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Assessment of MoDOT's Transportation Management Systems
Part II

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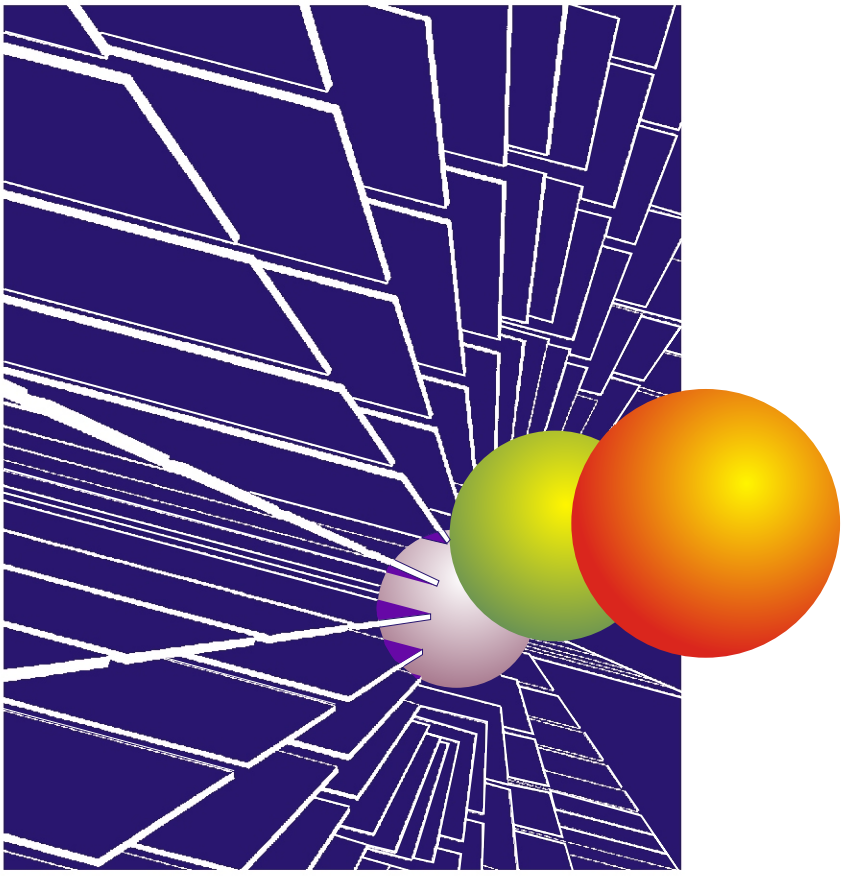

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16. Abstract

Management of the Missouri Department of Transportation (MoDOT) desired a high level evaluation of the existing Transportation Management Systems (TMS) to address the following questions with respect to TMS: What do we have? How are we using it? Is it helping us? What could we do better?

Interviews of 57 individuals throughout MoDOT management and TMS users were conducted to determine the current status, strengths and weaknesses of MoDOT's existing Transportation Management System and provides an analysis of how this system serves MoDOT. Based on the interviews it was found that TMS use varied widely depending on user confidence in the data, degree to which TMS provided the data the user needed, degree to which TMS supported the applications needed, and the degree to which the user found the interaction with TMS efficient.

Overall, it was concluded that TMS is not supporting decision making to the extent that it is capable. Primary recommendations for improving TMS include: re-evaluation of the focus, scope, and objectives of TMS, resolution of data issues, creation of a data maintenance process, marketing of TMS capabilities within MoDOT, improved communication with TMS users, and resolution of TMS budget/control. Secondary recommendations include: improving user-interface, move to GSP locations referencing system, improved TMS training, Web-enable TMS, add decision support systems, and integration of TMS data.

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Final Report

RI01-046B

Assessment of MoDOT'S Transportation Management Systems

MISSOURI DEPARTMENT OF TRANSPORTATION
RESEARCH, DEVELOPMENT AND TECHNOLOGY

BY:
James S. Noble, Ph.D., P.E.
Charles Nemmers, P.E.
Cerry M. Klein, Ph.D.

JEFFERSON CITY, MISSOURI
DATE SUBMITTED: December 31, 2003

Executive Summary

Assessment of MoDOT'S Transportation Management Systems

MoDOT's Transportation Management System (TMS) has required a significant investment in time and resources over the past 10 years. TMS was designed to collect, organize and process data into information that could then be used to support many of the decisions made within MoDOT. It was envisioned that once implemented TMS would increase operational efficiency by 10-15% and improve the use of transportation resources by 1-5%. However, the attainment of this vision has been hindered by the fact that TMS is often both misunderstood and underutilized. The MoDOT TMS is based on an excellent foundation and an excellent support team has been established. In order to determine how to move TMS to the next level this study was initiated by MoDOT management to determine with respect to TMS: What do we have? How are we using it? Is it helping us? What could we do better?

The study is based on a multi-level sampling approach (of 57 individuals throughout MoDOT management and TMS users) to determine the current status, strengths and weaknesses of MoDOT's existing Transportation Management System and provides an analysis of how this system serves MoDOT. A systems engineering analysis is conducted to determine disparities between MoDOT current practices, other DOT state-of-the-art practices, and MoDOT's desired decision support capability. Better and more informed decision-making should be possible as a result of this fundamental assessment of MoDOT's management systems.

Objective #1 - What does TMS currently have?

TMS currently has three primary components: data inventory, report generation capability, and data analysis capability. These components are embedded within six system modules: Pavement Management System, Bridge Management System, Traffic Management System, Safety Management System, Travelways, and State-of-the-System.

Objective #2 - How is TMS being used?

The interview responses were summarized with respect to:

- Overall Use – the degree to which TMS is used to support job decisions.
- Data Confidence – user confidence in data accuracy to support job responsibilities.
- Data Availability – the availability within TMS of data needed to support job responsibilities.
- Desired Applications – the degree to which TMS contains applications necessary to perform job responsibilities.
- Ease of Interaction – user experience when interacting with TMS.

Of these, "Overall Use" provides the most insight into how effective TMS is being used to supporting various decision making needs:

- High use was found in – GHQ Planning, GHQ Traffic/Safety, GHQ Adopt-A-Highway, District Planning, and District Operations/Traffic.

- Medium use was found in – GHQ Design Bridge / Inspection, GHQ Right of Way, GHQ Research, and District Management.
- Low or no use was found in – GHQ Project Development Management, GHQ Design, GHQ Operations Management, GHQ Maintenance, GHQ Motor Carrier Permitting, GHQ Risk Management, GHQ Legal and District Design, Construction and Maintenance.

It must be stressed that sometimes interviewees had perceptions of either the data or applications in TMS that did not match with the current state of TMS implementation. However, this fact does not diminish the significance of the findings of this study. All user and management perceptions, whether accurate or not, impact the overall effectiveness of TMS to support TMS decision making and need to be addressed.

Therefore, there is a two-fold answer to the question of "How TMS is being used?" First, it is only being used by a subset of those who should find value in TMS. Second, of those that do use TMS it is primarily used as a data warehouse to support the generation of reports relevant to overall analysis of the MoDOT transportation network (i.e. planning functions and some operations functions) versus more detailed analysis (i.e. design).

Objective #3 - Is TMS helping make better decisions?

Some functional areas are using TMS extensively and as a result have improved decision making ability: GHQ Planning, GHQ Traffic, GHQ Adopt-A-Highway, District Planning, and District Operations/Traffic. Some functional areas are using TMS little, if at all – GHQ Design, GHQ Maintenance, GHQ Risk Management, and District Design. Are better decisions being made? In general, it was found that the closer you get to a decision maker (i.e. GHQ management or Districts) the less data from TMS is being used to support decisions and hence it is not helping to make better decisions. The factors that lead to this conclusion are presented in the following.

1) The scope and objectives of TMS have fallen victim to "mission creep." TMS's focus is not well defined.
2) There is a "cry" from the users to "GET THE DATA CORRECT." Overall confidence in TMS is undermined by both actual and perceived data accuracy and data availability.
3) The system appears to be more tied to what was (ex. "data is the same as before"), than to what could be with respect to data contents and capability (ex. GIS/GPS, Web-applications, etc.)
4) The continuous log mile system is not working and is a source of data errors.
5) While the TMS is incrementally getting better, it still does not serve the users inside of MoDOT sufficiently and doesn't serve at all those outside of MoDOT.
6) The ownership of TMS must be resolved. Is data going to be a MoDOT corporate asset?
7) There is a need for both education on what TMS can currently do for individuals throughout MoDOT and training on how to use current TMS capabilities for TMS Users.

Overall, TMS is not supporting decision making to the extent that it is capable. Currently, TMS is primarily a data warehouse that needs to be refined and refurbished. Once the basic system issues are addressed, then decision support tools can be incorporated that allow for forecasting,

what-if analysis, etc. Only then will the data be able to empower decision makers to use decision tools that support making decisions that can be measured and validated.

Objective #4 - How could TMS be improved?

The following recommendations are based on the data collected during this research, as well as a review of past documentation related to TMS and best management information system practices. This analysis was conducted at a high-level due to the short study time frame and some of the recommendations might warrant a more detailed-level, intensive analysis. However, regardless of the level of analysis there are several issues that stand out and need to be addressed.

Immediate Needs

1) The focus, scope, and objectives of TMS need to be re-evaluated and clearly defined.
2) Several issues related to data quality (i.e. continuous log mile) and availability (i.e. outer roads) must be resolved.
3) A process for maintaining the data and its quality must be determined.
4) Market current TMS capabilities within MoDOT.
5) Communication of TMS related information to users needs to be enhanced.
6) Responsibility for TMS must be resolved so that TMS data needs and applications are determined by TMS users from all MoDOT functions.

Needs to be Addressed in the Near Future

1) A more user-friendly interface for TMS needs to be put in place.
2) The location referencing system (LRS) needs to move to GPS.
3) Increase and improve the training for TMS.
4) Make TMS Web-enabled.
5) Add decision systems support to TMS.
6) Data in TMS needs to allow for better and easier integration and cross-functional analysis.

TMS has evolved into an excellent tool that is often misunderstood and underused. Currently, TMS does lack certain functions that would make it a better tool and these are addressed in the above recommendations. All of these recommendations will require organization commitment to change and most will require hard work, but they are all achievable. The MoDOT TMS is based on an excellent foundation and has an excellent support team. It now must be decided if and how to move TMS to the next level so that its capabilities can be enhanced and optimally utilized for the benefit of MoDOT and the citizens of Missouri.

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1. Introduction

Problem description

The top management of the Missouri Department of Transportation (MoDOT) desired a high level evaluation of the existing Transportation Management Systems (TMS) and, as appropriate, related information systems. These systems, principally the TMS, receive, organize and process data into information that is used to support many of the decisions made with in the Missouri DOT.

MoDOT would like to know with respect to TMS: What do we have? How are we using it? Is it helping us? What could we do better?

This research project has taken a high level using a sampling approach to determine the current status, strengths and weaknesses of MoDOT's existing Transportation Management System and provides an analysis of how this system serves MoDOT. The systems engineering analysis provided as a result of this review highlights disparities between MoDOT current practices, other DOT state-of-the-art practices, and MoDOT's desired decision support capability. Better and more informed decision-making should be possible as a result of this fundamental assessment of MoDOT's management systems.

MoDOT's TMS History

Before starting an analysis of the current state of TMS, it is desirable to look back the mandate under which the TMS was initially created. When TMS was first proposed it sought to integrate the many different databases that exist throughout MoDOT. The concept of a TMS was given approval based on the following proposed benefits:

- Increase operational efficiency by 10-15% (*over 10 years this would translate to a $3.7 to $5.1 million gain) due to the re-alignment of resources, improved data capture and entry, elimination of duplicate data, and quick assess to information.
- Improve the use of transportation resources by 1-5% (* over 10 years this would translate to a $73.8 to $369.2 million savings) due to improved decision making based on better tools, better long range planning, ability to track performance, and improved transportation system analysis capabilities.

* Based on 1995 Maintenance and Construction Budgets (1998 TMS Project Status Report)

Together with the above benefits, TMS was approved based on the deliverables in the following six areas:

Travelways: an integrated representation of state, county, and city transportation networks; an accurate graphic presentation of the transportation network; an accurate historical and current view of transportation network; and an integrated GPS coordinate-based system.

Travelway Features: historical and current locations, specific lane/offset locations, inspection information, inventory of pavement structure (base, subbase, overlays, etc.), bridges and components, and traffic control devices

Pavement: ability to interface with pavement analysis tools (life-cycle and performance analysis), lane specific conditions, pavement structure data, and cost analysis based on maintenance and construction estimates.

Bridge: ability to interface with bridge analysis tools (Pontis and/or remaining life and life-cycle analysis), bridge element/component inspection information, cost analysis based on maintenance and construction estimates, and contain both on-system and off-system bridge inventory (historical and current).

Traffic: support long-range planning, reduce lag time for data acquisition, provide a single source for the most current traffic information, and reduce labor intensive traffic data analysis.

Safety: improve safety analysis capabilities, increase on-line access, reduce lag time for data acquisition, improve safety data quality, and reduce labor intensive safety data analysis.

With these benefits and deliverables to which TMS was designed in mind, we will now turn our attention to the issues that must be addressed if a transportation management system is to provide useful information and support decision making within an organization.

Information Systems

When reviewing and discussing TMS we must realize that TMS is basically a data repository or information system that can be used to affect decision processes and provide information to a variety of end users. To help better understand our analysis of the system we present an overview of our concept of an information system and how it relates to the day-to-day operation of an organization. The information presented is in terms of the current knowledge base related to information systems and is adapted primarily from Laudon and Laudon (2002).

What is an Information System?

"A management information system is a set of interrelated components that collect, process, store, and distribute information to support decision making, coordination and control in an organization." (Laudon and Laudon 2002). Additionally a management information system can also be used to better understand current data and problems through visualization and interrelationships. The advantage of having all data on hand in one accessible location is significant. This also allows for the better development of products and a better understanding of the entire system.

Within an information system there are several components that sometimes can be misunderstood. We define these terms below.

Data: Raw facts, without any processing, representing events that occur within or relevant to an organization and the environment in which it operates.

Information: Data that have been processed and shaped into a form that is meaningful and useful to those who use it.

Input: The collection of raw data from the organization and its environment for processing in an information system

Processing: The conversion, manipulation and analysis of raw data into appropriate forms for use.

Output: Distribution of processed information

Feedback: Output that is returned to help the organization evaluate or correct input

From these definitions we see that an information system, as a whole, is a feedback system dependent on raw data that is accurate and meaningful and appropriate processing of that data. This is best illustrated in Figure 1 below.

However, from a business perspective, an information system might be viewed slightly differently. It is often viewed as more of a management solution based on information technology than organized to solve a problem posed by the environment or the organization.

