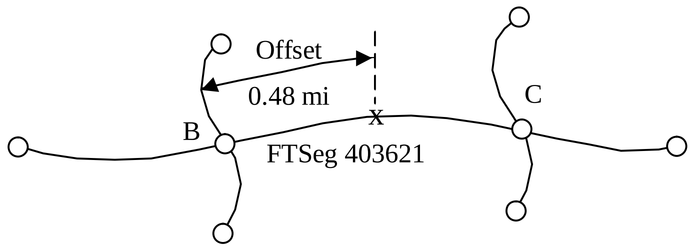

Figure 2.7: Specifying a Point Location Using LRS Offset

To precisely specify a point location on a network using LRS referencing one must specify three items:

An FTSegment Identifier	403621 (between nodes B and C)
An FTRP Identifier	B
An Offset Distance	0.48

The FTSegment identifier represents the FTSegment on which the point lies. The FTRP identifier represents the end node from which the offset is measured. The offset then is the mileage distance from the identified node to the point location of interest along the FTSegment, given to hundredths of a mile.

Note that the example shown in Figure 2.7 locates a single point. A segment would be represented similarly using two end points. The segment end points may be measured from the same end node or they may be measured from different end nodes.

2.3.4 Coordinate Referencing

Numerous NCDOT Units have access to and use GPS units. The TSU is one that expects to make significant use of GPS units in the future. These are devices that identify the geodetic (latitude, longitude, elevation) or geographic (N, E, Z) coordinates of a point on the surface of the earth. To precisely specify the location of a point on the earth's surface requires exactly these 3 coordinate values.

However, one difficulty with points is that they may not, when loaded into ArcGIS, appear directly on the lines that represent roads. Figure 2.8 illustrates this situation.

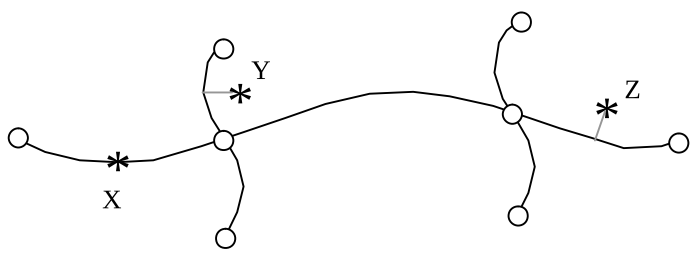

Figure 2.8: Specifying a Point Location Using Coordinates

Three example points are shown in Figure 2.8. Point X had coordinates that placed it directly on the roadway network. However, points Y and Z did not fall directly on the roadway network even though during measurement the field technician stood directly on the road to collect the coordinate data.

The reasons for the point and line not matching are numerous. The technology, accuracy, and precision of the instruments used to collect GPS data can vary widely. Thus, the GPS coordinates are not exact even though they may be reasonably accurate and precise. Second, the technology of placing a road in either CAD or GIS software is not completely accurate either. Thus, it is possible that the road, the coordinates, or both are inaccurately positioned. It is no wonder then that they might not match up visually. That is why we assume they do match if they are “close,” i.e., within a tolerance of each other. The process of determining that two points are close enough to each other to be the same point is referred to as “matching.”

What has to happen when situations like Y and Z occur is that they must be “snapped” to the line work. That is, they must simply be “put” somewhere on the line. This process of moving them from off the line to on it is called snapping. Snapping algorithms usually are produced in GIS software and they usually move a point to the line along a path perpendicular to the road. That is, they move from where they are to the closest possible point on the line. Figure 2.9 shows the GPS locations of the points from Figure 2.8 after they have been snapped to the line work.

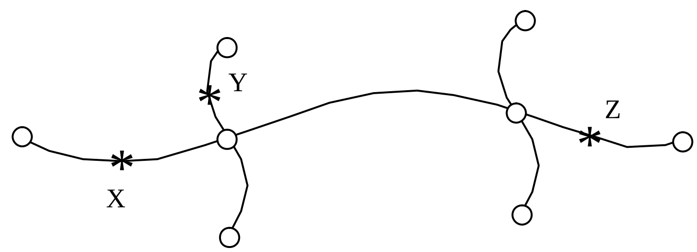

Figure 2.9: Snapping Coordinates to the Roadway Network

There are thus two key operations that are needed by the TSU. The first is snapping and the second is matching.

2.4 Spatial Data Integration Options

The LRS enables the NCDOT GIS Unit to maintain both the topology and the geometry of the State highway network. In this manner, one organizational Unit is responsible for the completeness and correctness of this network. But other Units may attach their data to the network and obtain the following benefits:

- They are not responsible for maintaining the network.
- They are responsible for maintaining only their data.
- Their data is combined with the data of everyone else using the LRS.
- Their data is available for multi attribute query and analysis via a GIS.
- Their data is readily available for use by customers and others.
- There is fast ad-hoc access to all data.
- There is access to versatile mapping resources.

There are two integration paths for external customers with respect to the LRS as follows:

- Convert their location referencing method and attribute database structure to that of the LRS.
- Maintain their current location referencing system and database structure and translate between systems when needed.

The advantages of conversion include all of those mentioned above plus the following:

- The connection to the LRS can be real-time.
- Tools for data maintenance can be made available and maintained by the GIS Unit.

- All customers have a uniform set of tools for accessing all data.
- Direct access to a highly reliable and accurate highway network.

The disadvantages of conversion are as follows:

- Reliance on the GIS Unit for the highway network.
- Reliance on the GIS Unit for the tools to use the system.
- Transition of TSU customers to LRS to access data.
- For customers not using the LRS, conversion software will be required to access TSU data.

The advantages of translation are as follows:

- The customer's data remains detached and removed from other data and access by other users.

The disadvantages of translation are as follows:

- Determining who will write the conversion software.
- Time delay while translation software is designed, implemented, tested, and placed into production.
- The connection is not real time.
- The translation will inherently contain errors.
- Customer must maintain their own location referencing method.

3.0 TRAFFIC SURVEY UNIT DATA

This data consists of spatial traffic survey data that is on the LRS. In fact, these tables show how it is placed on the LRS.

3.1 Spatial Data

It has been noted that point and segment data are the primary forms of data applied to the network. Point data occurs at a specified point. Multiple points may exist on a given FTSegment or on the Road Segments of which the FTSegment is comprised. Segment data, however, can occur over less than one, on one, or on multiple FTSegments. If it occurs over less than one FTSegment then its extent is specified on the underlying Road Segments.

Table 3.1: Multi Segment Attribute Illustration for AADT Data

AADT Locations

Station ID	Road Segments
1047362	1
1047362	2
1047362	3

Table 3.1 illustrates one set of road segments over which a particular station's data might apply. In the example shown, the AADT data from station 1047362 applies to three Road Segments whose IDs are 1, 2, and 3. Thus, station data can span multiple Road Segments and could also span multiple FTSegments. It is also the case that AADT might exactly match the extent of a single FTSegment exactly. Additionally multiple AADTs might occur on different portions of the same FTSegment.

3.1.1 ***Point Data Locations***

These data items represent the point locations at which counts are taken. These are referred to as collection elements. The following abbreviations and acronyms define TSU point data. These were previously described in Section 1.3.1.

- PTC
- PVC
- ATR
- AVC
- WIM
- MC
- TM

3.1.2 ***Segment Data Locations***

These data items represent the linear locations on which attributes are reported and thus are referred to as reporting elements. The following acronyms define TSU segment data. These were previously described in Section 1.3.2. The first 3 of these items are determined by a single station location but they may be averaged from multiple locations. The latter 3 are determined as a function of multiple station locations.

- AADT
- AADVT_SU
- AADVT_MU
- Volume Seasonality
- Vehicle Class Seasonality
- Truck Weight Seasonality

3.2 Attribute Data

This data consists of the attribute values for the point and segment data locations previously defined. This is public data that is to be made available on the LRS. This is the data that the TSU seeks to make readily available to its customers.

3.2.1 *Traffic Volume (AADT)*

The AADT is the annual average daily traffic for all vehicles. This value is an estimate of the average of all typical days throughout the year. The AADT value is derived through a series of processes. These are further discussed in Section 5.6.

