2013

# Cost-Effective Data Collection to Support INDOT's Mission

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Recommended Citation

Fricker, J. D., M. Noureldin, T. Stroshine, and W. Richardson. *Cost-Effective Data Collection to Support INDOT's Mission*. Publication FHWA/IN/JTRP-2012/35. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2013. doi: 10.5703/1288284315040.

**JOINT TRANSPORTATION RESEARCH PROGRAM**

INDIANA DEPARTMENT OF TRANSPORTATION
AND PURDUE UNIVERSITY

# COST-EFFECTIVE DATA COLLECTION TO SUPPORT INDOT'S MISSION


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SPR-3432
Report Number: FHWA/IN/JTRP-2012/35
DOI: 10.5703/1288284315040

## RECOMMENDED CITATION

Fricker, J. D., M. Noureldin, T. Stroshine, and W. Richardson. *Cost-Effective Data Collection to Support INDOT's Mission*. Publication FHWA/IN/JTRP-2012/35. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2012. doi: 10.5703/1288284315040.

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## JOINT TRANSPORTATION RESEARCH PROGRAM

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Published reports of the Joint Transportation Research Program are available at: http://docs.lib.purdue.edu/jtrp/

## NOTICE

TECHNICAL REPORT STANDARD TITLE PAGE

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
| --- | --- | --- |
| FHWA/IN/JTRP-2012/35 | | |

| | |
| --- | --- |
| **4. Title and Subtitle**<br><br>Cost-Effective Data Collection to Support INDOT's Mission | **5. Report Date**<br><br>December 2012 |
| | **6. Performing Organization Code** |
| **7. Author(s)**<br><br>Jon D. Fricker, Menna Noureldin, Timothy Stroshine, and Wayne Richardson | **8. Performing Organization Report No.**<br><br>FHWA/IN/JTRP-2012/35 |
| **9. Performing Organization Name and Address**<br><br>Joint Transportation Research Program<br>Purdue University<br>550 Stadium Mall Drive<br>West Lafayette, IN 47907-2051 | **10. Work Unit No.** |
| | **11. Contract or Grant No.**<br>SPR-3432 |
| **12. Sponsoring Agency Name and Address**<br><br>Indiana Department of Transportation<br>State Office Building<br>100 North Senate Avenue<br>Indianapolis, IN 46204 | **13. Type of Report and Period Covered**<br><br>Final Report |
| | **14. Sponsoring Agency Code** |

**15. Supplementary Notes**
Prepared in cooperation with the Indiana Department of Transportation and Federal Highway Administration.


**16. Abstract**

This study's main purpose was to provide an inventory of the data collection programs undertaken by INDOT's divisions and offices and to give recommendations regarding addition, removal, or modification of data collection programs. Chapter 1 provides a background for the data collection efforts at INDOT and in other State DOTs. The inventory phase of the project was accomplished through a series of interviews, which were converted into a series of technical memos in Chapter 2. Chapter 3 summarizes information about the data collection programs carried out by INDOT, including the data items collected, the data collector and/or owner entity, frequency of collection, the tools used for data collection and storage, and the purpose of collection. The information was compiled from the INDOT Data Collection Online Survey and phone interviews with INDOT employees. In Chapter 4, a set of flow diagrams were created to depict the creators and users of data within INDOT. The tables in Chapter 5 that summarize the data needs, use, and adequacy as seen by various units in INDOT is the result of another online survey. Chapter 6 presents suggested changes to the INDOT data collection programs that can continue to meet state and federal requirements, while making the data collection process more efficient.


| 17. Key Words | 18. Distribution Statement |
| --- | --- |
| data collection, SPR-3432 | No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161. |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
| --- | --- | --- | --- |
| Unclassified | Unclassified | 139 | |

**Form DOT F 1700.7 (8-69)**

# EXECUTIVE SUMMARY

## COST-EFFECTIVE DATA COLLECTION TO SUPPORT INDOT'S MISSION

### Introduction

The Indiana Department of Transportation (INDOT) collects a large amount of data for a variety of reasons and uses. Much of the data are required by federal legislation. Other data elements are collected because they will help INDOT fulfill its mission, which is to "plan, build, maintain and operate a superior transportation system enhancing safety, mobility, and economic growth."

The majority of the data is addressing mobility and congestion. Other data concern physical assets, including infrastructure inventory such as roadway geometry, pavement condition, and bridge condition, and nonphysical assets such as safety-related measures.

The challenges involved in transportation data collection and management are faced by all state departments of transportation. INDOT operates in a changing environment. Funding is decreasing, and traffic volumes decline when economic conditions falter. At a time when traffic data cannot just be extrapolated to fill gaps in the data base, the resources needed to track the changes in traffic patterns must be applied with as much efficiency as possible. Infrastructure inventory data also must be maintained as efficiently as possible to allocate maintenance funds. To meet these challenges, the following items are addressed in this report:

- What data are currently collected by INDOT?
- What are INDOT's data needs?
- How effectively do collected data meet those data needs?
- How can data collection be improved to more effectively meet those data needs?

Additional needs were expressed to identify data owners for each set of data. The recommendations presented herein are offered to demonstrate how day-to-day data operations can be improved with respect to quality, efficiency, and effectiveness.

### Findings

An inventory and description of the data types were formulated. A set of technical memos were created, based on interviews and online surveys of experts and INDOT business leaders for each data type. The memos in Appendix B provide a snapshot of INDOT's data collection activities in each business unit.

Chapter 3 summarizes in tabular format information about the data collection programs carried out by INDOT. The information includes the data items collected, the data collector and/or owner entity, frequency of collection, the tools used for data collection and storage, and the purpose of collection.

In order to represent the connections between databases, different offices, and data owners at INDOT, a series of flow diagrams are demonstrated in Chapter 4. The flow diagrams are structured as a series of nodes connected by arrows indicating the direction of the flow of information.

To gauge how well the data collected by INDOT are meeting the needs of its users, an online survey of data users at INDOT was undertaken. The survey focused on three types of data inadequacies: data that were unavailable, data that were inaccurate, and data that were outdated. The results are summarized and presented employing bar charts and tables in Chapter 5. This project found that the overwhelming majority of the data collection efforts at INDOT are done well. This is especially impressive, given how much data INDOT collects and the opportunities given to data users during this study to point out any shortcomings in INDOT's data collection program.

### Implementation

The following is a list of recommendations to improve data collection based on the surveys, interviews, and literature reviews conducted during this study. The suggestions below are described in more detail in Chapter 6 and offer either cost savings or a better basis for programming projects.

1. Investigate the accuracy of vehicle weight data collected by WIM stations and methods of weight calibration and verification, because those data items are crucial inputs for many INDOT functions, including pavement and bridge design and maintenance and capacity planning.
2. Resume collection of pavement surface distress and calculation of Pavement Condition Rating annually at the network level for all roads under State jurisdiction and consider employing new technologies of collecting surface distress data at the project level.
3. Collect and employ Falling Weight Deflectometer data to assess the structural strength at the network level. A complete coverage of roads under State jurisdiction in five years is achievable. Ground Penetrating Radar tests should be conducted as a supplementary measure to ascertain pavement thickness information when needed.
4. Identify bridges that can be inspected every 48 months instead of 24 months according to the FHWA criteria and Consider inspection at a 48-month interval for those bridges. This study found that an estimated eighteen percent of INDOT bridges meet the FHWA criteria for having their routine inspection intervals changed from 24 to 48 months.
5. Develop intersection and ramp databases to improve network-level safety analyses and contribute to safer intersections and ramps.
6. Develop a geospatially enabled database that displays the land parcels under INDOT ownership.
7. Make the vehicle classification information collected at sites equipped with ITS more accessible to data users.
8. Three major data systems—the Work Management System, the Scheduling and Project Management System and the *Automated Reporting Information Exchange System* – should be interfaced with other systems.

The interrelationships between databases at INDOT are being evaluated and modified on a continuous basis. The ongoing development, expansion, and refinement of the data warehouse and Management Information Portal can take into account the aforementioned recommendations.

There are also five recommendations to improve data governance and management. These recommendations are made because of issues regarding the difficulty cited by INDOT personnel in fulfilling their data requests and the seeming lack of cost information regarding INDOT's data collection activities. These recommendations are described in more detail in Chapter 6.

1. Periodically update the Data Collection Inventory tables developed in Chapter 3 and publish them online.
2. Institutionalize a system in such a way that data needs can be satisfied through online or an owner who can respond promptly to the requestor.
3. Monitor the total annual costs of itemized activities within each data collection program.

4. Adopt data governance procedures to evaluate existing and proposed data collection programs to justify the need for their execution, to ensure they operate in a cost-effective manner, to improve the quality of the collected data, and to ensure that data are labeled properly for the intended users.
5. Improve the format and content of agency information provided to the Indiana Transparency Portal as a potential avenue to inform the public of INDOT's performance in project delivery and in maintenance of infrastructure in good condition.

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## 1. DATA COLLECTION AT A STATE HIGHWAY AGENCY

### 1.1 General Introduction

The Indiana Department of Transportation (INDOT) collects a large amount of data for a variety of reasons and uses. Much of the data are required by federal legislation. Prominent examples of data required by the federal government are:

- A continuous data collection system called the Highway Performance Monitoring System (HPMS). http://www.fhwa.dot.gov/policyinformation/hpms/nahpms.cfm
- The National Bridge Inspection Standards (NBIS) require states to maintain an inventory of bridges greater than 20 feet on all public roads. http://www.fhwa.dot.gov/bridge/nbis.htm
- INDOT Real Estate Office must provide to FHWA Office of Real Estate Services proof of compliance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act. http://www.fhwa.dot.gov/realestate/index.htm
- For contracts that use Recovery Act funds from the American Recovery and Reinvestment Act of 2009, it is the State DOT's responsibility to report the number of jobs on projects managed by funding recipients, such as other state agencies or local governments. www.tdot.state.tn.us/construction/ARRA/FHWA%20FORM%201589%?20*Reporting*%20*Requirements*.pdf
- Fatal crash data must be given to the National Highway Traffic Safety Administration for the Fatal Analysis Reporting System. http://www.nhtsa.gov/FARS
- As part of the new Highway Safety Improvement Program (HSIP), states are required to submit an annual report describing not less than 5 percent of their highway locations exhibiting the most severe safety needs. http://www.fhwa.dot.gov/policyinformation/hpms/nahpms.cfm
- A census of all trucks and buses involved in fatal, injury, and tow-away crashes reported by states to the Federal Motor Carrier Safety Administration (FMCSA). http://ai.fmcsa.dot.gov/CarrierResearchResults/Outreach.asp?pgs=15
- Crashes involving trains must be reported to the Federal Railroad Administration. http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/ReportingRequirement.aspx

These federally mandated data collection activities will be described in more detail later in this report, as needed.

Other data elements are collected because they will help INDOT fulfill its mission, which is to "plan, build, maintain and operate a superior transportation system enhancing safety, mobility, and economic growth" (*1*). Much of the data are collected to assess mobility and congestion. Other data concern physical assets, including infrastructure inventory such as roadway geometry, pavement condition, bridge conditions, and non-physical assets such as safety-related measures.

While most of these data collection activities are ongoing and predictable, there are situations in which INDOT must collect or retrieve data for special cases not part of a routine schedule. There may be a need to conduct traffic counts before a project begins, to assess the impacts of a detour, or for a traffic impact analysis study. An example of needing to retrieve appropriate data quickly is the recent requirement to justify projects under the American Recovery and Reinvestment Act of 2009.

The validity of data collected and/or stored by INDOT has major implications. The road mileage certified for each city, town, and county in Indiana, for example, is used to determine how much funding from certain accounts is allocated to each jurisdiction.

Once the collected data are in electronic form, the data need to be checked for validity and prepared for archiving. At some point, these data may have to be retrieved for periodic reports or special requirements. While Figure 1.1 may look simple, the tasks involved in the various boxes can demand significant resources.

The literature reflects a growing concern about data collection and management in the transportation field. Numerous studies on specific aspects of data collection have been done for INDOT (*3–11*).

The challenges involved in transportation data collection and management are faced by all state departments of transportation. INDOT operates in a changing environment. Funding is decreasing, and traffic volumes decline when economic conditions falter. At a time when traffic data cannot just be extrapolated to fill gaps in the data base, the resources needed to track the changes in traffic patterns must be applied with as much efficiency as possible. Infrastructure inventory data also must be maintained as efficiently as possible to allocate maintenance funds. To meet these challenges, the following items will be addressed in this report:

- What data are currently collected by INDOT?
- What are INDOT's data needs?
- How effectively do collected data meet those data needs?
- How can data collection be improved to more effectively meet those data needs?

INDOT maintains a variety of spatial and tabular databases. They contain information about INDOT's assets and road network. To capture INDOT's current data collection effort, a comprehensive descriptive overview of the relationships within the INDOT data

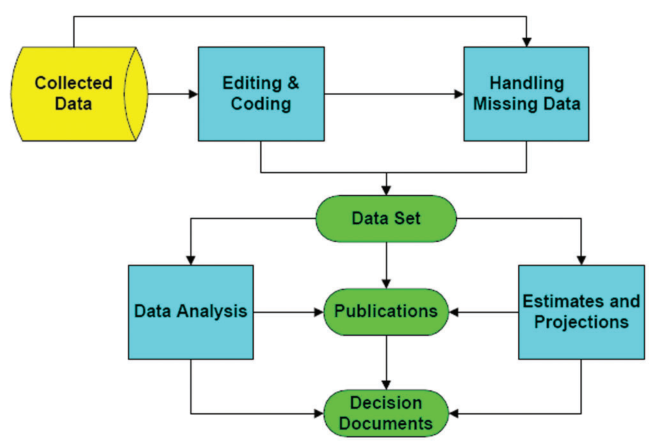



**Figure 1.1** Processing data (*2*).

management system was developed. This was done in the forms of technical memos about different databases as well as flow diagrams modeling the relationships between the databases. Attention was directed to the need and opportunity for data integration. To identify data needs and assess data quality, a survey of INDOT consumers of data was undertaken. Based on that survey and the overview of data collection practices, recommendations were offered to demonstrate how day-to-day data operations can be improved with respect to quality, efficiency, and effectiveness.

## 1.2 Data Management

### *1.2.1 Data Management Definition and Benefits*

This study has focused on developing an inventory of data collection programs undertaken by INDOT and cataloguing the data needs as identified by INDOT employees. In addition to fulfilling these objectives, the research project explored data quality and accessibility issues within INDOT. These issues were brought to light from the INDOT Data Needs Survey, previous research projects undertaken by the Joint Transportation Research Program, and published literature on data management in DOTs.

NCHRP Report 666 (*12*) defines data management as "the Development, Execution, and Oversight of architectures, policies, practices, and procedures to manage information lifecycle needs of the agency in terms of Data Collection, Storage, Security, Data Inventory, Analysis, Quality Control, Reporting and Visualization." The purpose of data management is to ensure usefulness of collected data to INDOT employees, improve data quality and evaluate the cost-effectiveness of data collection.

The Dye Management Group's 2003 study (*13*) of Montana DOT's data collection and needs lists the risks resulting from failure to manage data as an important organizational asset. They include:

- Inability to justify project decisions
- Failure to provide timely and accurate data which meets federal or state standards
- Loss of essential institutional knowledge due to work-force retirement
- Liability for safety and environmental impacts
- Rising cost due to redundant or unneeded data collection
- Cost overruns due to bad data about existing roadway and related features
- Limited ability to exchange data with outside agencies
- Excessive time spent by staff on data correction and data search activities

### *1.2.2 Data Management Process for State DOTs*

NCHRP Project 8–70 (*12*) defines the necessary steps contributing to the successful implementation of data management in a DOT. They are:

**1. Establish need for data management/governance**. The emphasis in NCHRP Project 8–70 and its accompanying report (NCHRP 666) was to implement data management and governance through senior management's appointment of individuals to a data governance board that addresses data-related issues from the top down within the agency. While an effective data management infrastructure could not develop without buy-in from senior management, it may make more sense for INDOT to form a data governance board from employees who are currently fulfilling the role of "business owner" for a database system. These employees would be responsible for authorizing access to the database and they could in turn assign employees from their office the responsibility of assuring the quality of the collected data.

**2. Assess current state of data management in the agency**. This step entails conducting an inventory of data collection and storage activities and evaluation of data quality and accessibility. While an inventory of data collection programs has been conducted and various data use issues have been identified, the topic of data evaluation based on quality was not deeply scrutinized in our study. From our brief exploration of data quality control practices, it seems that quality control and quality assurance of data throughout INDOT is non-uniform. For example, the INDOT Bridge Inspection Manual (*14*) contains formal processes for reviewing data quality. Similarly, Ong et al. (*15*) mentions the procedures that INDOT uses to assure quality of automated pavement data collection. These procedures are discussed in greater depth later in this chapter. Other data do not seem to have a formal quality control process. It is unclear whether traffic flow data undergo a formal quality review process; Weigh-in-Motion data at INDOT have a history of poor quality.

Examining the current state of data management requires an assessment of these influencing factors: the role of people, established processes, technology, and institutional structure. The maturity model for data management from NCHRP Report 666 is shown in Table 1.1. This table is applicable to individual data programs in state departments of transportation.

**3. Plan for data management**. At this step, the structure of the data collection programs and the access rules should be established. Important considerations include the evaluation for the need for data collection programs and the formulation of decisions pertaining to the addition, deletion, or modification of data collection programs.

Tables 1.2 and 1.3 present a way for assessing and evaluating data programs in terms of identified purpose(s) for data collection programs and assessment of its attributes. The assessment method presented in Table 1.2 is qualitative and brief. Its main function is to confirm that each data collection program exists for a

TABLE 1.1
**Data Management Maturity Model (*12*)**

| Level | 0—Ad Hoc | 1—Aware | 2—Planning | 3—Defined | 4—Managed | 5—Integrated | 6—Continuous Improvement |
|---|---|---|---|---|---|---|---|
| Technology/Tools | No tools in place | Planning for tools to support data management in some offices | Planning for tools to support data management across the agency or for a specific office | Implemented some tools to support data management but not widespread across the agency | Widespread implementation of tools to support data management but not integrated | Integrated, widespread implementation of tools to support data management and performance measurement | Ongoing assessment of new technology to support and improve data management and performance measurement |
| People/Awareness | Not aware of need for improved data management to support performance measurement processes | Aware of need for improved data management to support performance measurement processes<br>No action has been taken | Aware of need for improved data management to support performance measurement processes<br>Some steps have been made within the agency to improve technology or institutional setting to support data management in at least one office. | Aware of need for improved data management to support performance measurement processes<br>Some steps have been made within the agency to improve both technology and institutional settings to support data management in more than one office | Aware of need for improved data management to support performance measurement processes<br>Improvements are under way to improve both technology and institutional settings to support data management across the agency | Aware of need for improved data management to support performance measurement processes<br>Technology and institutional processes are in place to support data management for performance measures | The agency is able to develop performance measures and predict outcomes for programs based on success with other programs |
| Institutional/ Governance | No data governance in place | The agency is discussing needs/ plans for data governance | Some level of data program assessment and formulation of roles for data managers is underway in one or more offices of the agency | Data business planning underway, including development of governance models for multiple offices in the agency | Data business plan developed with data assessment complete and data governance structure defined | Fully operational data governance structure in place | Data governance structure fully supports data management activities across the agency |

TABLE 1.2
**Example Assessment of Importance of Data Collection Programs (*12*)**

| Data Collection Program | Value Ranking (Essential, Helpful, Not Needed) | Addresses Key Performance Measures | Used to Meet Federal or State Mandate | Used to Support One or More Defined Business Emphasis Areas | Risk Level Associated with Nonexistence of Data Collection Program |
|---|---|---|---|---|---|
| Network-level data collection of pavement IRI and rut | Essential | Yes. Network performance of pavements should be monitored as a measure of agency's ability to serve the traveling public | Data are reported annually to the FHWA in the Highway Performance Management System (HPMS) | Yes. Data are used to inform the agency of the pavement sections needing restorative treatment | High |

defined purpose and to articulate the level of risk associated with deletion of the program.

Data collection programs exist to fulfill one or several purposes; the most common purposes include:

- Maintaining an inventory of the location and attributes of agency assets
- Justification of project decisions to improve network condition
- Meeting federal and state mandates
- Conducting project design and environmental impact reviews
- Acquiring knowledge of physical and operational network conditions

TABLE 1.3
**Quantitative Evaluation of Data Collection Programs (*16*)**

| Criteria | Levels | Rank | Weight |
|---|---|---|---|
| Q1. Are there established protocols for collecting data for this asset? | No protocols available/planned | 1 | 20% |
| | Protocols under development | 2 | |
| | Protocols inconsistent among agencies | 3 | |
| | Experimental protocols | 4 | |
| | Widely accepted standard protocols | 5 | |
| Q2. What is the relative quantity and dollar value of the asset compared to those of the entire asset population? | Not important (<1%) | 1 | 20% |
| | Somewhat important (1%–5%) | 2 | |
| | Moderately important (5%–10%) | 3 | |
| | Important (10%–20%) | 4 | |
| | Very important (>20%) | 5 | |
| Q3. What is the relative importance of this asset to the agency and road users? (*A rating of 5 is automatically assigned to high risk assets*) | Not important to majority of users | 1 | 20% |
| | Somewhat important | 2 | |
| | Moderately important | 3 | |
| | Important | 4 | |
| | Very important | 5 | |
| Q4. How easy is it to collect data for this asset? | Very difficult | 1 | 15% |
| | Difficult | 2 | |
| | Moderately difficult | 3 | |
| | Easy | 4 | |
| | Very easy | 5 | |
| Q5. Are there automated procedures/tools for data collection for this asset? | No automated procedures | 1 | 5% |
| | Automated procedures under development | 2 | |
| | Experimental automated procedures | 3 | |
| | Automated procedures inconsistent among agencies | 4 | |
| | Widely accepted automated procedures | 5 | |
| Q6. How frequently do the data need to be collected? | Very infrequently (e.g., 5–10 years) | 1 | 10% |
| | Infrequently (e.g., 2–5 years) | 2 | |
| | Annually | 3 | |
| | Frequently (e.g., quarterly) | 4 | |
| | Very frequently (e.g., monthly) | 5 | |
| Q7. How Important is the accuracy of the data for the asset? | Not important | 1 | 10% |
| | Somewhat important | 2 | |
| | Moderately important | 3 | |
| | Important | 4 | |
| | Very important | 5 | |

Table 1.3 presents a quantitative way to evaluate several aspects of data collection programs. The reviewer evaluates seven factors of the data collection program pertaining to the existence of protocols for data collection, the specifics of the data collection process, the accuracy of the acquired data, the importance of the program, the monetary value and the utility of the assets whose condition is being monitored through the program, and the risk level associated with eliminating the program. The program's overall evaluation score is attained through a weighted sum of the individual scores assigned to the program aspects.

**4. Execute data management plan**. This step entails the development of a structure to the data collection program to ensure that data are collected with the proper standards, are of sufficient quality and accessibility, and are properly labeled. The consideration of these features is essential to guarantee that data fulfill the purpose for which they were collected.

The following elements are essential to proper execution of the data management plan:

- A standard for demonstrating the business value of existing or new data collected by the Department.
- Documented data gathering and measurement standards for divisions and business functions within the Department (for example, design, project delivery, maintenance, materials management, and traffic).
- Metadata should be included in the digital copy of the data, to provide a precise "label" to sufficiently describe the data, the collection method, the spatial and temporal coverage of collection, frequency of collection or "refreshment rate" and the intended purpose(s) for its collection.
- A data inventory and dictionary should be published and made available to the employees of the organization so that, if they need data, they know which INDOT offices and/or divisions should be contacted, the access and use rules for the data, and the data's integrity or quality.
- Data quality control standards, covering data integrity, validity, consistency, and accuracy.
- Roles and Responsibilities of staff tasked with data management should be clearly outlined.

**5. Maintain data management plan**. The Data Management Plan should be periodically updated to ensure that data collection programs are necessary and that they are functioning as intended. For data collection programs that have issues to be addressed, Data Action Plans should be developed to improve efficiency of data collection, data quality and accessibility.

**6. Link performance measures and targets processes to agency planning function**. This final step involves the use of collected data to inform employees of the agency's performance. This information is vital for employees to help them focus on ways to better meet the mission and vision of their department of transportation. The dissemination of agency performance data and agency-wide performance targets to data stakeholders outside the agency is optional.

Examples of agencies that publish their performance data for the public include Missouri DOT and Virginia DOT. Figure 1.2 and Figure 1.3 feature the various metrics used to evaluate the agencies' performance. Every three months, Missouri publishes a Tracker Document to demonstrate the agency's performance with 120 metrics in 18 categories. The categories comprise issues such as the network physical and operational conditions, environmental compliance of projects, economic development, and project delivery on time and on budget. The quarterly Tracker Document is available at http://www.modot.org/about/general_info/Tracker.htm (*17*).

Virginia DOT's Dashboard (Figure 1.3) exhibits the performance of their highways in terms of: delivery of construction projects (percent completed on time), execution of maintenance activity, operations (traffic mobility), safety, financial, and environmental compliance. The VDOT Dashboard can be viewed at http://dashboard.virginiadot.org/ (*18*).

The research team is aware that INDOT is currently undergoing a laudable process of internal dissemination of agency performance data. The metrics being monitored belong to specific categories that include agency finance, program delivery, road and bridge conditions, mobility, and safety. This information is being hosted in an internal website backed by Oracle Business Intelligence Enterprise Edition (OBIEE) software.

INDOT currently provides a few measures of its performance in the Indiana Transparency Portal, which is a web-based tool that presents to the public the performance of Indiana's public agencies. However, INDOT presents a limited perspective of its performance; most of the data contained pertain to management of construction contracts in terms of cost and duration. There are only a few measures related to asset performance: Percent of Roads with Acceptable Quality (as measured by IRI), Percent of Bridges with an Acceptable Evaluation, and Number of Traffic Fatalities on State controlled roads. The asset performance measures are available quarterly for the years 2009–2011. More information about the Indiana Transparency Portal and recommendations regarding its potential use for INDOT data publication are contained in Chapter 6.

### *1.2.3 Employee Roles for Data Management*

It is essential that responsibilities are assigned for oversight of data management and for resolving data quality and accessibility issues that data users face. The following is a proposed list of roles to be fulfilled for successful data management in a state DOT (*12,13*).

- Data Governance Board or Council.
  - Execution and enforcement of authority over the management of data assets and the performance of data functions.

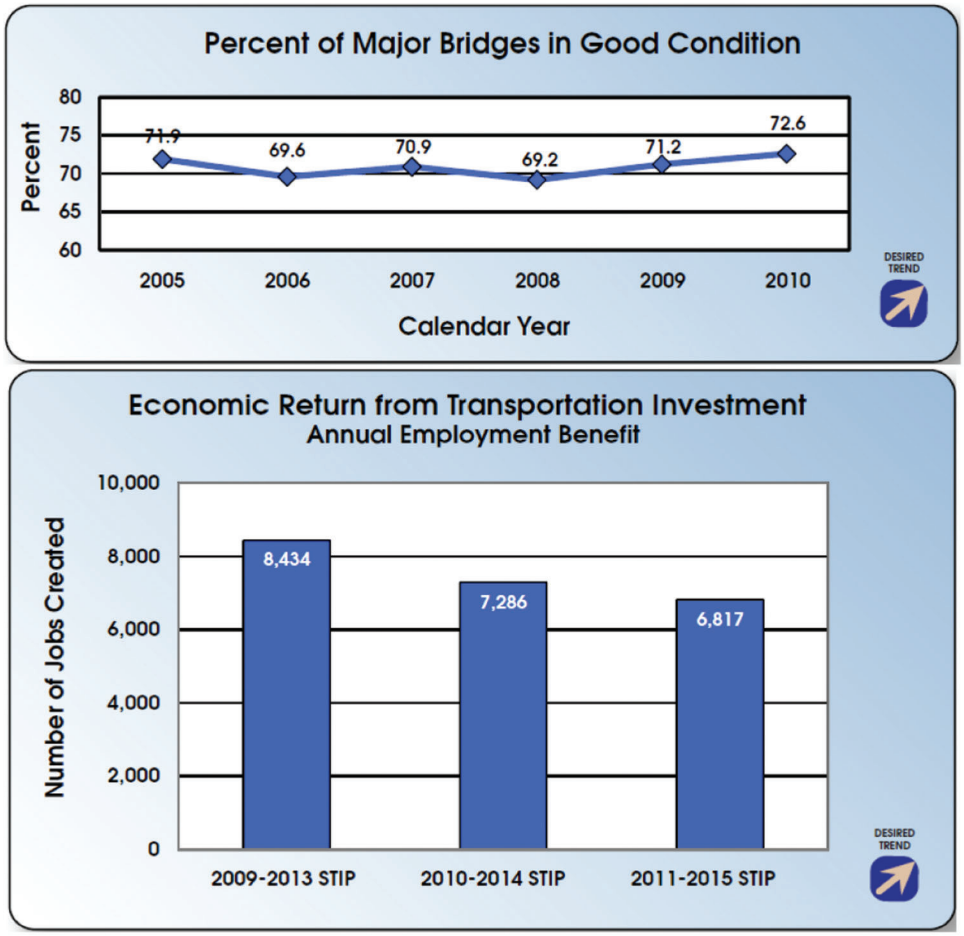



**Figure 1.2** Example of network condition and economic development performance metrics featured in Missouri DOT's tracker (*17*).

- Assignment of roles and responsibilities of data collectors and owners (such as who is responsible for data quality assurance or addressing insufficient data quality).
- Responsiveness to data users and continual outreach to ensure excellent data quality and accessibility.
- Dissemination of data catalogues and dictionaries for data collection programs.

- Data Steward.
  - Enactment of the data management policies and procedures on a daily basis.
  - Management of definition, collection, quality, and usage of data.
  - Regular evaluation of data quality, enforcement of quality standards, and identification of opportunities to share and reuse data.
  - Development of data dictionaries for data collection programs.
- Data Owner: Divisions or Offices of the DOT typically serve as the data owners for specific applications supporting their business area.
  - Ensuring the protection of the data and authorization of access to various data applications in their business area.
- Data Custodian: IT professional.
  - Maintenance of Databases and management of their security.
  - With the assistance of Data Steward, development of metadata for data.
  - Ensuring adequate operation of hardware and software used to support application systems.
- Data stakeholder or user.
  - Identification of data gaps or deficiencies that need to be addressed to use data in business processes.

### *1.2.4 Performance Measures for Data Management*

Because asset management requires the use of performance measures, management of data as an asset has to involve the use of measures to address its performance. The following six metrics were widely mentioned in data management literature (*12,19–21*) These metrics can be used to assess the performance of each individual data collection program in serving data users.


**Figure 1.3** Example of network condition and project delivery performance metrics featured in Virginia DOT's dashboard (*18*).

1. *Accuracy*—The measure of the degree of agreement between a data value or sets of values and a source assumed to be correct
2. *Timeliness*—The degree to which data values or a set of values are provided at the time required or specified
3. *Completeness*—The degree to which the data values are present in the attributes (data fields) that require them
4. *Validity*—The degree to which data values satisfy acceptance requirements of the validation criteria or fall within the respective domain of acceptable values

5. *Coverage*—The degree to which data values in a sample accurately represent the whole of that which is to be measured
6. *Accessibility*—The relative ease with which data can be retrieved and manipulated by data consumers to meet their needs

#### *1.2.5 Summary*

This research project documented the current state of data management in terms of quality control procedures being implemented for certain data collection programs and in terms of data flow among various offices and divisions of INDOT (see Chapter 4). The remaining sections of this Chapter discuss in detail both the primary data collection programs implemented by INDOT and the quality control procedures implemented for some of INDOT's data collection programs. For traffic data collection and for network-level pavement data collection, there are suggestions for enhancement of quality control or quality assurance procedures.

### 1.3 Traffic Counts and Flow Data Collection, Usage, and Quality

#### *1.3.1 Traffic Counts Data Collection and Federal Reporting*

INDOT collects traffic data throughout the State for multiple agency purposes, such as travel infrastructure design and future capacity planning, as well as for national reporting. In accordance with the Highway Performance Monitoring System (HPMS), Indiana must submit traffic data annually to the FHWA Office of Highway Policy Information (*22*). As stated in FHWA's Traffic Monitoring Guide (*23*), each state is to conduct short duration (48-hour) portable counts and permanent continuous counts. The short duration traffic counts, also known as coverage counts, are designed to supply the agency with traffic data over the geographic region. The traffic counts should be collected on all National Highway System, Interstate, Principal Arterial, and HPMS sample sections on a 3-year cycle and for the rest of the federal-aid road system (including ramps) on a 6-year cycle. INDOT's 110 continuous count sites are equipped with automatic traffic recorders and automatic vehicle classification stations to allow the agency to quantify hourly, weekly, and seasonal traffic variation and axle correction factors that are needed to convert coverage counts into Annual Average Daily Traffic for each road. The traffic count data are collected by 10 people in-house, by 3 Metropolitan Planning Organizations under contract with INDOT, as well as by up to 5 consulting firms. These counts are stored in TRADAS and are displayed on an Interactive Traffic Flow Map, which is available at the following website: http://dotmaps.indot.in.gov/apps/trafficcounts. Appendix A contains information about the new traffic data collection and data storage technologies being deployed or being considered for deployment by INDOT's Traffic Statistics Section (*24*).

There are a few challenges for INDOT to overcome with respect to conducting short term coverage counts. Due to recent changes in the HPMS Field Manual, INDOT must maintain 18,000 coverage count sites on non-state federal-aid roads, raising the total number of sites to be monitored from 30,000 to 48,000. Obviously, this change has a significant impact on INDOT's traffic monitoring costs. In 2010, the cost of a 48-hour tube count conducted on a street segment was approximately $200 (*25*). In addition to the increased number of coverage counts sites that need to be monitored, INDOT must contend with the possibility of conducting more frequent counts in counties with relatively high economic growth.

In order to face the previously mentioned challenges, INDOT could choose to monitor high priority sites at a more frequent interval than 3 years but a reduced duration of 24 hours. This possibility should be explored with extreme caution, however, since the FHWA's Traffic Monitoring Guide (*23*) recommends a minimum duration of 48 hours for conducting a coverage count. The recommendation was based on the Hallenbeck and Bowman study (*26*), which sought to demonstrate the accuracy-cost tradeoff of monitoring coverage sites. In Figure 1.4, the cost per year of collecting coverage count data is mapped against the degree of error (in percent of AADT) that can be expected when conducting counts at durations of 24, 48 and 72 hours and at 1, 3, and 5 year intervals. Figure 1.4 seems to express that the traffic variability over a relatively short period of time (one to three days) is more significant than the variability over the period of a few years. In this situation, the conclusion would be to invest more resources in lengthening the traffic monitoring duration rather than shortening the monitoring cycle.

Needless to say the Hallenbeck and Bowman's study ((*26*), as cited in (*27*)) was based on sites that don't experience high traffic growth. Therefore, it may be prudent for INDOT to conduct a study to arrive at scientifically backed policies for accurate and cost-effective traffic monitoring of coverage count sites.

The Highway Performance Monitoring System (HPMS) requires states to submit traffic data at three levels of coverage. Data items are to be reported for Full Extent, HPMS *Sample Panel* segments, or *Summary Level*. *Full Extent* data are data items that are required to be reported for the entire specified road system. For example, Average Annual Daily Traffic is required to be reported for the entire federal-aid road system. *Sample Panel* data are items that are reported for selected sections of the specified roadway system. The *Sample Panel* sections are formed by breaking up the entire road system into various segments. Each year, the set of segments for which data reporting occurs is rotated.

The AADT Single Unit Truck and AADT Combination Truck data are required to be reported as part

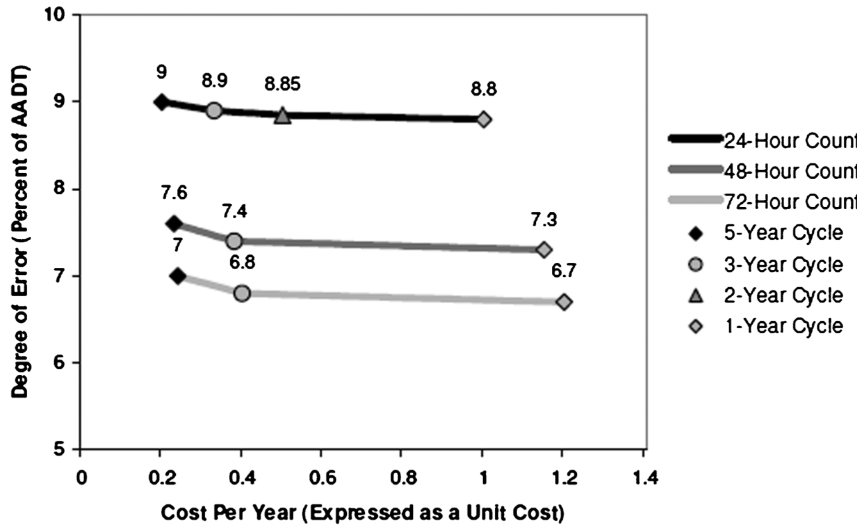



**Figure 1.4** Accuracy-cost tradeoff in highway traffic monitoring. (Source: Hallenbeck and Bowman (*26*) as cited in Washington State DOT (*27*).)

of *Full Extent* for some road types and at the *Sample Level* for other road types. (See Table 1.4.) The percent peak single unit truck and combination truck, k-factor, and directional factor are required to be reported for HPMS Sample Panel segments for all federal-aid road types.

For the *Summary-Level* reporting, the HPMS requires the reporting of the percentages of six vehicle types traveling on all public roads by six functional classifications of roads. (See Table 1.5.)