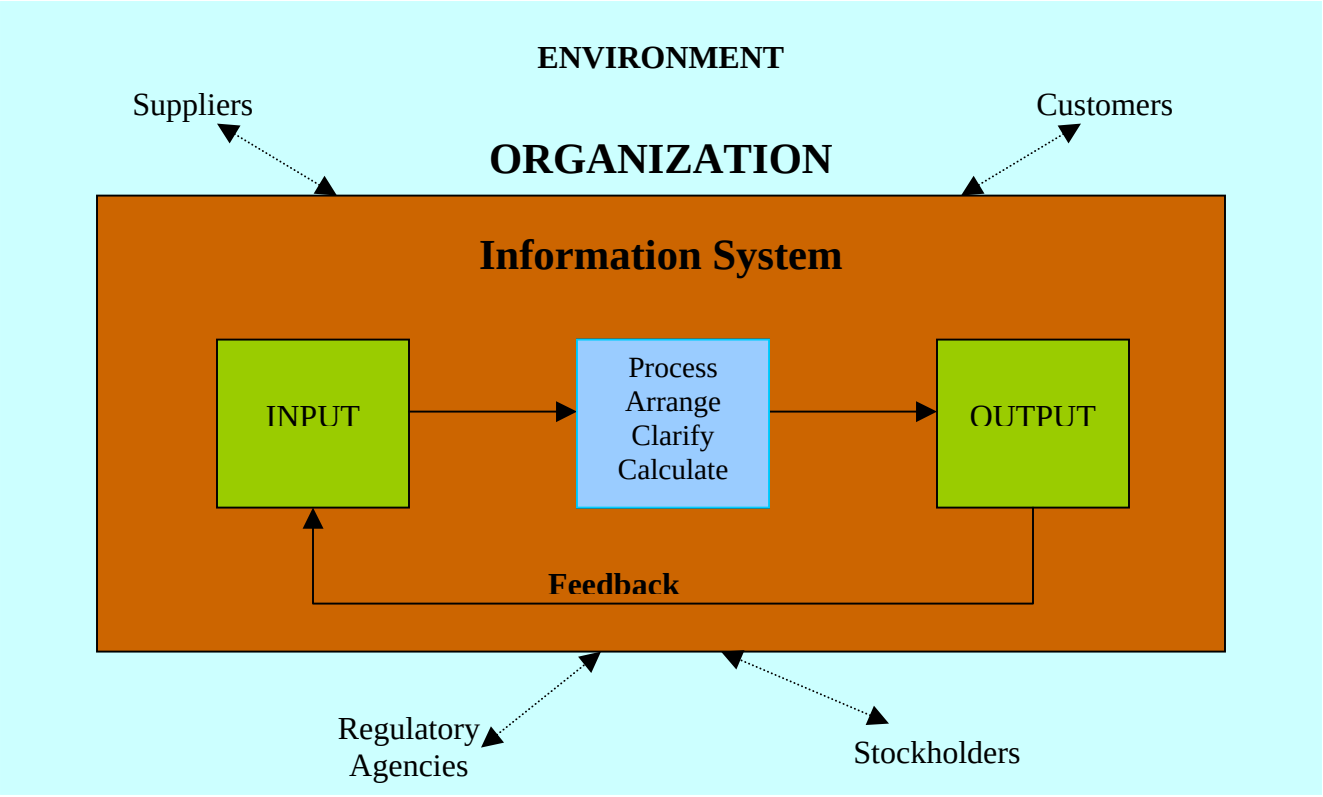

Figure 1: Information System Functions

This view emphasizes the managerial nature of information systems and places a larger burden on managers to better understand information systems and their capabilities. To fully understand its impact a manager must understand the broader organization, management, and information technology dimensions of systems and their power to provide solutions. Therefore, all levels of management must have basic information systems literacy in terms of what is needed and what is possible. There must be a realization that information systems are more than computers and databases and entail and affect the overall system itself.

Key Management Decisions for an Information System

With the advances, almost daily, in information technology and computer science it is quite difficult to build and maintain an information system that is at current technological capabilities. This presents several main challenges to those not only in charge of the information system, but also to the upper levels of management within an organization. These main challenges are summarized below.

How can Information Technology be used to help an organization become effective and Digitally Enabled?

It is a long and difficult road for an organization to become digitally enabled and to use this effectively. Despite heavy information investments many organizations do not obtain significant benefits. This may be due to improper application, the design of the organization, or a lack of proper usage. Often times an organization needs to make fundamental changes in culture as well as structure to fully gain the advantages of a management information system. "If organizations merely automate what they are doing today, they are largely missing the potential of information systems" (Laudon and Laudon 2002)

Does the Information Architecture and Information Technology Infrastructure support the goals of the organization and stay current with rapid technology changes?

This is a difficult and formidable task. Incompatible hardware, software, and telecommunications networks that prevent the free flow of information hamper most organizations. The difficulty lies in making sure that the infrastructure supports all levels of the information needs of the organization.

How can an organization determine the business value of an information system?

Are we getting the kind of return on our investment we should be? How should we measure that return? Understanding the costs and benefits of a large management information system is very difficult and can take years to realize and understand. But the questions must be asked to make sure the benefits are realized.

How can an organization ensure that their Information Systems are used appropriately and maintain a high quality of assurance?

Managers of these systems will be faced with ongoing problems of security and control. Information is vital to the daily life of an organization and steps must be taken to ensure that it is accurate, accessible, reliable and secure.

These challenges are real and an organization needs to consider them and develop a strategy for dealing with each of the issues. Putting a management information system in place is not enough. It must be properly managed and supported to be an effective tool.

Types of Information Systems

Because there are different interests and specialties within an organization, it is not often that a single information system can meet the needs of every user. An organization can generally be divided into four levels of needs: strategic, management, knowledge, and operational. Each of these areas can then be subdivided into functional areas such as financial, accounting, etc. Generally systems are built to meet the needs of each level and its interests and are integrated through common information.

Strategic-level Systems – Help senior management address strategic issues and long-term needs and trends.

Management-level Systems – Serve the monitoring, controlling, decision-making and administrative activities of middle managers. Often allows for what-if analysis.

Knowledge-level Systems – Support the organization's knowledge and data workers. The purpose of these systems is to help integrate new knowledge into the organization and for some data entry.

Operational-level Systems – Supports operational managers by keeping track of important data and transactions. The principle purpose of systems at this level is to answer routine questions and track the flow of transactions through the organization. This would include inventory and other information that must be easily available, current and accurate.

For each of these levels there are specific information systems designed to provide the information needed. These include: transaction processing systems (TPS) which performs and records the daily routine activities and keeps track of the basic data; knowledge work and office systems (KWS) which serve the information needs at the knowledge level and primarily aid data workers and include such things as word processing, digital imaging, desktop publishing, scheduling and communications; management information systems (MIS) which includes report generation, historical records, and primarily serve the functions of planning, controlling and decision making at the management level; decision-support systems (DSS) which are designed to help managers make decisions that are unique, rapidly changing and not easily specified in advance and include the ability to do analysis, condense large amounts of data, analyze data and are user friendly and interactive; executive support systems (ESS) which are for senior management and designed to support the strategic level of the organization by using information both internal and external and by filtering, compressing and tracking critical data and generally presenting results in a graphical manner.

The interrelationship of these levels and systems is given in Table 1 below.

Type of System	Information Inputs	Processing	Information Outputs	Users
ESS	Aggregate data; external, internal	Graphics; simulations; interactive	Projections; responses to queries	Senior Managers
DSS	Low-volume data or massive databases optimized for data analysis, analytic models and data analysis tools	Interactive; simulations; analysis	Special reports; decision analysis; response to queries	Professionals; staff managers; middle managers
MIS	Summary transaction data; high volume data; simple models	Routine reports; simple models; low-level analysis	Summary and exception reports	Middle managers
KWS	Design specifications; knowledge base	Modeling; simulations	Models; graphics	Professionals; technical staff
Office Systems	Documents; schedules	Document management; scheduling; communication	Documents; schedules; mail	Clerical workers
TPS	Transactions; events	Sorting; listing; merging; updating	Detailed reports; lists; summaries	Operations personnel; supervisors

Table 1: Characteristics or Information Processing Systems (Laudon and Laudon 2002)

Decision Making and Decision Support Systems

Decision-making is a major component of any manager's job and a central component of most professionals' activities. Whenever there is more than a single way to solve a problem a decision must be made. The process of making these decisions comprises three major phases: intelligence, design, and choice. In the first phase, the data are collected from which relevant information will be gleaned. In the design phase, the manager organizes the data into useful information and uses models to analyze it and produce potential courses of action. In the final stage, the manager must select the alternative they think best meets the objectives for the decision, i.e. make a choice.

Problems span a continuum between two extremes or problem types: structured and unstructured. Structured problems are those for which a solution can be determined by proven algorithms. An unstructured problem is one for which there are multiple potential solutions and no proven way to determine the best alternative. Design problems generally fall into this category. Between these two we get semi-structured problems that have elements of both problems to different degrees. Finding solutions to these problems requires expertise and an ability to use information in novel ways.

A decision support system (DSS) is designed to help in solving the structured and semi-structured problems. A DSS has three main components (see Figure 2). 1) A data management module that gives the user access to databases from which relevant data can be extracted. 2) A model management module that allows the user to select an appropriate model with which to

analyze the data. 3) A dialog management module that serves as the interface between the user and the other two modules. The dialog management module allows the user to enter queries and parameters, and then presents the results in a selected form, tabular or graphical.

There are different types of DSSs that serve individuals or groups. Some are also intelligent in that they are programmed to make selections for the user. DSSs also provide a quick way to perform sensitivity analysis. The user can also change parameters and answer what-if questions.

DSSs are a critical tool in helping mangers make good decisions. They also increase productivity and reduce the design phase of most projects. They are, however, sometimes quite expensive to develop and everyone involved must understand and accept their importance and potential uses (Oz 1998).

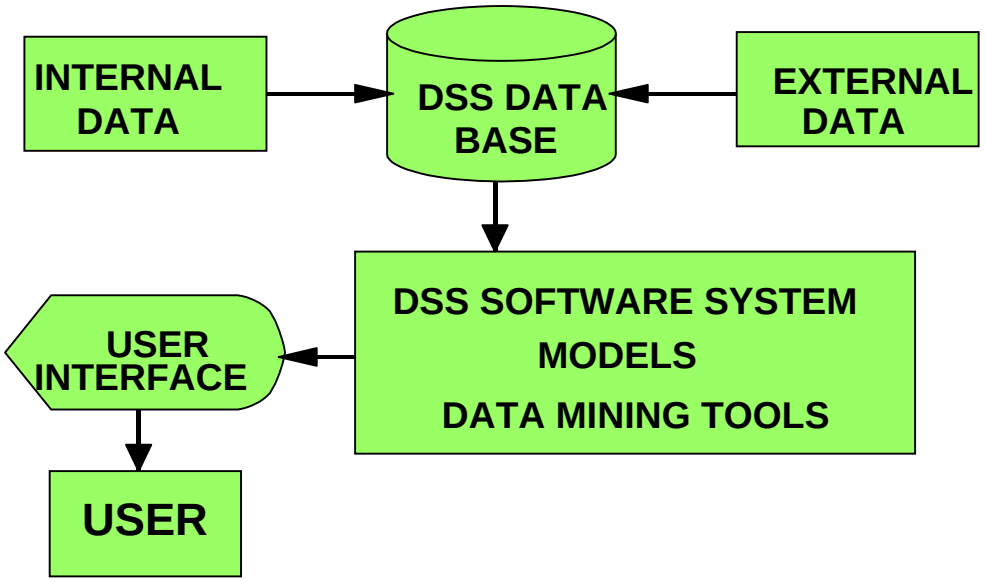

Figure 2: Decision Support System (Laudon and Laudon 2002)

Data Warehousing and Data Mining

Information technology has allowed for the development of and saving of extremely large amounts of data. However, the large sizes of some of these databases make them difficult to maintain and manipulate. This led to the development of a different way of looking at databases, termed data warehousing (see Figure 3). Data warehousing is the organization of very large amounts of data into different relational databases for efficient use. Data warehouses must be designed with maximum flexibility.

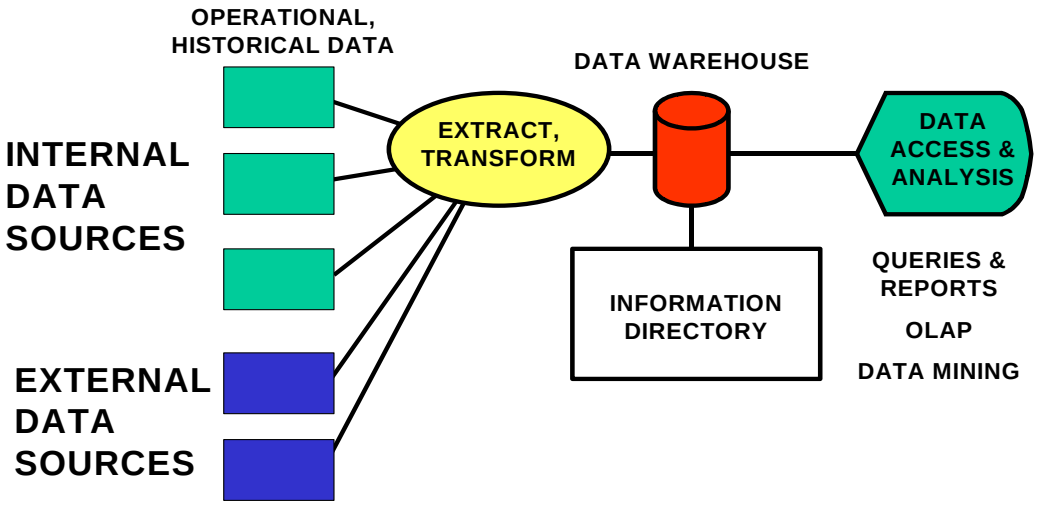

Figure 3: Components of Data Warehouse (Laudon and Laudon 2002)

When dealing with large amounts of data it is difficult to see patterns and trends. To help with this problem, data mining has been developed. Data mining is based on algorithms that search through large amounts of data for meaningful patterns and relationships that can be used to identify trends or other important aspects of the data. Data mining will often expose information about the data that was not known before. The purpose of the data mining is to improve operations and identify potential problems before they happen (Oz 1998).

Other recent trends include data marts, which are small data warehouses for a specific function, multidimensional data analysis, on-line analytical processing (OLAP), Web-based databases, and hypermedia.

In summary, the benefits of information systems can be significant. However, to truly realize these benefits an organization must be prepared for the challenges of developing and maintaining an information system. There has to be a change in organizational behavior to allow for the integration of the information system at all levels and an understanding of its uses and potential at the upper levels of management.

Transportation Management Systems at other State DOT's

The intent of this of this "state-of-the-art" review is not to search and develop a comprehensive list of studies on the development of databases at State DOT's, but rather to glean from an overview of the work in the transportation community some of the trends and commonalities of issues (and problems) that exist, particularly with respect to State DOTs and their databases.

Among the things we found is that there is not a clear picture of what the states are doing: 1) that there are many different approaches employed in attempting to solve the same problem; that states tend to reply "yes" to national surveys that ask questions like "Do you have inventories?" and, 2) there is not a "silver bullet" available to fix everything.

First, consider the following descriptions given by several states of their management information systems (FHWA IF-02-043):

- Florida: TAMS is a Web-based management system for pavement, roadway, bridges (Pontus), crash, financial management, outdoor advertising, utilities, facilities, and tolls.
- Maine: TIDE is a system that contains road geometry, pavement, bridge inventory (BRIDGIT – to predict needs from bottom-up), project history, accidents, uses ArcView and LRS.
- Michigan: uses a Location Reference System (LRS) that is attribute free, therefore has no intuitive "meaning," but very flexible.
- Mississippi: TMIS was designed to support analysis tools (PONTIS, PAP, Safety), but not integrated analysis. TMIS does have some degree of integration with their Financial Management System. They are having LRS integration problems.
- Ohio: BTRS has a new referencing system that is based on log points and latitude/longitude.
- Tennessee: TRIMS uses a county log-mile LRS and contains roadway features, geometry, inventory data, accident, traffic data, and photo logs.
- Virginia: ICAS uses GPS locations (but supports multiple location references), allows performance monitoring, and supports life-cycle analysis.

From the above it was found that one needs to be very cautious on the use of national surveys and guidelines when applying them to Missouri (or any other state for that matter). There is a commonality of understanding that a relational database for transportation infrastructure data is very necessary and desirable. However, how this is structured varies dramatically. There are systems that exclusively serve the State DOT (i.e. Missouri) and there are systems that provide easy access to the public (Mississippi) and many in between.

Second, a private company, VMS, Inc.(O'Lande and Horton, 2002), was organized in the early 1990's in order to provide money saving solutions primarily in infrastructure maintenance for State DOTs (VA, SC, TX, FL, UT, AL, OK, DC). VMS identifies having knowledge of assets and their condition as key issues in risk management, analyzing alternatives, optimizing decisions, predicting demands (and failures). VMS claims that they have been able to develop information solutions at a cost estimated to be 15 to 20% less than what state DOTs are now paying.

The Federal Highway Administration (FHWA) summarized the logic behind what most states have been attempting to accomplish in their effort to integrate highway facility and performance data in the publication of the "Data Integration Primer" (FHWA-IF-01-016). The "Data Integration Primer" serves as a summary of good practice as of August 2001.