Units:	Vehicles per day
Data Type:	Integer
Typical Range of Values:	10 - 170,000
Table Name:	AADT

Table 3.2: Traffic Volume Tables

AADT

Road Segs	Volume Ptr
1	A
2	A
3	B

Volume Values

Volume Ptr	Volume Values
A	100
B	120
C	150

This data tells us the AADT volume attribute values at any segment location on the network. This is how reporting elements are implemented in the LRS. Each road segment possesses a volume pointer that indicates a volume value for that road segment. The extent over which that volume value applies is the number of contiguous road segments that possess that value pointer. Thus, in Table 3.2 the value of 100 vehicles per hour occurs on both road segments 1 and 2.

There is one remaining open question regarding AADT. As specified here, AADT is stored relative to portions to the road network. In the current design AADT is not stored at the station. It would be possible to store an AADT value on both the reporting segment and the station if desired.

3.2.2 *Single Unit Truck Volume*

The AADVT_SU is the annual average daily vehicle traffic for single unit trucks. This value is an estimate of the average of all typical days throughout the year.

Units:	Single unit trucks per day
Data Type:	Integer
Typical Range of Values:	0 - 5,000
Table Name:	SUTV

3.2.3 *Multi Unit Truck Volume*

The AADVT_MU is the annual average daily vehicle traffic for multi unit trucks. This value is an estimate of the average of all typical days throughout the year.

Units:	Multi unit trucks per day
Data Type:	Integer
Typical Range of Values:	0 - 10,000
Table Name:	MUTV

3.2.4 *Volume Seasonality*

Volume seasonality provides a description of the pattern of travel on a facility throughout the year. It accounts for volume changes as seasons change and captures variations in seasonal travel.

Current

Units:	Groups
Data Type:	Integer
Typical Range of Values:	1 - 7 and 11 - 14
Table Name:	AADT

Proposed

Units:	Groups
Data Type:	Enumerated
Typical Range of Values:	01-99
Table Name:	VOLUMEGROUP

3.2.5 *Vehicle Class Seasonality*

The vehicle class seasonality accounts for differences in vehicles themselves on a highway. This represents a factor used to account for vehicle class.

Units:	Groups
Data Type:	Integer
Typical Range of Values:	01-99
Table Name:	VCGROUP

3.2.6 *Truck Weight Seasonality*

Truck weight seasonality groups road segments by truck weight.

Units:	Groups
Data Type:	Integer
Typical Range of Values:	01-99
Table Name:	TWRGROUP

3.3 Customers

The TSU has a number of primary customers. The first is the GIS Unit of the NCDOT. In particular this is the Road Inventory Information System Section (RIIS). This section utilizes AADT data from TSU to support FHWA data reporting requirements. The second TSU customer is other NCDOT units. The third are the NCDOT division engineers. Finally another customer is the general public.

The TSU expects that some of their customers would readily make use of the TSU LRS data. Others would prefer access to data in more traditional formats. Initially it is expected that the RIIS would prefer the former but the general public might prefer the latter form of access. There would be a transition for other NCDOT units and for the division engineers.

3.4 Historical Data

It should be noted that data is time dependent. Historically this has been handled by having archivable hard copies of maps and archivable files of data periodically stored in cabinets or on CD's. It is recommended that this practice be continued during the initial LRS startup. That is, it is recommended that periodic backups be made of the data.

One advantage of doing so is that it is possible to locate time dependent data. One could argue that a similar search can be made by using time stamped data in real time in the database. However, it is not recommended that dates be added to any of the database tables for this purpose. Initially that would increase the complexity of the database far more than would be productive. At some future time this point could be reconsidered. For the present it is recommended that the current process of an annual archive of a physical set of maps and data be replicated by an annual archive of the digital files.

4.0 DATABASE TABLES

This section defines the structure of the schema design for the TSU data. The schema design is in line with the structure of the database tables for RIIS. That is, the TSU design adopts the basic table format and schema design of the LRS as it has been defined and developed. Thus, TSU is converting its data to the LRS format. It is not maintaining a separate format that requires conversion programs.

This report includes a relational database schema. The schema is presented to the reader using two formats. In one format database tables are illustrated by identifying the table name along with its primary key(s) and attributes as follows.

TABLE NAME (**Primary Key**, Attribute 1, Attribute 2, Attribute 3, …, Attribute n)

When using this format a definition is provided for each attribute and a description is also provided for the overall content and meaning of the data contained in the table. The attributes are presented in bold face so that they can easily be identified.

In the second format, actual tables with representative data are presented. These tables are intended merely as a guide to enhance the illustration, where necessary, and the reader's understanding of the schema. They are provided in the following form. When using this format, each cell in each table contains data values.

Table 4.1: Database Table Format

TABLENAME

Primary key	Attribute 1	…	Attribute n

Both of the formats presented here complement and mirror each other. The second allows us to present example data that often further clarifies the reader's understanding of the schema design. This second format, however, will only be used when such clarification is absolutely necessary.

4.1 Collection Data

This report section presents the database tables that are necessary to store the TSU collection data. Each collection item that was previously discussed is presented.

4.1.1 ***Portable Volume Counts Station Location***

This table identifies the physical location of a PTC count station which is referred to as a coverage volume identifier. A PTC count station is a point location on the highway network. The offset method is used for its specification.

FPL_PTC_REC (CVRG_VLM_ID, FTSegID, FTRPID, Offset Distance)

CVRG_VLM_ID – The station identifier; a numerical value that combines county and station ID number in one overall value; unique statewide. 09100065 is an identifier wherein 091 represents Wake County and 00065 represents the station sequence number, unique county wide.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FTRP – The statewide unique LRS node identifier assigned to the network node from which the location of the CVRG_VLM_ID is measured.

Offset Distance – The distance between the location of the CVRG_VLM_ID being considered and an FTRP at one end of the given FTSegID.

4.1.2 ***Portable Vehicle Classification Counts Station Location***

This table identifies the physical location of a PVC (Vehicle Classification) count station. A PVC count station is a point location on the highway network. The offset method is used for its specification.

FPL_PVC_REC (CVRG_CLS_ID, FTSegID, FTRPID, Offset Distance)

CVRG_CLS_ID – The station identifier; a numerical value that combines county and station ID number in one overall value; unique statewide. 01001221 is an identifier wherein 010 represents Bucombe County and 01221 represents the station sequence number, unique county wide.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FTRP – The statewide unique LRS node identifier assigned to the network node from which the location of the CVRG_CLS_ID is measured.

Offset Distance – The distance between the location of the CVRG_CLS_ID being considered and an FTRP at one end of the given FTSegID.

4.1.3 ***Permanent Volume Counts Station Location***

This table identifies the physical location of an ATR (Automatic Traffic Recorder) station. An ATR count station is a point location on the highway network. The offset method is used for its specification.

FPL_ATR_REC (CNTNS_VLM_ID, FTSegID, FTRPID, Offset Distance)

CNTNS_VLM_ID – The station identifier; a character string value that combines county and station ID number in one overall value; unique statewide; and preceded by the letter A. A9101 is an identifier wherein the letter A indicates an ATR station, 91 represents Wake County, and 01 represents the station sequence number, unique county wide.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FTRP – The statewide unique LRS node identifier assigned to the network node from which the location of the CNTNS_VLM_ID is measured.

Offset Distance – The distance between the location of the CNTNS_VLM_ID being considered and an FTRP at one end of the given FTSegID.

4.1.4 ***Permanent Vehicle Classification Counts Station Location***

This table identifies the physical location of an AVC (Permanent Vehicle Classification) station. An AVC count station is a point location on the highway network. The offset method is used for its specification.

FPL_AVC_REC (CNTNS_CLS_ID, FTSegID, FTRPID, Offset Distance)

CNTNS_CLS_ID – The station identifier; a character string value that combines county and station ID number in one overall value; unique statewide; and preceded by the letter C. C4426 is an identifier wherein the letter C indicates a permanent classification station, 44 represents Henderson County, and 26 represents the station sequence number, unique county wide.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FTRP – The statewide unique LRS node identifier assigned to the network node from which the location of the CNTNS_CLS_ID is measured.

Offset Distance – The distance between the location of the CNTNS_CLS_ID being considered and an FTRP at one end of the given FTSegID.

4.1.5 *Permanent Vehicle Class and Truck Weight Station Location*

This table identifies the physical location of WIM stations. A WIM count station is a point location on the highway network that is regularly monitored and has a station identifier. Because the location is permanent it is sufficient to have a station ID. The offset method is used for its specification.