Finally, the HPMS report contains a metadata module for states to provide information on duration of counts conducted at permanent and portable count stations, type of volume and classification counts used for reporting, and the percent of count or classification information that was gathered in the reporting year, rather than factored from a previous year.

In addition to annual HPMS reporting, traffic volume and vehicle classification data collected by automatic vehicle classifiers and automatic traffic recorders at continuous count stations are submitted monthly to FHWA.

### *1.3.2 Vehicle Weight and Classification Data Collection*

Vehicle weight and classification are influential parameters for many DOT functions, affecting pavement, bridge and geometric design for improvement of existing highways and construction of new highways. From the safety perspective, crash rates are typically reported by vehicle class. Enforcement of vehicle load restrictions is a common function for Weigh-in-Motion data.

There are 47 Weigh-in-Motion (WIM) sites on highways under INDOT jurisdiction, 31 of which are located on interstate highways and 16 located on US and State routes. Sensors placed in the pavement detect the arrival of vehicle axles and generate signals that are processed to ascertain vehicle size and axle configurations for vehicle classification. Additionally, WIM equipment records vehicle weight and vehicle speed. These measurements are supplemented by a record of the date and time of the vehicle's arrival. The locations of WIM stations are displayed with a star symbol in Figure 1.5.

### *1.3.3 Travel Condition Data Collection and SAFETEA-LU Rule 1201*

INDOT's ITS TrafficWise initiative provides information to the public on the travel obstructions influencing the Indianapolis and Northwest Indiana metropolitan areas. The real-time collection of freeway speed and lanes' vehicle counts in these sites is conducted and subsequently stored in 30-second bins. This information is made available to the public through INDOT's website at: http://www.in.gov/indot/2420.htm (*29*).

TABLE 1.4
**AADT Single Unit Truck and Combination Truck Reporting Coverage (*22*)**

| Functional | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| **System** | **NHS** | **Int** | **OFE** | **OPA** | **MiA** | **MaC** | **MiC** | **Local** |
| Rural | FE | FE | SP | SP | SP | SP | | |
| Urban | FE | FE | SP | SP | SP | SP | SP | |

NOTE: FE = full extent; SP = sample panel sections.

TABLE 1.5
**HPMS Vehicle Summaries Table (*22*)**

| Constraint | Field Name | Data Type | Description | Valid Values |
|---|---|---|---|---|
| PK | Year_Record | Numeric(4) | Calendar year for the data | The four digits of the year the data represents |
| PK | State_Code | Numeric(2) | State FIPS code | Up to two digits for the FIPS code. See Appendix C for a complete list |
| PK | FS_Group | Numeric(1) | Functional system group | **Code** – **Description**<br>1 – Rural interstate<br>2 – Rural other arterial (includes other freeways & expressways, other principal arterials, and minor arterials)<br>3 – Rural other (includes major collectors, minor collectors, and locals)<br>4 – Urban interstate<br>5 – Urban other arterial (includes other freeways & expressways, other principal arterials, and minor arterials)<br>6 – Urban other (includes major collectors, minor collectors, and locals) |
| | Pct_MC | Decimal(5,2) | Percent of motorcycles | Code percentage as 0.00 to 100.00 |
| | Pct_Cars | Decimal(5,2) | Percent of passenger cars | Code percentage as 0.00 to 100.00 |
| | Pct_Lgt_Trucks | Decimal(5,2) | Percent of light trucks | Code percentage as 0.00 to 100.00 |
| | Pct_Buses | Decimal(5,2) | Percent of buses | Code percentage as 0.00 to 100.00 |
| | Pct_SU_Trucks | Decimal(5,2) | Percent of single-unit trucks | Code percentage as 0.00 to 100.00 |
| | Pct_CU_Trucks | Decimal(5,2) | Percent of combination-unit trucks | Code percentage as 0.00 to 100.00 |

This program's performance will be monitored in the future by the SAFETEA-LU rule 1201: Real-Time System Management Information Program (*30*). This rule mandates the existence of a real-time information program for traffic and traveling conditions along interstate highways by November 8, 2014, and along State-designated metropolitan area routes of significance by November 8, 2016. The rule also stipulates timeliness standards for the availability of this information, as shown in Table 1.6.

### *1.3.4 Signalized Intersection Traffic Count Data Collection*

The INDOT Office of Traffic Management collects traffic counts and turning movements at signalized intersections and travel time in the corresponding corridors for the purpose of signal retiming and new signal timing. The traffic count data are continually collected and subsequently stored in 15-minute bins at intersections with controllers that are automatic count capable. At other intersections, the data are collected manually at a maximum interval of 3 years. Travel times are collected continually in corridors that are equipped with Bluetooth readers. In other corridors, the travel times are measured with floating car studies before and after signal retiming.

Where higher frequency is needed, equipment is installed to automate the process. The data are approximately 90 percent accurate, whether done automatically or manually. The main data collection issue is the labor-intensive nature of manual data collection versus automatic data collection. Twelve-hour manual traffic counts require a minimum of 12 man-hours, often with 24 man-hours allocated. Similarly, Bluetooth data collection of travel times is preferred to floating car studies. In addition to being labor-intensive, floating car studies can't capture the continually changing travel time of a corridor.

The data are stored in PostgreSQL with an Access front end. The database is customized to meet data collection, storage, and access needs of the Office of Traffic Management.

JTRP research report SPR-3208 (*31*) presented a methodology for quantifying the benefits of traffic signal retiming, including reduced travel time for highway users and a reduction in vehicle emissions. The methodology relies on high-resolution traffic signal event data, because floating car studies cannot provide continuous data for a period of several months and

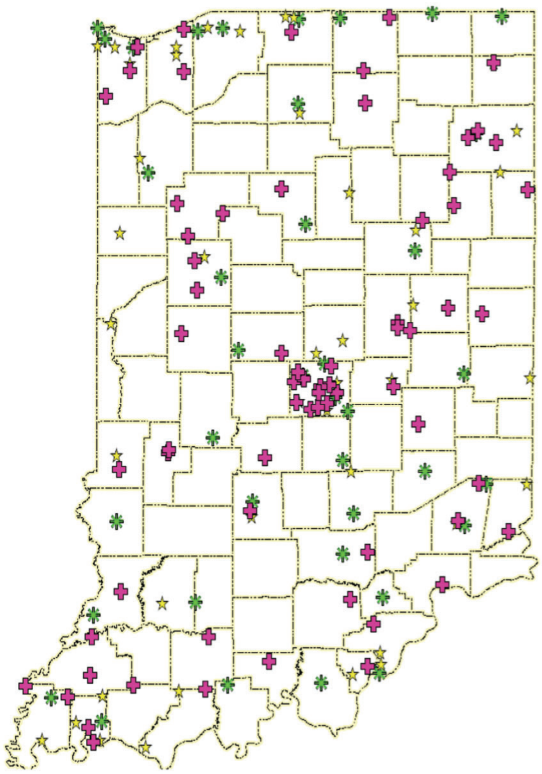


**Figure 1.5** Location of WIM stations (star symbol), automatic traffic recorders (cross symbol) and roadway weather information stations (asterisk symbol). Source: http://dotmaps.indot.in.gov/ArcGIS/rest/services (*28*).

therefore are less accurate in analyzing the operational effects of traffic signal retiming. A case study in research study SPR-3208 (*31*) estimated the benefit of an arterial offset optimization on a 5-mile corridor with 8 coordinated intersections on SR 37 in Noblesville, Indiana. The annual benefits from travel time reduction were valued at $470,000, with an estimated annual reduction of 200 tons of carbon emissions.

### *1.3.5 Traffic Data Quality Issues*

The responses to the Data Needs Online Survey (Chapter 5) made clear that INDOT personnel faced challenges in accessing traffic count data that are collected. In the past, INDOT only had historic county and interstate AADT flow maps posted online. Currently, the Interactive Traffic Flow Map website at http://dotmaps.indot.in.gov/apps/trafficcounts displays recent traffic count and classification information from individual stations and AADT flow maps for the years 2006–2011 are downloadable. Historic AADT flow maps are available at http://www.in.gov/indot/2469.htm.

The responses to the Data Needs Online Survey also revealed complaints that the vehicle classification data collected at sites equipped with ITS are not accessible. Another concern is WIM data, which suffer from poor accuracy. One survey respondent stated that WIM data are inadequate for enforcement of vehicle load restrictions. **Note:** During the duration of this study, INDOT was taking steps to enhance the accessibility and quality of the traffic data that it collects. The Traffic Statistics Section is deploying Midwestern Software solutions, an off-the shelf database software that enables various traffic data collection entities to upload their data and various users to access the data. This product should increase data accessibility and has the potential to facilitate examination of data accuracy issues in a timely manner. Hourly count and classification information from coverage count and permanent count stations along Interstates has also been made downloadable from the Management Information Portal (MIP). Appendix A contains the presentations that were given in the 2012 Purdue Road School conference citing these developments (*24,32*).

With respect to the accuracy of vehicle weight data, there are numerous published procedures available for routine calibration of WIM equipment and performance of quality checks, including FHWA's WIM Data Analyst's Manual (*33*) and the Traffic Monitoring Guide (*23*). There are a few JTRP studies that have also explored this issue. Nichols and Bullock (*11*) provided strategies and recommendations for INDOT to overcome the reasons for poor WIM data accuracy, such as incorrect calibration, changes in temperature, precipitation, and failing sensors. Wei and Fricker (*9*) developed a Weigh-In-Motion Daily Data Checking program to check WIM data on a daily basis. The methods typically involved in identification of missing or erroneous data were coded into the program. Additionally, a few data imputation techniques were explored to update missing or erroneous data.

Li et al. (*34*) sought to verify the accuracy of WIM vehicle classification through the collection of video

TABLE 1.6
**SAFETEA-LU 1201 Rule Timeliness Standards for Availability of Real-Time Travel Condition Information**

| | For Non-Interstate Routes Within Metropolitan Areas | For Interstate Routes |
|---|---|---|
| **Construction Activities** | ≤10 minutes from the time of closure or reopening | ≤20 minutes from the time of closure or reopening |
| **Lane Blocking Incidents** | ≤10 minutes from the time of incident verification | ≤20 minutes from the time of incident verification |
| **Roadway Weather Observations** | ≤20 minutes from the time the hazardous weather condition is observed | ≤20 minutes from the time the hazardous weather condition is observed |
| **Travel Time Information** | ≤10 minutes after calculation of travel time along a route | Not applicable |

and WIM traffic data at various WIM sites in Indiana. The main data accuracy issue for WIM equipment is the failure to classify vehicle counts. This problem is a common occurrence that increases with frequency as the total traffic count and number of lanes increases. To address this issue, a digital image-based vehicle monitoring and classification system was developed and utilized as a tool for categorizing unclassified vehicles detected by WIM. This system's ability to observe vehicles' lane changes as well as track vehicles in the presence of congestion or accidents on a roadway makes it possible to correct unclassified vehicle counts for WIM sites. Through examination of various WIM sites statewide, it was discovered that certain vehicle classes are more likely to be unclassified than others. Two-axle four-tire vehicles (Class 1–Class 3 vehicles) and single-trailer trucks (Class 8–Class 10 vehicles) account for 85 percent of unclassified vehicles by WIM equipment.

Li et al. (*34*) also tested the Transportable Infra-Red Traffic Logger (TIRTL), an alternative traffic surveillance system. The system uses infra-red light technology to detect vehicle characteristics that are needed in counting and classifying those vehicles. The performance of TIRTL and WIM equipment in classifying vehicles was compared by installing TIRTL equipment near WIM sites. The TIRTL system's potential errors were also evaluated through manual collection and videotaping of hourly traffic data. The TIRTL system had much fewer unclassified counts than the WIM system. Additionally, the TIRTL system demonstrated better performance in identifying Class 3 and Class 5 vehicles. These findings hold for all weather conditions except thunderstorms. During thunderstorms, the TIRTL system undercounted vehicles regardless of vehicle class.

### *1.3.6 Traffic Data Quality Targets*

A traffic data quality assurance program should establish standards to determine whether data can be judged as adequate in terms of quality. These standards include Accuracy, Completeness, Validity, Timeliness, and Spatial Coverage of the data. The definitions for these data quality measures are given in Table 1.7.

In general, the quality measures are sensitive to different components of the traffic data collection and dissemination program. The *Spatial Coverage* measure addresses the ability of the collected data to reflect the travel conditions over the entire road network. This measure is sensitive to the specifics of the traffic data collection sampling plan adopted by the state DOT. The *Accuracy* and *Validity* measures are sensitive to the equipment testing, calibration and maintenance. The *Completeness* measure refers to both the degree to which required data are present from a certain station and the collective data reporting rate for all stations. Therefore, *Completeness* is influenced by traffic stations' ability to both generate raw data and to fill all the required data fields in a station report. *Timeliness* is influenced by the process required for data cleaning and summarization before it is given to an end user within the agency or posted in a data warehouse. *Accessibility* is influenced by the data sharing rules within the agency

TABLE 1.7
**Definitions of Traffic Data Quality Measures (*35*)**

| Data Quality Measure | Definition |
|---|---|
| Accuracy | The measure or degree of agreement between a data value or set of values and a source assumed to be correct. Accuracy can be expressed using one of the following three error quantities:<br>1. Mean absolute percent error (MAPE)<br>2. Signed percent error<br>3. Root mean squared error (RMSE)<br>Note that in each of these error formulations, the error is the difference between the observed value and the reference (i.e., ground truth) value, and percent error is the error divided by the reference value |
| Completeness (also referred to as Availability) | The degree to which data values are present in the attributes (e.g., volume and speed are attributes of traffic) that require them. Completeness is typically expressed as a percentage, calculated as the number of available data values divided by the number of data values that should be available. Completeness can refer to both the temporal and spatial aspect of data quality |
| Validity | The degree to which data values satisfy acceptance requirements of the validation criteria or fall within the respective domain of acceptable values. Data validity is typically expressed as the percentage of data values that pass data validity criteria |
| Timeliness | The degree to which data values are provided at the time required or specified. Timeliness can be expressed in absolute (e.g., minutes, hours, days) or relative terms (e.g., percentage of data meeting timeliness criteria) |
| Coverage | The degree to which data values in a sample accurately represent the whole of that which is to be measured. As with other measures, coverage can be expressed in absolute (e.g., centerline-miles, lane-miles) or relative units (e.g., percentage of specified system) |
| Accessibility (also referred to as Usability) | The relative ease with which data can be retrieved and manipulated by data consumers to meet their needs. Accessibility can be expressed in qualitative or quantitative terms |

and the availability of satisfactory metadata to guarantee the users that they are using the correct version of traffic data for their analyses.

A traffic data quality study that was conducted for the FHWA Office of Highway Policy by the Battelle Memorial Institute has developed recommendations for setting data quality targets for traffic data used in various applications. A limited listing of the data quality targets proposed by the study is shown in Table 1.8. Targets were developed for transportation planning, transportation operations, highway safety analysis and pavement management analysis. The report's authors sought input from five state DOTs (Florida, Georgia, Washington State, California, and Minnesota) and 2 FHWA Divisions (Traffic Monitoring and Surveys Division and HPMS Division) to confirm the standards' practicality and reasonability. These targets can be examined by INDOT employees responsible for assuring the quality of traffic data as a means to "grade" the collected data in terms of quality.

Data adequacy standards can be applied for a mature traffic data program that has implemented the following elements to assure quality of its data and to ensure its usefulness for the end user (*35*):

- Routine staff training and professional development
- Effective equipment procurement procedures
- Bench testing new field equipment
- Thorough inspection and acceptance testing of new equipment installations
- Routine equipment testing and calibration
- Scheduled maintenance activities
- Timeliness of data collection
- Sufficient metadata (where, when, duration, raw count, factored count, factors, etc.)
- Uniform data format
- Data customer feedback through various channels

For detailed information on procedures and strategies to assure traffic data quality, the AASHTO Guidelines for Traffic Data Programs (*35*) is available for reference.

## 1.4 Pavement Data Collection, Use, and Quality

### *1.4.1 Pavement Condition Data Collected by the Vendor Pathway Services*

At the network level, the firm Pathway Services, Inc. collects the International Roughness Index (IRI), flexible pavement rut depth, concrete pavement faulting, and texture data on behalf of INDOT. These data inform INDOT of the pavement's functional condition across its highway network and therefore enhance its ability to estimate a reliable multi-year budget for pavement maintenance projects. Pavement condition information collected by Pathway Services is also submitted to the FHWA and Congress through the annual "Highway Pavement Monitoring System" report and the biennial "Status of the Nation's Highways, Bridges, and Transit" report, respectively. Ong et al. (*15*) provides a description of the equipment and sampling procedures used for pavement roughness and distress ratings (prior to 2010) data at the network level.

Table 1.9 shows the extent and frequency of data collection for pavement condition indicators that are required to be reported to HPMS. The Highway Performance Monitoring System requires states to submit pavement data items on either *Full Extent* or *Sample Panel* coverage. *Full Extent* data are data items that are required to be reported for the entire specified road system. *Sample Panel* data are items that are reported for selected sections of the specified roadway system. The *Sample Panel* sections are formed by breaking up the entire road system into various segments. Each year, the set of segments for which data reporting occurs is rotated.

HPMS also requires states to report details regarding the testing procedures, equipment, and frequency that were used to collect IRI, Rutting, Faulting, and Cracking Data. The frequency of collection of pavement roughness and surface distress rating data for state DOTs is shown in Figure 1.6.

### *1.4.2 Network-level Pavement Friction Data Collected In-house*

INDOT Research Division collects Friction Data annually for interstates and triennially for State and US routes. During testing, the friction-measuring trailer records the Road Name, Direction of Travel, Lane Type (Passing or Driving), Starting and Ending Mile Posts, Date and Time, County and District, GPS coordinates, Testing Speed, Pavement Type and recorded Friction number. The data are sent to the Districts, Office of Materials Management, and the Legal Division of INDOT.

Friction Measurement occurs with a trailer equipped with a hydraulic jack as shown in Figure 1.7. The hydraulic jack is directed at the tire to release a predetermined amount of water onto the pavement surface just before the tire reaches the wet pavement. The test tire inflation pressure is set at 24 psi (165 kPa). In the course of testing, the vehicle reaches the desired speed. Then, water is applied to the pavement, and the test wheel brake is locked 0.5 seconds after the beginning of the water application. When the test wheel is locked, this device produces a 100 percent slip condition. This condition is when the relative velocity between the surface of the tire and the pavement surface, i.e., the slip speed, is equal to the vehicle speed.

While the wheel is locked, the friction force on the tire is observed by a transducer. The friction number is then generated as the coefficient of friction (ratio of the traction force and the normal force on the test wheel) multiplied by 100.

Friction Testing is important to maintain, because inadequate pavement friction is a factor that contributes to vehicle crashes. In order to reduce the occurrence of these accidents, INDOT must first know the locations in need of improvement with respect to pavement friction. There is no federal requirement for

TABLE 1.8
**Traffic Data Quality Targets for Selected Applications of Traffic Data (*36*)**

| Applications | | Data | Data Quality Measure[1] | | | | |
|---|---|---|---|---|---|---|---|
| | | | Accuracy[2] | Completeness | Validity | Timeliness | Typical Coverage |
| Transportation planning applications | Standard demand forecasting for long range planning | Daily traffic volumes | Freeways: 7%<br>Principal arterials: 15%<br>Minor arterials: 20%<br>Collectors: 25% | At a given location 25%—12 consecutive hours out of 48-hour count | Up to 15% failure rate—48-hour counts<br>Up to 10% failure rate—permanent count stations | Within 3 years of model validation year | 55–60% of freeway mileage<br>25% of principal arterials<br>15% of minor arterials<br>10–15% of collectors |
| | Highway Performance Monitoring System | AADT | 5–10% urban interstate<br>10% other urban<br>8% rural interstate<br>10% other rural<br>Mean absolute error | 80% continuous counts 70–80% for portable machine counts (24-/48-hour counts) | Up to 15% failure rate—48-hour counts Up to 10% failure rate—permanent count stations | Data 1 year old or less | 55–60% of freeway mileage<br>25% of principal arterials<br>15% of minor arterials<br>10–15% of collectors |
| Transportation operations | Traveler information | Travel times for entire trips or portions of trips over multiple links | 10–15% RMSE | 95–100% valid data | Less than 10% failure rate | Data required close to real-time | 100% area coverage |
| Highway safety | Exposure for safety analysis | AADT and VMT by segment | 5–10% urban interstate<br>10% other urban<br>8% rural interstate<br>10% other rural<br>Mean absolute error | 80% continuous count data<br>50% for portable machine counts (24-/48-hour counts) | Up to 15% failure rate—48-hour counts<br>Up to 10% failure rate—permanent count stations | Data 1 year old or less | 55–60% of freeway mileage<br>25% of principal arterials<br>15% of minor arterials<br>10–15% of collectors |
| Pavement management | Historical and forecasted loadings | Link vehicle class | 20% combination unit<br>12% single unit | 80% continuous count data<br>50% for portable machine counts (24-/48-hour counts) | Up to 15% failure rate—48-hour counts<br>Up to 10% failure rate—permanent count stations | Data 3 years old or less | 55–60% of freeway mileage<br>25% of principal arterials<br>15% of minor arterials<br>10–15% of collectors |

[1]"Accessibility" for all applications is discussed in the text.
[2]Percentage figures correspond to estimate of Mean Absolute Percent Error (MAPE).

TABLE 1.9
**Comparison of Extent and Frequency of Pavement Condition Indicators Required for HPMS Reporting versus Those Collected by the Firm Pathway Services, Inc.**

| | HPMS Required Pavement Data Collection Extent and Frequency | INDOT Automated Data Collection Extent and Frequency |
|---|---|---|
| **International Roughness Index** | Annually for National Highway System at full extent<br>Biennially for non-National Highway System (full extent for interstates, other freeways and expressways, and other principal arterials) | Annually for interstates, State routes, and US routes |
| **Rut Depth** | Biennially for asphalt surface federal-aid roads for sample sections | |
| **Texture** | Not required | |
| **Faulting** | Biennially for concrete surface federal-aid roads for sample sections | |
| **Fatigue Cracking** | Biennially for federal-aid roads for sample sections | Collection of distress data at the network level is being reinstated after being suspended in 2010 |
| **Transverse Cracking** | Biennially for asphalt surface federal-aid roads for sample sections | |

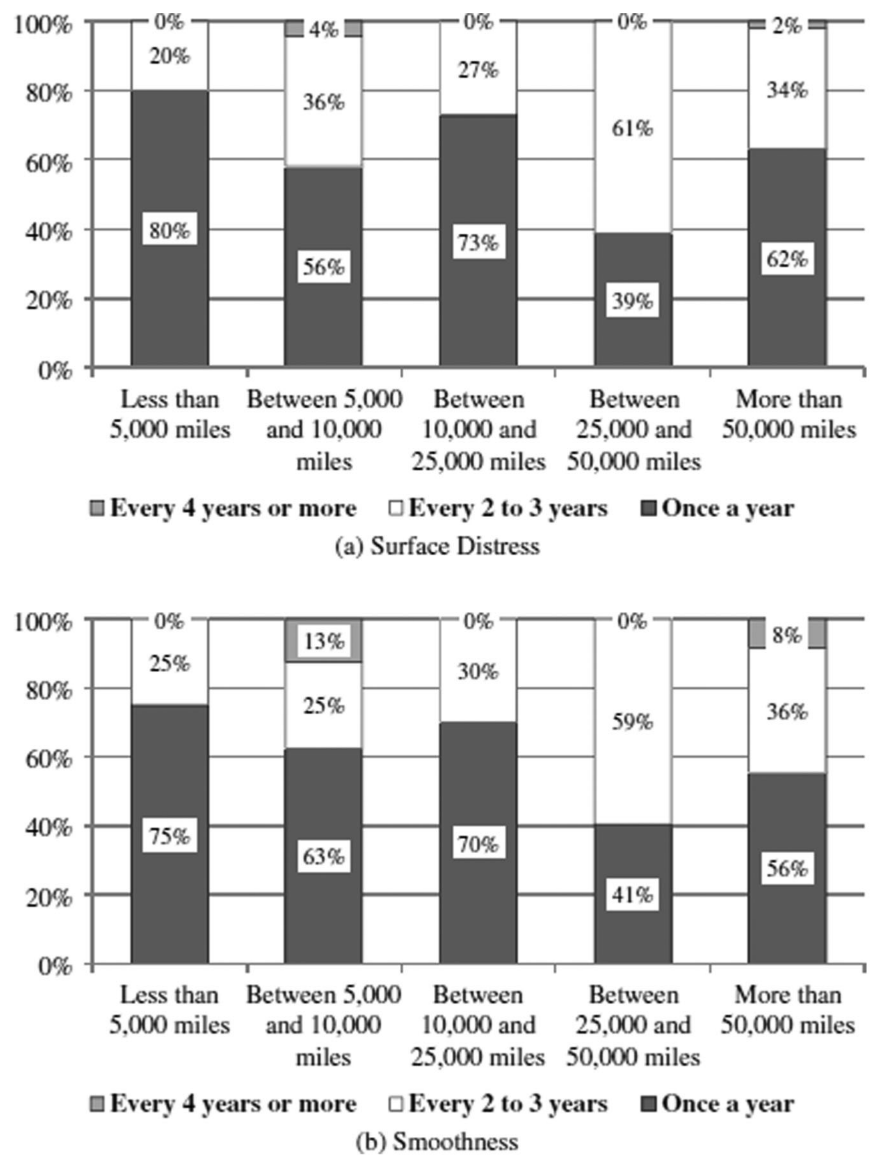



**Figure 1.6** Data Collection Frequency for (a) surface distress and (b) smoothness as a percent of agencies collecting the pavement indicators (*37*).

**Figure 1.7** Pavement friction measuring trailer's hydraulic jack.

collecting pavement friction data. However, FHWA issued a Technical Advisory in June 2010 (*38*) that stresses the importance of managing pavement friction by State and local highway agencies. This guide states that effective management of pavement friction must rely on examining friction data and vehicle crash data in order to recognize which crashes are attributable to poor surface friction. Furthermore, traffic volume data, geometric data (locations and characteristics of curves or grades, available sight distance) and intersection locations are factors that should be considered in the process of identifying locations requiring special attention or priority in receiving a treatment to improve pavement friction.

### *1.4.3 Quality Management of Pavement Condition Data Collected at the Network Level*

In collection of pavement condition data at the network level, the goal is to capture the spatial variation in condition for a given year and the temporal variation in condition for a given pavement segment. However, these variations may be confounded by variations that could result from: equipment miscalibration, changes in rating procedures over time, judgment of multiple raters, and spatial referencing errors. The role of pavement condition data quality management is to minimize the magnitude of the undesired variations.

Ong et al. (*15*) reviewed the state of practice for automated pavement roughness and distress condition data collection and quality management by state highway agencies. The review included documentation of variations in roadway imaging technologies used and types of sensors used to measure pavement roughness. Quality control and quality assurance studies by highway agencies were also summarized. The study proposed the introduction of formal quality management guidelines for pavement roughness and pavement distress data collected at the network level for INDOT. It should be noted that the study was done before the network-level collection of pavement distress data was suspended.

The set of procedures recommended for implementation of data quality control at the data pre-production, production, and processing phases is listed below:

- The pre-production phase is the phase prior to data collection. In this phase, the contractor's equipment should undergo calibration testing. Calibration testing includes ensuring the proper function of all sensors and subsequently the use of control sections to ensure accuracy and precision of measurements.
- During the production phase, periodical checks on accuracy should be performed every few weeks by using the INDOT Research Division Test Track. Software loaded in the data collection van should flag situations of invalid range for quantitative data in real-time. Data should be checked for completeness (continuous measurement, continuous imaging, no missing segments) a few times every day during the collection phase.
- The vendor should carry out back-end checks of quality in the office at least eight times before the data are given to INDOT: once after data collection has been completed for interstates, once after data collection has been completed for each district, and a final time at the end of the data collection cycle.

Ong et al. (*15*) recommended that, after INDOT receives the data from the vendor, quality assurance checks be conducted on the data. Global checks should be conducted for the detection of errors in data formatting, such as incorrect range or incorrect input type in any data field, prior to data's importation to the pavement management database. The completeness of the data should also be examined in terms of the presence of the right number of rows (segments) and columns (data fields) without duplication, and the absence of null entries for entire columns or rows. More detailed information about how to conduct these quality assurance checks is available in Ong et al. (*15*).

Figure 1.8 outlines a more extensive framework for quality management during collection of pavement condition data at the network level. The framework is applicable for quality management of pavement condition data collected at the network level, even if it is collected by in-house employees.

The previously-mentioned procedures for quality control and assurance of pavement condition data address the issues of data accuracy, completeness, and validity. Ensuring accuracy is accomplished by equipment calibration once in the data pre-production phase and a few times in the data production phase. Data Completeness and Validity are addressed in the data production and processing phases.

It should be noted that Data Timeliness and Coverage, otherwise known as the temporal and spatial sampling of condition data, are also aspects that affect data quality, but they are not addressed by the development of quality control or assurance procedures. They are addressed by examining the data collection procedures, which include how frequently condition data are collected (annually, biennially, or

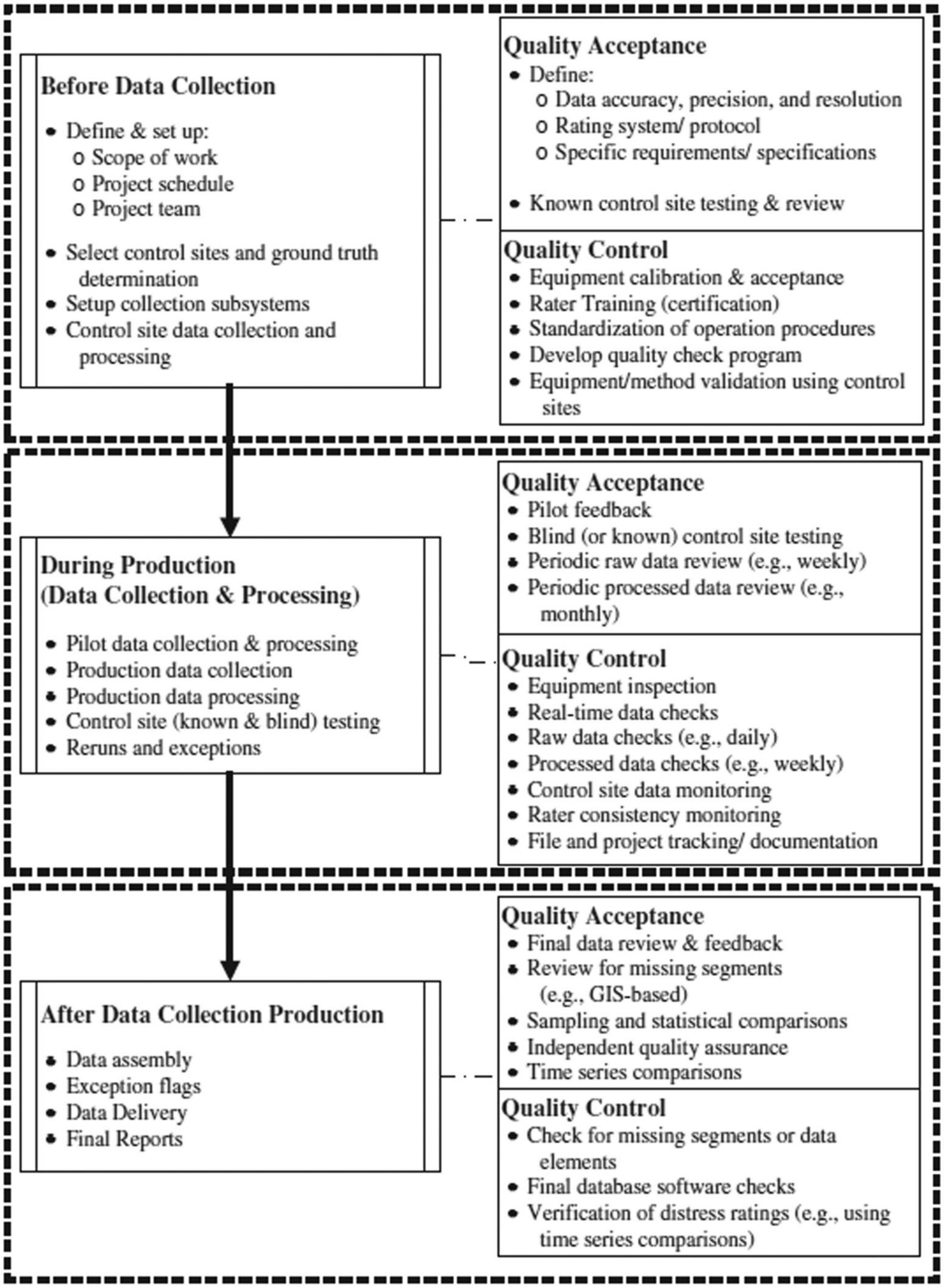



**Figure 1.8** Quality management plan components for network-level pavement data collection (*37*).

otherwise) and the number of measurements per mile or fraction of mile used to represent the condition of pavement segments.

*1.4.4 Project-level Pavement Deflection and Thickness Data Collected In-house*

The INDOT Research Division collects pavement Deflection and Thickness data at the project level.

Pavement Deflection is collected with the Falling Weight Deflectometer (FWD). Pavement layer thickness data can be collected with either pavement coring or through the use of the Ground Penetrating Radar (GPR). Deflection and layer thickness are both used to assess the structural strength of the pavement and material properties of the layers and subgrade. At the project-level, structural evaluation of the pavement is used for scoping restorative projects.

The GPR retains an advantage over pavement coring in that it is a non-destructive method to estimating pavement layer thicknesses. At the same time, pavement coring has a wider range of uses than the GPR. Whereas the GPR can only be used in evaluation of the pavement's structural strength for project scoping, pavement coring is also used to investigate failed pavements and for quality assurance of a contractor's pavement repair work.

Project-level Falling Weight Deflectometer (FWD) data are collected by the Research Division in response to requests from the INDOT Pavement Steering Committee and the District responsible for scoping an appropriate restorative action for a deficient pavement section. There are about 100 testing requests during every testing season, which is 7 months long.

The pavement deflection is measured with FWD equipment, which subjects the pavement surface to a dynamic load. The resulting deflections are measured at specific offset distances. Typically, the time-history of deflections at each offset is processed to determine the "peak" deflection. The set of "peak" deflections at a test location is used to construct an "imaginary" deflection basin as a target in "backcalculation" of a pavement's layer properties. In fact, the individual "peak" deflections occur at different times. The primary output of the FWD testing is the deflection in mils (1/1000 of an inch) of the pavement surface and subgrade in response to an applied force. Analysis of the results of FWD testing yields an estimate of the remaining traffic loading that the pavement can withstand before reaching failure. This estimate must be reliable to 95%, 90%, and 80% for interstate, US Highways, and State Highways, respectively.

Ground Penetrating Radar equipment assesses pavement layer thicknesses by transmitting pulses of electric energy that penetrate the pavement and are subsequently reflected back to a radar antenna. The amplitude and the arrival time of the pulses of electric energy at the radar are parameters that are used to ascertain the pavement layer thicknesses. Figure 1.9

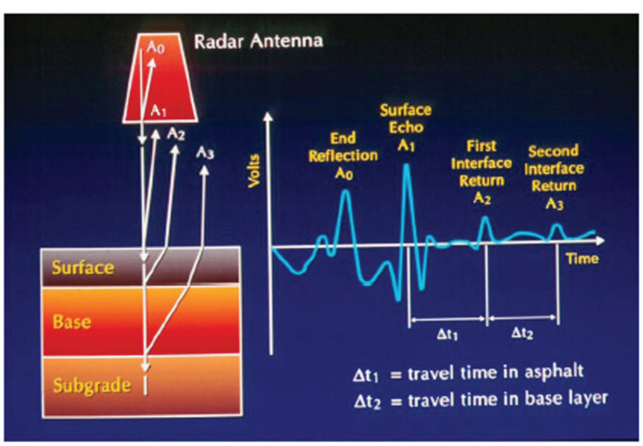



**Figure 1.9** Amplitudes associated with pavement surface and interfaces between layers (*39*).

provides a simple illustration of how GPR equipment measures pavement layer thicknesses. GPR data are collected at highway speeds (55 mph).

### *1.4.5 Potential for Network-level Collection of Pavement Deflection and Thickness Data*

Both FWD and GPR data are currently collected at the project level, most often at the request of INDOT districts. It should be noted that network-level FWD and GPR testing would be highly beneficial in informing INDOT of its pavements' structural condition across the highway network. This information is critical for reliable estimation of multi-year funding needs for pavement rehabilitation and reconstruction projects. Additionally, collection of network-level GPR data would reduce the need for widespread extraction of pavement cores, which would necessitate expensive repairs for the pavements.

JTRP study SPR-2408 (*39*) recommended that FWD and GPR data be collected on 2200 center lane miles of the 11,000 center lane mile network annually for network-level pavement structural evaluation. Conducting only three tests per mile in the driving lane in each direction was recommended. The information collected would allow the equivalent of 100% coverage of the whole network in 5 years.

### *1.4.6 Pavement Condition Data to Be Collected by INDOT: Pavement Condition Rating*

Pavement Condition Rating (PCR) is currently not collected on Indiana highways. However, INDOT has plans to develop a methodology to collect the data at the network level. In December 2010, INDOT released a PCR Data Collection Manual (*40*) that outlines the procedure for PCR rating at the project-level. The PCR data collected with these procedures is to be included in proposed pavement project applications (along with IRI, rutting, friction, age, and truck traffic) for consideration in project programming.

