Project Report for

"Directions in Transportation Data Management"

prepared for

Delaware Transportation Institute

And

The State of Delaware Department of Transportation

by

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INTRODUCTION: FOCUS OF THE RESEARCH

This project was initiated and funded as part of the Delaware Transportation Institute 1998 Program as a response to concerns about what were the current data management issues facing the State of Delaware Department of Transportation (DelDOT) Division of Planning, and what could be done to improve information systems. It was expected that improvements could be made that would allow better analysis capabilities and access to information resources. Also, that through better integration, more efficient and responsive systems could be developed to meet the many challenges of comprehensive transportation planning.

As a first priority, the Center for Applied Demography and Survey Research (CADSR) was instructed to do an internal analysis to identify information management issues and needs within the Division of Planning. An inventory of activities that use or produce data was conducted. Division personnel were interviewed to determine their information needs and discuss issues they felt were important to address. Activities were studied to determine the extent that there were inconsistencies in data sets, duplication of effort, and weaknesses or gaps in the information base.

The interviews revealed that Division of Planning data maintenance and production activities that have been ongoing responsibilities for many years, such as the maintenance of the Road Inventory and Accident databases, and the preparation of the yearly Highway Performance Monitoring Reports, were stable and efficient. When the needs and uses of information were examined for activities more directly involved with planning and project development, Division of Planning personnel indicated that their work would be supported by a greater ability to more efficiently find, access, relate, and make sense of information from a variety of internal and external sources.

This report discusses the status of information systems in the Division of Planning, examines issues concerning better access and usability of information, and poses initiatives for near term improvement. An effort was made to describe information needs of the Division, to explain why it is important for planners to address data management issues and have the capability to process and analyze information. Perhaps more than any other DelDOT Division, the Division of Planning faces the broadest information needs, and requires the efficient and effective use of information from the largest number of sources. Centralized versus distributed systems, operational versus

informational uses of information, advances in information technology, standards, and data integration are topics that are discussed in relation to possible solutions. A number of activities that were conducted in this project are discussed and include:

- A detailed study of data in use at the Division of Planning.
- Collection and processing of data to demonstrate how a comprehensive and integrated transportation information could be built.
- Examination of current and past efforts conducted by DelDOT that are relevant to addressing issues.
- A study of how transportation facilities are identified in DelDOT data sets.
- An investigation into how DelDOT's linear referencing system (route-milepoint) is implemented.
- A review of literature describing data management initiatives conducted by other transportation agencies.
- A review of the Division of Planning Intranet, and a demonstration of methods to document and find data using local area networks.
- Identification of standards and modern information technologies that support integration and optimal use of information resources.
- Preparation of a list of near term initiatives for the improvement of information systems.

The project was focused primarily on the specific needs of the Division of Planning, but the findings and recommendations are relevant to any transportation group involved in managing and using information from a number of sources.

CHAPTER 1

THE DIVISION OF PLANNING AND INFORMATION NEEDS

Introduction

This chapter begins the discussion of information systems and data management issues in the Division of Planning by first explaining the organizational structure and the types of activities that are the responsibility of the group. Information uses and needs are discussed to demonstrate the importance of information systems to the success of the Division. The concepts of operational versus informational systems are introduced as a way of addressing the types of information needs that exist, and as a way of determining appropriate solutions. This chapter seeks to identify the ways in which the Division of Planning utilizes data and data analysis in carrying out its functions. Through this identification it becomes apparent that the Division of Planning creates, analyzes, utilizes, and maintains a wide range of data as is vital to meeting its responsibilities.

The Division of Planning Organization

The Division of Planning is organized into five sections; Transportation Policy and Research, Intermodal Systems, Project Development, Administrative Unit, and Information Systems Support (working with the Administrative Unit) as outlined in the organizational chart on the following page. A brief description of the responsibilities of those sections studied is provided below with particular emphasis on those activities involved with information technology. More detail about issues and activities is presented in the next chapter.

Transportation Policy and Research

Major responsibilities of the Transportation Policy and Research section include; system planning, policy development, transportation research and education, study and promotion of projects, development of long range plans, and fulfillment of mandatory reporting to comply with Federal regulatory requirements. These responsibilities require the ability to effectively present a variety of information about the current status of the system, currently planned projects, and proposed

projects under study. The section's information resources include an advanced GIS capability to study and present information, a newly updated travel demand forecasting system, and a reliable local area network of powerful personal computers and peripherals. The staff is literate and skilled in the use of computers and features of the network.

Figure 1, An organizational outline of the DelDOT Division of Planning, Dec 1998

- **Transportation and Research Section**
  - System Planning
    - Highway Performance Monitoring System
    - Travel Demand Forecasting
    - Planning GIS
  - Policy Development
  - Local Government Assistance / T-Squared
  - Project Pipeline

- **Intermodal Programs Section**
  - Aeronautics
  - Transit
  - Transportation Data
    - Accident Studies
    - Data Collectiion / Road Inventory
    - GIS Mapping

- **Project Development Section**
  - Zoning Review
  - Corridor Studies
  - Environmental Studies
  - Transportation Safety

- **Administration Section**

- **Information Systems Support Section**

The Intermodal Programs Section

As the name implies, the Intermodal Programs Section addresses planning, policies, and regulations for all modes of travel, including those for transit and aeronautics. Representatives act as liaisons to the public and to a range of agencies on issues concerning transit, aeronautics, motor carriers, freight movement, commercial vehicle operations, and employer travel demand management planning. The section is focused as well with the analysis of how multiple modes of travel relate and work together to satisfy demands on the transportation system.

A major part of the section's duties is the development and maintenance of transportation system data. The Transportation Data Group within the Intermodal Programs Section maintains and updates the Road Inventory, the Accident Database, and the digitally produced DelDOT Official Road Maps, as well as preparation of a number of specialized cartographically oriented mapping products such as the Road Atlas, Aeronautics Map, and the Federal Functional Classification Maps. Fulfilling these operations involves nearly a dozen staff and relies heavily on the effective use of information systems.

The Project Development Section

The Project Development Section is responsible for traffic impact studies and corridor studies, environmental impact studies, land use and zoning review, and the Highway Safety Improvement Program (HSIP). A wide range of data is typically used in these studies. Accuracy is very important and often they manage or coordinate studies that need to obtain detailed project level information. The section is DelDOT's contact for many of the studies done by outside consultants, engineers, and surveyors. The Project Development Section meets the initial needs by finding and compiling data from a wide number of sources, and by providing contacts and guidance where data and information processing will be handled by outside groups. The information the Project Development Section utilizes takes many forms; hard copy reports and files, maps and drawings, GIS data, databases, and data/report products of various computer software.

The Information Systems Support Section

The Information Systems Support Section works with the Administrative Unit and handles configuration, installation, maintenance, and support of the local area network, servers, personal computers, e-mail, operating systems, and application software. The section is currently staffed by one person, who over the years has supported the development of an efficient, cost effective, and reliable system.

Administrative Unit

Administrative information systems such as those dealing with personnel records and accounting, were not studied and no one in the Administrative Unit was interviewed. Information systems to support administrative needs are crucial to the Department of Transportation and require great attention and resources. The focus of this project however was on systems more related to project management and development, research, planning, and policy.

Activities that were addressed

The many information intensive activities that are conducted within the Division of Planning were reviewed as part of this study and are listed in Table 1. Most of these activities/programs occur in all DOT's and their names give an idea of what they are about. Each of these are discussed in the final portion of the next chapter focusing on results of interviews.

Table 1, Information intensive activities that were studied by each DelDOT section

Transportation Policy & Research:

Systems Planning
Travel Demand Forecasting
Geographic Information System Applications
Public Presentations
Project Pipeline
Development of Long RangeTransportation Plans and Reports
Highway Performance Monitoring System

Development of the Planning Intranet
Air Quality Conformity

Table 1 (continued)

Intermodal Systems:

Transit Planning
Preparation of the official Delaware road maps
Maintenance of the Road Inventory
Maintenance of the Accident Database
Aeronautics
Commercial Vehicle Operations
Freight Movement

Project Development:

Environmental studies
Bike and Pedestrian Coordination
Corridor Studies
Zoning Review
Archeological Review and Documentation
Project Management
Highway Safety Program
Traffic Impact Studies

Information Uses and Needs

Division of Planning responsibilities are varied but in most cases are related to the identification, evaluation, advancement, and/or management of projects. "Projects" are the primary focus of the Division. The concept of planning or implementing a transportation improvement project automatically suggests the need to address impacts and relationships of the project to existing or future conditions. The public expects (and Federal and State laws in turn require) transportation agencies to consider congestion, mobility, optimization of existing facilities, environmental impacts, and quality of life impacts. Planning must address all modes of travel, with a mandate to better understand travel markets and their relationship to transportation facilities. The evaluation of possible, proposed, or planned transportation improvements must be based on well-defined, quantitative analysis procedures. These increasing information demands are best served by flexible and diverse systems that provide access to data on a range of topics, and that are readily available and usable to those who need them.

The Division's responsibilities include heavy demands to present findings, status, and goals of projects and policies. Presentations can include a variety of data summaries, charts, tables, reports, analysis, and maps to both internal and external audiences. Internal audiences include DelDOT staff and management, senior management, and consultants. External groups include State, county, and local planners, elected officials, community groups, and civic associations. The Division also works closely with the two Metropolitan Planning Organizations (MPO's), their staffs, technical groups, and councils.

Planning outreach introduces a dialog that often generates more questions and requests. Information must be understood to address various viewpoints. Answering sometimes unpredictable questions about the transportation system and impacts of projects, demands internal information systems capabilities that can analyze and present information quickly and clearly, and again, to a wide range of audiences.

A useful way of understanding information processes in the division is to group them into *operational* or *informational* systems. *Operational* systems serve more clerical and transactional operations or decisions on a day-to-day basis, that involve detailed data under constant change and are focused on the current needs and conditions. Operational systems serve more defined functions such as the maintenance of a particular database, the generation of a standard report, or the performance of a calculation. They are typically dispersed throughout an organization, involving quickly changing and diverse types of data, and generally lack historical data*. Most operational processes in the Division of Planning have been conducted for many years and are performed according to rules and procedures unique to those applications. Examples of operational processes in the Division of Planning are the maintenance of the Accident Database and statistics, the maintenance and update of the Road Inventory, and the preparation of travel demand forecasts. Many information systems applications in other DelDOT sections are operational such as General Accounting, Construction Estimate/Cost Tracking, and Materials and Supplies Management. Historically, the focus of information management at DelDOT and other

- From U.S. Department of Transportation, Federal Highways Administration, "Integrated Transportation Information Systems (IT IS) Workshop, prepared by GIS Trans LTD.

large organizations has best addressed operational systems that have relatively well defined data inputs and outputs, and specific functions.

In contrast, *informational* processes have a more long term managerial and /or analytical focus, often toward the goal of identifying a trend, developing a correlation, or testing a hypothesis. Data in informational systems is generally summary data that does not change frequently and includes historical data. Processing is more heuristic rather than repetitive. Informational use of

Table 2. Examples of operational processes in the Division of Planning

Maintenance of the Accident Database
Maintenance and update of the Road Inventory
Highway Performance Monitoring System
Preparation of the DelDOT Road Maps
Highway Safety Improvement Program
Project Tracking System

data often requires that information from many sources be related. An example of an informational process would be an analysis of transit ridership in relation to demographics around transit stops, or to answer questions such as; "What are the top 30 highway safety improvements that we should fund?" or "Is a particular enhancement to the transportation system approprate?", or "How can we best address air quality?" or "What is the relationship between land use and the performance of the transportation system?" Informational oriented processes require accurate, integrated data, easy access from a variety of sources, and tools to analyze the data.

Table 3. Examples of informational processes in the Division of Planning

Transit Planning
Preparing Presentations for Public Workshops
Environmental studies
Transportation System enhancements
Corridor studies
Highway Safety Program
Project Management
Preparing models for travel demand forecasting
Bike and Pedestrian Coordination

Activities most in need of information system improvements in the Division of Planning are those that are informational uses of data. Informational and presentation needs over the last six years appear to have been the driving force behind the Division's continued development of information systems and why they have taken advantage of technological advances. The acquisition of a Windows-based, thematic GIS, the local area network, the Planning Intranet, and the distributed personal computer capabilities in the Division of Planning have all been in response to the day to day informational demands of finding, accessing, analyzing, and presenting information as a part of the Division's mission. The shift from operational to informational systems, and from centralized to distributed systems, has certainly been encouraged by the availability and affordability of new computer technologies, but also it coincides with, and supports the demands for more comprehensive, informed, and multi-modal approaches to planning.

The Division of Planning has a mix of operational and informational systems. Some applications involve operational as well as informational uses of data. For instance, the preparation of travel demand forecasts involves the repetitive application of procedures in an operational process of allocating trips and assigning them to the transportation network, but the selection of appropriate models and the evaluation of results is informational. As another example, the maintenance and update of the Road Inventory is operational but the preparation of summary statistics from the data is informational.

The distinction between operational or informational is useful in discussing issues and solutions. As it turns out, many of the issues, and the activities most in need of information system improvements in the Division of Planning are those that are informational uses of data. The more operational activities such as the maintenance of databases and standard reports are currently being performed efficiently and satisfactorily.

Duties in regards to information systems

The Division of Planning's needs are our broad in the sense that they use and relate information from a variety of sources. However, with respect to any particular piece of information the data processing or application development is not complex. The Division does not create database

systems, but rather data tables. Planning is generally focused on analysis, and much of the analysis can now be accomplished by available personal computer based software, GIS, or database query utilities. The complexity to be addressed is often less in application development and more on how information can be structured, accessed, and related to support planning, projects, studies, and activities.

The more operational and complex that information systems are, and the more integrated with respect to the efforts and management of other divisions, the more likely that those systems should be developed and supported by a more centrally oriented information processing group such as DelDOT Information Management Resources (IRM). For instance one wouldn't want planners altering the corporate accounting system, nor would it be advisable to have planners working independently on massive software programming efforts that could not ultimately be supported by the agency. However, you would want planners to be able to manage, access, analyze, and present information in the most efficient and effective manner, and to be able to provide accurate and timely answers to support projects and policies.

Traditionally, there is an operational approach that first defines very specifically and narrowly what a particular information system application will do, how it supports a specific function of the agency, how important it is, and how it relates to other applications. Questions that could be answered by data resources that are not part of the established applications are considered as special requests that can be submitted to analysts, prioritized, and answered. This corresponds to how DelDOT's Transportation Information Plan (1992) outlines the ways information needs of the agency are to be met*. Operationally, this approach allows for the greatest control and predictability, least redundancy, and the greatest focus of resources. It is less useful in addressing the types of informational needs faced by the Division of Planning that are less easy to predict and design for, and that can require that information be related from a wide variety of internal as well as external sources.

Several recent ambitious data integration and analysis initiatives by DelDOT and other DOT's across the country such as development of data warehouses, user friendly data query systems, and enterprise GIS, have assisted in providing the informational support that planners need. In

Delaware such initiatives promise to offer increased access, quality, and usability of information. Ways need to be found to minimize the amount of planning resources that must be dedicated to the support of information resources. Information support and development is recognized as a significant overhead cost by the Division, and transferring those responsibilities to other groups would be welcome to the extent that the high level of service and functionality currently enjoyed could be maintained.

By necessity there will be some degree of distributed information processing. The Division of Planning must use special systems to meet needs and there are many types of analysis that are time sensitive, that need the continued involvement and direction of a planner, and/or involve quantities of work and attention that are beyond the already very stretched resources of IRM. There is a middle ground between working independently or being totally part of a central processing system. It is suggested that to determine where the responsibility should lie for the development and management of a particular information system is begun by looking at whether the application is operational or informational, how it can be maintained, and then to what extent it involves expertise of planners or information systems specialists.

An overview of information resources

A major change that has occurred over the last ten years is the large number of people who are now familiar with and skilled in the use of computers. Distributed through the ranks of the Division of Planning are numerous planners and engineers who can effectively use word processing, spreadsheet, presentation, and database management software, and regularly use a range of features offered by the network. The Division has at least four skilled GIS users, and others who are familiar with the development of the Intranet. Personnel appreciate the efficiencies that computer systems offer and are not afraid to use them. The success of the Division will greatly be supported by taking advantage of the skills of their personnel.

Staff continue to use main frame applications for project tracking, accounting, and for maintenance of the Road Inventory and Accident databases. Other needs are met by the standard range of Microsoft Office, or other specialized personal computer-based software such as is used

[*] Discussed further in this report on page 51

for travel demand forecasting or air quality monitoring. Division of Planning information systems include a Windows NT network (Microsoft Back Office) of high end personal computers with connections to DelDOTs main frame applications and to shared network resources (peripherals, disk storage, etc.). Personnel expressed satisfaction and confidence in the use of the personal computer based software and other utilities made available to them such as EMAIL, and access to the Intra/Internet. Over the last 2 years, the Division of Planning Intranet has quickly developed into a valuable resource for communication and information among the staff.

The MapInfo and Intergraph based geographical information systems (GIS) in the Division of Planning access a library of digital maps, databases, and cartographic elements, used to respond to the day to day need for data visualization and analysis, and to produce the Delaware's Official Road Maps. GIS resources provided by the Information Resource Management Section are also available. The Staff is quickly becoming familiar with user-friendly systems for viewing maps and spatial data.

The network, file servers, and utilities, as well as the standard Microsoft software and operating systems, are effectively maintained by the Information System Support Section within the Division. The development of the networks and personal computer base has been gradual and well planned to meet needs, and employs standard Microsoft products. Network configurations allow shared peripheral equipment and network file storage, links to central systems and data repositories, internet and intranet access and web page creation, and e-mail.

The Information Resources Management (IRM) group in DelDOT's Division of Financial Management and Budget (FMB) offers the Division of Planning support of centralized systems that include accounting, personnel management, communications between divisions, project tracking systems, and systems for the maintenance of the Road Inventory and Accident databases. Each year, numerous Division of Planning information requests are satisfied by IRM analysts. IRM has responsibilities in areas of planning and control of information systems, data management, application management, and technology management. Throughout DelDOT their responsibilities are extensive and include initiation of information system development projects, systems security, quality control, maintenance of implementation models, data backup, documentation, and support of standards. In addition IRM is involved in installation of software

and hardware, trouble shooting of technology problems, and all facets of applications development including the purchase, installation, design, evaluation, maintenance and training needed for applications.

More examples of informational needs in the Division of Planning

Addressing data management issues in the Division of Planning involves the realization that planners create, analyze, and maintain substantial amounts of data, and that information management is indeed an integral, necessary part of their responsibilities, particularly in the last decade. To further demonstrate information needs and responsibilities, this chapter ends with a list of the types of questions and issues that the Division of Planning typically works with:

What projects have been completed, are in progress, and are being considered for a particular roadway? How do they effect each other.

Have highway improvements produced safer roads? What types of improvements have provided the greatest benefits?

What roads are most suitable for bicycles? How will conditions change in the future?

Where are the major trip attractors in New Castle County?

What will be the effects of detouring traffic for construction projects?