FPL_WIM_REC (MNL_WIM_ID, FTSegID, FTRPID, Offset Distance)

MNL_WIM_ID – The station identifier; a character string value that combines county and station ID number in one overall value; unique statewide; and preceded by the letter W. W7413 is an identifier wherein the letter W indicates a WIM station, 74 represents Polk County, and 13 represents the station sequence number, unique county wide.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FTRP – The statewide unique LRS node identifier assigned to the network node from which the location of the MNL_WIM_ID is measured.

Offset Distance – The distance between the location of the MNL_WIM_ID being considered and an FTRP at one end of the given FTSegID.

4.1.6 *Manual Vehicle Class Count Location*

This table identifies the physical location where a manual vehicle class count is taken. An MC station is a point location where an individual performs a manual vehicle classification count on the highway network. Multiple counts may be taken at the same location but these would receive different identifiers. The offset method is used for its specification. It should be noted that StationID is not a sufficient identifier for this data item. Instead, each count must have a unique identifier because the counts may be taken in different locations.

FPL_MC_REC (MNL_CLS_ID, FTSegID, FTRPID, Offset Distance)

MNL_CLS_ID – The count identifier; a character string value that combines the year the count was taken, the initials MC, and a sequence number; unique statewide. 04MC0006 is an identifier that indicates a 2004 count identified as 0006.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FTRP – The statewide unique LRS node identifier assigned to the network node from which the location of the MNL_CLS_ID is measured.

Offset Distance – The distance between the location of the MNL_CLS_ID being considered and an FTRP at one end of the given FTSegID.

4.1.7 *Turning Movement Count Location*

This table identifies the physical location of an intersection study (turning movement count). An ATM count station is always a point location at a reference point in the FTSeg network (linear datum). That is, the count is always taken at an intersection and the intersection is always directly on an FTRP (see discussion in Section 2.1.3 for further clarification of this point). No offset distance is required. It should be noted that StationID is not a sufficient identifier for this data item. Instead, each count must have a unique identifier because the counts may be taken in different locations.

Turning_REC (TM_ID, FTRP)

TM_ID – The count identifier; a character string value that combines the year the count was taken, a TM (turning movement) indicator, and a sequence number; unique statewide. 04TM0006 is an identifier that indicates a 2004 TM count number 0006.

FTRP – The statewide unique LRS node identifier assigned to the network node at which this count is being taken.

4.2 Reporting Data

This report section presents the database tables that are necessary to store the TSU reporting data. Each reporting item that was previously discussed is presented.

4.2.1 *Total Volume*

4.2.1.1 ***Location* -** This table stores the physical location of a segment of road for which an AADT quantity value has been specified. The table indicates where along the length of this particular FTSeg the value lies.

FPL_AADT_REC (AADT_ID, FTRPID, FTSegID, FRM_DSTNC_QTY, TO_DSTNC_QTY)

AADT_ID – The AADT volume identifier. This is an arbitrarily assigned numerical value for this AADT volume location.

FTRPID – The statewide unique LRS node identifier assigned to the network node from which the location of both the beginning and end of the AADT value is measured.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FRM_DSTNC_QTY – The distance from one end of the AADT value to the FTRPID reference point.

TO_DSTNC_QTY – The distance from the other end of the AADT value to the FTRPID reference point.

4.2.1.2 ***Segments* -** This table identifies the underlying set of road segments that comprise this AADT segment.

FPL_AADT_XREF (RDSeg_ID, AADT_ID)

RDSeg_ID - Statewide unique LRS segment identification number assigned to this road segment. Multiple road segments may constitute a single AADT segments.

AADT_ID - An identifier for an AADT quantity value.

4.2.1.3 ***Values* -** This table stores the AADT value that is assigned to a segment of road. This table contains the most recent published data. If data is not available in a given year the data from the previous year is used. Thus if a station was not counted in 2006, for example, the analyst would use the 2005 data for that station. The presence of the field "year" enables the technician to know the time source of the data.

FPL_AADT (AADT_ID, AADT_QTY, Year)

AADT_ID – An identifier for an AADT quantity value.

AADT_QTY – A numerical value representing the average daily volume of traffic.

Year – The year that the AADT value was generated. Volume is updated on a two year cycle.

4.2.2 ***<u>SU Truck Volume</u>***

4.2.2.1 ***Location* -** This table stores the physical location of a segment of road for which a single unit truck volume quantity value has been specified. The table indicates where along the length of this particular FTSeg the value lies.

FPL_SUTV_REC (SUTV_ID, FTRPID, FTSegID, FRM_DSTNC_QTY, TO_DSTNC_QTY)

SUTV_ID – The single unit truck volume value identifier. This is an arbitrarily assigned numerical value for this SUTV volume location.

FTRPID – The statewide unique LRS node identifier assigned to the network node from which the location of both the beginning and end of the SUTV is measured.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FRM_DSTNC_QTY – The distance from one end of the SUTV value to the FTRPID reference point.

TO_DSTNC_QTY – The distance from the other end of the SUTV value to the FTRPID reference point.

4.2.2.2 ***Segments* -** This table identifies the underlying set of road segments that comprise this SUTV segment.

FPL_SUTV_XREF (RDSeg_ID, SUTV_ID)

RDSeg_ID - Statewide unique LRS segment identification number assigned to this road segment. Multiple road segments may constitute a single SUTV segment.

SUTV_ID - An identifier for an SUTV quantity value.

4.2.2.3 ***Values* -** This table stores the SUTV value that is assigned to a segment of road. This table contains the most recent published data. If data is not available in a given year the data from the previous year is used. Thus if a station was not counted in 2006, for example, the analyst would use the 2005 data for that station. The presence of the field "year" enables the technician to know the time source of the data.

FPL_SUTV (SUTV_ID, SUTV_QTY, Year)

SUTV_ID – An identifier for an SUTV quantity value.

SUTV _QTY – A numerical value representing the average daily single unit truck volume.

Year – The year that the SUTV value was generated. Truck volume is updated on a two year cycle.

4.2.3 *MU Truck Volume*

4.2.3.1 ***Location*** **-** This table stores the physical location of a segment of road for which a multi unit truck volume quantity value has been specified. The table indicates where along the length of this particular FTSeg the value lies.

FPL_MUTV_REC (MUTV_ID, FTRPID, FTSegID, FRM_DSTNC_QTY, TO_DSTNC_QTY)

MUTV_ID – The multi unit truck volume identifier. This is an arbitrarily assigned numerical value for this MUTV volume location.

FTRPID – The statewide unique LRS node identifier assigned to the network node from which the location of both the beginning and end of the MUTV is measured.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FRM_DSTNC_QTY – The distance from one end of the MUTV value to the FTRPID reference point.

TO_DSTNC_QTY – The distance from the other end of the MUTV value to the FTRPID reference point.

4.2.3.2 ***Segments*** **-** This table identifies the underlying set of road segments that comprise this MUTV segment.

FPL_MUTV_XREF (RDSeg_ID, MUTV _ID)

RDSeg_ID - Statewide unique LRS segment identification number assigned to this road segment. Multiple road segments may constitute a single MUTV segment.

MUTV_ID - An identifier for an MUTV quantity value.

4.2.3.3 ***Values*** **-** This table stores the MUTV value that is assigned to a segment of road. This table contains the most recent published data. If data is not available in a given year the data from the previous year is used. Thus if a station was not counted in 2006, for example, the analyst would use the 2005 data for that station. The presence of the field "year" enables the technician to know the time source of the data.

FPL_MUTV (MUTV_ID, MUTV _QTY, Year)

MUTV_ID – An identifier for an MUTV quantity value.

MUTV _QTY – A numerical value representing the average daily multi unit truck volume.

Year – The year that the MUTV value was generated. Truck volume is updated on a two year cycle.

4.2.4 *Volume Seasonal Group*

4.2.4.1 ***Location*** **-** This table stores the physical location of segments of road belonging to an VOLUME Group.

FPL_VOLUMEGROUP_REC (VOLUMEGROUP_ID, FTRPID, FTSegID, FRM_DSTNC_QTY, TO_DSTNC_QTY)

VOLUMEGROUP_ID – The VOLUME Group identifier. This is an arbitrarily assigned numerical value for this VOLUME Group location. A numerical two digit value ranging from 01 to 99 representing an VOLUME Group number if one is assigned.

FTRPID – The statewide unique LRS node identifier assigned to the network node from which the location of both the beginning and end of the VOLUME Group is measured.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FRM_DSTNC_QTY – The distance from one end of the VOLUMEGROUP value to the FTRPID reference point.

