GIS STRATEGIC PLAN
for the
IOWA DEPARTMENT OF TRANSPORTATION

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Iowa DOT GIS Strategic Plan

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A key element in the development of an effective strategic plan is an awareness of external trends. Technology is one of the major topical areas identified that can be routinely scanned for trends identification. Within this broad topical area, a range of issues are critical to the Department at the present time. Among those are global positioning systems, intelligent transportation systems, wireless communication, computer systems and software, and geographic information systems/transportation (GIS-T).

- Iowa DOT Strategic Plan (paraphrased)

1 INTRODUCTION

This report documents a project conducted by the Iowa Transportation Center for the Iowa Department of Transportation (DOT). The goal of the project was to develop a strategic plan for DOT implementation of geographic information system (GIS). In addition to documenting the recommended plan (Chapter 5), this report is intended to serve as a repository of relevant information, including a summary of work to date, related studies and efforts, and issues with the potential to affect the implementation of GIS at the DOT. The report is intended to be a living document, and as changes occur in the implementation environment, the observations and recommendations made herein should be updated to reflect those changes. As such, it may serve as a resource for the DOT GIS staff and as a central source of current information on activities related to the technology.

While important at the individual project or application level, a strategic plan should not attempt to provide firm estimates of the number of hours or dollars that will be required to implement GIS at the DOT. Rather, the plan is intended to serve as an overall framework and guide for pursuit of the most effective use of the technology available. The plan builds upon the work and investment already made in information technology and GIS at the DOT and elsewhere. For example:

- NCHRP project 20-27, the National Cooperative Highway Research Program project "Adaptation of GIS for Transportation" conducted by Al Vonderohe et al at the University of Wisconsin
- AASHTO pooled-fund GIS study. Forty-one states and a number of private sponsors are supporting this study being conducted by a consortium of the Alliance for Transportation Research, New Mexico State DOT and Universities, and Sandia and Los Alamos National Labs. The purpose of this study is to design a prototype GIS-T for ISTEA management systems and other state DOT functions
- Keystone's "Systems Application Study: An Evaluation of Geographic Information Systems for the Iowa Department of Transportation," conducted for the Department in 1989
- Bielfuss' "Highway Location Reference Procedure Project" conducted for the Department in 1990
- Pilot and demonstration GIS projects, conducted by the Department in cooperation with the Iowa Department of Natural Resources between 1990 and the present

Much information is available from the national studies, and together with lessons learned in Iowa and at other state DOTs, it has been incorporated into this document. For more information on any of the sections in this report, the reader may read sections in the literature (chiefly the NCHRP reports) referenced herein. In keeping with the dynamic nature of GIS and the rapidly developing technology, new information should be examined continually and incorporated - especially information on the experiences of Iowa and other states as they implement the information/database provisions of ISTEA and other legislative mandates. Efforts toward efficient reorganization of the DOT and total quality management also will contribute to better GIS utilization.

1.1 Geographic Information Systems [GIS]

Defined broadly, geographic information systems are powerful computer-based tools for the capture, storage, management, retrieval, query, analysis and presentation of spatial data. In its simplest form, one may envision it as maps or drawings with as much detailed data as needed about each point of interest for a given study or activity. More than just software, an effective GIS will comprise hardware, software, data, trained personnel, and user-friendly procedures to assure quality, security and efficiency. Applications can be as simple as recording the location of vehicular accidents in a standard error-free format to the sublime, requiring a significant investment in time, human resources and capital. Large-scale implementations of GIS can take years to come to fruition.

GIS are not end products. The decision to use GIS is nothing more than a decision to improve the tools at our disposal to support operational and management decisions. Because of the vast amounts of geographic based data already being collected, maintained and used by transportation agencies, GIS have the potential to be very valuable tools indeed.

1.2 GIS for Transportation [GIS-T]

Geographic information systems for transportation provide an electronic database (set of attributes or descriptors) for each point on a digital map. Therefore GIS-T can display network attributes, perform spatial analyses, conduct route analyses, and geo-reference elements of transportation inventory. A GIS-T can identify features existing at a specific location or conversely, find locations satisfying specific conditions. It can spot changes in area over time, find patterns, and model various scenarios very rapidly at a cost that is modest compared to an attempt to do the same work manually. Essentially a GIS-T can integrate uniform and relatively error-free spatial information with almost all transportation data currently being collected. (*see NCHRP, 1993a, Chapters 1,2*)

1.3 Need for Study

Preparation of a strategic plan is essential to help visualize the potential, limits and impacts of a GIS-T. In some pilot programs, a philosophy of "let's get the hardware and software, start loading data and decide what we are going to do with the system later" was adopted (Croswell, 1988). This philosophy has often led to inefficient use of resources and "dead end" programs. This can quickly dampen the ardor of former GIS supporters. A strategic plan should provide wider vision as well as methodical guidance for future decisions. Strategic planning is necessary regardless of the scale of implementation.

The purpose of this study is not to champion the use of GIS in all areas. In fact, when we examined studies of this sort, and the literature in general, we got the impression that the potential was oversold, that "nothing could go wrong", that all GIS stories are success stories, and that what an organization needs most is convincing that GIS is a powerful technology for solving all problems, i.e., that GIS is a "silver bullet". Demonstration projects and software demonstrations effectively promote the powerful capabilities of GIS, but rarely highlight potential costs. There are, however, documented cases of GIS failures at substantial levels of resource investment (Thrall, 1994). Much can be learned from close examination of GIS failures. A major feature of a good strategic plan is to avoid these well marked reefs and shoals.

While the foregoing warns us proceeding very far without a strategic plan has its drawbacks, so does doing nothing. If a large organization waits until all potential problems are identified and solved before proceeding, it may never implement an integrated, effective and efficient GIS. More importantly, some of the most difficult problems faced by those attempting to implement GIS will not surface until the technology is tried. This is a primary motivation for a pilot study, similar to the project currently underway at the DOT (see Chapter 3 for more details).

A compromise between the philosophies of "let's just get going" and "lets wait until we know everything" is essential. Limited financial resources, a mandate for more efficient government, improved quality and especially the lack of time and staff resources motivate the need for an effective, realistic, and (most of all) flexible plan for tapping the immense potential of GIS. The plan must provide for implementation independent of unresolved institutional issues and without wasting resources or creating more work for already-overloaded support units.

1.4 Study Approach

The purpose of a Strategic GIS Plan is to promote and guide the development of applications - the point at which GIS begins to pay off by streamlining analysis to support decisions. Plangraphics has identified a procedure for effective applications development. First, the operation of the organization (DOT) must be examined. This examination should encompass three components: data input requirements, processes used to produce output, and output products themselves. With applications defined in this manner and their context and priority within the organization identified, a foundation is laid for efficient system development. (see Croswell, 1988)

A strategic planning process based on applications definition should examine what offices will be affected by which applications. The applications are then prioritized. The system developed for the Iowa DOT uses one or more representatives from each office to estimate benefits and costs (where possible). Classification of the applications into categories is relative and based on programmatic needs, organizational activities, intensity of use, and possible efficiency gains from automation. The development, use and evolution of databases as well as communications, software and hardware need to be factored into the analysis. (see Croswell, 1988)

Candidate applications should then be selected and studied in detail to more fully define the full cost of implementation in a production environment. This "functional requirements study" will involve database design, hardware and software selection, communications, development of precise implementation procedures, and specification of staffing requirements.

1.5 About the rest of this report

This report has been organized into stand-alone chapters. Appendices cover the information obtained through surveys and literature reviews. Following this introductory chapter:

- v**Chapter 2 - Implementation** - Introduces the factors that are critical in the successful implementation of GIS as developed by the NCHRP 20-27 and shows how these factors are important to GIS implementation at the Department (NCHRP *1993a*). It also contains a list of implementation issues developed by the research team and some potential implementation problems.
- v**Chapter 3 - Related Efforts** - Reviews studies that were conducted on both a national level and state level for the implementation of GIS. It also contains a general overview of the computing resources at the Iowa DOT and past studies that have been conducted in the GIS arena.
- v**Chapter 4 - Project Activities to Date** - A progress report on GIS implementation to date. It summarizes what the research team focused on in the

identification of applications. It lists the offices visited , the questions asked and potential applications developed for each office along with a corresponding category for each application.

Appendix 4-A - Potential GIS Applications

Appendix 4-B - Implication of ISTEA Management Systems

Appendix 4-C - Office Applications Interview

v**Chapter 5 - Implementation Plan** - The Strategic GIS-T Plan itself (future activities). It describes recommended implementation processes and contains guidelines on how to select hardware/software, issues in database development, and how to evaluate the system after implementation.

Each chapter should be updated as required. For example, as new projects are designed, they should be summarized and referenced in Chapter 3. As steps are taken toward implementation, the documentation of same should be moved from Chapter 5 to Chapter 4. Such updating is key to management, quality control, and timely useful status reporting as the Plan is executed.

It will be important to credibly document and disseminate the experiences of all GIS efforts, successes as well as failures. This can be built into the reports within Measures of Effectiveness [MOEs] or Progress Reports. The precise reason(s) for meeting or not meeting a milestone or deadline will be equally important to the designers of future GIS-T applications and should be noted and referred to during future project selection and configuration. This provides a specific mechanism for disseminating good concepts and ideas and learning from (and avoiding a repetition of) past mistakes.

2 IMPLEMENTATION ISSUES

Prior to development of a GIS strategic plan, an organization should address needs and impacts in six critical areas - called Factors - listed below (NCHRP, 1993a). But it is important to evaluate these Factors in a context specific to Iowa, since national models may or may not be relevant. GIS is not new to the Iowa DOT and experience has led to the identification of some current factors that could hinder necessary changes within the organization. The final section of this chapter identifies and discusses these potential restraints along with associated implementation problems.

Much of this chapter is taken directly from the Adaptation of GIS for Transportation, the recent NCHRP 20-27 project. That report asks many of the questions facing states as they investigate the best use of GIS technology and provides a good starting point for GIS strategic planning in any transportation agency. This chapter resulted from a close examination of the 20-27 findings with a view toward their relevance to the Iowa DOT. Following each section of NCHRP information, implications for Iowa are presented.

2.1 Six critical success factors

An early step in the planning process for implementing GIS at the DOT is to examine existing agency needs and resources. These may be categorized under six headings called "critical success factors" and are addressed in this strategic plan:

vFACTOR 1: Integrated Information System Strategy

vFACTOR 2: Staffing

vFACTOR 3: Requirements Definition

vFACTOR 4: Data Architecture and Strategy

vFACTOR 5: Education and Training

vFACTOR 6: Sponsor and Champion.