How many miles of road of a particular functional class are in a particular district? How many miles are on the National Highway System?

How congested will roads get in the future?

If emissions are decreased in newer cars what will be the effect on overall air quality?

What is the percentage of "through" vs. "local" trips on a given roadway?

Where are new markets for transit?

When and why did the Department accept maintenance on a road?

How many people live in a particular area?

Where are the portions of the transportation systems that have elicited the most complaints?

What policies have the greatest support from the public?

Where can detailed information about a particular corridor be found?

To what extent will improvements in signalization reduce congestion?

Where in Delaware is transit most successful?

What will be the expected impact of a proposed regional shopping center?

In what situations and where are carpooling efforts most effective?

CHAPTER 2
INFORMATION ACTIVITIES AND ISSUES IN THE DIVISION OF PLANNING

Introduction

The previous chapter provided some background on the information activities and needs, and organizational structure of the Division of Planning. This chapter discusses findings and the data management issues that were identified in the interviews with personnel. Interviews were with those who extensively use and/or manage information for planning. About 15 interviews were held to gain familiarity with individual responsibilities and procedures, and to discuss problems, issues, or strengths that need to be considered to improve information systems. The issues that emerged were those related to the development of more responsive, efficient, and integrated information systems.

General findings of the interviews

Information system related activities in the Division of Planning can be grouped in four general categories,

- Maintenance of DELDOT databases and digital maps

  Examples: Road Inventory, Accident Database, Travel Demand Forecasting Model, Official DELDOT Road Maps

  Primary concerns[*] : Efficient and accurate maintenance and update of data. Access to the data.

- Collection and analysis of information to support project development

  Examples: transportation system enhancements, corridor studies, environmental review, Project Pipeline, preparation of data for planning studies and consultants

  Primary concerns: Availability of accurate and accessible information and capabilities for

[*] As voiced by Division of Planning personnel

compiling and integrating information from many sources.

- Annual reporting

  Examples: Highway Performance Monitoring System (HPMS), Highway Safety Program, Long Range Plan, Project Pipeline

  Primary concerns: Efficient and accurate data update procedures to meet product requirements. Capabilities for compiling and integrating information from many sources.

- Planning analysis and presentation

  Examples: Long Range Plan, Highway Safety Program, transit system development, air quality conformity, public meetings, traffic impact studies

  Primary concerns: Availability of accurate and accessible information and capabilities for compiling and integrating information from many sources. The ability to quickly and clearly present information.

Several personnel indicated that those operations that focused on maintenance of DelDOT databases had gone on for many years, and are efficient and satisfactory. As mentioned in the previous chapter, the major areas of concern were more in the informational use of data for project development, planning, evaluation, and presentation. ***The primary issues that were identified related to the need to better find, access, and to relate and understand information.*** There was also a general sense that information systems were not integrated and that more benefits could be realized if information was more widely available and usable outside of the primary function for which it was created. These issues are discussed in detail in the next section of this chapter.

While the activities reviewed throughout the Division included overlapping data needs, there is little evidence of the development of an integrated approach to information systems. Individuals within each section focus on particular responsibilities and needs of their applications, and with the exception of the developing local area network, there are no mechanisms to allow information to flow more easily between sections and applications. Rather than having data stored and organized by a particular theme (i.e traffic volumes, road capacity, land use), data is stored by section,

individual, or project. Information is sometimes difficult to use outside of the particular computer platform or primary purpose for which it was developed due to the use of different data formats, access issues, or in how transportation facilities are identified.

In order to better understand information needs and areas that can benefit from a more integrated approach, applications were tabulated with major data sets and elements as shown in Figure 2.[*] The row for data sources includes the major data sets used by the Division of Planning. These data sets embody how information is currently maintained and structured at DELDOT, and they are managed on computer systems as VAX databases, MapInfo and Intergraph digital map layers and databases, personal computer software such as Access, Excel, and DBASE, text files, and TRANPLAN binary files. Currently these data sources are not integrated, coordinated, or easily used across applications. Examples of the data elements included in these data sets are also shown in Figure 2. An "X" in the matrix indicates a element which *could potentially* support a particular application. Improved integration would mean that these data elements are more easily used across data sets and applications, as well as across the sections in the Division of Planning and other divisions.

Personnel were very satisfied with the computer software and hardware at their disposal, and had a high level of comfort and skills with the standard array of Microsoft Office software for word processing, presentations, spreadsheets and database management. They were satisfied with the features offered by the local area network for e-mail, file management and storage, and use of peripherals. The support of operating systems, basic personal computer software and hardware, and the network were also viewed as satisfactory.

[*] To understand the relationship of data resources by tabulating data elements by activities is not new to DelDOT. As part of DelDOT's Transportation Information Plan (TIP) (1992) an attempt was made to cross reference activities with data elements for the entire Department (the TIP Matrices). The TIP was a major effort to address needs and integration of information resources for the entire agency and is discussed in Chapter 4.

Bikeways and Greenways	Corridor Studies	Support For Consultants	Air Quality Modeling	System Enhancements	Transit System Development	Research	Presentation	Project Development	Project Nomination	Federal Reporting	Highway Safety Improvement	Understanding Travel Demand	Long Range Planning	Data Elements / Application	Data Sets
X	X	X		X	X	X	x	X	X	X	X	X	X	road structure	Road Inventory
X	X	X		X	X	X	X	X	X	X	X	X	X	functional class	
X	X	X		X	X	X	X	X	X	X	X	X	X	pavement condition	
						X				X	X		X	income, debt, expenditures	Highway Performance Monitoring Systems (HPMS)
						X				X				road system condition (sample)	
						X				X				accident summaries	
						X				X				transit	
						X				X			X	condition of road system (sample)	
X	X	X		X	X	X	X	X	X	X	X		X	accident locations	Accident Databases
X	X	X	X	X	X	X	X	X	X		X	X	X	trip generation	Travel Demand Forecasting Model
X	X	X	X	X	X	X	X	X	X	X	X	X	X	projected volumes	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	traffic zone data	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	trip tables by purpose	
X	X	X	X	X	X	X	X	X	X	X		X	X	road network model	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	capacities	
X	X	X		X	X	X	X	X	X	X	X	X	X	project status	Project Databases
X	X	X		X		X	X	X	X	X	X	X	X	level of service for bicycles	Bicycle Databases
X		X				X	X	x						digital roads and base maps	DELDOT Cartographic Maps
X	X	X		X		X	X	X						towns	
X	X	X		X		X	X	X						yearly map series	
X		X		X		X	X	X						map text and symbols	
X		X				X	X	X						hydrography	
X	X	X		X	X	X	X	X					X	digital roads, center line	IRM GIS Resources
X	X	X		X		X	X	X					X	hydrography	
X	X	X		X	X	X	X	X	X		X		X	linear referencing system	
X	X	X		X	X	X	X	X			X		X	orthophotography	
X	X	X		X	X	X	X	X	X		X	X	X	landuse	
X	X	X		X	X	X	X	X	X		X		X	digital roads and basemaps	Planning GIS
X	X	X			X	X	X	X				X	X	address matching	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	demographics	
X	X	X	X	X	X	X	X	X	X				X	numerous presentations and maps	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	traffic counts, traffic summary	Traffic Summary
X	X	X	X	X	X	X	X	X	X	X	X	X	X	demographics	Data External To DELDOT
X	X	X		X	X	X	X	X			X		X	traffic impact studies	
X	X	X		X		X	X	X					X	historical, archeologic data	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	local comprehensive plans	
X	X	X		X		X	X	X				X	X	wetlands, environmental data	

Issues To Be Addressed For More Effective Information Resources in the Division of Planning

Data Discovery

A first step in using information is to know what information is available and whether it is appropriate for use in a particular application. At the Division of Planning, those who need information know of its existence through established procedures, previous inquiries, and/or an informal network of associates and contacts. Data developed or available in one section of DELDOT are sometimes unknown to members of other sections unless specific inquiries are made. Archives does a good job in preserving the great body of hard copy information that is generated each year, but no digital information clearinghouse or reference sites exist within DELDOT or in outside agencies for most of the data needed by the Division of Planning. Documentation of data sets such as data dictionaries, explanations of coding, and metadata that would indicate source, content, and accuracy are not currently available. There are also no incentives or requirements in Delaware regarding publication or distribution of data generated by public or private agencies. While there are many examples of large efforts in data collection and preparation, very little attention has been devoted to making data known and available.

The Project Development Section is a group that is constantly in search of information, whose job involves the collection of massive amounts of diverse and detailed data from internal and external sources for corridor studies, environmental review, and transportation enhancements. Members of this section repeatedly stressed in interviews the need to know what data are available and its accuracy and reliability. The Transportation Policy and Research Section is another group which because of its wide ranging data needs, must often spend a great deal of time in search of information. Both of these sections benefit from members of their staff who through previous work and contacts are familiar with most of the data that is available for their applications. The Transportation Services Development Section indicated that it also would benefit from knowing what information is available.

Data Access and Availability

Once data is identified as useful to an application, the next question is whether the data can be obtained for use in a particular application. Security issues, data formats, and data transfer mechanisms determine the degree to which information is available for use.

Information can be restricted from general use because of privacy issues or because of potential abuses or liabilities. For instance, portions of accident records are confidential. As another example, for a corridor study knowing the location of rare plant species, or archaeological sites would be relevant, but general publication of this information might endanger the resource. Restricting access is also necessary for data management reasons as in the case where data is time sensitive, and control insures that the most current data is provided. Where there is no sensitivity, privacy, or management issues associated with information that can support needs, data should not be restricted.

The Road Inventory is one major data set maintained and used by Planning that currently operates under certain restrictions. To use Road Inventory information beyond what is available in menu systems on the VAX, it is necessary to submit a written data request to the Division of Financial Management and Budget's Technology and Information Section. This request can take days to weeks to be filled simply due to workloads of this section. Basic queries, views, or extractions of VAX data not already provided at this time require the attention of a programmer. Difficulty in accessing information residing on the VAX such as Road Inventory, or Project Status, was a major data issue identified by the Intermodal Programs Section. The Highway Safety Improvement Program in developing the projects that will be funded, needs information about the roadway, accidents, and past, current, and future projects. Privacy or security issues would not seem to be the reasons for restricting access, as members of the Section are responsible for the update and maintenance of this information.

One solution that would make centralized data more available and perhaps decrease the workload of programmers, would be to provide the Road Inventory, Accident Database, and Project tracking data on the Division of Planning's local area network or through a DelDOT data

warehouse. Personal computer software now available in Planning would allow most users to perform basic queries and exploratory analysis if data were available in standard spreadsheet or database formats, such as Microsoft Access, Sequal Server, DBASE, or Excel.

The needs of many Planning applications are time sensitive. Information is often needed to complete analysis and prepare materials to meet deadlines. Difficulties in obtaining data encourage users to seek out alternatives that are necessary to get the job done, but are less desirable from the standpoint of overall department efficiency. For instance, the Multimodal Programs Section now enters Road Inventory data once in the VAX system and again in personal computer systems so that it is available for their analysis needs. As another example, in the area of GIS, if an easily accessed and integrated road network representation is not available to meet immediate needs, then users will develop various divergent map layers and databases within their sections. This leads to duplication of effort and the generation of numerous digital products that are not easily shared.

Integration: Data Format Issue

A data format is the manner in which data is organized and stored. WordPerfect and MS Word are examples of word processing formats. Excel spreadsheet, fixed format text file, Oracle, and MS Access are examples of formats for data tables. Integraph design file, MapInfo table, ARC/INFO export file, and TRANPLAN network are examples of formats for geographical information system files. Each section in DELDOT works with computer systems that support data in one or more formats. If data is to be shared between groups it is important to use the same format or one which can be easily converted. Data may be known and accessible but may be difficult to use because it originates in systems that use different formats.

Over the last few years, computer software manufacturers are including the capability to retrieve and save data in numerous formats and many conversion utilities exist. Incompatibilities of data systems due to different or proprietary data formats is less of a problem than it once was. However, different data formats do cause complications and extra work, especially for those who are not as familiar with methods for bringing together data from a variety of sources.

Examples of data formats at DELDOT include VAX data formats, Integraph GIS formats, MAPINFO GIS formats, TRANPLAN binary files, and a range of personal computer spreadsheet and database formats such as Excel, DBASE, and ACCESS. The current file format used for accident data and the Road Inventory is not directly usable by standard personal computer software. Outputs of the Travel Demand Forecasting Model, such as zone-to-zone trip tables, are in a TRANPLAN binary format not directly usable by other software. Many users have difficulties translating from various GIS formats used by DELDOT and outside agencies.

Mandating that everyone at DELDOT use the same computer software and hardware as a solution would be impractical and unnecessary. Instead, standard information formats should be identified and staff throughout the department should be encouraged to make data available in those formats.

Integration: Identification of Transportation Facilities

A particular data table used by the Division of Planning is focused most often on a portion of the transportation system, such as sections of road, or traffic zones, or a transit routes. The subject of the data forms records in a data table identifying each road section, traffic zone, or route, and related data about each entity (i.e.road, zone, route). To relate information from various sources about a particular subject it is necessary to identify each entity in a standard, unambiguous manner. If for instance, one data set identifies a road as "Delaware Route 2" and another data set identifies the road as "Maintenance Road 11", and yet another as "Kirkwood Highway", then there is a problem (particularly from a data processing standpoint) of relating the data. A review of data sets available in the Division of Planning revealed that a lack of a standard way of identifying transportation facilities was an impediment to integration.

In addition to being identified by a name, portions of the road network need to be identified by some method such as specifying the beginning and end mile point of the road sections, or specifying the intersections that bound the portion of road under consideration. Most transportation data about roads is referenced using a linear referencing system that identifies data by route and mile point. In order to compare or combine data from different road databases, the identification of roads and the scheme for assigning mile points must be the same. The

Transportation Safety Group often needs to bring information about roads together from many sources so that factors that effect the safety of roads can be understood and projects to improve safety can be identified. This group indicated that differences in the way roads were identified and in ways that mile points were assigned, were the primary impediments that prohibited or made it much more difficult to use available information.

Integration: Locating projects and project information

A basic capability for those involved in project development is to know what projects have been, are being, and will be conducted in a particular area of interest. While data about projects conducted at DelDOT have started to include standard identification and mile points, a simple operation such as mapping all projects of a certain type is still not easy for Division of Planning staff. Reviewing past projects referenced in some cases only by a road number often requires staff to sift through numerous hard copy or microfiche files for the length of a roadway, that include every type of project or action. The format of data files, differences in how roads are identified, and access of project databases contribute to difficulties in quickly referencing what is happening in a particular area. Difficulty with being able to reference projects and how they relate to transportation facilities and their environment can potentially lead to problems.

Integration: Digital Representations of Transportation Facilities

There is a great need for map based information systems to support key applications in DELDOT. Historical development of information systems and various work products have led to the creation of five different digital representations of the road network (see Figure 3).

Figure 3, Digital Representations of the Road Network at DELDOT

Name	Source Scale	Use	Road Segment Identifier
Cartographic Base Map	24,000	Mapping Products	Internal Identifier
DELDOT Center Line File	12,000	Accurate Linear Referencing Network	Roadway ID, Beg/End Mile Point
Street Info File	100,000	GIS products for Planning, address matching	Internal Identifier
TRANPLAN Network	100,000	Travel Demand Forecasting Model	Link ID from Beg/End Nodes
Route-Mile Point Databases	NA	Road Inventory, Traffic Counts	Maint. ID, Beg/End Mile Point

Each one of these representations is updated and maintained independently by sections in the Department and serve as a framework to reference data about transportation facilities. Differences in the cartographic accuracy, the types of information represented, how roads are segmented and identified, and the purpose that they were designed for, make it difficult (and sometimes undesirable) to integrate these products. Graphic features (text, road signs, special symbols) designed for one of these road network representations are generally not usable in another because they will not overlay properly due to differences in accuracy.

An "ideal" road system representation for use in Planning applications, would have the following key features:

- The greatest positional accuracy
- Address matching capabilities
- Support for linear referencing and dynamic segmentation
- A standard method of identifying roads
- Extensive text layers and graphics for high quality cartographic products
- An efficient, continuous, and cost effective update procedure
- Versions readily available in standard formats to encourage the use of a standard and accurate representation.
- Associations with databases which contain information about roads and portions of roads

The current digital representations of roads (Figure 3) have some but not all of these features. The DelDOT Cartographic Base Map and associated graphics are ideal for many cartographic applications and the official road maps which are made each year, but does not support linear referencing, and the lack of attribute data for the road segments makes it much less useful for GIS. The DelDOT Center Line File supports linear referencing and dynamic segmentation and is the most accurate representation for roads, but currently it cannot be used for address matching and there are not as many associated graphic files (such as road names and other feature labels) for cartographic work. The Street Info road base used for GIS applications in Planning, supports address matching, has features to support the travel demand forecasting model, and is attributed for GIS applications, but does not support linear referencing. Over the years these representations

have been used and features have been added to them to make them more useful for their primary purpose. There are numerous mapping products, programs, and linked data files corresponding to each of these digital representations.

Further descriptions of planning activities that were studied

Impact and environmental studies in the Project Development Section

Activities studied in the Project Development Section all had extensive information demands. Staff are constantly looking for accurate and reliable information for project development and impact studies. They work with a very wide array of information from sources external to DelDOT. Perhaps more than any other group in DelDOT. Finding data and accessing it are the most pressing information issues. They voiced interest in the development of Statewide data clearinghouses. Often the data they need is not available at the required accuracy, so the Project Development Section also is involved in data collection and field survey projects making them a producer as well as a user of information. Most of the data that is collected is for a specific project or land use studies, and most of the information that is produced is usually in the form of permits, small and large reports, and a variety of presentation graphics. Information is gathered in many forms, such as hard copy drawings and maps, GIS data, data tables, video logs, reports, and project files. The Project Development Staff issues are not just around digital data but information in other media. Staff through numerous efforts have good familiarity and communication with data producers within DelDOT and in external agencies.

The Environmental Studies group needs data such as wetlands, soils mapping, archeology, historic preservation, land use, tax parcel data, hazardous waste and underground storage tank sites. Information that is produced is in the form of permits and reports. The Corridor Studies group must examine numerous alternatives and impacts in their work and they need to consider all types of social impacts of transportation enhancements. Projects and activities are scrutinized in great detail at times. In order to maintain the credibility of DelDOT, the Corridor Studies group require data of the highest accuracy where sources are known and reliable. Groups that deal with land

use issues and zoning review need tax parcel information, zoning, land use , and a range of specific site data.

Transportation Safety

The Transportation Safety Group within the Delaware DOT Division of Planning has the responsibility for implementing the State's Highway Safety Improvement Program (HSIP). This is supported by an Federal Highway Administration (FHWA) initiative to develop and implement, on a continuous basis, a program that has the overall objective of reducing the number and severity of accidents, and decreasing the potential for accidents on all highways. Safety projects in the HSIP can involve additions or changes in signs or signals, road surface treatments, roadway maintenance, and rehabilitation of roadways and intersections. The approach includes a detailed study of historical data, a systematic process for identifying and ranking safety projects that considers costs and benefits, and a follow-up evaluation over three years to determine the status and effectiveness of safety projects. Historical data managed and studied by the Transportation Safety Section indicate that the HSIP has been very successful in providing a safer transportation system. Areas where improvements have been made generally show less accidents that have been seen prior years.