TO_DSTNC_QTY – The distance from the other end of the VOLUMEGROUP value to the FTRPID reference point.

4.2.4.2 ***Segments* -** Note, however, that while AADT, SU, and MU segments generally reside on only one route, VOLUME group segments often cover many more roads.

FPL_VOLUMEGROUP_XREF (RDSeg_ID, VOLUMEGROUP_ID)

RDSeg_ID - Statewide unique LRS segment identification number assigned to this road segment. Multiple road segments may constitute a single VOLUME group segment.

VOLUMEGROUP_ID – The VOLUME Group identifier. This is an arbitrarily assigned numerical value for this VOLUME Group location. A numerical two digit value ranging from 01 to 99 representing an VOLUME Group number if one is assigned.

4.2.5 ***Class Seasonal Group***

4.2.5.1 ***Location* -** This table stores the physical location of segments of road belonging to a VC Group.

FPL_VCGROUP_REC (VCGROUP_ID, FTRPID, FTSegID, FRM_DSTNC_QTY, TO_DSTNC_QTY)

VCGROUP_ID – The VC Group identifier. This is an arbitrarily assigned numerical value for this VC Group location. A numerical two digit value ranging from 01 to 99 representing an VC Group number if one is assigned.

FTRPID – The statewide unique LRS node identifier assigned to the network node from which the location of both the beginning and end of the VC Group is measured.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FRM_DSTNC_QTY – The distance from one end of the VCGROUP value to the FTRPID reference point.

TO_DSTNC_QTY – The distance from the other end of the VCGROUP value to the FTRPID reference point.

4.2.5.2 ***Segments* -** Note, however, that while AADT, SU, and MU segments generally reside on only one route, VC group segments often cover many more roads.

FPL_VCGROUP_XREF (RDSeg_ID, VCGROUP_ID)

RDSeg_ID - Statewide unique LRS segment identification number assigned to this road segment. Multiple road segments may constitute a single VC group segment.

VCGROUP_ID – The VC Group identifier. This is an arbitrarily assigned numerical value for this VC Group location. A numerical two digit value ranging from 01 to 99 representing an VC Group number if one is assigned.

4.2.6 *Weight Seasonal Group*

4.2.6.1 ***Location* -** This table stores the physical location of segments of road belonging to TWR Group.

FPL_TWRGROUP_REC (TWRGROUP_ID, FTRPID, FTSegID, FRM_DSTNC_QTY, TO_DSTNC_QTY)

TWRGROUP_ID – The TWR Group identifier. This is an arbitrarily assigned numerical value for this TWR Group location. A numerical two digit value ranging from 01 to 99 representing an TWR Group number if one is assigned.

FTRPID – The statewide unique LRS node identifier assigned to the network node from which the location of both the beginning and end of the TWR Group is measured.

FTSegID – Statewide unique LRS segment identification number assigned to this network segment.

FRM_DSTNC_QTY – The distance from one end of the TWRGROUP value to the FTRPID reference point.

TO_DSTNC_QTY – The distance from the other end of the TWRGROUP value to the FTRPID reference point.

4.2.6.2 ***Segments* -** Note, however, that while AADT, SU, and MU segments generally reside on only one route, TWR group segments often cover many more roads.

FPL_TWRGROUP_XREF (RDSeg_ID, TWRGROUP_ID)

RDSeg_ID - Statewide unique LRS segment identification number assigned to this road segment. Multiple road segments may constitute a single AVC group segment.

TWRGROUP_ID – The TWR Group identifier. This is an arbitrarily assigned numerical value for this TWR Group location. A numerical two digit value ranging from 01 to 99 representing an TWR Group number if one is assigned.

4.3 Other Tables

SEASONAL ADJUSTMENT FACTOR (**VOLUMEGroup_ID**, **Month**, **Day**, Factor Value)

This table gives the factor value used for calculating AADT for each specific VOLUME group for any given month and day of the week.

VOLUMEGroup_ID – specific group number for the different areas of use of an Automatic Traffic Recorder

Month – month that the count reading is taken

Day – day of the week that the count reading is taken

Factor Value – factor used as a multiplier in calculating AADT; depends on number of axles estimated per vehicle, day of the week, and time of the year

COUNT STATION ATTRIBUTES (**CVRG_VLM_ID**, VOLUMEGroup_ID, Axle Factor, Count Cycle)

This table gives the count cycle used at count stations, specific axle factor used at the station, and the designated VOLUME Group for a specific count station. Thus this table stores attributes that are essential for the AADT calculation.

CVRG_VLM_ID – identification number of a count station; numerical value that combines county and station ID number in one overall value; unique statewide

VOLUMEGroup_ID – specific group number for the different areas of use of an Automatic Traffic Recorder

Axle Factor – factor calculated that is used to account for the different number of axles a vehicle can have when passing over a count station

Count Cycle – specific cycle of time used for counting cars at the count station

INACTIVE STATIONS (**CVRG_VLM_ID**, Reason)

This table identifies all inactive stations and gives the reason a specific count station is inactive.

CVRG_VLM_ID – identification number of a count station; numerical value that combines county and station ID number in one overall value; unique statewide

Reason – reason for inactivity of the specific count station

RETIRED STATIONS (**CVRG_VLM_ID**, Year)

This table identifies all retired stations and gives the year a specific count station was retired.

CVRG_VLM_ID – identification number of a count station; numerical value that combines county and station ID number in one overall value; unique statewide

Year – year of retirement for the specific count station

STATION ACTIVATION TIME (**CVRG_VLM_ID**, Year)

This table give the year a specific count station was activated.

CVRG_VLM_ID – identification number of a count station; numerical value that combines county and station ID number in one overall value; unique statewide

Year – year of activation of the specific count station

RENUMBERED STATIONS (**CVRG_VLM_ID**, Old Station Number)

This table relates a specific old count station number to its new station ID.

CVRG_VLM_ID – identification number of a count station; numerical value that combines county and station ID number in one overall value; unique statewide

Old Station Number – old identification number given to a specific count station

GLOBAL STATION LOCATION (**CVRG_VLM_ID**, County Name, Urban Name)

This table gives the specific county ID, urban ID, and station ID for a specific count station.

CVRG_VLM_ID – identification number of a count station; numerical value that combines county and station ID number in one overall value; unique statewide

County Name – the county in which the count station is located

Urban Name – name for a specific urban area, or city, in which the count station is located

SEASONAL ADJUSTMENT FACTOR

VOLUMEGroup_ID	Month	Day	Factor Value
01	01	Monday	1.11
01	01	Tuesday	1.14
01	01	Wednesday	1.10
01	01	Thursday	1.09
01	01	Friday	0.99
02	01	Monday	1.07
02	01	Tuesday	1.07
02	01	Wednesday	1.06
02	01	Thursday	1.02
02	01	Friday	0.92
03	01	Monday	1.04
03	01	Tuesday	1.05
03	01	Wednesday	1.05
03	01	Thursday	0.99
03	01	Friday	0.94

COUNT STATION ATTRIBUTES

CVRG_VLM_ID	VOLUMEGroup_ID	Axle Factor	Count Cycle
047 00001	2	0.99	annual
031 00002	2	0.60	annual
031 00004	1	0.60	annual
047 00002	6	0.77	annual
031 00007	3	0.90	annual
031 00008	4	0.75	annual
031 00009	5	0.65	annual

INACTIVE STATIONS

CVRG_VLM_ID	Reason
031 00003	equipment malfunction
031 00006	under repair

RETIRED STATIONS

CVRG_VLM_ID	Year
031 00001	1971
031 00005	1977

STATION ACTIVATION TIME

CVRG_VLM_ID	Year
047 00001	1951
031 00001	1963
031 00002	1951
031 00003	1982
031 00004	1951
031 00005	1963
047 00002	1951
031 00006	1963
031 00007	1951
031 00008	1951
031 00009	1982

RENUMBERED STATIONS

CVRG_VLM_ID	Old Station Number
091 00016	103 0010120
050 00010	103 0010121

GLOBAL STATION LOCATION

CVRG_VLM_ID	County Name	Urban Name
047 00001	Y	---
031 00001	X	---
031 00002	X	---
031 00003	X	---
031 00004	X	---
031 00005	X	---
047 00002	Y	---

5.0 PROGRAMS

Programs are tools used to conduct one's business or to execute one's business process. Migrating TSU data to the LRS database, which will enable it to be distributed and used for analysis, may require the development of several new programs. This section discusses the requirements for some of those key programs, prefaced by a discussion of related pre-existing programs and the planned updates to those programs.