> NCHRP: For GIS-T to be most effective, it must be fully integrated with the agency's overall information systems strategy. GIS-T can provide the conceptual basis for the overall information systems architecture with nearly all of the corporate data linked through location. To define GIS-T requirements, potential GIS-T applications for both the short and long term must be identified and prioritized. Internal agency needs as well as the potential for

> interaction with other agencies, both public and private, must be considered. A broad view of potential applications will require a GIS-T with the full range of functionality.
>
> Given a list of potential GIS-T applications, it is now possible to identify both general and application-specific functional requirements for the GIS-T. (NCHRP *1993a, Section 4.3*)

Iowa DOT Implication: The success of the GIS at Iowa DOT will be greatly determined by the ability to integrate the technology into an overall information system strategy. The DOT's "Futures Agenda" identifies rapidly changing technologies as opportunities to improve services and productivity as does the DOT's "Strategic Plan". Chapter 4 of this report details the research team's efforts to define GIS-T applications meeting the needs of individual office missions. As part of this project, the DOT's "Information Processing Program and Plan" was reviewed. This plan covers a one-year time frame, but does attempt to forecast needs for two years and supports the DOT's Futures Agenda as well. The goal of the IPP Plan is to "increase agency productivity through computer automation of functions where feasible and practical and to provide the most effective information services possible to agency divisions."

During this project, regular meetings were held with representatives of DOT's Bureau of Information Services. However, while the goals of this project and the IPP Plan are certainly complementary, no explicit attempt has been made to date to coordinate the GIS planning activities with the DOT's overall IS strategy. Explicit tasking of a GIS-T Coordination Committee serving as a subcommittee of the IP Steering Committee would include this essential integration effort.

2.1.1 FACTOR 1: Integrated Information Systems Strategy

In an integrated information system strategy; three important considerations are: use of multiple technologies, integration of data and systems, and effective planning.

2.1.1.1 Multiple technologies

> NCHRP: DOTs need to plan for and combine the simultaneous implementation of several promising technological developments. At the present time GIS is not the only emerging technology that should be incorporated in an information technology plan. There are a number of others all of which must be coherently integrated. Treating the different emerging technologies in isolation (i.e., developing a separate plan for each) is to miss

> their interdependencies and to fail to take advantage of the ways in which they complement each other. There will be significant benefits in merging them into a single, coherent plan. *(NCHRP 1993a, Section 3.1.1)*

Iowa DOT Implication: The Iowa DOT should include GIS implementation in an overall information technology plan. Currently, planning for GIS is not fully integrated into planning for other emerging technologies. For example, a GPS committee has recently been formed at the DOT. Liaison or more formal coordination should be provided with the proposed GIS Coordination Committee. The GIS strategic plan should fit into a larger plan that includes GPS and other emerging technologies. It is also critical that coordination be provided between GIS plans and plans for ISTEA mandated management systems at the Department. An early step should be establishing communication between the GIS Coordination Committee and the Management Systems Committees. Issues such as database design and development cannot be effectively approached and resolved without such coordination.

> NCHRP: Several of the technologies on the following list have been around for some time. They constitute new technologies in that they will be reaching practicality and affordability within the next 5 years; in every case, they will be extended beyond the isolated pilot implementations to become ubiquitously applied, generally accepted state of the art. The list includes the following:
> 1. Networking. Included among many noteworthy developments relevant to networking are developments in fiber optics, national planning for "data highways," ISDN implementation by telephone companies, and developments in data compression techniques.

Iowa DOT Implication: The Department has several networks already in place. There is considerable interest in providing high speed access to Internet, Iowa's ICN network, World-Wide-Web (W3) , and others. An assessment of current conditions and a plan for future connections and networks should be integrated with the plan for GIS implementation. Data users must be provided effective access to the Internet in order to assure the best utilization of resources, promote data sharing and minimize duplication of effort.

> NCHRP: 2. Low-cost powerful computing engines, from parallel-processing supercomputers to $1000 1000-MIPS (Millions of Instructions per Second) personal computers before the year 2000. There is consensus agreement among experts concerning the 1000-MIPS prediction. What can so much cheap computing power possibly be used for? It is a prerequisite and an

> enabling technology underlying several of the other new technologies on this list.

Iowa DOT Implication: Low-cost, powerful computers are already having their effect on the DOT. Past trends toward decentralized networked computing are likely to continue. Today, GIS is known for its complexity and significant computing requirements. Perhaps the most important implication for GIS is the capability of desktop computers to perform the processing-intensive GIS tasks. These computers, together with more user-friendly interfaces will give authorized personnel at the DOT the capability of accessing GIS databases and applications.

To this category, we would add low-cost yet powerful portable computers. Use of these (pen or voice based, small, rugged) computers in conjunction with advanced data capture technologies (e.g. GPS, bar codes, ...) is promising for field studies (maintenance, inspection, ...) and is currently being investigated by the DOT.

> NCHRP: 3. Distributed and cooperative computing based on decomposition of computing tasks and assignment of subtasks to separate but interconnected computing engines. Appropriate decompositions are determined on the basis of separability of functions, different mixes of the functions being needed for different applications, and the efficiency and possible standardization of communication among the functions.

Iowa DOT Implication: "Distributed and cooperative" accurately describes the way the many functions of the Department are already accomplished. Networks are already in place at the DOT to support this type of environment. Computing resources should be made available to support all organizations to accomplish the mission of the DOT. New processes including information engineering, departmental reorganization, new management systems, and TQM strategies should produce the requirements for distributed and cooperative computing (computing driven by business process needs).

> NCHRP: 4. Client-server network architectures. The essential idea here is division of labor among network nodes. Each node is specialized to provide a particular computing service to other nodes on a network. Each node functions as both a server to, and client of, other nodes on the network.

Iowa DOT Implication: This point is closely related to point 3. "Server-net" is a term which is often used by GIS researchers. It is the focus of many discussions about the future application of GIS. It implies a departure from existing network architectures, but the precise nature and detail of this departure is not always clear. For example, the Iowa DOT already has a network whereby one might access GIS from many nodes (although presently not supporting a graphics environment, GIS can be run from the command line). Databases are not rampantly duplicated, and applications (e.g. PMIS) exist on workstations where they are supported. There are many servers and clients in the DOT network, although not all nodes function as both server to and client of all other nodes on the network. "Server-net" seems to be a logical growth path for use of computer networks to support and access GIS, so more work needs to be done in order for this concept to be of practical use to the DOT.

> NCHRP: 5. Computer-based graphics (high resolution, true-color, dynamic, three- dimensional) and realistic, interactive visualization.

Iowa DOT Implication: These technology developments are useful, but most of the technology to support most GIS applications already exists and is not fully utilized. But it is characteristic of all technology that "nice to have" features eventually gravitate into the "essential" category. Another important consideration for the Iowa DOT is to avoid letting problems with graphics (e.g. plotting resolution which does not support aerial photography) interfere with progress in other areas where GIS can develop independently. As problems are identified which cannot feasibly be solved in-house, consultants should be brought in to provide solutions or vendors should be required to solve the problems with their new products. In most cases vendors will be willing and capable of solving these problems if the problems and the corresponding responsibility are well defined.

> NCHRP: 6. Geographic information systems. Many planners might omit this from the list because they would consider GIS technology an application rather than a new core technology. Given the potential role of the concept of location as the basis of data integration, GIS technology is not just an application but is a central part of the technology infrastructure.

Iowa DOT Implication: GIS is viewed differently by different offices and by different persons at the DOT. Some view it as technology, others as application. It may be desirable to view GIS in both ways, with interpretation often colored by project objectives and organizational perspectives. This timely topic must be revisited by the proposed GIS Coordination Committee.

> NCHRP: 7. Computer-aided design-for many different kinds of design, from design of highway intersections to design of buildings to design of VLSI circuits. Of particular importance for these purposes is computer-aided design of software systems, an area that has come to be referred to as a computer-aided software engineering (CASE). Essential aspects of CASE technology are rapid and incremental prototyping capabilities.

Iowa DOT Implication: While the DOT has extensive experience designing roadway elements with CADD, it is not known whether CASE-type experience is available. Rapid and incremental prototyping of GIS applications would be preferred to typically long development times where applications do not necessarily build upon themselves incrementally.

> NCHRP: 8. New data storage and processing capabilities. These include object-oriented data structuring; storing, managing, and processing text in the form of document images; storing, managing, and processing images of other kinds; graphical querying; optical (laser-disk) storage; and laser-disk database publishing.

Iowa DOT Implication: Multi-media is useful, will enhance some applications and indeed facilitate others, e.g., bringing up images of as-built drawings, and should not be ignored for long term consideration. However, there are many useful applications that could be designed using existing and efficient low-tech functionality.

> NCHRP: 9. Data-collection technologies. These include GPS (both geodetic and navigation capabilities), video, weather radar, softcopy photogrammetry, total station data collectors, electronic notebooks, and telemetry systems such as those for pavement condition and traffic counts.

Iowa DOT Implication: GPS technology is promising and is being closely examined by the DOT for potential application. A GPS committee has been formed, and the Motor Vehicle Division and the Operations and Finance Division as well as the Office of Transportation Data (among others) have taken steps toward appropriate use of the technology. Currently, provision of real-time differential GPS (sub-meter accuracy) is being investigated. Some of the most promising applications of the technology are improving the quality of base-maps, use of GPS for recording accident locations, and asset management (signs, pavements, and other inventories).

The other data collection technologies also hold promise for the Department. A recent project evaluating data capture technologies for Iowa is summarized in Chapter 3.

2.1.1.2 Data and systems integration

> NCHRP: The data integration problem is especially important for GIS technology adoption, because the costs of geographic data acquisition and maintenance are high and thus need to be shared across applications, and because GIS data provide the potential for integrating many other kinds of data.
>
> Data that can be shared across applications need to be considered as a corporate resource, rather than "owned" by particular applications. This is not a property unique to geographic data but it is especially apropos for GIS spatial data because of their cost, because of their centrality to integration of data of many other kinds (that is, because of their usefulness to the organization as a whole), and because of their potential use in so many different applications. (*NCHRP 1993a, Section 3.1.2*)

Iowa DOT Implication: Unlike many other organizations, DOTs already possess a large amount of spatially referenced data. For many years the Iowa DOT has viewed data as a corporate resource and the Bureau of Information Services (BIS) maintains computers and software that store data and serve the whole Department. The BIS must struggle with data integration and is impeded by lack of a common referencing system and a host of reporting requirements, each with its own referencing standard. There is duplication of data and difficulty in accessing data.

Currently the DOT is studying referencing systems. Past studies are described in Chapter 3 of this report. Chapter 4 describes the interview process used by this study team to address the data integration/access problem as each office was asked to comment on the issues surrounding use of "their" data in a corporate database.

2.1.1.3 Effective planning

> NCHRP: Information technology planning never ends - it should be considered a continuous, ongoing process attending to a regularly reviewed and updated product. At any given point in time, the product (i.e., the plan) in its current form must be recognized as rapidly becoming outdated. Only thus can an organization deal with the moving target of rapidly changing technology.
>
> Any good information technology plan must address a range of time horizons, say 10 years, 5 years, and 1 year. The longer-term horizons are necessary to set context and to assure that the organization is not planning itself into dead ends. The shorter-term ones are necessary to assure relevance

> to current conditions and responsiveness to unpredicted constraints or opportunities (e.g., financial exigencies or appearance of new software). (*NCHRP 1993a, Section 3.1.3*)

Iowa DOT Implication: Chapter 5 of this report is intended to serve as an initial GIS Strategic Plan. An early task of the Iowa DOT GIS Coordination Committee should be to revise this plan with regard to the department mission and foreseeable circumstances. This continuous process includes updating this document to produce future versions.