The Pavement Condition Rating is calculated to reflect the surface condition of a pavement section. For each surface type (asphalt or concrete), there is a list of distresses to be quantitatively assessed by extent and severity. The extent and severity are assigned on 0–3 scales. For each distress type, the extent and severity ratings are multiplied together with a distress-specific weight. The resulting products from various distresses are summed together to form a deduct value. This deduct value represents how much the pavement surface has deteriorated from perfect condition.

Figures 1.10 and 1.11 show the forms for calculating PCR for asphalt and concrete surfaces, respectively. The manual contains distress type definitions and criteria to be used in assigning extent and severity scores for each distress.

In addition to the effort of automating the network-level collection of PCR data, INDOT should

| ASPHALT | | | | |
|---|---|---|---|---|
| RATING FORM | | | | |
| PAVE TYPE | ASPHALT | SEVERITY | | EXTENT |
| DATE: | | 0=NONE | | 0=NONE |
| RATER | | 1= LOW | | 1=FEW |
| ROUTE TYPE: | | 2=MODERATE | | 2=SEVERAL |
| ROUTE NO. | | 3=HIGH | | 3=MANY |
| DIRECTION: | | | | |
| REF POST | | WEIGHT x SEVERITY x EXTENT = DEDUCT PTS. | | |

| DISTRESSES | WTS | SEVERITY 1,2,3 | EXTENT 1,2,3 | DEDUCT POINTS |
|---|---|---|---|---|
| 1 RAVELING | 0.5 | 0 | 0 | 0 |
| 2 PATCHING | 1.0 | 0 | 0 | 0 |
| 3 POT HOLES | 1.5 | 0 | 0 | 0 |
| 4 WHEEL PATH CRACKS | 1.5 | 0 | 0 | 0 |
| 5 TRANSVERSE CRACKS | 1.5 | 0 | 0 | 0 |
| 6 BLOCK CRACKS | 1.5 | 0 | 0 | 0 |
| 7 LONGITUDINAL JOINTS | 1.0 | 0 | 0 | 0 |
| 8 EDGE CRACKS | 2.0 | 0 | 0 | 0 |
| 9 LONGITUDINAL CRACKS | 1.0 | 0 | 0 | 0 |
| 10 PUMPING | 1.0 | Y=5 OR N=0 | Y=5, N=0 | |
| 11 MAINTENANCE PERFORMED | 0 | | YES or NO | 0 |
| | | | TOTAL DEDUCTS | 0 |
| | | | 100 - DEDUCTS = PCR | 100 |

**Figure 1.10** PCR calculation form for asphalt surface pavement sections (*40*).

| CONCRETE PAVEMENT | | | | |
|---|---|---|---|---|
| RATING FORM | | | | |
| TYPE | CONCRETE | SEVERITY | | EXTENT |
| DATE: | | 0=NONE | | 0=NONE |
| RATER | | 1= LOW | | 1=FEW |
| ROUTE TYPE: | | 2=MODERATE | | 2=SEVERAL |
| ROUTE NO. | | 3=HIGH | | 3=MANY |
| DIRECTION: | | | | |
| REF. MARKER: | | WEIGHT x SEVERITY x EXTENT = DEDUCT PTS. | | |

| DISTRESSES | WTS | SEVERITY 1/2/3 | EXTENT 1/2/3 | DEDUCT POINTS |
|---|---|---|---|---|
| 1 D-CRACKS/ASR | 1.0 | Y OR N | Y=5, N=0 | 0 |
| 2 PATCHING | 1.0 | 0 | 0 | 0 |
| 3 FAULTING | 1.0 | 0 | 0 | 0 |
| 4 JOINT or CRACK SPALLS | 1.5 | 0 | 0 | 0 |
| 5 TRANSVERSE CRACKS | 2.5 | 0 | 0 | 0 |
| 6 LONGITUDINAL CRACKS | 1.5 | 0 | 0 | 0 |
| 7 CORNER BREAKS | 2.0 | 0 | 0 | 0 |
| 8 PUMPING | 1 | Y OR N | Y=5, N=0 | 0 |
| 9 MAINTENANCE PERFORMED | 1 | Y OR N | | 0 |
| | | | TOTAL DEDUCTS | 0 |
| | | | 100 - DEDUCTS = PCR | 100 |

**Figure 1.11** PCR calculation form for concrete surface pavement sections (*40*).

take note of the rapidly evolving 3D laser imaging technology that can collect high resolution automated pavement surface distress data at highway speeds. Such a tool could potentially be useful for district offices for enhanced scoping of pavement restorative treatments.

## 1.5 Bridge Data Collection, Usage, and Quality

### *1.5.1 Bridge Inspection Types*

Bridge inspection data are required to be collected for the National Bridge Inventory (NBI). The data are also essential for the management of structure condition for the safety and mobility of the traveling public. The National Bridge Inventory Standards establish various types of inspections, listed and defined in Table 1.10. The INDOT Bridge Inspection Manual (*14*) outlines the proper procedures for performing different types of inspections.

### *1.5.2 Routine Bridge Inspection Interval: Practices of Different States*

For routine inspections, the FHWA recommended inspection interval is 24 months. The FHWA also established criteria for lengthening or shortening the previously mentioned inspection interval for certain structures in Technical Advisory T5140.21 (*42*). The routine inspection interval can be extended up to 48 months or it can be shortened to 12 months. With respect to damage, in-depth, and special inspections, the FHWA allows states to set inspection intervals with no specific recommended inspection interval value.

For routine inspections, FHWA has established criteria for utilizing a 48-month inspection interval. These criteria are contained in an attached technical memo in Chapter 2. Nevertheless, many states have more stringent criteria for allowing a structure to be inspected at a 48-month interval for routine inspections. In general, an inspection interval should be applicable to all structures within a certain state, whether these are under state or local maintenance jurisdiction.

Table 1.11 shows the breakdown, by percent, of routine inspection intervals used for bridges and culverts (*43*). The criteria for utilizing various inspection intervals for states neighboring Indiana are summarized in the attached technical memos. Inspection practices for states shown in Table 1.11 can be viewed in depth in the following references: Michigan DOT Bridge Operations Section (*44*), Illinois DOT Bureau of Bridges and Structure (*45*), and Richardson (*46*).

### *1.5.3 Analysis of Deterioration Rate for Indiana Bridges*

After exploring the routine inspection interval practices for several states, Richardson (*46*) used 2008

TABLE 1.10
**Federal Highway Administration Inspection Types (*41*)**

| Inspection Type | Description |
|---|---|
| Damage | This is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions |
| Fracture Critical Member | A hands-on inspection of a fracture critical member or member components that may include visual and other nondestructive evaluation |
| In-Depth | A close-up, inspection of one or more members above or below the water level to identify any deficiencies not readily detectable using routine inspection procedures; hands-on inspection may be necessary at some locations |
| Initial | The first inspection of a bridge as it becomes a part of the bridge file to provide all Structure Inventory and Appraisal (SI&A) data and other relevant data and to determine baseline structural conditions |
| Routine | Regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements |
| Special | An inspection scheduled at the discretion of the bridge owner, used to monitor a particular known or suspected deficiency |
| Underwater | Inspection of the underwater portion of a bridge substructure and the surrounding channel, which cannot be inspected visually at low water by wading or probing, generally requiring diving or other appropriate techniques |
| Damage | This is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions |
| Fracture Critical Member | A hands-on inspection of a fracture critical member or member components that may include visual and other nondestructive evaluation |
| In-Depth | A close-up, inspection of one or more members above or below the water level to identify any deficiencies not readily detectable using routine inspection procedures; hands-on inspection may be necessary at some locations |
| Initial | The first inspection of a bridge as it becomes a part of the bridge file to provide all Structure Inventory and Appraisal (SI&A) data and other relevant data and to determine baseline structural conditions |
| Routine | Regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements |
| Special | An inspection scheduled at the discretion of the bridge owner, used to monitor a particular known or suspected deficiency |
| Underwater | Inspection of the underwater portion of a bridge substructure and the surrounding channel, which cannot be inspected visually at low water by wading or probing, generally requiring diving or other appropriate techniques |

TABLE 1.11
**Routine Inspection Intervals for 17 States (*43*)**

| State DOT | Total Structures | Structure Type | | Owner or Structure | | | % of Structures Inspected | |
|---|---|---|---|---|---|---|---|---|
| | | Bridges | Culverts | State | Local | Other | 48 Months | 12 Months or Less |
| Indiana | 18274 | 16832 | 1442 | 5132 | 12664 | 478 | 0.00 | 0.03 |
| Illinois | 25806 | 21664 | 4142 | 7513 | 17613 | 680 | 42.17 | 2.06 |
| Kentucky | 13523 | 10672 | 2851 | 8784 | 4624 | 115 | 16.94 | 10.52 |
| Michigan | 10887 | 9488 | 1399 | 4408 | 6368 | 111 | 0.01 | 3.63 |
| Ohio | 28066 | 26296 | 1770 | 885 | 18448 | 763 | 0.00 | 99.98 |
| *Arizona* | *7210* | *3361* | *3849* | *4469* | *2268* | *473* | *44.49* | *0.51* |
| New Mexico | 3836 | 2164 | 1672 | 2933 | 699 | 204 | 34.62 | 5.79 |
| *West Virginia* | *6921* | *6417* | *504* | *6628* | *108* | *185* | *24.41* | *14.77* |
| Montana | 4929 | 4725 | 204 | 2449 | 1938 | 542 | 17.16 | 0.18 |
| Colorado | 8278 | 6617 | 1661 | 3442 | 4534 | 302 | 14.32 | 0.98 |
| North Dakota | 4478 | 3641 | 837 | 1111 | 3298 | 69 | 10.09 | 1.03 |
| Texas | 49226 | 31408 | 17818 | 32086 | 16467 | 673 | 9.34 | 0.66 |
| South Dakota | 5961 | 4811 | 1150 | 1811 | 4021 | 129 | 7.40 | 0.77 |
| *Connecticut* | *4168* | *3569* | *599* | *2775* | *1235* | *158* | *5.66* | *0.84* |
| Washington | 7645 | 7395 | 250 | 3080 | 3869 | 696 | 5.42 | 6.80 |
| Arkansas | 12482 | 9690 | 2792 | 7084 | 5239 | 159 | 4.85 | 15.61 |
| Oklahoma | 23387 | 16722 | 6665 | 6759 | 15767 | 861 | 1.43 | 4.78 |

and 2009 National Bridge Inventory Data for Indiana structures to estimate the probability of occurrence for several condition deterioration scenarios. The objective of this analysis was to determine whether it is appropriate for INDOT to lengthen the routine inspection interval for certain bridges. Such an action could result in a more cost-efficient schedule for inspection and resource savings

Table 1.12 shows the results of Richardson's analysis. The chance of a bridge dropping from a condition rating of "6" (for deck, superstructure, or substructure) within 24 and 48 months is at most 5% and 16%, respectively. Table 1.13 is provided for reference to what the numerical scale of a bridge's deck, superstructure, or substructure condition rating corresponds to in terms of the qualitative observation of the condition of these bridge elements.

### *1.5.4 Recommendation for Utilizing 48-Month Routine Inspection Intervals Allowed by FHWA*

Richardson (*46*) suggested that INDOT utilize the FHWA's criteria for allowing a 48-month extended interval for routine inspections of certain structures. He recommended that the current routine inspection schedule remain in effect for 2011 and 2012 and that the extended interval be activated starting in 2013. The reason for the recommendation to start taking effect in 2013 is to obviate the need to look through the recorded conditions in past years to modify the inspection interval for any structure since such a task would be time-consuming.

Richardson (*46*) estimated that, if the bridge inspection interval is increased to 4 years for eligible bridges, it would lead to a resource saving of 18%. This figure is obtained assuming that half of the eligible bridges are scheduled for an inspection interval of 4 years while the other half keeps the 2-year inspection interval. The bridges that are eligible for a 4-year inspection interval but kept on the 2-year inspection interval could be inspected on a "floating schedule", meaning that the bridge inspectors would have the flexibility to inspect those bridges anytime between 24 months and 48 months after the last routine inspection. Such a strategy would be beneficial to INDOT because Bridge Inspectors are being strained with the current inspection workload.

In addition to considering the findings of Richardson (*46*), INDOT should examine the forthcoming results

TABLE 1.12
**Probability of Condition Deterioration Scenarios for 24- and 48-Month Intervals (*46*)**

| Condition Deterioration Scenario | Deck | Superstructure | Substructure |
|---|---|---|---|
| Percent drops of 2 or more condition ratings during 2 year period | 19% | 12% | 23% |
| Percent of bridges staying in condition rating "6" for 24 months | 95% | 96% | 98% |
| Likelihood of dropping 2 or more condition ratings within first 24 Months | 0.95% | 0.48% | 0.46% |
| Percent drops of 2 or more condition ratings during 4 year period | 22% | 16% | 26% |
| Percent of bridges staying in condition rating "6" for 48 months | 84% | 84% | 93% |
| Likelihood of dropping 2 or more condition ratings within first 48 months | 3.52% | 2.56% | 1.82% |
| Difference in likelihoods of 2 or more condition ratings | 2.57% | 2.08% | 1.36% |

TABLE 1.13
**Descriptions for NBI Condition Ratings (*47*)**

| Code | Condition | Description |
|---|---|---|
| N | N/A | |
| 9 | Excellent | New |
| 8 | Very good | No problems encountered |
| 7 | Good | Some minor problems |
| 6 | Satisfactory | Structural elements show minor deterioration |
| 5 | Fair | Primary structural elements are sound; minor section loss, cracking, spalling, or scour |
| 4 | Poor | Advanced section loss, deterioration, spalling or scour |
| 3 | Serious | Deterioration has seriously affected primary structural components; local failures possible |
| 2 | Critical | Advanced deterioration of primary structural elements; must be closely monitored if not closed |
| 1 | "Imminent" failure | Major deterioration or section loss; bridge is closed to traffic |
| 0 | Failed | Out of service and beyond corrective action |

of the current NCHRP Project 12–82: Developing Reliability-Based Bridge Inspection Practices. The NCHRP study aims to arrive at scientifically based bridge inspection practices to ensure bridge safety and serviceability and effective use of inspection resources. The study's findings are very likely to be utilized by AASHTO in its review of the current national inspection standards.

### *1.5.5 Quality Control of Bridge Data*

INDOT's Bridge Inspection Manual (*14*) outlines the procedures for the conduct of bridge inspection, including the Quality Control/Quality Assurance process that inspection data undergo. Quality Control is performed for a sample number of county-owned or state-owned bridges meeting any of the following criteria:

- A rating of 4 or less for items 58, 59, 60, or 62 (Deck, Superstructure, Substructure, Culvert)
- A rating that changed by more than 2 for items 58, 59, 60, or 62 (Deck, Superstructure, Substructure, Culvert)
- Bridge posted for 10 tons or less
- A rating of 3 or less on Item 113A (Scour rating)

The Quality Control process consists of both Field and Office Reviews to ensure that inspections are performed on time, condition ratings are properly documented, a suitable load posting is present, suggested maintenance and rehabilitation actions are appropriate, and a scour action plan is both active and appropriate. This process ensures the timeliness and completeness of documentation contained in bridge inspection files.

Quality Assurance consists of three types of reviews: Office Review, Peer Field Review and Post-Inspection Review. An inspected bridge can potentially undergo any one or combination of these reviews. These reviews address the accuracy of bridge inspection data.

- Quality Assurance Office Review examines bridge inspection files to verify the presence of bridge design and/or rehabilitation plans, load rating calculations, and scour plan of action. The load rating calculations are thoroughly scrutinized with respect to the assumptions made and the involvement of a Professional Engineer in making the calculations is checked.
- Quality Assurance Peer Field Review ensures that the bridge inspection was conducted correctly in terms of use of proper procedure for type of inspection, documentation of critical areas, proper measurement of deficiencies, and proper use of equipment.
- Quality Assurance Post-Inspection Review can only be done on a sample consisting entirely of bridges needing rehabilitation or replacement, new bridges, bridges with critical findings, or bridges with unusual changes in condition as assessed through a routine, fracture critical, or underwater inspection. This review is conducted on a sample of bridges and it requires the Quality Assurance Officer to conduct an inspection 6 months after the original inspection to verify the values reported for selected inventory and condition appraisal data items within certain tolerance limits.

The sampling rules for selecting bridges to undergo the aforementioned reviews and the detailed processes of these reviews are explained in depth in INDOT's Bridge Inspection Manual (*14*). It should be noted that the data undergoing quality control and/or quality assurance come only from bridges in poor condition.

## 1.6 Safety Data Collection, Usage, and Quality

### *1.6.1 Data Collection*

Indiana State Police has maintained a contract with Open Portal Solutions since 2003 to electronically store crash record data that are submitted by police officers. Approximately 200,000 reports are submitted each year by Indiana Police officers. Crash records are stored in a database named Automated Reporting Information Exchange System (ARIES) and the records are accessible to Indiana State Police. Both the Central and the District offices of INDOT can access this database and use the query tool to extract the data and export them to Microsoft Access or Excel to produce crash analysis reports. In the past several months, vehicle accident data from ARIES have been uploaded to the data warehouse to enhance data accessibility.

Crash records contain the date and time of the crash, the site of the crash along the road or within the intersection, the drivers' identities, the number of vehicles involved, the circumstances contributing to the crash, weather conditions, number of deaths or injuries caused by the crash and the monetary estimate of the crash damage. In addition to the crash record data being available to the State Police and INDOT, the data are also shared with the Indiana Criminal Justice Institute and the Bureau of Motor Vehicles; this practice assists these agencies in carrying out their duties to protect the public's safety.

The timely and accurate collection of crash data serves multiple business functions for INDOT. INDOT's district offices produce crash analysis reports for their jurisdictions. The INDOT Offices of Traffic Support and Traffic Management use crash data to improve safety and mobility in work zone areas. ARIES crash data are also used to bill the insurance company for the repair cost of infrastructure damaged during motor vehicle accidents.

One of the most crucial uses of crash data is the generation of the annual Five Percent Crash Report and the Strategic Highway Safety Plan. The Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) requires states to submit these documents as proof that a data-driven process is used to identify and prioritize safety improvement needs. The Five Percent report consists of a list of Indiana State and Local Roadway Segments and Intersections and Interchange Ramps with the highest safety improvement needs. The inclusion of Interchange Ramp Crashes is a new practice that made its debut in the 2010 report. The locations listed in the report account for the top five percent of all Indiana fatality or serious injury crashes in the three years prior to the report year. After identifying the locations with the highest need for safety improvement, states prioritize safety projects in the Strategic Highway Safety Plan. The plan also identifies countermeasures designed to lower the number and severity of crashes, injuries, and deaths that occur each year on Indiana's highways. Completing the Five Percent Report and updating the Strategic Highway Safety Plan is crucial because the availability of federal funding for safety improvement projects under SAFETEA-LU's Highway Safety Improvement Program (HSIP) is contingent upon the submission of these documents to FHWA Office of Safety.

### *1.6.2 Data Quality and Integration*

Open Portal Solutions, the developer of ARIES software, has provided a significant improvement in the availability of timely and accurate crash record data. The reporting of crash report submittal has gone from 8% submission within five days in 2003 to 85% submission within four days in 2010. To ensure that crash data stay current, ARIES monitors the timeliness of crash report submissions monthly for all police departments in Indiana. The accurate recording of the crash locations is being ensured by a new "point-and-click" location functionality (*48*). Currently, ARIES presents an approximate latitude and longitude of a crash location when the police officer enters in his field laptop the road name where the crash occurred. With the new tool, the police officer will be shown a navigable online map on the field laptop where the assignment of the crash location is possible by simply pointing and clicking to the exact site to output the latitude and longitude of the crash location. This tool has the potential to eliminate the issue of inaccurate location assignment of crashes, provided that the underlying online map is representative of the most current road network and the road network is correctly overlaid on Indiana's geographic map. The location assignment problems that currently arise are due to the inconsistent reporting by the police officers for reasons such as the same road segment having multiple names or assignment of the crash to the incorrect segment of the correct road (for example, CR 600 North instead of CR 600 South).

### *1.6.3 Data Needs*

INDOT has made great strides in the quality of its roadway crash data, but the data's usefulness remains limited by issues of data integration. In order for INDOT to increase the safety of its highways, vehicle accident circumstances must be viewed in light of the physical and operational environment of a crash site. FHWA Office of Safety partially addressed this problem with a guidance memorandum to inform states of the data elements that can represent the environment of vehicle crash sites.

The memorandum (*49*) lists traffic and roadway geometry data elements that would enhance states' safety project programming decisions and result in more beneficial use of funds provided by HSIP. As a user of SafetyAnalyst software for roadway safety management, the INDOT Office of Traffic Safety recognizes the importance of obtaining Table 1.14 data and has even identified additional data elements it needs for enhanced safety analysis (Figure 1.12). The additional data elements should be sought from the Office of Inventory and Tracking (roadway inventory data from EXOR), the Operations Division (guardrail information from WMS), and the Research Division (Pavement Friction Data).

It should be noted that many of the data elements listed in Table 1.14 are already being collected by states for the Highway Performance Monitoring System (HPMS) on *full extent* of federal-aid roadways (all functional classification except for rural minor arterials and all local roads) and ramps located within grade-separated interchanges. Therefore, this situation represents an opportunity for data integration or data sharing between the Office of Inventory and Tracking and the Office of Traffic Safety. The HPMS GIS file that is submitted to FHWA annually provides 16 of the 38 data elements listed in Table 1.14. If the needed resources are available, any additional desired data elements can then be collected and layered on the base certified roads layer. However, a separate intersection

TABLE 1.14
**Roadway Inventory, Geometric, and Traffic Data Elements Recommended by FHWA-SA-11-39 Report for Use in Traffic Safety Analysis (*50*)**

| Data Elements | Definition |
|---|---|
| **Roadway Segment** | |
| Segment ID* | Unique segment identifier |
| Route Name* | Signed numeric value for the roadway segment |
| Alternate Route Name* | The route or street name, where different from route number |
| Route Type* | Federal-aid/NHS route type |
| Area Type* | The rural or urban designation based on Census urban boundary and population |
| Date Opened to Traffic | The date at which the site was opened to traffic |
| Start Location* | The location of the starting point of the roadway segment |
| End Location* | The location of the ending point of the roadway segment |
| Segment Length* | The length of the segment |
| Segment Direction | Direction of inventory if divided roads are inventoried in each direction |
| Roadway Class* | The functional class of the segment |
| Median Type | The type of median present on the segment |
| Access Control* | The degree of access control |
| Two-Way vs. One-Way Operation* | Indication of whether the segment operates as a one- or two-way roadway |
| Number of Through Lanes* | The total number of through lanes on the segment This excludes turn lanes and auxiliary lanes |
| Interchange Influence Area on Mainline Freeway | The value of this item indicates whether or not a roadway is within an interchange influence area |
| AADT* | The average number of vehicles passing through a segment from both directions of the mainline route for all days of a specified year |
| AADT Year* | Year of AADT |
| **Intersection** | |
| Intersection ID | A unique junction identifier |
| Location | Location of the center of the junction on the first intersecting route (e.g., route-milepost) |
| Intersection Type | The type of geometric configuration that best describes the intersection/junction |
| Date Opened to Traffic | The date at which the site was opened to traffic |
| Traffic Control Type | Traffic control present at intersection/junction |
| Major Road AADT | The Annual Average Daily Traffic (AADT) on the approach leg of the intersection/junction |
| Major Road AADT Year | The year of the Annual Average Daily Traffic (AADT) on the approach leg of the intersection/junction |
| Minor Road AADT | The Annual Average Daily Traffic (AADT) on the approach leg of the intersection/junction |
| Minor Road AADT Year | The year of the Annual Average Daily Traffic (AADT) on the approach leg of the intersection/junction |
| Intersection Leg ID | A unique identifier for each approach of an intersection |
| Leg Type | Specifies the major/minor road classification of this leg relative to the other legs in the intersection |
| Leg Segment ID | A unique identifier for the segment associated with this leg |
| **Ramp/Interchange** | |
| Ramp ID* | An identifier for each ramp that is part of a given interchange. This defines which ramp the following elements are describing |
| Date Opened to Traffic | The date at which the site was opened to traffic |
| Start Location | Location on the roadway at the beginning ramp terminal (e.g., route-milepost for that roadway) if the ramp connects with a roadway at that point |
| Ramp Type | Indicates whether the ramp is used to enter or exit a freeway, or connect two freeways |
| Ramp/Interchange Configuration | Describes the characterization of the design of the ramp |
| Ramp Length | Length of ramp |
| Ramp AADT* | AADT on ramp |
| Ramp AADT Year | Year of AADT on ramp |

*Highway Performance Monitoring System full extent elements required on all federal-aid highways and ramps located within grade-separated interchanges, i.e., National Highway System (NHS) and all functional systems excluding rural minor collectors and locals.

database would need to be generated since the HPMS GIS files do not map intersections present in the federal-aid road network.

FHWA-SA-11-40 Report (*51*) is an excellent reference for states to estimate the cost of collection of data elements in Table 1.14. The document conservatively estimates that states only collect data elements required by HPMS and assumes that states will collect all 38 data elements on non–federal aid roadways.

As INDOT continually evaluates its data needs for improving roadway safety, it can refer to the Model Inventory of Roadway Elements (MIRE) as the most comprehensive listing for data elements that can be used for safety management. Additionally, the

| |
|---|
| Number of through lanes by direction |
| Lane width |
| Roadway surface type |
| Shoulder width |
| Shoulder surface type |
| Median presence |
| Median type |
| Median width |
| Number of intersections |
| Number of driveways |
| Auxiliary lane count |
| Auxiliary lane width |
| Speed zones |
| No passing zones |
| Horizontal curve radius |
| Horizontal curve length |
| Vertical grade |
| Vertical grade length |
| Presence of curbs |
| Guardrail location |
| Guardrail type |
| Friction number |

**Figure 1.12** Additional data elements desired by the INDOT Office of Traffic Safety for enhanced safety analysis.

FHWA's attempt to develop MIRE MIS (management information system) in pilot state DOTs should be closely observed. These agencies' experiences in collecting and storing MIRE data elements and incorporating them into safety programs shall serve as an example of best data utilization practices for all state DOTs.

## 1.7 Land Record Data Collection

### *1.7.1 The Land Record System Database*

The Land Record System (LRS), under the purview of the INDOT Division of Real Estate, tracks the progress of the land acquisition process prior to construction of transportation projects. The land to be acquired is represented as parcels in the database. For each parcel, an identification number and the name and address of its current owner(s) are recorded. After contacting the property owner(s), each parcel record is augmented with 2 data elements: the identity of the person informing the property owner(s) of acquisition and the date of contact. The appraisal process brings about additional data including the appraiser's identity, the detailed description of the parcels, the property classification (house, rental, business), and the assessed value of the parcels. The negotiation process generates the offer value and date in addition to the relocation compensation made to property owners. If the negotiation succeeds, the dates of the deed signing and deed recording in the county office are added to the Land Record System. If the negotiation process fails, the property condemnation process is commenced. The date of the condemnation lawsuit filing against the land owner is recorded.

Due to the significance of land acquisition data to the project delivery process, the Land Record System is slated to be rolled into the Scheduling and Project Management System (SPMS). This action underscores how INDOT seeks to improve coordination between various offices responsible for different aspects of project delivery. Additionally, there is the realization that adding a spatial component to the LRS database will enhance its functionality beyond reporting to the FHWA Office of Real Estate Services to prove compliance with the Uniform Relocation Assistance and Real Property Acquisition Act. Ideally, a spatial component would add the capability to map parcels and their status as the project progresses through the land acquisition process. This capability could further increase the efficiency of project delivery, resulting in cost and time savings.

### *1.7.2 Potential Usage of IndianaMap's Statewide Parcel Data*

IndianaMap is a statewide digital map developed by the Indiana Geographic Information Council and the Indiana Geological Survey and funded in part by INDOT. The map, which is available at http://inmap.indiana.edu/index.html, contains a land parcel layer provided by 86 counties as part of the Data Sharing Initiative program established by the Indiana Department of Homeland Security. The information attached to this layer includes local parcel identification and statewide identification numbers. The parcel layer does not contain legally binding information and is not meant to be used for any official or business purposes. However, it can be used to make a preliminary estimate of land acquisition costs for project alternatives. However, the layer can be used as a starting point to identify the land that INDOT owns and manage excess land.

### *1.7.3 National Guidance for Designing a Geospatially Enabled Right-of-Way Management System*

NCHRP Project 8–55 "Integrating Geospatial Technologies into the Right-of-Way Data-Management Process" (*52*) provides a wealth of guidance for state DOTs to build a geospatially enabled ROW information management system. The project produced NCHRP 695, a document that details the steps to be taken by the state DOT to assemble a geospatial information management system for land record data. These steps are summarized in Table 1.15.

NCHRP 695 features an extended discussion of the importance of building up support for the endeavor, establishing a task force responsible for collaborating with information technology professionals, and setting outcome goals for the function of the system, with input from the end users of the system. The guidance is applicable to

TABLE 1.15
**Summary of the Implementation Process for a Geospatially Enabled Right-of-Way Management System (*52*)**

| Activity | Steps |
|---|---|
| Building Support: Chapter II | 1. Recruit a champion<br>2. Obtain leadership, stewardship, management support<br>3. Appoint an initial working group<br>4. Establish linkage to agency performance measures and goals<br>5. Research related efforts (internal and external) |
| Assessing Your Requirements: Chapter III | 1. Define your enterprise<br>2. Identify needs<br>3. Identify use cases<br>4. Review business processes<br>5. Evaluate best practices for incorporation<br>6. Review legal and regulatory requirements |
| Assessing Your Capabilities: Chapter IV | 1. Assess existing ROW systems<br>2. Identify existing database structure(s)<br>3. Identify existing geospatial capabilities (GIS tools)<br>4. Identify related existing information systems<br>5. Assess current policies for IT deployment |
| Defining the System: Chapter V | 1. Define type of system<br>2. Determine a starting point<br>3. Define data structure<br>4. Define geospatial capabilities<br>5. Define document management<br>6. Define reporting requirements<br>7. Define links to other systems |
| Developing an Implementation Plan: Chapter VI | 1. Identify phasing options<br>2. Evaluate feasibility<br>3. Develop timelines with milestones |
| Implementation: Chapter VII | 1. Confirm/revise requirements<br>2. Secure resources<br>3. Develop detailed design<br>4. Develop test plan<br>5. Establish procedures for configuration management—Versioning<br>6. Develop software<br>7. Develop training plan<br>8. Train users |

three types of agencies: 1) Agencies with no enterprise-level ROW land management system or replacing their ROW land management system to include a spatial component, 2) Agencies desiring to geospatially enable the enterprise-level ROW management system or add ROW management to an enterprise geospatial warehouse, 3) Agencies desiring to build a ROW management system within the agency enterprise GIS system.

Tables 1.16 and 1.17 illustrate the business process functions that can be supported and the land acquisition activities that can be enhanced through the presence of a geospatial component in a ROW management database. These tables are important for the task force to contemplate as it decides on the capabilities it desires from the new system, which undoubtedly affects the system's design and its practicality for potential users.

NCHRP Web Only Document 95 (*53*) can be consulted for recommendations of the data elements and attributes of parcels to include in a geospatially enabled ROW management system. The recommendations of the document are made in light of all phases of the land management process, including appraisal, acquisition, relocation, and property management phases.

NCHRP 695 report appendices (*53*) showcase a logical model that can be used to inform the design of a ROW management system. The logical model consists of diagrams that illustrate the relationships between the land acquisition process and the flow of relevant information between employees in various divisions within a state department of transportation and the right-of-way office.

As mentioned previously, INDOT is currently under the process of forming a legally binding geospatial layer to use for land management. The publications resulting from NCHRP Project 8–55 are invaluable resources in terms of guiding INDOT through the technical and the administrative challenges of implementing an enterprise-wide geospatially enabled land management system. Such a system would make INDOT more efficient in acquiring needed ROW and in managing excess land.

TABLE 1.16
**Summary of Business Process Functions Throughout the Land Management Process (*52*)**

| Right-of-Way Area | Business Process Function |
| --- | --- |
| Project Development | Project establishment<br>Initial planning<br>Early acquisition<br>Project authorization<br>Project agreement<br>Funds encumbered<br>ROW mapping and engineering<br>Utility relocation and management<br>Staff identification<br>Parcel identification & cost estimation<br>Title document processing<br>Identification of parcel type |
| Corridor Management | Corridor management |
| Appraisal | Parcel selection<br>Initial review<br>Appraiser assignment<br>Contract appraiser<br>Value donation<br>Waiver<br>Process<br>Appraisal review<br>Appraiser certificate<br>Just compensation establishment |
| Acquisition | Pre-negotiation<br>Negotiation<br>Closing |
| Relocation | Relocation planning<br>Services<br>Assistance payments |
| Property Management | Pre-construction property management<br>During construction property management<br>Post-construction property management<br>Rodent control<br>Security inspection<br>Hazardous materials<br>Acquired property<br>Construction |
| Project Closing | Update excess to inventory<br>Review project plans<br>Accumulate and store records<br>Status report<br>ROW certification<br>State-defined processes<br>Final claims<br>Close accounting<br>Re-open if necessary<br>Encroachment cleaning<br>Excess property disposition<br>Construction |

## 1.8 Environmental Data Collection

### *1.8.1 The Office of Environmental Services Core Business Functions*

The Office of Environmental Services (OES) maintains responsibility for ensuring compliance of federally funded highway projects with national and state environmental laws and regulations. In addition to addressing issues of natural environment such as water quality, impacts on wetland, impacts on threatened and endangered species, laws also address issues of the human environment such as impacts on cultural resources and noise control. The Clean Water Act, the Endangered Species Act, the National Historic Preservation Act and the Noise Control Act are just a few of the national laws that state departments of transportation must comply with in the project development process.

During the project development process, state departments of transportation are obligated to submit NEPA (National Environmental Policy Act) documentation to the Environmental Protection Agency. This documentation includes information of the anticipated environmental impacts of all transportation project implementation alternatives. The documentation must also address the impact minimization and avoidance efforts to be undertaken by state DOTs during project construction and operation phases. The data necessary for preparing NEPA documentation are collected in field studies conducted by District Environmental Scoping Teams. The OES' Environmental Policy Section is then responsible for completing the documentation. The data collected to prepare NEPA documentation vary greatly between different projects due to the fact that each project is unique in the nature of impacts it imposes upon the environment.

In conjunction with the NEPA documentation process, the OES' Cultural Resources Section undergoes a documentation process in compliance with the National Historic Preservation Act (NHPA), which requires the evaluation and minimization of impacts on locations listed in the National Register of Historic Places. The staff of the Cultural Resources Section is responsible for conducting field studies that yield data necessary to assess the magnitude of impacts a transportation project imposes on the historic location. Additionally, the staff is tasked with supporting the Historic Bridge Preservation Program initiated by INDOT. The program requires identifying of bridges eligible for inclusion in the National Register of Historic Places and keeping a Historic Bridge Inventory, a database for bridges constructed before 1965.

The OES' Ecology and Permits Section employs one person in each district to investigate the need for waterway permits and to prepare permit applications. Depending on the type of permit requested, the applications are typically sent to one of four agencies: the US Army Corps of Engineers, the Environmental Protection Agency, the Indiana Department of Environmental Management or the Indiana Department of Natural Resources. The status of permit applications is stored in the Environmental Permit Tracking Application.

The data collected and managed by the Office of Environmental Services was summarized in this section. The databases storing information pertaining to INDOT's compliance with environmental regulations at the network level were described in detail. For more

TABLE 1.17
**Right-of-Way Activities that can be Enhanced with the Presence of a Geospatially Enabled Right-of-Way Management System (*52*)**

| | Geospatial Activity | Description |
|---|---|---|
| Project Development | Identify parcels during alignment selection | Overlay and analyze multiple layers affecting alignment selection. Estimate ROW cost for alignment selection |
| | Identify environmental impacts<br>Perform environmental studies and hazardous waste sites evaluation | Overlay and analyze multiple layers that could support identification of environmental impacts during the roadway alignment selection |
| | Identify parcels for ROW | Identify parcels by overlaying the parcel cadastre layer with the road design layer |
| | Define parcel type of take and divide parcel to ROW/excess | Analyze each selected parcel to determine if it is a whole or partial take |
| | Identify complexity | Analyze each selected parcel for complexity (See geospatial activities under Appraisal and Relocation for more detailed descriptions) |
| Appraisal | Initial parcel review for value/complexity | Determine appraisal complexity by overlaying and analyzing multiple layers including elevation, utilities, land use, imagery etc. |
| | Elevation changes affecting the parcel/property | Analyze the elevation that would affect the property with the new roadway |
| | Determine appraisal technique | Determine the method of appraisal employed for the parcel by interfacing with an external appraisal system |
| | Sales comparison | Analyze and determine appraisal value for paired sales (sales comparison method), by interfacing with available historical parcel sales records |
| | Specialty appraisal | Identify and extract parcels requiring specialty appraisal by analyzing the existence of special properties on each parcel |
| | Identification of parcels with utilities | Identify and extract parcels with subsurface, surface and aerial utility facilities by overlaying and analyzing with utilities layer (electricity, natural gas, water, sewage etc.) |
| Relocation | Identify parcels for requiring relocation | Identify and extract parcels that require relocation assistance by analyzing each parcel's relocation indicators |
| | Identify available properties for sale, lease, community amenities | Identify possible locations for relocation, by analyzing and overlaying multiple layers including demographic data and interfacing with external real estate management system or lease/sale property management system |
| | Identify available areas for relocating utilities | Determine possible areas for adjusting the effected utilities by overlaying utilities layer with multiple layers including roadway ROW layer, parcel cadastre layer, and road network layer |
| Property Management | Parcel Requirement Type | Determine the requirement type of each parcel, either as substantially excess or substantially ROW, by overlaying ROW project parcels using the new ROW roadway layer |
| | Clearance/demolition | Analyze and identify level and type of clearance required for personal property/improvement clearance, and display the clearance status thematically |
| | Grading | Determine cut and fill volumes, and total cost for the earthwork for the new roadway by overlaying and analyzing multiple layers including, topography/elevation of terrain and soil type layer<br>Display the grading status for each parcel |
| | Justification of ROW/excess disposal | Analyze and justify ROW (access/relinquishment/lease) and excess land disposal by overlaying multiple layers including roadway network (for highway safety, traffic demand), soil type layer vegetation layer etc. |
| | Manage excess lands | Identify and extract excess land based on the analyzed parcel requirement type, and by overlaying the new roadway ROW |

information about the databases maintained and the data issues faced by the Office of Environmental Services, consult Chapter 2.