Furthermore, AASHTO/FHWA joint activities and task forces in Asset Management have led to a comprehensive effort to develop a "Transportation Asset Management Guide (NCHRP project 20-24 (11)). In the process of developing this guide the contractor, Cambridge Systematics / Parsons Brinckerhoff, was unable to clearly articulate exactly what the components of an

infrastructure inventory database should be, so they relied on a self-assessment exercise to frame the subject of Transportation Management Systems (see representative self-assessment pages from the NCHRP project 20-24 (11)'s training course in Appendix B).

Finally, the literature review led us more towards what are desirable performance indicators (NCHRP 20-24 (11)), what are better practices (FHWA IF-02-043), and what would be desirable components of a relational-integrated-database for the future. FHWA and AASHTO held the "Data Integration for Asset Management Forum and Peer Exchange" in Chicago in December 2001. The common threads from this conference mesh with the best information identified in our review of the practices of the states.

Conclusions:

1. Missouri DOT may have doubts, frustrations and difficulties with their TMS but they are not alone. The following comments from other states support this point:
    - "We need to drop everything and make the system run"
    - "Many people still do not know how to use TMS (sic). Our challenge is to get the word out again and again"
    - "Less data is better than more"
    - "We still have not resolved the issues related to road segments"
    - "The first eight or nine years were the hardest"

2. Attributes of the better systems included:
    - Enable people to graphically view the data; tie it to imagery (satellite, aerial photo, ArcView…)
    - Assure easy and multiple access to data (Web-based)
    - Make it easy to query
    - TMS needs to be a GIS-linked data warehouse
    - Develop standards for data quality
    - Treated data as a corporate asset
    - NCHRP Project 20-27, "Development of System and Application Architectures for Geographic Information Systems in Transportation" (GIS-T) developed models for achieving data integration are very useful.

2. Study Objectives

The MoDOT Transportation Management System was initiated in 1995. Over the past eight years of implementation the scope of the TMS has been refined. MoDOT management is interested in whether the TMS is being used to its potential as a decision support system. Therefore, the objective of this study is to determine with respect to MoDOT's Transportation Management System (TMS):

1. What does TMS currently have?
2. How is TMS currently being used?
3. Is TMS helping make better decisions?
4. How could TMS be improved?

3. Study Approach and Procedure

1) The research team became familiar with TMS capabilities. This involved attending an overview session, followed by high-level tutorial. User training manuals were obtained and studied, as well as information on the TMS database specifications and field definitions.

2) Conducted interviews of both management and direct TMS users at both the General Headquarters and Districts offices (See Appendix C for general questioning framework). The objective in conducting these interviews was to obtain insight into TMS use, TMS perceptions and decision making based on TMS at the different levels shown in Figure 4 below. It was important to interview both those that use TMS on a daily basis, as well as those who are in positions that should require the use of TMS information to make decisions. This enabled the researchers to capture both experiences with TMS and management perceptions that are impacting the use of TMS throughout MoDOT. Overall, the study interviewed 57 individuals. Of these 57 individuals, 29 were from General Headquarters and 28 from Districts 2, 4, 5, 6, and 7. In addition to conducting individual and small group interviews, a TMS User Group meeting was attended and we reviewed all the minutes since the TMS group began meeting in July 2003.

3) Based on the data collected from the interviews a systems analysis was conducted to determine what issues need to be addressed to improve the use of TMS as a decision support system within MoDOT.

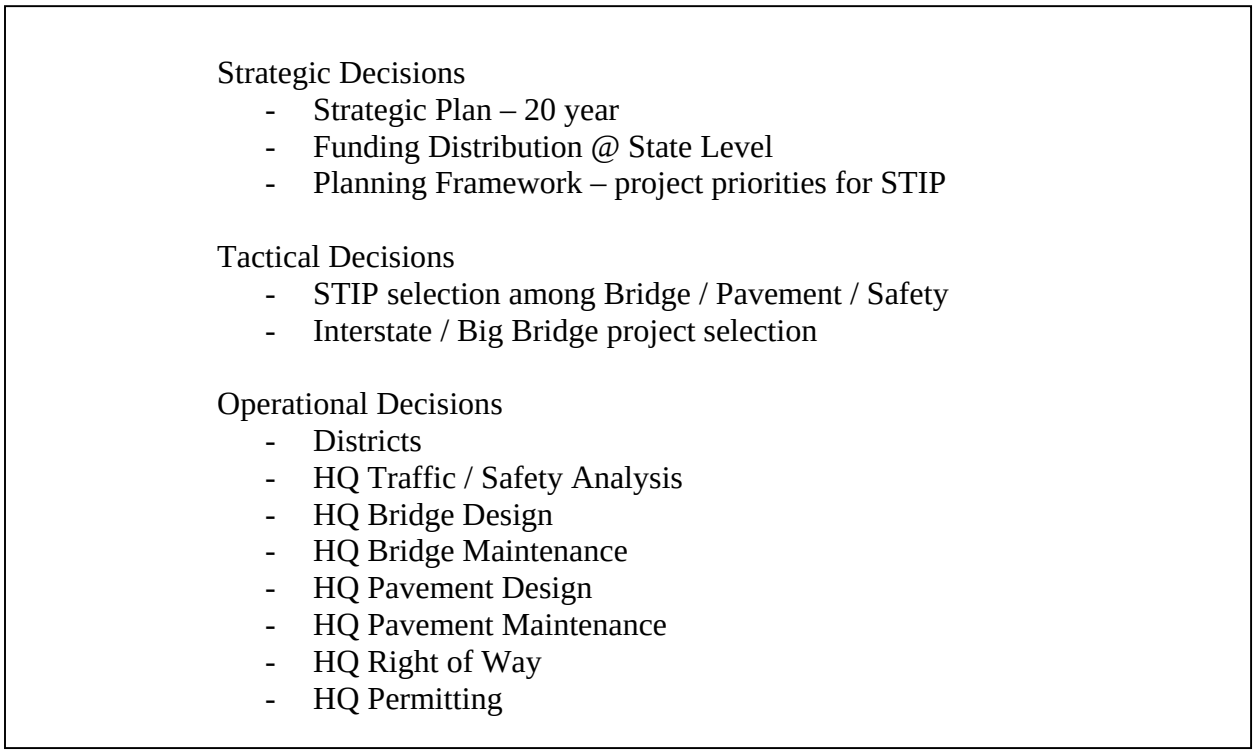

Figure 4: Framework for MoDOT Decision Making

4. Results and Discussion

Objective #1 - What does TMS currently have?

First, when evaluating what TMS currently has it is important to realize that there are three components that make up TMS: data inventory, report generation capability, and data analysis capability. The following will list the major contents of each component.

- TMS Data Inventory
  - Pavement Management System
    - Condition, friction survey, structural history
  - Bridge Management System
    - State and not-state bridge data, inspections
  - Traffic Management System
    - Traffic volumes
    - Level of service
    - Signal inventory
  - Safety Management System
    - Accidents since 1987
  - Travelways
    - Work zones
    - Outdoor advertising
    - Billboards
    - Junkyards
    - Adopt-A-Highway
  - State-of-the-System
    - Integration of bridge, pavement, safety, traffic, and projects

- Report Generation Capability
  - The Pavement Management System provides:
    - Automated pavement condition reports, including average rut depth, condition index, cracking, International Roughness Index, joint condition, and present serviceability.
    - Friction survey data including: friction number, peak, and percent slip and pavement type.
    - Pavement structural history
  - The Bridge Management System provides:
    - Access to State and Non-state bridge data
    - Automated reports on bridges maintenance condition levels
    - Inspection data: NBI, MOBARS, and CORDLIB
    - Bridge structure data reports including: federal ID, location, annual average daily traffic, approved posted lead, and bridge ratings
  - The Traffic Management System provides:
    - Summary traffic information from the Traffic Data System (TRADAS)
    - Level of Service (LOS) information
    - Maintenance of inventory data for signals, lighting fixtures and flashers

        - Standardized data on lighting fixture types, traffic signal classifications, and capacity analysis type
        - A variety of traffic volume reports, including Annual Average Daily Traffic, Vehicle Miles Traveled, Percent Trucks or Commercial Vehicles, Peak Hour Volumes, Equivalent Single Axle Loads (ESAL)
    - The Safety Management System provides:
        - Current year accident data, plus data from 1987 to present
        - Calculation of statewide average accident rates and intersection expected accident rates
        - Ability to view accident images on-line
        - Ability to establish accident rate parameters
        - Standardized data on contributing circumstance, accident classification, accident types, accident severity ratings, accident vehicle action types, and investigating agencies
        - Reports on High Accident Locations and Wet/Dry Accidents
    - The Travelway Features Management System provides:
        - Location information, inspection data, permits, and financial transactions
        - Data on involved parties such as Feature Owners, Landowners, Inspectors
        - Data on Billboards, Junkyards, 5-YR STIP Projects, Work Zones, and Adopt-A-Highway
        - Transfer of financial data to the Financial Management System (FMS)
    - The Travelways Management System provides:
        - Ability to update information concerning Speed Limits, Functional Class, Access Control, Pavement Design, Roadway Type, Truck Routes, Travelway Status, Scenic Byways, Federal System Classification
        - Ability to track and manage travelway errors
    - Visualization of GIS data via ArcView and aerial photography

- Data Analysis
    - The Pavement Management System provides:
        - A regression on the Condition History
        - DTIMS Analysis Tool

Objective #2 - How is TMS being used?

In order to collect data on how TMS is being used the research team interviewed over 55 individuals, split roughly evenly between General Headquarters and the District offices. The team was impressed by the personnel interviewed in that they were professional, frank, and truly concerned about making TMS work for the good of MoDOT. In all interactions comments were addressed to TMS, not individuals. In fact, all viewed the TMS staff at headquarters very highly. It was commonly stated that they were very helpful, good to work with, and were willing to do what it took to address their issues.

1. Summary of interview responses

The following are edited interview summaries of key interview responses with respect to the different MoDOT functions. They are edited in the sense that multiple identical comments by interviewees have been combined into a single statement for brevity. Following the interview summaries, an overall summary of the analyst's interview perceptions is given that accounts for the frequency of a given response.

The interview summaries are presented in the following order:

- GHQ Planning
    - Long Range / Programming
    - TMS Support
- GHQ Project Development
    - Management
    - Design
    - Bridge Design / Inspection
    - Right-of-Way
- GHQ Operations
    - Management
    - Traffic / Safety
    - Maintenance
    - Motor Carrier Permitting
    - Adopt-A-Highway
- GHQ Other
    - Legal
    - Risk Management
    - Information Systems
    - Research
- District
    - Management
    - Planning
    - Design
    - Operations

GHQ Planning

1. What is the range of decisions for which your position is responsible?
   - Coordinate Long Range Planning (20 years), Programming (STIP – 5 year plan) and Data Collection (generating and checking, ARAN, bridge, accidents).
   - Development of a Planning Framework for long range needs priorities.
   - Development of statewide program for improvement of states 32k miles of road.
   - Primary responsibility for statewide priorities for Interstate Highways.
   - Development of 20 yr plan – every 3-5 years update, requires an 18-month process.
   - Air quality, bike/pedestrian, and policy development.
   - Liaison to the districts for planning.
   - Aid in strategic plan development. Work with MoDOT directors on business plans.

2. To what degree does TMS support making these decisions?
   - Significant – very much. TMS is the basis of most Long Range Planning and Programming decisions (probably more so than for traffic and design decisions).

3. From your perspective what are the strengths of the TMS in its current form?
   - Allows for quick integration of various data sources in order to determine programming priorities.
   - Graphic representation of data – current GIS system is used to generate county maps.
   - Can get an overview of the entire system – State of the System (SOS) Report.
   - Bridge data is fairly complete – manual inspections provide a check.
   - Helps justify decisions - ability to see financial impact on conditions if change scenarios.
   - TMS staff.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - Need for data to be more complete (i.e. originally only listing 1st incident of an accident, so crossovers many times didn't get properly identified when searched).
   - Some data issues – more a matter of missing data (shoulder type/width, type of signals, pedestrian data, non-primary accident data).
   - Accuracy of data (#'s from ARAN questionable since don't collect condition from all lanes, IRI is subjective, friction data is not standard, noted a significant improvement in pavement condition once ARAN began … too much subjectivity).
   - People don't trust TMS data.
   - Data seems to be behind – update process needs to be improved.
   - No clear-cut process for how to correct data errors – current process appears ad hoc.
   - Different data queries on related topic can all give different results.
   - Needs to have data on District level Preventive Maintenance – possibly some way to collect it automatically? (i.e. need to be able to determine the impact of PM vs. replacement – what went into keeping a given asset in the current condition).
   - Not so much a weakness, but a reality – having TMS has raised the accountability of the data that is presented. Previously, accuracy wasn't challenged (especially if a map), but now it is possible to look at the data in more detail.

- Need to be able to better integrate programming and TMS databases for what-if analysis so can use it more as a decision tool.
- Requires quite a bit of effort to get down to the more detailed levels of TMS data.
- Administrative/Financial divisions are not TMS users, they question the unknown.
- Few in upper management utilize TMS or understand what it can do.
- Need better training – especially that focused on different user needs.
- Training is fast and furious for two days and that is it. No training for updates.
- Interface could be easier. Need to know system well to get what you want out of it.
- Because of size and cumbersome nature of TMS, a lot of data is not being used.
- Data defaults to one direction on non-divided roads, can only pull up by road segment instead of an entire route.

5. How has TMS evolved over the time of your using it with respect to your needs?
   - Before TMS Programming required a wide range of people, each with their own data set to work on "synthesizing" their data in order to develop the final program
   - Districts didn't used to have planner/programmers prior to '95, now they do and this has increased their use of central resources such as TMS

6. What additional TMS capabilities would enhance your ability to make decisions?
   - Ability to incorporate even more data sources and weighting of factors to determine STIP programming priorities and the ability to conduct "what-if" analysis
   - Model to evaluate performance impact of budget decisions
   - Integration of TMS and Financial
   - Reduce number of independent system (District STIP, State STIP, TMS, Financial, Human Resources)
   - Ability to generate GIS for STIP directly (vs. currently STIPs final form is generated from a different database)
   - A hyperlinked SOS "hardcopy" with overall condition data
   - Would like to see a conceptual report where the user puts in the important parameters interested in and then TMS generates report related to those parameters
   - Needs to have software interface made more intuitive (provide summary SOS online with mappings).
   - Overall ratings for congestion and safety
   - I70 segment rating with logical end/begin points
   - Need to put what is already on Program/STIP so don't keep working on same areas
   - Need continuing training (currently on 2 days of training at start)
   - Process for fixing errors needs work
   - Design data needs work
   - Would like to see all public roads added to TMS
   - Ability to obtain information by Area Engineer

Comments

- Wonderful system, powerful, but not many use it. More might use it if it had easily accessible reports.

GHQ Planning - TMS

1. What is the range of decisions for which your position is responsible?
- Manage TMS.
- Collect and report data on Pavement, Bridge, Travelways (main focus – attributes, maintain line work).
- Query TMS using GIS and Access.
- Maintain data accuracy of traffic counts (3000 count sites), accident/crash locations (180k / yr in state, 90k on state roads).
- Supplies data to customers both internal and external.
- Some TMS training.
- Lots of Q&A from TMS users.

2. From your perspective what are the strengths of the TMS in its current form?
- Integrated Location Reference Systems (LRS) (i.e. can see pavement conditions together with accidents or see all 1 lane bridge accidents => all within 30 minutes!).
- Single database so data can be trusted (pavement updated every year per NHS, traffic data annually, bridges annually).
- Data able to be changed by appropriate people: GHQ – log-miles, ADT; Districts – lights, flashers, ratings on collectors.
- Has cut down time considerably.
- Allows what-if analysis.
- LRS integration - can look at a road and all its associated attributes.
- Lots of information all in same location.
- Use of GIS.
- It is broad based and has the data needed to make decisions.
- Gives a high level view of information.