2.1.2 FACTOR 2: Staffing

Many staffing issues need to be addressed with the implementation of GIS. The existing staff may perceive a need to change its focus to accommodate the new technology. There will be a need to include training for the staff. The possibility of adding staff members or to reposition/reassign GIS-trained staff members to make implementation work must be recognized from the outset.

> NCHRP: Merely turning evaluation and adoption of the new technology over to traditional data processing staff, on the belief that this is just one more technology included in that staff's repertoire, will not work. The knowledge and expertise required (e.g., concerning the potential use of the concept of location as a data integrator) is not a part of traditional data processing training and experience. Significant additional training is required, for example, in the areas of geographic reasoning and of cartographic design. (*NCHRP 1993a, Section 3.2*)

Iowa DOT Implication: Defining staffing needs for implementing GIS involves examining the current organization and functions of staff and the changes that implementation of GIS might require. Staffing needs are anticipated for all divisions. GIS positions should be filled with personnel having high ability in geographic reasoning/aptitude.

2.1.3 FACTOR 3: Requirements definition

Requirements Definition includes a detailed description and analysis of the types of data needed in each department, how they are used and processed, and how they are stored and transferred to other departments.

> NCHRP: A requirements definition results from a study of the organization and its data. The process involves a number of critical decisions concerning

applications, data, software, and hardware. A requirements definition lays the technical groundwork for implementation planning and request for proposal (RFP) development.

A requirements definition should be undertaken by all those implementing GIS-T. The reasons include the following:

1. Fine tuning of previously determined generic requirements to meet more specific needs of the agency.
2. Involvement of personnel throughout the organization in determining needs-and the potentially resulting widespread interest in the implementation effort. (*NCHRP 1993a, Section 3.3*)

Iowa DOT Implication: The need for an effective Requirements Definition was the impetus for the interviews with different departments/offices/transportation centers. The result of the interview process was a better understanding of what information is used in the offices. A list of potential GIS applications also resulted (see Appendix 4-A). The requirements definition was fine tuned as specific questions were asked to obtain direct answers.

2.1.4 FACTOR 4: Data Architecture and Strategy

NCHRP: A well thought out data architecture and strategy are vital to the success of GIS-T. The requirements definition will have established priorities for application development. The first few applications to be developed will drive the selection of the scale of the initial spatial database, but the implementation strategy should consider future applications and the availability of data. Further, strategies need to be established early for maintaining the quality of the information in the database. (*NCHRP 1993a, Section 3.4*)

Iowa DOT Implication: The GIS-T Pooled Fund Study is developing a data architecture and strategy model for state DOTs. This Strategic Plan is the first step toward establishing an architecture for the Iowa DOT.

2.1.4.1 Choice of initial spatial database

NCHRP: Given the range of geographic extent and levels of abstraction that support decision making throughout the highway life cycle, no single spatial database at a fixed scale can be expected to support all applications (see Figure 7). Eventually, DOTs should probably plan on supporting at least three different scales:

1. 1:500,000 for statewide planning. This relatively high level of abstraction supports agency-wide budgetary planning and analysis,

program development and evaluation, and policy making at the upper management level.
2. 1:100,000 for district-level planning and facilities management. this intermediate level of abstraction supports budget development, strategies for program delivery, and management of resources and facilities.
3. 1:12,000-1:24,000 for engineering. These relatively large scales support preliminary engineering for projects and other aspects of program delivery that require detailed information over considerable geographic extents.

Iowa DOT Implication: Different map scales are currently being used at the Department. For statewide planning, a 1:100,000 scale base map already exists. With GPS, its is possible to improve this to 1:24,000 scale which will have an error of no more that 17 meters (95 percent of the time). However, design and engineering applications will require much better accuracy. With GIS, data at various levels of accuracy can be stored and utilized. Before a base map is created, applications identified in Requirements Definition should be examined with respect to the benefits and costs of establishing better accuracy and precision.

> NCHRP: It is wise to develop cost recovery mechanisms, perhaps in the form of charge-backs from future applications, so that the large investment in a multipurpose spatial database is spread over more than the initial applications. Manager of the first applications should not have to bear these cost alone. Also, there is a danger of associating the cost of database development with the cost of application development, with a resulting apparent high cost of applications, unless the distinction is made clear from the outset.

Iowa DOT Implication: Initial GIS applications could be expensive. The Department may want to separate database development costs from applications development costs, where possible. Once initial applications have been developed, returns to scale will create lower marginal cost of further applications development.

> NCHRP: It is critical that long-term responsibility for maintenance of spatial databases be established early. This responsibility need not necessarily be with the group that develops the database to begin with.

Iowa DOT Implication: The Iowa DOT should formally assign responsibility for maintaining the database needed to support GIS. It should be clear to all divisions who is responsible for the Department-wide GIS database (possibly BIS, Transportation Data or another office), although data supporting only intradivisional applications need not necessarily be maintained by a central office.

2.1.4.2 Sources of digital data

> NCHRP: Edge-matched digital spatial data for transportation and hydrography at 1:100,000 scale are generally available from USGS in Digital Line Graph (DLG) format. (During 1991, there were parts of some midwestern states for which these data were not yet available). DLG data include topological relationships. However, a number of DOTs have entered into cooperative agreements with USGS to fund (on a matching basis) production of these larger-scale data or to help produce these data themselves.

Iowa DOT Implication: The Iowa DOT currently uses the USGS DLGs for a base of county highway and transportation maps.

> NCHRP: Topologically Integrated Geographic Encoding and Referencing System (TIGER) data are available from the Bureau of the Census. A number of transportation agencies are working with TIGER data that include state and federal highways and local roads. TIGER data are derived from 1:100,000 USGS quads in rural areas and from GBF/DIME files in urban areas. Digital transportation data are also available from private sector vendors. These data are typically derived from TIGER, GBF/DIME, and 1:100,000 (improved spatial accuracy, edge matching, address geo-coding, etc.) beyond what is available from government sources. In any case, transportation agencies acquiring spatial data from outside sources will save scanning or digitizing cost, but should expect to invest in preparing the data to suit their own needs.

Iowa DOT Implication: A study is currently underway to use TIGER files for transportation planning at the Department (see Chapter 3, Rushton/Armstrong Study).

2.1.4.3 Quality control

> NCHRP: A viable data strategy includes quality control methods during both database development and database maintenance (3, 31). Otherwise the integrity of the spatial databases may be undermined, thus threatening the entire GIS-T enterprise.
>
> The five steps in database quality assurance and quality control form a loop (31 after 32):
>
> 1. Define database properties.
> 2. Establish processes to create the database.
> 3. Define quality control measures.

4. Obtain quality control measurements.
5. Take corrective actions.

Database properties will have been defined by the requirements definition. Processes are established to create those properties. Quality control measure might follow the methods outlined in the data quality section of the Spatial Data Transfer Standard (21): (1) comparison to an independent source of higher accuracy, (2) comparison to original source, (3) internal evidence, and (4) deductive estimate. In addition to positional and attribute accuracy checks, quality control measures should also include checks for logical consistency (do the data make sense internally and when related to other data) and completeness (geographic and taxonomic). Quality control measures, results, and corrective actions should be documented and combined with other historical metadata to produce a lineage of the database, resulting in a quality report.

Iowa DOT Implication: The department will have to develop a system of control structured along the lines of the five steps listed above. The department, or its GIS Coordination Committee will also have to determine who will be responsible for quality control of GIS.

2.1.5 FACTOR 5: Education and training

The NCHRP 20-27 report recommends three levels of GIS involvement: core staff, master users, and other users.

NCHRP:

1. Core staff must be intensely trained to the point where they are adept at database and application design and at GIS-T programming.

2. "Master" users must be trained to the point where they are comfortable with the high-level programming or macro languages of the GIS.

3. Other users must be trained minimally production staff to the point where they are comfortable with the applications and management to the point where they can make informed decisions about the technology. *(NCHRP 1993a, Section 3.5)*

Iowa DOT Implication: The Iowa DOT need not have three levels of GIS involvement in every Division. The DOT should have only one GIS core staff. Divisions with significant GIS requirements will likely designate one or more "master" developers, and it is invisioned that GIS applications will be "used" by staff in all DOT Divisions.

NCHRP: An introductory short course in GIS-T has recently been offered for the Federal Highway Administration (FHWA) and is being offered on a regular

> basis through 1992 (33). Some universities offer introductory continuing education short courses on GIS-T. Training services (introductory through advanced) can be obtained from consultants and from software vendors. Such services can be provide either on-site (if demand is high enough) or at remote central locations of the provider's choosing.

Iowa DOT Implication: The DOT recently brought in an NHI short course on GIS. It also routinely sends personnel to GIS workshops and conferences. This should continue.

2.1.6 FACTOR 6: Sponsor and Champion

> NCHRP: Examination of the most successful GIS-T operations reveals the presence of two key individuals. One shall be dubbed "the Sponsor" and the other "the Champion."
>
> The Champion is a technical manager, often in a user division but sometimes in the MIS area. The Champion is a technical leader who has vision, devotion, and enthusiasm and works well with people. This person leads the technical team and is probably also top candidate for Director of the "core" staff. The Champion seeks the approval of the Sponsor for initiatives and procurements. The Sponsor is a manager at the Bureau or Division Chief level. This person has budget authority and is a member of the management implementation team. The Sponsor must create the conditions for potential Champions to emerge, must be able to recognize them when they do, and then must be able to support them.
>
> Without Champions, sponsors must assign technical implementation tasks to staff without an enthusiastic leader and the effort might flounder. Without sponsors, Champions confront negative institutional inertia and become frustrated in attempting to implement the vision beyond the bounds of their limited sphere of influence. (NCHRP *1993a, Section 3.6*)

Iowa DOT Implication: The DOT should appoint a GIS Coordinator for the Department. Sponsors should include knowledgeable key staff who have a vision for exploiting GIS technology for the improvement of transportation in Iowa.

> NCHRP: With the appropriate commitment of resources the process can be complete in months rather than in years. Hardware costs have declined dramatically in recent years and will continue to decline. Thus, hardware should be selected to support the software and applications not the reverse.

Iowa DOT Implication: The hardware costs surrounding GIS are not expected be the deciding factor concerning GIS development. The software functionality and the applications to be implemented will determine the hardware to be selected.

2.2 Iowa DOT Initial Issues

During the first phase of GIS strategic planning for the Department, many issues were identified through one-on-one and roundtable discussions with DOT staff, discussions within the project team, review of publications such as trade journals and technical articles, attending regional and national conferences and meetings, and by other means. The following is a list of some of these issues and recommendations that came about through these efforts. **These are NOT the recommendations of this study**, rather they are intended to serve as the focus of important issues and concerns. They will also prove to be historically important as a benchmark.

Selected responses included that the Iowa DOT should ...