The HSIP progresses from a general listing of accidents to hazardous spot locations that are ranked according to a statistical index. This index provides a basis for the comparison of sites by taking into account the type of roadway (i.e. interstate, minor arterial), the volume of traffic, and the number of accidents in the prior 3 years. The Average Accident Rate and Critical Accident Rate statistics are needed to understand the relative safety of a given site, but also to measure progress year to year in safety improvement. A brief description of the HSIP process is provided in Figure 4.

The primary challenge of data integration for the HSIP is to link data about accidents, the features of the roadway, and about past, current, and future projects. The bulk of the work is in compiling and relating information, and efforts to integrate information could offer the greatest improvement to the process. Staff indicated that one of the greatest impediments to effectively using information is the lack of a consistent and practiced method of referencing information to roads.

They stressed that standards for the identification of roads , the inclusion of location information in data sets, and methods that take into account historical changes in the transportation , would support their efforts to prioritize and select safety projects. Much of

Figure 4: Outline of DelDOT's Highway Safety Improvement Program Process

1) Preparation of a General Accident Listing
Data for all reported traffic accidents which occurred in the State of Delaware during a three year period (close to 60,000) are collected, assigned to 3 tenths of mile intervals for all roadways and listed.

2) Identifying high accident locations
All roadways are divided into urban and rural types, and they are further subdivided into four functional classes: Interstate, principal arterial, minor arterial, and collector. These functional classes are then divided into two-lane, multi-lane divided and multi-lane undivided categories. Average Accident Rates are then calculated for each roadway type . A Critical Accident Rate for each roadway section is calculated and is a statistical test of significance of the calculated accident rate for each section of the roadway. A particular site is not necessarily considered safer than another purely from the number of accidents. This judgement must be adjusted by considering the roadway type and the volume of traffic on the road (VMT). This adjustment is done in calculating the Average Accident Rates and the Critical Accident Rates. The Critical Ratio of these two rates is then used as the main index for identifying high accident locations.

3) Screening of high accident locations for new projects
All sections with an accident history of 15 or more incidents in the last three years are listed in descending order of Critical Ratios. Each location is screened for a possible new safety improvement project by first identifying whether or an improvement is already being considered for that location that could improve safety.

4) Communication of safety project priorities and identification of potential projects
Safety priority for the high accident locations is communicated through appropriate Department channels to ensure that safety problems are brought to light in project development. If improvements are not initially identified, then a safety study is conducted as an initial qualifying step for the inclusion of a given site in the DelDOT safety program. Research, study, and ranking continue until sufficient candidate site and projects are generated to fill out the safety program.

5) Selection of safety program project sites
The number of projects selected for implementation is limited by available resources. The use of a benefit-cost analysis provides an economic approach to determining the best use of DelDOT funds by selecting projects that rank highest. The process of selecting the sites to be selected also involves review by DelDOT committees that address all projects of various types that are nominated.

6) Project implementation
Once safety projects are selected, DelDOT Transportation Safety staff facilitate their implementation by compiling and disseminating information about each project, and by generating cost estimates for both Traffic and Road Design projects.

7) Project monitoring and evaluation
For purposes of evaluation, a record of accident experience is kept for each project constructed under the HSIP. Evaluation is normally based on 3-year before and after periods. Accident rate changes from the initial measures are calculated as the major evaluation technique for safety improvement performance.

8) Generalization of evaluation results
The findings of project evaluations are used to improve the selection of candidate safety projects. Where a certain type of project has been found successful, candidate program locations where conditions and circumstances at the candidate site are given higher priorities and the results used in the benefit-cost analyses.

historical project data is not in a digital format, and some of the recent information is not in a readily used format. Roads sections are identified by route numbers and street names in various formats, and their extent is sometimes described by intersections and other times by beginning and end milepoints. Some of the data compilation can be automated but particularly in the final stages of prioritization it takes a planner to view information together from many sources and examine the relationships that exist. This view would be greatly assisted by being able to group and integrate data by location to examine the project data, roadway information, and accident data, site by site.

Much of the demands are in preparing lists of projects that include location information, descriptions, critical accident ratios, and relevant past or current projects. Preparing the lists and examining the safety issues and solutions requires relation and processing of road inventory, accident, and project data from DelDOT centralized databases. The calculation of critical accident ratios and preparation of the general accident listing is automated through programs created by DelDOT Information Resource Management but considerable labor (4 to 6 months) is dedicated to sifting through a range of information and ranking projects. To the extent possible, HSIP staff would like to have an information system where rules for identifying candidate sites could be applied to accident, roadway, and project data.

Policy Development

The role of the Policy Development group is to work with elected officials at the federal, state, and local levels regarding proposed and adopted laws, regulations, and procedures related to transportation in Delaware. One of the group's primary roles is to work with membership of the Delaware Legislature on proposed, pending, and adopted laws which shape how DelDOT operates.

The group's primary data management issues are access, analysis, and presentation of a wide range of transportation-related data. In some ways, the group is somewhat like the Program Development section in that it is one of the main "consumers" of data within the Division; however, it does not maintain large databases on its own. Any data management needs that are

maintained by this section tend to relate to the daily and/or annual workloads of the group and are generally met by"off the shelf" spreadsheet and word processing programs.

Because of the continually-evolving nature of the projects undertaken by this group it is difficult to outline the specific data types used by, or which might be used by, its staff. For example, at any given point in time the group could be dealing with financial, personnel, regulatory, environmental, or technical matters for several dozen policy-projects. As the data management, processing, analysis, and presentation capabilities of the entire Division are improved and streamlined, the Policy Development group will also improve in a corresponding manner. As a consumer of transportation data, this group will receive benefits in terms of "turn around time" through short and long-term improvements in general data management capabilities of Division.

Transportation Data Group

The Transportation Data Group has three primary responsibilities; the maintenance of accident databases, maintenance of the Road Inventory, and the update and creation of the DelDOT official road maps.

In Delaware, accident reports are prepared manually by State and local police. The information to be obtained has been gradually moving toward a standard set of data that has been cooperatively specified over the past few years by representatives from Delaware law enforcement agencies, the Department of Public Safety (DPS), the Delaware Justice Information System, and DelDOT. The data collected is a product of a balance between the needs of analysts, and the priorities of law enforcement. Hard copy accident reports are collected and keyed by DPS personnel into mainframes maintained by the Delaware Office of Information Service and are also entered into DelDOT data servers by staff in the Transportation Data Group. DelDOT maintains three clerical staff to input the data and to manually copy hundreds of reports per week to satisfy requests of planners, engineers, consultants, insurance agencies, and other groups. Minimizing the large amount of effort in data entry and data distribution is a major concern, and improvements in information technology such as document imaging and network based information distribution systems have been considered to ease the burden.

The Delaware Safety Management Process is a current program sponsored by the Delaware Office of Public Safety and the Delaware Department of Transportation (DelDOT through IRM). Its mission is to maximize the safety of Delaware's transportation system, and it is currently focused on advances in crash data collection and reporting. The primary, short-term focus of the Delaware SMP is to design and carry out pilot projects for making improvements to crash data collection and reporting through standards and information technology. As described in the plan "ROADMAP, Action Plan For Crash Data Collection and Reporting"* technologies such as mobile data computing, global positioning systems (GPS), and GIS, are being tested in these pilots to convert the manual collection process to a computerized method that promises to radically improve communication and usability of accident information between more than a dozen groups who need and use the data (see Figure 5 from ROADMAP). The plan also presents an accident data dictionary specifying content and coding for a comprehensive set of crash data elements.

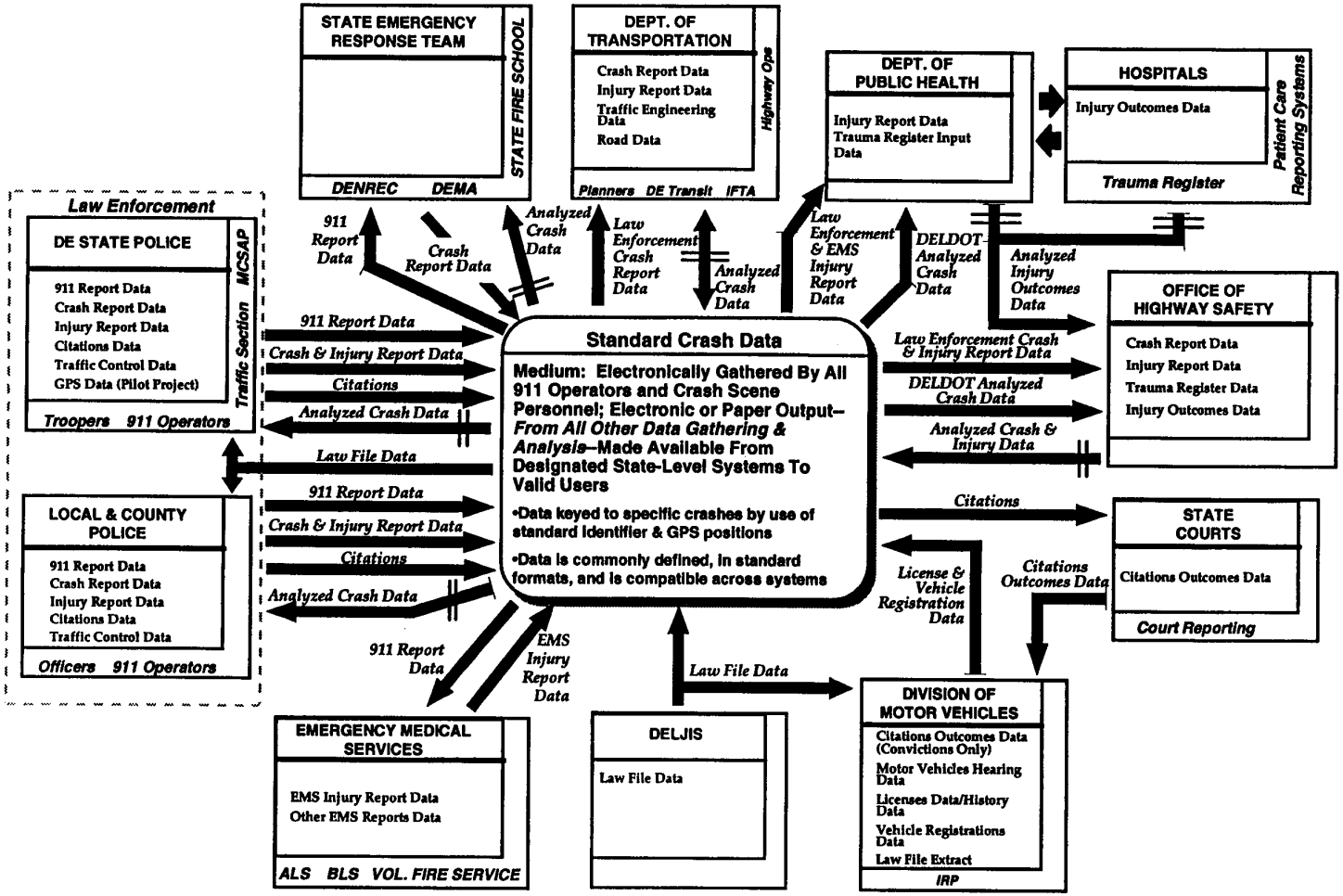
Current outputs of ROADMAP implementation are an approved set of data elements and a pilot of automated systems being tested in a few police vehicles in Delaware. In the pilot vehicles, data is being entered through user friendly forms and the data is transmitted to centralized computing facilities. Police can enter a description of the accident site and use GPS to specify the location. Efforts are also being made to equip law enforcement vehicles with Mobile Data Computers that will support the electronic collection and reporting of crash data, and carry out a wide range of other support functions. These activities addressed by the Safety Management Process are similar to many information technology approaches now being adopted by DOT's and public safety organizations across the country, and provide a long term solution to efficiently collecting and distributing accident data.

The maintenance of the Road Inventory is a major responsibility of the Transportation Data Group. Road Inventory data support many needs in the Division of Planning and other groups in DelDOT. Performing the field surveys and the data input necessary is a sometimes overwhelming task given the limited resources that are available. The inventory is not up to date and errors exist in the databases. Staff are very open to information technologies that could improve productivity and the quality of the data. In particular, pilot projects are being conducted

* State of Delaware Safety Management Process: ROADMAP, Action Plan For Crash Data Collection and Reporting, Sponsored by DelDOT, Marlow Espinoza-Hale and John D. Salamone, Mitretek Systems,

to see how state of the art video logging and desk top computing systems to view image and video data can be used to decrease time in the field and make the information more available.

Figure 5, ROADMAP Action Plan, Crash Data Collection and Reporting



Organizations and Data Flow Associated With The Fully Evolved Crash Data Collecting and Reporting Process

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The creation of the DelDOT Road Maps was the first area outside of computer aided drafting systems for engineering drawings where digital mapping was introduced at DelDOT. Each year a set of maps are created with a high degree of cartographic quality. Procedures have been in place for many years and are reliable and efficient. The primary question that has been raised in regards to this operation is the degree in which these 24,000 scale cartographic mapping products could be integrated with other digital map products at DelDOT such as the Center Line files, the Division of Planning Street Info layers, and the travel demand forecasting model. Preliminary investigations indicate that because the official road maps involve specific cartographic elements not necessary for other uses, that the degree of duplication of effort is not severe and the opportunities for integration are limited. Investigations continue though to determine how to most efficiently use resources to maintain the several digital map products used at DelDOT.

Project Pipeline

The Project Pipeline Program is a process based on networked information systems that allows a wide range of people inside DelDOT as well as from other agencies and groups to nominate, rank, and review transportation projects in an orderly and open manner. With this program, project nomination, promotion, selection, and timing, can be more coordinated and it is easier to see overlapping needs in the 2 to 3 hundred projects being considered each year. The Project Pipeline is implemented much like a spreadsheet that orders information about the project, its location and originator, and allows for feedback from those who are concerned. It promotes additional dialog

between otherwise more separate interests once they see the projects for the same transportation facility nominated by each other. The Pipeline Process is successful simply by relaying preliminary information, originator of the nomination, and location and or facility to be addressed.

Those working on the Pipeline Process have a concept of a more sophisticated information system able to evaluate potential impacts and discover relationships between projects. For instance, one operation of interest would be a radial search around the location of a project to determine other past or nominated projects in an area, utilities, populations impacted, AADT and level of service of roads, and accidents. Such capabilities would then allow for a review of projects in more detail beyond describing the relationship between the projects primarily by naming the facility and location.

Travel Demand Forecasting

The ability to examine and predict impacts on the transportation system of future changes in land use or transportation facilities is a powerful capability. The DelDOT Travel Demand Forecasting Model can examine various scenarios of land use distributions and transportation enhancements. The software in use is TRANPLAN, a personal computer based system that implements the standard "four step process" and has been in use for about 15 years by DOT's across the country. The model has recently gone through a major update project for areas of the State and portions of Maryland. Trip generation models have been updated as well as the road network model. Though TRANPLAN itself is a Fortran based program whose data inputs and outputs are in a uniquely structured text format, the Division of Planning has created a very helpful interface with MapInfo GIS to prepare data and view results.

Primary inputs include a model of the road network with present as well as future enhancements, models for trip generation, demographics, population and employment projections by traffic zone, free and constrained flow impedances, and some indication of modal split. Primary outputs are calculated traffic volumes on road network links, zone to zone trip tables by trip purpose, and predictions of levels of service. Using population and employment projections by traffic zone and assumptions about demographics and future road networks, the system can provide estimates that of impacts of various scenarios of land use and transportation system enhancements.

The model is traffic zone based and is designed to address volumes along major roads rather than the impacts of a particular subdivision. Even at a slightly generalized level, the maintenance of the model is intensive. To study a particular scenario involves great care in preparing inputs and making assumptions. Outputs must be scrutinized as well, and adjustments made by checking other information such as traffic counts. Maintaining and using travel forecasting models is a major commitment of resources. MapInfo GIS has been very effectively used by the Division of Planning to assist in the preparation of inputs such as network models and trip generation data. The mapping capabilities of GIS have been crucial to being able to display output data such as estimated traffic volumes, and to relate and map outputs with other data. Much of the output data still is not easily used outside of the Systems Planning Group and the transportation network model itself is not integrated with other digital representations of roads such as the Street Info file or the Center Line file. Efforts have recently begun to associate the network road segments with DelDOT linear referencing route and milepoint values that provide integration with other data sets about roads.

Conclusion

The Division of Planning activities are very information intensive. Access, analysis, and presentation of information provides a focus or foundation for most activities of the Division, and there are major investments of resources in information and information systems. Use of information systems fall into four general categories.

- Maintenance of DelDOT databases and digital maps
- Collection and analysis of information to support project development
- Annual Reporting
- Planning and presentation

Interviews and study of systems indicated that improvements were needed in these four primary areas for; better data integration, the ability to better find information, the ability to more easily access information, and determining direction of further development of geographical information

systems (GIS) to meet analysis and presentation needs. The following chapters deal with each of these areas.

CHAPTER 3

FINDING, ACCESSING, AND USING DATA

The relation between finding and referencing data

Being able to efficiently locate accurate and reliable information was the primary data issue of the Project Development Section. Given that there are numerous projects in various stages that have sometimes very great information demands, they are in a constant search for information, and often need to initiate work to get information that is not currently available. They are not just looking for information but also whether it is fit for the use they have in mind. Often the information is collected for the use of an outside consultant or engineer so the section is involved in distributing of information as well. Similar needs of being able to better find and access information are expressed by the Transportation Policy and Research Section and the Intermodal Programs Section in relation to the many projects, programs, and policies they need to support.

Often, data is found at DelDOT by asking around to a network of contacts and acquaintances. Once the right type of information is found, it is usually necessary to ask questions about its accuracy, or format, or date of the data, and then if its acceptable, there are questions about how to transfer the information. Finding accessible and appropriate information is more of a process of making contacts, finding the right resources, accessing the information, and making preparations to put it in a usable form. The search is to find appropriate and usable information.

The ease of finding information is directly related to how well producers or collectors of information let it be known that they have it. To increase the ability to find data means that others need to better reference and make their data available. Finders depend on the keepers. The producer needs to be encouraged to reference and share, and the easier it is to prepare and reference the data, the easier it will be to find it. The data could be referenced in a number of ways. Lists could be maintained of data and providers. There could be regular meetings of information providers where the available data was discussed. The producer could issue a

compact disk of all the data they had available. Information could be documented and made available on the Internet. The main point though is that finding information depends on how easy it is, or how much it is in the interests of the producers to reference and provide the data.
The data producers at DelDOT are a first consideration. If the requirements were minimal in terms of time and expertise, and if it was part of an effort supported by the group and administration, personnel could likely be convinced to document and make some of their data available and more easily discovered. Procedures would need to be simple and well understood to increase the chances of long term improvements.