3. From your perspective what are the weaknesses of the TMS in its current form?
- Data that needs work: line work (especially of county roads and city streets), number of lanes/widths, shoulders, ramps, and outer roadways.
- Too much historical data – need to capture new pavement specifications.
- Needs to focus on original plan before adding more capabilities.
- Some data good – some is not.
- Performance curve – historical data can be weak.
- Update of data is too slow.
- Not a good interface for inputting data.
- Change from county to continuous log miles in 1996 still creates problems.
- Lots of information, therefore easy to have data inaccuracies, can be overwhelming.
- High maintenance cost.
- Dependence on the consultants.
- Currently accident data can go through 3 levels (officer, clerk, patrol office to MoDOT) some state Patrol use palm pilots to minimize error and speed up data transfer.
- Signage information needs to be improved.

- Problem with who maintains the data and TMS.
- Need marketing and better training.
- Difficult to integrate data easily across functions due to lack of horizontal linkages.
- Users do not trust data.

4. How confident are you that the data contained in TMS is sufficiently valid (accurate and timely) to support your decision making responsibilities?
   - Data is better than used to have and continues to get better.
   - Others are scared to trust data, but is same data as had before.
   - Most "data" problems are application issues where an update application breaks something else.
   - Most issues arise from people who don't understand the system – access data incorrectly.
   - Job to ensure that it is accurate, but realizes there are problems due to sheer quantity of data. Still believes TMS is useful (even though districts complain about accuracy).
   - Confident in data. Same data using before, but knows others do not trust the data.

5. How has TMS evolved over the time of your using it with respect to your needs?
   - Need to realize that the TMS focus is on planning – so keep it within Planning.
   - Initially scope expanded too fast, should now focus on original plan, rather than add new features.
   - TMS design had 1 person from each function – built modules over four months.
   - TMS has 50 people working on it.
   - TIERS originally had 20 people, now 11 => other 9 are now in IS.
   - Now must compete with other IS projects for funding vs. being able to manage own budget and hire own people.
   - IS controls updates of "tables" and writing programs.
   - Originally IS and Planning worked together, then just Planning maintained, now IS back – need to work on integration and communication between the two groups.
   - Adding Permitting (put out an RFP before contacting TMS staff), STAR/Gateway – all are examples of need to integrate more with projects that either impact or interface with TMS.
   - Always upgrading and moving forward.
   - In the last year has improved more than in the last 5 years.

6. What additional TMS capabilities would enhance your ability to make decisions?
   - Need application to make maintenance of line work easier.
   - People need to use TMS directly – overcome aversion to computers, trust GHQ, look past former bad experiences (bad information or wrong use).
   - Could market TMS more – but need to make sure don't over do it.
   - Conversion from Log Miles to GIS is constrained by GPS accuracy – need to keep LRS for now as GPS accuracy is still 5-10 years away.
   - GPS would be a plus, however, line work is currently not accurate enough for GPS.
   - New LRS using GPS – starting Spring '04 – county by county using satellite to convert.

- Web –based could be an advantage especially for work zones – more cost effective.
- New data definitions for accidents in work zones are needed – whether work zone is active or not (decision must go through MoDOT, HP, Police, etc.).
- LR6000 – allows mileage changes and stub city street intersections (eventually will add whole route).
- Would like to be able to link data better. Need better tools in this area.

7. How do the District Offices and people use the TMS in their dealings with you or your programs?
   - Districts use TMS to do their own specific planning based on State-of-the-System reports, ADDT, condition reports – mostly Planning.
   - Need to look at intended use – don't program a job based on data, but look at overall general areas.
   - Traffic uses TMS a lot.
   - Permitting will use it.
   - Operations/Maintenance uses TMS the least.
   - Design uses TMS data but don't know it (ARAN, pavement conditions, and ADT projections.

Comments:

- Intent is to give general picture and ideas and then let you go out and fill in the details Data is a starting point.
- To maintain data should not be that hard. Need to develop apps for this – not many more people needed.
- Training is better than marketing – let SuperUsers do the selling.
- How TMS stays funded is an issue – TMS competes against general IS for budget. Should give TMS a separate budget and let them work with it.
- Need better coordination of new applications. Need to know specifications and how interact. Biggest problem sees is they expanded too far, too fast. Adding too many applications without communication with TMS people.
- Districts use queries that are provided. They do not know system that well.
- Problems with data do not have to do with TMS. Either before input or as input, not after it is in the system.
- Need to improve communication.
- Don't have resources to get data as clean as it should be.
- IS trying to isolate TMS. Need to have fewer obstacles from IS, IS is killing innovation.
- Politics of IS versus Planning a problem – i.e. ownership and purse strings in terms of projects that are done related to TMS.

GHQ Project Development: Management

1. What is the range of decisions for which your position is responsible?
   - Manage statewide design and construction of bridges and pavement.
   - Long range planning.

2. To what degree does TMS support making these decisions?
   - Is beginning to be useful – but still getting less than needed from TMS to support their work.

3. From your perspective what are the strengths of the TMS in its current form?
   - Trust data providers and people maintaining TMS.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - Not as user friendly as would like it to be – use needs to be more efficient versus complicated, currently too dependent on a few Super Users.

5. What additional TMS capabilities would enhance your ability to make decisions?
   - Ability to determine pavement structure, performance curves.
   - Ability to analyze how bridges are performing.
   - Complete asset info – right-of-way to right-of-way.
   - Integrate DNR info into Environmental Mgmt system – wetlands, cultural issues – all on a map.
   - Ability to determine contribution of new projects to STIP on overall system improvement.
   - Ability to conduct “what-if” analysis.
   - Ability to get historic data.

GHQ Project Development: Design

1. What is the range of decisions for which your position is responsible?
    - Do not make decisions on what highways are to be designed or reconstructed. Give support to the field once the field (or HQ) makes the decision. The provide highway design technology leadership (design policies, standards, technologies etc.- help select the software used in HQ and field to implement highway designs)
    - Set policy and deal with bidding, lawyers, design standards and practices, informed consent, environment.
    - Provide guidelines for design, develop standards, support design technologies
    - Deal with environmental process (pre design) and concerns and help set policy. Manage the (post design) construction bid letting process.
    - Environmental assessment.
    - Direct I70 studies statewide.

2. What data is required for designers (in the districts) to make these decisions?
    - Data needed is generally given to them or is available in their handbooks.
    - Accident records, traffic counts, existing geometrics, pavement cross-sections, bridge details (i.e. highway engineering data).
    - Wetlands, soil mappings, endangered species, historic properties, etc.
    - Planning information on budget available, type of roadway to be designed (i.e. 2 lane or freeway), local involvement etc.
    - When need design data it is obtained from GEOPAC which is not linked to TMS.
    - Photometric data not linked to TMS.
    - CAAD is a large part of what they support, they support MoDOT's use of dozens of software design and analysis packages (most of which link into the GEOPAC/CAAD systems).

3. To what degree does TMS support making these decisions?
    - Does not and has never used TMS.
    - Does not feel that TMS can support unit.
    - Maintain own data bases and use other software for their design activities.
    - Cannot see value in TMS for HQ design function; know that the field designers use TMS data for design.
    - TMS has not be helpful in environmental studies.
    - Only TMS accident info is used by I70 study.

4. From your perspective what are the strengths of the TMS in its current form?
    - TMS designed for planning.
    - TMS might be good for the system level analysis and program direction and initiatives, but they don't believe that it is in fine enough detail to use for design.
    - TMS same as current information they get from manuals.

5. From your perspective what are the weaknesses of the TMS in its current form?
    - The data is not "fine" enough.

- Does not have data they need (i.e. guardrails, exact GIS locations).
- Do own capacity analysis and geometrics because the data TMS has is not accurate enough for their work.
- Does not have the environmental data needed.
- The data is not accurate enough. It is not at the service level.
- Does not contain photometric data.
- Not linked to GEOPAC/CAAD.
- Not "user" friendly for "what if" inquiries.
- Too many problems with data (had to verify everything back in 2000), had to check microfilm (2001).
- Doesn't have geometrics (ex. ARAN doesn't have vertical/horizontal geometrics on I44).
- Minimal urban data.
- No basic GIS environmental data – creating own GIS layer.

6. What additional TMS capabilities would enhance your ability to make decisions?
    - More accurate data.
    - Environmental data.
    - Inclusion of GEOPAC data.
    - Better GIS data.
    - Support for CAD.

Comments:

- The discussion indicated that the Design unit did not see as needed or important opportunities to evaluate and analyze traffic volume, accident, truck, etc. data to develop design strategies for MoDOT. Planning decided "number of lanes – the field designed it – HQ design/environment supported".
- There is a political aspect here in terms of funding. Design believes that budget has been taken to support TMS development. They mentioned this and said they did not feel they were getting value for their investment and would like to see a deliverable. In effect they have less money to support their design/environment missions and they would spend their data resource funds on things they need.
- A good point brought out was that their field people, including maintenance, collect a lot of good, accurate data for road segments they are designing. This data needs to be imported into TMS to enhance its quality and to bring the data to a service level.
- The "final as built" plans would be of great value if they could be electronically inserted into the TMS. As it is now this real information is not used and TMS relies on less accurate information.
- The FHWA sponsored IHSDM software program, which purports to use "global" accident frequency data correlated to highway geometric data, should be a valuable design tool as it would highlight those areas of potential accident vulnerability. MoDOT is not able to use IHSDM as there are system design problems related to interfacing with their CAAD software, plus linkage with the TMS doesn't exist so MO accident data and traffic data would need to be manually inserted into the model.

GHQ Project Development: Bridge – Design / Inspection

1. What is the range of responsibilities/decisions associated with your position?
   - Bridge Design.
   - NBIS on all bridges.
   - Inspect non-MoDOT bridges – enter into TMS.
   - Load ratings (coordinate non-state and collect data on state and non-state).

2. To what degree does TMS support these responsibilities?
   - TMS not relevant to project selection (District Engineer's drive selection process). No selection problem exists since there just isn't enough money to require difficult choices. This issue doesn't motivate data maintenance.
   - Bridge rehab uses conditions / traffic data from TMS combined with District reports.
   - Significantly – TMS is only data source for bridge inspection.

3. From your perspective what are the strengths of the TMS in its current form?
   - All District, Planning and HQ Design people see same data.
   - Removed manual cross checks, improved data quality since still has several cross checks (Latitude/Longitude, # lanes).
   - Now have component / super structure data.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - Don't use TMS for permitting, as clearance data might not be accurate.

5. How confident are you that the data contained in TMS is sufficiently valid (accurate and timely) to support your decision making responsibilities?
   - 50% confident in data (has been getting better)
   - Problems in roadway data – GPS data missing, outer roads/ramps not on system, functional classes often not correct
   - Sign trusses not in system
   - Rail/pedestrian bridges only have clearance data

6. How has TMS evolved over the time of your using it with respect to your needs?
   - Queries have gotten better – easier to conduct own queries – able to query based on features.
   - Required an investment of 50% FTE over 3 years to get system to current status.
   - Bridge maintenance not active in database transition.

7. What additional TMS capabilities would enhance your ability to do your job?
   - Ability to determine projects on bridge condition (like Pontus).
   - If TMS is to help with more design decisions then need to add more data fields.
   - Would like to be able to use TMS to help make decisions on how to maintain bridge conditions and to see the consequences of investment decisions.
   - Need performance curve data – life, loading changes, etc.
   - Need for data on complete bridge cycle – design – build – maintain.
   - Need better mechanism for getting enhancements (i.e. own budget to spend).
   - Add bridge management tool (i.e. eligibility list for federal funds, etc.).

GHQ Project Development: Right of Way

1. What is the range of decisions for which your position is responsible?
   - Land acquisition.
   - Property management.
   - Radio towers, offices.
   - Capital improvements.
   - Outdoor advertising.
   - Scenic byways.

2. To what degree does TMS support making these decisions?
   - Provides inventory – digital pictures.
   - Really not much – maintain own databases.
   - Will support decision making strongly – once up and running.

3. From your perspective what are the strengths of the TMS in its current form?
   - Provides good overall tool.
   - Good support from TMS staff and TIERS.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - TMS massive – Three blind men and an Elephant.
   - Need a consistent / integrated location of information – TMS does not contain much of what is needed (currently have several stand alone databases: Parcel Acquisition System (Lotus Notes), TMS Advertising Permits (used daily – inspection, permits, vegetation cutting), Excess Land Database, Payroll ($ and budget) => could probably save 10-15 hours per week if was integrated.
   - Complex – has big learning curve.

5. What additional TMS capabilities would enhance your ability to make decisions?
   - Add GIS/GPS, district access, pictures, inventory of excess land, radio tower inventory, and screen junkyards.
   - Automatic data collection from field – GPS, laser, mobile wireless.
   - Cross reference between locations systems.
   - More ArcView – display assets and get information from maps.
   - Need to tie data to budget units – could be significant savings in man-hours and increase speed of delivery.

GHQ Operations: Management

1. What is the range of decisions for which your position is responsible?
- Manage all operations – budget/planning of inventory operation and maintenance.

2. To what degree does TMS support making these decisions?
- Could be significant if data accuracy is improved.

3. From your perspective what are the strengths of the TMS in its current form?
- Data sufficient for accidents.

4. From your perspective what are the weaknesses of the TMS in its current form?
- Data accuracy (lane-miles – up to 20% off due to not including outer roads/ramps/shoulders).
- Line-work has become the bottleneck – it is often inaccurate and takes too long to update.
- Mission focus is not clear.
- Update processes need to be defined.
- GPS and line work do not match.

5. What additional TMS capabilities would enhance your ability to make decisions?
- Only add new capabilities if they are support a defined mission.
- TMS could become the basis of a smart/visual system for fleet management if utilized GPS capability (snow, mowing salt, strippers, herbicide).
- Need to determine level of accuracy needed (ex. line work 99% accurate within 1 ft by ___ date and inventory 99% accurate within 1% by ____ date), develop a prioritized plan to achieve this level of accuracy and a plan to keep it accurate.
- Should use available GIS data to aid in move toward use of GPS more quickly and economically.
- GIS maps should be developed with inventory data links that could be used in both daily operations and planning/budgeting.
- Pavement/condition inventory should include structure/type/thickness and allow for "what-if" analysis.
- Once a mission/plan for updating/changing TMS is developed – would be willing to allocate 5% of 3000 people for 1 year to get inventory correct.
- Need a training plan for each district so they are able to use TMS effectively.
- Develop and have a plan for updating and maintaining the data.
- Add all roads including county – all non-state roads.
- Ability to identify trends.

Comments
- Two main concerns are accuracy of data and a methodology to keep data up-to-date.
- Need to develop a focused plan with action steps to get data correct and then have the discipline to maintain it.
- Need to evaluate what the system is suppose to do.

GHQ Operations: Traffic

1. What is the range of decisions for which your position is responsible?

- Analyze traffic data statewide to determine areas that have problems, especially in terms of safety.

2. To what degree does TMS support making these decisions?

- Significant - could not do what they do without TMS.

3. From your perspective what are the strengths of the TMS in its current form?

- Overall, they are a whole better off than they use to be.
- They can find problems they couldn't before using TMS.
- Can see all the data and determine what data is good and what is bad – (always used this data before but didn't know it was bad).
- ArcView capabilities, especially related to public information. They answer lots of public questions

4. From your perspective what are the weaknesses of the TMS in its current form?
    - Need more current data.
    - Some data is not reliable – such as geometrics and parts of pavement.
    - GPS in data now not accurate – taken from old quad maps.
    - Log miles a problem especially when road segments change – i.e. straighten out a road – changes log miles and affects crash sites, etc.
    - Design issues not being taken care of by the data.

5. How has TMS evolved over the time of your using it with respect to your needs?
    - Everything that is added is a plus for them.
    - The more data the better – as long as it is reliable.

6. What additional TMS capabilities would enhance your ability to make decisions?
    - Would like it to be GPS based.
    - The reliability of the data needs to be increased so that people will use TMS more.
    - Add vertical clearance of signals and bridges.