### *1.8.2 Environmental Permit Tracking and Environmental Commitment Tools*

The Environmental Permitting Tracking Application, which consists of the Permitting and Violations Databases, aids OES staff in tracking the status of permit applications and in maintaining a record of violations against issued permits. The 2009 Information Technology Roadmap (*54*) mentions INDOT's intent of rolling the Environmental Permit Tracking Application into the Scheduling and Project Management System (SPMS). This action is anticipated because this tool contains information that affects the pace of projects' progress.

SPMS currently houses the Environmental Commitments Database, a database that records the commitments made to uphold permit conditions or to mitigate the environmental impacts of projects.

As defined by the INDOT Categorical Exclusion Manual (*55*), commitments are "promises made during the environmental evaluation and study process to moderate or lessen impacts from the proposed action." Figure 1.13 shows a screenshot of example actions that can be included in the Environmental Commitments Database. The Commitments Database contains 19 fields,which are shown in greater detail in Figures 1.14 through 1.18.

Figure 1.14 showcases the information to be inserted into fields 1–4. The information should provide the project identification and commitment identification numbers as well as the commitment description. The date the commitment is uploaded in the database is noted.

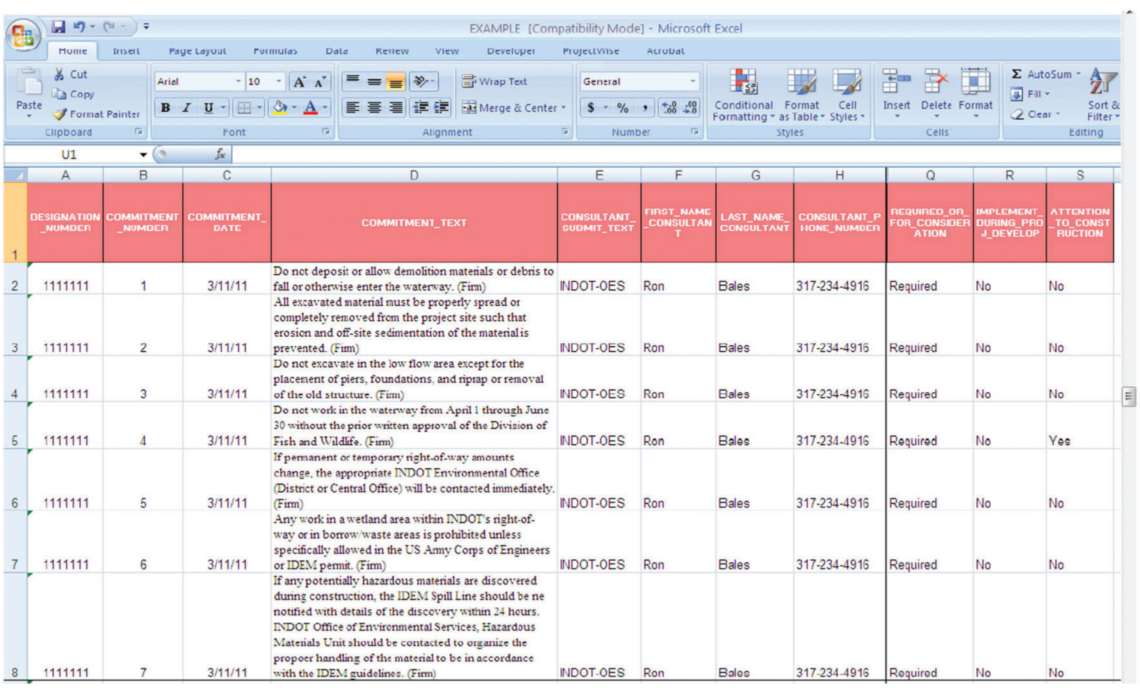
As shown in Figure 1.15, Fields 5–8 show the identity and the contact information for the party suggesting the committment. If the commitment is required through a permit condition, the Office of Enviromental Services' contact information is entered here. Otherwise, the design consultant's contact information is entered.

Fields 9–12, which are shown in Figure 1.16, contain the identity of the INDOT employee who has uploaded the commitment to the database. Only INDOT employees are capable of uploading commitments to the electronic database. Design consultants wishing to include a commitment must write them in a preformated spreadsheet and submit it to the project manager for electronic upload.

Fields 13–16, which are shown in Figure 1.17, represent the contact information for the permitting agency. These fields are only filled in for commitments required by permit conditions.

The last three fields in the Environmental Commitments Database are shown in Figure 1.18. Field 17 notes whether the commitment is required by a permit or is being considered for implementation to mitigate environmental impacts. Field 18 expresses whether or not the commitment is to be recorded in the project design documents. Field 19 expresses whether or not the attention of the construction personnel should be brought to the commitment during the preconstruction conference.

Commitments are usually uploaded during the NEPA process. Once the NEPA review process is over, the Commitments Summary Form is uploaded to the



| | DESIGNATION_NUMBER | COMMITMENT_NUMBER | COMMITMENT_DATE | COMMITMENT_TEXT | CONSULTANT_SUBMIT_TEXT | FIRST_NAME_CONSULTANT | LAST_NAME_CONSULTANT | CONSULTANT_PHONE_NUMBER | REQUIRED_OR_FOR_CONSIDERATION | IMPLEMENT_DURING_PROJ_DEVELOP | ATTENTION_TO_CONSTRUCTION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1111111 | 1 | 3/11/11 | Do not deposit or allow demolition materials or debris to fall or otherwise enter the waterway. (Firm) | INDOT-OES | Ron | Bales | 317-234-4916 | Required | No | No |
| 3 | 1111111 | 2 | 3/11/11 | All excavated material must be properly spread or completely removed from the project site such that erosion and off-site sedimentation of the material is prevented. (Firm) | INDOT-OES | Ron | Bales | 317-234-4916 | Required | No | No |
| 4 | 1111111 | 3 | 3/11/11 | Do not excavate in the low flow area except for the placement of piers, foundations, and riprap or removal of the old structure. (Firm) | INDOT-OES | Ron | Bales | 317-234-4916 | Required | No | No |
| 5 | 1111111 | 4 | 3/11/11 | Do not work in the waterway from April 1 through June 30 without the prior written approval of the Division of Fish and Wildlife. (Firm) | INDOT-OES | Ron | Bales | 317-234-4916 | Required | No | Yes |
| 6 | 1111111 | 5 | 3/11/11 | If permanent or temporary right-of-way amounts change, the appropriate INDOT Environmental Office (District or Central Office) will be contacted immediately. (Firm) | INDOT-OES | Ron | Bales | 317-234-4916 | Required | No | No |
| 7 | 1111111 | 6 | 3/11/11 | Any work in a wetland area within INDOT's right-of-way or in borrow/waste areas is prohibited unless specifically allowed in the US Army Corps of Engineers or IDEM permit. (Firm) | INDOT-OES | Ron | Bales | 317-234-4916 | Required | No | No |
| 8 | 1111111 | 7 | 3/11/11 | If any potentially hazardous materials are discovered during construction, the IDEM Spill Line should be ne notified with details of the discovery within 24 hours. INDOT Office of Environmental Services, Hazardous Materials Unit should be contacted to organize the propoer handling of the material to be in accordance with the IDEM guidelines. (Firm) | INDOT-OES | Ron | Bales | 317-234-4916 | Required | No | No |

**Figure 1.13** Examples of environmental commitments made during project development process.

| DESIGNATION NUMBER | COMMITMENT NUMBER | COMMITMENT DATE | COMMITMENT TEXT |
|---|---|---|---|
| 1111111 | 1 | 03/11/2011 | < text > (Firm) |
| 1111111 | 2 | 03/11/2011 | < text > (For further consideration) |
| 1111111 | 3 | 03/11/2011 | < text > (Firm) |

**Figure 1.14** Commitment identification and description.

| CONSULTANT SUBMIT COMMITMENT | FIRST NAME CONSULTANT | LAST NAME CONSULTANT | CONSULTANT PHONE NUMBER |
|---|---|---|---|
| Acme CE Services, LLC | Brighton | Early | 317-111-1111 |
| Acme CE Services, LLC | Brighton | Early | 317-111-1111 |
| Acme CE Services, LLC | Brighton | Early | 317-111-1111 |

**Figure 1.15** Consultant information.

| OFFICE DOCUMENTING COMMITMENT | DOCUMENTER FIRST_NAME | DOCUMENTER LAST_NAME | DOCUMENTER PHONE NUMBER |
|---|---|---|---|
| INDOT Environmental Services | Ron | Bales | 317-234-4916 |
| INDOT Environmental Services | Ron | Bales | 317-234-4916 |
| INDOT Environmental Services | Ron | Bales | 317-234-4916 |

**Figure 1.16** Documenter information.

| AGENCY_ REQUIRING COMMITMENT | CONTACT_ FIRST NAME | CONTACT_ LAST NAME | CONTACT_ PHONE NUMBER |
|---|---|---|---|
| IDEM | Autoresponse | Autoresponse | 317-555-5018 |
| IDNR | Christie | Stanifer | 317-111-3333 |
| USFW (and IDNR) | Michael | Litwin | 812-222-1111 |

**Figure 1.17** Requesting agency information.

| REQUIRED OR FOR CONSIDERATION | IMPLEMENT DURING PROJ DEVELOP | ATTENTION TO CONSTRUCTION |
|---|---|---|
| Required | Yes | No |
| For Consideration | Yes | Yes |
| Required | No | No |

**Figure 1.18** Commitment status.

Electronic Records Management System (ERMS) and the actions to carry out or to avoid during construction are written into construction contracts.

#### *1.8.3 The Office of Environmental Services Wetland Mitigation Database*

The OES maintains a Wetland Mitigation Database that tracks the locations and compliance status of wetlands that were constructed by INDOT for the purpose of compensatory mitigation. Construction of wetlands is implemented as compensation for wetlands destroyed in projects. Wetland compensation is an obligation attached to the attainment of certain permits and therefore wetland mitigation data must be tracked and reported to the US Army Corps of Engineers (*56*). The USACE Regulatory Guidance Letter No 08-03 (*56*) provides guidance on the information required in Wetland Mitigation reports, which are most typically annual reports.

#### *1.8.4 The Office of Environmental Services Noise Barrier Database*

The Noise Barrier Database stores information on the barriers' locations (city/county and name of adjacent highway route), length and height, the materials used to construct them, the construction cost per square foot, and the year of construction. The data are reported every 3 years to the FHWA Office of Natural and Human Environment. The noise barrier information for all states is published at http://www.fhwa.dot.gov/environment/noise/noise_barriers/inventory/ (*57*).

### 1.9 Summary

This study's main purpose was to provide an inventory of the data collection programs undertaken by INDOT's divisions and offices and to give recommendations regarding addition, removal, or modification of data programs. This purpose was pursued through the development of an inventory of the data collection programs implemented by INDOT. The inventory contains information about the data items collected, the data collector and/or owner entity, frequency of collection, the tools used for data collection and storage, and the purpose of collection.

The data collection programs implemented by INDOT are described in Chapter 1 and summarized in Chapter 3. Additionally, Chapter 2 displays the technical memos, a compilation of the raw responses of INDOT employees to the INDOT Data Collection Online Survey and phone interviews.

An additional achievement of this research was the exploration of data quality and accessibility issues within INDOT. The issues were brought to light from the INDOT Data Needs Survey and a few previous research projects undertaken by Joint Transportation Research Program. The data quality control procedures implemented for data collection programs were described in Chapter 1. The flow of data among various INDOT divisions and offices is exhibited in Chapter 4. The concerns of INDOT data users regarding uncollected data, inaccessible data, and poor quality data are revealed in Chapter 5.

This research project has revealed opportunities for INDOT to improve individual data collection programs and to establish links between databases to enable INDOT to fulfill its mission in an efficient manner. These recommendations are listed in Chapter 6.

## 2. TECHNICAL MEMOS

### 2.1 Introduction

Because INDOT collects so much data, an inventory and description of the data types was thought to be an important first step. To present the results of this inventory step in a concise fashion, a set of technical memos was created. Each memo has information about a specific piece of the data collection effort at INDOT. The memos provide a look at every type of data collected by INDOT of which the research team was aware. They provide basic information about data collection at INDOT and are intended to provide a snapshot of INDOT's activities in this area.

To create the technical memos, the researchers identified personnel at INDOT who were expert creators or users of the databases. The research team then created an online survey to distribute to these experts. A link to this survey was distributed via e-mail to the experts. After receiving the user's response to the survey, the research team attempted to summarize the responses. In cases where the team had questions about some of the survey responses, a follow-up email or phone call was used to clarify or supplement the responses. Based on the information collected in this way for a particular database, a technical memo was created summarizing the findings. Each technical memo was posted online, so that members of the Study Advisory Committee could review the memos for accuracy and completeness.

### 2.2 Technical Memos

The following 16 technical memos are presented in Appendix B:

1. Bridge Data (Figure B.1)
2. Bridge Inspection: Federal Requirements and Surrounding State Practices (Figure B.2)
3. Bridge Inspection Interval: Assessment of Alternative Bridge Inspection Frequencies (Figure B.3)
4. Environmental Data Collection (Figure B.4)
5. EXOR and TRADAS (Figure B.5)
6. Falling Weight Deflectometer (Figure B.6)
7. Geographic Information Systems (Figure B.7)
8. Intelligent Transportation Systems (Figure B.8)
9. Management Information Systems (Figure B.9)
10. Pavement Coring Data (Figure B.10)
11. Pavement Friction Data Collection and Measurement Equipment (Figure B.11)
12. ROW Data Collection by the Land Records System (Figure B.12)

13. Road Weather Information System and Maintenance Decision Support System (Figure B.13)
14. Signalized Traffic Count Data (Figure B.14)
15. Vehicle Accident Data Collection System (Figure B.15)
16. Work Management System and Maintenance Quality Survey (Figure B.16)

## 3. DESCRIPTION OF DATA TYPES

### 3.1 Introduction

This chapter summarizes information about the data collection programs carried out by INDOT. The information includes the data items collected, the data collector and/or owner entity, frequency of collection, the tools used for data collection and storage, and the purpose of collection. *Cost information is also included for the data programs that provided this information to the research team.* The information was compiled from the INDOT Data Collection Online Survey and phone interviews with INDOT employees. The data types are described in more detail in Chapter 1.

### 3.2 Data Summary Tables

The following 17 data summary tables are provided in this chapter:

1. Roadway Physical Inventory (Table 3.1)
2. Roadway Videolog and Geometry (Table 3.2)
3. Roadway/Roadside Features (Table 3.3)
4. Network-level Pavement IRI, Rut Depth, Texture, and Faulting Data (Table 3.4)
5. Network-level Pavement Friction Data (Table 3.5)
6. Project-level Pavement Deflection Data (Table 3.6)
7. Project-level Pavement IRI Data (Table 3.7)
8. Pavement Coring Data (Table 3.8)
9. Project-level Pavement Thickness Data (Table 3.9)
10. Bridge and Culvert Data (Table 3.10)
11. Traffic Counts from Traffic Statistics Section (Table 3.11)
12. Traffic Flow Data from ITS Technology Deployment Division (Table 3.12)
13. Signalized Traffic Count Data (Table 3.13)
14. Vehicle Crash Data (Table 3.14)
15. Land Record System Data (Table 3.15)
16. Environmental Data (Table 3.16)
17. Weather Condition from Road Weather Information System (Table 3.17)

TABLE 3.1
**Roadway Physical Inventory**

| Roadway Physical Inventory | Collector Entity | Frequency of Collection | Cost of Collection (FTE/yr or $/yr) | Tools Used to Collect and Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Roadway designation (interstate, State route, US route), length | Central Office Division | As amended | Not provided by data collection program | Oracle-based EXOR stores the data at the Office of Roadway Inventory | HPMS reporting to FHWA on the extent and characteristics of state jurisdiction roadways |

TABLE 3.2
**Roadway Videolog and Geometry**

| Roadway Videolog and Geometry | Collector Entity | Frequency of Collection | Cost of Collection (Contract Amount) | Tools Used to Collect and Store Data | Primary Uses of Data |
|---|---|---|---|---|---|
| Lane information (width and type)<br>Median and shoulder types and sizes<br>Horizontal curvature:<br>•Curve radius<br>•Degree of curve<br>•Curve length<br>Vertical curvature:<br>•Initial and final grades of the curve<br>•Curve length<br>Cross-section superelevation | Pathway services | Videolog information: annual data collection for interstates, biennial data collection for non-interstates<br>Roadway geometry: biennial data collection | Current contract amount is $4.7 million for 3 years of data collection; this amount also includes pavement, IRI, rut, texture, faulting data collection | PathRunner XP vehicle collects data<br>Oracle-based EXOR stores the data at the Office of Roadway Inventory | HPMS reporting to FHWA on the geometry of sample panel roadway sections<br>The basic geometric characteristics of a roadway section are useful for analysis of highway deficiencies done for the Highway Economic Requirements System (HERS) |

TABLE 3.3
**Roadway/Roadside Features**

| Roadway/Roadside Features | Collector Entity | Frequency of Collection | Cost of Collection (FTE/yr or $/yr) | Equipment Used to Collect Data | Software Used to Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|---|
| Location of roadway/roadside<br>Work activity accomplishments of maintenance and traffic crew and cost of work activities | INDOT Operations collects roadway/ roadside asset inventory layers<br>INDOT Maintenance and traffic crew report work activity and cost | Asset inventory collection is done periodically to activate or deactivate assets in the network<br>Work accomplishment data collected daily | Not provided by data collection program | The underlying roadway and roadside asset network was downloaded from EXOR and reconfigured by GIS Office. It is also supplemented with Trimble Data Loggers | WMS, a database system based on Agile Assets software, is used to store data about the roadway and roadside asset network<br>Maintenance Quality Survey, an application used by the Operations Division and developed by the GIS Office, contains roadway/roadside asset condition information. This information is imported from the management information portal | Development of annual work plan and its budget for maintenance and traffic crew<br>Tracking the progress of activities contained in the annual work plan |

TABLE 3.4
**Network-level Pavement IRI, Rut Depth, Texture, and Faulting Data**

| Collector Entity | Frequency of Collection | Cost of Collection (Contract Amount) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|
| Data collected by Pathway Services<br>Data stored by Pavement Management Section in Engineering Services and Design Support | Annual data collection on the right driving lane of interstates and US and State routes in 0.1 mile increments | Current contract amount is $4.7 million for 3 years of data collection. This amount also includes videolog and geometric characteristics of the roads | PathRunner XP vehicle collects data<br>Deighton's dTIMS software is used to store data | INDOT Central Office and District Offices use data to jointly develop a candidate list of pavement projects<br>Data are reported to FHWA in the annual Highway Performance Monitoring System (HPMS) report |

TABLE 3.5
**Network-level Pavement Friction Data**

| Network-level Pavement Friction Data | Collector Entity | Frequency of Collection | Cost of Collection (per lane-mile) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Pavement friction data on interstates and US and State routes<br>Weather Condition during measurement<br>Speed of equipment measuring the friction number | INDOT Research Division | Interstate data collected annually<br>US and State route data collected triennially | $17 per lane-mile in FY 2010 | Text file is generated by the equipment that measures pavement friction<br>Data are stored in Microsoft Access | District level: pavement maintenance and preservation engineers use data to scope maintenance or preservation activities<br>State level: INDOT Office of Materials Management<br>Legal Division of INDOT |

TABLE 3.6
**Project-level Pavement Deflection Data**

| Project-level Pavement Deflection Data | Collector Entity | Amount of Data | Cost of Collection (per lane-mile) | Tools Used to Collect or Store data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Deflection of the pavement surface and subgrade in response to FWD-applied force<br>Weather condition during measurement | INDOT Research Division | Project-level data collection is done upon request of the INDOT Pavement Steering Committee and INDOT Districts<br>There are about 100 testing requests during every testing season (7 months) | $10 per lane mile (estimate from INDOT Research Division) | Text file is generated by the falling weight deflectometer that measures pavement deflection<br>Data are stored in Microsoft Access | District Offices use data to scope restorative action (resurfacing/rehabilitation/reconstruction)<br>Office of Pavement Engineering: data provide input parameters, such as pavement layer moduli and subgrade modulus, for pavement design |

TABLE 3.7
**Project-level Pavement IRI Data**

| Project-level Pavement IRI Data | Collector Entity | Amount of Data | Cost of Collection (per lane-mile) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| IRI, the measure of pavement surface roughness, is generated from longitudinal pavement profile | INDOT Research Division | Project-level data collection is done for warranty projects. There are about 30 warranty project sites tested every year | $14 per lane-mile in FY 2010 | Inertial road profiler is used to collect data | Pavement preservation units use data to scope preservation treatments |

TABLE 3.8
**Pavement Coring Data**

| Pavement Coring Data | Collector Entity | Amount of Data | Cost of Collection (per lane-mile) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Thickness, density, mixture volumetric properties for HMA pavement<br>Thickness, flexural strength, splitting tensile strength, air content for PCCP pavement | When coring is conducted for quality assurance, the contractor collects core samples. Otherwise, coring samples are collected by district testing crew<br>District testing labs conduct core analysis | Greenfield District cuts approximately 750 cores per year, excluding cores cut for acceptance on construction contracts<br>Crawfordsville District cut 500 cores in 2011 | Greenfield District, FY 2008: $52/core. This figure does not include cost of core analysis<br>Crawfordsville District, FY 2011: $32/core | Cores collected for design purposes are photographed and logged in Excel spreadsheets containing descriptions of cores at each depth | INDOT Office of Pavement Engineering and District Design Sections:<br>•Scoping for in-house designs of restorative project<br>•Quality assurance of contractor's adherence to standard specifications when implementing a pavement project.<br>Office of Materials Management: failed material investigation<br>Division of Research: research |

TABLE 3.9
**Project-level Pavement Thickness Data**

| Project-level Pavement Thickness Data | Collector Entity | Amount of Data | Cost of Collection (per lane-mile) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Estimate of concrete pavement thickness, HMA pavement thickness, and HMA thickness in composite pavements | INDOT Research Division | Project-level data collection is done upon request<br>There are about 30 testing requests annually for pavement, bridges and soils forensic investigations | $33 per lane-mile in FY 2010 | Ground Penetrating Radar is used to collect data<br>Data are stored in Microsoft Access.<br>Data are stored in Microsoft Access. | Office of Pavement Engineering:<br>•Data provide input parameters for pavement design<br>•Office of Geotechnical Engineering<br>District Offices |

TABLE 3.10
**Bridge and Culvert Data**

| Bridges and Large Culverts (Culverts >4 ft) Data | Collector Entity | Amount of Data | Cost of Collection (FTE/yr or $/yr) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Data such as attributes, location, and condition ratings are collected through inspections<br>1882 data items are collected, 116 of which are National Bridge Inventory data items | INDOT Bridge Inspection teams conduct inspections on 5720 state-owned bridges<br>Consultants conduct inspections for local bridges and bridges on the toll road<br>Inspection data for state-owned and county-owned structures are available from the Central Office's Bridge Inspection and Inventory Section | Routine inspections are conducted every 2 years for bridges and every 3 years for large culverts<br>Additional inspections take place, as needed. The additional inspection types include damage, fracture critical, in-depth, initial, special, and underwater inspections | Not provided by data collection program | Inspection data are recorded on paper.<br>InspectTech, an Oracle-based database, stores inspection report information including comments, photos, and drawings. | Data are used to make maintenance and rehabilitation decisions for bridges and large culverts.<br>Data are reported to the FHWA as required by the National Bridge Inventory Program |

TABLE 3.11
**Traffic Counts from Traffic Statistics Section**

| Traffic Counts | Collector and Owner Entity | Amount of Data | Cost of Collection (FTE/yr or $/yr) | Sites Collecting Data | Software Used to Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|---|
| Raw traffic data are processed to produce annual average daily traffic, vehicle classification, (seasonal, weekday, axle) adjustment factors, and annual growth | INDOT Traffic Statistics Section | Coverage counts once every 3 years<br>Automated traffic recorder (ATR) and weigh-in-motion (WIM) data are continuously collected to provide vehicle classification and weigh data<br>Additional counts are done on an as-needed basis for state-specific projects | The counts are done by 10 people in-house, 3 MPOs under contract and (up to 5) consulting firms under contract | 30,000 sites exist for coverage counts; 10,000 used annually (the HPMS Field Manual of 2010 will necessitate an increase of the number of coverage count sites to 48,000)<br>110 permanent count stations and 47 WIM sites exist on Indiana's highways | Oracle-based TRADAS<br>Data are also loaded into EXOR and can be published to the data warehouse | Production of traffic flow maps (AADT)<br>HPMS reporting of AADT<br>•Data are an essential input for the process of pavement and bridge design<br>•Traffic data are critical for planning to ascertain future highway needs<br>•Vehicle classification data are used to obtain crash rates by vehicle class |

TABLE 3.12
**Traffic Flow Data from ITS Technology Deployment Division**

| Traffic Flow Data | Collector Entity | Amount of Data | Cost of Collection (FTE/yr or $/yr) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Counts and speed per lane on interstates surrounding the Indianapolis metropolitan area (I65, I69, I70, I465) and the Gary metropolitan area (I65, I94 and the Borman Expressway) | ITS Technology Deployment Division in the Office of Traffic Management | Data have been collected at 30 second intervals for the past 8-10 years | Not provided by data collection program | Microloops in the pavement or remote traffic microwave sensors used to collect data<br>Oracle software stores the data | ITS dynamic messaging signs<br>INDOT TrafficWise website to inform the public of traveling conditions<br>NAVTEQ |

TABLE 3.13
**Signalized Traffic Count Data**

| Signalized Traffic Count Data | Collector and Owner Entity | Amount of Data | Cost of Collection (FTE/yr or $/yr) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Traffic counts and turning movements at signalized intersections<br>Travel time on corresponding corridors | INDOT Office of Traffic Management | For automatic count capable intersections: every 15 minutes<br>Other intersections: As needed for signal with a maximum interval of approximately 3 years<br>For Bluetooth-enabled corridors: travel times collected continually<br>For other corridors: travel times collected before and after signal retiming with floating car studies | Not provided by data collection program | PostgreSQL with Access frontend stores the data | Signal retiming and new signal timing on interstates and US and State routes<br>HPMS requires the collection of signal type and percent green times for sample sections of urban routes with functional classifications 1–6 |

TABLE 3.14
**Vehicle Crash Data**

| Vehicle Crash Data | Collector and Owner Entity | Amount of Data | Cost of Collection (FTE/yr or $/yr) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Date and time of crash<br>Weather conditions<br>Location of road or Intersection where crash occurred<br>Drivers' identities<br>Number of vehicles involved<br>Accident type and manner of collision<br>Number of deaths or Injuries resulting from the crash<br>Driver contributing, vehicle contributing, environment contributing circumstances for each vehicle involved in the crash<br>Dollar estimate of crash damage | Open Portal Solutions on behalf of INDOT Office of Traffic Safety and Indiana State Police | Approximately 200,000 reports are submitted each year by Indiana police officers | Not provided by data collection program | Officers have on-site access to a computer application on their laptops to locate crashes by latitude and longitude<br>Automated Reporting Information Exchange System (ARIES) stores crash records<br>Data can be exported to Microsoft Access or Excel<br>Data are becoming available in the data warehouse | District Offices of INDOT can access ARIES and extract data to produce crash analysis reports.<br>MPO, County, and City employees that need to conduct local crash analysis can access ARIES after signing a WEB Access Agreement<br>INDOT uses ARIES crash data to recover cost of damaged infrastructure from insurance<br>INDOT Office of Traffic Support and Traffic Management are responsible for improving work zone traffic control<br>ARIES crash data are used to produce Indiana's Five Percent Report, which identifies locations statewide with the highest safety need. This annual report is submitted to FHWA's Highway Safety Improvement Program and it is the basis for updating Indiana's Strategic Highway Safety Plan<br>Fatal crash data must be given to the National Highway Traffic Safety Administration for the Fatal Analysis Reporting System<br>Crashes involving commercial vehicles must be reported to the Federal Motor Carrier Safety Administration |

TABLE 3.15
**Land Record System Data**

| Land Records System Data | Collector Entity | Data Update Frequency | Cost of Collection (FTE/yr or $/yr) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Land acquisition for highway project:<br>•Project code number<br>•Parcel legal description: property owners' names and addresses, location with respect to project centerline & stationing<br>•Date and person associated with initial contact with property owners<br>•Appraisal process: appraiser identity, property characteristics relevant to appraisal, the value of land determined)<br>Land acquisition occurred with owner acceptance:<br>•Offer value & relocation Compensation<br>•Date of deed signing and recording<br>•Payment information (amounts, recipients, dates)<br>Land acquisition occurred with owner rejection:<br>•Condemnation suit filing date<br>Record of excess land: for any portion of land acquired by INDOT in excess of ROW limits specified by approved construction plans, the following additional information is recorded:<br>•Land suitability for sale<br>•Land suitability for wetland conversion<br>Sale of excess land:<br>•Sale Price<br>•Date of sale<br>•Buyer name<br>•Area sold | Each district has a ROW engineer or consultant that collects the data and enters them into Oracle | Parcel status is updated monthly | Not provided by data collection program | Oracle database: stores parcel information<br>Electronic Record Management System: stores electronic copy of the deeds in perpetuity as required by the Indiana Commission of Public Records | District offices use data to track parcel information for a project in progress<br>INDOT Real Estate Office to report to FHWA Office of Real Estate Services as proof of compliance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act |

TABLE 3.16
**Environmental Data**

| Environmental Data | Collector Entity | Amount of Data | Cost of Collection (FTE/yr or $/yr) | Tools Used to Collect or Store Data | Primary Users (or Uses) of Data |
|---|---|---|---|---|---|
| Project Commitments Database<br>Environmental Permitting/ Violations Database<br>Wetland Mitigation Sites' Status Database<br>Noise Barrier Database<br>Historic Bridge Inventory | Office of Environmental Services | Project Commitments Database updated when a commitment is entered<br>Environmental Permitting/ Violations Tracking is updated weekly<br>Wetland Mitigation sites' status is updated monthly<br>Noise Barrier Database is updated quarterly<br>Historic Bridge Inventory is static | Not provided by data collection program | Oracle, Excel, Access, ArcGIS, . net/web are used to store data | Project Commitments Database states the commitments made to mitigate harmful environmental impacts. The commitments made are incorporated into final contract documents<br>Environmental Permitting/ Violations Database tracks status of applications for future permits and violations of current permits. Issuer of waterway permits must be informed of compliance<br>Wetland Mitigation Database contains status of mitigation sites. Status is reported to the US Army Corps of Engineers annually<br>Noise Barrier Database contains barrier locations, construction materials and costs. This information is currently reported to FHWA triennially, but this reporting is not mandatory<br>Historic Bridge Inventory lists bridges contained in the National Register of Historic Places |

TABLE 3.17
**Weather Condition from Road Weather Information System**

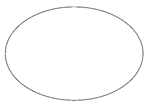
| Weather Condition | Collector Entity | Amount of Data | Cost of Collection (FTE/yr or $/yr) | Tools Used to Collect or Store Data | Primary users (or uses) of data |
|---|---|---|---|---|---|
| Roadway surface and air temperatures<br>Humidity, dew point, wind speed and direction<br>precipitation presence | Road Weather Information System (RWIS) | Continuous collection and storage for 2 years | Not provided by data collection program | For data collection, INDOT has 30 weather stations equipped with road sensors throughout Indiana | Maintenance Decision Support System for deployment of winter maintenance vehicles |

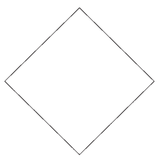
## 4. FLOW DIAGRAMS

In order to represent the connections between databases at INDOT and the different offices at INDOT, we have created a series of flow diagrams. The flow diagrams are structured as a series of nodes connected by arrows indicating the direction of flow of information. This section explains the meaning of the symbols used in the flow diagrams and the structure of these flow diagrams.

First, here is an explanation of what the **node** symbols on the flow diagrams mean:


= Source of Data (may be database, software package, etc.)


= Office/Division/Section/Unit of INDOT (hereafter called "office")

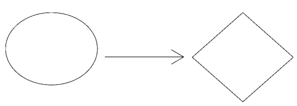

= Report produced by an office of INDOT

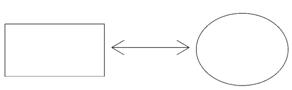
The flow diagrams also make use of two types of **arrows**:


= Information flows in one direction only, from the tail to the head

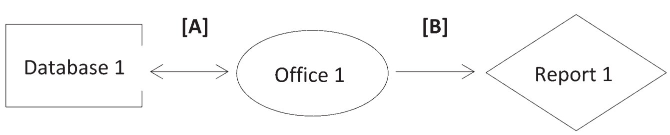

= Information flows in both directions; both nodes receive information

Each connection contains two nodes with an arrow between them. Examples of flow diagram connections:


= Data from an office are processed and then put into a report.


= Data from a source are both accessed by and input into a database by an office.

Here is an example of a simple flow diagram:



In this flow diagram, Office 1 processes raw data, and stores them in Database 1 for later use by Office 1 (and also other offices that need to access the data). This is represented by connection **[A]**. Office 1 also produces Report 1. This is represented by connection **[B]**.

Some arrows are labeled with the type of data that flow from node to node. These labels represent important types of data that flow between nodes. Not all arrows are labeled. This often means that there are too many types of data that flow between nodes to label on a flow diagram.

There are two types of flow diagrams that were created: Office Diagrams and Data System Diagrams. Office Diagrams show how data flow through the different offices at INDOT. They use the office as the central point for the diagram. These diagrams are labeled by the name of the INDOT office. Data system diagrams show how data flow through a software system at INDOT.

Figures 4.1 to 4.13 show several different flow diagrams. Figures 4.1 to 4.11 have just the office as the central part of the diagram. However, there are a few cases (Figures 4.9 and 4.10) when the data and office uses are very closely intertwined with the office itself. The diagram for the Office of Roadway Inventory (Figure 4.9) shows that this office and EXOR are closely related. The diagram for Technical Services (Figure 4.10) shows that WMS is the key software system for that database.

The two data systems diagrams (Figures 4.12 and 4.13) can be viewed as two parts of one diagram. The GIS part of the diagram is shown in part 1. This shows all the data that flow into GIS. All the data are then put into the GIS system and some of them are then put into the data warehouse. The data warehouse is shown as part 2 of the diagram.