1. use GIS and should purchase a GIS software package(s).
2. get a SQL compatible (Structured Query Language) database for GIS, should use DB2, and should investigate using GIS with existing software, e.g. DB2, SAS, etc.
3. decide on a referencing system
4. use GIS for the seven ISTEA management systems
5. use GIS in its divisions
6. use GIS for video logging
7. use GIS for MARS (mobile accident reporting system)
8. use GIS for permit routing as both a database and as software
9. consider parallel data structures, as in the case of PMIS (pavement management information systems)
10. develop a GIS support structure including a core staff that must have access to the GIS software and access to the database. In addition, users must have the opportunity to make mid-course corrections with respect to allocation of resources from one project to another, or one task to another. Such flexibility must be built in. It is impossible to know one or two years in advance of decision making - things happen too fast. A better model is incremental development.
11. obtain a good plotter or upgrade its current plotter so it can be used for producing aerial photos.
12. deal with standards and accuracy but avoid getting stuck on the issue - use metadata to keep track of variance

13. keep working with the ITC GIS-T lab, vendors and consultants to access technical assistance in application development and planning
14. link base records to GIS
15. use low-cost desktop GIS
16. develop coordination of GIS
17. establish procedures for database quality control, documentation, and maintenance
18. find funding for GIS
19. get training for support staff and application developers
20. provide additional GIS education to those who need or desire it

The following items concerning the DOT's proposed implementation of GIS were also identified by the project team:

1. GIS software is changing rapidly. The major software vendors are in competition with each other to develop the same functionality. Ultimately the choice is determined more by the database and hardware situation than compatibility with existing software.
2. GIS is the base. There will always be a need for other application software, e.g. TRANPLAN, Superload, Pavement Management, Permit routing, etc. We should develop an information management system that will facilitate development of integrated systems.
3. Applications currently under development highlight the issue of information system coordination. These applications are: Permit routing, sign inventory and maintenance management, ISTEA management systems, Mobile accident reporting system (MARS) and legislation for routing on local roads (this includes secondary, and requires a tie between base records and graphics), (municipal roads may be needed for routing and accident reporting).
4. There is currently no comprehensive database to support multiple GIS application development which simultaneously updates graphics and data. The base records database is not SQL. A real world coordinate system is also needed.
5. A GIS coordinator is needed.

2.3 Identify impediments to change and potential implementation problems

Four possible impediments to change are presented in the NCGIA report:

> NCGIA: First of all, every organization is conservative. Resistance to change has always been a problem in technological innovations.
>
> Second, change requires leadership. There needs to be a "missionary" within an existing department who is willing to be the leader. This individual also needs commitment of top management and other individuals within the department. It is important to know that despite the economic, operational, and political advantages of GIS, the technology is new and outside many senior managers' experience.
>
> Third, leaders take great personal risk when trying to promote change. There is ample evidence of past failures of GIS projects and an initial "missionary" is an obvious scapegoat for failure.
>
> Finally, GIS can be a sufficiently radical change within an organization to be called a "paradigm shift". This "paradigm shift" changes the set of rules or concepts that provide the framework for conducting an organization's business. (*NCGIA 1991, Section 67C*)

Iowa DOT Implication: With strong leadership and commitment from DOT top management and others throughout the department, reluctance to change can be replaced with GIS accepted as a welcome challenge and opportunity to improve the efficiency of DOT management and operations.

NCHRP Report 359 lists eight potential problems or obstacles to full implementation of a GIS in a state DOT:

> NCHRP:
>
> Institutional Inertia, often justified in terms of investments (in older ways of doing things) that have to be fully amortized.
>
> Urgent, unanticipated needs that don't fit into, and that take priority over, general plans.
>
> Staff deficiencies and in particular, absence of a GIS champion.
>
> Absence of the resources required for planning.
>
> Lack of management support-for planning in the first place, and then for doing anything with a plan once it has been articulated.
>
> Interference from higher, centralized authority (i.e., above DOT level).
>
> Required technology that is not yet mature and available (e.g., networking).
>
> Required standards not yet established (e.g., open systems standards). (*NCHRP 1993b, Section 3.3*)

The NCGIA curriculum also lists potential implementation problems:

> NCGIA: A first possible implementation problem is an overemphasis on technology. The planning teams are usually made up of technical staff who emphasize technical issues in planning and ignore management issues. The

planning teams are forced to deal with short term issues and usually have no time to address longer term management issues.

A second possible implementation problem is that there are rigid work patterns already established in most offices. It is difficult for planning teams to foresee necessary changes in work patterns. Implementation may also mean that a formerly stable workforce will be disrupted and some staff may find their new jobs too demanding. The people who are in comfortable jobs will not seek change and productivity will suffer unless the staff can be persuaded that the new job is more challenging, better paid, etc.

A third possible implementation problem is organizational inflexibility. Planning teams must foresee necessary changes in reporting structure, organization's "wiring diagram". There may be a problem because departments that are expected to interact and exchange data must be willing to do so.

A fourth possible implementation problem is in the decision making process itself. Many GIS projects are initiated by an advisory group drawn from different departments and projects may be derailed as any important or influential individuals are left out of the planning process.

A fifth possible implementation problem is in assignment of responsibilities. the assignment is a subtle mixture of technical, political and organizational issues. Typically, assignment will be made on technical grounds, then modified to meet pressing political and organizational issues.

A sixth possible implementation problem is defining system support staffing needs. There needs to be a minimum of a system manager responsible for day-to-day operation and a data manger responsible for database design. The planning team may not recognize the necessity of these positions. In addition, there may be the need to add additional positions and management may be tempted to fill these positions from existing staff without adequate attention to qualifications. With the new positions, personnel departments will be unfamiliar with nature of positions, qualifications required and salaries.

The final possible implementation problem is the integration of information requirements. Management may see the integration as a technical data issue, not recognize the organizational responses which may be needed to make integration work at an institutional level. (*NCGIA 1991, Section 67D*)

Iowa DOT Implication: These implementation problems, while real enough and present in varying degrees in almost any large organization, need not nip GIS in the bud. But they do need to be recognized and planned for from the beginning. If and when they do arise in the course of an individual application, they can be handled in a calm and deliberative manner such that the overall strategic plan can proceed. Alternate and/or parallel paths must be considered where conflicts are anticipated; and must be developed ad hoc where unanticipated. Specific training to upgrade the skills and qualifications of DOT personnel assigned to GIS-T tasks is also important.

3 RELATED EFFORTS

The purpose of this chapter is to document, in a single location, the history and status of relevant studies and efforts to the Iowa DOT GIS Strategic Plan. It is presented in the three sections to follow: National GIS-T studies, Other State GIS-T Status and Experiences, and Iowa GIS-T Efforts.

3.1 National GIS-T studies

3.1.1 NCHRP 20-27

Adaptation of Geographic Information Systems for Transportation, "documents and presents a top-level design and implementation plan for geographic information systems (GISs) for transportation." Included in the report is a summary of state DOT actions with respect to GIS-T. The project, sponsored by the National Cooperative Highway Research Program and designated NCHRP 20-27, was developed by Alan P. Vonderohe, Larry Travis, Robert L. Smith at the University of Wisconsin in Madison, Wisconsin. Results and recommendations of this study as published in NCHRP reports 191 and 359 were used extensively in developing the strategic plan described in Chapter 5 of this report. The results have also been widely accepted at DOTs throughout the U.S.

3.1.2 AASHTO GIS-T Pooled Fund Study

The purpose of the GIS-T Pooled Fund Study being conducted by the Alliance for Transportation Research is to "develop and demonstrate an integrated approach to implementing the seven transportation planning systems outlined in ISTEA." State-of-the-art approaches from several fields including Information Engineering, Geographic Information Systems and client/server computing will be incorporated into the demonstration.

The prime objectives of the Pooled Fund Study are to develop a GIS-T server net prototype and provide it to the State transportation agencies participating in the project. (The States participating in the project will contribute $1,000,000 of the $1,500,000 project budget.)" Demonstration of the design, implementation, and operation of multiple management systems in this server net environment is also an objective of the project.

The server net will be a means of integrating hardware, software, data, applications systems, and access methods to create a network computing environment consisting of a range of technologies. These technologies will be capable of collecting, managing, combining, analyzing, and disseminating transportation and other geographic information. Specifically, the project will produce the following deliverables:

1. An integrated data model for the ISTEA management systems (pavement, bridge, safety, congestion, public transit, intermodal planning and traffic monitoring).
2. An integrated systems analysis and design for these systems.
3. Results of the GIS-T industry evaluations.
4. ISTEA demonstration systems.
5. Interim and final reports, demonstration video and other technical publications

These products were originally scheduled to be available in 1995.

3.2 Other State GIS-T Status and Experiences

3.2.1 Overview of AASHTO Conducted Review

An overview of the AASHTO conducted review of state DOT work in GIS was covered as part of the Lewis and Fletcher TRB workshop (1991). Forty-three of the states had some active pilot project underway, twenty-two had a definite GIS-T implementation plan, and seven had operational systems (Colorado, Kansas, Louisiana, Wisconsin, Oregon, Rhode Island, and Ohio.)" The hardware being used by the DOTs consisted of 38% workstations, 30% PC's, 11% microcomputers, and 21% mainframes. Forty-two percent of the software in use was Intergraph, 31% was ARC/INFO, 8% was McDonnel Douglas, and 2.7% (one system) was either MapInfo, MOSS, SAS, TransCAD, Ultimap, Atlas Graphics, or Map Graphics. However, it was not clear how much of this hardware and software was strictly GIS.

Typically, the states involved in GIS were seeking standards in data exchange, data definition, and mapping standards.

Four areas of GIS application were specified by the DOTs: roadway inventory (46%), pavement management (32%), executive information system - EIS (11%), and accident analysis (4%). Of these applications, pavement management was receiving the most funding.

Four primary areas of research activity were also specified by the DOTs. These activities were: 1) development of benchmarks to evaluate commercial GIS software, 2) incorporation of CD-ROM, photo data, and three-dimensional analysis, 3) definition of dynamic segmentation, 4) updating of cartographic databases.

The state DOTs had experienced several problems in GIS implementation - of which Cost/funding was just one. Other hindrances included the lack of understanding/knowledge of GIS, the lack of trained staff, the lack of digital base maps, the lack of a clear demonstration of applications, the lack of top level management commitment, and the organizational complexity and communications within the DOTs.

NOTE: The information presented in the Lewis and Fletcher TRB workshop is now somewhat dated, but it was the only information found that discussed both hardware and software.

3.2.2 GIS-T Conference Roll Call of States

The following update on the status of GIS at selected state DOTs was summarized from oral presentations made by the representative indicated at the AASHTO GIS-T conference, April 11, 1994. (Representative name given if available - note: spelling of names may be incorrect). It is difficult to assess which state is in the "lead" regarding GIS development, as each presenter had his/her own way of describing each state's efforts.

- B. Nelson: Roadway imaging using a Mandli GPS - data stored on 12" GPS used to digitize state highway system at 52.8 feet increments using a van. GPS. Hope to have laser log data available to everyone's desk,

to tie image to GIS turfism - if there is a gonna work". State government has a wide area token ring network.