File names and directories

When data is produced it is saved to a file in a particular directory that reflects some organization, and then given a name. Fortunately computer operating systems now allow for longer file names, but finding and knowing what the information is, still depends on making a contact with the creator or keeper of the data if that is the only way it is referenced. This is the main way that data is organized and accessed in the Division of Planning. Information is stored in various areas associated with the responsibilities and activities of individuals and the sections and programs they are involved in. Information is located by having a familiarity with programs and responsibilities of the agency and by making personal contacts. Central systems primarily focus on applications for maintenance and display of corporate data, and not as much on the distribution of the data that the applications are built on. To get data from central systems is a similar process involving making an inquiry to IRM and submitting a request for the information.

Use of computer networks to find data

Great advances in communication within the Division of Planning have been made with the development of the Division Intranet and DelDOT Web Site. Very large amounts of information on activities and the transportation system are being made available on the Intranet. There are many benefits of using networks to distribute and access data. The Division of Planning has made a good start, and has the necessary hardware and software in place to do even more.

The use of the Intranet and networking in general at DelDOT has so far been very successful in improving communication in the Division of Planning. It is the ideal tool to not only allow others to know about and understand information, but also a tool to access the information. It already has been a forum for information standards and policies and is being used now to better find information. One very effective use of the Intranet is how it provides a medium for coordination of project nominations in the Pipeline Process. Another effective application is the manner in which those projects for the Highway Safety Improvement Program are implemented and tracked. Development of the Division of Planning Intranet has been very fast with most of the work occurring over the past few years.

Search capabilities of networks

The Division of Planning Intranet is organized in a similar way as the Division's organizational chart and the typical way Web sites are created. Each section within the division has a separate page that displays activities, and each activity has other related pages. Personnel in Planning recognize that its use is now primarily for indexing and displaying static information, and hope to build more capabilities for on-line data retrieval and custom queries of databases residing on DelDOT information networks.

Besides page to page links for finding information there is another lesser known feature of the Division of Planning Intranet that allows a search through data holdings in a similar manner in which indexed searches on the World Wide Web are performed. Using a feature of MicroSoft Back Office, a text string can be found within a text file, a hypertext document, or even a binary file as might be used for word processing or spreadsheets within a file server. When such a search is initiated, links to those files with matches to the text string can be returned. So a quick way of referencing information could be as simple as describing it in a document and placing it in an area that can be searched. This search capability is extended in the Index Server Module.

A hypertext file reference could be as minimal as typing a statement such as "Population Estimates provided by the Delaware Population Consortium for the year 2000 are in the file called 'depop2000' in the 'demog' directory of the shared workspace". The main issue that has to be addressed is confining the search and having the files structured so that you are more likely to find

what you are looking for instead of a lengthy list of references and files that happen to, for instance, mention the words “traffic count” but otherwise provide no other information about traffic counts. Better use of this feature would be to design well documented data repositories where data could be submitted and searched, and to document the data sources and quality to a much greater degree. An even more useful manner to document data is to describe it in a hypertext file and then include a live link to a utility to transfer the data, or to a site where the data can be obtained. Figures 6 below shows the Division of Planning Navigation Page and Figure 7 on the next page demonstrates a search utility that is in place.

Figure 6, Division of Planning Intranet Navigation Page

Navigation

- Planning Programs, Projects & Activities
- Project Development & Implementation Process (PIPELINE)
- Technology^2 (T^2)

Division Sections:

- Intermodal Programs
- Policy
- Project Development
- Transportation Policy and Research

- Calendar
- Contact Directory
- DelDOT Library Catalog
- Traffic Summary Data
- Links to Outside Agencies
- Miscellaneous

Figure 7, Division of Planning Search Utility

Planning (Top) | Navigate | Search | INTRANET | Calendar
Feedback | What's New | Help | INTERNET

Division of Planning

Search

Use the form below to search for documents in the Planning Web containing specific words or combinations of words. The text search engine will display a weighted list of matching documents, with better matches shown first. Each list item is a link to a matching document; if the document has a title it will be shown, otherwise only the document's file name is displayed. A briefexplanation of the query language is available, along with examples.

Search for:

Start Search | Clear

Query Language

The text search engine allows queries to be formed from arbitrary Boolean expressions containing the keywords AND, OR, and NOT, and grouped with parentheses. For example:

`information retrieval`
finds documents containing 'information' or 'retrieval'

`information or retrieval`
same as above

`information and retrieval`
finds documents containing both 'information' and 'retrieval'

`information not retrieval`
finds documents containing 'information' but not 'retrieval'

`(information not retrieval) and WAIS`
finds documents containing 'WAIS', plus 'information' but not 'retrieval'

`web*`
finds documents containing words starting with 'web'

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Revised: July 13, 1999.

Metadata standards and clearinghouses

If the source, quality, and content of data is unknown, then the usability and value of the information is much less. Standards have been developed over many years by the Federal government for the comprehensive and consistent documentation of data. The Content Standards for Digital Spatial Metadata (the Content Standards) include items to fully identify source, quality, methods for creation, content, and distribution of data sets. The standard dictates the order and content of documentation and includes a standard text format for the metadata (see Appendix for and example of a standard metadata file). By having documentation in this standard format it is possible to develop search tools that can treat the bits of documentation much like database fields, and refine searches for data. So for example, including information in the documentation about data content, date, accuracy, and the spatial area the data addresses, allows search utilities to answer questions such as, "Show me all of the digital photography around the City of Newark area at a scale of 12,000 or better, that were taken during the winter or early spring after the year 1994."

Documentation and facilities for finding information then can get much more involved and powerful, than posting data on a web site. Finding the information still depends on someone to reference or publish it, and the requirements of documentation increase to take advantage of the improved search features. Documentation is viewed as tedious work by most, particularly those not accustomed to doing it. Like system maintenance, it is an overhead that day to day draws no immediate benefits. There are a number of software packages available now that ease the burden of documentation to an extent.

Most meetings in the last 20 years to address GIS issues and coordination in Delaware have called for the need to know what information is available and what information development efforts are underway in the State. An important effort in Delaware to allow communication among public and private agencies is the development of the Delaware Spatial Data Clearinghouse (www.nsdi.udel.edu). A project funded by the Federal Geographic Data Committee, and with the support of the Delaware Geographic Data Committee and over two dozen Delaware State and local agencies, it seeks to provide a mechanism for agencies to document and make their data available, and forms another node in a developing network that forms the National Spatial Data Infrastructure (NSDI). Supported by State Legislation (House Bill 395) that calls for a data

clearinghouse for data related to planning activities, the Clearinghouse effort is currently focused on making user friendly documentation tools available and building support for a community effort to reference and distribute data. As most data for transportation planning activities is spatial data, and there is great need for information from external agencies, the Division of Planning could benefit a great deal from such and effort. The Division of Planning and the Information Management Resources group have pledged support to the Clearinghouse and have offered to provide metadata and data about transportation facilities.

The Clearinghouse is based on proven Internet technologies initially emerging from the library community, that can search vast holdings of data references and provide on-line links to data and resources across the State. The documentation (metadata) in the standard format (Content Standards) must all reside in one or more "nodes" but the data itself can be distributed anywhere on the network . Demonstrations of the Clearinghouse technology were developed last year and the project is now in an implementation phase focused on populating the facility with data and metadata. Clearinghouse technology has been directed nationally toward the access of GIS data, but can be used to reference data of any type of information including reports, databases, and hard copy materials. Whether or not the effort is successful depends on whether providers will provide metadata and data to the Clearinghouse, and several outreach efforts are underway. The Clearinghouse can be accessed at www.nsdi.udel.edu.

Advancement of the Delaware Spatial Data Clearinghouse could substantially assist the Division of Planning's need for external data. DelDOT should support the Clearinghouse by providing accurate and well documented transportation data and by also encouraging outside agencies to also document and provide data.

Data Access

To access data is to be able to view it or obtain it for use or distribution. One may be able to find information but not access it. Levels of access include the ability to view, change, or copy the information. Access requires knowledge of the data, security clearances, and some type of facility to view or obtain the data.

Access to data can be limited for security reasons, such as when the information is sensitive or private and is not for public distribution. For example some personnel information is private. As another example, sometimes information is provided to an agency that needs it with the requirement that it will only be used for a specific purpose and will not be distributed. Access can also be limited because of data management issues concerned with data integrity. For instance, a database such as the Road Inventory or Project Accounting databases, should only be edited by personnel who have that responsibility and follow proper data management procedures to insure the quality of the data.

The level of access to data also can be limited by the types of tools that are available to view, obtain, or use it. For example, someone may have permission to use information but because the data is in a special format that requires special software that the potential user does not have, the information is inaccessible in the sense that it can not be used. As another example, centralized data is often provided to users in computerized forms or user interfaces. If a potential user of the data wants to see information in the database that is not included in the form, then a special request must be processed through the organization that takes some time and the information is not *readily* accessible. If needs are time sensitive and will not wait for the request to be processed then the information is for all practical purposes inaccessible. Most planners can give several examples of frustrations where they knew where information was and could get permission to use it, but were discouraged because of procedures to obtain it. These frustrations are perhaps greater now with a new generation of planners who themselves have substantial information skills to manage and process data, and are very aware of the efficient access that can be achieved with the Internet and the computer resources now at their disposal.

Methods to improve data access

If DelDOT data is useful to the Division of Planning and is not sensitive or private, and their are no data management or integrity issues that cannot be overcome, then efforts should be made to allow the information to be accessed and used in the easiest way possible. The network utilities and resources now in place in DelDOT could facilitate better access along with making data easier to find. Data could be accessed through the Intranet. Regularly updated data libraries could be established on network file servers. A gradual effort could be conducted to make agency data

more consistent and usable (see chapters on integration), and guidelines could be provided to insure that data is properly referenced and used appropriately. A few standard file formats for data could be adopted so that data conversion could be minimized.

A more involved approach would be the creation of a data warehouse. Data warehousing is a recent information technology concept that supports informational processing by addressing integration of data, easier access and analysis of information, data integrity, and the need for cross-functional analysis. The steps in developing a data warehouse involve:

1) Policies to determine what information will be included, how it will be maintained, and how users will access data.
2) Transformation of data to insure quality, consistency, and usability.
3) Storage strategies to maximize system flexibility, manageability, and overall accessibility.
4) Analytical capabilities to do modeling, computation, and "what if" analysis on large data volumes in a multi-user environment.
5) Access capabilities to select, view, and manipulate information.

A data warehouse is not simply a data repository. A full implementation addresses the integration of data and how users can interact with data systems to meet informational needs. When implemented for an entire transportation agency warehouses can require commitment and extensive resources[*].

DELDOT IRM currently is undertaking a data warehousing project that is in its beginning stage. It would be worthwhile for the Division of Planning to gain a better understanding of this effort, how it could support their needs, and how they can become involved in the design and operation of the data warehouse.

Conclusions

[*] Comments mentioned here concerning data warehousing have been discussed in literature produced by GIS Trans Ltd. in a number of forums, in particular the AASHTO GIS-T '98 Symposium, April 19,1998, presented in Salt Lake City.

Being able to efficiently locate accurate and reliable information is a major concern in the Division of Planning. There is a continual need in most sections, particularly the Project Development Section, for a wide array of information to address projects and policies. Potential users of information also try to discover the extent that information that is located can meet their needs.

The ease of finding information and determining its appropriateness for a particular use depends on the extent that producers and collectors of information describe the information they have and let it be known that they have it. At DelDOT there has not been an extensive effort to reference or distribute data, and the most common way information is located and understood is by inquiries with a network of acquaintances and contacts. This approach often works well, but because of the continual turnover of personnel and the generally disjointed nature of information systems at the Division of Planning, finding information in some cases can be very difficult and key information about the accuracy and other features of data are sometimes lost. This is not a problem peculiar to DelDOT, but is common to all public agencies. At the base of it is the fact that documentation, archiving, and collecting data can consume considerable resources, and is seen more as an overhead that is not immediately gratifying or productive, and is not appreciated until some future need arises.

Advances in computer technology that include computer network communication and storage, web pages, and data query and transfer utilities have revolutionized the way that information can be referenced, located, and accessed. The Division of Planning has made great progress in the last few years in providing information on the Intranet, and every group is represented and has realized some benefits. The Highway Safety Improvement Program, and the Pipeline Process have used the Intranet to vastly improve the nomination, prioritization, and acceptance of projects. Current systems allow for search and query of the Division's data holdings. The current computer systems and networks in place are able to support many more initiatives to improve data documentation and access.

The following near term improvements/initiatives are suggested:

- Further encourage personnel to document and make their data available.

- Make personnel aware of computer network search capabilities and methods that they can use to document data.
- Promote the establishment of a DelDOT data warehouse.
- Continue to build features of the Intranet
- Prepare data in accessible data formats to assist secondary uses of information.
- Where security and data management issues can be resolved, allow easier access to data residing on DelDOT centralized databases.
- Encourage the establishment of statewide efforts to document, publish, and document data. Provide and maintain data on the Delaware Spatial Data Clearinghouse.

CHAPTER 4
BUILDING TOWARD A COMPREHENSIVE TRANSPORTATION INFORMATION SYSTEM

The benefits of structure

The sources of information that are needed for project development and planning are diverse and widespread. A transportation agency could never collect (or predict) all of the information that might be needed. It would be desirable however to build and manage a body of information that would include a comprehensive set of data and utilities to meet most needs in addressing transportation facilities, their performance, and the needs of the public. Data that was produced and managed by the transportation agency itself would be the largest part of that set.

In studying the Division of Planning's information resources it was obvious that there was a large quantity of data that was available within various parts of the group, but there was no sense that data was collected and managed as part of a coordinated information library or system that preserved and facilitated access and use of the data. Data currently is stored by sections within the Division, individuals, or by project, and there are few established methods for sharing or documenting data.* Data is distributed among many projects and individuals. Finding data sometimes is accomplished by making inquiries to their associates likely to have that information as part of past or present projects.

There are advantages to defining a data framework for a comprehensive transportation library. First, it defines a core data set that will be the focus of information system responsibilities and investments. Second, by treating data as a part of a larger structure, there is an appreciation and greater likelihood of making the data consistent and usable with other information and across purposes. Other advantages are that a framework provides a model for an integrated systems, and can be structured to fit the business needs of the agency.

* A major exception to this is the recent development of the Division's Intranet that is very promising in terms of moving toward a model and powerful tool for integrated systems

The current organization of information systems in Planning would be best described as being based around projects, individuals, and programmatic responsibilities. As projects and programs are a primary concern of the Division, this has been a functional and natural approach to organization of digital holdings. This organization though is centered on the activities or individuals and has not promoted communication among them. Information systems are being effectively used to get things done in each activity , but there is a common perception of the disjointedness of information activities.

The Division is to an extent dependent on information resources produced from the types of projects and activities that it has worked on, and sometimes there is a scramble to extract the data for projects and activities, and fill gaps as new needs arise. As projects are numerous and vary spatially as well as temporally, understanding what information is available and getting it in a usable state is sometimes difficult. Reliability and consistency are always a concern. A reactive approach is efficient for the atypical needs and questions that can arise ("one offs"), that often can never be anticipated. At other times inefficiencies, particularly persistent ones, can lead to a drain of resources, missed opportunities, and a poor reflection on the knowledge of the agency.

One suggested data-organization framework

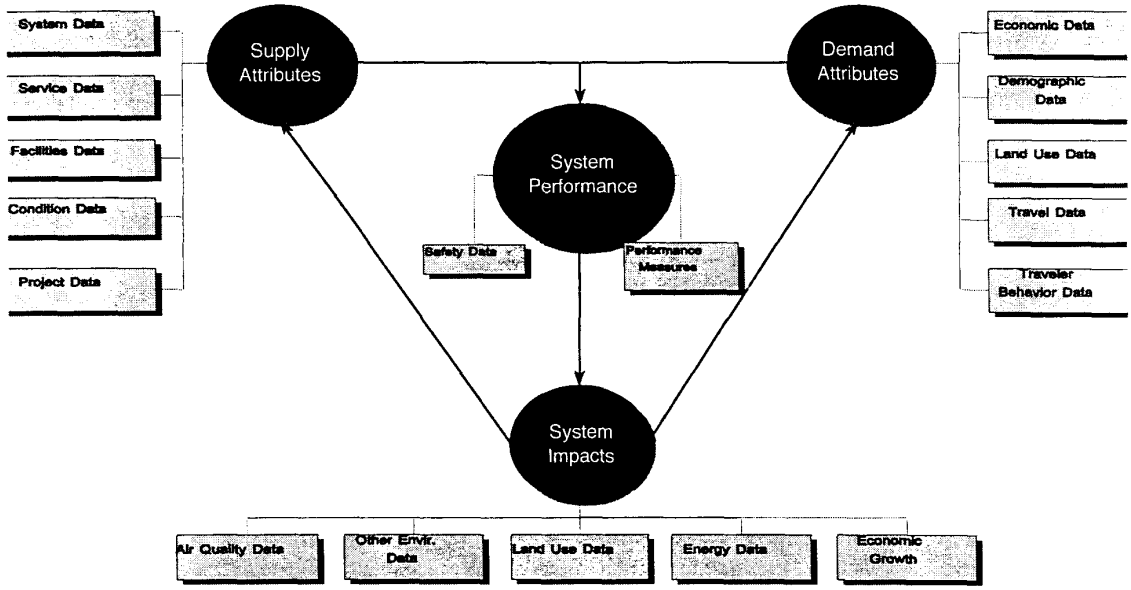
While projects are a primary link between transportation information at the DOT, they may not be the best method of organizing the information. Report 401 of the National Cooperative Highway Research Program "Guidance Manual for Managing Transportation Planning Data", advises,

> "…given the large quantity of data necessary for the development, evaluation, and implementation of transportation strategies that support planning objectives, that the manner in which data are grouped affects the efficiency and stability of the planning process … efficiency, because planners rely on timely access, and stability, because of the time and costs of collecting data, as well as the need for systematic and reliable monitoring over time, work against constant modification of databases." [*]

[*] National Cooperative Highway Research Program (NCHRP) Report 401, Guidance Manual for Managing Transportation Planning Data, National Academy Press, Washington, D.C., 1997, pgs 3 and 6

The data framework suggested in Report 401, was not structured by planning issues or activities "that tend to vary spatially and temporally" but rather "by the major attributes of the transportation system, which remain relatively constant and facilitate the data retrieval process"*.
The report suggests that transportation data should be organized in relation to the four major attributes of the system; supply, demand, performance, and impacts (see Figure 8).

Figure 8, Data organization framework suggested by NCHRP Report 401



These four categories are each split into sub-categories. Supply Attributes include data sets for Systems Data, Service Data, Facilities Data, Condition Data, and Project Data. Demand data is organized into Economic, Demographic, Land Use, Commodity Flow, Travel, and Travel Behavior data. System Performance Attributes are organized as Safety Data, and Performance Measures. System Impact Attributes into Air Quality, Other Environmental, Land Use, Energy, and Economic Growth data. This forms a hierachal data framework for multi-modal transportation planning. An example of the data framework for highways with some DelDOT data sets included is shown on the next few pages.