5.1 ADM and LARS

Two significant tools have already been developed by the GIS Unit to support the LRS – the ArcMap Data Maintenance (ADM) tool and LRS Access and Reporting System (LARS). These tools will be briefly described in this section as will a proposed extension to LARS.

ADM utilizes ArcMap to support graphical modifications of the linework due to realignments, retirements, and extensions of new roads in the LRS geodatabase. ADM works with the lines in the digital file. It also utilizes menus to support entry of a limited amount of data that must accompany the line work. Items entered include route number, county number, roadway class, direction, and an indicator for one way roads. Using ADM, a new road, along with a basic set of descriptive information, is entered into the geodatabase.

LARS supports tabular entry of road data (realignments, retirements, and extensions) into the LRS Oracle database. It utilizes drop down menus and screens and has no graphical component. In doing so, it stores the same attribute data that was entered by ADM (route number, class, etc.) but stores it in the LRS Oracle databse. In addition, LARS stores the location of end points for new roads. These may occur at an existing intersection in the roadway network or they may occur in the "middle" of existing roads. The latter type of point location is specified using the offset method described earlier. Finally, LARS creates and assigns new FTSegment identifiers to new roads.

The process of entering roads is not complete with the initial use of the ADM and LARS tools. After using ADM to enter graphics and basic data into the geodatabase and LARS to enter location and basic data into the Oracle database, technicians must then link the tabular and graphic data together. To do so they must re-enter ADM, retrieve the FTSegment identifier generated by LARS, and add it to the attributes. To summarize, the current functionality of these tools is as follows. This connection then enables the data to be graphically displayed with the linework.

- ADM
  - Graphical entry of roads (realignments, retirements, and extensions) in the geodatabase
  - Menu entry of basic identification, class, and spatial attributes
- LARS
  - Menu entry of roads (realignments, retirements, and extensions) in the Oracle database
  - Menu entry of basic identification, class, and spatial attributes

Extensions are planned for both ADM and LARS. Presently, ADM can only operate on new roads. In the future, it will be extended to handle realignments, retirements, extensions, and other less common graphical changes in road network topology. Any similar changes will also have to be made in LARS.

Presently LARS only enters and stores the same limited amount of attribute data that ADM enters. It is not currently configured to allow technicians to enter other attribute data. TSU data, for example, cannot presently be entered into the LRS database. Thus, in the future a new tool must be developed to support the definition of tables for new attributes, support data migration (loading) to those tables, and support future editing of data in those tables including entering, changing, and deleting individual values.

Finally, the new tool must have a graphical component so there is no need to go back and forth between tools to enter new data into the system. However, external users and customers should still have access to the database, control over their own attributes, and autonomy in how and when they carry out their work, while at the same time being separated from anything to do with revising the LRS road network itself. Such a new tool should be ideally suited to support the functionality needed by the customer community. To summarize, the following are a list of anticipated extensions for both tools.

- ADM
  - Realignments
  - Other topological road network changes
- LARS
  - Realignments
  - Other topological road network changes
- New Tool
  - Attribute data
    - Road Inventory Information System Section
    - Traffic Survey Unit
    - Other Units
  - Functionality
    - New table definition
    - Data migration (loading tables)
    - Data manipulation (enter, delete, modify)

5.2 Migration

Just as the RIIS road inventory data were loaded into the LRS database, so too will TSU data need to be loaded. This process is referred to as migration. Prior to loading data, all database tables must be fully defined. Table definition is the first step in the migration process. The second step is loading the data. The third step is checking the correctness of the loaded data. This third step is particularly critical because the migration process is essentially a one time batch process. If numerous discrepancies are found in the loaded data, changes need to be made in the data migration program to remove the errors and the data must then be reloaded. If only a few errors are found, the LARS tool can be used to correct the data. In either case, the initial data set should be error free.

Presently only the collection elements can be loaded into the LRS database. These already exist in a GIS format. All count station locations have been digitized and placed on the line work using ArcGIS. What is needed next is a program to enter these locations into the LRS database.

Reporting elements, on the other hand, cannot presently be migrated to the LRS database. AADT segments and assignment of seasonal groups do not exist in a format that requires migration. Seasonal groups do exist, but they have not yet been assigned to LRS FTSegments. These have not yet been defined. Programs will need to be written to create these. These programs will be described below in the Major Operations Section of the report. To do so, however, requires a review of how location is presently handled by the DCS for reporting elements (AADT segments and seasonal group segments). This review will be presented in the following section.

5.3 Location Determination and Specification

All data entered into the LRS database must be translated onto the LRS network in a particular position. For TSU this process involves determining the position at which a point collection element should be placed on the network or the extent over which a segment reporting element is placed on the network. That is, reporting data is "applied" over some segment of road which is itself a collection of road segments.

Table 5.1: AADT Data Reporting

STA	Road Segment
A	1
A	2
A	3
A	4
A	5
A	6
A	7
A	8

Table 5.1 illustrates a database table that indicates the location of a reported AADT for count station A. Figure 5.1 illustrates that the count station itself has a point location on the network. The figure also shows that the AADT value derived from that count station spans across the specified 8 road segments shown. It should also be noted that Road Segments 1 to 6 belong to one FTSegment and Road Segments 7 and 8 are located on another FTSegment.

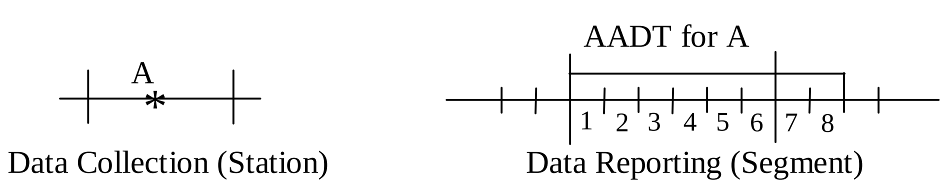

Figure 5.1: Data Collection and Reporting

LARS and ADM are for maintaining the LRS network with access by the GIS Unit only. LARS supports the entry of locational data into the LRS database. The ADM tool references this data to the appropriate FTSegments and Road Segments. However, these tolls are not used for non-LRS features and data.

5.4 Data Manipulation

After TSU data has been added to the LRS database, users will require the ability to enter new data, to delete existing data, and to change, modify, or correct existing data. The user interface tool will be developed to support these basic relational database data manipulation operations.

There are two approaches to the user interface for the LRS. The first is a purely tabular approach, allowing direct access to the LRS database using a set of database access tools. Such an approach would be based on the development and use of a set of data entry and editing forms (utilizing drop down menus) that constitute the user interface. This type of functionality is provided by LARS, which presently allows network to be entered into the LRS database. LARS could in the future be extended to allow attribute data to be entered into the LRS.

The second approach incorporates a graphical component into the user interface, providing point and click functionality for finding locations and assigning attribute values. This approach would also use pull down menus to initiate operations and enter data. A key advantage of this approach is that it would provide the perception that AADT is connected to GIS linework in a manner similar to the way it is connected to CAD drawings at present. Given the stated intention of TSU to ultimately to have such a graphical user interface it is recommended this approach be taken.

5.5 Major Operations

A number of important operations must be provided for TSU personnel to effectively utilize the new LRS database. These are discussed in this section.

5.5.1 *Station Location*

A critical functionality for TSU is to enter count station data. There are three primary methods that should be available to TSU for finding count stations. The first of these is via the Station ID. That is, using this identifier should enable TSU personnel to locate count stations, all of their associated publicly available data, as well as their reporting element.

The second method is to identify locations by description. This involves specifying the route on which the count station lies, a nearby intersection, and a direction from that intersection toward the station. This will theoretically enable the technician to be on the same reporting element that previous counts were taken on. The technician at this point may be either close to or distant from the actual point location of previous counts. In either case the technician is on the correct reporting element and thus they will take a valid count for this station.

Finally in the future, count station locations will be field referenced using GPS coordinates and location counts will be tied to those coordinates. To be entered into either the GIS or the LRS database, a program is needed to translate station coordinates to positions on the LRS network.

First, the database contains a set of coordinates that represent count station locations from the previous year. It also contains station IDs. When new data for the current year arrives, the station coordinates differ from previous station coordinates. The previous coordinates identify the reporting segment on which the count should have been taken. If the new coordinates fall anywhere on this same reporting segment, the count location is valid for that segment. If the new coordinates do not fall on the expected reporting segment, the count was taken at the wrong place and the location of the count is invalid. Thus, new data is available for a new reporting segment (the actual location at which the new count was taken) but no data is available for the original reporting segment.