- Diane Pierzinski:

plan for GIS. Arc/Info was GIS service center for coordination GIS program was directed to assist in putting together an GIS will be the point of contact for all applications; coordinated with re-engineering. will be an integral part of re-engineering. Oracle highways integrated with GIS. 4 permanent staff with GIS classification. Budget is in the 2-3 Million dollar range. In the past, have focused on technology but failed at communication. Issue: how to train diverse group of people with limited resources, people and money.

Colorado - Doug Wazy: Have used an ARC/Info system since the mid 80's, used VAX platform. 5 people in GIS support group - integrated data sets for whole department and provide assistance; applications/systems oriented, state-wide plan, management systems, traffic operation centers for Denver (graphics display of current conditions) very preliminary work with weather, work with local agencies (corridors, land use). Last 8 years, data are accessed by non GIS staff through Arc/View. Public information, personnel are even accessing data. Leveraging GIS investment into more uses; technology is not the problem, bureaucracy is.

Connecticut - Frank Blish: Using Intergraph. Testing being done to attach base map to TIGER Parcel maps and improve accuracy to 1 inch = 100 feet which will cost $35 million if implemented. Examining ARC/info to Intergraph interface for integrating Roadway images into GIS. ARC/info and Intergraph with environmental department working on video integration, facilities management. Examining ISTEA management system integration. Need reorganization effort prior to GIS.

Delaware - Ken Richter: Intergraph hardware and software products being used for GIS. Base maps developed from quads @ 1:24,000. - getting intelligence for centerline file to use attributes, have new project using digital orthophoto @ 1:12,000 to fit current centerline files to aerial photos. Wetlands mapping on aerial photos using GPS control points. Replacing hydro data with digital orthophoto using GPS control. Conflating centerline file to TIGER to attach attributes to linework. Began a strategic plan 4 years ago and now getting benefits. Past problem is a lack of goals and objectives.

DC - Ty Troyer, Public works: PC ACR/info / ARC/view / ARC/cad. No GIS budget, staff (1), new base maps @ 1:1,000.

Florida Rebecca Clemons: GIS since 1985 (some considered as pilot projects now; used GDS, Arc/info, Intergraph). Platforms varied and efforts were not coordinated. Two dedicated support staff. Formed two committees. Base Map @ 1: 24,000 not readily available because of varying software, now want to pull together. $1.9M budget for next year. Must meet with provisions of external advisory board. 2 levels of advisory board, 2 levels of advisory committee.

Executive level steering committee and working level group. (Assistant directors set direction and work level). Now surveying for GIS needs. Need data plan. Translation is a problem.

Georgia - Darrell Elwell: Using 5 DEC workstations running Arc/info (want 14). University of Georgia is digitizing map base @ 1:24K, there will be a route/milepoint link to road characteristics data, will try to use GIS for ISTEA management systems; looking to do a strategic plan this year, converting databases to relational database management systems; '96 Olympics ATIS/ATMS system to use GIS and incorporate different systems (ARC/info, Intergraph, GDS). Governor established a GIS task force at the state level; possible partnership with utilities is being considered. Hope to get top down support from Governor and Legislature. GIS staff is volunteers & those with other responsibilities; need staff. Currently, 3- GIS staff. Ride share application being developed with Georgia Tech. They noted resource problems.

Idaho - Dick Palmer: Using Intergraph, bought Microstation, MGE 3.5 years ago, just beginning to use. Word of advice, buy Training! Planning section is only division using GIS. Laying ground work for GIS since 1986 (1:24,000 scale base map effort with USGS started as a cooperative effort with cartography); now have only 1:100,000 base maps. Now establishing statewide GPS base stations; working on video log. 6 People - 3 cartographers, 1 using GIS software.

Illinois - James Wright: 4-5 years BIS has been working with planning on a roadway reference system (database uses link-node), all roads (major collectors up to highways), digitizing done from 1:24,000 base maps. Building data structure that will work with Intergraph/IBM. IDMS Shop, 400,000 records of roads (+400K on municipal roads file). Next year, will work on GIS plan to see where GIS will fit in. Interfacing existing key route system to link node base so there would be one standard reference, have tied in marked routes; uses batch programs. Built good foundation but need to decide where it goes. Toll Highway Authority received 15 million dollars to get GIS going. (Note: Ted Smith from the Iowa Transportation Center had a personal interview with staff of Illinois ILDOT, see: notes from that interview)

Indiana - Bill Holloway: Began planning in 1984 before GIS was called GIS there; 1st workstation was purchased in 1989, now have 139 VAX's workstations. Uses GDS. Connected into state backbone which ties into all state agencies. Working on building base map last 4 years. They are automating their designers out of existence. Have approval for snow/ice routing system

(Purdue doing it). Totally automating permitting & routing. Bridge and feature inventory is accessible through GIS.

Iowa - (Please see the remainder of this report)

Kansas - Brian Logan: Intergraph Microstation and MGE. 10 workstations; primary applications are pavement management, roadway geometrics, needs analysis; trying to get Segment Manager on-line; trying to get sign inventory system on line using video. No GIS budget, 5 staff in planning. Converting accident database analysis system should be $1M. Local government trying to use accident info, wants info on GIS job classifications for personnel office; persistence is key to success. Converting database, executive level support for GIS/video logging. Committee formed. Want to bring in people who are already trained.

Louisiana - Mark Suarez: Intergraph - homegrown GIS activity on VAX 150 workstation, GIS on 2 workstations, GIS on 2 workstations moving to Oracle & MGE instead of VAX system. No GIS budget. One person located in computer center. 1:24K USGS Quads base maps. Public hearing maps. Strip maps, summary logs, ISTEA , Converting to MGE with RDMS,. Works a lot with LSU. Organizational chart developed for GIS staff, but yet to be approved by upper management, GIS location/survey is attached to GIS leads to moving toward PC based field system, primary reason for success is talent of one individual, road block was Chief Engineer being against computers and was against GIS, but he retired. Tommy Howell, Intergraph consultant will be coming to LDOTD.

-moving into Clipper (Unix) and DOS environment

-150 GIS applications (?)

-Cartography section is automated

-Had first statewide GIS conference this year

-automated cartography helps maintain base maps

Maine - Kevin Reilly: Using GDS on DEC VAX stations, 3 of 42 are dedicated to mapping. Currently acquiring base map (7/8th of the state is digitized), mostly automated mapping applications; Redistricting maps done for the legislature. Ground water is linked to the base map. DOT to MPO links. Top Management have adopted 5 year plan for GIS with full time staff. Budget to begin in July. Bringing in natural resource databases. (Have additional material from interview with Kevin Reilly)

Maryland - Alisoun Moore: Using Intergraph MGE and Segment Manager; 6 work stations. 1:24,000 scale base map. Winter storm mapping system. Strategic Plan prepared by Greenhorn and O'Mara. Four GIS staff separate from cartography. 1/2 to 1 Million dollar budget next year. GIS located in planning; activities throughout the DOT as recommended in the strategic plan. Now integrating various systems into server net environment. Novell network will support pilot projects. Management support is good. Primary applications include accident analysis, plat map retrieval, pavement management, environmental planning prototype, roadway planning maps, and inventory maps. They want a user friendly PC access environment for MGE. They have developed an "intelligent" network. Key to success is the champion and cooperation of MIS staff. Keys to success are the project champion, cooperation from MIS staff, Steering committee and Technical advisory committee. Roadblock is currently a lack of training for core and end users. (note: we have additional interview material for Maryland from a personal interview to be added)

Michigan - Don Diget: Executive level views information technology as a business driven process so there is no specific GIS budget or staff. (Twelve people from Michigan attended the AASHTO GIS-T conference this year.) Forty GIS Plus workstations and 4 MGE workstations. The absence of a standard platform is viewed as a mixed blessing. There are three informal GIS positions. There are interface problems with software, but have solid data model. They have an ATLAS and ARC/Info interface for communicating with other state agency GISs. Now developing a local road atlas at 1:24,000 scale. Michigan accident location index gives every road in the state a unique number which is tied to route information. It will be used for addressing and federal and MPO applications.

Minnesota - Todd Smith: 6 people in GIS here. 450 workstations but only 2 with MGE and 3 with Arc/info. Now in pilot stages. Has an agency wide technical and executive council for geographic information. The council is unbiased and represents the organization, not offices. $1.5 million budget for the biennium. No formal GIS positions, but 3 informal positions exist. Base map is 1:100,000 scale. 1:24,000 is not complete. Applications in the planning area include the base map development, conversion between (testing) Arc/info and MGE. They want the MN utilities to use GPS and report the data back to the DOT. There is a Governor's council for geographic information which has both public and private representatives. GPS committee. GIS is not in one place in the organization, and this is seen as a success (an organization wide responsibility). They have an agency wide council for geographic information that is both technical and managers across the agency to discuss GIS issue. They feel a need for policy decisions on what to do about GIS. Managers and technical people now sit at the same table.

Missouri - Keith McGralen: Have been using GIS for 7 years; settled in RISC 6000 IBM platform & PC's as emulation terminals (trying to do a pilot project with this); ARC/info shop. 15 workstations.. Have established a GIS section with 6 positions. Job specifications have been established. Budget is greater than $500,000 per year. Applications include: Pavement Management, ISTEA management systems, needs analysis, traffic analysis, clean air analysis, and accident analysis. Clean Air Act has a major impact on Missouri. Also another pilot project that is a spin off of design section pilot project for migration to districts.

Nebraska - Intergraph MGE up and running in 60 days. Have been using it now for 1 1/2 years. Have network. Producing products for executive management. 2 staff plus one more scanning position. (3 positions authorized by legislature). Job classifications have been written. Staff in Transportation Planning Division. Special maps for management produced weekly. ASCII data on floppy disk are brought into the GIS. Pavement management, bridge, and highway safety maps produced. Mandli system with video log. Highway safety & construction application up and running. Work on wetlands. Success is due to products for executive management (little lower level use of GIS). Not many intermediate users, primarily used as a decision making tool for management. Roadblocks are lack of funding and personnel.

New Mexico - Tom Henderson, GIS Manager: Using Arc/Info on 3 Sun Spark-Stations. Now in the base map creating and initial applications development stage. Working with Sandia & University to develop 1:100,000 scale base map. Will eventually incorporate dynamic segmentation. Have lost all experienced staff. Drawing from integrated highway database for specialized purposes. Now moving GIS from BIS to Planning Division.

New York -Les Marklin, Director of Mapping & GIS Bureau: Bureau was established 9 months ago. A study last spring added GIS to the Bureau, and moved it from Engineering to the Information Management Division. A major task is now selecting a GIS vendor for corporate installation (evaluations to 8 months). Selected ARC/info as the corporate GIS; use Arc/View at the PC level, expect to have substantial implementation of this. An analysis indicated that 80% of the needs could be met by a PC level GIS. Will use dynamic segmentation to link reference system. Not yet staffed, but will have a GIS support section. Now searching for a GIS Director. There is much interest at the county residency level. The base map is being converted to digital 1:24,000 scale, (20% complete).