* NCHRP Report 401, quote pg 6, figure pg 7

Figure 9 Detailed data organization framework for highways (Adapted from NCHRP Report 401 with DelDOT examples)

Highway Supply

Systems Data

Route and lane miles by functional class
Road Capacity
Functional Road Classification (Road Inventory)
Truck Routes
Snow emergency routes
Land use for system expansion
Road network models
Div. of Planning Street Info file
DELDOT Center Line File
DELDOT Cartographic Base
TRANPLAN Travel Demand Forecasting Model
TIGER Line File

Service Data

Intermodal access (rail, water, air, by highway route mile)
Fare, fee data (tolls, tax)
Data on service providers

Facilities Data

Inventory of facilities
Bus terminals and stops
Rest areas
Park and ride lots
Truck terminals
Intermodal facilities
Cargo transfer equipment
Snow removal facilities
Signalization
Delivery and pickup (on-street, off-street parking)

Condition Data

Pavement data (i.e Overall pavement condition, structure, age, roughness)
Any data pertinent to condition of routes, bridges, ramps, etc.

Project Data

Pipeline Process
Traffic Impact Studies
LUPA Reviews
Highway Safety Improvement Program
Capital Improvement Program
TEA 21 Implementation

Transportation Enhancement

Figure 9 continued

Demand Data

Economic Data

Income data by household and region - historical, current and projected
Employment data by SIC and region - historical, current and projected.
Vehicle ownership data by household and region
Travel cost data (e.g. auto operating costs, parking costs, transit fares, tolls etc)
Data for income and employment projections
Industrial operations
Wholesalers and distributors
Commodity production and consumption data
Export/import data by point of exit/entry
Proxy data for projecting commodity production and consumption data

Demographic Data

Population and labor force data (size, density, distribution) - historical, current and projected.
Household characteristics (e.g. household size, number of licensed members etc.

Land Use Data

Acreage data
Housing data
Employment data
Access data (e.g. accessibility to services)
Zoning data
Tax Parcel / property data

Commodity Flow Data

Commodity flow data by O-D
Modal split on commodity flow data by O-D
Factors affecting modal split
Relative modal rates
Delivery time by O-D
Other

Travel Data

Trip generation data (e.g. person trips by purpose, vehicle trips by purpose, transit trips
By purpose, non-motorized trips, etc.) historical, current and projected
Trip distribution data (e.g. trip length distributions, trips by time-of-day) historical,
Current, and projected.
Other origin/destination data.
Special generator data (e.g. tourism, conventions, special events etc)
Traffic volume data (e.g. annual average daily traffic, design hourly volume, peak hour
Traffic percentage, directional split, peak period volume, turning movements,
Zone to zone modal split, external station traffic counts)
VMT data

Shipper modal selection factors

Figure 9 continued

Demand Data (Continued)

Travel Behavior Data

Mode choice data
Route choice data
User preference data
Time of day for pickup and deliveries
Carrier behavior data

System Performance Data

Safety Data

Incident data
Accident data
Security data
Medical services

Performance Measures

Highway performance data (e.g. recurrent and non-recurrent congestion, person and Vehicle mile/hours of delay, lane and vehicle mile of roadway operating at Substandard level-of-service, average system speed, incident location and Response) historical, current, and projected.
Transit performance data (e.g. average system speed, on-time performance, cost per Passenger trip, passengers/hour, recovery ratio, etc. historical, current, projected.
Intermodal system performance (e.g. transfer time between modes, delay along terminal Access routes, etc)
User cost data
Delivery time by O-D and mode/intermodal
Cargo damage by mode/terminal
Congestion at terminals
Shipment costs

System Impact Data

Air Quality Data

Vehicle registration data (vehicle populations by class, fuel type, vintage etc.) historical, Current, and projected.
VMT data (e.g. VMT by functional road class and time-of -day, VMT mix by vehicle Class, mileage accumulation rates by vintage, traffic counts by time of day, VMT Forecasts.
Speed data
Trip data
Impact assessment
Interurban emission contribution by mode

Figure 9 continued

Systam Impact Data (continued)

Other Environmental Data

Visual and aesthetic impacts
Noise and vibration impacts
Ecosystems
Archeological and cultural impacts
Parklands

Land Use Data

Socio-economic impact
Neighborhood impacts

Energy Data

Energy consumption impacts by mode
Energy efficiency impacts by mode
Energy price impacts

Economic Growth Data

Local employment impacts (e.g. expected job creation of transportation projects in local Area, etc.)
Regional employment impacts
Access to natural resources
Access to domestic markets
Access to ports and foreign markets

The DelDOT Transportation Information Plan

While discussing the development of a comprehensive transportation database it is important to discuss DelDOT's significant initiative in this area, the Transportation Information Plan (TIP). A study of the TIP was conducted in this project to see what was in place to support the creation of comprehensive and integrated information systems, and to see how the TIP might help address the primary data management issues in the Division of Planning..

The DelDOT Transportation Information Plan (TIP) was created in 1992 as a agency wide effort to define a methodology to identify the goals and requirements of the Department as a whole, and to outline a comprehensive plan in regards to information resources that would guide DelDOT in

the development of new projects. The TIP addresses a structure for an information resource that can comprehensively and reliably meet DelDOT's needs.

The TIP was to provide a defined and logical approach for designing and implementing the applications that would solve DelDOT's information-related problems. The difficulties of centralized information resources to meet the demands of frustrated users was referenced in the TIP as the driving force for the proliferation of independent efforts and alternative computer hardware and software systems. The specific problems that were to be addressed by the TIP's creation were the wide spread development of independent, uncoordinated information systems, difficulty in supporting these systems, and the resulting data that tended to be redundant, inconsistent, inaccurate and untimely. [*]

The TIP methodology directs development toward widely shared databases, transactions, and technology. Data is organized and managed along subject boundaries rather than along system or organizational boundaries. The TIP methodology requires;

1) Management involvement
2) Information resource models
3) Implementation/Migration Plan
4) Formal Information management policies and procedures
5) Effective IRM organizational structure
6) Appropriate skill base.

The products of the TIP were several Models and a Strategic Information Plan. The Functional Model defines the activities performed at DelDOT. The Conceptual Model defines the entities and the relationships between entities. The Conceptual Applications Model provides an understanding of the overall picture and how things fit together. The Distribution Model defines where (geographically) information is needed. The Technology Model defines a comprehensive blueprint for the necessary computer technology resources. The Strategic Information Plan defines the projects and the Implementation / Migration Plan for completing those projects.
In addition, the TIP matrices plot the relationships between all entities, activities, organizations, and applications.

[*] Transportation Information Plan (TIP), State of Delaware Department of Transportation, January 7, 1992, pgs 3-1, 3-2

Observations about the TIP as it relates to issues in the Division of Planning

The TIP is focused toward the selection and development of major software applications to meet operational requirements. The Functional Model developed as a result of identifying what DelDOT does and needs to know, is implemented primarily by an application and work flow based approach. Information applications are needed to meet operational requirements for the numerous and demanding needs of groups across DelDOT, and the TIP employs an accepted and powerful approach to organize resources, and support the development, and most importantly, maintenance of applications. Some of the applications that were addressed in the TIP are shown in Figure 10.

Uses of data such as an analysis of the impacts of a particular transportation system enhancement, the wide array of public presentation needs, the development of yearly Capitol Improvement Plans, the many uses of GIS for project development, and other informational uses that cannot be viewed as well defined information system applications, and are not the focus of the TIP.

The conceptual framework of the TIP, based on models of entities, activities, and applications has the flexibility to address integration. However there is a gap between the concepts, and practical application and implementation of the TIP. For instance, entities are defined (not all that occur in Planning), but the full definition of entity attributes and formats are available only on data dictionaries on Adabase systems in IRM. Full definitions of standards and formats of primary identifiers are in some cases not clearly defined in the TIP materials reviewed. For the Division of Planning, a data dictionary and documents on identification and coding policies are appropriate tools to support data integration, though these are not available as part of the TIP.

In regards to Division Planning issues concerning finding and accessing information, the IRM Pro Forma Policies included in the TIP document state that:

"All data within DelDOT shall be managed to maximize the ability to share and utilize the data for as many agency purposes as possible. Organizations within DelDOT shall agree upon the meaning and representation of data so that it may be captured, maintained, and accessed in a common, sharable database to maximize its benefit while minimizing its cost…..Data shall be stored in databases which are generally accessible to the agency at large."*

TIP documents do not describe specifically how data will be referenced, shared, or stored for easier access.

Figure 10, Examples of applications addressed by the TIP (Jan 1992)

APPLICATION PRIORITY RANKING

	APPLICATION	ABBRV	PROCESS	DATA	RAW	NORMAL
1.	ROAD/BRIDGE FEATURES	RBF	18	140	158	100
2.	PROJECT STATUS INFO	PSI	66	48	114	72
3.	ACCOUNTING	ACT	18	58	76	48
4.	HUMAN RESOURCE MGMT	HRM	22	52	74	46
5.	OUTSIDE SERV PROVIDER	OSP	30	40	70	44
6.	ENGINEER'S ESTIMATE	CEC	46	18	64	40
7.	MATL & SUPPLIES MGMT	MSM	22	38	60	37
8.	ROAD/BRIDGE USAGE	RBU	38	18	56	35
9.	CUST INFO REPOSITORY	CIR	32	22	54	34
10.	MATL & EQUIP USAGE	MEU	18	26	44	27
11.	ROW PROPERTY ADMIN	ROW	22	18	40	25
12.	ROADWAY FEATURES PERMIT	PRF	14	22	36	22
13.	FLEET, EQUIP & ASSETS	FEA	14	16	30	18
14.	PLAN SHEET TRACKING	PST	22	6	28	17
15.	FIXED ROUTE MGMT	FRM	10	16	26	16
16.	IRM MODEL MAINT	IMR	16	19	26	16
17.	LABOR DIST MGMT	LDM	18	6	24	15
18.	HAULING PERMIT	HPA	14	8	22	13
19.	FHWA CURRENT BILL	FCB	18	0	18	11
20.	SUBDIVISION MGMT	SUB	10	8	18	11
21.	BUDGET PREPARATION	BUD	8	8	16	10
22.	COMMUTER SERVICES	CSM	10	6	16	10
23.	IRM SERVICE REQUESTS	SRM	8	8	16	10
24.	PUBLIC CARRIER CERT	PCC	6	8	14	8
25.	PAVEMENT MGMT	PMA	8	0	8	5
26.	DEMAND RESPONSE MGMT	DRM	8	0	8	5
27.	OFFICE SERVICES	OFF	6	0	6	3

* TIP, pg 8-5

The TIP is focused on information generated within DelDOT, and with the exception of long standing reporting requirements, does not appear to address data and relationships with external sources of information. The Division of Planning requires large amounts of information from external sources. For example, when the Project Development Section say they would like to find and obtain information more easily, they are referring often to information such as property owners, floodplains, addresses, demographics, archaeological sites, hazardous waste locations, comprehensive plans and a wide range of other information not available at DelDOT. The Division of Planning has responsibilities to provide information to the public and external agencies that are not addressed in the TIP.

IRM continues of course to make progress in several areas under the guidance of the IRM Steering Committee since the last update of the TIP 1992. One IRM effort that may provide support for distributed information systems and informational needs is the initiation of a data warehouse project. An internal, application based, operational approach remains dominant perhaps as a necessity to effectively use information resources staff to meet the majority of the information needs of DelDOT.

The TIP methodology is a powerful and appropriate way to approach the structure and management of information systems. The need to update the TIP is a crucial part of its application as it was to fill a function as " a single information strategy which effectively provides intelligence to the decision making process". Information technology, functions, needs, personnel, and data are changing, and therefore the TIP needs to change and evolve. Evidence that the TIP would be subject to the test of time is provided in the TIP Conclusion;

> "The divergent activities of the Department seemed just too numerous and complicated to be neatly categorized into an orderly and usable architecture. However, the TIP Methodology has provided DelDOT with the chance to get it's arms around the operations of the entire Department. And this may be the last chance before the proliferation of

> microcomputers and personalized applications makes the capability of creating a centralized, data-sharing environment virtually impossible to achieve." [*]

Since this was written, microcomputers did proliferate, GIS applications rapidly developed, local area network capabilities have dramatically increased, and the Division of Planning was required to take an ever more comprehensive and multi modal approach.

Conclusions

The current organization of information systems in the Division of Planning would be best described as being around projects, individuals, and programmatic responsibilities. As projects and programs are a primary concern of the Division this is a natural organization of digital holdings but is one that does not encourage integration and use of data beyond the initial purpose for creating it.

Defining a data framework for a comprehensive transportation library focuses information systems responsibilities and investments around a core data set, and increases the likelihood that data will be consistent and usable with other information and across purposes. An organization based around the major attributes of the transportation system has advantages over one structured by planning issues or activities that tend to vary spatially and temporally. A data organization framework like that presented by NCHRP Report 401 should be considered as a foundation for improvements in data management.

The DelDOT Transportation Information Plan (TIP) was created in 1992 as an agency wide effort to define a methodology to identify the goals and requirements of the Department as a whole, and outline a comprehensive plan in regards to information resources that would guide DelDOT in the development of new projects. The Models and Strategic Information Plan represent a substantial effort to define how DelDOT uses information systems and to set priorities for future use. The TIP is focused on the prioritization and development of applications. The strength in this focus is that it is a practical approach to handling the numerous demands on IRM to build and maintain applications.

[*] TIP, pg 6-1

The TIP is less applicable to the type of informational needs of the Division of Planning. Members of the Division of Planning were unaware of how the TIP could be applied to address data management issues. TIP documents do not describe specifically how data will be referenced, shared, or stored for easier access. The TIP Matrices demonstrate common data needs between applications but do not define a comprehensive transportation data framework. Major progress in GIS and computer networks that have occurred since the TIP was prepared in 1992 are not addressed.

CHAPTER 5
INTEGRATION

The need for data integration and improved data management

Using a definition from a National Cooperative Highway Research Program report, to integrate is " - to form, coordinate, or blend into a functioning or unified whole; to unite". Using another definition, integration is " the state of interoperability among the agencies' information processes that produce the maximum feasible synergy".*

With the new requirements by programs such as the Intermodal Surface Transportation Act and the Clean Air Act, and with the more multi-modal focus of transportation agencies, there is a pressing need for more information and the ability to relate various types of information in comprehensive planning approaches that go well beyond considerations dealing solely with the construction of roads. The public increasingly expects transportation agencies to make decisions that consider quality of life, future impacts, and costs versus benefits. A greater sophistication with all of the information that is involved and how it is related, supports comprehensive planning. The public expects a broad awareness about everything that relates to the transportation system.

Theoretically, more and "better" information supports better planning. Of course this is not always true as in the case where efforts are overly dedicated to data collection and preparation, and where little time is actually spent using information to solve a specific problem. Given the sometimes overwhelming information requirements of comprehensive planning, there is a necessary trade off of the quality of information, and the resources necessary to obtain and use it. Planners and analysts must continually make a judgement, on a task by task basis, concerning the amount of time they can put toward preparation of information versus use of information.

* NCHRP Report 401, pg. 12

Integration, and better data management in general, promises to optimize the benefit of resources put toward data collection, processing, and analysis. Integration is about saving time and costs. It is about efficiencies occurring from shared information, and from the consolidation of an agency's various needs and responsibilities into a consistent set of data requirements and management procedures serving the agency as a whole.

From the standpoint of fulfilling the mission of agencies, the best indicators of the success of integration and data management efforts is an increased consistency and quality of information, and increased resources spent using information, relative to resources spent obtaining and preparing it. Examples can be found attesting to the benefits of more integrated systems, such as the development of a comprehensive transportation management systems initiated by Michigan DOT (MDOT) to reduce duplication of effort and coordinate through an implementation of GIS. This initiative yielded dramatic results, with the percentage of time spent maintaining data decreasing from 70% to 30%, while the time spent analyzing data went from 30% to 70%*.

Impediments to Integration

Integration can be difficult for a number of reasons:

- Lack of consistencies or standards between data sets making them incompatible. Examples are differences in record structure, file format, coding, and differing levels of accuracy.
- Lack of communication and coordination. If users in an organization are unaware of overlapping needs or activities it will lead to less cooperation and coordination with the development of information resources, causing a number of difficulties in sharing information.
- Restrictions in use or access of data.
- Lack of tools or skills to use data from various sources. Even when data is accessible and consistent, personnel with the tools (e.g. software, information networks) and skills to relate and make sense of information are necessary.
- Institutional impediments that would restrict the flow of information.

Centralized Versus Decentralized Approaches

In the past there have been two institutional approaches to data management; a centralized approach, and a decentralized approach.

A centralized approach is traditionally where data-collection and maintenance responsibilities are turned over to a centralized MIS group, and all data are accessed through the support of that group. With this approach the MIS group can more easily standardize around particular computing platforms making technical support for a large number of users easier. Security and control measures for data maintenance and storage are more easily implemented. Development of information systems can be more focused. Data management and quality control procedures are more easily implemented. On the down side, information users must sometimes be completely dependent on the central group to fill data requests and build applications. In a planning department where special, time sensitive requests for information and analysis are a day to day occurrence, working solely through an outside information systems group can be practically impossible. For the information management group who often are also responsible for the support of a range of financial, personnel, and facilities management data sets, it can be difficult to program resources to serve sporadic specialized requests. Separation of the information specialists and those with expertise in planning can cause problems as requests must be specified exactly to use the information specialist's time efficiently. In some cases it is difficult for planners to specify what is needed before hand as in the case of exploratory data analysis.

A decentralized approach is where data are collected and stored on an application-by-application basis at the information user site, with applications typically not coordinated with each other. With the widespread use of personal computers, and with the availability of powerful, higher level software, there has been a decentralization of all data related activities. This is efficient for the computer literate planner or analyst, focused in one application area, who has ready access to information and a wide range of tools to use it. Data is produced and managed closer to its source and to the professionals who are most familiar with its uses. Basic data processing and analysis operations can be performed by planners and analysts, offering a better use of personnel skills and quicker response. There can however be large inefficiencies, in data collection, management, and dissemination. There is a great tendency to have redundancies, and many divergent software

[*] NCHRP REPORT 401, pg 20.

systems, data storage mechanisms, data dissemination capabilities, and knowledge bases/training resources. The ability for a MIS group to support a range of systems and data sets becomes increasingly difficult, requiring the need for skilled information system personnel at the distributed sites. Such difficulties and related overhead costs have begun to move many agencies back toward a centralized approach.

Integration At DELDOT Division of Planning

The Division of Planning's interest in having better data integration is primarily motivated by the need for comprehensive multi-modal planning and project development that demands the use of a vast array of information. To evaluate and develop projects, to identify and initiate safety projects, and to estimate the performance of the present and future transportation systems requires a more heuristic approach, rather than a very definable operational process. Unlike data maintenance operations, such as maintaining the Road Inventory or the Accident Database, other uses of information in Planning such as long range planning and project development, require the relation of information from many sources and sometimes beyond the initial purpose of creating the data.