To determine how close a station is to its coordinates from the previous year requires a tolerance. Specifying a tolerance will enable a proximity check (matching) to be made that will support two things. First, the distance between the new point and the previous one can be determined. Second, the FTSegment on which one or both of the points lie can be determined.

The TSU needs a program to store attribute data using coordinate data referencing. The program will also find matching coordinates. Finally, it will identify road segments on which coordinates lie and identify all intervening road segments. This functionality is needed by TSU. The program will also identify stations that are not in the correct location. That is, those which do not lie on the correct reporting segment. TSU can then determine what must be done for these. Essentially if a station is in a new location then there is a valid count for the new location but there is no count for the old location. Figures 5.2 to 5.5 illustrate these scenarios and are discussed in the following paragraphs.

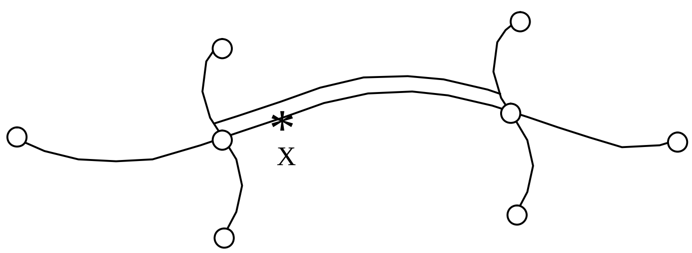

Figure 5.2: Station Location Matching Illustration

Figure 5.2 shows a situation where we have a count station (X) identified on an FTSegment. Assume that this count was taken in 2003. Clearly it lies on the middle FTSegment toward the left intersecting road. Also assume that the reporting element for this station matches the FTSegment in this case and is shown by the double line. Thus, the double line in Figure 5.2 represents the reporting element for this station.

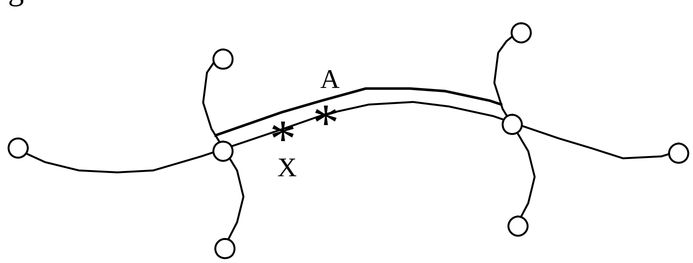

Figure 5.3: Close Matching of Two Counts

Figure 5.3 illustrates the concept of obtaining a close match of two count locations from two different years. The original count location from 2003 is shown as point X. The new location from 2005 is shown as point A. These two points are "close." That is, they are within an acceptable tolerance of each other. Thus, the 2005 count is deemed to have been taken in the same location as the 2003 count.

Figure 5.4 illustrates another form of match between two count station locations. In Figure 5.4 the original location from 2003 is again shown as the same point X and the new location from 2005 is shown as point A. But, these two points are "distant." That is, they are not within the required tolerance of each other. Thus, they were not taken in the same location. However, they both lie on the same reporting element. Therefore, the 2005 count, while taken in a different location from the 2003 count, is valid for this reporting segment.

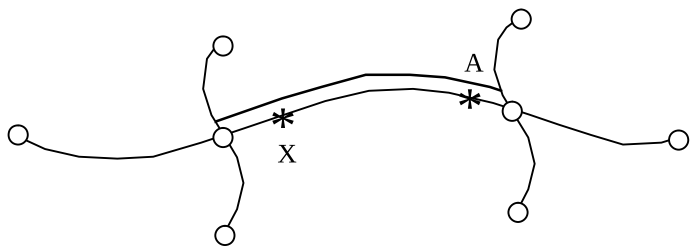

Figure 5.4: Correct But Distant Matching of Two Counts

A different scenario is illustrated in Figure 5.5. Here the new 2005 count A is even further "distant" from the original 2003 count X, so much so that it is no longer on the original reporting segment. Thus, point A is an entirely new count on an entirely new segment. As a result, no count exists for the original reporting element originally defined by the 2003 point X count.

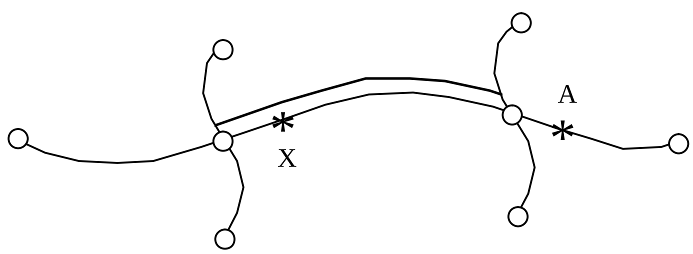

Figure 5.5: No Matching of Two Counts

Each of these different scenarios must be properly identified and handled in the TSU software.

In summary the following list indicates some of the functionality needed by TSU that is directly related to count stations and their location.

- Find stations based on station ID
- Find stations based on coordinates
- Find stations based on description

- Determine if new coordinates lie on the same FTSegment as prior coordinates
- Identify locations for which no counts were taken
- Identify locations where new counts were taken

Note that when referring to description we normally mean a posted route location specification.

5.5.2 ***Reporting Segment Definition***

A program must be developed that will generate reporting segments for each of the six TS segment data items. This could be written as one program or as six different programs, but most likely it will be written as two. One program would handle volumes and one program would handle seasonality.

The programs will share some of the same functional operations. In particular, identifying boundary points and FTSegments are common operations. The interface can be graphical for boundary point and/or FTSegment specification or it can be menu driven using the LRS offset referencing method. (Using a county, route, milepost reference would be possible but is not recommended.) In either case the definitions of the extent of the segments must be stored in the Oracle database. To display these, the GIS accesses the Oracle tables and simply associates that data with the correct graphical segments.

However, the logic of choosing the limits of a segment will differ, to varying degrees between reporting data types. To correctly capture this logic, TSU will develop this critical program(s) or IT function or it will outsource the development. The program will require both database and GIS interface components. Unfortunately, none of the reporting segments can be automatically generated; they need to be manually identified. That is, the program must allow TSU personnel to specify the boundaries of reporting segments based on their analysis. A variety of automated inputs will be used to support the manual process. These inputs will be graphical in nature (derived from the GIS) and will require a graphical user interface to support their use when generating segments. These automated inputs will be ArcGIS based. How this is done will be discussed in the following two subsections.

It should also be noted that identifying reporting segments is an operation that is needed for both the published LRS tables and the unpublished TSU working tables. In all cases there are two sets of tables – published and unpublished.

5.5.2.1 *Volumes*

It is expected that this program will allow a technician to manually generate the reporting segments for volumes. These segments are then considered to be semi-permanent. However, another program needs to be written to allow editing and modification of reporting segments. This is a functionality needed by many users. This second program needs to be written by the GIS Unit because its utility is universal.

The identification of the location of a volume reporting element will be determined as noted above. The key concept is that ultimately there is a 1:1 relationship between the count station and the volume reporting element. Presently there may be redundant stations, but these will be identified and eliminated over time. Using other data available through GIS, for each count station there must be a corresponding volume reporting element. Its boundaries are defined as noted above. The boundaries are determined by the technician and entered using the program. The technician determines the location of those boundaries by visual inspection, by analysis, by using other data available through GIS, and by utilizing other data that is available through the LRS such as the number of lanes.

In addition to identifying a count station and defining its reporting segment other operations will be required. These necessitate an ability to edit existing segments. It will be necessary to allow the technician to reconfigure segments. This means changing their boundaries. Additionally, it may be necessary to combine adjacent segments or to split an existing segment into two or more other segments. Thus, because segments must be defined by technicians, as opposed to being generated automatically, this tool is primarily an editing tool.

In summary, the following functionality is needed for volume reporting elements.

- Create new segments
    - Identify a station
    - Define a reporting segment
    - Assign a station ID to the segment containing the station
- Edit existing segments
    - Reconfigure segments
    - Combine segments
    - Split segments

It should be noted for volumes that all primary roads in the state are counted. Thus, there should be a volume assigned to all segments of all primary roads. Secondary roads, however, are different. Because there are so many of them counts for these roads are merely sampled. Thus, volumes would not exist for many secondary road segments.