Comments:

- TMS didn't degrade the data – same data they had before only now it can all be seen at once.
- Willing to give up TMS bells and whistles to get accurate and current data.
- Maintenance of data is now in IS, doesn't seem to work as well as before.
- There is a problem between IS and the rest of the TMS users
- Need to better market the system. Buy-in is very important.
- Lot of the concerns related to TMS seems to be related to local information. Not about making decisions, more about inventory.

GHQ Operations: Maintenance

1. What is the range of decisions for which your position is responsible?
   - Report NBIS – bridge inspection report.
   - Schedule maintenance work – determine bridges / pavements requiring maintenance.
   - Respond to District questions concerning status of bridges in each District.

2. To what degree does TMS support making these decisions?
   - Currently, TMS does not play a significant role in their decision making. Will be at least one more year before data is transferred. There are also data accuracy issues that need to be resolved. It was clear that TMS as it now exists is not used by the decision maker, and that the people relied upon for decision support only use TMS after using the old system and their engineering judgment.
   - Still using the 2001 DBXL data as the basis of decision making, together with more subjective criteria.
   - "Don't need a TMS to make decisions on fixing only 30 bridges per year" (issue of funding priority – currently preventative maintenance competes with new project within each District, plan is for in the future to have funding based on State of System which should improve maintenance visibility). Many decisions not made based on data, rather political issues. Hence, upper management not asking how to maintain bridges at a 6-7 level, which would probably reduce, overall cost of maintaining the system.
   - Note some TMS users (Planning) use TMS for making decisions without apparently little knowledge as to the accuracy and timeliness of the data. The sense is that people believe that if it is in the TMS it must be right and those closer to the data use don't support this level of confidence.

3. From your perspective what are the strengths of the TMS in its current form?
   - Has potential to have data for element level decisions.
   - Good for NBIS data.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - Data completeness – only contains 30% of data from DBXL. Only has data necessary for NBIS annual report. Better transition approach would have been to scan DBXL reports into TMS and inspectors could of updated during inspection reporting and scan could then be deleted.
   - Need to be able to add pictures, design plans, video, letters
   - Data accuracy – lane miles are missing ramps, outer roads, etc.
   - Data entry - difficult to have enough trained people to enter data into TMS.
   - Requires going to TMS group to write a new query.
   - Bridges not tied to ArcView
   - Permitting does not use data modified by Maintenance to determine over dimension load routings. Rather design capacities are used which require a 25% deterioration to trigger a load rating change.

- Performance information is not easily available (i.e. which decks perform best? life expectancy of bearings, joints, decks, etc.).
- Data for 16,000 bridges not on the State system is collected for the NBIS, but not sure if this data is in TMS (or should be)

5. How has TMS evolved over the time of your using it with respect to your needs?
   - Prior to 1980 maintained paper records for each bridge (NBIS data + more). On back of data form wrote 4-6 years of recommendations – had to retype form every 4-6 years
   - Developed DBXL in-house, had limited data fields, but engineers were able to write own queries and had data they needed for selecting projects for work.
   - Experimented with Pontus in mid 1990's, but it is not meeting MoDOT's needs.
   - Began transition to TMS in 2001 – TMS currently does not have all previous data they had and need.
   - The movement from legacy systems to TMS was not smooth. It requires too much piece by piece review and entry and requires levels of knowledge higher than data entry clerks possess.
   - Real problem coming this year as the inspection cycle has TMS data sheets that still have not been corrected or adjusted with the older more accurate DBXL information and notes.
   - Currently very active in "Feeding the Baby" putting data into the TMS.

6. What additional TMS capabilities would enhance your ability to make decisions?
   - More relational files so that bridge information could be strengthened and could also contribute to broader based policy decisions (i.e. guardrail and bridge approach guard rail belong to two different owners and different data bases).
   - Ability to query the database directly and more easily to ask "What-if" questions. Currently this is done through a third party relationship that is "unfriendly" enough that they chose to not ask very many questions of the database.
   - Bridge element information in the system

Comments:

- Interdepartmental decision-making is almost independent of the TMS data (i.e. bridge posting and bridge inspection data are done by hand, bridge data and oversize truck routings are not linked through the TMS).
- Middle to Top management is not using TMS bridge data for decisions.
- Condition data (from the NBIS elements) is available to provide some more macro analysis and performance related analysis (i.e. tracking the % of bridges above level 6 six statewide, or by system – Interstate/NHS by type of bridge, by age, by district, etc.), however, there wasn't evidence of demand for this information.

GHQ Operations: Motor Carrier Permitting

1. What is the range of responsibilities/decisions associated with your position?
    - Manage truck permitting.

2. To what degree does TMS support these responsibilities?
    - Potential is significant with respect to overweight/dimension data.

3. From your perspective what are the strengths of the TMS in its current form?
    - Single location for all roadway specifications.
    - Would like to use ArcView once data is sufficiently accurate.

4. From your perspective what are the weaknesses of the TMS in its current form?
    - Data accuracy – must have 100% accuracy for vertical and horizontal clearances, shoulder width, bridge weight capacity, turn radius, restrictions (due to construction, etc. – all several weeks in advance).
    - User access to data is too cumbersome (i.e. recently took 500 pages of data to get the 10 pages they needed).

5. How confident are you that the data contained in TMS is sufficiently valid (accurate and timely) to support your decision making responsibilities?
    - Not at all – have found ramps going the wrong way, bridge clearances that don't account for overlays, shoulder/pavement widths still based on 1993 data, etc.
    - Currently only issuing permits with large margin of error when using TMS data.

6. How is the data that you use collected and entered into TMS?
    - Not sure how is currently, but have been providing data collected from Districts to TMS, however, doesn't seem to be making it to TMS, missing feedback link.

7. How has TMS evolved over the time of your using it with respect to your needs?
    - Historically they have used maps (manually updated), together with telephone calls to Districts to determine load routes.
    - Currently issue 340,000 permits per year, up to 1200-1400 per week, can take between 30 seconds to 15 minutes to issue permit with current number of call agents (10) – however, often permit demand exceeds processing ability (i.e. last week often maximized the call queue at 15 and had maximum wait time of 26 minutes, not counting those that skip permitting and "wildcatted")
    - RFP for new system to automate routine load permits that will combine IRP and IFDA data with TMS bridge/pavement data to allow for online permitting. Phase 1 requires TMS data and will be completed by Summer 2004. Will integrate business functions as well in Phase 2.
    - Superloads (which can take several weeks to process) would still be processed manually.

8. What additional TMS capabilities would enhance your ability to do your job?
    - Must have reliable data.

GHQ Operations: Adopt-A-Highway

1. What is the range of responsibilities/decisions associated with your position? (from routine to periodic - 4 to 6 most common)
    - Management of adopt-a-highway (3500 adopters, 5000 miles of road).

2. To what degree does TMS support these responsibilities? (significant/direct to somewhat/indirect to not at all)
    - Significant – provides complete process automation.

3. From your perspective what are the strengths of the TMS in its current form? (Ex. What is most useful, best data, etc.)
    - Single process for Adopt-A-Highway – single set of correspondence (previously each District had their own process).
    - Everything is tied to the roadway.
    - Very pleased and happy with TMS.

4. How confident are you that the data contained in TMS is sufficiently valid (accurate and timely) to support your decision making responsibilities?
    - Totally confident – entered all own data and accuracy is sufficient for needs.

5. How has TMS evolved over the time of your using it with respect to your needs?
    - This application was designed for to meet a specific purpose

6. What additional TMS capabilities would enhance your ability to do your job?
    - Automatic sign requisition (vs. scan and send)

GHQ Risk Management

1. What is the range of decisions for which your position is responsible?
   - Promote risk assessment within decision making throughout MoDOT.
   - Process property damage recovery claims.
   - Manage litigation.
   - Occupational Safety and Health.

2. To what degree does TMS support making these decisions?
   - TMS not currently used, but could:
     - Provide accident data for both liability and property damage claims.
     - Help rank accident locations.
     - Provide inventory of geometric features.
     - Provide traffic data.

3. From your perspective what are the strengths of the TMS in its current form?
   - Has potential to provide system level data for risk assessment that could be used in design.
   - To the extent that real data is used to support decisions it strengthens MoDOT's position in lawsuits.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - Does not support a strategic perspective for using safety management data within risk assessment.
   - Needs to be able to support analysis of frequency of loss and severity of loss for different risks.
   - Needs to be linked with national databases.

5. What additional TMS capabilities would enhance your ability to make decisions?
   - Addition of models to used current data to support Risk Assessment (for both mitigation and litigation) – interface with IHSDM (Integrated Highway Safety Design Model) – enable ability to assess risk due to changes from design standards (i.e. 12' to 10').
   - Linkage between MO accident data, litigation data and National severity rating for different design features.
   - Ability to analyze railroad grade crossings with respect to Risk Management issues.

GHQ Information Systems

1. What is the range of decisions for which your position is responsible?
   - Coordinate all information systems functions.

2. From your perspective what are the strengths of the TMS in its current form?
   - Perceived to be a good value – does save time in report generation, but hard to estimate the ROI.

3. From your perspective what are the weaknesses of the TMS in its current form?
   - Perception that "Planning" owns TMS – so others don't use it.

4. How has TMS evolved over the time of your using it with respect to your needs?
   - Response to ICE-T.
   - Started an executive steering committee '92 - held affinity groups to design Enterprise Data Model.
   - Original concept
     - Multi-layered DSS
       - Location Reference System
       - Module development – Safety, Transportation, etc.
       - DSS – general tools for analysis
   - Data originally not GPS – rather log mile – not accurate (old TigerData).
   - Underestimated data collection requirements – county maps.
   - Currently still transferring data – lots of work.
   - TMS designed as a static information system – new intelligent transportation systems require a more responsive system than TMS.
   - Goal was a DSS – not just the current database for geographic features.
   - Cost to populate budgeted at $10.5M – 2003 $23M.
   - Since real-time systems are going to become the system to choice – the utility of TMS will plateau (currently TMS feeds Real-time, in future Real-time will feed TMS).

5. What additional TMS capabilities would enhance your ability to make decisions?
   - Future will have TMS integrated with Real-time systems (not TMS on steroids!).
   - Need to modularize geographic data – make more efficient (GIS data alone is 12 TB).
   - Need to interface with ERP so can value assets.
   - Need to tie into STIP / Planning so can do "what-if" analysis.
   - Need to add more static GIS layers.
   - Need to improve GIS integrity – switch to GPS coordinate system.

GHQ Chief Council Office

1. What is the range of decisions for which your position is responsible?
   - Project Dev – property acquisition – eminent domain, construction contracts, environmental law.
   - Risk Mgmt – product liability, fleet vehicle liability.
   - Defense of general liability.

2. To what degree does TMS support making these decisions?
   - Risk Mgmt uses TMS to evaluate accident situations.

3. From your perspective what are the strengths of the TMS in its current form?
   - Ability to easily pull accident reports.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - What information is being released that might open them up to litigation.
   - Not easy to use.
   - Was developed without needs assessment.
   - They were never contacted for input.

5. How has TMS evolved over the time of your using it with respect to your needs?
   - Spent $M without sufficient needs assessment.

6. What additional TMS capabilities would enhance your ability to make decisions?
   - Project Dev – footprint of future roads (for environmental issues).
   - Graphical presentation of “what-if” for what it would look like after construction (ground, damage to remaining property) – animated simulation.
   - Need condition of property tied to location.

GHQ Research

1. What is the range of decisions for which your position is responsible?
    - Research design and corridor level decisions.

2. To what degree does TMS support making these decisions? (significant/direct to somewhat/indirect to not at all)
    - It helps. Uses it mainly to get system overviews.

3. From your perspective what are the strengths of the TMS in its current form?
    - Current use as Mid/High level program guidance.
    - Use of State-of-System to design 5-10 mile corridor – adding lanes, get initial conditions from TMS (pave/bridge ratings, accidents, traffic volumes). TMS allows for evaluation of initial design assumptions.
    - TMS helps set a clear priority that you can defend.
    - Has helped make better decisions over time.
    - Gives data for discussion.

4. From your perspective what are the weaknesses of the TMS in its current form?
    - Not being used for predictive analysis – trade-off analysis.
    - Non-TMS super users (Designer, District Planners) find it too hard to find things – too complex to get Project level/site specific data.
    - Data is suspect.

5. How has TMS evolved over the time of your using it with respect to your needs?
    - Is getting harder to use.

6. What additional TMS capabilities would enhance your ability to make decisions?
    - Needs graphical/maps that predict traffic hotspots.
    - Needs data accuracy check.
    - Needs to be able to support conceptual analysis better (Planning / Concept / Design / Operations) to see if options are justified and consistent with data trends.
    - Need to be able to see data trends (2 yrs ago, 1 yr ago, present).
    - Determine common request (use 80/20 rule) and provide trends on this data.
    - Need analysis ability to evaluate trade-off between decisions concerning operations and construction impact on accessibility versus mobility.
    - Graphical representation of data – that allows you to dig down into the data.
    - Some conversion equations for different forms of data.
    - Need expense per mile.
    - Better and easier interface.
    - Use TMS as basis of a feedback loop for Planning – Concept – Design – Program – Construction.

District: Management

1. What is the range of decisions for which your position is responsible?
   - High level decisions.
   - Determines all aspects of what happens in the district.

2. To what degree does TMS support making these decisions?
   - Somewhat – use TMS but don't trust data (four key data areas – safety, traffic, bridges, lane miles (pavement)).
   - The idea behind TMS is good, but causes more work than necessary due to the lack of confidence in the data. Must regenerate most of the data so in practice District is not really using TMS much to drive decisions.

3. From your perspective what are the strengths of the TMS in its current form?
   - It is conceptually good to have a one-stop data shop and to get a system view.
   - Smaller applications seem to work well, but larger applications have problems.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - Data: confidence lacking due to: how current the data is, data control (problematic as to who collects and inputs the data), maintenance process
   - People were more comfortable with old printouts than with TMS.
   - Do not know how TMS is managed or how decisions about it and its applications are made.
   - Continuous log mile LRS is a problem.
   - Doesn't include outer roads, ramps, etc.
   - Too much data has to be regenerated at the local level.

5. How has TMS evolved over the time of your using it with respect to your needs?
   - TMS has evolved, but it is not clear as to why or who it has benefited. Process appears too ad hoc. Applications are nice, but good data would be a whole lot better.
   - The system is not being enhanced by TMS to the degree that it could be.

6. What additional TMS capabilities would enhance your ability to make decisions?
   - Baseline data must be correct before anything else.
   - Need a board to oversee TMS and approve changes and updates.
   - Need the districts to input the data.
   - Need better interface between TMS and NPO.
   - Need a process for maintaining the data.
   - Need a unique identifier system – GPS or something – but it needs to be unique, not change, and be intuitive. (Would prefer GPS-based system).
   - Need to automate traffic counts.

Comments:

- All the district engineers have TMS on their radar screen. Data is confidence is the biggest issue. Funding decisions are being made on this data, but the people being impacted have no confidence in the data.
- Control over the system is a problem. Appears to be turf issues in terms of getting TMS where it needs to be. Doesn't know whom to go to make request to make TMS better for all of us. Wants reliability and confidence related to the process. If that were in place, then would support TMS.
- Doesn't think people understand the capabilities of TMS.
- The cost of the resources to maintain it and to develop the databases is a concern.
- Need data to drive decisions, therefore, "Let's make it work. If we can't then drop TMS and find something that will work."

District: Planning

1. What is the range of responsibilities/decisions associated with your position?
    - Plan when to replace, rehab, and build new facilities. Evaluate the impact these decisions would have on system performance.
    - Determine future physical and operational needs.
    - Evaluate urban sprawl and how to deal with it.
    - TMS Super User with focus on obtaining information for others. Use ArcView.

2. To what degree does TMS support these responsibilities?
    - TMS is all that is available, but data issues stand in the way of its effectiveness.
    - Significant. TMS is good enough to support the decisions made.
    - TMS it is somewhat useful in obtaining required information, but often use GHQ's to generate data needed.
    - TMS can be a significant tool. It spans all areas and provides one source of information.
    - Potential for TMS is great – the concept is great - TMS should support us significantly, but does not due to the lack of confidence in the data.