North Carolina - Ed Schuller: 30 people in GIS unit includes HPMS support people, not all are in cartography; 2 million dollar budget plus matching grants. Completed environmental review application. Environmental application on ARC/info (AML) is user friendly. Using Arc/info for GIS & Intergraph for digitizing. Will complete digitizing 1:24,000 and will be adding intelligence. Grant received from NHTSA to do traffic safety work. Improving evaluation in DOT. Collecting spatial data. Using Aerials.

Ohio - Chuck Zampart: In 1980, all systems were tied together using control nodes. System running on VAX. Applications include project location, road inventory, bridge permits, pavement management, accident analysis and congestion management, functional class maps for FHWA, statewide planing, intermodal terminals planning. Scans and highways for public hearings. Scanning aerials; using GPS with Ohio State University to digitize county and interstate system in GIS. Generating state highway map with GIS in 1995. Will do environmental analysis for projects including historical, wetlands, and hazmat which will save $200,000/project (currently being paid to consultants) and cut six months off construction time. Will be selecting software later this year (RFP later this year).

Oklahoma - Teresa Cola: Intergraph MGE, MGA, Dynamo; All the state highways with 5 years of data on accidents, bridges, rail, APMS, and signs are accessible on GIS. Rural with no data available at 1:24K; 6 staff (they are scattered about the Department); GIS committee. (budget is lumped with CADD)

Oregon - Chris Levy: 200 workstations (most of which are set up for road design) 2 for GIS, 1 or 2 with Windows NT and GIS. Have software that they wrote. Have had other dynamic segmentation since 1987, trying Segment Manager as result of '92 GIS-T, 1.5 staff, now analyzing systems that might use GIS, study revealed that regions spend $1.5M in time looking for data that is used for road design. Pilot project in Districts assigned attributes to each segment of highway, loaded bridge data and accident data (working O.K.) Developing base for study in HPMS, (MGE used for submittal). Driven by requests (did not feel that they were proactive) for planning for ISTEA management systems, geology, traffic section. Need simple GIS that is user oriented.

Pennsylvania - Tony Pietropola: Didn't get into GIS until 1990. Tried bottom-up approach in 1980's, didn't work. Top down approach now being very successful in the 90's, GIS Strategic Plan developed by Baker Engineers 1990. All cartography has switched from VAX to UNIX. Taking data from mainframe, completed conceptual design. Sneaker net to display data on GIS, conceptual design by GIS-Trans, Computer Resource Associates is designing database. CRA is also helping building base map. Hope to have base maps by 1994. Pietropola is BIS - Planning staff for GIS (they have developed a partnership between planning and BIS). Base map 41K miles . State road system was digitized. GIS used for safety have won national awards. Key to success is the balance between products & development. Strategic plan has led to concept design which has led to database design. They have full executive management support and don't do anything without them.

South Dakota - Tom Vanney: Uses Intergraph. In early stages. 1 GIS staff in planning (the GIS coordinator). Has executive decision mapping system project. GPS project.

Texas **-** Bobby Davis, Manager of GIS Development Mapping Support Section: Currently working on a business systems plan. Mapping using MGE and Segment Manager is being done in Planning producing a 1:24,000 base map. Working with 22 states for data standards. Acquiring GPS. RS standards upgrading with map status. Evaluating digital orthoplotter. Developed tagging process to add intelligence to prepare the GIS base map. Developing Draft Strategic plan. GPS will be used to inventory local roads. No relational database. Hoping to increase visibility and support.

Utah - Susan Miller: Just getting into GIS. Executive committee just formed from many areas of the DOT, 1 pilot project digitizing archeology in one county. Planning looking at GIS vendor package to implement ISTEA systems, pavement management, and traffic safety.

Vermont - Jim Lossman: Will be using ARC/info. Intergraph for CADD and maybe some MGE later. Issued RFP for consultant for GIS services. Trade-off between speed in project and definitive scope of work. Need definitive scope. Made changes in RFP. Want to integrate existing data into GIS. Pre-construction management. Statewide GIS & 911 system initiative. Digital orthophotos underway. Looking at lots of management applications. Want to create town maps in GIS.

Virginia - Dan Dyke: Evaluating proposals for strategic plan. 1) applications 2) institutional issuers of staff/budget 3) technical (database) integration/reduncy. Virginia geographic information network 1:12K base map. Use GIS for needs assessment. Use Atabase on mainframe and VAX - How do we reach those systems without making duplicate databases?

Washington - Ron Cition: MGE, Dynamic Segmentation & Map Publisher are in production. 1:500,000 and 1:100,000, Trying to figure out HPMS and LRS data requirements. Decision packages to legislature to establish 3-5 people and GPS base stations. Pilot to determine Arc/Info Intergraph link. Wants a road map of how to get from A to B (GIS development) in an incremental way. Also notes the power of the mandate.

Wisconsin - Dave Casper: Hewlett Packard Arc/Info (40 licenses) & Arc/View. Fifty workstations. Gearing up for formal applications developed by engineering/planning - need training and will get it. 8 GIS staff, 15 plus with GIS skills. 1:100K base map from DLGs. Developing their own applications and developing their own solutions. Applications include pavement management, highway inventory, photo log, preliminary highway design, highway safety, records management, information systems planning. Success due to project orientation and informal data sharing, now formal with DNR. GIS user group meets quarterly. Environmental database development was major activity, led to discovery of issues. Division of highways GIS work group, 10 training classes. Must build applications that produce a product. Formal agreements with utilities. Trying to integrate linear referencing systems. Division of highway GIS support group integrating GIS into highway life cycle. Now have statewide GIS-T committee. Roadblock is a lack of focus on statewide applications.

Wyoming - Lowell Fleaner: Director and executive staff created an Information Technology Manager. 10 subcommittees & one oversight committee. Are reviewing information systems of which GIS is one.

3.2.3 GIS at the Pennsylvania DOT

When the PennDOT began developing a Strategic Plan to implement a GIS in four years, they did so considering the following complementary components: sequence and priorities of applications, the system's organizational growth, and a financial scheme. These three components were the structural basis for the GIS Strategic Plan Executive Report. A summary of that report follows.

GIS Strategic Plan Executive Report

Opportunities for GIS applications in transportation and transportation decision making are numerous. Within the PennDOT these applications shall "...follow traditional areas of agency responsibility." Safety management, congestion management, projects management, roadway management, and bridge management are top priority areas for application development. These transportation applications typically begin as data retrieval, evolve to data integration, and finally mature to data analysis.

Five principal areas of the PennDOT's computer capabilities were evaluated with respect to GIS. These areas were hardware and software, data organization and structure, organizational issues, operations and procedures, and linkages. The findings and recommendations from these evaluations were then incorporated into a modular Strategic Plan.

Each of the Strategic Plan modules were developed based on four criteria: small and affordable, task and product orientation, resources, and execution sequence and critical path. These modules were also grouped into five development phases which also represent Strategic Plan development phases. The five development phases are:

1. Historical Development. This phase includes assessment of what has been accomplished in regards to GIS development. This assessment may, for instance, be of hardware and software, telecommunications, and data resources.

2. System Design. Organizational issues are addressed in this phase, and the known technical issues are planned for. GIS hardware and software are selected.

3. System Development. The Department's existing computer system is to be technically advanced to accommodate a GIS in this phase. This will ". . .parallel and advance the simultaneous production of addition applications." Graphic and non-graphic databases/systems are linked.

4. System Implementation. Initially in this phase, GIS applications are generated from a central organizational unit upon request from end-users within PennDOT. This will allow for testing and fine tuning of the system and additional training for the support staff. The needs for

establishing a distributed system are also analyzed in this phase. A "full-service GIS" central organizational unit is created.

5. System Distribution & Maintenance. This phase is the culmination of the Strategic Plan, providing Department, and other, end-users with the system. Modules for testing the distributed system are developed, and remote users are trained in this phase. A distributed GIS for "bottom-up" applications is created and operated.

Multi-year cost plans were generated based on the development phases and modules. Recommended costs per year were stated for four categories: personnel, training, capital, and contracts; however, these costs may dramatically change due to the implementation sequence and progression options selected by PennDOT. Technological advances may also affect cost. PennDOT's budget and Multi-year EDP Plan will include the Strategic Plan.

PennDOT will determine which modules will be executed at the beginning of each annual budget cycle. These modules will be selected based on prevailing needs and available resources.

Pennsylvania DOT's GIS Strategic Plan

The following information comes from the document published by the Pennsylvania Department of Transportation entitled Pennsylvania DOT's GIS Strategic Plan.

PennDOT initiated a GIS Strategic Plan for transportation for several reasons:

- resource and commitment expense of a GIS,
- cooperation required between organizations utilizing a GIS,
- technical expertise and planning necessary to operate a GIS, and
- need for decision maker support of a GIS.

The GIS Strategic Plan was guided by an executive steering committee of top officials in PennDOT , the Interagency Work Group, and other departments. This executive committee was also in direct communication with the PennDOT's top decision making forums. PennDOT identified five tasks as necessary for the strategic plan:

- Task 1 Identify the scope and focus of a GIS.
- Task 2 Review existing computer capacities.
- Task 3 Develop a modular strategic plan.
- Task 4 Presentation to top management.
- Task 5 Finalize GIS Strategic Plan.

Task 1: Assess Priorities

The objective of Task 1 was to: "Develop a categorized list of potential applications and recommended priorities." A literature review and interviews of PennDOT managers, PennDOT staff, and representatives from other state agencies were used to determine top priority and high priority GIS transportation applications. The high priority applications of GIS are:

- vSafety Management,
- vCongestion Management,
- vProject Management,
- vRoadway Management, and
- vBridge Management

Other potential GIS Transportation Applications included:

- vEnvironmental Impacts/Design Management:
  - vProvide decision support on the inventory of potential environmentally sensitive locations,
  - vArchaeological Locations,
  - vHistorical Locations,
  - vWetlands,
  - vWildlife Habitat,
  - vFarmlands,
  - vParks,
  - vHazardous Waste, and
  - vLand Use (zoning).
- vVehicle Routing, including:
  - vHazardous Materials,
  - vOversize/Overweight,
  - vSchool Bus Routing,
  - vEvacuation Planning, and
  - vDetour Planning.
- vAdministrative Management, including:
  - vFacilities,

- vTort Liability,
- vRevenues,
- vExpenditures,
- vPersonnel,
- vDriver Licensing,
- vCommercial Driver Licensing, and
- vVehicle Registration.

vMaintenance Management, including:

- vSnow Removal,
- vSurface Treatment,
- vPipe Replacement,
- vResurfacing,
- vConcrete Rehabilitation,
- vMowing,
- vSpraying,
- vLine Painting, and
- vEquipment Inventory.
- vinventory of aerial photography

vGeological Management

- vdecision support on geological information
- vGeographic information including:
- vhazard inventory
- vrock and soil boring logs

Task 2: Review of Existing Computer Systems

Specific Objective: "Assess and maximize the utility of existing computer systems for a GIS, identify linkage options among the various systems and assess the immediate need to enhance existing computer components."