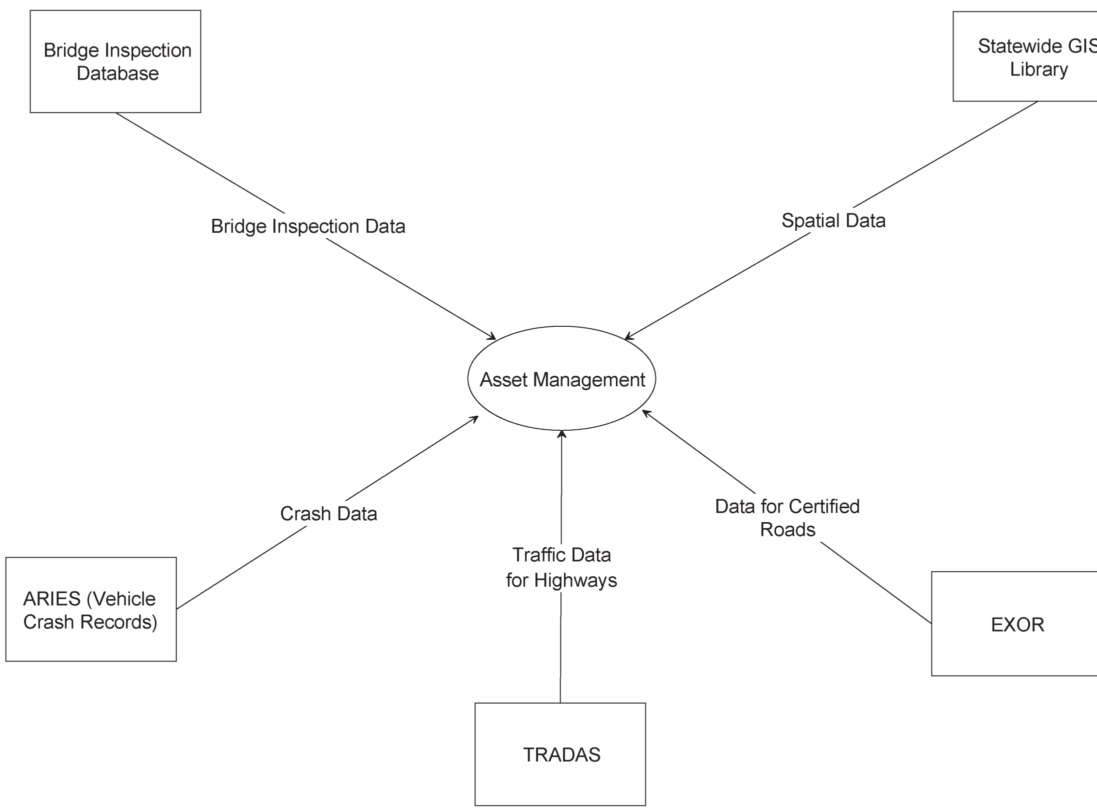



**Figure 4.1** Office diagram: asset management flow diagram.

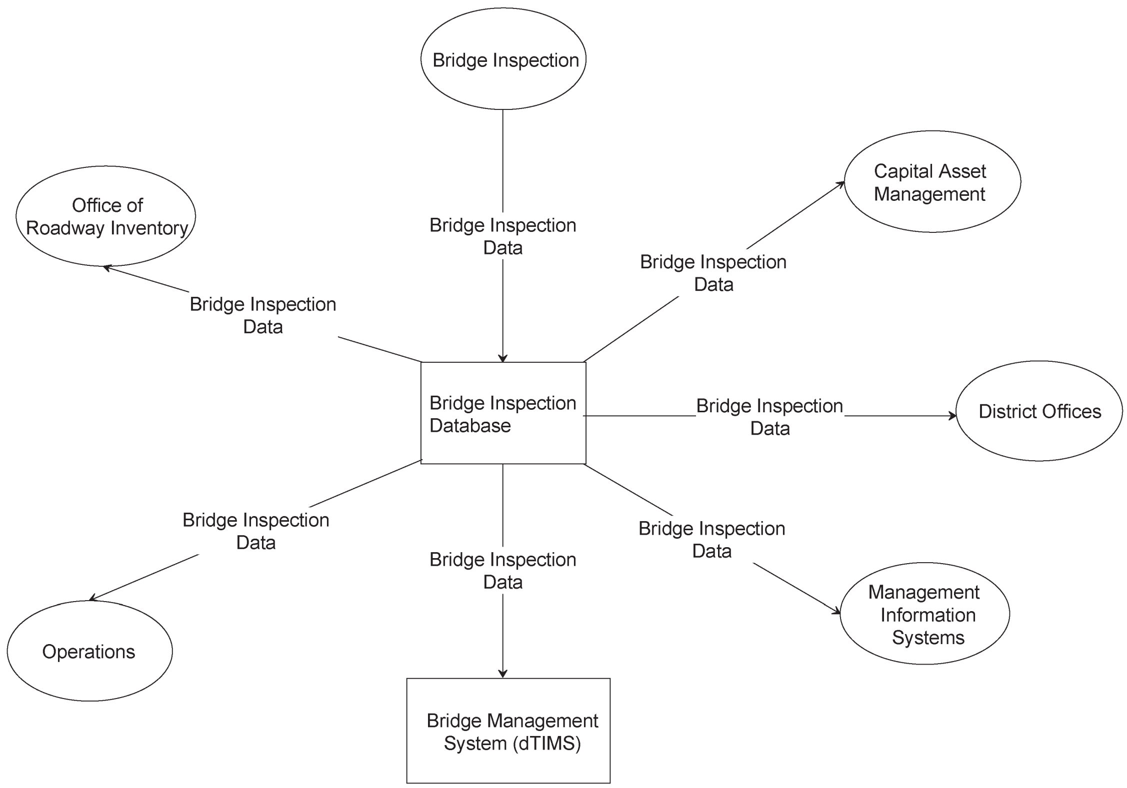



**Figure 4.2** Office diagram: bridge inspection flow diagram.

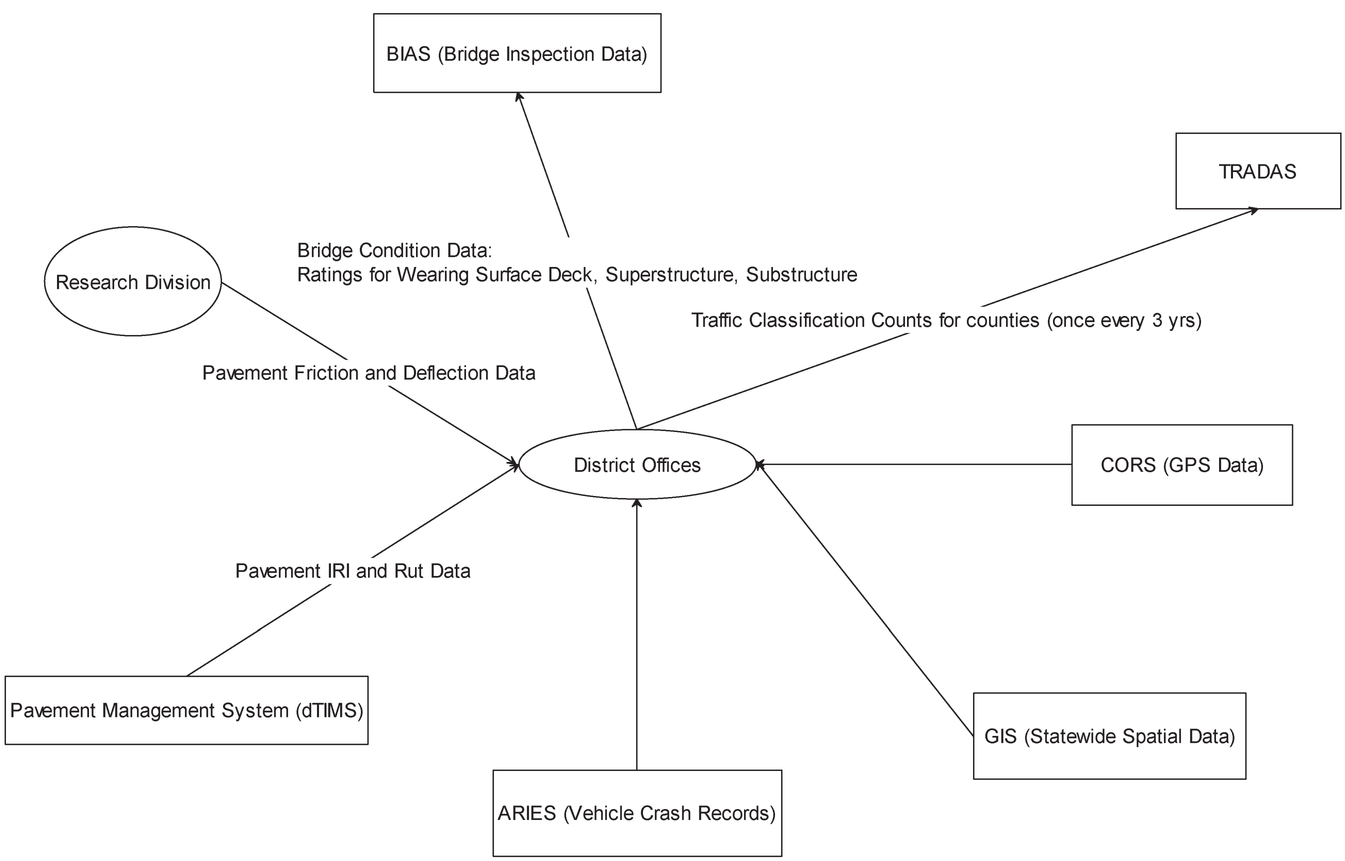



**Figure 4.3** Office diagram: district offices flow diagram.

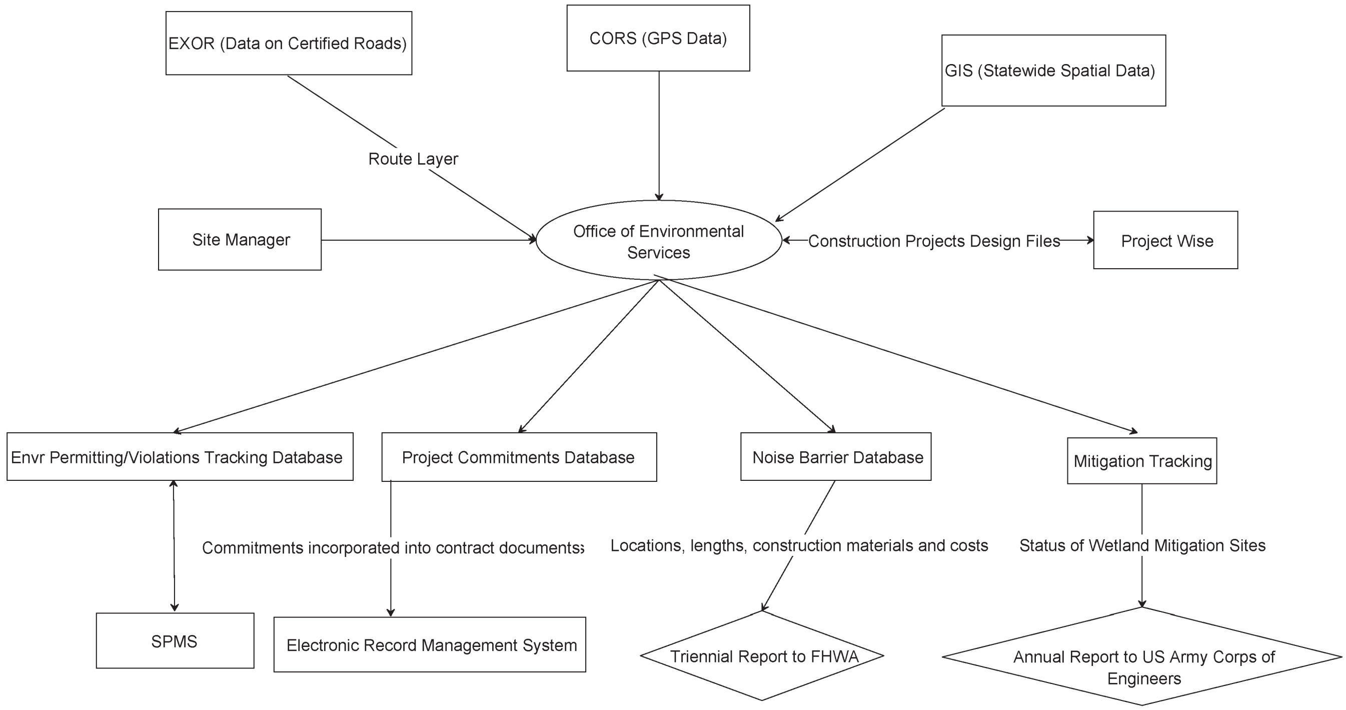



**Figure 4.4** Office diagram: environmental services flow diagram.

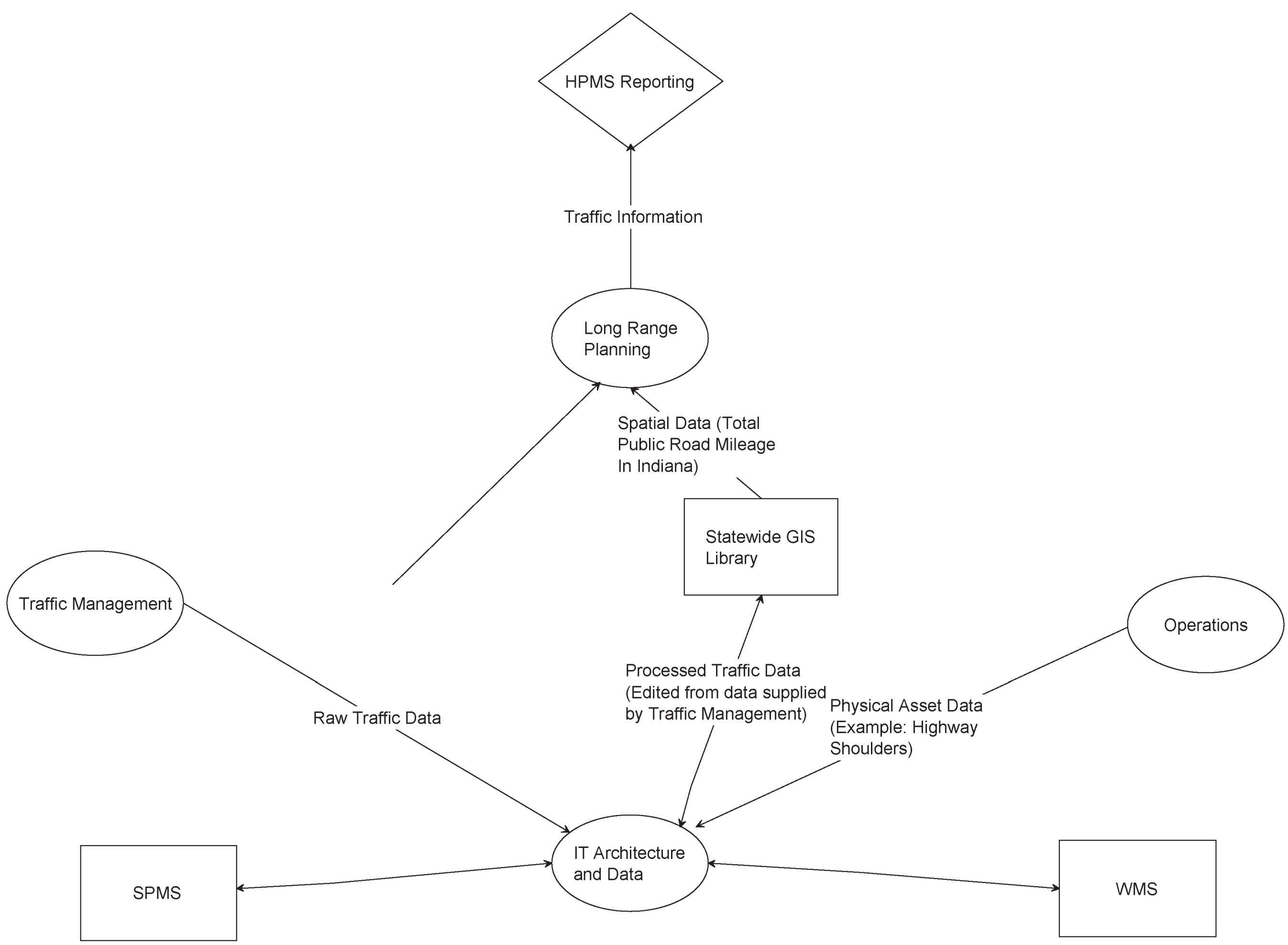



**Figure 4.5** Office diagram: IT architecture and data flow diagram.

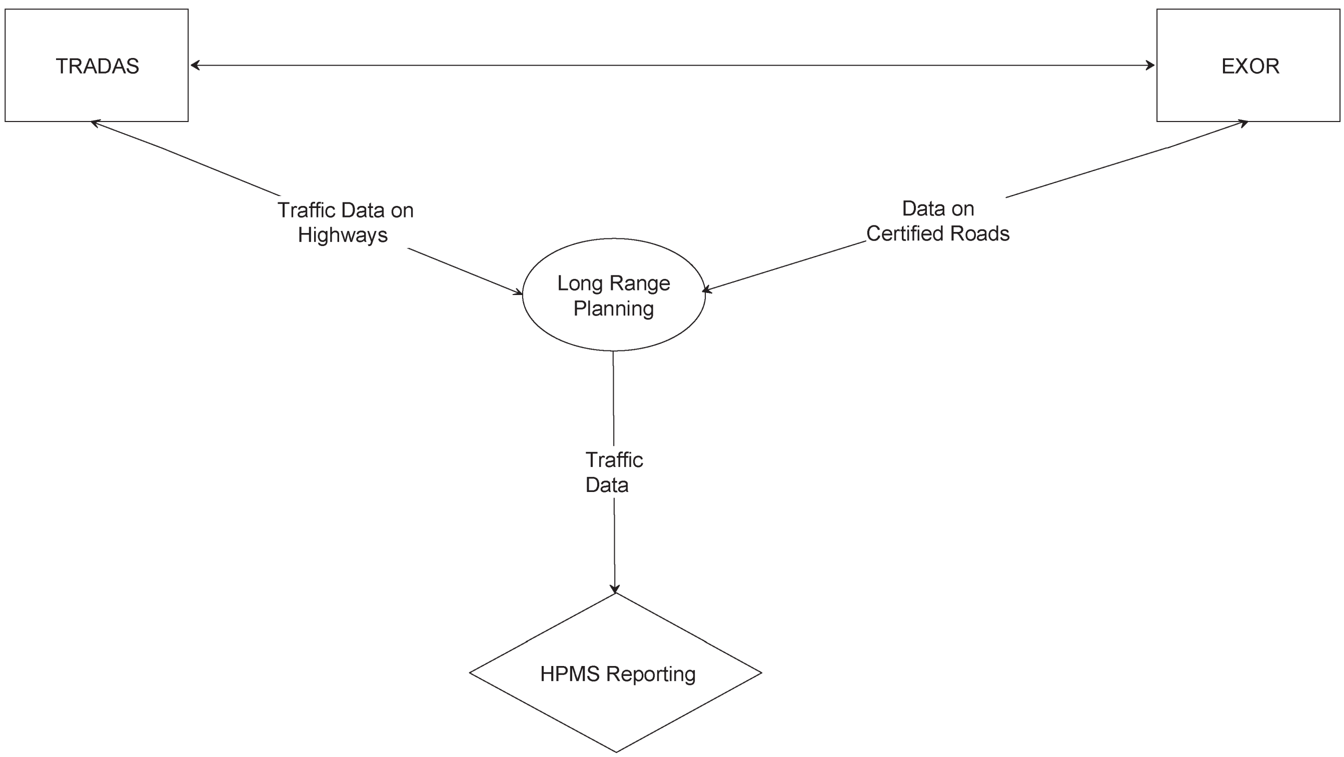



**Figure 4.6** Office Diagram: long range planning flow diagram.

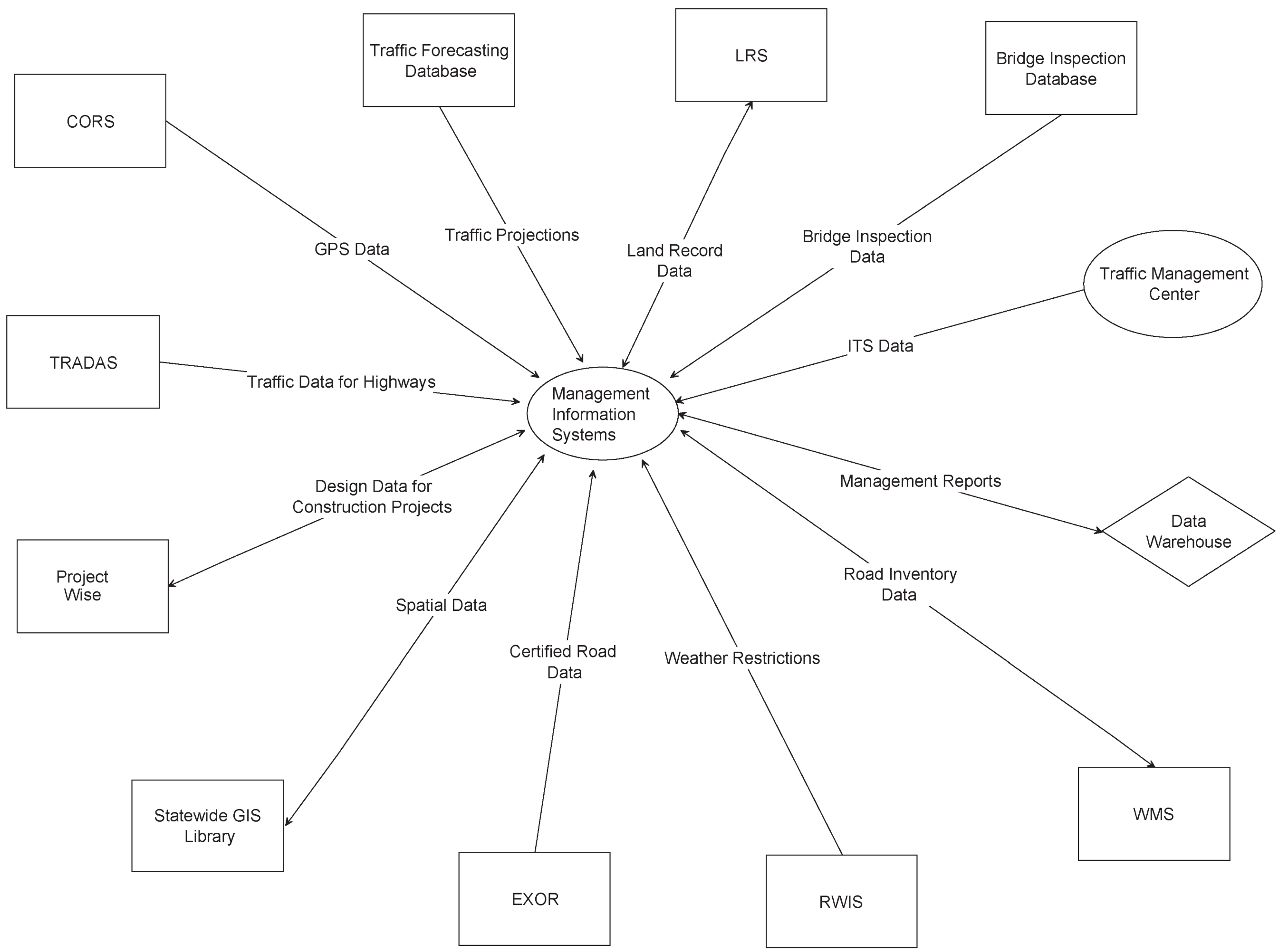



**Figure 4.7** Office diagram: management information systems flow diagram.

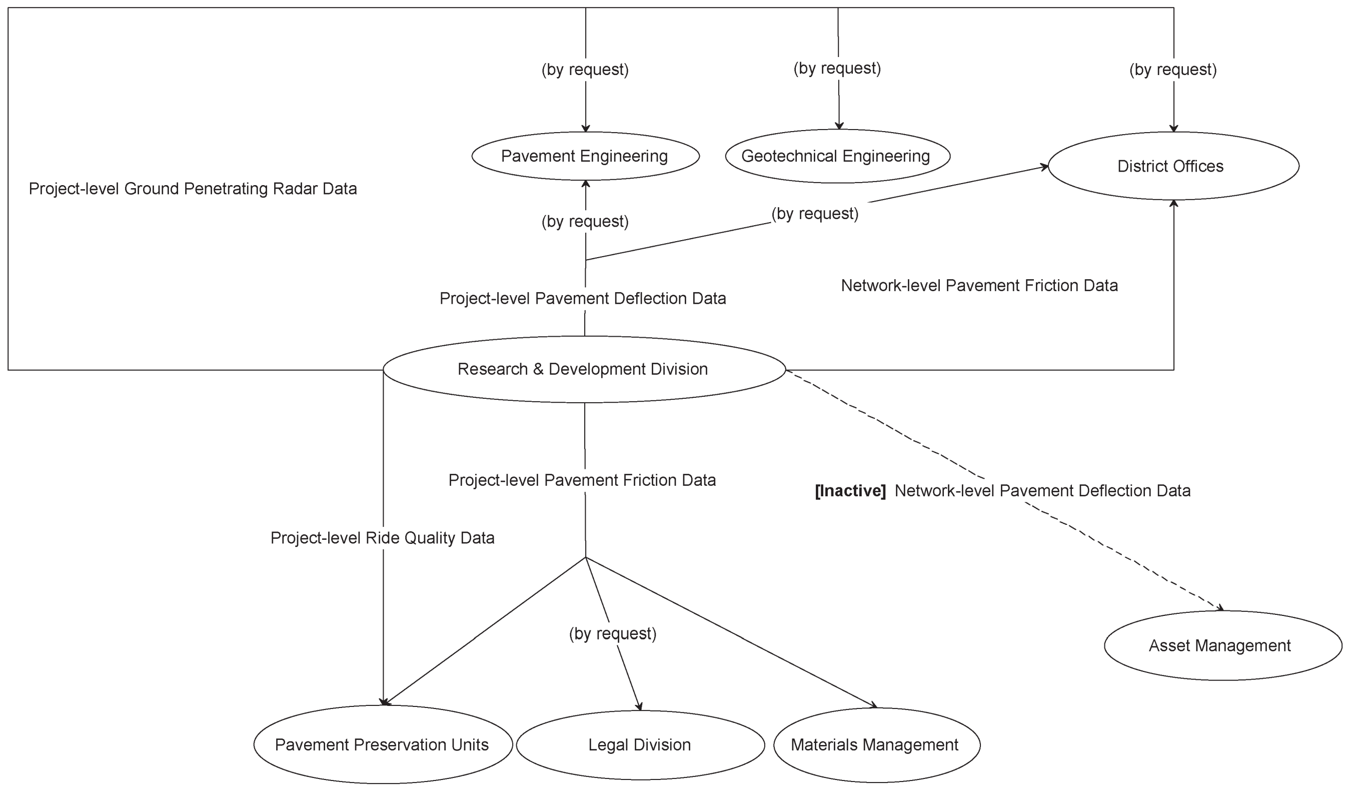



**Figure 4.8** Office diagram: research and development flow diagram.

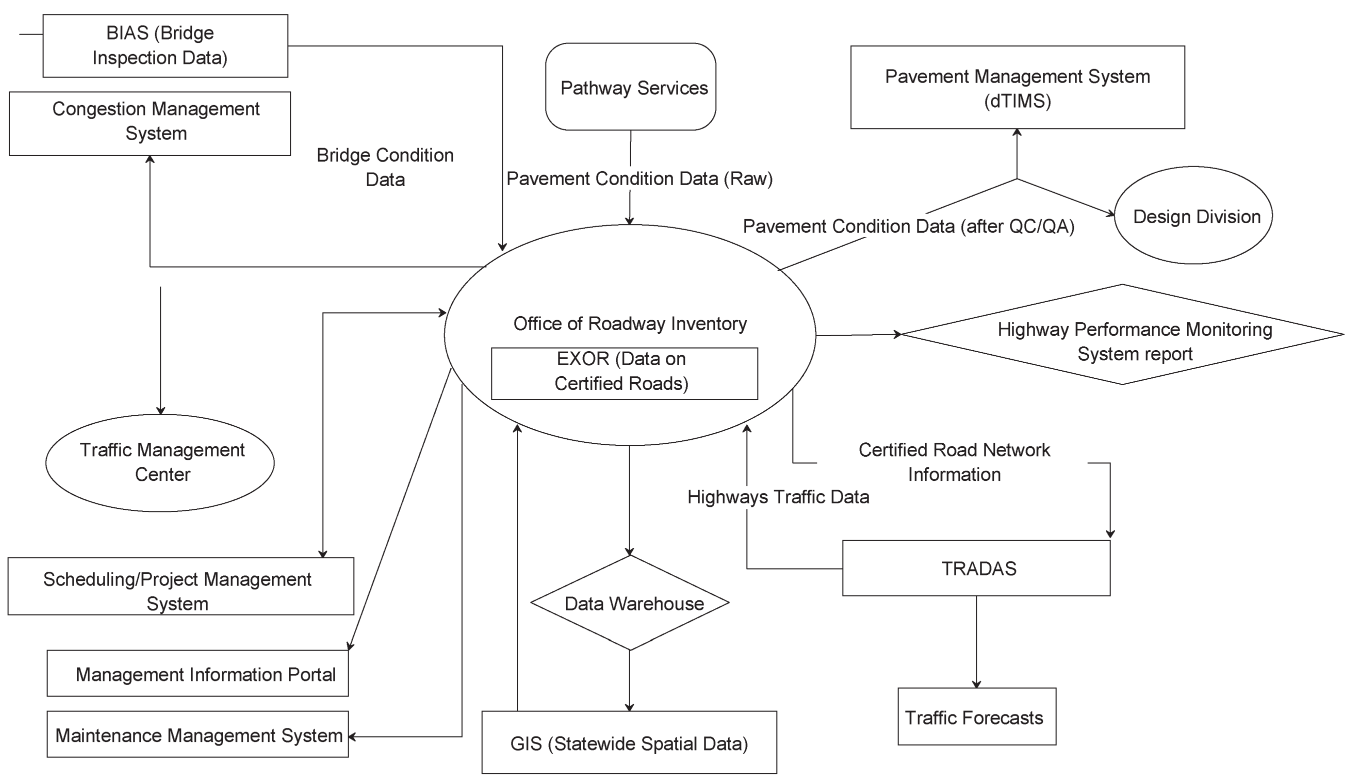



**Figure 4.9** Office diagram: roadway inventory flow diagram.

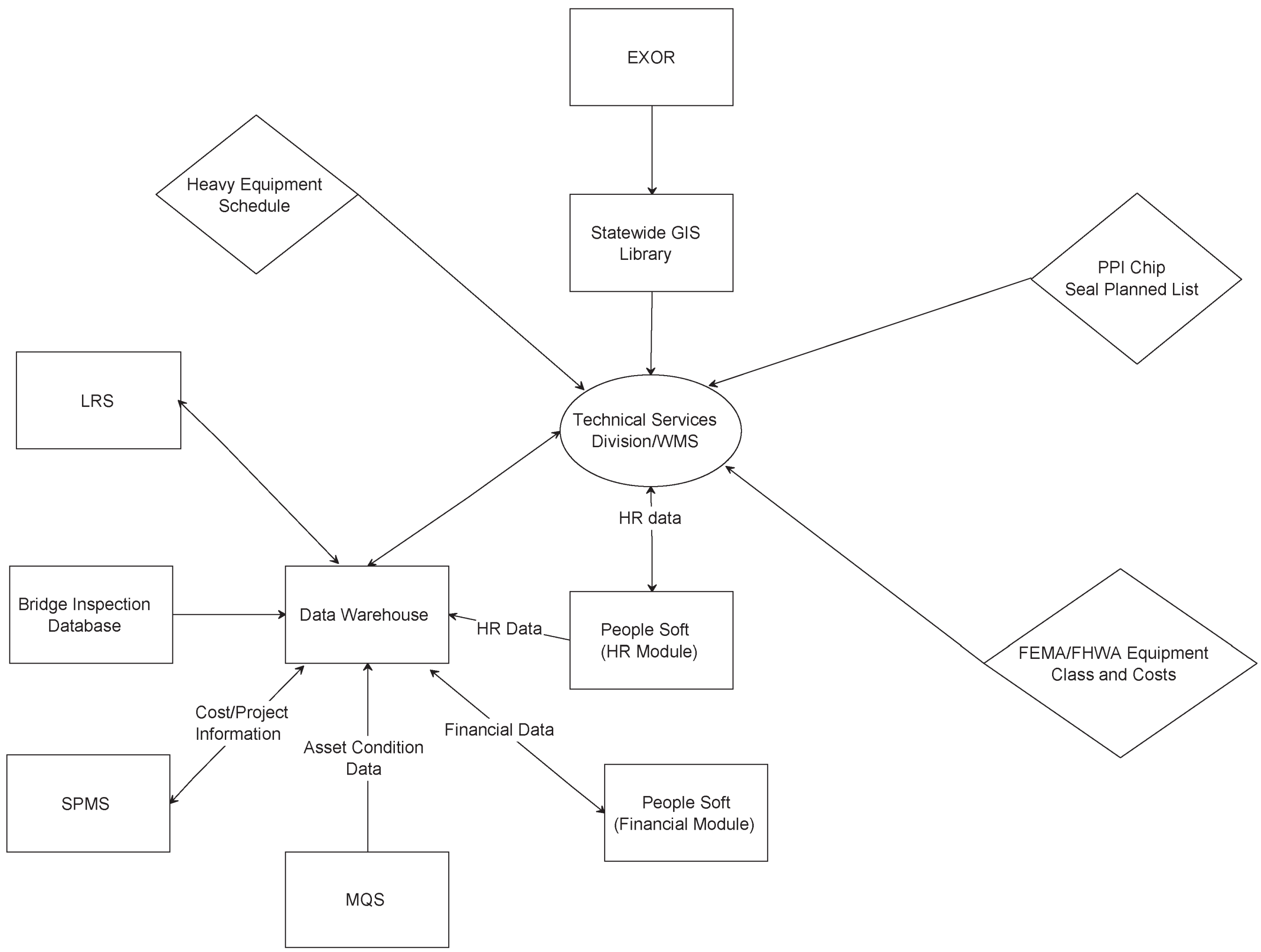



**Figure 4.10** Office diagram: technical services flow diagram.

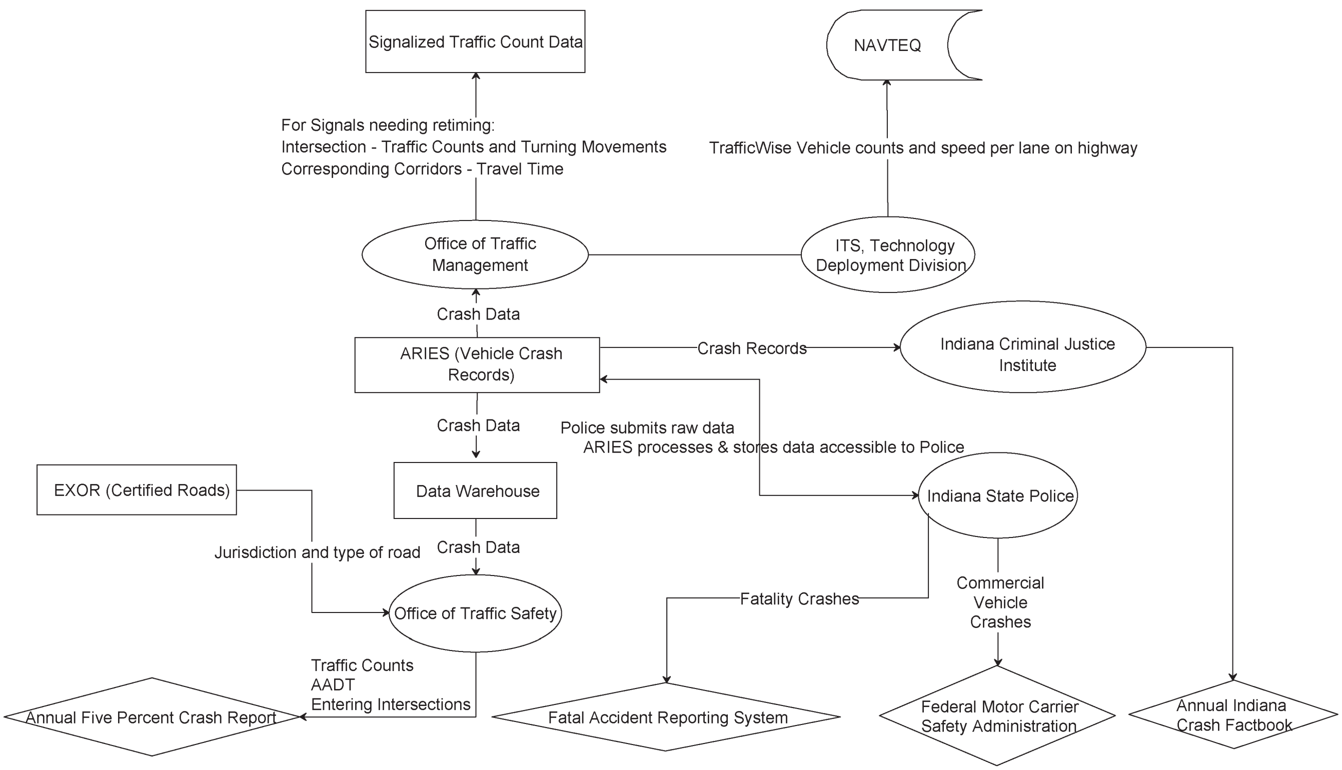



**Figure 4.11** Office diagram: traffic safety flow diagram.

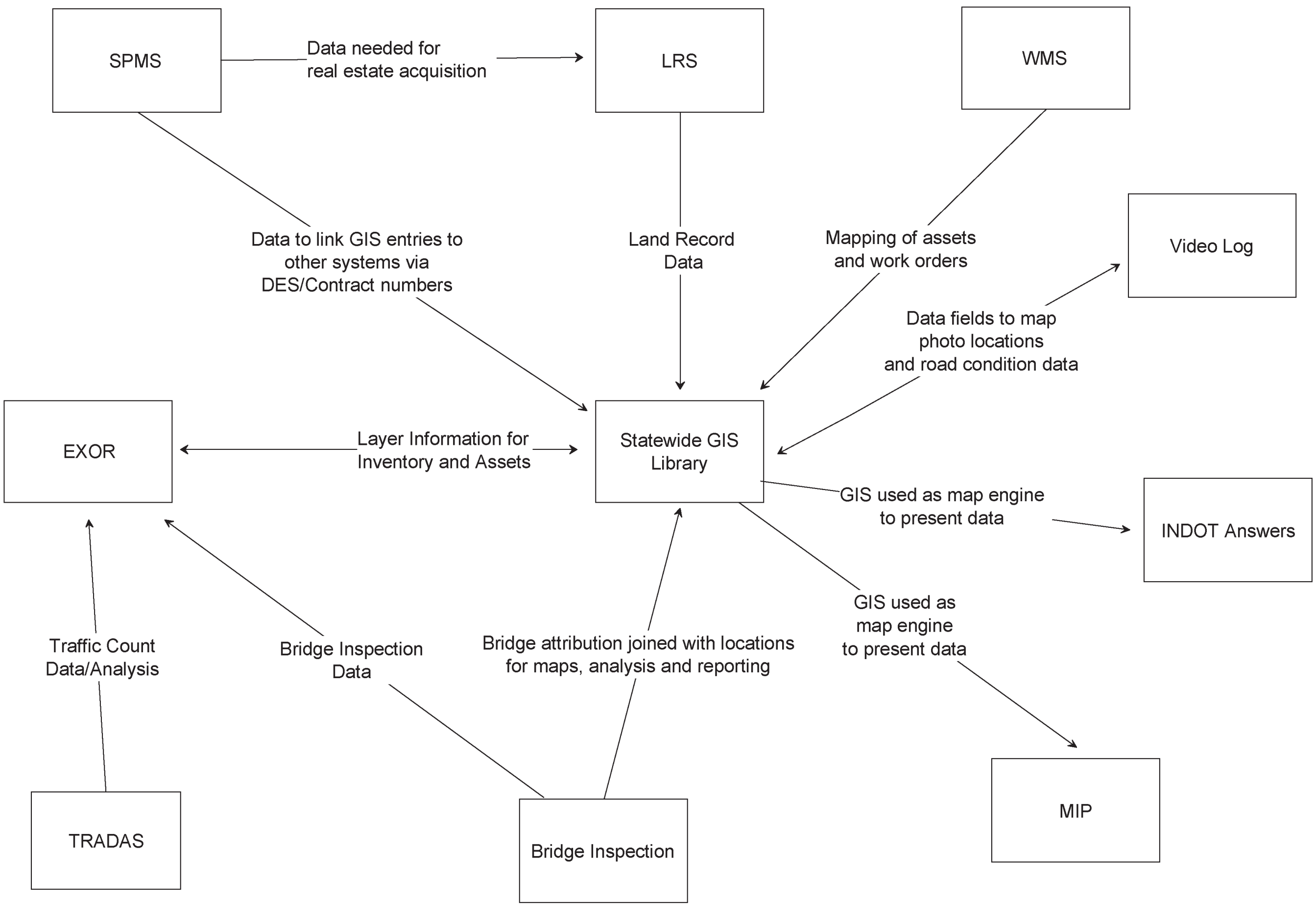



**Figure 4.12** Data system diagram: GIS and data warehouse flow diagram (Part 1).

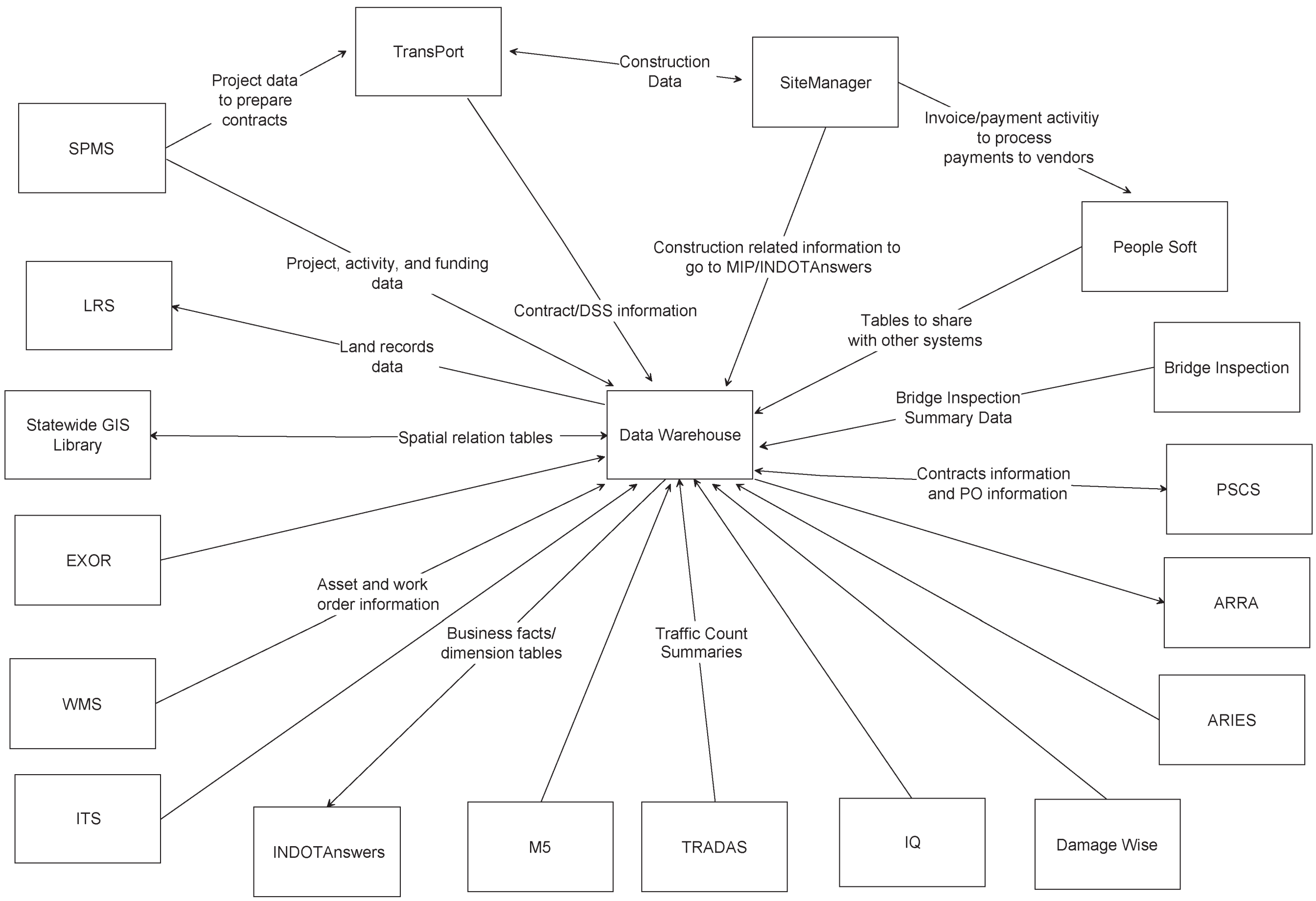



**Figure 4.13** Data system diagram: GIS and data warehouse flow diagram (Part 2).

## 5. SURVEY OF DATA NEEDS, USAGE, ADEQUACY

To most efficiently do their jobs, data users need to have access to quality data. To gauge how well the data collected by INDOT are meeting the needs of its users, some mechanism for feedback from data users was needed. At a SAC meeting, the mechanism suggested was to take a survey of data users at INDOT. This was done using an online survey with Survey Monkey, an online survey creation program.