3. From your perspective what are the strengths of the TMS in its current form?
    - Can get data from one source and in less than a day.
    - Able to get a wide range of information.
    - Has the ability to help analyze system and plans.
    - TMS could allow for more integrated decisions and long range planning.
    - TMS can analyze scenarios, whereas the legacy system could not.

    a. Can analyze over several different data sets and then overlay with ArcView. This is a major strength.
    b. TMS makes it easier to see the mistakes that have always been in the data.

    - ArcView is the strongest asset since it allows one to visualize data.
    - Can access accident reports.

4. From your perspective what are the weaknesses of the TMS in its current form?
    - Data accuracy is suspect – hurts confidence in using TMS.
    - Difficult to impossible for Districts to input data. No ownership of data at the district level.
    - Results of two queries for same thing can result in two different results.
    - District must still verify and check data.
    - Users don't trust how data is collected or entered. Need to take the subjectivity out of data collection.
    - Not user friendly. Cumbersome to use (i.e. sometime there are three different TMS areas to search to obtain related information).
    - ArcView and other applications are very slow.
    - Entering data is a problem. Too many screens – takes too much time.
    - Overall training could be improved – both initial and follow-up. Few in the Districts learn Impromptu and even fewer learn/use ArcView. Initially the training covered too much general detail. Better to give an overview and target training to needs of the user. Would be desirable to have a "TMS can do" list that circulates and gets updated to expose users to TMS capabilities.
    - Training is needed for new releases or updates. System changes with new releases and causes problems and down time.
    - Marketing and training - There has been insufficient training for TMS so many users do not know what it can do or how to query properly.
    - System maintenance a problem, especially the communication between users and those responsible for changes in TMS or the data. (i.e. submit data to TMS but don't know if it is ever use or inputted).
    - Can't fix things know are wrong in the system
    - Communication needs to be better in terms of new releases and what impact they will have.
    - Continuous log miles, not GPS based. Log mile system causes user errors.
    - Does not tie information and projects together for assessment
    - The data is not integrated. It is in silos and it is difficult to go horizontally across the data.
    - Does not integrate data needs and processes
    - A lot of analysis tools on top of TMS that are not utilized.

5. How confident are you that the data contained in TMS is sufficiently valid (accurate and timely) to support your decision making responsibilities?
    - The data is probably accurate enough for what they do at headquarters, but the data needs to be better for the districts since they make the actual decisions on what projects are done.
    - County log vs. continuous logs causes confusion (sometimes people enter Workzones into wrong district)
    - Significant time lag between District finishing work and state SOS reflecting true state of system – makes programming difficult if not on actual SOS.
    - Takes too long to update information in TMS (ex. took 1 year to update Area Engineer boundaries and they were still incorrect).

- Districts must verify own data, but can't load own data – impossible to tell age of data.
- Accident location problems. ADT is hard to tell if actual or projected. Signal data is not up-to-date. Line work incorrect
- Little confidence in data (ex. run same query 2 days apart and got back different results).
- If accident data were accurate many jobs would take just 5 minutes, but instead it takes 2 days due to checking each accident.
- Currently 30-50% accurate data is used for project selection – this causes problems (ex. selected project on correct route, but realized problem was 3 miles away that needed to be addressed).
- Data is not timely. District keeps some of its own databases to compensate.
- 95% accuracy would probably be sufficient

6. How has TMS evolved over the time of your using it with respect to your needs?
    - Lots of District people have quit trying to get information from TMS; "Washed their hands of it because it is so cumbersome" – TMS is just not intuitive enough (i.e. they are still using 1995 Bridge Service Manual).
    - TMS User Group has helped.
    - It has been said that "the data is no worse than before," but now we can see some of the "warts" however "No Worse" isn't good, TMS should be better than before.
    - Have added quite a few reports and done several upgrades, but most do not know anything about these or how they are to be used
    - TMS seems to keep adding functions for certain applications, but these are of no use when the data is bad. Need to focus on getting the data correct before increasing functionality.

7. What additional TMS capabilities would enhance your ability to do your job?
    - Need to "do the basics right" – even if it requires making major changes (i.e. GPS) - get data correct. Conduct TMS review using District groups – Design, Traffic, DE's, Planning – not GHQ functional group heads.
    - Obtain fiber connection (D2, 3, 9 currently too slow and too many server problems).
    - Add ability to forecast system performance (i.e. pavement performance).
    - Need to communicate on when/what updates are completed so that Districts can perform accuracy checks.
    - Need to streamline interaction with TMS – learning curve too big and there are too many places to look for data.
    - Needs to be GPS/GIS based.
    - Need a friendlier interface.
    - Needs a better user manual.
    - ArcView needs to be easier to use and utilized to its full potential
    - Districts need to have input in terms of data and changes to system.

- MoDOT needs to be clear on the scope and objectives for TMS: Data reservoir? State / national reports? Decisions on pavements / bridges? Long range planning" System inventories (billboards, adopt a highway, bridges…)?

Comments:

- Most people do not understand the how TMS works and what it can do. Most just use the reports instead of use it as an analysis tool. There needs to be more marketing of the product and more and better training. Need to know why people are using it and why not. Need to determine what type of training is needed and to connect projects with information in the system.

- TMS needs a major marketing and training campaign. Most people do not know what it can do or what it should be used for. Needs to be an attempt to educate the masses on databases and what they can and cannot do with relevant examples from their real world. One problem with the data is that now it is easy to see data mistakes. Before, probably used the same data, but just didn't know the mistakes were there. Would like to see integration of all the MoDOT databases and have only one database (TMS, project and financial). Need to take care of current databases, validate them, update them and not spend time on developing new applications until the data is secured and trustworthy. There needs to be input from the districts in terms of the data input as well as to what data is needed and how it is entered.

District Design: Pavement / Bridge Inspection

1. What is the range of responsibilities associated with your position?
   - Design
   - Pavement
   - Bridge Inspection

2. To what degree does TMS support these responsibilities?
   - Not fully utilizing potential.
   - Bridge project selection is still based on old philosophy – not TMS data.
   - Pavement data is not used at all.

3. From your perspective what are the strengths of the TMS in its current form?
   - Bridge data is correct since District is able to modify and input data.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - Functional data separation keeps data from being integrated.
   - Data, Data, Data
   - Line work not correct
   - Training needs to be improved.
   - Need to develop new way to index data locations (GIS/GPS). Data location shift (e.g. signs, pavement markings, etc.) due to continuous travelway maintenance updates.

- Need dates with Accident or Traffic data used on TMS SOS system, so that designer knows if current information is being presented.
- Need to incorporate existing Horizontal and Vertical information found on old mainframe computer. This would help identifying existing substandard roadway design, which must be documented in Design Exceptions submitted to GHQ.
- Big headache is pulling down data for Access – they now put it into Excel.

5. How confident are you that the data contained in TMS is sufficiently valid (accurate and timely) to support your decision making responsibilities?
   - Significant concern on accuracy of pavement data (ex. CR is FAIR, IRI is POOR, resulting in PSR of GOOD?).
   - Considers DTIMS to be Garbage in = Garbage out.
   - Pavement data is updated yearly – but evaluations are not consistent.
   - Construction engineers ignore TMS data (ex. TMS generated statewide Interstate list – selected a Business Loop instead of Interstate).
   - Some data is missing (TMS has 4500-4600 miles for D6, but actually have 6000 miles => 30% difference, not all 250 miles of city/state maintained road in TMS, outer roads/interchanges), so District spends 2-3 months per year developing own ratings for all roads in district.
   - ARAN data is for one lane only – though some times the lanes are made of different materials.
   - Basic bridge data was transferred to TMS – but is still transferring additional data (process has taken over 1 year)
   - District takes field measurements to check data, but when they send this data to GHQ they are never sure this new data makes it into the TMS.
   - They maintain their own databases. Many view data as bad.

6. How is the data that you use collected and entered into TMS?
   - Give data to GHQ, but never get to input data = > need access to change old data that is incorrect.
   - Stopped submitting pavement data to GHQ because it wasn't used, nor missed.
   - Need ability to change roadway data. GHQ shouldn't worry about Districts skewing data since it is currently incorrect anyway. Since Districts are not using TMS data due to lack of confidence it in, let Districts input data so they could use it.
   - Some Districts let bridge inspection input/modify their own data, therefore, they have confidence in TMS.
   - It required 2-3 bridge inspection cycles to work out data errors, but is getting better.

7. What additional TMS capabilities would enhance your ability to do your job?
   - Need to be able to print bridge comments, need space for bridgework summaries.
   - Bridge programming needs more information to make decisions (ex. expansion device information is only in comment section since not required by NBI, but is needed for programming).
   - Some data is getting worse – need to strategically place people to reverse the trend.
   - Need County Log reference included in ArcView. Now user must exit to find Continuous Log mile equivalent in TMS.

- The "Help" definitions for TMS State Of System (SOS) need to be revised (e.g. PSR definition doesn't explain 40 point rating as good or bad. Rut definition uses 0.5 to 5.0 units with 5 being best, but Pavement 1/4 Mile Summary measures ruts in inches with 5 inches being bad.)
- Improve speed and performance of TMS applications.
- Need to link external data sources on TMS (e.g. CD final roadway plans, right of way deeds, county assessors maps, courthouse records, etc.).
- Need to add pavement thickness on TMS SOS system.
- Need a custom TMS desktop icon, which would include information specifically needed by design.
- Need a more user friendly ArcView when adding information to maps or enlarging segments of data shown.
- Need county road names and numbers included on ArcView maps for all counties.
- Need to have a road segment selection option on the TMS SOS system.
- Need information arranged for design Conceptual Reports and 3-R Conceptual Study Reports used in design.
- Need access to existing speed limits on different roadway segments for design.

District: Operations (Traffic, Maintenance, Work zones)

1. What is the range of responsibilities/decisions associated with your position?
   - Preventative maintenance
   - Work zone management
   - ADT, pavement, traffic signal inventory, speed limits, sound walls, bridges
   - Adopt-a-highway
   - Safety, accidents / Incident Management
   - Projections for ITS

2. To what degree does TMS support these responsibilities?
   - Accidents use TMS – but must check data.
   - TMS does not support preventative maintenance since non-contract work isn't entered into TMS.
   - Work zones find TMS of high value to work zone management.
   - TMS in current form is a screening tool.
   - TMS is a useful tool and has a direct influence on decisions.
   - TMS could support responsibilities, but data issues limit its usefulness.
   - TMS is a primary tool, but they must maintain parallel databases to do work.
   - TMS is the tool they have – can't do without it, but lack confidence in it.

3. From your perspective what are the strengths of the TMS in its current form?
   - A very useful tool. Good for preparing overview reports and plans.
   - Gives access to a lot of data, having all data in one place.
   - Great concept, however, it is not fully utilized.
   - Traffic functions such as work zone, billboards (using GPS).

- Bridge information has helped with preventative maintenance planning.
- GHQ staff has been very helpful and willing to help with generating reports.
- Very good help desk
- Photo logs are used for design / planning.
- Helps manage work zones – most problems are user issues or GHQ update problems.
- Easier to get some data with TMS than before.
- Accident locations on urban arterials pretty accurate.
- Efficiency with TMS is better, but must still go through data since do not trust it.
- TMS provides a single location for information (though they do maintain some stand alone databases (i.e. striping log, sign log)
- ArcView provides great perspective on data.

4. From your perspective what are the weaknesses of the TMS in its current form?
   - The login process is too cumbersome. Should be able to login by function and go directly to desired area (i.e. Adopt-A-Highway) versus having to get to the correct server and then work through menus (Maybe developing login scripts that are functionally oriented would address this issue?)
   - Doesn't have a user-friendly interface. Terminology is complicated.
   - Not intuitive, too complicated, too cumbersome, too difficult to use, big learning curve, therefore, must be daily user to get most out of it.
   - Since all data is within TMS and not handbooks – the people in the field no longer have access to data they need without calling the District office (i.e. preventative maintenance work zones – hourly volumes and location/log miles).
   - Difficult to keep up with county road name changes (i.e. Adair changing from #s to names), particularly difficult now because of the 911 conversions.
   - Data confidence - requires too much checking and verification before use.
   - Database maintenance - data updates take too long to be useful (sometimes over 1 year to get new roads entered into the system).
   - Control of data - Can't update most data, must go through Jeff City.
   - Must maintain different databases to keep track of their data.
   - Not including outer roads and segments is a problem.
   - Interaction between Access and TMS requires user to export data to Excel, but then can't input information back.
   - Can't go horizontally through the data.
   - System typically not stable for a week after updates.
   - Don't think current LRS is working. Log miles are a problem – should be GPS based.
   - Continuous log miles can impact a district without their knowing it (ex. US 71 in St. Joseph changed and impact District but they are not notified or line work not updated to reflect the change)
   - Need more training. All users were initially trained in TMS, but when ArcView was added there was little formal training on how to use it. ArcView cannot be used by normal user (requires a Super User). Might be good to have advanced training after 1 year and also tailor training to different areas.

- Exceptions to business rules – impacts confidence in system. Can't get a consistent copy of business rules – each person asked gives a different answer.

5. How confident are you that the data contained in TMS is sufficiently valid (accurate and timely) to support your decision making responsibilities?
   - 50% confident in safety data – usually conduct manual checks on Highway Patrol data with regards to location (ex. MO141 junction had 50-60% of accidents logged incorrectly; 20% of I64 accidents not on I64 due to HP locating incorrectly) (ex. currently looking at 400 accidents and have found 50 errors – probably due to line work errors and officer data log) (ex. on 18 miles of I44 found 24% of accidents were located incorrectly).
   - Accident locations incorrect – Highway Patrol doesn't understand TMS log system – could be improved by changing the process and training, GPS accident entry. Checking accident reports takes around 3 minutes each (location, drawing, narrative) – have spent around 20 hours reviewing the 400 accident report
   - ADT time lag / inaccuracies is a big issue (data not collected often enough based on growth/decline projections) (ex. I40, I70, MO370 – 2 of 3 incorrect – up to10,000 per day off. MO370 not data collected since 1997, has been based on projections ever since), (poor decisions have been made because of incorrect data – i.e. did night work in Chillicothe because ADT was twice actual).
   - ADT accuracy depends on year of count and location.
   - Traffic count data has had errors that can only be noted if look at previous years data.
   - This year is the first year that the traffic data looks good in the past 4 years.
   - If doing a traffic study for District use then always collect own data – which doesn't get added/counted in TMS even though it is submitted.
   - Traffic studies should only take 5 minutes, but since can't trust data it takes two days to do a job.
   - Bridge data is pretty good.
   - Pavement condition information is a starting point, but must have people go look at pavement to make any maintenance decisions.
   - Pavement data needs to start with getting the arterials correct, then worry about collectors.
   - Pavement data in TMS not used at all.
   - Can take 1 year or more to update line work (i.e. US63 in Randolph was still showing 2 lanes vs. 4 lanes in some places).
   - Line work errors – could use aerial photography to improve.
   - Log points are a function of the business rules, which are not always followed consistently – too many exceptions.
   - The friction maps are useful.
   - Preventative maintenance keeps own lane mile data on paper.
   - Work zone locations are incorrect many times.
   - ADT – not confident, Bridges - confident, Pavement – not confident, Accidents – not confident.

6. How has TMS evolved over the time of your using it with respect to your needs?
    - Used old system until reached point had to use TMS (ROSCO combined with yearly microfilm for accidents).
    - TMS system implementation/maintenance – work required to make TMS function has been underestimated.
    - TMS is a great undertaking – but it is not maintained well. TMS doesn't have the staff to accomplish the task.