A review of existing hardware and software was done within PennDOT including databases and data communications. This was accomplished through interviews with PennDOT staff, review of documentation provided, and contact with system vendors and other state DOT's. Computer resources were discussed from the stand point of present capacity, present load, and excess capacity that could be used to support a GIS system.

The offices, centers and bureaus interviewed include: Bureau of Transportation Systems Performance, Center for Highway Safety, Bridge and Roadway Technology, Bureau of Information Systems, Bureau of Design, and Computer Resource Associates (a private consulting firm).

The findings and assessments of the interviews included:

The assessment of the existing computer systems focused on six specific issues relating to maximizing their utility:

1) Hardware and Software: Addresses existing hardware and software of the two primary systems, IBM and Intergraph.

2) Data Organization and Structure: Looks at existing databases and their structures, both graphic and non-graphic.

3) Operations and Procedures: Studies data collection, work flows and maintenance.

4) Institutional: Identifies the organization issues that are expected to arise as the GIS progresses.

5) Linkages: Investigation of options for linking the various computer systems.

6) Available Technology: Discussion of vendors which support state-of-the-art GIS.

Recommendations (Hardware and Software): Expand upon the Intergraph workstations that PennDOT already possess. The existing CADD system will require upgrading.

Data Organization and Structure: Make the necessary data in existing non-relational databases available in a relational format. Utilize software that allows updating of data. Utilize relational database formats for all future database application development.

Operations and Procedures: Evolve beyond the use of tape transfer between the IBM and Intergraph systems by establishing a direct link between the two.

Linkages: Take full advantage of RIS Technology under LU 6.2 protocol in order to retrieve data from diverse system environments, IBM and Intergraph.

Task 3: Develop a modular strategic plan

The objective of Task 3 was to "...incorporate the Task 1 priorities and the Task 2 recommendations while defining a modular, flexible approach to developing a GIS." Hardware, software, manpower, training, and consulting requirements were also to be specified. The modular form of the GIS was envisioned to be highly flexible with each module being a "unit of effort." The estimated costs of project were given in appendix pages A-1 to A-8 of the PennDOT "Modular GIS Strategic Plan (Final)".

The "modular form" is achieved by dividing the myriad tasks necessary to achieve a multifunctional/multi-modal GIS into modules. Each module is a unit of effort in the overall development of a transportation GIS and fully usable as a component of our decision support system.

The modules were developed based on the following criteria:

- Small and affordable: Each module is the smallest level of effort that must occur to advance the state of the GIS, thus sustaining growth along a critical path.
- Task and Product Orientation: As the GIS matures through the phases, the number and type of applications will grow, thus generating more "business" products.
- Resources: Estimates of the costs, manpower and duration are made for each module.
- Execution Sequence and Critical Path: The modules' execution must be sequenced in a logical order.

The modules are the smaller jobs that must be completed within a certain phase. Modules may rely on other modules being completed first before work can start on the next module.

Task 4: Formal Presentation

Task 4 of the study was to make a formal presentation of the strategic plan to the top management of the Department.

Task 5: Final Report

Task 5 was to prepare final documentation of the Strategic Plan.

3.2.4 GIS at the Maine DOT

The following information is from the GIS Five Year Plan for the Maine Department of Transportation which was submitted by Graphic Data Systems Corporation on the 10th of December, 1993.

- vChapter 1: General introduction and layout of the plan.
- vChapter 2: GIS Implementation. Broken down into three implementation phases.
  - vPhase 1: GIS startup. Extends through the first year of implementation and includes initial organization, design, and development activities.
  - vPhase 2: GIS expansion. Includes years two and three of implementation and focuses on expanding the GIS environment and GIS user community.
  - vPhase 3. Mature GIS operation. Includes years four and five of implementation and focuses on ongoing operation of the GIS.
- vChapter 3: GIS Implementation Tasks. These tasks include:
  - vorganizational tasks
    - vestablishment of GIS services group
    - vconfirm phase 1 objectives
    - videntify and obtain required training
    - vdesignate GIS project support staff
    - vschedule ongoing committee meetings
    - vreview Phase 1 GIS implementation accomplishments
  - vdatabase development
    - vtransfer digital map data into GDS
    - vdevelopment of a logical model for the GIS database
    - vdesign the GDS/ORACLE data structure
    - vInventory potential internal and external data sources
    - vdevelop a data dictionary of the GIS database
    - vestablish GIS data load and maintenance procedures,
    - vdevelop on-line GIS data catalog
    - vobtain and load application data sets
  - vapplication development

- vestablish application development procedures
- vdevelop application work plan and assign resources
- vdevelop detailed application requirements specifications
- vdevelop and test applications
- vtrain application users
- vreview application development procedures and standards
- vperform application audit

vsystem management

- vevaluate and procure additional hardware resources
- vobtain and test ARC/INFO translator
- vobtain and test other required GIS software
- vre-assess system requirements

3.2.5 GIS at the Maryland State Highway Administration

The following information was prepared by the Maryland State Highway Administration (MDSHA) and entitled GIS Strategic Plan.

The study in Maryland was undertaken to develop short and long range strategies for GIS development. GIS development had already shown examples of effectiveness throughout the administration.

The report provides an overview of the external and internal factors at the State Highway Administration. The external factors include the Year 2000 Organization and Federal Regulations. The internal factors include the background of GIS development and current GIS activities at the MDSHA.

In an overview of the study that was performed for the state of Maryland, interviews in various offices determine the databases available and the knowledge of GIS. The report follows the overview with a summary of all the interviews.

The next section presents recommendations for the MDSHA to follow for GIS implementation:

- vorganization
- vhardware and software
- vtraining
- vstandards
- vstrategic databases
- vapplications

budget actions required.

The final section of the report gives the short and long range plans for GIS at the Maryland State Highway Administration.

3.3 Iowa GIS-T Efforts

The following section includes Iowa DOT efforts in the area of computing technology and GIS development.

3.3.1 History of computing at Iowa DOT

This section will include the history of computing at the Iowa DOT, including early computer automation and experience with CADD.

3.3.1.1 Geographic Information Systems in the Iowa Department of Transportation

Since 1986 the Iowa Department of Transportation (DOT) has been utilizing Intergraph hardware and software for computer aided design, drafting and mapping. There was a need for system compatibility in order for work to be shared among and between divisions. Also, a driving concern was the value of commonalty in road design software developed for joint use among state DOTs.

The DOT chose Intergraph because it best fit the needs of the whole organization.

3.3.1.2 Planning & Programming Division

The DOT maintains roadway inventory records on an IBM mainframe in a Cullinet database management system. The DOT also maintains digital maps for all 99 counties and 953 incorporated cities in Iowa. The county maps were developed from U.S. Geological Survey's (USGS) 1:100,000 digital line graphs. The city maps were digitized from previously maintained paper maps or USGS 7 1/2 minute quadrangle maps. Primary road data from the base records on the Cullinet database have been linked to these digital maps.

3.3.2 Existing Computer Based Systems at the Iowa DOT

The Information Processing Program and Plan (IPPP) developed for fiscal year 1993 by the Bureau of Information Services was reviewed to determine what spatial-information the Iowa DOT currently possesses. The uses/applications of this information were then determined by examining the systems presently operating or under development within the Department. GIS is included in the IPPP FY 93 as a future direction for information processing. "The agency will continue to monitor the continuing advance of Geographic Information Systems which will tie graphics to analytical decision-making processes." (IPPP, 1993)

The IPPP lists current (1993) system titles along with the system users and a brief narrative on each. Many of the systems have spatially related components which can be stored and operated using a GIS. The document presents a description of the systems recommended for future development. Four departments have requested GIS technology to perform some function in their activity.

3.3.3 System Application Study: An Evaluation of GIS for the Iowa DOT

Daren L. Coudriet, Paula A. Brown and David R. Luhr of Keystone Management Systems conducted a study which evaluated GIS for the Department. Their findings were presented in a March 17, 1989 report.

Keystone concluded that a GIS application would be important and appropriate for the Iowa DOT. Three principal observations supported this recommendation:

- vImproved functionality of operating groups within the Iowa DOT would provide easy access to accurate and complete data. Keystone noted that at the time the data environment at the Iowa DOT was distributed over a wide range of systems and was in various formats.
- vA GIS would provide location referencing through a computer generated map. They reasoned that the graphics format would aid in information communication.
- vA GIS would provide a wide platform of applications that may eventually be useful to the entire Department in addition to other state agencies.

Keystone proposed a trial implementation of IBM's GFIS system in the form of a pilot project. The pilot project was to be used to evaluate the implementation process and the immediate benefits. The pilot project, however, was never initiated by the Iowa DOT. The demo was viewed as being limited in scope and lacking easy expansion capability. The Iowa DOT also indicated that specification of a particular vendor's software platform was premature.

3.3.4 Highway Location Reference Procedure Project

The Highway Location Reference Procedure project was conducted by Gene Mangum and Larry G. Walker of C.W. Beilfuss & Associates beginning March 1990. The purpose of this project was:

"Establishment of a highway network locational reference process that will primarily allow for correlation of pavement management data, and secondarily provide a basis for other existing and future data base integration and for the planned Iowa DOT Geographic Information System. In addition, the locational reference process will be able to correlate network applications with a statewide spatial location methods to facilitate the relationship of Iowa DOT data to that of other agencies and to allow for the graphic display of the network in map form."

The proposed Highway Location Reference Procedure included three categories - Linear, Spatial, and Segmental. The linear referencing schemes used by the Iowa DOT - Milepost, Milepoint, and Stations - would remain in use, but the implementation of these schemes would be different. The new procedure would consider milepost markers as reference posts. Milepost and displacement nomenclature would be used for locational reference. The milepoint and station reference schemes utilized by the Iowa DOT would remain essentially unchanged by the new referencing procedure. The Milepost/Milepoint/Segmental Cross Reference process would accommodate the milepost and displacement nomenclature and take milepoint discontinuities into account.

The spatial reference schemes used by the DOT are Latitude-Longitude, Accident Nodes, Political Subdivisions and X-Y Cartesian Coordinates. These same schemes, with different implementations, would be supported by the proposed system. Latitude-Longitude would be used as general reference for any kind of data or position reporting. The new reference process would allow for the direct correlation of accident nodes with any other referencing system, in addition to supporting their present use. The existing political subdivision reference method would also be maintained. A new Geographic Node/Shape Description process would use Transportation inventory Lambert coordinates as a basis, and the Spatial/Linear/Segmental Cross Reference would accommodate conversion between systems.

The segmental reference scheme would support all existing schemes and add an additional scheme for pavement management sections.

Various cross reference processes were offered in the proposed reference procedure: 1) Accident Node Edit/Interface between the base records and the accident system; 2) Geographic Node/Shape Description; and 3)Spatial/Linear/Segmental.

CWB made 19 recommendations at the conclusion of the project which included improvements for locational reference and pavement management systems. Improvements were to provide a common locational reference for the highway that would take into account all data collection procedures within the Iowa DOT. The highway location reference system would provide consistent, unambiguous data for pavement management as well as provide a basis for implementing any GIS software. The process was also to reduce the cost of future GIS implementation and data transfer between state agencies.