Information systems at the Division of Planning are predominantly decentralized. Personnel function mostly independent of each other, focused on their specific responsibilities in areas that include HPMS, highway safety, project development, accident tracking, road inventory, travel demand forecasting, GIS and other reporting and planning applications. Many of them have been using or providing information in the same way for many years. While working independently, each group functions efficiently and satisfactorily with minimal redundency. There is an increasing technological expertise in the use of personal computer based spreadsheet, database, and presentation software, and personnel appreciate the freedom and efficiency that a distributed approach offers to fulfill their specific responsibilities. Computer systems hardware support a standard Microsoft Windows and networking platform. There is however very little use of information across applications as might serve multimodal and comprehensive planning. There are concerns for better integration and dissemination of information as would be expected from a decentralized information system.

Recent DelDOT initiatives that support data access and integration

There are a number of long term initiatives underway by DelDOT IRM to respond to the need for more accessible systems and integrated data. Data access and integration begin with awareness and communication, and the local area network and the several Intra and Internet applications within DelDOT have greatly improved the ease and extent of communication. Network data storage and access facilities are gradually being improved. There is a gradual move toward use of use of Oracle and MS Access as a standard for relational database systems. There is a growing appreciation and demand for interoperability of systems that is promoting changes in the way DelDOT handles information, and in the features that software vendors are building into their products.

Most transportation data has a spatial dimension and geographical information systems (GIS) provide powerful visualization tools that have been extensively used at DelDOT. GIS provides a way to accurately represent features of the environment and the transportation system, and encourages the integration and relation of data. DelDOT has produced a large array of useful data that includes an accurate centerline file to support linear referencing, digital orthophotography, numerous layers to create maps of high cartographic quality, transportation modeling networks, and land use data. Increased capabilities to view and analyze data have focused efforts on improving the quality of information and specifications to allow data to be more useful beyond its primary purpose.

DelDOT IRM has also begun a data warehouse project that hopefully can develop toward an integrated data repository and a facility that supports more heuristic and informational uses of information.

Planning Division personnel are open to and recognize the potential of IRM activities. Indications are that some of these initiatives are not yet ready to support Planning's immediate needs, and that they are not as yet a major part of the division's long range information system plans. In regards to centralized data resources at DELDOT, Division of Planning personnel primarily expressed a desire for easier access to the information that currently exists and progress in this area would be

welcome. Hopefully, emerging information technologies can offer some of the benefits of central maintenance and quality control of data, and allow users to better access data and use powerful distributed systems to meet their needs.

Integration through technology

Current work by DOT's toward integration to support modern multi-modal approaches to transportation planning predominantly depends on technological solutions that provide a middle ground between traditional centralized and decentralized approaches. Through the use of computer network technology, the actual storage and management of data can be effectively distributed while providing mechanisms for a centralized referencing system that bring together information resources. This allows for the autonomy that some users and groups need and enjoy in the distributed approach, while supporting conformance to broader shared standards and access.

The first most important step in the integration process is to ensure that all information is shared with all legitimate users. As information is made accessible through the use of computer networks, and users begin to take advantage of it, they will request changes that make the data more useful. Over time with the assistance of information specialists, users can collectively consolidate their needs and specifications into a consistent set of data requirements.

Communication and sharing of information is greatly supported and redefined with all of the Intra\Internet applications. E-mail, web sites, distributed processing, and shared data storage all allow for a level of integration that would otherwise be impossible. The use of resources and people are not as limited to institutional frameworks, or where the person is located, or in what division he or she works. The Division of Planning has made, and will continue to make very significant advances in making information available through the development of their Intranet. This development should continue with the addition of greater facilities for the archiving, search, and access of information.

Geographical information systems (GIS) are another quickly growing information technology that is the focus of many integration efforts of departments of transportation around the nation. The

information that is used in planning applications takes many forms such as databases, reports, maps, and projects. Data is generally about a particular place or transportation facility. GIS mapping shows how data relates and the preparation of the GIS data often involves integration steps.

Powerful relational database management systems (RDMS) used by GIS and information query systems are changing to be more accessible and user friendly. Data warehouse and clearinghouse technology is taking advantage of advances in network capabilities and RDMS. Video logging, imaging, and a range of remote sensing technologies are providing the tools and foundation for groups to work together without leaving their office. Integration in the future will be primarily facilitated by these and other technologies.

Integration around location

What is in common about most transportation data is that it has a spatial component. Transportation information, whether it is concerned with the supply and demand of transportation, or impacts or performance of transportation systems, is almost always referenced and relevant to a particular location. Many of the types of questions about transportation systems have a spatial dimension , such as "What are the pavement conditions at each road", or "How can this population (located here) be effected by this transportation improvement project (over there)". Data integration efforts can be focused around location.

GIS is often the spatial analysis or display tool, but the integration is in how the data is located and in efforts to insure that data is consistently referenced in space and time. Linear referencing, global positioning systems, addressing systems, and other locational systems can be the basis for referencing, querying, and relating data. Locating data is dependent on consistent methods for identification that depend on standards.

Integration through standards

When there exists many data producers and users of information distributed across an agency, as there are at DELDOT, information standards are crucial in supporting integration efforts.

Standards can be identified for most activities. Those standards most relevant to the integration of transportation data are:

- location standards
- transportation facility identification standards
- database coding standards
- documentation standards
- accuracy and quality control standards
- web page development standards
- data collection standards and specifications
- data file format standards

Considerable progress can be made in minimizing the disadvantages of distributed information systems by addressing standards. Areas of standards that focus on the identification and location of transportation facilities are particularly important to transportation agencies and are discussed with examples in the next chapter.

A first priority for standards in transportation area is to have standard well known identifiers for components of the transportation system. For example many transportation databases are comprised of information about roads. If databases identify roads differently, then integrating the information from a database management perspective can be impossible unless a relation can be established through a common identifier. Such is the case with several databases managed within the Division of Planning, as described in the next chapter of this report.

Conclusions

Current work by DOT's toward integration to support multi-modal approaches to transportation planning, predominantly depend on technological solutions rather than on organizational ones. Current information technology now available to DelDOT allows for a level of integration that was not possible before. The greatest progress toward integration will result from networked data resources, the Intranet, e-mail, and computer network data search and transfer utilities,

CHAPTER 6

INTEGRATING DATA ABOUT ROADS

Route - Mile Point Data and Linear Referencing Systems

Much of the information maintained and/or used by the Division of Planning is information about roads. Examples include the Road Inventory, pavement condition files, HPMS, and the Traffic Summary. The road segments addressed in such data sets are referenced using DELDOT's standard linear referencing system (LRS) where roads are grouped into particular routes and each route is identified by a Maintenance Road Number. Each maintenance road has a beginning and end point. Using field measurements, each road is measured along the curvilinear, three dimensional path of the center line of the road in units of miles, as tabulated in the Road Inventory. Within a particular county, any portion of a road then can be referenced and located by its Maintenance Road Number and its beginning and end mile points. In the case where data concerns an event at a point location along a road, such as an accident site or a traffic count measurement, it is reference by the route identifier (Maintenance Road Number) and a single mile point. DELDOT's LRS has been in use for decades and is the basis for referencing information about roads in many data sets.

This project embarked on a detailed study of several data sets at DELDOT that contained information about roads to see to what degree they could be related and the extent that they met requirements for integration as outlined in the previous section. The data sets that were addressed included the Road Inventory, HPMS FTA Section 15 reporting, the Traffic Summary, Pavement Management System databases, the DELDOT Travel Demand Forecasting Model, Accident databases, a Bridge database, automated road condition data (ARAN), the DELDOT Center Line File, and inventories for suburban and municipal roads. The study revealed that to varying degrees, each data set differed in its construction to a point that made integration difficult.

Relating and integrating route-mile point data sets.

Each record in a data table for road information concerns a particular portion of, or point on a road. If data sets use different methods of identifying roads and referencing data along the roads, then it is impossible to relate the information. Relational database systems that can bring various information together depend on common identifiers within data. One or more fields forming a unique identifier for a record in one data base can be matched to a record(s) in other data sets using the unique identifier to join information about a particular road. The route, and the mile point reference, are the primary identifiers for each data table record and determines the subject of the other information in the record. For example a unique identifier for a portion of roadway could be formed by using four fields; the Maintenance Road Number, the County ID (Maintenance Road Numbers are not unique across counties), the beginning mile point and the end mile point. If the coding or format of any one of these fields is not consistent between data sets then there will not be a "relate" established.

Integration of route mile point data sets depends on:

- A common, unique route identifier
- A common linear measurement scheme
- From a data processing point of view, common ways of naming and coding route and measure fields in a data set. For example in one data set a maintenance road will be listed as route "23" while in another it might be listed as "000230". Both sets mean to reference Maintenance Road 23 that everyone is familiar with, but the coding in the data set is different. As another example, in one data set milepoints could be expressed as a character field such as "0345" with an implied decimal point, while in another data set they are expressed numerically as 3.45 miles
- A method of dealing with changes to the LRS over time (such as road realignment)
- A similar resolution. For example automated data collection might provide information at every tenth of a mile, where as pavement condition ratings could be specified over the entire length of a particular roadway. In order to use the information together you might have to employ averaging or aggregation of the automated data
- For some types of analysis a similar method of portioning or segmenting the roads in the data

- A common database format, such as Access, DBASE, or Oracle, or a software environment that allowed the user to use data sets in different formats

Any difference or inconsistency in the features above will present impediments to integration of data sets, as will be further discussed in the next section with examples from data sets used by the Division of Planning.

Examination of road data at DELDOT in regards to integration

Identification of roads

A first requirement of integration is that roads be identified in a standard manner. The most well known identifier of roads in Delaware besides the road name is the Maintenance Road Number, sometimes called the road number (ROAD_NO is some data sets). It is alphanumeric (i.e. Road 342A) so it is stored in databases as a character field. In some DELDOT data Maintenance Road Number is formatted differently. For example Maintenance Road 32 might be stored as "00032", or "0320", or "32". These three forms are not equivalent from a data processing perspective and data sets can not be related if there is this type of inconsistency. The first example, "00032", is the most common form. It is coded as a 6 place character field with the sixth place blank or to a letter (e.g. route 32B would be coded as "00032B"). In other DELDOT data sets as with the HPMS yearly submission , the Maintenance Road Number is not listed as a separate field, but is combined in another road identifier called the SECTIONID. SECTIONID is a 12 place character field where the first 6 places holds the Maintenance Road Identifier and the next 6 places lists the ending mile point of the road segment with an implied decimal point after the 9 position. For example HPMS would use the code "000420002480" to say the section of road with Maintenance Road = 42 and end mile point 2.48 miles. Notice that in this HPMS example, nothing is said about where the road section of road begins, so more information is needed to fully identify the road, such as the length of the road, or the beginning mile point.

The Maintenance Road Number serves as a useful identifier because it has been in use for many years and it is referenced on many maps. Maintenance Road Number is not by itself a unique identifier, the numbers repeat in each county. For instance there is a Maintenance Road Number

"46" in New Castle, Kent, and Sussex counties. Therefore to uniquely identify a route, data sets must include a Maintenance Road Number and a County identifier field. This need for multiple fields to identify a road in itself is not a problem since the relational database systems such as Oracle, and Microsoft Access that are available to the Division of Planning and other DELDOT departments can form relationships between data sets using multiple fields. The main problems for integration are that Maintenance Road Number and the County identifier are coded differently in the data sets. Some data sets use a "1" for New Castle, a "2" for Kent, and a "3" for Sussex. Others use the Federal Information Processing Standard (FIPS) code as used by the U.S. Census Bureau where New Castle is coded as "003", Kent is "001", and Sussex is "005".

Another route identifier that has been established in DELDOT for data processing applications, is the Roadway Identifier. The Roadway ID (RDWAY_ID) serves strictly as an internal identifier and is the root for all primary keys in many DelDOT databases. The strengths of this identifier is that it is a numeric field that is unique across the State and exits for suburban and municipal roads as well as county, State, and interstate roads. Look up tables (cross reference tables) are available at that associate Roadway Id's with Maintenance Road Numbers and names in a particular county. Some of the DELDOT data sets list both the Maintenance Road Number and Roadway ID. Figure 11 lists identifiers used in DelDOT data sets that were studied. To integrate these data sets first requires that roads are identified by a common identifier.

Mile Points and Measures

The mile points specified in the Road Inventory, as derived by field measurements, should be the basis of any mile points used in any of the DELDOT data sets. The route naming and the measures form a common standard. Beginning and end mile points specified in the data sets, with unique route identifiers, uniquely specify a particular portion of roadway. Fields for the beginning mile point and end mile point should be included in all data sets describing features for road facilities.

As with the road identifiers there is not a consistent way of formatting mile point data. Some data sets include beginning and end milepoint as a 2 decimal numeric field. Others specify the end point and the section length but not the beginning mile point. In some cases the mile point

Figure 11 EXAMPLES OF HOW ROADS ARE IDENTIFIED IN DELDOT DATA SETS

DATA SET	Primary road ID	Primary ID format	Secondary road ID
Road Inventory (Digital-Planning)	Maintrd	4 C, with 0 suffix, "032A" "0020"	RDWAY_ID
Suburb Road Inventory	Road Name	50 C, "Washington Avenue"	Internal Road Number
Municipal Road Inventory	Road Name	50 C, "Washington Avenue"	Internal Road Number
HPMS	Section ID	12 C, 6 Maintrd + 6 end milepoint "000010000480" e.g. Maintrd 1, endmp .48	SECTLEN, LRSPNT
Pavement management history	Maintrd	6 C, with 0 suffix, "00032A", "000020"	RDWAY_ID, Integer
Accident Database	Maintrd	6 C, with 0 suffix, "00032A", "000020"	
Traffic Summary	Maintrd	C, with 0 suffix, no preceding 0's e.g. "32A", "20"	
Bridge Database	Maintrd	C, no 0 suffix or preceding 0's e.g. "32A", "2"	
IRM Center Line File	RdwayID	Integer	Lookup tables to Maintrd
Spring 1998 ARAN data	RdwayID	Character	
Travel Demand Forecasting Model	LINKID	8 C, 4 beg node + 4 end node	Lookup tables to Maintrd

information is formatted as a character field (e.g. "002340" to signify mile point 2.34). The Bridge database that was studied listed the mile point of a bridge in two fields one for the integer portion of the mile point and one for the decimal portion (e.g. one field contained "2" and another contained "0.34" to signify mile point "2.34"). Different formats for milepoints, just like with route or county identifiers, impede integration and data queries.

It is important that one official, accurate measuring scheme is used, otherwise data sets will be locating information differently. The measuring system should be sufficiently accurate and specified so that data derived from automated data gathering equipment (i.e.video logging, vans) will be compatible with data sets currently managed.

Roadway direction, dual highways, and reverse mile pointing

Some data sets at Deldot reference a point in the road, but do not specify what side of the road or direction that is being considered. For instance if an accident is reported an Road Number 34 at milepoint 1.3, that would not be enough information to say in what direction or lane it occurred in. In some databases this is handled by adding a DIRECTION field.

Where the roadway is a dual highway there have been two procedures to assign a milepoint. One method, that is the more generally accepted is assign measures to one side of the road, defined as the forward direction, and then at the end of the route (where the identifier changes) continue the numbering in the reverse direction. This is called reverse milepointing, and any point on a road is assigned a forward milepoint in one direction and a reverse milepoint in the other. Differences in measuring schemes were also noticed in data sets that were studied. For instance, in one case the numbering restarted a zero to measure the other side of the road, when the end of the forward direction of the road was reached.

Road Segmentation

How portions of roads are addressed in data sets in terms of where they begin and end forms the unit of analysis of the data set. Ideally, records in each data set would address the same road segments. Then with standard coding and formatting of route identifier, county identifier, and

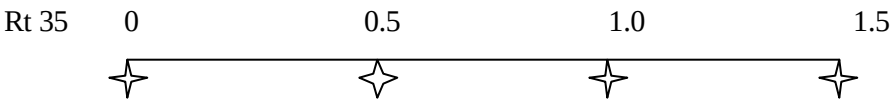
beginning and end mile points that would uniquely identify the road segment, a relationship could be defined in a relational database that would support a high degree of integration and flexibility in analysis. Guidelines and tools that would encourage a consistent segmentation would support integration. Such guidelines are not promoted at DELDOT at this time. When data sets do have a similar segmentation it is usually because they came from the same group or were derived from a particular data table template.

To better explain the issue of segmentation, consider an example of a route as described in the two data sets below. Suppose in an analysis you wanted examine the relationship of the number of accidents and AADT. The difference in how the two data sets organize information about Route 35 through the segmentation makes the analysis difficult. For instance, "What is the AADT for the portion of road between 0.25 and 0.8"? One could imagine doing a type of overlay, but the data is not directly comparable. If you then want to consider other factors such as

Data Set #1:

Route	Beg.Milepoint	End Milepoint	Traffic Volume (AADT)
35	0	.5	18,000
35	.5	1.0	25,000
35	1.0	1.5	21.000

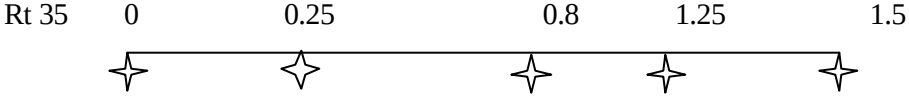
Data Set #1 Segmentation:



Data Set #2:

Route	Beg.Milepoint	End Milepoint	Number of Accidents per month
35	0	.25	40
35	0.25	.8	60
35	0.8	1.25	100
35	1.25	1.5	60

Data Set #2 Segmentation:



pavement friction, and speed from other route mile point databases using other segmentation schemes, the analysis gets considerably more difficult (if not impossible) and involves more assumptions beyond what is contained in the data, than if all of the data sets organized information about roads in the same manner. The segmentation forms the units of analysis. The difficulties that arise from having differing units of geographical analysis are the same as those that are encountered when, for instance, one tries to relate demographic data from two data sets where one addresses zip codes, and another planning districts and where the boundaries of the areas don't match. There would be various methods of overlays of areas and assumptions of the distribution of the demographics that could be used to perform the analysis, but the data could not be related directly, and the validity of the analysis would suffer since the assumptions would form a departure from the original units of the data.

Each record in a DELDOT data set about roads represents a particular road segment and each of the data sets studied had a different scheme for segmenting. The Tiger Line File for roads, segments roads at every physical feature such as intersections, railroads, or water bodies, changes in census geography, and political boundaries. The DELDOT Center Line File and the pavement management databases segment at each point where any road intersects with another. The ARAN data has a record for every tenth or one hundreth of a mile down the course of a road. The Road Inventory lists information at every point in a road where changes occur somehow, for instance where a shoulder begins or ends, a divide in the highway, a change of road classification, a bridge, a political boundary, or some other feature change. This meant that is was difficult to take one record from one data set and find the same road segment, as defined by route and beginning and end mile points, in another.