7. What additional TMS capabilities would enhance your ability to do your job?
    - Need to focus TMS requirements – do a few things and do them well – ensure base data is correct.
    - Basic preventative maintenance never gets put into TMS – only contract work base on the STIP – therefore SOS doesn't reflect reality and what goes into maintaining the system is not visible. (Districts can only use the FMS to show where money was spent and what for – but FMS is even less intuitive than TMS).
    - Generate "flags" based on age and condition on when to do preventative maintenance (like DTIMS) – currently only way to see if preventative maintenance treatments are working is for the field to make observations
    - Too much focus on providing capabilities for "Power Users" – need to determine the key reports that "main" users need – pavement, geometrics, reports targeted to specific users.
    - Need to streamline interaction with TMS – learning curve too big and there are too many places to look for data.
    - Need current database of ADT's.
    - Allow Districts to help collect data. Train Districts on how to collect data. Give Districts ownership of their data.
    - Update Log miles to GPS/GIS – St. Louis County already has. Sooner convert to GIS/GPS the better.
    - Need rules for acceleration/deceleration/ramps.
    - Add collision diagrams.
    - Add selection of roadways and intersections.
    - Import truck values (Equivalent single axle load – ESIL).
    - Improve flexibility of data (ex. signal inventory sorting, portability between Excel).
    - Make sure unique identifiers never change
    - Add environmental and judicial data.
    - Would like to see TMS be Web-based and accessible to everyone. Needs a user friendly interface and more training at all levels.
    - Don't mess with adding sign logs, striping, etc. until LINE WORK is fixed. Fixing LINE WORK has not seemed to be a management priority
    - ArcView would be nice if it was easier to use.
    - Easy way to provide public information about work zones.
    - Would like to be able to get data for plans from NPO and then produce projections.
    - Add protocols for adding ramps or outer road line work.
    - Keep those that have knowledge of system and how created.

B. Overall interview perceptions

The following is a TMS evaluation based on interview ***perceptions*** with respect to:

- Overall Use – degree to which TMS is used to support job decisions
- Data Confidence – user confidence in data accuracy to support job responsibilities
- Data Availability – availability within TMS of data needed to support job responsibilities
- Desired Applications – degree to which TMS contains applications necessary to perform job responsibilities
- Ease of Interaction – user experience when interacting with TMS

It must be stressed that sometimes interviewees had perceptions of either the data or applications in TMS that did not match with the current state of TMS implementation. This fact does not diminish the significance of the findings of this study. All user and management perceptions, whether accurate or not, impact the overall effectiveness of TMS to support TMS decision making and need to be addressed.

	Overall Use	Data Confidence	Data Availability	Desired Applications	Ease of interaction
GHQ Planning					
Long Range / Programming	High	Med	Med	Med	Med
TMS Support	High	High	Med	High	High
GHQ Project Development					
Management	Low	High	Med	Low	Med
Design	NONE	Low	Low	Low	Med
Bridge Design / Inspection	Med	Med	Med	Med	High
Right of Way	Med	Med	Low	Med	Med
GHQ Operations					
Management	Low	Low	Low	Low	NE
Traffic/Safety	High	Med	High	High	High
Maintenance	Low	Med	Low	Low	Med
Motor Carrier Permits	Low	Low	Low	High	Med
Adopt-A-Highway	High	High	High	High	High
GHQ Other					
Legal	Low	High	Med	Med	Med
Risk Management	NONE	NE	High	Mid	NE
Information Systems	NONE	Med	Med	Low	NE
Research	Med	Med	Med	Low	Med
District					
Management	Med	Low	Med	Med	NE
Planning	High	Low	High	High	Med
Design	Low	Med	Low	Med	High
Operations	High	Low	Med	Med	Low

Table 2: Overall Interview Perceptions

Note: Evaluations are based on a **Low, Med,** and **High** scale (in addition to ratings of: NONE = did not use, and NE = no evaluation).

Apart from the above five evaluation criteria, two other issues should be discussed with respect to the different functions within MoDOT: Feedback/Communication and Separate Databases.

In general there was consensus among the Districts that the Feedback/Communication loop between GHQ and the Districts needed to be addressed. Common themes included: 1) data submitted to GHQ doesn't seem to make it into TMS, and if it does it is not clear when, and 2) data and application use needs are not taken seriously. Individuals at GHQ in Design, Bridge Design, Maintenance, and Motor Carrier Permitting raised similar issues.

The second issue concerned the maintenance of separate databases that either replicate TMS data or contain data that users believe should be in TMS in order to support job responsibilities. Types of data that were being maintained included: contractor work zones, maintenance road restrictions, District Adopt-A-Highway, driveway permits, vertical clearances, State bridge records, environmental data (historic sites, clearances, archeological sites, etc.), parcel acquisition, excess land, striping logs, signage logs, lane mile data, SOS reports based on old log mile records, speed limits, signal head vertical clearances, to name a few. In general most all District functions maintained some kind of separate database and at GHQ is was most prevalent in Design, Maintenance and Motor Carrier Permitting.

As a side note, the TMS Users group that was initiated July 2003 by District TMS Users started out by generating an extensive list of TMS issues to address with respect to six different categories (see Appendix D). This group (which has the majority of the 35 +/- TMS "Super Users" involved in it) is heavily invested in TMS and desires to see it be used for the overall benefit of MoDOT. However, it appears that this group might be losing some of its initial energy and/or ability to address its concerns. Due to the familiarity that this group has with day-to-day use of TMS it would be valuable to explore ways to incorporate their perspectives and address their concerns.

Therefore, there is a two-fold answer to the question of "How TMS is being used?" First, it is only being used by a subset of those who should find value in TMS. Second, of those that do use TMS it is primarily used as a data warehouse to support the generation of reports relevant to overall analysis of the MoDOT transportation network (i.e. planning functions and some operations functions) versus more detailed analysis (i.e. design).

5. Conclusions

Objective #3 - Is TMS helping make better decisions?

Some functional areas are using TMS extensively – GHQ Planning, GHQ Traffic, GHQ Adopt-A-Highway, District Planning, District Operations/Traffic. Some functional areas are using TMS little, if at all – GHQ Design, GHQ Maintenance, GHQ Risk Management, and Districts Design.

Are better decisions being made? In general, we found that the closer you get to a decision maker (i.e. GHQ management or Districts) the less data from TMS is being used to make decisions. The factors that lead to this conclusion are presented in the following.

1) The **scope and objectives of TMS have fallen victim to "mission creep**." Over the years it has morphed into many things. Is it …

a. a data reservoir?
b. a report generator (SOS or NBIS)?
c. for management analysis of program and policy items?
d. for project selection?
e. for project design?
f. everything for everybody?

2) There is a "cry" from the users to **"GET THE DATA CORRECT."** Data confidence has been undermined by both data accuracy and data availability.

From a data accuracy perspective issues include:

a. Traffic volumes (ex. some Districts report that they find some ADT off by a significant number)
c. Accidents and accident locations (ex. Districts report a significant percentage of Interstate accidents mislocated in certain areas)
d.

From a data availability perspective issues include:

a. Road and bridge location (road mileage in some districts is significantly less than reported due to multiple lanes, ramps and outer roads not included)
b Conditions of roads and bridges (maintenance work done by MoDOT is not in TMS)

We found a wide range of confidence in the data. Some believe that this is the best data there is and use it. Others will not even consider trusting the data. In general we found that:

a. GHQ Planning knows the strengths and weakness of the TMS data and factors this into their decisions.
b. Traffic / Safety, especially in GHQ have knowledge of the data, are pretty sure it is the best data they can get and are comfortable with the studies and programs they champion.
c. Management in MoDOT HQ accepts TMS data as reasonably correct (not perfect, but the best they have) and use it.

d. Districts data confidence ranges from:
    i. Use the TMS data with little question.
    ii. Use the TMS data for accidents and travel data, but rely on their "own" records for construction, maintenance, bridge, and pavement information and performance.
    iii. Lightly use the TMS and rely heavily on their own records / judgment for everything else (except perhaps accidents).
e. The further you get from Planning (with the exception of Traffic and off-system bridges) the lower the confidence is in the data. HQ's Design and Environment do not use TMS.

3) The system appears to be more tied to what **was,** than to what **is** or what even **could be**. Often we heard that the data is the "same as before." However, we found a strong desire to move to GIS/GPS, ArcView, Web-based applications, etc. While some of this is available, there is not a clear MoDOT commitment that this is where the future is going.

4) **The continuous log mile system is not working** (GHQ, Districts, Highway Patrol… all have problems) and it is a major source of data errors. Change in this would not only be a step to improving the data quality and reliability, but would be a sign to the MoDOT TMS users that MoDOT is listening.

5) While the **TMS is incrementally getting better**, it still does not sufficiently serve many of the users inside MoDOT, nor those outside of MoDOT (i.e. MPO's, cities, counties, 911 operators, EMS operators, utilities, trucking industry, ….public at large). User friendly, Web based applications based on accurate data are what we heard as critically needed.

6) **Who owns TMS?** This must be resolved. Is data at MoDOT a corporate asset? or Is data something needed for reports? or …? Answering these questions leads one to determine if **data** is line or staff. This issue of whether IS **supports** TMS or **owns** TMS is critical relative to: TMS priorities, people, data quality, budget, service, field, etc. This is a festering problem that needs to be addressed.

7) There is a **need for both Training and Education** in the TMS arena. There are users that are frustrated due to not being able to execute their job responsibilities and there are managers that have little understanding of what TMS is or is capable of doing.

Overall, TMS is not supporting decision making to the extent that it is capable. At the moment, for the most part, TMS is a data warehouse that needs to be cleaned up. Then decision support tools can be incorporated that allow for forecasting, what-if analysis, etc. Only then will the data be able to empower decision makers to use decision tools that support making decisions that can be measured and validated.

6. Recommendations and Implementation Plan

Objective #4 - How could TMS be improved?

The following recommendations are based on the data collected during this research, as well as a review of past documentation related to TMS and best management information system practices. This analysis was conducted at a high-level due to the short study time frame and some of the recommendations might warrant a more detailed-level, intensive analysis. However, regardless of the level of analysis there are several needs that stand out as needing to be addressed.

The recommendations are divided into two groups. The first group is those needs that should be addressed immediately so that TMS can be enhanced and better utilized. The second group is needs that are important and should be addressed in the near future. Along with each recommendation, implementation issues related to the recommendation are discussed.

Recommendations – Immediate Needs

Recommendation: The focus, scope, and objectives of TMS need to be re-evaluated.

Implementation: There is a consensus from users that there has been "mission creep" with respect to TMS. Many feel that TMS has expanded too far and no longer spends the time and resources needed on the base line, original objectives of TMS. MoDOT management needs to determine the scope and focus of TMS for the next five years and give direction as to what is most important for TMS. This should involve a careful look at the history of TMS, the original implementation plan as well as adjustments to that plan, the budget, and the desired capabilities of TMS.

Recommendation: Issues related to data must be resolved

Implementation: The major concern of users was data. If the users do not trust the data then TMS will never reach its full potential and no amount of bells and whistles can compensate for perceived poor data. The issues related to data include accuracy (e.g. incorrect placement of accidents, pavement analysis), currency (e.g. how old is the ADT information), and availability (e.g. environmental data, ramps, outer roads). The first step in this process would include the determination of the actual quality of the existing data in terms of its accuracy and its age. There is a wide variation in terms of perception of this quality depending on who is using it. Another issue to be addressed is the expectation of the data. That is, is this data only designed for use at higher levels of decision-making or can the lowest levels reliably use it? When the quality of the data is determined, then it needs to be rectified as quickly as possible in relation to the scope determined for TMS by MoDOT management. The correction and enhancement of the data should be done at both the district and

headquarters levels. Data needs to be viewed as a corporate asset and treated as such.

Recommendation: A process for maintaining the data and its quality must be determined

Implementation: Once an effort has been made to bring the data up-to-date and to a high level of reliability, it then must be maintained to retain those levels. The first thing to be done is to determine priority levels of data for currency and quality. Higher priority levels would be for data that needs to be very accurate and almost real time. Lower priority levels would be for data that can be used without concern even if it is aged or of lower reliability. After the determination of these levels of data, a process for maintaining each level must be determined. Within this process would be the degrees of quality and currency wanted for each level and protocols for achieving this. For example, one may want ADTs to be based on data within the last year, 90% of accident reports in TMS to have been landed correctly, or pavement conditions to be based on two lanes instead of one. One may also have that any data sent to headquarters will be put into the system within four weeks of receipt. The target ranges for quality and currency need to be determined by both the district users and headquarters as well as the quality control procedures. Another aspect related to this is the determination and dissemination of the data responsibilities for both the districts and headquarters. This would include who is responsible for collecting, maintaining, and entering the data. Giving ownership of data to users generally will result in higher quality data and more acceptance of the data. As part of this it should also be determined who inputs data and who checks the data for quality and at what level. Lastly, there needs to be a simple, quick process for correcting any inaccuracies found in the data at either the district or headquarters level.

Recommendation: TMS Education and Training

Implementation: Across MoDOT there is a wide variation of understanding concerning TMS. This involves upper management as well as users. TMS is a mystery to some and to others there is a wide diversity of misunderstandings related to capabilities (either thought to have but actually doesn't or thought not to have but actually does). Most people's exposure to TMS is only the initial training. There is no follow-up training or consistent, coordinated dissemination of information. Therefore, education needs to be provided on the capabilities of TMS. This should include upper management in particular as well as the districts. Education could include some training, but should mainly concentrate on getting out an accurate picture of TMS and its capabilities. This could also involve such things as mini-courses, applications of the week, demonstrations, a newsletter, etc. The bottom line is that many people misunderstand TMS and this needs to be corrected in order for TMS to be more widely

accepted and used. Lastly, it also needs to be an ongoing effort, not a one-time event.

Recommendation; Communication of TMS related information for users needs to be enhanced.

Implementation: Many users expressed concern over the lack of information they were given related to TMS rollouts, updates, data entry, etc. This leads to distrust and a lack of confidence in TMS and the data. Communication needs to be free flowing and pertinent. This could be established by a Web page dedicated to TMS issues and e-mail updates. The Web page could include such things as FAQs, weekly updates, a user interaction section for questions and answers, hints and suggestions, and any other information related to TMS.

Recommendation: Responsibility for TMS needs to be resolved as well as budget issues.

Implementation: Ownership always enhances a product. TMS seems to be suffering from problems related to who is responsible for TMS data, updates, etc. This is directly tied to the budget as well. TMS can be better managed and maintained if it is given its own budget and clear lines of responsibility are delineated. With a dedicated budget, it would be easier to plan for and implement the recommendations made above. This is a critical issue in terms of making TMS the tool it was designed to be. In addition, TMS data needs and applications need to be determined by all TMS users from all MoDOT functions.

Recommendations – Needs to be Addressed in the Near Future

Recommendation: A more user-friendly interface for TMS needs to be put in place

Implementation: TMS is viewed as a cumbersome and hard to use tool by many due to its interface. It is not intuitive for most users and for the casual user it is not conducive at all. The interface keeps many from using TMS. This interface needs to be designed with all users in mind and input from the users should be sought. It should be a graphical interface and allow a user to ascertain information without the need of going through multiple screens.

Recommendation: The location referencing system (LRS) needs to move to GPS

Implementation: Everyone we talked to wanted a GPS referencing system. Even though log miles is an appealing (and historic) idea there are problems inherent with it. The key here is that the system needs to be static. This implies that changes made by an update only impact the intended component, not

the entire system. The classic example is that when a curve is straightened at the Iowa border on US71 and every log mile for US71 in southern Missouri changes. Several districts are already collecting GPS information and intend on moving to GPS coordinates. This is obviously the direction for the future and it needs to be addressed and decision on how and when to implement it should be made. A possible concern here is the accuracy of GPS. However, initially GPS accuracy is probably good enough for most of the roadways in the system and there may be ways to increase the accuracy. Stronger use of aerial photography (or satellite imagery) now available in TMS may be helpful.

Recommendation: Increase and improve the training for TMS

Implementation: Many felt that the current training was not sufficient. They initially receive several intense days of training, but there is no follow-up. Much of what they learn they do not use for several months and then they have to relearn it. Likewise, the training may not cover the eventual needs of the user. Follow-up training in the districts would be beneficial. This training needs to be hands-on and use relevant examples. Note that the users were all very pleased with the support from TMS staff and learned from that, but they also wanted more in-depth training and refresher training so they would not always need to depend on TMS staff. This would make them more efficient and provide better in-house resources for the districts.