The survey focused on three types of data inadequacies: data that were unavailable, data that were inaccurate, and data that were outdated. The survey also attempted to identify what types of data may have inadequacies. This was done by asking users to pick a category for the data that they accessed. The categories of data that were listed are as follows:

- Bridge/Other Structures
- Environmental
- Highway Geometry
- Intersection
- Land Record/Right-of-Way
- Other Roadway Physical Features
- Pavement
- Ramps
- Safety
- Traffic Control Devices
- Traffic Flow

To identify the categories of data that users believe are inadequate, users were asked to choose the categories of data they accessed which they believed were inadequate for their data needs. To distribute the survey to INDOT personnel, the web address for the survey was distributed to director level personnel at INDOT via e-mail, with a request to pass it along to subordinates who were also data users. Figure 5.1 is the e-mail that was sent to the chosen personnel.

The survey request was sent to 75 INDOT employees. The response rate was quite high: 58 responses were received.

Figure 5.2 shows the results of the survey. In Figure 5.2, the bar on the left represents the total number of users of a category of data. The bar on the right represents the users that felt that the data in that category were not meeting their needs in some way. Figure 5.2 indicates that the categories of data that are most frequently used are Bridge/Other Structure data and Pavement data. Highway Geometry is also a frequently used category of data. Figure 5.2 also indicates that Ramp data are the least frequently used

Dear User of Data in INDOT:

If you use data as part of your job, we need your input for a JTRP project that is assessing the data requirements of INDOT personnel. If others in your office are direct users of data, please forward this email to them. The comments we receive will help us and the INDOT personnel on the Study Advisory Committee as we consider changes to INDOT's data collection programs.

In order to do your job properly, you need different types of data. In some cases, you may not have access to the data you need. In other cases, the data that are provided to you may lack appropriate accuracy or may be outdated. Please complete a short survey in order to identify types of data that you are lacking and types of data that are inadequate for your data needs. The survey is available at http://www.surveymonkey.com/s/DP2B67G. In our trials, it took less than five minutes to complete the survey.

Thank you for your input.

Sincerely,

The team for SPR-3432 "Cost-Effective Data Collection to Support INDOT's Mission."
Jon Fricker, Menna Noureldin, and Timothy Stroshine

The contact person at INDOT for this project is Brad Steckler (BSTECKLER@indot.IN.gov).

Jon D. Fricker
Professor of Civil Engineering
Purdue University
School of Civil Engineering
550 Stadium Mall Drive
West Lafayette, IN 47907-2051
Phone 765-494-2205

**Figure 5.1** E-mail sent to chosen INDOT personnel.

type of data. By looking at how many of the users of a category of data felt that they lacked data, potential problem areas can be identified.

Figure 5.3 shows the percentage of users of a category of data that felt that the data were inadequate. The most problematic areas are Bridge/Other Structure data and Traffic Flow data. Pavement data, Land Record/Right-of-Way data, Other Roadway Physical Feature data, and Highway Geometry data each also had over 15 percent of users who reported that the data were inadequate. Figure 5.3 seems to indicate that Environmental data is the type of data that is best meeting user needs, because it had less than 5 percent of its users saying that it had inadequate data.

The results of this survey should be combined with other information collected during the course of this study. For example, Environmental Data received good scores in the online survey summarized in Figures 5.2 and 5.3. However, the technical memos and interviews with INDOT personnel indicate that Environmental data may have some shortcomings.

To see what types of improvements can be made to data collection, it is important to see which INDOT offices suggested improvements to the different categories of data collected by INDOT. This is summarized in Table 5.1.

Table 5.1 is a matrix containing the types of improvements each office of INDOT suggested for the different data types investigated in this study. The columns of the matrix are the different offices that gave feedback and the rows of the matrix are the data categories investigated in this study. More details about the suggestions for improvements are listed in Table 5.2.

The key shows the different types of suggestions that were offered by INDOT personnel. The categories are "Collect More Data/Increase Data Accessibility," "Increase Accuracy/Reliability of Data," "Collect Data More Frequently," and "Data integration needed." "Collect More Data/Increase Data Accessibility" indicates that a data user is lacking one or more data items in a certain data category. "Increase Accuracy/Reliability

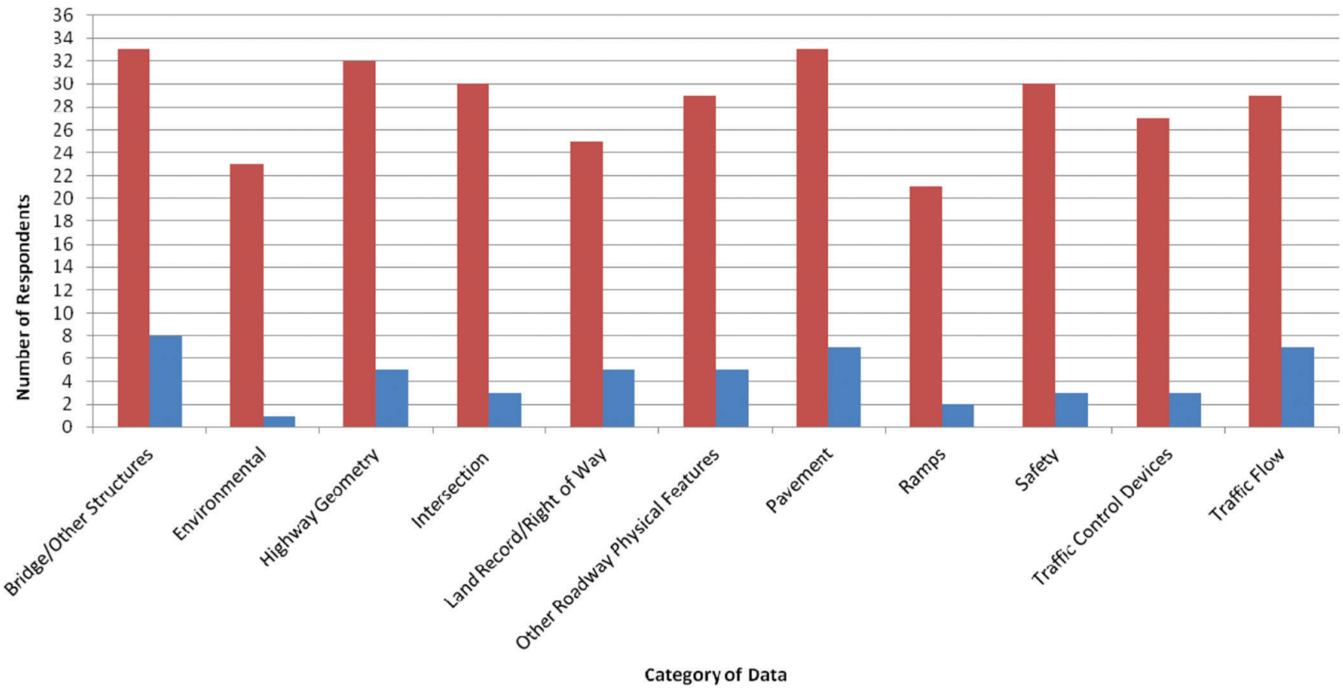



**Figure 5.2** Comparison of the total number of data needs survey respondents and the number indicating that they lack adequate data (by data category).

of Data" indicates that although the data users have data available from a certain data category, the quality of one or more collected data is not adequate. This could be due to the method of data collection or needs for improvement in the processing of data. "Collect Data More Frequently" indicates that data users have data available, but one or more data items within the data category are too outdated for their needs. "Data integration needed" indicates that data users have the data they need and that the data are of sufficient quality, however, the users must spend time extracting data from multiple sources. By linking those sources, the data users could much more efficiently use the data available.

Tables 5.1 and 5.2 indicate that some offices have many suggestions for improving data collection. The offices that offered the highest number of suggestions

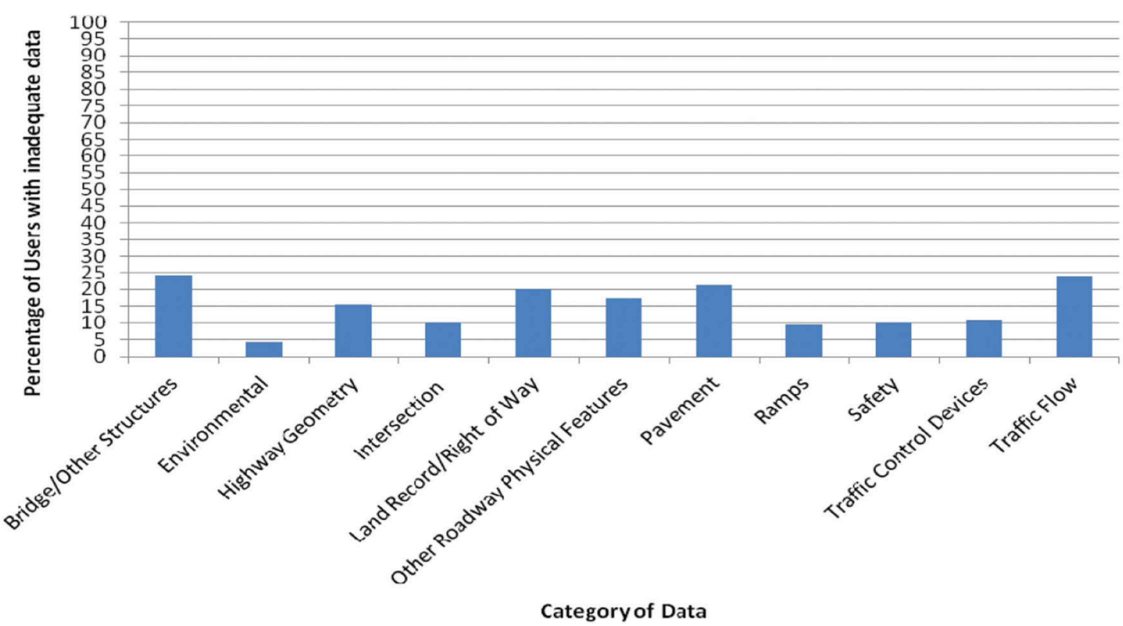



**Figure 5.3** Percentage of data needs survey respondents indicating that they lack adequate data (by data category).

TABLE 5.1
**Improvements Suggested by Survey Respondents to Improve the Data Provided for the Needs of INDOT Personnel**

| | AM/Bridges | AM/Inventory and Tracking | AM/Mobility and Congestion | AM/Roadway Safety | Central Highway Design | District Offices | Environmental Services | Operations | Traffic Management Center |
|---|---|---|---|---|---|---|---|---|---|
| **Bridge and Culverts** | * ^ | | | | * | * ^ | | ^ | |
| **Construction Project Data** | | | | | | | * | * | |
| **Environmental** | | | | | * | | | | |
| **Highway Geometry** | | | | * | * | | | | |
| **Intersection** | | | * | * | | * | | | |
| **Land Record/ROW** | | | | * | * | ^ | | * | |
| **Other Roadway Features** | | | | * | * | | | | |
| **Pavement** | | * | | * | * | # | | ^ | |
| **Ramps** | | | | * | | * | | + | |
| **Safety** | | | | # | + | * | | | * |
| **Traffic Control Devices** | | | * | * | | * | | | * |
| **Traffic Flow** | + | | * | * | + | + | | | * # |

Key:
*= Collect more data/increase data accessibility.
# = Increase accuracy/reliability of data.
+ = Collect data more frequently.
^= Data integration needed.

TABLE 5.2
**Improvements Suggested by Survey Respondents to Improve the Data Provided for the Needs of INDOT Personnel (Detailed View)**

**BRIDGES & CULVERTS**

| Central Highway Design and Technical Services | Asset Management Division/Bridges | District Offices | Operations Division |
|---|---|---|---|
| Additional details of structure features (beyond condition and survey) would be helpful | Large Culvert Inspection data are separated into 6 different inventories, one for each district. Integration of Large Culvert Inspection Inventory into Bridge Inspection Inventory is currently underway. This integration will unite condition data for bridges and large culverts in one location | Some districts are lacking information on large culvert condition ratings. One district's Capital Program Management wants a report that cross references bridge inspection data with SPMS | Data issues exist between Bridge Inspect Application Software (BIAS) and Work Management System. The Bridge Inspection crew is responsible for generating asset codes/names that are supposed to be utilized by Maintenance crew. The problem is that for a given bridge, these codes cannot be used by maintenance crew until the bridge has undergone inspection. This issue necessitates the creation of a temporary bridge identifier by Maintenance crew for bridges that have undergone maintenance activity but have yet to be inspected.<br>Bridge condition data collected through Bridge Inspection crew are not interfaced with Work Management System; asset condition data are essential for planning and budgeting maintenance activities |

**PAVEMENT**

| Central Highway Design and Technical Services | Asset Management Division/Roadway Safety | Asset Management Division/ Inventory and Tracking | District Offices | Operations Division |
|---|---|---|---|---|
| Pavement layer thicknesses are not provided in projects' scopes | Need to have access to pavement friction data | Need information on pavement original design specification | Pavement Condition Rating (PCR), a measure of surface distress, is currently all collected by districts, which is costly and unsafe for district personnel | Pavement condition data contained in Pavement Management System (PMS) have yet to be interfaced with the Work Management System (WMS). This interface was to be available through the Management Information Portal (MIP). Asset condition data are essential for planning and budgeting maintenance activities |

TABLE 5.2
*(Continued)*

| TRAFFIC FLOW | | | | | |
|---|---|---|---|---|---|
| **Central Highway Design and Technical Services** | **Asset Management Division/Mobility and Congestion** | **Asset Management Division/Bridges** | **Asset Management Division/Roadway Safety** | **Traffic Management Center** | **District Offices** |
| Traffic Counts conducted for projects are often outdated due to project postponement caused by funding issues. Traffic Reports difficult to interpret for a non-traffic engineer | Lacking vehicle classification counts throughout the state | Traffic data are not received as frequently as desired | Need Average Annual Daily Traffic data on ramps and on major and minor road approaches for intersections | Lacking vehicle classifications data at ITS sites.<br>Lacking Maintenance of Traffic Activities at Construction sites (such as lane availability and speed limit changes)<br>Weigh-in-Motion data are not accurate | Average Annual Daily Traffic Data available online are not updated.<br>One district stated reliance on printed traffic flow maps for extraction of Average Annual Daily Traffic and Average Daily Truck Traffic |

| TRAFFIC CONTROL DEVICES | | | |
|---|---|---|---|
| **Asset Management Division/ Mobility and Congestion** | **Asset Management Division/ Roadway Safety** | **Traffic Management Center** | **District Offices** |
| Lacking information on type of control at intersections | Need information on type of Traffic Control Device at each intersection. (Signal-Timed, Actuated, System OR Stop Control) | Lacking information about traffic control devices | One district is lacking information on traffic control devices |

| SAFETY | | | |
|---|---|---|---|
| **Central Highway Design and Technical Services** | **Asset Management Division/ Roadway Safety** | **Traffic Management Center** | **District Offices** |
| Safety information not received frequently enough. Outdated accident reports are received. This necessitates looking up unprocessed safety data contained in ARIES | Safety Data should be linearly referenced so that high crash locations can be more easily found | Lacking information about safety | One district is lacking road safety data and information |

| HIGHWAY GEOMETRY | | | |
|---|---|---|---|
| **Central Highway Design and Technical Services** | **Asset Management Division/ Roadway Safety** | **Traffic Management Center** | **District Offices** |
| Difficult to locate old plans showing existing geometry | Detailed information on geometric attributes of road segments is desired to make more cost-effective decisions on site specific safety improvements. Data elements that would be useful include:<br>•Locations, radii, and lengths of horizontal curves<br>•Locations, grades, and grade lengths for vertical curves<br>•Locations and lengths of no passing zones | Lacking information about highway geometry | Geometric information is tedious to obtain from as-built plans, aerial photos, and videolog |

TABLE 5.2
*(Continued)*

| HIGHWAY GEOMETRY | | | |
|---|---|---|---|
| **Central Highway Design and Technical Services** | **Asset Management Division/ Roadway Safety** | **Traffic Management Center** | **District Offices** |
| | •Speed limits for different road segments<br>•Access control (number of driveways or intersections) for road segments<br>•Shoulder widths and surface types<br>•Median types and widths | | |

| INTERSECTIONS | | |
|---|---|---|
| **Asset Management Division/Mobility and Congestion** | **Asset Management Division/Roadway Safety** | **District Offices** |
| Lacking intersection location and type of control information | Need to form a database that contains intersection information to make more cost-effective decisions on site specific safety improvements. Information should include:<br>•Intersection identification/Log Mile location<br>•Type of Intersection<br>•Traffic Control<br>•Major and Minor Road Identification, Jurisdiction, Functional Classification, and Average Annual Daily Traffic | Information is tedious to obtain from as-built plans, aerial photos, and videolog |

| RAMPS | | |
|---|---|---|
| **Asset Management Division/Roadway Safety** | **District Offices** | **Operations Division** |
| Need to form a database that contains ramp information to make more cost-effective decisions on site specific safety improvements. Information should include:<br>•Interchange Identification/Ramp Identification for Location<br>•Ramp Length<br>•Ramp Configuration<br>•Average Annual Daily Traffic on ramps | Information is tedious to obtain from as-built plans, aerial photos, and videolog | The process of annual addition of new route and ramp sections to Work Management System (WMS) is a slow, often inaccurate process. As a result, there is extensive reliance on the GIS office to extract information from EXOR (Data on certified public roads). The same solution is being considered for implementation with respect to adding new ramp sections to the Work Management System |

| OTHER ROADWAY FEATURES | |
|---|---|
| **Central Highway Design and Technical Services** | **Asset Management Division/Roadway Safety** |
| Need information on location and characteristics of existing underdrains and outfalls | Need information on guardrail locations and types to make more cost-effective decisions on site specific safety improvements |

| LAND RECORD/ROW | | | |
|---|---|---|---|
| **Central Highway Design and Technical Services** | **Asset Management Division/Roadway Safety** | **District Offices** | **Operations Division** |
| Need accurate information about existing ROW and property lines | Need ROW width for road sections | Data need to be more accessible. One district's Capital Program Management wants a report that cross references land record data with SPMS | Need to know ROW limits |

TABLE 5.2
*(Continued)*

| ENVIRONMENTAL |
|---|
| **Central Highway Design and Technical Services** |
| Need information on jurisdiction of waterways to assess the need for permits |

| CONSTRUCTION PROJECT DATA | |
|---|---|
| **Central Office of Environmental Services** | **Operations Division** |
| Design Data on Construction Projects are available. Need history for construction site location. Need spatial integration with construction project data | Construction and in-house past and present project data are available. Need data on planned projects. Need spatial component. Need a way to accurately estimate projected need of materials |

were the Office of Roadway Safety, Central Highway Design, and the district offices. The most common category of suggestions for improvements was the "**Collect more data/Increase data accessibility**" category. All INDOT offices that responded to the survey lacked one or more types of data, whether because the data are not collected or they are collected but not accessible to users who need it. The data types that received the most suggestions from the "**Collect more data/Increase data accessibility**" category were Traffic Control Devices, Traffic Flow, Pavement, Bridges/Culverts Intersections, and Land Record/Right-of-Way. The data type that received the most "**Data integration needed**" suggestions was Bridges/Culverts. Traffic Flow is the data type that received the most "**Collect data more frequently**" suggestions.

In order to give recommendations about how to make data collection more cost effective, it is important to first look at the suggestions given in the survey in more detail. Due to these inadequacies, INDOT's data collection should be refined in some areas. The most critical categories to change are Bridge/Other Structures, Traffic Flow, and Pavement data. Land Record/Right-of-Way, Other Roadway Physical Feature, and Highway Geometry may also need to be changed. The research team took this information into account when formulating the recommended changes, which are included in Chapter 6.

# 6. SUMMARY AND RECOMMENDATIONS

This study's main purpose was to provide an inventory of the data collection programs undertaken by INDOT's divisions and offices and to give recommendations regarding addition, removal, or modification of data collection programs. This purpose was pursued through the development of an inventory of the data collection programs implemented by INDOT. The inventory contains information about the data items collected, the data collector and/or owner entity, frequency of collection, the tools used for data collection and storage, and the purpose of collection. The data collection inventory was compiled from an INDOT Data Collection Online Survey and phone interviews with various INDOT employees.

An additional activity of this research was the exploration of data quality and accessibility issues within INDOT. The issues were raised as a result of the INDOT Data Needs Survey, along with the findings of some previous research projects undertaken by the Joint Transportation Research Program. A summary of the data quality and accessibility issues voiced by INDOT employees are shown in Chapter 5 in Table 5.1.

This research project has revealed opportunities for INDOT to improve individual data collection programs and to establish links between databases to enable INDOT to fulfill its mission in an efficient manner.

## 6.1 Recommended Changes to INDOT's Data Collection Programs

The following is a list of recommendations regarding changes to the INDOT data collection programs. These recommendations were developed from the previously mentioned surveys, interviews, and literature reviews.

1. Pavement Condition Data:

    a. Collect Pavement Condition Rating (PCR) annually for all roads under state jurisdiction. INDOT is currently collecting this information annually at the project-level only. Pavement distress data should be collected by an automated van at the network level in order to assist the scheduling of restorative treatments and the estimate of budgets needed to program the treatments. Prior to 2010, network-level collection of PCR data was conducted on behalf of INDOT by Pathway Services so INDOT should be able to estimate the cost of collecting this data item from old contracts with Pathway Services. INDOT should also take note of the rapidly evolving 3D laser imaging technology that can collect high resolution automated pavement surface distress data, including rutting and cracking, at highway speeds. Such a tool could potentially be useful for district offices for enhanced scoping of pavement restorative treatments.
    b. Collect Ground Penetrating Radar and Falling Weight Deflectometer data at the network level to ascertain pavement thickness and structural strength. Testing at a spatial interval of three points per mile would enable complete coverage of the roads under state jurisdiction every five years. Currently, these data are only collected at the project-level. Collecting data about pavements' structural strength is necessary for programming rehabilitation projects and arriving at a good budget estimate for these programmed

treatments. The annual cost of this testing can be approximated with the cost of current project-level in-house FWD and GPR testing. Testing 2200 lane miles per year would yield a cost of $22,000 per year for FWD testing ($10/lane mile) and $72,600 per year for GPR testing ($33/lane mile). These unit costs, which were cited in Chapter 3 of the report, include fuel cost, equipment depreciation, engineering evaluation, and the wages of technicians conducting the tests.

2. Bridge Condition Data:
   Use an inspection interval of 48-months for routine inspections of bridges that meet the FHWA criteria for extended routine inspection intervals. Currently, all INDOT bridges undergo a routine inspection every 24 months. This research project evaluated the risk of using a longer interval for bridge routine inspections and concluded that 18 percent of INDOT bridges can safely have their routine inspection intervals changed from 24 to 48 months. Challenges in bridge inspection scheduling can be addressed by inspecting eligible bridges anywhere between 24 and 48 months.
3. Roadway Physical Inventory Data:
   Develop intersection and interchange ramp databases to improve network-level safety analysis and contribute to safer intersections and interchange ramps. The desired data elements in an intersection database include the location, geometric and traffic flow attributes, and the type of traffic control enforced at each intersection. An interchange ramp database should exhibit the location, length, configuration, and AADT of interchange ramps. As stated in Chapter 1, FHWA-SA-11-40 Report (*51*) is an excellent reference for INDOT to estimate the cost of collecting data to assemble intersection and interchange ramp databases.
4. Land Record Data:
   Develop a geospatially enabled database that displays the land parcels under INDOT ownership. Land parcel data from 86 counties can be accessed from IndianaMap (http://inmap.indiana.edu/index.html) and used for this purpose. Such a database could be used to display the status of parcels owned by INDOT or being acquired by INDOT for various reasons, including execution of transportation projects. Currently, INDOT maintains land record data to manage property acquired during delivery of transportation projects, but it needs to develop a legally binding record of the land it owns in order to manage excess land property.
5. Traffic Flow Data:

   a. Investigate the accuracy of vehicle weight data collected by WIM stations because these data items are crucial inputs for many INDOT functions, including pavement and bridge design and maintenance and capacity planning. The Data Needs Survey revealed that the poor accuracy of Weigh-in-Motion (WIM) data is a persistent problem for INDOT. One survey respondent stated that WIM data are inadequate for enforcement of vehicle load restrictions.
   b. Make the vehicle classification information collected at sites equipped with ITS more accessible to data users. Vehicle classification data from coverage count and permanent count sites located on the interstate are currently available in the Management Information Portal (MIP).
   c. Investigate a strategy to efficiently manage the newly expanded short coverage count program. Due to recent changes in the Highway Performance Monitoring System, INDOT must now monitor 18,000 sites on non-state federal-aid roads, raising the total number of sites monitored from 30,000 to 48,000. INDOT must also consider how to cost-effectively monitor sites with significant traffic more frequently than the three-year interval recommended by the Traffic Monitoring Guide. These issues could be explored and resolved in a future study.

## 6.2 Data Integration Recommendations

An important part of cost effective data collection is integration of data after they have been collected. Because many data users use multiple types of data, effective data integration will allow data users to do their jobs more efficiently. The results of the Data Needs Survey indicated that there were three major data systems that would benefit from data integration. These systems were the Work Management System, the Scheduling and Project Management System, and the Automated Reporting Information Exchange System (ARIES).

### *6.2.1 Work Management System (WMS)*

WMS has a Planning/Budget Projection tool that uses asset condition data as an input. However, there is no way of linking bridge condition data (from Bridge InspectTech) with the WMS system. Such a link would make the Planning/Budget Projection tool more effective at producing accurate projections.

A link between WMS and pavement condition data would also be valuable. Some meetings were held to discuss linking WMS and pavement condition data through the MIP, but an actual interface has never been created.

Plans to interface WMS with Fleet (M5) have been made, however this interface has yet to happen. This interface will help to eliminate the redundancy of entering the same data into multiple databases. Traffic (LSC) materials should be interfaced to WMS from M5. However, M5's traffic material component is not working and therefore cannot be interfaced to M5. This component should be fixed so that it can be interfaced with WMS. Currently, WMS users enter vehicle information and assignment directly into WMS and so do the M5 users; this is redundant. WMS also needs equipment assignment, attribute, and cost information from M5; however, this information must also be entered directly into WMS.

The main reason that this interface has not happened is because a key value for the interface has not been determined. Once data analysis on these two systems is conducted, a key value can be found, and these databases can be interfaced.

### *6.2.2 Scheduling and Project Management System (SPMS)*

Like the WMS system, there is no link between the data in Bridge InspectTech and the data in SPMS. Such a link would make the SPMS tool more convenient for the personnel tasked with scheduling bridge projects in SPMS. The SPMS system should also have a link to Land Record System data. LRS data includes the following negotiation data: offer value for property, the date that the offer was made, and relocation compensation made to the owners. Once the property has been acquired by INDOT, data on the dates of deed signing and deed recording in the county office are recorded. Data are also collected for the payment amount, date, and recipient. By linking these databases, SPMS will have more accurate information for its project scheduling, as well as better tracking of cost estimates during the ROW acquisition phase of a project.

#### *6.2.3 Automated Reporting Information Exchange System (ARIES)*

The Roadway Safety Section of the Asset Management Division needs to interface vehicle crash information from ARIES with roadway physical inventory data such as locations and attributes of horizontal and vertical curves, locations and length of no passing zones, shoulder and median widths, access control, speed limits, and the approximate ROW width along the network of state-jurisdiction roadways (interstates, State routes, and US routes). This information should be sought from the Office of Inventory and Tracking.

The Roadway Safety Section of the Asset Management Division also needs to know the locations and types of guardrails in order to analyze their effectiveness in reducing the severity of traffic accidents. This information should be sought from the Operations Division's Work Management System (WMS).

### 6.3 Data Management Recommendations

Data Management is needed to ensure adequate, timely, accurate data is utilized in INDOT's decision-making. Data Management includes the development of a structure to the data collection program to ensure that data are collected with the proper standards, are of sufficient quality and accessibility, and are properly labeled. The consideration of these features is essential to guarantee that data fulfills the purpose for which they were collected.

Additionally, a transparent process needs to be developed to aid decision-making on the addition, deletion, or modification of data collection programs. Such a process must consider the purpose of the data collection program, the cost of the data collection program, the monetary value and the utility of inventorying or monitoring the condition of a certain asset within each program, and the risk level associated with eliminating that program.

The following elements are essential to proper execution of the data management plan:

- A standard for demonstrating the business value of existing or new data collected by the Department
- Documented data gathering and measurement standards for divisions and business functions within the Department (for example, design, project delivery, maintenance, materials management, and traffic)
- Metadata should be included in the digital copy of the data to provide a precise "label" to sufficiently describe the data, the collection method, the spatial and temporal coverage of collection, frequency of collection or "refreshment rate" and the intended purpose(s) of collection.
- A data inventory and dictionary should be published and made available to the employees of the organization so that, if they need data, they know which INDOT offices and/or divisions should be contacted, the access and use rules for the data, and the data's integrity or quality. Chapter 3 shows data inventory tables that should be updated periodically to inform INDOT employees of the major data types collected by different offices and divisions within the agency.
- Data quality control standards should be implemented for data collection programs. These standards address data integrity, validity, consistency, and accuracy.
- Roles and Responsibilities of staff tasked with data management should be clearly outlined. These roles include Enactment of the data management policies and procedures on a daily basis; Management of definition, collection, quality, and usage of data; Dissemination of data catalogues and dictionaries for data collection programs; Responsiveness to data users in terms of ensuring data quality and accessibility; and Ensuring the protection of the data by authorizing access to various data applications.

### 6.4 Data Publication Recommendations: Indiana Transparency Portal

With respect to publication of agency performance information for data stakeholders outside the agency, INDOT must consider the advantages and disadvantages of such an action. The obvious advantage would be highlighting excellent performance in certain program areas, especially regarding operational or physical network condition. An indirect advantage is showing the public that the agency is monitoring its own performance and is constantly striving to cost-effectively deliver safe mobility to road travelers. If agency performance information is made available to state legislators, it can validate the need for increased funding for maintenance and improvement of the highway infrastructure. Agency performance information can also be made available to researchers, so they can help INDOT to find ways to further improve its performance and operation. Among the possible disadvantages of publishing performance data are (1) the personnel resources needed to create and maintain a Tracker or Dashboard and (2) the potential for individuals or groups to misunderstand, misinterpret, or misuse the data.

After weighing the advantages and disadvantages of data publication, INDOT should investigate methods to improve its current use of the Indiana Transparency Portal Performance Measurement Dashboard, a web-based tool, in publication of aggregate information on agency-wide performance. As mentioned in Chapter 1 of this report, the INDOT performance measure data currently published in the Indiana Transparency Portal website provide a limited perspective of the agency's performance. Most of the measures presented pertain to the management of construction contract cost and duration. There is limited pavement and bridge condition data made available; they are percent of pavement miles with acceptable ride quality, percent of bridges with an acceptable evaluation, and number of fatalities on State controlled roadways. This scope should be expanded to reflect a more disaggregate view of pavement and bridge condition (such as percent of pavement miles with ride quality, IRI, in excellent, good, fair, and poor conditions; percent of bridges with excellent, good, fair, and poor evaluation). In addition to providing traffic fatality information, INDOT could also provide the number of traffic non-fatal injuries. With respect to mobility, INDOT could start by publishing traffic flow conditions on the busiest sections of the interstate system during the times of greatest congestion for a given year.