5.5.2.2 *Seasonality*

1. Continuous volume counts are analyzed to generate a seasonal profile for the year for each station.
2. A statistical analysis identifies which stations have common seasonal patterns that can be used to generate a group.
3. A descriptive analysis identifies what characteristics (attributes) of the highways at each station within a group are common.
4. Statistics such as seasonal factors are generated for the group using data from all stations.
5. The descriptive characteristics of the highway at short-term traffic monitoring stations are compared to the descriptive characteristics of each group to see which group the station matches best. It is assumed that because they have the same descriptive characteristics, they have the same seasonal pattern, and raw data can be factored using the group's seasonal factors. This is recorded this in a TSU inventory table as ATRGroup.

Steps 1 through 4 constitute a statistical analysis process performed independently and are not addressed in this document. Step 5 describes what is done by TSU today. The TSU goal is to change Step 5 to compare entire highway segment characteristics (attributes) instead of just at the traffic monitoring stations. Once this is done for the entire highway system, it is possible to factor any traffic count collected anywhere on the system. When a new short-term traffic count station is referenced in the LRS, it's just a lookup routine to determine what group has the appropriate seasonal factors.

The desired groupings are for seasonal patterns only and the analysis of the seasonal patterns is independent of the groupings. The desired process being set up is to look at highway segment attributes as compared to seasonal group attributes and decide which one is the best match. The result is the assignment of the group ID to the highway segment.

5.5.4 *Data Editing*

It is expected that all LRS database attribute value editing will be done using a new tool that has already been described and planned for development. New and additional recommendations could be made for future extensions to the tool based on its use by TSU and additional functionality needs of TSU, if any. These needs remain to be defined pending full implementation of the tool and its use by TSU personnel.

5.5.5 *Publishing*

Publishing data means to make it available to the general public through the LRS. A program will need to be written to do so. That program would take the TSU working copies of the data and place them into the LRS as a published table. This is expected to be done on an annual basis. However, it is possible that it could be done more often, depending on the needs of users and the ability of the LRS to sustain such updates.

It should be noted that the data editing tool should be able to operate on both the working and the published tables.

5.6 AADT

Effectively and accurately publishing AADT data is an important State and public service. Essentially this entails processing data from a count station to determine a value for AADT and then indicating a portion of the highway network over which that value applies. This was described and illustrated above in Section 5.3 entitled “Location Determination and Specification.” While this is true for all reporting elements, AADT is particularly important, especially for TSU.

5.6.1 *Ownership*

Presently, AADT reporting elements are determined by the RIIS. Upon implementation of TSU data in the LRS database, this activity will be transferred to TSU. Thus, TSU will be the Unit defining the reporting elements of the AADTs. To do so, a new program will need to be written to define the AADT locations and permit their modification. This was first mentioned in Section 5.5.2 above entitled “Reporting Segment Definition.” There, it was indicated that both a definition program and a modification program would be required to support this TSU activity.

5.6.2 *Graphical User Interface*

Some of the characteristics of the program would be as follows. The technician would ideally utilize a map displaying count station locations and other GIS based data resources. The technician would identify a particular count station by selecting one of those displayed. Note that this initial step does not so far include defining the extent of the AADT reporting element. The next step would be to separately specify the extent of the reporting element.

A new tool that is yet to be developed for TSU will be used for data entry and editing functions. This tool should provide the graphical user interface desired by TSU as well as the ability to enter and edit attributes.

5.6.3 ***Business Process Enhancement***

One new aspect of the definition of the extent of the reporting segment is the ability of TSU to access the number of lanes present on any given segment. This is a perfect example of how the LRS database will enhance the business processes of various NCDOT Units. In the case of TSU, the LRS database will make available the number of lanes to TSU personnel, and this will enable them to perform analysis to better determine and assign AADT extent. This necessary extension will improve the process of specifying ever more accurate AADT values over the NCDOT State maintained road network. In other words, by using the LRS database TSU personnel have access to data that makes a positive difference in the quality of their work. This data was not previously readily available. But with it, the extent of the AADT can be more accurately determined. This constitutes a business process improvement.

5.6.4 ***How AADT is Assigned***

At the present time, AADT values are not directly assigned to Universe File records. Instead, the count station identifier is assigned to a Universe File record. The assignment is made as follows. Any Universe record on which a count station falls is assigned that count station. If that record is later subdivided, all of its subdivisions are assigned that same count station.

If records exist that have no count stations within their borders, they are assigned the count station closest to them. Thus, most every record in the Universe File is assigned a count station. This process is updated annually.

In the future, TSU would like to specify count station location using GPS coordinates as was discussed in Section 5.5.1 entitled “Station Location.”

5.7 Data Access by the General Public

Access to TSU data will be made available to TSU personnel, to other NCDOT units, to Division engineers, and to the general public. The general public includes restaurant owners, builders, homeowners, local governments, the media, and others.

Making data available outside of TSU is referred to as publishing data. TSU initially expects to do so in a manner similar to that in which it is currently done – annually. That is, a snapshot of the data is to be made publicly available at a specific point in time while working copies of the data continue to evolve. The work of the TSU is dynamic – it is continuously evolving, as is the data.

The items to be published are as follows.

- Collection data
  - Count station ID
  - Count station location
  - AADT value at the station
  - Coordinates
- Reporting data
  - Count station ID
  - Count station location
  - AADT value at the station
  - AADT value on the reporting segment
  - Reporting segment location

Two “rules” to keep in mind are that there must be a station on every reporting segment and there never would be more than one station on a segment. These rules apply for AADT and class data. They do not apply to seasonality.

To make this data available to the general public, a translator will be required. The TSU has determined that an offset referencing system is the most appropriate general public referencing system, and that conversion software should make TSU data available in this format. A tool to provide this functionality needs to be defined as does it functional specification. At minimum it must provide the following:

- Conversion to an offset referencing system
- A standard set of queries to be executed by public service customers
- User friendly interface screens for the public
- User friendly presentation formats

TSU must decide what data should be made publicly available, what the public actually needs to have, and the format in which the information should be delivered. The general public will commonly need specific kinds and types of data and this need can be determined, specified, and standardized ahead of time. Once these data needs are defined, software can be written to meet them. To do so will require the following:

- Determine the inputs the customer will need to provide
- Determine the format and layout for the data entry screen
- Determine the outputs that will be provided back to the customer
- Determine the format layout for the data display screen

The display screen can present data to the customer in two ways as tabular data or a map. It would also be possible to combine these presentation forms. What is required is a decision on which option to choose and an implementation to deliver that choice. It is expected that the overall general public interface should be map based and it should be supported by drop down menus.

Functionality should be based on the most common needs. The tool to be developed cannot arbitrarily accommodate absolutely any kind of information request. This must be remembered in specifying and developing it and then, subsequently, in using it. Standardization, therefore, should be a high priority goal.

Finally, emphasis should be placed on maximizing user friendliness. One key to the success of the system is its ability to easily meet a customer's data need. This is one area where impediments are particularly troublesome. Access to TSU through the World Wide Web is discussed in Section 8.3. It should be noted that this too is a candidate delivery vehicle for TSU data as well as a tool that TSU can use for data collection.

ArcIMS is seen by TSU as the most “public friendly” web tool for making its data readily available on the web. Ideally that data should be interactively available and should be able to be queried and searched. Such functionality would be far superior to simply viewing PDF files is as currently done.

6.0 DATABASE SERVER ORGANIZATION

NCDOT database servers are enterprise class servers capable of meeting the data processing needs of large users. The TSU is one of those users that provides NCDOT with mission critical data.

One question is whether or not it would be appropriate for TSU to have a dedicated server. While this would be ideal, it may not be necessary initially. First, NCDOT database servers possess the speed and capacity to meet the needs of a number of users. If TSU is the first Unit to provide data to be included in the new LRS database, the load placed on the server will be acceptable initially.

Second, for reasons of data sharing, TSU data should be physically co-located with attribute data of the RIIS and other users. Greater physical proximity of TSU data to other data will result in faster data queries and operations.

It is expected that the GIS Unit will develop a plan for the organization of the LRS database on both development and production servers. That plan will include procedures for loading, manipulating, moving, and testing data. It will also include a specification of an appropriate set of security measures for the data. Finally, it will include a definition of who has access to the data and which data is made available to which users including the public. The LRS server is expected to be partitioned. The database schema has been designed in such a way that the database itself is partitioned into the following primary groupings.