Recommendation: Make TMS Web-enabled

Implementation: The TMS support personnel would need to be contacted to see the feasibility of moving TMS to the Web. Access and security would be an issue that would have to be resolved, but the benefits of making TMS Web-enabled would be significant. With TMS as a Web application, it would then be accessible from every desktop and be more likely to be used, if joined with a user-friendly interface. This could also potentially reduce costs and would make new updates and rollouts much easier and quicker. It would also potentially make the input of data and the correction of data easier as well.

Recommendation: Add decision systems support to TMS

Implementation: The original goal of TMS was to have a system that a supported making good decisions. Currently TMS is not a decision support tool in the classic sense. It does support decisions, but only as a data repository. Decision support capabilities need to be added to TMS. This would require an extensive study to determine the types of decisions made at MoDOT that would require support and the type of support needed. It would then be necessary to design, develop, or buy and integrate the

support tools. Many of these already exist in terms of forecasting, scheduling, and project management, but other more specific decisions would require potentially custom tools. As part of this, it would also be necessary to determine the associated data requirements, which might entail data from sources other than TMS.

Recommendation: The data in TMS needs to allow for better and easier integration and cross-functional analysis

Implementation: TMS was originally designed to meet the needs of certain areas. It was determined to put relevant data into silos for specific use by those main users, for example, bridge and traffic. This makes those components of TMS work well, but it does not allow a user to easily access relevant data from the different silos for analysis. It is possible to do, but is quite cumbersome and time consuming. Applications should be developed that allow for this cross-functional analysis. One potential way to do this would be to make ArcView the main interface to the data. If all data was accessible through ties into ArcView maps then a user could easily pull up needed information from across the databases. This cross-functional analysis ability is essential to making TMS a tool that supports good decisions.

In summary, TMS is an excellent tool that is often misunderstood and underused. TMS does lack certain functions that would make it a better tool and these are addressed in the above recommendations. Most of these recommendations will require work, but they are all achievable. An excellent foundation has been established and an excellent team has been put into place. It now must be decided if and how to move TMS to the next level so that its capabilities can be enhanced and optimally utilized for the benefit of MoDOT and the citizens of Missouri.

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APPENDIX A

Work Plan

ASSESSMENT OF MoDOT's TRANSPORTATION MANAGEMENT SYSTEMS

Principal Investigator
James S. Noble, Ph.D., P.E.
Department of Industrial and Manufacturing Systems Engineering
Phone: 573-882-9561
NobleJ@missouri.edu

Co-PIs
Charles J. Nemmers, P.E.
University of Missouri-Columbia
Department of Civil and Environmental Engineering
E2509 Engineering Building East
Columbia, MO 65211
Phone: (573) 882-0071 Fax: (573) 884-4784
nemmersc@missouri.edu

Cerry M. Klein, Ph.D.
Chair, Department of Industrial and Manufacturing Systems Engineering
Phone: 573-882-9566
KleinC@missouri.edu

Background:

MoDOT's top management has expressed a desire to evaluate its existing Transportation Management Systems (TMS) and, as appropriate, related information systems. These systems, principally the TMS, receive, organize and process data into information that is used to support many of the decisions made with in the Missouri DOT.

MoDOT would like to know with respect to TMS: What do we have? How are we using it? Is it helping us? What could we do better?

This research will specifically ascertain the current status, strengths and weaknesses of MoDOT's existing Transportation Management System and provide an analysis of how this system serves MoDOT. The systems engineering analysis provided as a result of this review will identify any disparity between current practices and the state of the art practices. Better and more informed decision-making may be possible as a result of this fundamental assessment of MoDOT management systems.

Study Proposal:

The primary objective of this study is the global evaluation of the current conditions and practices surrounding Missouri's Transportation Management Systems so as to provide professional observations and recommendations to MoDOT on how it can best use the TMS information to enhance the decision making process.

The specific steps will be:

(1) Identify and document the current practices of MoDOT with respect to its Transportation Management Systems, including the data collected and tools used.
(2) Assess the advantages and disadvantages of current decision making practices via a multi-level sampling of representative MoDOT decisions.
(3) Compare the existing system and practices used with state-of-the-art in engineering systems and other state DOT decision support processes so as to identify the strengths and weaknesses of MoDOT's TMS.
(4) Develop a report documenting the study approach, the key findings and recommendations on improving the TMS system and related procedures so as to enable MoDOT to strengthen its decision making process.

Please note that this is a global review and analysis of the TMS. While details relating to data quality, statistical sampling techniques, data collection practices, etc. will be sampled and studied; they will be studied to "test" the strength of the overall TMS. Detailed analysis of all the data elements and systems and their components is not within the scope of this evaluation, nor possible within the time frame suggested for this study.

Overview of the research approach /methodology:

The research team will consist of Dr. James Noble as Principle investigator, with co-PI's: Mr. Charles Nemmers, P.E. and Dr. Cerry Klein. Dr. James Noble and Dr. Cerry Klein will team to lead the systems engineering study and overall analysis on the project. Mr. Nemmers will both manage the administrative aspects of the project and will provide the highway and transportation linkages with the systems engineering aspects of the evaluation by participating in the decision maker interviews, data analysis, and "best practices" assessment.

All data from MoDOT management systems and available in MoDOT offices will remain at MoDOT and not be copied and transferred to other machines off of MoDOT premises.

Listing of research tasks

A. Gather and compile information on the MoDOT decision making process through discussions with key MoDOT personnel and available literature *(Klein, Noble, Nemmers).*

   Analyze and document the representative decision-making processes used at strategic, tactical and operational decision levels. The operational level decisions will include both representative district decisions and HQ level decisions.

B. Discover, understand, and document MoDOT's TMS *(Noble and Klein).*
    - Conduct an inventory of the data available within the TMS. This will include an analysis of the types of information, data, resources, etc. used for management decision-making.
    - Analyze the various strengths and weaknesses of the data collected by MoDOT with respect to decision making.
    - Understand the purpose, need, relevance, application, etc. of the data used by MoDOT in their various management systems.

C. Analyze and document the advantages and disadvantages of the Transportation Management System used by MoDOT. *(Nemmers, Noble, Klein)*
    - Develop a conceptual framework for evaluating current systems and practices in order to understand the various management systems used by MoDOT in their decision-making process.
    - Analyze the various strengths and weaknesses of the TMS with respect to other state DOT system engineering practices.
    - Use the information collected to develop recommendations for efficient use of these systems.

D. Prepare a final report and a presentation detailing results and recommendations. *(Nemmers, Noble, Klein)*

Key Project Deliverables

1. An inventory of the data available to MoDOT.
2. Develop a conceptual framework and evaluate current TMS practices with respect to state-of-the-art DOT practices.
3. A report on the systems used and current practices relating to MoDOT's use of their data systems, principally TMS, in support of decision making.
4. Recommendations of how the findings of this research can be applied immediately to assist MoDOT in making better decisions.
5. A list of potential studies will be developed for MoDOT consideration that could deliver significant benefits to MoDOT in strengthening the effectiveness of their decision making.
6. Final report documenting the evaluation of the TMS.

Project Time Line

The final report will be completed by December 31, 2003, and the Task Order will expire on January 31, 2004.

No work will be conducted at MoDOT facilities after-hours.

APPENDIX B - Self-assessment charts from the NCHRP Project 20-24 (11) Training Course

3. Self-Assessment

3.2.4 PART D. INFORMATION AND ANALYSIS

Do Information Resources Effectively Support Asset Management Policies and Decisions?

		Strongly Disagree			Strongly Agree
EFFECTIVE AND EFFICIENT DATA COLLECTION					
D1.	Our agency has a complete and up-to-date inventory of our major assets	1	2	3	4
D2.	Our agency regularly collects information on the condition of our assets.	1	2	3	4
D3.	Our agency regularly collects information on the performance of our assets (e.g., serviceability, ride quality, capacity, operations, and safety improvements).	1	2	3	4
D4.	Our agency regularly collects customer perceptions of asset condition and performance.	1	2	3	4
D5.	Our agency continually seeks to improve the efficiency of data collection (e.g., through sampling techniques, use of automated equipment, other methods appropriate to our transport systems).	1	2	3	4
INFORMATION INTEGRATION AND ACCESS					
D6.	Agency managers and staff at different levels can quickly and conveniently obtain information they need about asset characteristics, location, usage, condition, or performance.	1	2	3	4.
D7.	Our agency has established standards for geographic referencing that allow us to bring together information for different asset classes	1	2	3	4
D8.	Our agency can easily produce map displays showing needs/deficiencies for different asset classes and planned/programmed projects.	1	2	3	4
D9.	Our agency has established data standards to promote consistent treatment of existing asset-related data and guide development of future applications.	1	2	3	4
USE OF DECISION SUPPORT TOOLS					
D10.	Information on actual work accomplishments and costs is used to improve the cost-projection capabilities of our asset management systems.	1	2	3	4
D11.	Information on changes in asset condition over time is used to improve forecasts of asset life and deterioration in our asset management systems.	1	2	3	4

Table 3.4 Information and Analysis Diagnostic

Benchmark	Common Gaps	See these Sections of the *Guide*
EFFECTIVE AND EFFICENTY DATA COLLECTION (D1-D5)		
Compete and current asset inventory and condition data	Data do not reflect full range of assets under agency responsibility	
Efficient data collection and processing methods provide credible data at acceptable cost	Existing data lack credibility; data collection perceived as not worth its cost	Section 7.4 Cost Tracking
Information on customer perceptions collected and used.	Information on customer perception of condition/performance un-available	Section 8.2 Information Needs and Data Quality
INFORMATION INTEGRATION AND ACCESS (D6-D9)		
Managers at all levels can easily access information they need	Lack of data sharing across units; duplication and inconsistency	
Maps of asset condition, need, and projects are readily available	Staff lack good tools to access data or lack training on their use	Section 8.3 Data Integration and Accessibility
Geographic referencing and data standards in place	Lack of consistent geographic referencing	
USE OF DECISION SUPPORT TOOLS (D10-D16)		
Tools are available to calculate performance measures	No systematic process for identifying needs	
Tools are used to systematically identify needs and projects	Project selection lacks credible justification	Section 8.4 Decision Support
Tools are used to analyze project or strategy benefits and costs and compare alternate solutions	Lack of ability to relate investment levels to resulting performance or benefit	
SYSTEM MONITORING AND FEEDBACK (D17-D20)		
Agency monitors system condition/performance	No systematic process for monitoring capital programs	Section 7.4 Program Management
Actual condition/performance compared to target values	No systematic process for monitoring maintenance programs	Section 8.5 Systems Monitoring and feedback
Information periodically provided to decision-makers and external stakeholders	No mechanism for providing monitoring results to decision-makers and external stakeholders	Section 8.6 Reporting and Documentation

APPENDIX C

Interview Procedure and Questions

The following general introduction to the TMS study provided the entry point into the types of information being collected depending on the background of the person being interviewed. The interviewees were then given follow-up questions to make sure all of the relevant questions were addressed.

As part of our evaluation of the TMS at MoDOT we are interviewing a wide range of TMS users from different organizational units, disciplines and different levels to obtain your impression of TMS with respect to: its pro's and con's; strengths and weaknesses; opportunities, etc.

Please share with us your understanding of the Transportation Management System and how you use it?

If you could change two things about TMS what would they be?

Which part of TMS do you like best? Get the best service from?

Management Questions

1. What is the range of decisions for which your position is responsible? (from high level/occasional to low level/routine)
2. What are the primary objectives for these various decisions?
3. What data is required to make these decisions?
4. To what degree does TMS support making these decisions? (significant/direct to somewhat/indirect to not at all)
5. In what way do you interact with TMS information? (Ex. executive summary reports, basic reports, direct user)
6. From your perspective what are the strengths of the TMS in its current form?
7. From your perspective what are the weaknesses of the TMS in its current form?
8. How has TMS evolved over the time of your using it with respect to your needs?
9. What additional TMS capabilities would enhance your ability to make decisions?
10. How do the District Offices and people use the TMS in their dealings with you or your programs?
11. How does the TMS help serve those outside of MoDOT, i.e. FHWA, Locals, AASHTO, industry groups, business community, TV/radio?

TMS User Questions

1. What is the range of responsibilities/decisions associated with your position? (from routine to periodic - 4 to 6 most common)
2. What are the primary objectives for the various decisions you make? What data is needed to make these decisions?
3. What are your responsibilities that require using TMS?

4. To what degree does TMS support these responsibilities? (significant/direct to somewhat/indirect to not at all)
5. In what way do you interact with TMS information? (Ex. executive summary reports, basic reports, direct user)
6. If you are a direct TMS user, 1) how often and to what extent do you use it? 2) what types of information/reports do you use and how often?
7. From your perspective what are the strengths of the TMS in its current form? (Ex. What is most useful, best data, etc.)
8. From your perspective what are the weaknesses of the TMS in its current form? (What is least useful, poor data, etc.)
9. How confident are you that the data contained in TMS is sufficiently valid (accurate and timely) to support your decision making responsibilities?
10. How is the data that you use collected and entered into TMS?
11. How has TMS evolved over the time of your using it with respect to your needs?
12. What additional TMS capabilities would enhance your ability to do your job?

APPENDIX D

TMS User Group – 54 Issues to Address
by category and ordered as added to brainstorming list

(Identified at July 10, 2003 and August20, 2003 TMS User Group Meetings)

A. Data Issues

1. Missing Roadway Data – status and who is responsible to enter the data? (Includes Outer Road and Ramp data [#45])
2. Incorrect Accident Data
4. Occasional data errors
12. Shifting of data locations due to travelway maintenance.
21. Percent Trucks
21a. Accidents on undivided roadways
21b. ESALS
33. County Roads naming convention and names and numbers updated.
41. GPS Issues
46. Update to Pavement Depth of Roadways
47. Materials Associated wit Pavement thickness
48. Project and Job Numbers Available with Pavement thickness
49. Metadata with shape files and coverages
50. Status of State of the System Pavement tables
51. Side Street Volumes
53. Work Zone data input tied to project data.

B. <u>Training Issues</u>
8. New Software Training
15. Clarification of TMS data items (definitions)
16. Specialized Training
22. Training on how to get the data needed.
23. Educate non-TMS users on what the system can do and what data is available.
24. Let everyone use TMS.
25. Creativity in reporting or using the data – many tools can be used such as Access, TMS, ArcView stand alone, Spreadsheets, Crystal Reports, Impromptu, etc.
26. MoDOT employees needs database training and culture change to use databases more.
31. What pavement data is available?
52. Create TMS flyer or brochure to get the word out about what TMS can provide (for non-users)

C. Processes and Responsibilities

3. Who is correct contact person for issues
5. Who is responsible for data maintenance?

7. Agreement on Business Rules
9. Structured process for inputting data
11. What section is responsible for what data
17. Timing of data updates
20. Fixes that were not asked for appearing and causing problems with data inaccuracies
35. Giving district personnel authority to fix data (enter data)
51. Side Street Volumes
54. Testing

D. Needs, Wants and Wishes

6. Application performance
10. Final design plans added into TMS
13. Where is horizontal and vertical curve data?
19. More user-friendly applications
26. MoDOT employees needs database training and culture change to use databases more.
27. More detailed online TMS Help
28. Index for finding what I need in TMS
29. Link Programming and other external data sources to TMS – FMS, County courthouses for property records, deeds, Dept. of Conservation, DNR, DOR, MPO/RPC, etc.
30. Pavement thickness needs to be in State of System browser and reports.
32. Links to Microstation and Geopak
34. Lack of manpower and resources for TMS support staff.
42. TMS customized per desktop or district
43. Discussion Database.

E. Queries and Reporting Issues

14. Customized State of System reports by section, department, or work unit
25. Creativity in reporting or using the data – many tools can be used such as Access, TMS, ArcView stand alone, Spreadsheets, Crystal Reports, Impromptu, etc.
36. Include 5 yr accident rates in State of System
42. TMS customized per desktop or district
44. Query in ArcView by Area Engineer

F. Log Mile Issues

12. Shifting of data locations due to travelway maintenance.
18. Continuous log mile use or lack thereof
37. County Log Index for ArcView
38. Remove County Logs from TMS
39. Stop using old logsheets that are no longer updated.
40. Make log information available in field
41. GPS Issues