In addition to expanding the scope of the information published by INDOT to the Indiana Transparency Portal Performance Dashboard, the Dashboard should be improved to make it more navigable. Currently the data user must go through a hierarchy of options to find the data contained in the Performance Dashboard. The "Agency Summary" tab is the first location that should be viewed. If the desired data is not found there, the user must then query the data at the "Performance by Program" or "Performance by Fund" tabs. The list of indicators that can be queried is shown in Figure 6.1. If the desired data is still not found, the user must resort to manually searching through each program or fund to find the data.

| |
|---|
| **% of available pool vehicles used per month** |
| **% of bridges with an acceptable evaluation** |
| **% of research projects that result in an implementation** |
| **% of roads with acceptable International Roughness Index (IRI) quality** |
| **% of state match for federal state construction plan contracts awarded on-schedule** |
| **% of state match for federal state construction plan dollars awarded on schedule** |
| **% total INDOT budget spent on consulting, ROW, construction and preservation** |
| **Construction contracts completed within 105% of award amount** |
| **Duration from selection of professional consultant to notice-to-proceed (in days)** |
| **Local planning agencies contract letting: percent let (advertised) on-time vs. annual plan, year-to-date (state fiscal year)** |
| **Local planning agencies contract letting: % of planned estimated cost of contracts let (advertised) on-time vs. annual plan, year-to-date (state fiscal year)** |
| **Net change of construction contract cost** |
| **Percentage of Condemnations** |
| **QA of contract packages from production to assure 100% complete** |
| **Real estate schedule attainment** |
| **Traffic fatalities on state controlled roads** |

**Figure 6.1** List of INDOT performance indicators as reported to the Indiana Transparency Portal.

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## APPENDIX A. INDOT TRAFFIC DATA, STATISTICS AND WEB PORTAL

Appendix A is available here: http://docs.lib.purdue.edu/cgi/viewcontent.cgi?filename=3&article=2984&context=jtrp&type=additional

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Wayne Richardson

**Date:** 20 May 2011

**Re:** Bridge Data Collection Interview: Bill Dittrich and Gerald Nieman via phone and email during the month of April 2010

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## Bridge Data

Bridge Inspection: Interviews were conducted via telephone and email with both Bill Dittrich and Gerald Nieman. INDOT has about 5720 bridges on the state system and over 19,000 when all county bridges are included. The information is stored in an Oracle web-based database called InspectTech. INDOT inspects its bridges every 2 years as required by federal regulations. The inspections are still generally done on paper, in the field, and then transferred into InspectTech back at the office. InspectTech stores all of the report information as well as additional comments, photos, and drawings that the inspector feels are appropriate. There are approximately 116 Federal bridge inventory items that need to be collected for each bridge in the inventory. InspectTech, which stores the bridge inventory data information, currently consists of 1882 data items, because INDOT requires many additional data items in order to properly manage the bridges in the state.

The amount of data (number of fields) collected at each bridge site depends on the complexity and size of the bridge. A part of each inspection includes updating and verifying information that already exists in the database. New photos are usually taken at each inspection. In addition, drawings and load capacity ratings may also be produced which are attached to the bridge file. Bridges that are classified as "Fracture-Critical" are required to have an "arms-length" or "hands-on" inspection. Fracture Critical bridges are steel bridges where if one main member fails, all or a part of the bridge may collapse, due to lack of redundancy. An "arms-length" or "hands-on" inspection is conducted within an arms-length of bridge members of interest.

The quantity of data stored for each bridge is large, and will grow tremendously over time. The data stored is intended to cover the entire approximately 75 year life of a bridge, (and act as the official bridge file). This is done for all bridges in the state (not just those on the INDOT State system). A large server is required to store the data and allow speed in its use. The current system, which only houses the INDOT Bridges, runs slowly due to the internet or the server running slowly; however, access to bridge data by INDOT bridge personnel is reliable. There are overlaps in data needs and uses between the bridge inventory data base and data bases maintained for other INDOT assets. Gerald Nieman (Bridge Inventory Unit) is currently working with others at INDOT to try and link various databases to the bridge data base. The current thought is to accomplish this through the data warehouse.

I was directed to confer with Professor Robert Connor, of Purdue University, by Bill Dittrich at INDOT, about new ideas that could assist the bridge inspection program in the state. Prof. Connor is working on a project that deals with the inspection interval of bridges for NCHRP. As this project progresses, recommendations can be made to INDOT about inspection interval and data that should be collected. A literature review on inspection intervals and other bridge asset management practices has been started and will be included in a future memo.

**Figure B.1** Bridge Data technical memo.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Wayne Richardson

**Date:** July 3, 2010

**Re:** Bridge Inspection Interval: Federal Requirements and Surrounding State Practices for Routine Inspections

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## Bridge Inspection

(See Table 34 on next page for Inspection Definitions)

Bridge inspection is mandated by the federal government. The requirements are laid out by the Federal Highway Administration (FHWA) in the National Bridge Inspection Standards (NBIS). The last major revision to NBIS in 1988 set the frequency for inspections. The standard routine inspection interval was set at 24-months. It states that longer intervals are allowed, but have to be applied for with the FHWA and should not exceed 48-months. It also states that some bridges may need to be inspected more often than 24-months. It lists specific considerations for bridges that can never apply for longer inspection intervals and that are good candidates for shorter inspection intervals. These considerations include: Condition Rating of 5 or less, weight limit below legal loads, span length greater than 100 feet, no redundancy in load path, or being susceptible to vehicular damage (clearance less than 14', narrow thru or pony trusses). If a state decides to use the 48-month routine inspection interval, it must get the criteria approved by the FHWA. Once the criteria are established and approved by FHWA, then the criteria are set for the future. There is no yearly approval process. All bridges that meet the criteria are then inspected on 48-month intervals as long as they continue to meet the criteria. Once a bridge no longer meets the criteria, its routine inspection interval reduces back to a 24-month interval or shorter.

Michigan and Ohio do not allow extended inspection intervals. Michigan requires 24-month inspections and inspects 4% of bridges more often than that due to different circumstances. The "Guideline for Bridge Inspection Frequencies" from Michigan states what criteria are used to cause inspections to be done more often than 24-months in Michigan. Every bridge in the state of Ohio is required to be inspected each calendar year and never at an interval exceeding 18-months. There are a few private bridges that are not inspected by the state but still must be inspected on the 24-month interval at most.

Kentucky is another story altogether. A phone call was placed to the Kentucky Transportation Cabinet's Bridge Maintenance Branch of the Division of Maintenance on May 26, 2010. Kentucky, as of the 2005 NBI data report, used 48-month inspection interval for some bridges (17%) as can be seen in NCHRP Synthesis 375. Per the information gathered by the phone call, Kentucky no longer uses the 48-month inspection interval. It had been used previously but only for pre-stressed concrete bridges. The reason that Kentucky no longer uses the 48-month inspection interval is because of the difficulty in coordinating inspection rotation and keeping track of when each bridge needs to be inspected. The issue is that a bridge that may be inspected every 48 months might lie near a bridge that is on a 24-month inspection interval; it is not efficient to inspect bridges close to each other on different intervals. This inefficiency was not saving Kentucky enough resources with the "apparent decrease in confidence" of safety brought about with longer inspection intervals.

**Figure B.2** Bridge Inspection: Federal Requirements and Surrounding State Practices technical memo.

TABLE 34
U.S. FEDERAL INSPECTION TYPES

| Inspection | Description |
|---|---|
| Damage Inspection | An unscheduled inspection to assess structural damage resulting from environmental factors or human actions. |
| Fracture-Critical Member Inspection | A hands-on inspection of a fracture-critical member or member components that may include visual and other nondestructive evaluation. |
| Hands-On Inspection | Inspection within arms length of the component. Inspection uses visual techniques that may be supplemented by NDT. |
| In-Depth Inspection | A close-up inspection of one or more members above or below the water level to identify any deficiencies not readily detectable using routine inspection procedures; hands-on inspection may be necessary at some locations. |
| Initial Inspection | First inspection of a bridge as it becomes a part of the bridge inventory to provide all Structure Inventory and Appraisal data and other relevant data and to determine baseline structural conditions. |
| Routine Inspection | Regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements. |
| Special Inspection | An inspection scheduled at the discretion of the bridge owner, used to monitor a particular known or suspected deficiency. |
| Underwater Inspection | Inspection of the underwater portion of a bridge substructure and the surrounding channel that cannot be inspected visually at low water by wading or probing, generally requiring diving or other appropriate techniques. |

*Source: Code of Federal Regulations (1).*

Illinois is one of 13 states that inspect more than 4% of their bridges on 48-month intervals. Only 8 states inspect more than 10% of their bridges on 48-month intervals. Illinois has the second highest percentage of its bridges on the 48-month inspection interval with 42.2%. Illinois Department of Transportation (IDOT) follows all of the federal requirements while pushing 42.2% of bridges to the longer interval. For a bridge to qualify for a 48-month interval in Illinois, it must: have condition rating of 7 or greater; be capable of carrying the legal load in Illinois; not be susceptible to vehicular damage; not be longer than 100 feet; not be older than 50 years (or if reconstructed, not more than 30 years since reconstruction); be load redundant; cannot carry an interstate or be on the Strategic Highway Network; have an AADT of 30,000 and ADTT of 3,000 or less; be structurally redundant. Illinois also has specifications that make the inspection interval a 12-month interval and just over 2% of bridges have these specs. These specifications include: has a Structural Evaluation of 3 or less, or has a condition rating of 4 or less with AADT greater than 100; has a posted weight limit due to deterioration; or has an uncommon design with little performance history.

The NCHRP Synthesis 375, titled "Bridge Inspection Practices", provides background information on the bridge inspection intervals used by states as of the year 2005. Chapter 1 contains a table that shows this information for the states that surround Indiana. Ohio is one of the most “conservative” states because it inspects all bridges each calendar year. Illinois is one of the more “liberal” states because it applies the 48-month interval to more than 40% of the bridges in its state. An interesting finding is that for routine inspections in all fifty states, 11% of bridges are inspected on a shorter interval, and 5% are inspected on the longer interval compared to the normal 24-month interval.

**Figure B.2** Continued.

**SPR 3432**

# Memo

**To:** Study Advisory Committee

**From:** Wayne Richardson

**Date:** 11/9/2010

**Re:** An Assessment of Alternative Intervals for Bridge Inspection Frequency – A Framework and Case Study Involving 24- and 48-month Intervals.

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## Bridge Inspection Interval Report Summary

As part of this research project, the feasibility of modifying the routine inspection interval for certain bridges in Indiana is explored as a way to save some of the resources (and cost) allocated by INDOT towards collection of bridge inspection data without compromising the mission of the INDOT Bridge Inspection Program.

The mission of INDOT's State Bridge Inspection Program is explained in The Bridge Inspection Manual
The three objectives of the program are as follows:

1. Ensure Public Safety
2. Provide for the efficient use of resources in maintaining the serviceability of Indiana's bridges and small structures
3. Comply with all federal and state laws, rules, and policies

Currently, most bridge inspections done at the county level are done by consultants. INDOT personnel carry out all routine, fracture critical, and special detail inspections. Indiana toll road bridges are inspected by consultants as those bridges are no longer maintained by INDOT. A few structures maintained by INDOT may be inspected by consultants, but this is limited to the Ohio River bridges and other large, complex bridges. All underwater inspections are conducted by consultants. The majority of routine inspections are done by INDOT personnel. Therefore, modification of routine inspection intervals represents the best opportunity to save resources or to allocate them more efficiently for the INDOT Bridge Inspection Program

INDOT explains its bridge inspection practices in the Bridge Inspection Manual, which is available at the following link:
http://www.in.gov/dot/div/contracts/standards/bridge/inspector_manual/index.htm
The standard routine inspection interval of 24 months is used for almost every bridge in Indiana. If a bridge has a deck, superstructure, substructure, or culvert rating of "4" or less, the inspection interval is reduced to 12 months. A possible cost-saving strategy would involve lengthening the routine inspection interval for certain eligible bridges to 48 months.

FHWA allows for bridges to be inspected every 48 months if certain requirements are met. The requirements recommended in *An Assessment of Alternative Intervals for Bridge Inspection Frequency: A Framework and Case Study Involving 24- and 48-month Intervals* meet all requirements set by FHWA. The requirements do not allow a structure to be inspected using the extended interval if a bridge…

- *has a maximum span longer than 100 ft
- *has any condition ratings below "6"
- *is highly susceptible to vehicular damage
- *has posted weight limits
- *has fracture critical details
- *has just been constructed or reconstructed
- Requires action to address scour

**Figure B.3** Bridge Inspection Interval: Assessment of Alternative Bridge Inspection Frequencies technical memo.

Those with * are federal requirements. Scour was added as a requirement because it was thought that any bridge that needs attention/action should not be eligible for an extended interval. This is the thought of the researcher and not FHWA. If action is undertaken to address scour, the bridge may not meet the reconstructed requirement. If a bridge has just been constructed or reconstructed, it has to have 2 inspections at the 24-month interval before the 48-month interval can be used. Also, as outlined in the report, only the first time a bridge has a condition rating of "6" shall it still be eligible for the extended interval. After the 48 months, the bridge will be placed on the 24-month inspection interval again. The NBI data used for the requirements are laid out in the following table. The italics are additional definitions applied in the report but no given by FHWA. The NBI data can be found at: http://www.fhwa.dot.gov/bridge/nbi/ascii.cfm

| **Requirement** | **NBI Requirement** | **Federal** |
|---|---|---|
| Maximum Span less than 100' | Item 48 < 0305 | X |
| Condition Ratings of "6" or Greater | Items 58-62 > "5" | X |
| Not Susceptible to Vehicular Damage | Item 43B ≠ 10;54B > 0427; *Item 69 = 5* | X |
| No Posted Weight Restrictions | Item 70 = 5 & Item 41 ≠ "K"; "P"; or "R" | X |
| No Fracture Critical Details | Item 92A ≠ Y | X |
| No Action Required to Address Scour | *Item 113 ≠ 4, 3, 2, 1, or 0* | |
| Not Unusual Design or Material | Item 43A ≠ 7; 8; 9; or 0 | X |

A report will be made available to the SAC, Bridge Inspection Department and INDOT entitled *An Assessment of Alternative Intervals for Bridge Inspection Frequency: A Framework and Case Study Involving 24- and 48-month Intervals.* This report shows that the 48-month inspection interval can be used for bridges with a condition rating of "7" or greater without compromising safety. The report recommends that the 48-month interval be applied for bridges with minimum "7" ratings or the first inspection in which a bridge receives a rating of "6". From the 2009 National Bridge Inventory (NBI) data, 36% of bridges maintained by INDOT have a minimum condition rating of "7" or greater. If the 48-month interval is applied to the bridges maintained by INDOT, an 18% reduction in routine inspections can be realized.

This 18% reduction in routine inspections can be reinvested in additional inspections. The additional inspections can be used for some of the bridges with "5" condition ratings. Bridges that are critical for INDOT can be inspected more frequently. As those with condition rating "4" already are inspected every 12 months, the interval can be shortened even more to 6 or 9 months. Any additional inspections when bridges are in the lower condition ratings will increase the safety to the public. Using the 48-month interval will also allow a more efficient use of resources. This means that the extended interval is recommended as it follows the three parts of INDOT's mission for its Bridge Inspection Program.

**Figure B.3** Continued.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Menna Noureldin

**Date:** 04/18/2011

**Interview Source:** Kelly Myers

**Re:** Environmental Data Collection

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## Office of Environmental Services Databases

The INDOT Office of Environmental Services is responsible for storing and updating data for 13 databases. About half of the maintained databases are project-level databases, with several of them used to ensure that highway construction projects are in compliance with the National Environmental Policy Act (NEPA).

The following is a description of the 13 databases and their update cycles:

1. Milestones - project time lines and milestone status
2. Time management - amount of time spent on each project
3. PROBE data - unknown
4. Agency review - projects at risk for not meeting deadlines, forecasting for future submissions, justification for finding agreements
5. Field and lab results - design data (i.e., pay quantities), project design development, federal/state law requirements
6. Permitting database - tracking and communication of permitting status
7. Violations tracking - managing statewide compliance and INDOT liability
8. Environmental commitments - records the commitments made to uphold permit conditions or to mitigate the environmental impacts of projects
9. Historic bridge inventory - federal and state regulation compliance and identify preservation status
10. Compensatory wetland mitigation database - tracking locations, maintenance, and compliance status
11. Noise walls - tracking for federal reporting purposes
12. Threatened and endangered species - Database is maintained to evaluate impact of projects on animals on the Threatened and Endangered Species List
13. Archeology archives - tracking for ability to evaluate environmental impact of projects on archaeological sites

**Figure B.4** Environmental Data Collection technical memo.

| Database Name | Updating Cycle | Database Used for Federal Reporting |
|---|---|---|
| Milestones | Daily | No |
| Time Management | Daily | No |
| PROBE data | Monthly | No |
| Agency Review Times | Monthly | No |
| Field and Lab Results | Daily | Yes |
| Permitting | Daily | No |
| Violations Tracking | Weekly | Yes |
| Environmental Commitments | N/A | No |
| Historic Bridge inventory | Static | Yes |
| Compensatory Wetland Mitigation | Monthly | Yes |
| Noise Walls | Quarterly | Yes |
| Threatened and Endangered Species | Annually | No |
| Archaeology Archives | Weekly | No |

The Application and Technical Specialist for the Office of Environmental Services has stated time resources limits data collection as well as its reliability and currency more than money does, but financial resources limit unified data collection. The accuracy and reliability of the databases is rated as "Fair," due to inconsistent data entry, unreliable frequency, and limited resources for updated technology. Specifically, spatial data was singled out as having poor accuracy and precision. Much of the information is in reports rather than in a database type format, which leads to inaccessible information.

<u>The softwares used to store, access, and manage the data are</u> Oracle, Excel, Access, ArcGIS, and .net/web. Non-linking databases was stated as a data collection issue that result in duplications of entry and user error. <u>The following data sources are frequently accessed:</u> CORS (GPS Data), EXOR (Data on certified roads), GIS (Statewide Spatial Data), ProjectWise (Design data on construction projects), Work Management System (Crash Data), Data Warehouse for all project-specific data(SPMS/MIP), Site Manager. In turn, GIS and ProjectWise frequently access data from the Office of Environmental Services.

<u>The following comments were received in rating the difficulty of data and information tasks:</u>

- Data entry - most systems are user friendly for entry, but data entry in multiple locations is time-intensive
- Data collection - tech accuracy, multiple sources, equipment failure
- Divisions - multiple storage locations, no access to others data, unsure of data quality, each group captures own data instead of single data storage
- Reports - standard reports often require manipulation to get into a needed/usable format
- Ease of use: most systems are available to users, but also require decent technical skills
- Technological concerns for data entry and retrieval include interoperability between software packages, networking speed and speed of the computers for accessing the data from various INDOT divisions or offices
- Data needs include enrichment of the field and lab results database with consultant data, pre-site disturbance data for long-term project tracking, and post-construction data

**Figure B.4** Continued.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Wayne Richardson

**Date:** June 9, 2011

**Re:** EXOR and TRADAS Data Collection Interview: Eric Conklin via phone May 13, 2010

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## EXOR and TRADAS

Eric Conklin was interviewed regarding both EXOR and TRADAS. Eric's office uses these applications for traffic counts, pavement condition, and physical features inventory. The information collected is stored on Oracle databases. These databases will be updated in the next few years. The physical features inventory makes up the data that need to be reported to the Federal Highway Administration to meet the requirements of the Highway Performance Monitoring System (HPMS). There were 98 fields that need to be submitted yearly prior to the HPMS 2010 reassessment; currently, there are 63 fields that must be submitted to the FHWA annually.

There is a great deal of data that must be collected. Traffic counts cover average daily traffic, vehicle classification, and weigh-in-motion counts. These counts are for both in-house system wide use and for reporting the HPMS. There are 30,000 count sites in the state of Indiana for coverage counts. 10,000 of the count sites are covered annually. One hundred and ten permanent count stations exist around the state. These stations are used to come up with seasonal, weekday, and axle adjustment factors as well as to determine annual growth factors. Approximately 65% of the coverage counts are classification counts. Additional counts are done to support specific state projects. The counts are done by 10 people in-house, 3 Metropolitan Planning Organizations under contract as well as 5 consulting firms under contract. These counts are all kept in TRADAS.

Pavement condition data are collected yearly by a consulting firm. The physical features inventory is done continuously. The pavement condition data consultant is collecting information on roughness, rutting, cracking and more. As these data are collected, the physical features inventory is also updated. The physical features inventory includes roadway type, locations, length, pavement type, number of lanes, turning lanes, median and shoulder type, speed limit, widths, etc. Another aspect that is covered is an administrative inventory. This administration inventory includes urban area boundaries, corporate limits, functional classification, National Highway System requests and reviews, ownership and maintenance responsibility, and district identification.

The office collects raw data or receives them from others who collect the data on contract. Then the data undergo a QA/QC process to get readable raw data which are then summarized and formatted correctly to be put into the EXOR database. This goes for the raw data from pavement condition equipment or the Excel files regarding the physical assets. EXOR has the spatial aspect by connecting it to GIS with either latitude/longitude or by milepost/offset.

The upgrading to a spatially enabled software package or EXOR on the oracle database is very important. The procedures to collect, store, and access the data are easier and quicker now, and are much more precise. Upgrading the databases as already planned will help.

**Figure B.5** EXOR and TRADAS technical memo.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Menna Noureldin

**Date:** July 19, 2010

**Re:** Falling Weight Deflectometer Data Collection (Dr. Nantung)

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## Falling Weight Deflectometer testing

Project-level FWD testing is done by INDOT Research Division upon request of INDOT Pavement Steering Committee, INDOT District, and INDOT consultants. These requests are made on the basis that the section to be tested requires a restorative action. There are two test types, with identical testing procedures (test spacing and drops) but a different placement for the sensors and location of the testing spots.

The measurement trailer contains weights (Figure 1) that drop on a force plate (Figure 2) and multiple deflection sensors (Figure 3) in order to develop a longitudinal profile of the pavement's surface and subgrade deflection responses to an applied force.


**Figure 1** FWD equipment weights.

**Figure B.6** Falling Weight Deflectometer technical memo.

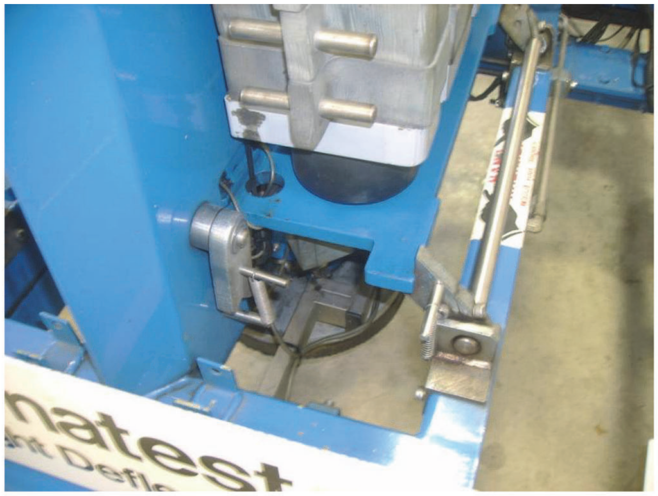


**Figure 2** FWD force plate.

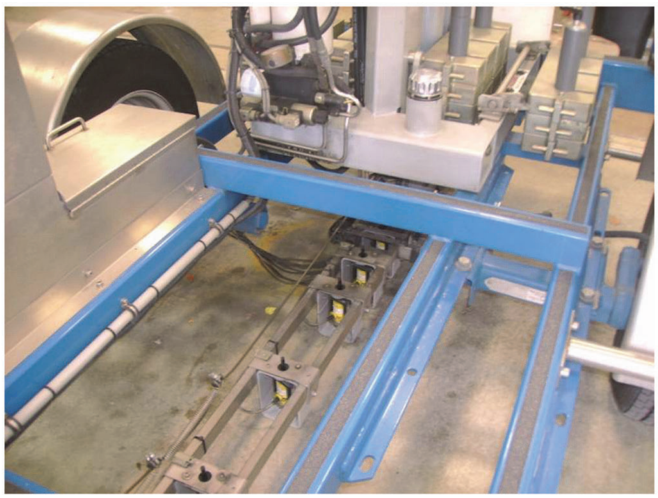

**Figure 3** FWD deflection sensors.

Test Spacing and Drops for Underseal or Overlay (Figures 4 and 5):

- General—Every 100 meters, 3 drops (7000, 9000, 11000 lbf)
- Severe Distress (more than 2 transverse cracks in 20 feet)—Every 50 meters, 3 drops (7000, 9000, 11000 lbf)
- High Deflections (larger than 8 mils at 9000 lbf)—Every 50 meters, 3 drops (7000, 9000, 11000 lbf)


**Figure 4** Overlay test spacing (0"represents the force plate location).

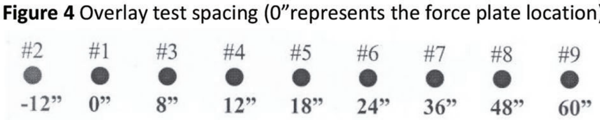


**Figure 5** Underseal test spacing (0"represents the force plate location).

**Figure B.6** Continued.

FWD Data Generation:

Figure 6 shows the screen displayed as the testing progresses. The first column of the data (units of psi) represents the pressure applied by the force plate as a result of dropped weight. This pressure is measured by a gauge shown in Figure 7.

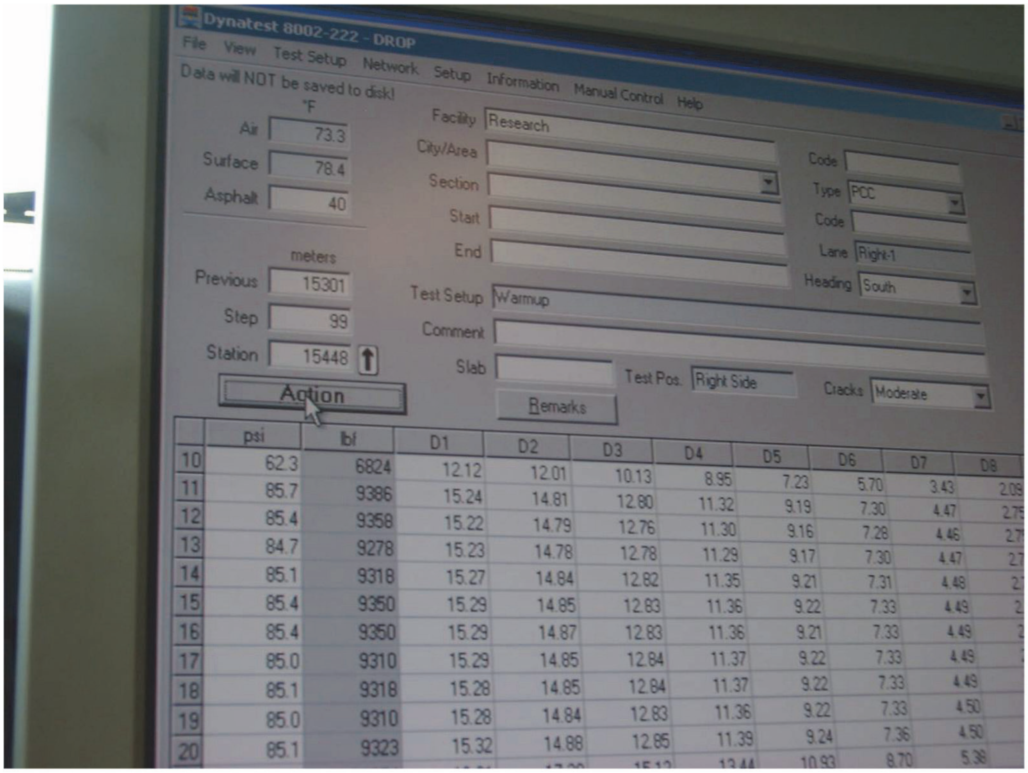


**Figure 6** Testing display screen.

**Figure 7** Pressure gauge.

The equipment generates a text file that includes the name of the data collector, the test type, the road name and direction of testing, lane of testing, the date and time of testing, start and end mile posts for the test section, stationing, pavement surface type, air and surface temperatures, the force/pressure applied to the pavement surface, the deflection in mils (1/1000 of an inch), and comments from operators.

**Figure B.6** Continued.

Testing Issues:

- If the temperature is below 40 degrees (Fahrenheit) and/or the subgrade is frozen, test results may be misleading or invalid.

- Since the device is stationary during testing, road closure and/or maintenance and protection of traffic is required.

FWD Results Adjustment and Analysis:

Since the deflection measured in asphalt pavement is temperature-dependent, all measured deflections are converted to deflection that would occur at the standard temperature of 70 F. The adjustment is made according to the method prescribed in Figure 8.

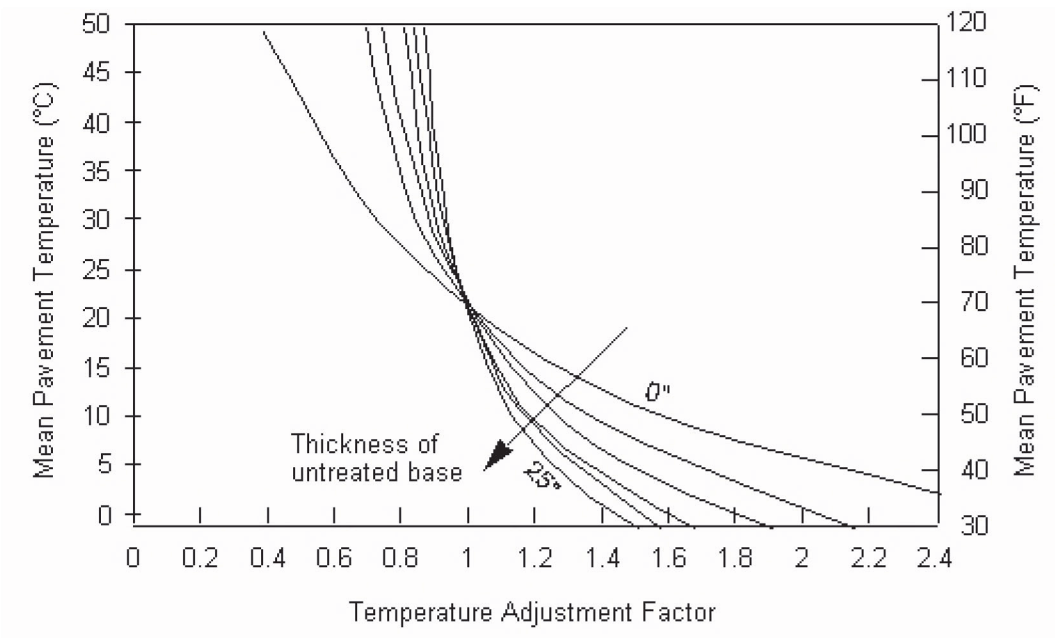


**Figure 8** Sketch of Asphalt Institute temperature adjustment factors for Benkelman Beam Deflections.

The FWD deflection results are used along with pavement thickness information to determine the structural number of the pavement, elastic modulus of pavement layers, modulus of resilience, and CBR of subgrade soil. An estimate of the remaining ESALs that the pavement can bear before it fails (PSI =2.5) is obtained by using the AASHTO flexible or rigid pavement design equation. The remaining ESAL estimate must be reliable to 95%, 90%, and 80% for Interstate, US Highways, and State Highways, respectively. Traffic data (annual average daily traffic (AADT), percent single unit trucks and semitrailers, and an annual traffic growth factor) are used to estimate the remaining service life of the pavement. Based on the remaining estimate of service life, the FWD test, depending on the test type, will clarify if the pavement needs an overlay or an underseal action.

The information from the FWD testing is crucial to the pavement scoping process for pavement candidates of resurfacing/rehabilitation actions (based on structural adequacy), budgeting for timing of resurfacing/rehabilitation/reconstruction (based on the pavement remaining ESALs), and providing input parameters for pavement design. Therefore, the uses of the FWD data are in three important processes in project developments. They are: scoping process, budgeting process, and design process.

**Figure B.6** Continued.

**SPR-3432**

# Memo

**To:** Study Advisory Committee

**From:** Timothy Stroshine

**Date:** October 26, 2010

**Re:** INDOT GIS System (From interview with Joel Bump)

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## Geographic Information System (GIS)

Geographic Information System (GIS) is used by INDOT to map out geographic data. The GIS system utilizes a combination of data, hardware, and software. Once GIS data have been collected, they are stored as visual data. Similar types of visual data are stored together in groups called layers. For instance, all the highways in the state are stored on a layer. The software component of the GIS system contains both server and workstation software. The server software is ESRI ArcGIS Server, and the ESRI ArcGIS Desktop is the workstation software that INDOT uses.

GIS data are used for analysis of where things are located, traffic forecasting, and publications that require mapping (such as annual reports). Some of the GIS data collected are federally mandated. For example, the planning division of INDOT uses GIS to keep up with Highway Performance Monitoring System (HPMS) reporting. For those reports, GIS is used for finding the total public road mileage in Indiana. Additionally, the GIS layers are imported into CAD (Computer Aided Design) drawings when these drawings need to be produced by INDOT. Almost every division of INDOT utilizes the data from GIS. One of the principal users of GIS data is the planning division of INDOT. Other main INDOT users include the Scheduling Project Management System (SPMS) and the Work Management System (WMS).

GIS is a part of the Data Warehouse that INDOT maintains. GIS receives some data from outside agencies. GIS also receives some data from internal INDOT sources. For example, Traffic Management provides some raw data that must be processed. The data have unique section or site Identifications, so they can be related spatially back to a section of road on the GIS and used for mapping and analysis. The GIS system can link to the data via the unique keys to physical locations on the road network in GIS. The data on both ends are in Oracle databases, so no data conversion is needed. The Operations Division provides some data on assets, such as the shoulders of highways. The planning division also provides GIS with some data, such as traffic counts, road networks, and some boundary layers. (The boundary layers provided are city, county and urban area boundaries.)

Most GIS data layers frequently change, and therefore must be updated in order to keep the system useful. GIS data have been updated at various intervals, depending on the data layer. There are some layers that are static, and therefore do not need to be updated. An example is the bedrock layer, which is a geological layer that represents the ground itself. Other layers are updated on an as needed basis, such as the layers for wells and state parcels. Still other layers are updated at regular intervals, ranging from daily updates to annual updates. For instance, SPMS project location data are updated daily, while the road network is updated quarterly. There are some instances when outside agencies request GIS layers that are not available. In these cases, the necessary data can be collected: and the new layer or layers can be added. An example of this is adding a layer with the locations of every billboard beside highways in Indiana.

**Figure B.7** Geographic Information Systems technical memo.

SPR 3432

# Memo

**To:** Study Advisory Committee

**From:** Wayne Richardson

**Date:** 8/18/2010

**Re:** ITS interview conducted with Division Supervisor Troy Boyd from the Technology Deployment Division of the Traffic Management Business Unit.

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## Intelligent Transportation System (ITS)

The Traffic Management Unit is the Business Unit that oversees the ITS activities statewide. INDOT's ITS initiative is TrafficWise. ITS collects freeway speed and number of vehicles for each lane on the highway. This information is collected with either micro-loops in the pavement or with side fire microwave sensors. The information is separated into 30 second bins and stored indefinitely. It has been collected for 8 to 10 years by INDOT. This information is used in multiple ways. The information is used to update the Dynamic Messaging Signs (DMS) as well as the TrafficWise websites brought to the public by INDOT. This information can also be disseminated by Highway Advisory Radio system. As of now, Northwestern Indiana and the area around Indianapolis are covered by TrafficWise. The website shows the speeds broken down into categories that are color coded. In addition to speed groupings, the websites have access to cameras that show the interstates' conditions.

Hoosier Helpers is a key part of the TrafficWise initiative. It involves patrols of the freeways in the areas around Indianapolis and in Northwest Indiana as well as Southern Indiana near Louisville. The Helpers report incidents and help to quickly resolve problems on the interstate. The Helpers are in constant contact with the staff at the Traffic Management Center (TMC). This contact allows for the reducing the effects of crashes on the motoring public. It also allows for the DMS and websites to be updated with information about crashes and other incidents that the Helpers respond to. The Helpers and TCM are also in contact with the Indiana State Police. ITS keeps these incident data.

ITS shares its data with NavTeq, as an agreement was made between INDOT and NavTeq. All of the information that ITS collects is shared and NavTeq has put some of its equipment on INDOT's Right of Way. INDOT receives all of the information NavTeq collects for its consumers. The information NavTeq collects is mostly additional speed data on major highways (interstates). This sharing allows for verification of information and can be used as a way to check that the sensors are all working as they can malfunction. Also, this gives Indiana access to additional data since NavTeq has sensors on the interstates all across Indiana.

It was mentioned that the data from ITS are available in the INDOT Data Warehouse. Joel Bump added additional information about what from ITS is in the Data Warehouse. The ITS data are summarized and stored as 15 minute observations. Space for this database is an issue and a few weeks ago, more space was allocated for the database. The ITS incident data are no longer transferred to the data warehouse. The format of the incident data has changed and that is why it is no longer stored. This issue will be resolved at some point in the future.

**Figure B.8** Intelligent Transportation Systems technicalmemo.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Timothy Stroshine

**Date:** November 15, 2010

**Re:** INDOT Management Information Systems (from online survey completed by Jay Lytle)

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## Management Information Systems

Management Information Systems does not collect any data itself. However, it does use data that are collected by other INDOT offices. Management Information Systems is responsible for reporting some data from other offices. The data are mostly current enough and accurate enough to meet their data use needs. The difficulty of both accessing data from other divisions and generating reports from that data was rated as 2 out of 10 in the Data Collection Survey. This means that the current system for generating reports from data is working well.

The software that is utilized includes AgileAssets and TRADAS. Oracle databases are the backend for both of these types of software. The difficulty of using this software was rated at 2 out of 10 in the Data Collection Survey, indicating that the current software is user friendly.

Management Information Systems uses data from many different sources. The table below describes the sources of data and the data used from each source.

| Source | Data Used from Source |
|---|---|
| BIAS | Bridge inspection data |
| CORS | GPS data |
| EXOR | Certified road data |
| GIS | Not specified |
| LRS | Land record data |
| Project Wise | Design data for construction projects |
| RWIS | Weather restrictions |
| TRADAS | Traffic data for highways |
| Traffic Forecasts | Traffic projections |
| WMS | Road Inventory data |

There are some concerns and difficulties with data entry and retrieval. One concern is that different sources of data have different definitions for data. Some examples of different definitions are the definitions for award date, contract completion date, and travel lanes. There are some concerns about the quality of certain data. Some examples are traffic count data, road inventory data from Work Management Systems (WMS), and Scheduling Project Management Systems (SPMS) data.