FTSegments – (Topology)
RoadSegments – (Topology)
Posted Routes
Jurisdictions
Attributes

The discussion above focused on that data to be directly included in the LRS database and to be made publicly available. However there are numerous other datasets and databases TSU needs server support for. It is highly desired that these datasets and databases be transferred to the same server as TSU attribute data. These datasets will be used for analysis and could benefit from co-location with TSU LRS data.

It is important for Traffic Surveys that the concept of "working" tables be implemented. These are tables that only TSU would access and would work with and they would not be published. "Public" tables are those which the public has access to. The data in published tables does not change except to correct errors that are discovered. Working tables, on the other hand, evolve continuously as new data values are generated.

Published tables are obtained by taking a snapshot of the working tables. Presently this is done on an annual basis and it is proposed that this continue annually. It should be noted that TSU maintains numerous data files which are not available to the general public but that still must be stored on the server. As a result, it is expected that there will be certain published LRS tables that are available for the general public and working tables that will be available privately only to TSU personnel. The public data will be updated annually. The private data will be updated constantly. The process of publishing will be one of moving a copy of the private data to the public server workspace. Thus, the published data should never be more than a year old. a question remains to be solved as to how customers are going to be notified of the changes.

7.0 IMPLEMENTATION

The LRS database has been designed. The spatial aspect of the database, i.e., the network model, has been implemented. The next step in implementation is for the GIS Unit to load the RIIS road attribute data. This activity is expected to be completed by mid 2007. If it were ready, the TSU LRS database attribute data could then be loaded.

The elements required by TSU to migrate data to the LRS database have been identified elsewhere in this report. Those elements have been further tagged as to whether they would be developed or provided by the GIS Unit or by TSU. The need for server space has been identified. The need for integration with GIS is currently being met through the development of an LRS database GIS tool set. Basic commercial programs including ArcGIS and Oracle are available. ADM and LARS have been developed to meet the spatial data needs of the state highway network. LARS extensions are planned to support the needs of attribute data. The additional programs needed for data migration, reporting element extent definition, and data display and delivery to customers have been identified.

An implementation schedule should be developed for this effort. The GIS Unit currently has a schedule for its planned development activities. TSU should enter into discussions with the GIS Unit to articulate and enumerate the tools to be developed and to determine the unit responsible for development, for the cost, and for the schedule. This interaction can serve as a template for the integration of other customers into the GIS Unit database in the future.

8.0 ROLES AND RESPONSIBILITIES

The GIS Unit of the NCDOT IT Branch is providing the LRS framework for the work proposed here. This includes the database schema structure and the linear referencing model. The GIS Unit also is expected to provide the server on which the data will be stored and the middleware required to access it. They will provide all necessary database functionality for data population, maintenance, and management.

The GIS Unit is expected to provide a standard database user interface to support the following needs.

Table 8.1: Functionality for LRS Users

Functionality	User
Data Query	Outside (public) Users Other NCDOT Units TSU Personnel
Data Entry	TSU Personnel
Data Editing	TSU Personnel
Program Interface	TSU Personnel

It should be noted that the functions identified above are database interface tools. Still, as discussed in this report, numerous spatial capabilities will also need to be integrated into these tools.

8.1 LRS

The RIIS is expected to maintain what is referred to as the LRS database. The LRS database is an Oracle database that captures the topology and geometry of the State maintained highway network. The topology of the network is how it is connected together. The geometry of the network is its physical size, usually measured in linear miles. Note that the Oracle model of topology and geometry is not the same as the ArcGIS representation of these same items.

The RIIS maintains the Oracle network as well as about 92 road inventory attributes. By having one NCDOT organizational unit maintain the topology and geometry of the network, this unnecessary burden is removed from other units. Thus, TSU need only maintain its raw attribute data and can feel confident that the network on which that data is being placed meets a good quality standard and is under the auspices of a single authority. If discrepancies do arise, a single unit is in charge. Standardization can easily be maintained.

In light of these observations, TSU is relying on the GIS Unit for the existence and maintenance of the LRS Oracle database to provide a standard, State maintained highway network. Furthermore, it is relying on the GIS Unit to provide the software user interface to enter, modify, and delete attribute data. It is also relying on the existence of a set of tools to load new data into the LRS database.

8.2 GIS

It is expected that an additional set of tools for graphical data entry and editing via the GIS will be made available. The form of these tools is yet to be defined. However, it is expected that GIS would provide a display of the topology and geometry of the highway network, while simultaneously displaying any desired LRS attributes or combination of attributes. The choice of attributes would be made via drop down menus and would be displayed over the map. (In addition, standard displays of predetermined attributes could be preprogrammed.)

The functionality provided by the GIS will initially be limited to display. A second level of functionality will be the determination of locations in support of data entry and editing. Functions that will be required for users are as follow.

- Display data
- Find geographic locations
  - Map point and click
  - Drop down menu selection
- Respond to queries
- Enable data entry
- Enable data query
- Enable data display
- Support data storage and archiving

This means that ArcMap and Oracle will simultaneously be running and the monitor will display both. In one scenario, for data entry or editing, locations will be determined by pointing on the map and clicking to identify a point on the network or double-clicking to identify a segment. Either of these scenarios can be used to identify boundaries for new data.

The alternative to using a map for identifying locations is to do so using drop down menus or forms. The GIS Unit should provide options for doing so. The TSU requirement would be for an LRS offset referencing specification. That is, the user would select a drop down menu or standard form specifically designed and provided to support LRS offset referencing location selection. That drop down menu would then enable the user to enter intersections, offsets, directions, and routes to access a specific geographic location.

The alternative to using the graphical GIS interface is to query the database directly. This option is not recommended. It is expected that the user interface provided by the GIS Unit would support the basic needs of all LRS database users.

A final need for TSU that must be provided by the GIS Unit is conversion software to support the offset referencing method for TSU data customers.

8.3 World Wide Web

It is expected that ultimately data would be made more broadly available using the World Wide Web. The utility of utilizing the web for data delivery, for data collection, and more broadly as a business tool, is well established. When the LRS database is made available to customers via the web, the data of all units participating in the LRS will be able to be included.

The GIS Unit will be undertaking such an initiative in the future. Presently, some amount of data is available on the web through ArcIMS tool. This tool's capabilities will be extended in the future and, like LARS, this tool will be a vehicle for customer interaction for all LRS database attributes via the web.

One particularly attractive advantage of the web for TSU is the fact that, through using it, geographically dispersed divisions, districts, and county offices can all be linked together. This will open tremendous opportunities for data sharing, data collection, and business process improvement.

For example, instead of transferring traffic counts via paper forms, TSU will be able to electronically transfer data. It may even be the case that some carefully monitored attribute values could be entered remotely by field personnel instead of centrally by office personnel. This would free up those in the office to focus more on data quality issues and improvement rather than on data entry. A further step would be to execute centralized planning and scheduling and deliver those schedules to field personnel via the web. This represents an evolution from the back and forth movement of data to the transference of numerous work schedules and activities, documents, maps, and forms. The opportunities for business process improvements via the web abound.

9.0 CONCLUSIONS

Our goal is to make information reliable, relevant, accessible, and affordable, and this requires careful analysis of how we identify, collect, store, retrieve, manage, analyze, communicate, and present our data. The NCDOT TSU database design demonstrates that a carefully planned migration path to an interoperable database design which makes use of a uniform LRS (and the integrated use of GIS and DB tools) can lead to the advantages enumerated earlier.

Based on the work completed to date, a number of conclusions, or "next steps," were reached by TSU. One is that the Unit will formalize and accept the preliminary database design for immediate implementation. If modifications are deemed necessary as the implementation evolves, these would be made. But the advantages and benefits merit immediate implementation.

It is recommended that TSU develop an implementation plan sequencing the order of database table design, application development, and maintenance interface development with appropriate estimates of time and manpower requirements. The plan should include: creation, capture, or entry of data; organization of data; modifications or changes to data; storage of data; as well as the processing or use of such data for reviews and checks, planning, calculation and analysis, design, reporting, distribution, or any other necessary function. All such activities should be negotiated and coordinated with the GIS Unit.

All work should be based on sound principles of transportation spatial data theory. Using the linear referencing system will provide benefits, noted earlier, which have been avidly sought by users. Still, it must be understood that the path to full implementation is long.

10.0 PRESENTATION SLIDES