One approach to the problem of the many road segmentation schemes in use is to divide the road network into a large number of distinct, very small fixed length segments. The length of each of these micro segments would need to be small enough to accommodate the smallest interval of data collection, typically on the order of 0.01 mile. The benefit of this approach is that segments would never need to be subdivided in a fixed segment approach. Practically speaking this would create very large databases and a level of detail of data collection that is beyond the resources that are available.

Where possible and practical it would be beneficial to have a standard fixed segmentation scheme to collect data. Perhaps the most likely candidate would be to construct road segment records at sections between intersection or access points of local roads, similar to the manner in which the DelDOT Center Line is segmented. One segmentation scheme will never meet all needs however.

Historical considerations and changes to the road network

An accident could be located very accurately on a particular route and milepoint. If in later years the road is changed is some way, for instance, if it is realigned or shortened, then the roadway will be measured differently. Accidents located using milepoints from the old network would have to be adjusted to the new measurement scheme in order to correspond and be related to current data.. Unlike using a verticle and horizontal coordinate as provided by a GPS to locate the accident, a route milepoint measure depends on the roadway and the measurement system staying the same.

Proposed standard Roadway Reference System

A proposed standard for linear referencing is described as the Roadway Reference System in the project report of a 1992 DelDOT pavement management project[*]. The recommended referencing system for Delaware presented in the report was the subject of much discussion and was adopted as a standard scheme for specifying location references to satisfy the four objectives:

- Provide an unambiguous milepoint location reference along roadway
- Permit tracking of the changes or "evolution" of milepoint references over time due to alignment and other modifications along the roadway.
- Maintain compatibility with field milepoint measurements.
- Retain consistency with current DelDOT practice to the maximum extent possible.

The major data elements of the proposed Road Reference System are listed in figure 12.

[*] Pavement Management System for the State of Delaware, Project Report - Phase II, PCS/Law Engineering, November 1992, Appendix B

Figure 12, Major Elements of the Road Reference System from "Pavement Management for the State of Delaware'

Roadway Type - The type of roadway. Valid codes are: 1= State maintenance road (and Interstates); 2= Suburban development street;3= Municipal street;4= Ramp; 5= Other.

County - County in which the roadway lies. Valid codes are: 1=New Castle, 2=Kent, 3= Sussex.

Road Number - The DelDOT road number. Depending on Roadway Type, this will be either the state maintenance road number, the suburban development street number, the municipal street number, or the ramp number.

Roadway Identifier - A unique identification number for the roadway, assigned by the system at the time that the roadway is created. An internal identifier that is the route for all primary keys.

Roadway Status - A code designating whether the roadway record represents current, historical, or proposed data. Valid codes are: 1=In-service; 2=Abandoned (historical); 3=Under construction; 4= Approved future roadway (not yet built); 5=Proposed future roadway (but not officially improved); 6= Superseded. "Superseded" means that the roadway remains in service but that this roadway data record is been superseded by more current data; the old roadway record is retained in the database for historical purposes.

Divided Status - Divided status of roadway along a particular segment. 1=Undivided bidirectional; 2=Divided; 3=Unidirectional travel in the forward milepoint direction; and 4=Unidirectional travel in the reverse milepoint direction

Beginning Date: The effective starting date for the roadway data stored in the record

Ending Date: The effective ending date for the roadway data stored in this record. If the record represents current data, the ending date is a null value.

Milepoint Direction : Direction for increasing forward milepoint references for the roadway.

Beginning Milepoint : beginning milepoint of a segment. In historical segment databases there a distinction is made between new and old beginning milepoints.

Ending Milepoint : Ending milepoint of a segment. In historical segment databases there is a distinction is made between new and old ending milepoints.

The system has added complexity as it addresses a manner in which historical information about roads can be related to new information in the case where alignments change. It does this by keeping historical information in roadway and segment databases, and including dates of changes.

When this roadway reference system was proposed in 1992 there was considerable discussion among DelDOT staff, and at that time it was adopted as an agency standard. DelDOT IRM databases include features of the standard in how roads are identified and measured, but databases that would track changes have not been maintained.

Conclusions

Differences in how road information data sets identify roads and implement the linear referencing system impede integration. The Transportation Safety Group in the Intermodal Section of the Division of Planning have indicated that a lack of a consistent implementation of a standard road identification and referencing system causes great difficulty in being able to use and rely on information that they need for analysis of road sites. Access to data, and differences in data storage formats also cause problems.

IRM staff have an understanding of appropriate identification and referencing standards, but there seems to be some confusion or lack of awareness by those involved in the many applications in the Division of Planning. Division of Planning staff expressed a willingness to adopt and conform to standards, but direction and tools are needed to assist the effort. Even small improvements in the manner in which roads are identified in data sets could significantly improve integration to assist in using information beyond its use in a particular report or application.

A common need for planners is to be able to list road features and projects for a specific area of interest. A standard road referencing system allows for integration of information by location. Data for projects and any other transportation information should include a standard locational reference.

CHAPTER 7
CONCLUSIONS AND RECOMMENDATIONS

Main findings of the study

Traditional approaches to information systems at DelDOT have focused primarily on the operational aspects of data processing, and on specific computer programs and applications. Needs that are met by systems such as those for accounting, database maintenance, project tracking, or the preparation of standard reports for federal compliance, are generally well met by existing systems. Improvement is needed to meet information needs that are less predictable, that involve bringing information together from many sources, such as the analysis and presentation of transportation system enhancements, the effects of future growth and distributions of populations, and collection and analysis of information for project development. Interviews and the examination of systems conducted in this study indicated that improvements were needed in four primary areas for; better data integration, the ability to better find information, the ability to more easily access information, and determining direction of further development of geographical information systems (GIS) to meet analysis and presentation needs.

Rather than addressing issues by looking toward alterations in organizational structures, or whether systems should be more or less centralized or decentralized, this study and initiatives across the country suggest that issues are best approached by the application of standards and policies that promote better access, and current information technologies. Inter/Intranet technologies, use of network resources, GIS, and data warehouses are among technologies now within DelDOT's means to significantly improve information systems.

Primary goals of this research were to investigate and document the Division of Planning's needs and uses of information , and to provide a blueprint for activities that would provide near term improvement of information systems. Figure 13 summarizes suggested initiatives and organizes them into four categories according to the areas addressed. Initiatives are numbered to reflect the author’s attempt to rank them as to their relative importance (where a one is considered to be of

highest priority). Some of the initiatives have already begun to an extent, and priorities within the Department may fluctuate depending on project work, circumstances, or opportunities.

Figure 13, Summary of initiatives for near term improvement
(Initiative numbers are a ranking of importance suggested by the author)

Group 1: Data organization and access

Initiative 1: Meeting near term data access and publication needs
Initiative 3: Incorporate standards for the identification of transportation facilities and their attributes into Division of Planning data sets, and provide the data in standard formats.
Initiative 6: Identifying data storage resources and organization
Initiative 12: Implementation of a data warehouse
Initiative 14: Providing an on-line data dictionary
Initiative 18: Revisiting the Transportation Information Plan (TIP)

Group 2: Standard Identification and digital frameworks to reference transportation data

Initiative 2: Establish/reinforce identification standards for transportation facilities.
Initiative 4: Creation of a digital road network representation reflecting standard identification of transportation facilities.
Initiative 8: Provide user friendly tools to assist in using standard identification for roads.
Initiative 11: Online utility to log data errors and identify issues
Initiative 15: Standardization and integration of digital representations of transportation facilities
Initiative 16: Develop and maintain a road network model.

Group 3: Finding and documenting data

Initiative 9: Building data documentation and search capabilities.
Initiative 10: Become active in the Delaware Geographic Data Committee and the Delaware Spatial Data Clearinghouse

Group 4: Special Analysis and Information Technology Applications

Initiative 5: Mapping Projects
Initiative 7: IT support for the creation of the Hazardous Spot Location List (List 1) for

Transportation Safety
Initiative 13: Using images and video logs
Initiative 15: Address the need for dynamic segmentation and analysis capabilities
Initiative 17: Insure continued DelDOT support for the Safety Management Process

Initiative Descriptions by Category

Group 1: Data organization and access

Meeting near term data access and publication needs

Policies, procedures, and mechanisms for planners to access data should be reviewed with the goal being to provide more streamlined access to the data they need. Currently, planners are finding it difficult to access information about road features, accidents, and projects stored in centralized data resources. In some cases, personnel can get to the data, but there is difficulty using it. Access and a few basic database query and GIS mapping capabilities would contribute substantially toward meeting these needs. For example, being able to view a map of projects, accidents, and/or road features, or examine records for these data bases individually or in aggregate subject to some search condition. Regular dumps of data sets to a network data storage area, accompanied with policies for use of the data would be one such near term solution to existing access difficulties.

Incorporate standards for the identification of transportation facilities and their attributes into Division of Planning data sets, and provide the data in standard formats.

As an initial step to making data more easily integrated, standards for the identification of transportation facilities and their attributes should be incorporated in Division of Planning data sets. Specifically road and route identification, and official road measurements should be used in data sets to allow information to be more easily related across data sets. Data sets should be provided on the Planning Intranet in standard data formats (e.g. Access, Oracle) available to all planning staff and other DelDOT sections.

Identifying data storage resources and organization

Currently most data for the Division of Planning has been stored on NT Servers and organized by Planning Section (i.e. Project Development, T-Squared Center, Transportation Planning and Research) then by software application (Excel, Access, TranPlan), then by user. GIS data is generally organized by software platform (MapInfo or Geomedia), then data type (table, workspace, query) and then by geographic area (county, Statewide). Other methods of organizing data holdings on the servers have evolved over the years. There is no stable data library or organization for data that exists, or that has been suggested. Network administrators working with data system users have developed an informal organization that allows individuals to find their information and allow for efficient preservation of the information. If an individual wishes to use information managed by another, a contact is made and the data is transferred from one users project space to another.

In terms of building a comprehensive transportation database or repository, and in terms of coordinating the efforts of a large group of users, there is a question as to whether there is a better strategy for the organization and storage of information. Other methods of organizing information such as organizing information by its relationships to transportation agency functions (e.g. travel demand, supply, performance, and impacts) may have advantages over an organization by group, individual, or software application. This initiative would examine alternative methods of organizing information.

Investigating the implementation of a data warehouse.

Data warehousing is a recent information technology concept that supports information processing by addressing integration of data, easier access and analysis of information, data integrity, and the need for cross-functional analysis. The steps in developing a data warehouse involve:

1) Policies to determine what information will be included, how it will be maintained, and how users will access data.
2) Transformation of data to insure quality, consistency, and usability.

3) Storage strategies to maximize system flexibility, manageability, and overall accessibility.
4) Analytical capabilities to do modeling, computation, and "what if" analysis on large data volumes in a multi-user environment.
5) Access capabilities to select, view, and manipulate information.

The concept of a data warehouse is not simply accumulating data, and when implemented for an entire transportation agency can require commitment and extensive resources.

DELDOT IRM currently is undertaking a data warehousing project. As part of this initiative, it is suggested that the Division of Planning gain a better understanding of this effort, how it could support their needs, and how they can become involved in the design and operation of the data warehouse. Work in this initiative would be focused on the performance of the five steps mentioned above.

Providing an on-line data dictionary

A data dictionary is available on the Adabase system in IRM, but is not accessible through personal computers in Planning or through the Intranet. Standards for the format of identification fields and other attributes could be relayed to personnel it they were described in a data dictionary that was available on-line or at least as a continually updated hard copy document.

Revisiting the Transportation Information Plan (TIP)

The current TIP was presented in January 1992. Entities, activities, and responsibilities as pertain to the Division of Planning should be reexamined toward identifying updates or improvements that would allow the TIP to assist with current needs and issues.

Group 2: Standard Identification and digital frameworks to reference transportation data

Establish/reinforce identification standards for transportation facilities.

Much of DELDOT's information is data about transportation facilities and much of the difficulty in relating and integrating information across data sets that are used and managed in the Division of Planning has to do with inconsistencies in the identification of transportation facilities. Standards for the identification of transportation facilities should be clear, and there should be support and tools to insure that data is referenced in a standard way. Standards to support and conform to agency wide standards should be established or reinforced for the following areas:

Road/Route identifiers, including County, municipal, and suburban roads
County Identifiers
Official measures / mile points
Road segmentation schemes
Road Direction conventions
Intersections
Ramps
Access points
Transit routes
Transit stops

Any data set prepared in the Division of Planning should include standard identification schemes.

Creation of a digital road network representation reflecting standard identification of transportation facilities

In the past official road maps and the Road Inventory embodied the standard for the identification and location of transportation facilities. With the growing use of geographical information systems (GIS) it is more common and efficient for users to interact with transportation data through computerized representations. Project Development, and travel demand forecasting, as well the applications of the Planning Cartographic Section and GIS group, all use digital road models in their work. A digital version of the transportation network that accurately depicts location, identifiers, and measures for roads, forms a framework to reference a wide array of data.

The Center Line file created in DELDOT IRM serves as an excellent start. Currently it is undergoing a revision to correct mile point references. When it is completed, the Division of Planning should review it carefully to help in identifying any errors or issues in its use. The file should be subject to continuous review and update by a designated group in DELDOT, and efficient maintenance procedures should be supported to obtain the highest quality and accuracy. Future versions should add to its usefulness by including items such as address ranges, access and intersection identification points, and impedance (link, intersection, and turning impedance as used in routing applications).

As a standard, the digital road network and attribute data need not, and should not be tied to specific software and should be made easily available by anyone. At a minimum, current versions should be available in INTERGRAPH MGE, GEOMEDIA, MAPINFO, ARC/INFO, and ARC/VIEW formats, and should be documented and contributed to the Delaware Spatial Data Clearinghouse and updated on a regular basis.

Provide user friendly tools to assist in using standard identification for roads

Some operations within DELDOT employ methods for identifying roads or setting mile points using different methods. A standard, regardless of its general usefulness, may not be easy to use by personnel to implement. For instance the use of the ROADWAY ID to identify County, Municipal, and Suburban roads may have advantages as a primary identifier for roads, but is awkward to use if one is accustomed to identifying roads by their road name (e.g. Main Street) or by the maintenance road. Utilities that would help personnel standardize around one method of identification or mile pointing would support the standard.

Suggested utilities would be simple cross index tables, easy to use relational database system forms that would allow users to determine standard route and measure information, and GIS based graphical utilities that would allow users to locate identification information by searching a computerized map.

Online utility to log data errors and identify issues

Interviews with personnel indicate that when using various data products they have noticed errors, and cases where data is out of date. An on-line utility to document errors in DELDOT data would assist those who have the responsibility to maintain it. A procedure to review error logs and distribute the information to the appropriate contact would also be needed.

Standardization and integration of digital representations of transportation facilities.

The IRM Center Line file in its current state does not support all GIS and analysis needs of the Division of Planning. In addition to the Road Inventory, historical development of information systems and various work products have led to the creation of four different digital representations of the road network (see figure 2).

Figure 2, Digital Representations of the Road Network at DELDOT

Name	Source Scale	Use	Road Segment Identifier
Cartographic Base Map	24,000	Mapping Products	Internal Identifier
DELDOT Center Line File	12,000	Accurate Linear Referencing Network	Roadway ID, Beg/End Mile Point
Street Info File	100,000	GIS products for Planning, address matching	Internal Identifier
TRANPLAN Network Nodes	100,000	Travel Demand Forecasting Model	Link ID from Beg/End

Each one of these representations is updated and maintained independently by sections in the Department and serve as a framework to reference data about transportation facilities. Differences in the cartographic accuracy, the types of information represented, how roads are segmented and identified, and the purpose that they were designed for, make it difficult (and sometimes undesirable) to integrate these products. Graphic features (text, road signs, special symbols) designed for one of these road network representations are generally not usable in another because they will not overlay properly due to differences in accuracy.

An “ideal” road system representation for use in Planning applications, would have the following key features:

- The greatest positional accuracy
- Address matching capabilities

- Support for linear referencing and dynamic segmentation
- A standard method of identifying roads
- Extensive text layers and graphics for high quality cartographic products
- An efficient and continuous update procedure
- Versions readily available in standard formats to encourage the use of a standard and accurate representation
- Associations with databases which contain information about roads and portions of roads

The current digital representations of roads (figure 2) have some but not all of these features. Ideally it would be desirable if efforts could be focused on the development and maintenance of one representation. If for instance, address matching capabilities could be added to the Center Line as well as high quality graphics layers, then perhaps the Center Line file could serve most uses. Each of the representations serve the applications they were developed for well, though data tied to each representation is not easily shared.

The desirability of integrating these representations and the extent that it is possible should be considered as part of this initiative with the focus placed on the costs and benefits of integration with particular emphasis on maintenance and update issues. At a minimum ,each representation should reflect standard methods for identification of transportation facilities and should be made available in compatible software formats so that transfer of data is facilitated. An initial step has been taken by the Department of Planning in a project focused on insuring that the Street Info file references correct route names and mile point measures.

Develop and maintain a road network model.

The road network model used by TRANPLAN is an example of a more detailed representation of roads that specifies impedance (typically in units of time) to travel along a section of road and the descriptions of various turn options and impedances at intersections. Such a network model allows the travel demand forecasting models to perform gravity modeling by specifying the paths and time needed for trips. Other applications include the determination of optimum routes for the delivery of services, optimum locations of service centers, and when intersections are linked to detailed signal settings, a number of signal performance simulations. Such models have been

developed for some Delaware roads by researchers though never incorporated into DELDOT information systems.

It is suggested that the Division of Planning support the further development of the digital road network representation to include detailed information about link and turning impedances, access points, signals, and intersection characteristics. Such enhancements would provide a most detailed representation of transportation facilities to support analysis, and would provide a foundation for research and evaluation of travel performance enhancements. Researchers and consultants would be able to build on this road network model rather than having to regenerate it for each study. Access points could be linked to trip generation data to better model the relationship between travel supply and demand. A suggested method to proceed is to first specify the data structures for what will be modeled (access points, intersections, turns, etc.), and then initiate a research project to develop and demonstrate applications of the network model.

Group 3: Finding and documenting data

Building data documentation and search capabilities.

Interviews in Planning stressed the need to be able to more easily locate and access data**.** The current information organization is distributed across users, and to find and access information requires that one questions and makes arrangements with individual users. Intranet search tools are now available on the Division of Planning Intranet to allow users to search for information on specific topics such as "traffic counts" or "pedestrian safety" that are referenced in data holdings. The technology is based on software that can index topics within data on servers and then provide pointers to that data in answer to data queries. Easy methods are available to personnel to document and reference data of all types, and make them available to those looking for the information.

It is suggested that training be provided to personnel to acquaint them with the data search technology and to show them how they can reference their data..

Become active in the Delaware Geographic Data Committee and the Delaware Spatial Data Clearinghouse

Interviews with Division of Planning personnel expressed a need to more easily find and obtain information. This year through House Bill 395 , the Delaware Geographic Data Committee (DGDC) was established as a cooperative effort among state agencies, state-funded agencies, the University of Delaware, county and municipal governments, and others to improve the coordination of the use of Geographic Information Systems (GIS) and geo-referenced data. With the support of DGDC, the Federal Geographic Data Committee, the University of Delaware, the Office of State Planning Coordination, and over two dozen State and local agencies, the Delaware Spatial Data Clearinghouse (www.nsdi.udel.edu) is being established as means to reference and distribute spatial data. As much of the information that is used by the Division of Planning is spatial data (as is most transportation data) these efforts are very relevant. To succeed they need the participation and contribution from State and local agencies, and in particular DELDOT.