The other divisions of INDOT have changing needs for the data that they get from Management Information Systems reports. One person said: "The agency is becoming more integrated from an information needs standpoint. We are finding that most divisions require reports with information from various systems. People need a 'one picture view' of a stretch of road. This means to make a good decision people need to know what construction contracts have impacted a stretch of road, what road maintenance has been done on a stretch of road, what is the road rating, where are crashes occurring/types of crashes, what is the traffic count, what projects are being planned on that road and when, what utility work permits have been issued on that stretch of road, what are the traffic counts/forecasts on the road, what parcels do we own along that stretch of road and what are the statuses of projects and land acquisitions along that stretch of road." This shows that there is a need in the future to have an efficient system for accessing different types of data. With an efficient system, Management Information Systems will be able to provide reports that meet the needs of data users.

**Figure B.9** Management Information Systems technical memo.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Menna Noureldin

**Date:** 12/15/2011

**Interview Sources:** Mike Nelson, Thomas Campanelli

**Re:** Pavement Coring Data

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During the November 2011 SAC Meeting, several members of the SAC requested information about the nature and extent of INDOT's pavement core testing. Subsequently, the research team sent an inquiry to the Greenfield and Crawfordsville districts regarding pavement core testing. The inquiry consisted of the following questions:

1. What are the purposes for conducting pavement core testing?
2. Which entities, whether within INDOT or external, request pavement coring information?
3. How many requests do you receive for pavement core testing in a typical year?
4. Which INDOT office or division stores the data generated from testing? Are the data also stored at the district level?
5. What is the average cost of testing each core sample?

Responses provided by Mike Nelson, the Greenfield District Testing Engineer, and Thomas Campanelli, the Crawfordsville District Materials Engineer, are listed below. Mr. Campanelli also provided an Excel spreadsheet example of how INDOT records the qualitative descriptions characterizing the material obtained at each depth for pavement cores.

Mike Nelson

1. Coring done by INDOT is primarily conducted as part of our preliminary engineering process for in-house designs. Other reasons are for failed material investigations and research.

   Density cores are also cut for all QC/QA asphalt pavements as part of our standard acceptance process. Thickness cores are cut from concrete pavements for acceptance. Note that the density and thickness cores are not actually cut by INDOT personnel, but they are witnessed by INDOT construction personnel as part of our contract oversight.

2. Most of the cores in Greenfield District are cut at the request of our district design section (Terry Summers). A few cores are requested by the Office of Materials Management in Indianapolis (Ronald Walker) or the Division of Research at Purdue (Tommy Nantung). All cores that are cut as part of INDOT construction contracts are done per INDOT standard specifications; there is no formal request.

3. Greenfield District cuts approximately 750 cores each year. This excludes cores cut for acceptance on construction contracts.

**Figure B.10** Pavement Coring Data technical memo.

4. For design purposes, the cores are photographed and logged by the Testing Department, and the necessary data are forwarded to the design section. We retain a copy on a disk. Terry will have to clarify how Design maintains the data long-term. Cores cut for research or failed materials are not logged per se. The actual cores are given to the end user.

5. I conducted a rough analysis of Greenfield's coring costs in 2008, which indicated a cost of approximately $52 for each core cut. Note that these costs only include INDOT equipment and labor for obtaining the specimen. I actually have a technician who logs and interprets the core section, which requires a significant amount of experience and engineering judgment. If the cost for the core analysis were added into the breakdown, the cost would be significantly higher. If this operation were outsourced, profit/overhead would also be a consideration. If all of these additional costs were added to the breakdown, the overall cost would be at least 2-3 times my rough estimate.

   Core Rig = $62,816/25 years = $2,513
   Truck = $50,000/15 years = $3,333
   Labor = 1125 man hrs @ $15.81/hr = $17,786
   Labor benefits @ 46% = $8,182
   Core Barrels (avg. cost) = $7,500
   Total = $39,314 (per year)
   Cost per core = $39,314/750 = $52.42

Thomas Campanelli

1. As far as I know, almost all requests are for data to assess the current condition of roadways slated for future construction -- pavement preservation, resurfacing, widening, etc. We occasionally get a request to core pavement that is showing unusual deterioration or premature failure.

2. Nearly all requests come from Pavement Design. Our current liaison is Scott Chandler. I'm copying him on this memo with the hope that he can provide some additional input.

3. The number of requests varies from year to year. We still have one open request for 2011, but the number of cores per request has ranged from as few as 4 to as many as 88 this year. The total is approximately 500 cores in 2011.
   2007 - 16 requests
   2008 - 20
   2009 - 42 (We had to borrow a second coring rig and use two crews to handle the workload!)
   2010 - 22
   2011 - 24 (so far)

4. The data consist of an Excel spreadsheet with descriptions of each core, along with jpeg photos of each core. These are sent to the person who requested the coring. A sample is attached. I don't know how these reports are retained, but most are sent to someone in the district. Testing also retains copies. We occasionally get requests to core roadways that had been previously cored. If our data are not too old (taken within the last 3 years), we can usually avoid recording by resubmitting the original data. Testing's records are probably the most complete.

5. As noted in 4 above, we don't usually do any actual testing. Our estimated cost in 2011 to do the coring and describe the cores is $16,056, or approximately $32.11 per core. However, this is for Testing personnel only. It doesn't include the cost of traffic control provided by the subs.

**Figure B.10** Continued.

**INDIANA DEPARTMENT OF TRANSPORTATION**
**BITUMINOUS FIELD SAMPLE SUMMARY**

State Form 44920 (5-95)
TD-538

| Month | | Day | | Year | |
|---|---|---|---|---|---|
| 0 | 4 | | 0 | 8 | 09 |

Purpose: 75

Sampled From:

Location: SR-25 from mm31+08 to 34+03

Sampled By: ____________

| Bituminous Field Sample Report | | | | | | |
|---|---|---|---|---|---|---|
| **Core or Sample Number** | **Station Number or Mile Marker** | **Lane** | **Loc.** | **REMARKS** | **Sequence Number (Lab No.)** | **ADDITIONAL REMARKS** |
| #1 | mm 33.50 | NBDL | 4-lane | 1.25 inches of 9.5mm stone and gravel surf. | | rest of core was crumbled |
| | | | | 4.00 inches of 19.0mm base gravel | | depth was aprox. 12 inches |
| | | | | | | |
| #2 | mm 33.50 | NBDL | 4-lane | 1.25 inches 9.5mm stone and gravel surface | | next to curb depth was b inches 6 inches |
| | | | | the rest of core was crumbled | | |
| | | | | | | |
| #3 | mm 33.80 | NBPL | 4-lane | 1.50 inches 9.5mm gravel surface | | 13 inches depth |
| | | | | 2.0 inches 19.0mm base gravel | | |
| | | | | 8.25 inches of concrete on bottom | | |
| | | | | | | |
| #4 | mm 33.90 | SBDL | 4-lane | 1.50 inches 9.5mm stone and gravel surface | | core below surface was very weak |
| | | | | Aprox. 4.0 inches 19.0mm gravel Int. | | |
| | | | | Apox. 5.00 inches 25.0mm gravel base | | |
| | | | | | | |
| #5 | mm 33.90 | SBDL | 4-lane | 1.75 inches 9.5mm stone surface | | next to curb |
| | | | | 3.00 inches 19.0mm gravel Int. | | Aprox. 6-7 inches deep |
| | | | | Base was crumbled | | |

**Figure B.10** Continued.

SPR-3432

# Memo

**To:** Study Advisory Committee
**From:** Menna Noureldin
**Date:** July 19, 2010
**Re:** Pavement Friction Data Collection and Measurement Equipment (Dr. Li and Kamron Yates)

## Pavement Friction Data Collection

An interview conducted in INDOT's Research Division illuminated the process for collecting pavement friction data. The data are collected annually for Interstates and triennially for State and US routes. Information collected includes the Road Name, Direction of Measurement, Lane Type (passing or driving), Starting and Ending Mile Posts, Date and Time, County and District, GPS coordinates, Testing Speed, Pavement Type, and recorded Friction Number. The friction number ranges from 0 to 100. The value is dependent upon tire smoothness and on the testing speed.

The data are generated by the equipment in the form of a text file that can then be easily converted into Microsoft Excel or Access files. A CD copy of the data is disseminated to the district offices for use by pavement maintenance and preservation engineers, as well as to the Office of Technical Services, Office of Materials Management, and the Legal Division of INDOT.

## Pavement Friction Measurement

Kamron Yates led the demonstration of the friction-measuring trailer. The trailer contains GPS location sensor, Mileage sensor, and friction sensor as shown in Figure 1. Outside the trailer, the hydraulic jack, shown in Figure 2, is directed at the tire to release a predetermined amount of water onto the pavement surface just before the tire reaches the wet pavement.

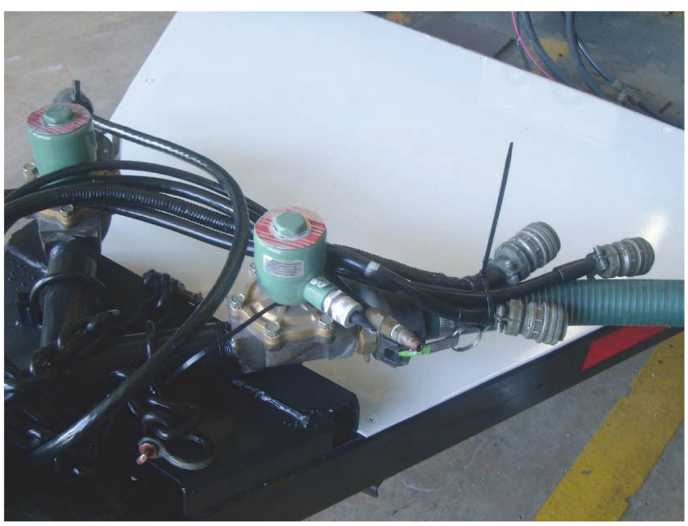

**Figure 1** Sensors inside friction-measuring trailer.

**Figure B.11** Pavement Friction Data Collection and Measurement Equipment technical memo.

**Figure 2** Hydraulic jack.

Calibration track at INDOT Research Division: The equipment is calibrated weekly as well as monthly. The track (Figure 3) contains three pavement surfaces; one asphalt surface, one smooth concrete surface, and one rough concrete surface.

**Figure 3** Three pavement surfaces for calibration of equipment.

Friction testing is done at three speeds according to the context of measurement. Inventory testing is done at 50 mph nominally (49-51 mph). Calibration is conducted at 30 mph nominally (29-31 mph). Special (warranty) testing is done at 40 mph nominally (39-41 mph).

The friction value can be attained with a smooth tire or a ribbed tire, although ribbed tires are not used anymore.

Friction Measurement Generation:

The test tire inflation pressure is set at 24 psi (165 kPa). In the course of testing, the vehicle reaches the desired speed. Then, water is delivered to the pavement, and the test wheel brake is locked 0.5 seconds after beginning of

**Figure B.11** Continued.

the water delivery. When the test wheel is locked, this device produces a 100 percent slip condition. The relative velocity between the surface of the tire and the pavement surface, i.e., the slip speed, is equal to the vehicle speed.

The wheel should remain locked for approximately 1.0 second and the data (friction force on the tire as observed by a transducer) is measured and averaged. The transducer can detect the peak friction force because the data measurement is continuous when the test wheel remains locked.

The test result is reported in terms of the classic Coulomb's friction law below:

$$\mu = \frac{F}{N}$$

where μ = coefficient of friction;
F = tractive force or friction force; and
N = normal force on the test wheel.

The friction number is the product of 100 and the coefficient of friction (μ*100).

<u>Issues with friction measurement:</u>

Safety is an issue while measuring friction on highways, where other vehicles on the roadway are operating at a much higher speed than the friction-measuring trailer.

The result of the friction testing is invalidated if done on an already wet pavement surface or when the pavement temperature is below 40 F.

<u>Central Control System:</u>

Inside the vehicle, tire temperature and air temperature are shown above a computer screen that displays a menu for choosing a test or calibration procedure to conduct. The computer screen shown in Figure 4 is connected to a control system that was developed in-house by Karen Zhu. For friction testing, the control settings that can be changed include water flow amount and how long the tires lock up (1-1.5 seconds).

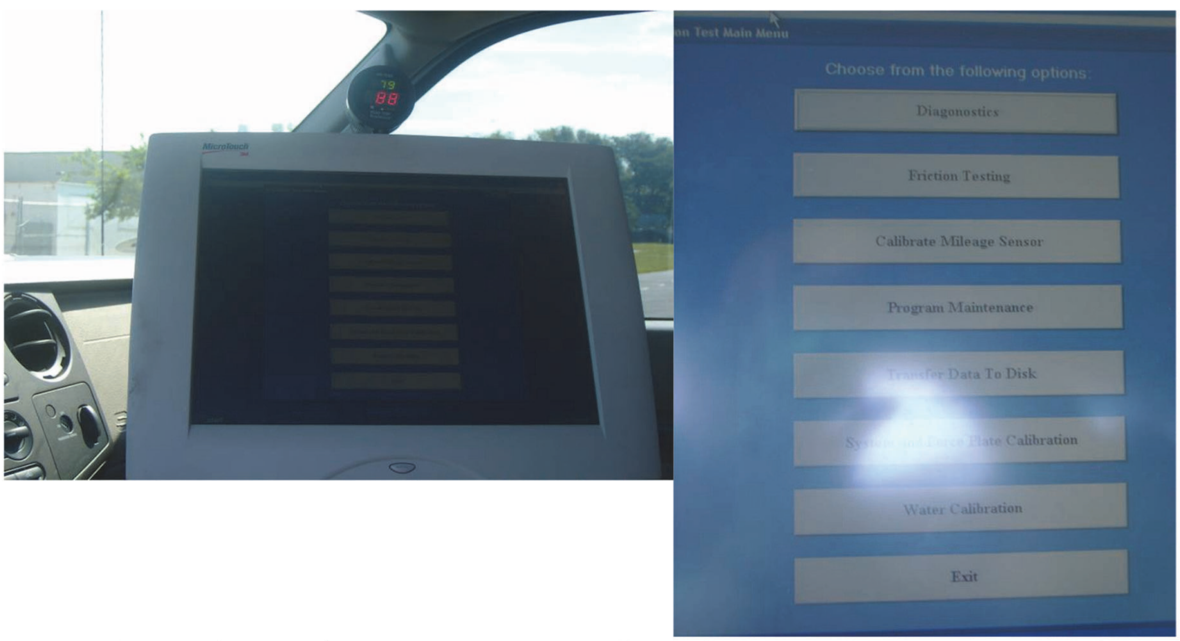


**Figure 4** Display screen for testing. (Diagnostics, Friction Testing, Calibrate Mileage Sensor, Program Maintenance, Transfer Data to Disk, System Force Plate Calibration, Water Calibration, Exit.)

**Figure B.11** Continued.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Menna Noureldin

**Date:** May 19, 2010

**Interview Source:** Kathy Heistand

**Re:** ROW Data Collection

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## ROW Data Collection by the Land Records System

A telephone interview was conducted with the Business Owner of the Land Records System (LRS) database, revealing the process by which LRS collects ROW information. The data are collected as the ROW acquisition process progresses. For each project where INDOT has to acquire ROW, the LRS assigns numbers to the parcels that make up the ROW area to be acquired. These parcel numbers are stored, along with the name and address of the current parcel owner. A legal description of the parcels is also generated, which states the parcel location with respect to the project centerline and stationing. Once this information is stored, the property owner of each parcel is contacted.

The property owners must then be notified that INDOT plans to acquire their land. Once this has occurred, the person who contacted the property owner and the date of contact are recorded in LRS. An appraiser is then tasked with valuing the property; the data generated from the appraisal process include the appraiser's identity, the assessed value of the property, and a detailed description of the property, such as the type of property (house, rental, business).

The negotiation process generates data that includes the offer value and relocation compensation made to the owners. The date that the offer is sent is recorded. A landowner has five days to respond with an acceptance or counteroffer. If the negotiation process succeeds, the dates of deed signing and deed recording in the county office are recorded, as well as the payment amount, date, and recipient. The paper copy of the deed is retained for 3 years after reception of final payment to all those who were displaced. An electronic copy of the deed is retained in perpetuity inside ERMS (electronic record management systems) as required by the Indiana Commission of Public Records.

If the negotiation process fails, a condemnation suit may be filed by the condemning agency, with the date of lawsuit filing recorded. A condemning agency is required to provide a written offer to purchase at least 30 days prior to filing a condemnation suit. Additionally, the law says that the condemning agency will need to file a condemnation complaint not more than 2 years after the acquisition offer letter to the owner of the property.

**Each district has a ROW engineer or consultant that collects the data and enters them into Oracle. Data in Oracle are available both at the district level and with the Real Estate office in Indianapolis. The data contained in LRS are reported to the FHWA Office of Real Estate Services in order to comply with the Uniform Relocation Assistance and Real Property Acquisition Policies Act. The data contained in LRS do not have a spatial (GIS) component. ROW width is an attribute in EXOR, but it is to be used as a reference. The need to get the fine-grained (legally binding) INDOT ROW mapped in a GIS database has been identified. However, resources have not been available to make it a reality.**

**Figure B.12** ROW Data Collection by the Land Records System technical memo.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Wayne Richardson

**Date:** 7/13/2010

**Re:** Road Weather Information System and Maintenance Decision Support System interview with Bill Cornett July 7, 2010

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## Road Weather Information System (RWIS)

The RWIS is made up of stations that possess sensors in the field that relay weather information. There are currently 28 statewide in Indiana. These stations are made up of two pavement sensors and more sensors on a pole near the roadway. The pavement sensors are set up in the bridge deck and on the approach and they record surface and subsurface temperature. On the pole is the remote processing unit (RPU) as well as sensors that measure: temperature, humidity, wind speed, gust, and direction. A camera is present and rotates around taking photos in all directions. Also on this station is a precipitation sensor. INDOT uses a reliable but not very high tech sensor that just acknowledges if there is precipitation or not. These stations are dependable but could be upgraded in the future with additional funding. The stations located along the Indiana Toll Road have fallen into disrepair since the road has been privately leased. The information from these stations is relayed via landline to a central location. The information is stored for two years.

## Maintenance Decision Support System (MDSS)

Meridian Environmental Technology Inc. has developed a suite of MDSS management tools. The goal of the system is to help make decisions about maintenance deployment to best utilize resources, especially during winter weather. The MDSS receives data from RWIS and other sensors (such as National Oceanic and Atmospheric Administration (NOAA) sensors at airports) to try to predict time and location-specific weather forecasts along the roadways. Effective decisions regarding deployment of snowplows cannot be made without this information. Recommendations are made by the system regarding maintenance treatments at an “optimal rate” according to the predictions. As more information is gathered by multiple states, the recommendations made regarding snowplow deployment can become more reliable for the type of response to new storms.

Fifteen states have pooled their funds to develop this operational MDSS. INDOT went with statewide implementation in the winter of 2008-2009. As the system uses many different input sensors, it can predict the weather rather accurately. Of the 15 states, there is receptivity for the states which leads to better regional information predictions. This prediction can have multiple uses. It is currently used for maintenance deployment. Other uses could be ITS type by informing the traveling public through dynamic message boards. This may be an area of interest to INDOT in the future as a way of expanding its capabilities for informing the public.

**Figure B.13** Road Weather Information System and Maintenance Decision Support System technical memo.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Menna Noureldin

**Date:** 09/13/2010

**Re:** INDOT Signalized Traffic Count Data (Interview with Traffic Management, Signal Systems Manager Jim Sturdevant)

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The INDOT Office of Traffic Management collects traffic counts and turning movements at signalized intersections and travel time at the corresponding corridors for the purpose of signal retiming and new signal timing. The traffic count data are continually collected at 15-minute bins at intersections that are automatic count capable and as needed for signal retiming at other intersections with a maximum interval of approximately 3 years. Travel times are collected continually by Bluetooth in enabled corridors and manually before and after signal retiming.

Installation of automated data collection equipment is done on the basis of whether the data at the location are dynamic enough or show enough variation with respect to time of collection (time of day or time of year). All new or rebuilt intersections are enabled with automated data collection equipment.

The data are approximately 90% accurate whether done automatically or manually. The main data collection issue cited was the labor-intensive nature of manual data collection versus automatic data collection. Twelve- hour manual traffic counts require a minimum of 12 man-hours, often with 24 man-hours allocated. Similarly, Bluetooth data collection for time travel is preferred to floating car studies; in addition to being labor-intensive, floating car studies can't capture the continually changing travel time of a corridor.

The data collected by the Office of Traffic Management with respect to signalized traffic counts and corridor travel times are stored in Postgre SQL with Access frontend. The database was customized to meet data collection, storage, and access needs of the Office of Traffic Management. Currently, there is no web interface to facilitate data sharing with other INDOT offices or divisions.

**Figure B.14** Signalized Traffic Count Data technical memo.

**SPR-3432**

# Memo

**To:** Study Advisory Committee

**From:** Menna Noureldin

**Date:** **09/14/2010**

**Re:** Vehicle Crash Data Collection System

**Interview Sources:** John Nagle, Melissa Baldwin, Roger Manning

**Document Sources:** Center for Road Safety Five Percent Report, Tippecanoe County Area Planning Commission 2008 Vehicle Crash Report, INDOT Highway Safety Improvement program webpage, NHTSA 2010 Report "The Model Electronic Crash Data Collection System")

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## INDOT Crash Record Database (ARIES) Description and Uses

From January 1, 2003, Indiana State Police has utilized the services of Open Portal Solutions to generate and store electronic records for crash data from the crash records submitted by police officers in Indiana. Crash records in the Automated Reporting Information Exchange System (ARIES) are accessible to the Indiana State Police. The record for each collision can be searched using a query tool using time or location attributes such as date of crash or county where the crash occurred.

The database is used to investigate the crash history of locations to help identify, prioritize and justify projects. It is also used to determine systematic safety improvements such as Cable Safety Barrier on the Interstate System. The database is essential for preparation of the Five Percent Report required annually (5% locations that have the highest safety needs) and submitted to FHWA under SAFTEA-LU's Highway Safety Improvement Program (HSIP).The Five Percent Report identifies locations with the highest safety needs using both the frequency/density and severity of crashes. The locations are ranked first by KA crashes (number of crashes with fatal and/or incapacitating injury outcome), and then by Index of Crash Cost. The Index of Crash Cost is a statistical measure that indicates whether or not the total crash loss at a location is significantly higher than the loss expected for the exposure and the type of location. The crash cost index is the difference between the actual crash loss and the expected crash loss, for all crash types, divided by the standard deviation of the difference of estimates.

The five percent lists are presented by state jurisdiction segments, state jurisdiction intersections, local jurisdiction road segments and local jurisdiction intersections. Each list is then sorted by county and then by decreasing value of the Index of Crash Cost.

As a result of the Five Percent Report, safety experts conduct onsite safety reviews across the state. INDOT then programs projects at the locations where engineers conducting the reviews identified feasible infrastructure projects to improve safety. The report's results therefore provide the basis for updating Indiana's Strategic Highway Safety Plan (SHSP) in order to utilize HSIP funding. The SHSP is a living document designed to identify, analyze, and prioritize the greatest threats to highway safety. It identifies countermeasures designed to lower the number of crashes, injuries, and deaths that occur each year on Indiana highways. It encourages government agencies and safety advocates to work across jurisdictional boundaries to address crash problems regardless of where they occur.

The crash data are also available to the general public with a fee of $12 per crash report at buycrash.com. ARIES/VCRS (Vehicle Crash Record System) crash data are well integrated with the State DOT's roadway inventory file using automated location coding tools (as calculated by the application when a certain intersection or milepost of

**Figure B.15** Vehicle Accident Data Collection System technical memo.

Interstate, State, or US road is inserted). A "clickable" electronic map application has been proposed to aid officers in accurate crash location referencing from the field.

## Strengths and Weaknesses of ARIES Crash Reporting Process

One of the strengths of ARIES is that it is a nearly complete picture of all crashes regardless of severity, which provides more information on which to evaluate roadway safety performance. As the database and electronic reporting have matured over the five years since its deployment, electronic crash submissions have increased from 32% to nearly 100 percent, to the point that paper crash reports are being eliminated. Additionally, the timeliness of crash report submissions has improved from 8% of reports submitted within 5 days in 2003 to 83% submitted within 5 days in August 2009. A weakness of ARIES is that it is an "as submitted" database and crash reports are not edited for accuracy after submission. Although the automated process is continually improving, erroneous data may escape built-in automatic checks. Further, it is a "Live" database, meaning there is no cut-off for entry or supplementing (correcting) of crash reports. For example, if a police agency finds that a crash report from 2003 had not been transmitted to the database, it can be submitted at any time. In addition, while most reports are transmitted to the database within five days, it is possible that some will not be transmitted for several weeks, months or years. ARIES data records are not always supplemented, or if they are, not always in a timely fashion. An example would be when an injured person dies after a crash report is submitted.

The biggest issue for crash data is the consistency with which the original reports are filled out. For example, some roads have various names and this complicates the process of extraction of electronic record for crash analysis reports. The ARIES system uses location information provided on the report (Roadway Name/Number and Intersection Name/Number) to determine a location for map display. Very consistent and correct (spellings, etc.) of these fields is required. Additionally, a few local police agencies use different software systems to generate an electronic crash report which they need to convert to ARIES format for the crash record to be stored with the State Police.

Problems also arise from the outdated State Roadway Inventory, with respect to new roads, new alignments, road name changes, one-way road pairs, interstate ramp crashes, and county road crashes. A lot of intersection crashes are not counted as such because they occur at commercial entrances (private roads owned by business owner) or are school entrances. For example, approximately 24% of crashes reported in Tippecanoe County are excluded from this roadway safety analysis because they occurred in alleys, parking lots/garages, loading docks, and private property.

As a Metropolitan Planning Organization (MPO), the Area Plan Commission of Tippecanoe County compiles an annual crash report, that is similar to the Five Percent Report but with a more local focus, to encourage public safety and awareness and to help identify hazardous locations that may require further study or qualify for Indiana's HSIP funding. MPOs receive a portion of INDOT's HSIP funding. Every year, Tippecanoe County (MPO) has to conduct a quality check on the record of approximately 6000 crashes as part of their annual local vehicle crash report. The estimated time for the quality check process is 100-150 hours. The quality checks are conducted by checking the ARIES crash report diagram and narrative fields against alphanumerical fields that represent crash location for consistency. Tippecanoe County's performance of a data quality check for its annual vehicle crash report introduces the question of whether there's a need for INDOT to do the same for its Five Percent Report.

## Criteria for Classification of Vehicle Crashes and Report Completion

If the answer to each of the traffic incident questions below is "yes", the incident is a crash:

1. Did the incident involve one or more motor vehicles?
2. Of the motor vehicles involved, was at least one in motion?
3. Did the incident originate on a traffic way, or on private property; and where injury or apparent damage occurred?
4. Was there at least one occurrence of injury or damage, which was not a direct result of a cataclysm (act of nature)?

A report should be completed and is required by law if the crash involves more than $1,000 or more in property damage, or when personal injury or death has occurred.

**Figure B.15** Continued.

SPR-3432

# Memo

**To:** Study Advisory Committee

**From:** Jon D. Fricker

**Date:** Posted 10/26/2010, Revised 11/17/2011

**Re:** Work Management System, Maintenance Quality Survey

**Sources:** Telephone conversation about INDOT's Work Management System (WMS) between Krystal Cornett (KC), Work Management Section, Highway Operations Division, INDOT and Jon Fricker (JF), Purdue University, Thursday 25 February 2010, 10:01-10:27AM

Spreadsheet of the Maintenance Quality Survey Inspection program. The program evaluates road-related features on the basis of the quality with which they have been maintained.

Telephone conversation about INDOT's High Mast Tower Lights' Inspections between Larry Goode, MQ Manager, Division of Maintenance, INDOT and Menna Noureldin, Purdue University, Monday 12 December 2011, 1:40-1:47 PM

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## Work Management System

Several days before the phone call, KC had assembled and sent to JF a 6-page description of the WMS. During the same time frame, KC had been sent the proposal for SPR-3432 and the notes from the SAC meeting of 15 February 2010. JF had a few questions about the WMS (based on KC's description and on comments made during the SAC meeting) and KC wanted to (a) clarify to the SAC members what WMS is and does, and (b) clarify whether she could play a meaningful role as a new SAC member.

Most of JF's questions had to do with terminology. Those details are not presented here. The summary presented below deals mostly with issues that arose in the SAC meeting and are likely to be important to the research study.

1. INDOT's Work Management System (WMS) is incorporated with several major INDOT data systems. It is a data collection tool and a data receptacle. WMS tracks roadway, roadside, and facility assets. Each asset type has numerous attributes, which are available upon request. (It is a lot of information.) In the list below, the first column in each pair of columns is the asset type and the second column indicates in which WMS module the asset is tracked.

**Figure B.16** Work Management System and Maintenance Quality Survey technical memo.

**Inventory Item: Roadway/Roadside Assets in Work Management System**

| Asset Type | WMS Module | Asset Type | WMS Module |
|---|---|---|---|
| Arms | Signals | Medians | Roadway |
| Attenuators | Roadway | Mowables | Roadway |
| Bridge Structures | Roadway | Overhead Structures | Roadway |
| Controller | Signals | Plumbing | Facilities |
| Curbs | Roadway | Poles | Signals |
| De-icing System | Facilities | Pumps | Facilities |
| Detectors | Signals | Road Sections | Roadway |
| Ditch | Roadway | Roofs | Facilities |
| Dividers | Roadway | Safety | Facilities |
| DWTS | Facilities | Shoulders | Roadway |
| Electrical | Facilities | Sign | Roadway |
| Employee | Resources | Signals | Signals |
| Equipment | Roadway | Site | Facilities |
| Fences | Roadway | Small Culverts | Roadway |
| Fixtures | Roadway | Snow Routes | Roadway |
| Guardrail | Roadway | Special Markings | Roadway |
| Head | Signals | Striping | Roadway |
| HVAC | Facilities | Structures | Facilities |
| Interconnect | Signals | Turn Lanes | Roadway |
| Mechanical | Facilities | Underdrains | Roadway |

2. Maintenance Quality Survey, an application used by the Operations Division and developed by the GIS Office, contains roadway/roadside asset condition information. This information is imported from the Management Information Portal. Quality data are collected using tough book, touch screen laptops, used by the Maintenance Quality Survey (MQS) collectors. Paper forms are often used to record data for small structures and underdrains, which are entered into WMS and stored in the same MQS table.

3. In regards to asset inventory data, the Pathways roadway inventory data are used as a baseline. WMS is used to create/edit/deactivate assets. Roadway asset inventory data can be collected by construction, testing, traffic, and/or maintenance personnel, using the GIS functionality of WMS with/without GPS or adding a tabular record directly into the inventory table, while in the office using RP's.

4. Before 2007, WMS just had quantities of assets (e.g., 32,000 culverts in a Subdistrict), without locations. Now asset locations are being entered.

5. Field users report work performed and asset condition. It is expected that every asset (culverts, signals, etc.) will be reported individually in WMS by July 2010.

6. WMS includes inventory and work activity data. Example: guardrail repair. It is already in the Management Information Portal (MIP) with SPMS or PS. Contact: Joel Bump. Only select work activities are in MIP; those were filtered to the activities considered most important to SPMS at the time. Other work activities could be added, if deemed beneficial to anyone.

7. Work on assets is identified in the WMS. It allows annual work plans to be converted into monthly schedules (in 2-week periods). Crew leaders, et al. (see WMS description p. 2) can enter assets and their associated data in the WMS.

8. It is possible that assets entered into WMS are not in other databases, and vice versa. For example, a bridge in WMS may not be in the BMS database. EXOR may not have some new roads in its database. Snow routes are only in WMS; we cannot see some of them in the WMS GIS functionality, though, because our base route layer is missing segments from EXOR and any assets that are on that missing EXOR route won't show up in the WMS GIS.

9. Date when work has been performed or is scheduled to be performed is in the WMS.

10. Some features allow projections of asset condition and alternatives for asset management. With at least three years of data, work order histories and/or the trend in asset condition can be projected to create a work plan.

**Figure B.16** Continued.

Example If a minimum quality rating of 90% is desired for pipes, how much should be budgeted to maintain that rating? Or, what average condition rating can be maintained, given a specified budget?

11. It was decided that KC participate as a member of the SAC, at least until the next SAC meeting. By doing so, KC will be better able to monitor the study's activities and inform the researchers and SAC members as to how WMS relates to other INDOT data collection efforts.

| **MQS Inspection Program**<br>50% of all items inspected each year. | **WMS LOS Categories** |
|---|---|
| **Shoulders**<br>Drop-off or build-up exceeding +/- 2 inches for 15 linear feet. Every 100 linear feet. | Shoulders |
| **Small Culvert**<br>50% or more of culvert obstructed or water covering 6 feet or more of the paved surface, for 10 linear feet. Evaluate every fourth culvert, every five (5) miles of travel. | Culvert |
| **Underdrain**<br>More than 25% of pipe obstructed. Evaluate every fourth underdrain, every five (5) miles of travel. | Underdrain |
| **Ditch Obstruction**<br>50% or more of ditch filled with debris or standing water 1 inch in depth or greater that covers 6 feet or more. Every 100 linear feet. | Ditch |
| **Pavement Deterioration**<br>Pothole exceeding 1.5 inches in depth. Each six (6) feet by six (6) feet of adjacent paved surfaces.<br>Rutting exceeding 1.5 inches in depth within wheel track. Each 1/10th of a lane mile.<br>More than two cracks within a four (4) foot by four (4) foot square area: Single or at widely scattered locations. 1 per lane mile. | PVMT Detail? |
| **Pavement Failure**<br>Pavement blow-up exceeding 2 inches. Each.<br>Sag, push, or slip exceeding 2 inches. Each.<br>Non-flush manhole or curb inlet exceeding +/- 1 inch. Each. | PVMT Fail |
| **Bridge Obstruction**<br>Clogged drain holes and gutter lines, and poor quality expansion joints and deck surface. Each. | Bridge |
| **Guardrail**<br>50% crushed, 50% torn, wrong height, missing rail. Each rail panel.<br>Spacer Block—rotting or missing block-out. Every 3 continuous block-outs. | Guardrail |
| **Cable Barrier**<br>Cable Barrier—Cable touching ground. Every 0.5 miles of cable rail system. | Guardrail |
| **Crash Attenuator**<br>Damaged or Missing. Each or 2 deficiencies per guardrail (on each end). | Attenuator |
| **Sign**<br>Sign that cannot be clearly read. Each: sign per mile.<br>Missing sign. Each: sign per mile.<br>Missing or damaged mile marker. Each. | Sign |
| **Pavement Marking**<br>Excess of 150 linear feet missing or significantly faded. Each 0.10 of a mile. | PVMT Markings |
| **Special Marking**<br>Stop bar with 25% or more missing, one or more significantly faded or covered. Each.<br>Lane arrow with 25% or more missing, either arrow significantly faded or covered. Each.<br>Pavement word and symbol with one or more elements missing; significantly faded or covered. Each.<br>Transverse lines delineating an island with 25% or more missing, faded, or covered. Each. | Special Markings |

**Figure B.16** Continued.

### High Mast Tower Lights' Inspections

During the November 2011 SAC Meeting, MQ Manager Larry Goode requested the inclusion of information about High Mast Tower Light inspections in the final report. The inclusion highlights INDOT's constant efforts to fulfill its mission of cost-effectively ensuring that highway infrastructure is safe for the traveling public. In years past, the inspections were conducted by a consultant, but they are now conducted in-house at a dramatically reduced cost.

The research team sent an inquiry to Larry Goode to ask about the specifics of the in-house inspections of High Mast Tower Lights. The inquiry consisted of the following questions:

1. What information is collected during inspections (e.g., locations of the towers, their structural soundness, their operational status)?
2. Are the locations and conditions of the high mast towers recorded in the Work Management System (WMS) or the Management Information Portal (MIP)?
3. To which INDOT office or division is the information communicated for the purpose of conducting maintenance on the towers?
4. What is the cost of collecting this data? AND/OR What are the resources required every year to collect this data (personnel or equipment)?

Below are the responses received, as well as a cost comparison of inspecting High Mast Tower Lights in-house versus outsourcing.

1. Information collected
    a. GPS tower location
    b. Structural soundness, loose bolts, cracks, and section loss.
2. Recorded on shared Y: drive on an Excel spreadsheet Not recorded in the work management system or the management information portal.
3. Communicated to the Division of Highway Maintenance and District Support (Highway District Maintenance Directors, District Traffic Engineers, and Traffic Operations Managers)
4. INDOT Quality Assurance Inspectors
    a. Two 2 man crews, one North and One South
    b. Refer to attachment for cost of inspections.

**Figure B.16** Continued.

**High Mast Tower Inspection**

**Data Cost Calculations**

| | |
|---|---|
| Over 200 towers inspected per year | |
| | |
| North Team | |
| 2 men x 3 wks x $776.75 = Labor cost of | $4,660.50 |
| 3 wks x 3 days lodging x $80 = Lodging cost of | $720.00 |
| 10 gal x $3.25 x 4 days x3 wks = Fuel cost of | $390.00 |
| Van est. cost =$21/day x 12 days | $253.00 |
| | $6,023.50 |
| South Team | $6,023.50 |
| Tools | $200.00 |
| | |
| Total Est. Cost | **$12,247.00** |
| | |
| Cost of Contract $200,000 | |
| or $732 per tower | |

**Figure B.16** Continued.