The Division of Planning and IRM have both offered letters of support that were instrumental in securing federal funding for the effort, and have offered to supply data to the Clearinghouse. It is suggested that DELDOT take a very active role in DGDC and in supplying "official" transportation data to the Clearinghouse. The DGDC could be used as a mechanism for the strategic acquisition and maintenance of data that could be used by many State agencies. The Clearinghouse could provide a very efficient mechanism for the distribution of a range of transportation data.

Group 4: Special Analysis and Information Technology Applications

Mapping Project Data

Much of the Division of Planning's work revolves around the development, implementation, and evaluation of transportation system enhancement projects. A capability desired by several groups in the Division is to be able to map past, current, and proposed future projects in a given area. This initiative would focus around identifying sources of project data, and determining what needs to be done in terms of preparation of project databases, and GIS, so that mapping available data

can be accomplished to some extent by any group in the Division. A pilot effort to map projects to support the Project Pipeline and the Highway Safety Improvement Program is suggested.

Using images and video logs

Prepare a simple cataloging and viewing capability for image data. Design a small effort to view existing image data such as scans of hard copy files or digital photography. This could be in the context of recent video logging pilot projects now being conducted at DelDOT, or as a means to investigate how accident reports or project files could be more easily accessed.

Information Technology support for the creation of the Hazardous Spot Location List (LIST 1 of the Highway Safety Improvement Program) for the Transportation Safety Group

The Transportation Safety Group has developed a successful systematic methodology to identify and specify project for inclusion in the yearly Highway Safety Monitoring Program (HSIP). The HSIP proceeds from the General Accident Listing to a list of Hazardous Spot Locations (LIST 1) that is an ordered list describing the most hazardous areas as indicated by the number of accidents and Critical Accident Ratios. Also included in the Hazardous Spot Locations are references to existing HSIP and other projects that are underway for roadways in the State. Through safety audits, studies, and communications within the Department, as well as coordination with the Project Pipeline Process and the Project Development Section, the Hazardous Spot Location list evolves into the final yearly HSIP project list. This is an intensive process that can take 4 months or more work from Transportation Safety Group staff. Much of the data included is available in existing databases that now must be extracted by a mostly manual process, and it is suspected that some of the work could be significantly reduced (by 50% or more) by using more automated methods to scan and extract data from accident, road inventory, and project databases.
It is recommended that a pilot project be initiated to determine what portions of the work can be automated, and to determine the features of the databases that would support the automation.

Address the need for dynamic segmentation and analysis capabilities

Much of the information that Division of Planning uses is referenced to road sections such as traffic counts, projected volumes, pavement condition, safety projects, and capacity. Information about these road sections are in data tables that reference the route, and beginning and end mile points. In a similar way information such as locations of accidents and transportation facilities (e.g. signs, access points, bus stops) can be referenced as a point location identified by a route and mile point. Dynamic segmentation in GIS is a very powerful tool to display and analyze route and mile point data. Dynamic segmentation is currently not an included feature in MapInfo GIS software.

It is suggested that Division of Planning personnel examine the types of analysis that can be accomplished using dynamic segmentation, and address how in the future they may obtain the capability. There are some capabilities now available with Intergraph software that could be investigated.

Insure continued DelDOT support for the Safety Management Process

The Delaware Safety Management Process (SMP) is a current program sponsored by the Delaware Office of Public Safety and the Delaware Department of Transportation (DelDOT through IRM). Its mission is to maximize the safety of Delaware's transportation system, and it is currently focused on advances in crash data collection and reporting. The primary, short-term focus of the Delaware SMP is to design and carry out pilot projects for making improvements to crash data collecting and reporting through standards and information technology. DOT's across the country are pursuing automated accident data collection tools to provide accurate and timely data to analysts and assistance to police in the field.

The Office of Public Safety is depending on DelDOT to support information management components of the SMP. It is in the interests of the Division of Planning to become familiar with the SMP and support it to the extent that it can assist with the clerical demands on the maintenance of the Accident Database and the analysis needs of the Transportation Safety Group.

APPENDIX A

Example Of Metadata for the DelDOT Center Line File

Example Metadata for the DELDOT Center Line File for New Castle County

Metadata:

Identification_Information
Data_Quality_Information
Spatial_Data_Organization_Information
Spatial_Reference_Information
Entity_and_Attribute_Information
Distribution_Information
Metadata_Reference_Information

Identification_Information:
Citation:
Citation_Information:
Originator: Delaware Department of Transportation

Publication_Date: 19960801
Title: DELDOT Center Line File for New Castle County
Edition: Summer96
Geospatial_Data_Presentation_Form: map
Series_Information:
Series_Name: DELDOT Center Line Clearinghouse Set
Issue_Identification: Clearinghouse Series 1a
Publication_Information:
Publication_Place: Dover, Delaware
Publisher: DELDOT
Other_Citation_Details: Developed as part of NSDI-CCAP 96
Online_Linkage:
Online Help Note<URL:http://www.nsdi.udel.edu/cline/transfer.txt>
Online_Linkage: Sample Graphic<URL:http://www.nsdi.udel.edu/cline/clinenc.gif>
Online_Linkage:
Retrieve Data (1.8MB zip file, 14MB ARC/INFO export file)<URL:ftp://ftp.nsdi.udel.edu/nsdi/cline/clinenc.zip>
Larger_Work_Citation:
Citation_Information:
Originator: DELDOT
Title: DELDOT Center Line File
Edition: Summer96
Publication_Date: 19960801

Description:

Abstract:

The DELDOT Center Line File forms an official representation of most roads in Delaware. A route system is defined which forms the framework for linear referencing of spatial features and events on the road network by specifying route identifier and mile point. Also contains railroads and municipal boundaries. Road center lines match roads as shown on the Spring 1992 Orthophotography for Delaware. This version was translated from InterGraph at the Center for Applied Demography and Survey Research at the University of Delaware as part of a demonstration of Spatial Data Clearinghouses for the Federal Geographic Data Committee(FGDC).

Purpose:

Useful for linear referencing of data for roads, and as a base map for geographical information system applications.

Time_Period_of_Content:

Time_Period_Information:

Single_Date/Time:

Calendar_Date: 19960801

Currentness_Reference: publication date

Status:

Progress: Complete

Maintenance_and_Update_Frequency: Annually

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: -75.7988

East_Bounding_Coordinate: -75.4100

North_Bounding_Coordinate: 39.8460

South_Bounding_Coordinate: 39.2863

Keywords:

Theme:

Theme_Keyword_Thesaurus: Delaware Spatial Data Clearinghouse Themes

Theme_Keyword: Center Line File

Theme_Keyword: roads

Theme_Keyword: railroads

Theme_Keyword: base map

Place:

Place_Keyword_Thesaurus: Delaware Spatial Data Clearinghouse Places

Place_Keyword: New_Castle_County

Place_Keyword: Delaware

Temporal:

Temporal_Keyword_Thesaurus: None

Temporal_Keyword: Summer of 1996

Access_Constraints: None

Use_Constraints:

DELDOT IRM should be notified if data is to be used in any project. Errors do exist in the data. The data set is not complete.

Point_of_Contact:

Contact_Information:
Contact_Person_Primary:
Contact_Person: I.Kenneth Richter
Contact_Organization: DELDOT Information Resources Management (IRM)
Contact_Position: IRM GIS Manager
Contact_Address:
Address_Type: mailing address
Address: DELDOT, P.O.Box 778
City: Dover
State_or_Province: DE
Postal_Code: 19903
Country: USA
Contact_Voice_Telephone: 302 739-4095
Contact_Facsimile_Telephone: 302 739-6119
Contact_Electronic_Mail_Address: ken@smtp.dot.state.de.us
Hours_of_Service: Weekdays 9-5
Browse_Graphic:
Browse_Graphic_File_Name: <URL:http://www.nsdi.udel.edu/cline/clinenc.gif>
Browse_Graphic_File_Description: View of data set.
Browse_Graphic_File_Type: GIF
Data_Set_Credit: InterGraph Design File and Related Attribute Tables
Native_Data_Set_Environment: Windows - NT
Cross_Reference:
Citation_Information:
Originator: DELDOT
Publication_Date: 19980801
Title: DELDOT Center Line File
Geospatial_Data_Presentation_Form: map
Publication_Information:
Publication_Place: Dover,DE
Publisher: DELDOT
Other_Citation_Details:
The Center Line File is available for all areas in Delaware.

Data_Quality_Information:
Attribute_Accuracy:
Quantitative_Attribute_Accuracy_Assessment:
Attribute_Accuracy_Value:
Most roads have complete and correct attributes. Beginning and end mile points were derived from the DELDOT Road
Inventory. Some minor roads, railroads, and incorporated area boundaries, do not have attributes.
Attribute_Accuracy_Explanation: Relation Database Operations and Review of data set.
Attribute_Accuracy_Report: General Review, No Report
Logical_Consistency_Report: At least 95% Accurate

Completeness_Report:
Some minor roads are not in the data set. Some municipal boundaries are out of date.
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Quantitative_Horizontal_Positional_Accuracy_Assessment:
Horizontal_Positional_Accuracy_Value: 5
Horizontal_Positional_Accuracy_Explanation: Comparison with Orthophotography
Horizontal_Positional_Accuracy_Report: Resolution as reported.
Lineage:
Source_Information:
Type_of_Source_Media: paper
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 19960801
Source_Currentness_Reference: publication date
Source_Citation_Abbreviation: DELDOT Road Inventory
Source_Contribution: Roads, beginning and end mile points
Source_Citation:
Citation_Information:
Originator: DELDOT
Title: DELDOT Road Inventory
Publication_Date: Unknown
Source_Scale_Denominator: 8000
Source_Information:
Type_of_Source_Media: GIS file
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 19950801
Source_Currentness_Reference: publication date
Source_Citation_Abbreviation: DELDOT 24,000 Cartographic Base
Source_Contribution: Roads, railroads, municipal boundaries
Source_Citation:
Citation_Information:
Originator: DELDOT Cartographic Section
Title: DELDOT 24,000 Scale Cartographic Base.
Publication_Date: Unknown
Source_Scale_Denominator: 24000
Source_Information:
Type_of_Source_Media: digital orthophotography
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 19920301
Source_Currentness_Reference: publication date
Source_Citation_Abbreviation: Digital Orthophotography for Delaware
Source_Contribution: Accurate placement of all map features.

Source_Citation:
Citation_Information:
Originator: State of Delaware
Title: Spring 1992 Digital Orthophotography for Delaware
Other_Citation_Details: See Cross Reference
Publication_Date: 19960601
Source_Scale_Denominator: 12000
Process_Step:
Process_Description:
DELDOT Cartographic Base registered to Delaware State Plane coordinates.
Process_Date: 19950601
Process_Step:
Process_Description: Road center lines aligned to digital orthophotography
Process_Date: 19950601
Process_Step:
Process_Description: Mile point attributes placed on road segments
Process_Date: 19960601

Spatial_Data_Organization_Information:
Indirect_Spatial_Reference: Roadways of Delaware
Direct_Spatial_Reference_Method: Vector

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
State_Plane_Coordinate_System:
SPCS_Zone_Identifier: 3551
Transverse_Mercator:
Longitude_of_Central_Meridian: 75 25 00
Latitude_of_Projection_Origin: 38 00 00
False_Easting: 200000
False_Northing: 0
Scale_Factor_at_Central_Meridian: 1,200,000
Grid_Coordinate_System_Name: State Plane Coordinate System 1983
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Planar_Distance_Units: meters
Distance_and_Bearing_Representation:
Distance_Resolution: 150
Bearing_Resolution: 30
Bearing_Units: Decimal degrees
Bearing_Reference_Direction: North
Bearing_Reference_Meridian: Geodetic

Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6000000,378,137.meters exact
Denominator_of_Flattening_Ratio: 298.25722210088

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: clinenc.pat
Entity_Type_Definition: Polygon Attribute Table for clinenc
Entity_Type_Definition_Source: Center for Applied Demography and Survey Research
Attribute:
Attribute_Label: fnode#,tnode#,lpoly#,rpoly#,nc#,nc-id
Attribute_Definition:
Internal coordinate feature management use by ARC/INFO line layers
Attribute_Definition_Source: Computed
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Positive Real Numbers
Enumerated_Domain_Value_Definition: Coordinate management
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 0
Attribute_Value_Accuracy_Explanation:
These values are generated by the system and form a consistent coordinate management scheme with zero error as
they are computed and somewhat arbitrary.
Attribute_Domain_Values:
Range_Domain:
Attribute_Units_of_Measure: NA
Attribute:
Attribute_Label: LENGTH
Attribute_Definition: Length of road segment in meters.
Attribute_Definition_Source: Computed
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Positive Real Numbers
Enumerated_Domain_Value_Definition: Length in Meters
Enumerated_Domain_Value_Definition_Source: NA
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 20
Attribute_Value_Accuracy_Explanation:
+ or - 20 meters from actual road length. In previous tests LENGTH was used to calculate mile points. Known mile

points of intersections were within 1/100th of a mile of known mile point. Note this value is a 2 dimensional length and
will be less accurate where road changes elevation significantly. In the future this value should be replaced with road
inventory lengths.
Attribute_Domain_Values:
Range_Domain:
Attribute_Units_of_Measure: Meters
Attribute:
Attribute_Label: IGDS-LEVEL
Attribute_Definition: Number for each different data layer, used to seperate layers.
Attribute_Definition_Source: DELDOT
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Positive integers
Enumerated_Domain_Value_Definition: Intergraph Design File Layer Number
Enumerated_Domain_Value_Definition_Source: DELDOT IRM
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 100
Attribute_Value_Accuracy_Explanation: Percentage Correct
Attribute:
Attribute_Label: IGDS-COLOR,IGDS-STYLE,IGDS-WEIGHT
Attribute_Definition: InterGraph Design File Attributes
Attribute_Definition_Source: DELDOT
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: positive integers
Enumerated_Domain_Value_Definition: Intergraph Design File Layer Number
Enumerated_Domain_Value_Definition_Source: DELDOT IRM
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 100
Attribute_Value_Accuracy_Explanation: Percentage Correct
Attribute:
Attribute_Label: MSLINK
Attribute_Definition: Internal InterGraph numeric link identifier to attribute tables
Attribute_Definition_Source: Generated within InterGraph
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Positive Real Numbers
Enumerated_Domain_Value_Definition:
Graphic feature internal numeric identifier, used to link to attribute tables.
Enumerated_Domain_Value_Definition_Source: Software assigned
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 100
Attribute_Value_Accuracy_Explanation: percentage correct where mslink not equal to zero
Attribute:
Attribute_Label: RDWAYID

Attribute_Definition: Primary numeric identifier for routes used by DELDOT IRM
Attribute_Definition_Source: DELDOT IRM
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Positive Integers
Enumerated_Domain_Value_Definition: Numeric route identifier
Enumerated_Domain_Value_Definition_Source: DELDOT IRM
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 90
Attribute_Value_Accuracy_Explanation: percentage correct where rdwayid not equal to zero
Attribute:
Attribute_Label: BEGMP
Attribute_Definition: Beginning Mile Point of road segment on rdwayid route.
Attribute_Definition_Source: DELDOT
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Positive Real Numbers, 2 decimal points
Enumerated_Domain_Value_Definition: Route beginning mile point
Enumerated_Domain_Value_Definition_Source: DELDOT
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 60
Attribute_Value_Accuracy_Explanation:
percentage correct where rdwayid not equal to zero Errors in this attribute due to data conversion are suspected.
Attribute_Domain_Values:
Range_Domain:
Attribute_Units_of_Measure: miles, 2 decimal points
Attribute:
Attribute_Label: ENDMP
Attribute_Definition: End Mile Point of road segment on rdwayid route.
Attribute_Definition_Source: DELDOT
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Positive Real Numbers, 2 decimal points
Enumerated_Domain_Value_Definition: Route end mile point
Enumerated_Domain_Value_Definition_Source: DELDOT
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 60
Attribute_Value_Accuracy_Explanation:
percentage correct where rdwayid not equal to zero Errors in this attribute due to data conversion are suspected.
Attribute_Domain_Values:
Range_Domain:
Attribute_Units_of_Measure: miles, 2 decimal points
Attribute:
Attribute_Label: MNTRD
Attribute_Definition: Route identifier as used in DELDOT Traffic Counts

Attribute_Definition_Source: DELDOT
Attribute_Domain_Values:
Codeset_Domain:
Codeset_Name: Maintenance Roads in Delaware
Codeset_Source: DELDOT
Attribute_Value_Accuracy_Information:
Attribute_Value_Accuracy: 90
Attribute_Value_Accuracy_Explanation: percentage correct where rdwayid not equal to zero

Overview_Description:
Entity_and_Attribute_Overview:
This version of the center line is made up of several data layers which correspond to various classes of roads or other data. Use
IGDS-LEVEL to seperate these layers. RDWAYID is a numeric identifier for routes and MNTRD is the alphanumeric route
identifier as used in DELDOT traffic counts. ENDMP and BEGMP may be incorrect due to conversion errors.
Entity_and_Attribute_Detail_Citation: See Polygon Attribute table for field definitions

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: I.Kenneth Richter
Contact_Organization: DELDOT Information Resources Management (IRM)
Contact_Position: IRM GIS Manager
Contact_Address:
Address_Type: mailing address
Address: DELDOT, P.O.Box 778
City: Dover
State_or_Province: DE
Postal_Code: 19903
Country: USA
Contact_Voice_Telephone: 302 739-4095
Contact_Facsimile_Telephone: 302 739-6119
Contact_Electronic_Mail_Address: ken@smtp.dot.state.de.us
Hours_of_Service: Weekdays 9-5
Resource_Description: DELDOT Center Line File
Distribution_Liability: None
Standard_Order_Process:
Fees: No Charge
Non-digital_Form:
This file can be obtained in InterGraph format by making arrangements with DELDOT IRM. An online version in ARCINFO
format can be downloaded now. See FTP reference above.

Technical_Prerequisites:
For use in other GIS than ARC/INFO obtain a translator utility which will convert an ARC/INFO export file (.E00)
Available_Time_Period:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 19970119

Metadata_Reference_Information:
Metadata_Date: 19970521
Metadata_Review_Date: 19970119
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: David Racca
Contact_Organization:
Center for Applied Demography and Survey Research, University of Delaware
Contact_Position: Associate Policy Scientist
Contact_Address:
Address_Type: mailing address
Address: 284 Graham Hall
City: Newark
State_or_Province: DE
Postal_Code: 19716-7330
Country: USA
Contact_Voice_Telephone: 302 831-1698
Contact_Facsimile_Telephone: 302 831-3587
Contact_Electronic_Mail_Address: dracca@udel.edu
Hours_of_Service: Weekdays 9-5
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998

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