According to the Iowa DOT report GIS Demonstration Project March 1992 (see 3.3.5, below), the DOT's Highway Division is implementing the CWB's 19 recommendations as part of a pavement management project. This report also revealed that an additional support team from the Bureau of Information Services was formed to expedite the process.

The following questions about the CWB referencing report were developed by the GIS Strategic Plan team:

1) Did the specifications of this report "support the ... planned GIS" as noted on Section I, page 1?

2) 30+ interviews resulted in "Statement of Understanding"

3) 19 recommendations related to correlating linear/spatial systems

4) milepost/milepoint scheme was to be modified

5) does the proposed referencing procedure provide a "convenient/reliable interface with TIGER files"?

6) CWB reference "procedure" includes...
- method of expressing location of features
- conventions to state locations
- process to convert
- procedures to update & notify

7) ref systems in use
- linear (milepost, milepost, stations)
- spatial (lat-long, ALAS nodes, political subdivisions, XY)

- segmental (base records, PMIS, accident records)

8) modifications were recommended for Milepost system

9) the addition of a comprehensive cross-referencing system was recommended

10) did milepost & displacement replace fractional milepost?

11) are stations still used? are they on all highways?

12) can accident nodes be cross referenced to all other reference systems as of now?

13) how can township, range, section be referenced now?

14) what is a "customized" Lambert?

15) what is "control section & aliases" in the base records?

16) how does the cross reference between base records and the ALAS nodes work?

17) how did CWB develop such a detailed Gantt chart? was it used/accurate?

These questions should be addressed by DOT GIS staff in the near future.

3.3.5 GIS Demonstration Project at The Iowa DOT

In 1990 the DOT conducted a Geographic Information System (GIS) demonstration project funded by the US Department of Energy to study a corridor between Cedar Rapids and Dubuque, on US 151. The purpose was to utilize the GIS and the database to determine the most energy efficient and cost effective route between Cedar Rapids and Dubuque for a proposed realignment of US 151. This project combined data from the DOT and the Department of Natural Resources to determine the optimal alignment. The DOT had been using an Intergraph CADD system since 1986. Therefore, an Intergraph UNIX workstation was purchased and Intergraph loaned their Modular GIS Environment (MGE) and Modular GIS Analyst (MGA) products.

Data available at the DOT included the highway and transportation (H&T) maps stored as digital line graphs on the Intergraph VAX system, roadway inventory records stored in a Cullinet database management system on an IBM mainframe, and planimetric data from nine aerial photographs around Cascade, Iowa. The DNR had the following data available in digital format:

hazardous waste sites, public lands, sanitary landfills, private and municipal wells, and underground storage tanks.

The DOT's county maps were available in digital form and were used as the base map for the GIS. These originated as USGS 1:100,000 Digital Line Graphs, and were updated by the Cartography section. The maps contained many layers of information, all in graphic form, minus attributes. Hence, a major effort was required to topologically correct the CADD maps (called cleaning in MGE) and to create features to attach database information. These files contain line features, area features and point features. The DOT road information (base records) were combined with the county maps and used as the base for the GIS project.

Once the DOT county maps were "clean" and the database information attached, they could then be utilized for analysis. Some examples include primary roads with a sufficiency less than 50, US 151 with sufficiency less than 50, US 151 with surface width less than 24 ft., and sufficiency less than 50 with accidents greater than 10 in that year. Information on the cities along US 151 was loaded.

Because DNR was utilizing ARC/INFO GIS products, merging their data with the DOT's was one of the biggest challenges of the entire project. After much work, graphics were successfully exchanged between the DNR's ARC/INFO system and the DOT through the use of the Digital Exchange Format (DXF). Four steps were involved in transferring the DOT's files to the DNR:

- The files were moved from the VAX to the Intergraph workstation
- A DXF file was created using the DXF utility of the Intergraph Microstation 32 software
- A carriage return and line feed were added at the end of each element record in the DXF file using a "C" program
- The files were translated from the UNIX operating system to the DOS operating system by using a utility in Intergraph's UNIX product.

Compared to this exchange process, the exchange of files from the DNR's ARC/INFO software to the DOT's Intergraph system was much more difficult. DXF was used to translate graphics while the attributes were exchanged using an ASCII character data file. The standard translation package in ARC/INFO was used to transfer the graphics into a DXF file. The data were then output as ASCII files in the same order as the graphics were output to the DXF file.

The Microstation utility DXFIN was used to bring the DXF file into the Intergraph system. Once the graphic elements were in the DOT's system, the database table was loaded. The attributes were also re-associated with the corresponding graphic elements. In addition, exchange procedures were developed for the DOT's existing IBM Cullinet Database Management system. Data from the base record history file was completed imported into the GIS Informix database.

Aerial photos of a section of the corridor also were utilized in this project. DOT's Photogrammetry section digitized planimetrics of the area where aerial photos were available. Contour lines were taken off the photos. Currently the DOT uses aerial photos for public hearings. It was recognized that it may be much easier to warp the aerials to fit an alignment in the CADD system than it was to warp the alignment by hand to fit the photos as was previously done. Another related technology utilized for the project was videologging. The DOT has a video logging van which captures and stores images on video disks. An experiment was performed which linked the videolog to the GIS to access photos of a section of road with the associated attributes from the database.

At the completion of the demonstration project, the DOT purchased three more Intergraph UNIX workstations each with MGE software. Overall, the demonstration project was successful. Long-term benefits of a GIS were perceived to be its potential to improve the DOT's ability to analyze the large volume of data it collects as well as to reduce the redundancy in the collection of the data. The results of this project encouraged the (then) Planning and Research Division and the Highway Division to investigate other GIS applications, such as advanced planning, project planning, cartography, maintenance and pavement management. The planning staff then proceeded to plan a pilot project for corridor analysis to pursue other GIS applications.

Concerns arose during the project related to the complexity of GIS hardware and software and the required education and experience of GIS users. Based on these concerns the following recommendation was made: "...it is vital that the role of the support team and users of GIS be established prior to full implementation." The project revealed that it is essential for the GIS to fit the organization's needs, for a GIS is dependent on staff commitment and the support of upper management. The principal investigators concluded that the long-term benefits of a GIS package are numerous, and that GIS deserve further investigation.

3.3.6 Summary of GIS Informal Survey Responses

Following a FHWA GIS/Videologging Workshop at the Iowa DOT, a survey was distributed to those attending. This survey included several questions regarding GIS within the Iowa DOT. Twenty surveys were completed and returned.

All respondents thought GIS would be useful to the DOT. Most thought GIS would be useful to the DOT as a whole; however, certain specific areas of usefulness were also mentioned:

vpavement management

vpavement history

vpavement material condition testing

vaccident location

vmaintenance

vbridge inspection

vadvanced planning

vpermit routing for overweight and oversize permits

Respondents were also provided the opportunity to express which data they thought would be useful in a GIS database. The responses collected can be broken down into several categories: pavement management, bridge management, maintenance, highway design, planning, safety, and general data. The desirable data by category are:

vpavement management - pavement history, various road tests, project histories and locations, materials history, and all pavement information

vbridge management - bridge locations, bridge deck conditions

vmaintenance - maintenance files

vhighway design - planimetric and contour information, design plans, design data, contour line of area along highway

vplanning - socio-economic data

vsafety - accidents

vgeneral data - ROW on primary highways, infrastructure

Other opinions expressed were that the database should be developed from an agency standpoint, and that a Task Force should be utilized to determine the needs for a database.

Most respondents showed interest in being involved in the exploration and implementation of GIS. Many respondents would like to become involved through participation in a Task Force. Others were more interested in involvement through GIS applications relative to their department.

3.3.7 Development of a Spatial Infrastructure for Transportation Planning and Public Policy Analysis

The research being conducted at the University of Iowa has two purposes. The first is to develop a method for adapting TIGER files for use in transportation and locational models. This entails defining a set of critical road parameters and associating them with each road segment. The second purpose is to use the digital data set in a project that will demonstrate how the data can be used with transportation and locational models.

The first part of the research will ensure that the database established can be used in transportation applications. This will be accomplished by developing efficient and effective editing techniques for preparing and enhancing subsets of the complete TIGER database. A two day workshop for appropriate personnel in Region VII is to be prepared and presented. The workshop will cover methods for updating and editing TIGER transportation infrastructure files, using TIGER files for investigating geographical accessibility problems in rural areas of the midwest states, and using distances computed from the updated and edited TIGER files in a spatial decision support system to investigate regionalization questions.

The second part of the project is to use updated and edited TIGER files prepared by the state DOTs in Federal Region VII for spatial decision support tasks. Through this an enhanced TIGER file for the remainder of Iowa will be developed and an experimental model to infer origin-destination flows from traffic count stations will be tested.

This research is relevant to the current study of applications of GIS for the Iowa DOT. An efficient way of editing TIGER files is to be developed. The second purpose of this research project will demonstrate how the data can be used by an organization, such as the DOT, to efficiently manage information and uses for transportation designs.

3.3.8 Enhanced Sign Management Inventory System Using Bar Coding Techniques

The enhancement of Sign Management Inventory System Using Bar Coding Techniques study was conducted by Ed Jaselskis of Iowa State University's Department of Construction Engineering during 1993 and 1994.

A features (including signs) inventory system is being established by the Office of Maintenance, and GIS is one of the alternatives being considered for the system.

As required by the ISTEA legislation, more efficient sign management inventory programs must be developed by the state DOTs. The objective of this project is to develop an enhanced sign inventory management system that will allow field crews to automate the collection of field information. This may be accomplished using suitable technology such as portable computers, bar code scanners, or other methodologies. An automated database and procedures would be established to provide enhanced access to and processing of information.

3.3.9 Automated Recording of Bridge Inspection in the PONTIS Format

The Automated Recording of Bridge Inspection in the PONTIS Format study was conducted by Fouad Fanous and Lowell Greimann of Iowa State University.

The Iowa Department of Transportation has recently adopted PONTIS for its bridge management system. PONTIS is a PC-based system that was developed by the Federal Highway Administration in cooperation with the California Department of Transportation and utilizes selected base record information from the Cullinet database.

The United States Department of Transportation requires states to have a Bridge Management System (BMS) by September 1996. A BMS would utilize computerized bridge inspection data to predict future structural conditions of bridge elements so that future manpower and funding needs can be estimated.

The automated recording of bridge inspection data system will be developed to enhance the PONTIS BMS computer program that was developed by CalTrans. The computer methodology will be used as an integrated data base that includes the PONTIS rating system for bridge management.

The project does not specify the computer system being utilized, but rather it states that they will evaluate what already exists at the Department and will utilized a program that expands upon it. The system they select must be capable of recording and easily retrieving bridge inspection data and must have graphic capabilities needed for sketches of bridge structures.

3.3.10 High Speed Computing Through GIS

The objective of this project is to demonstrate the capabilities of travel demand models in a high speed, GIS-based environment. The project, funded by the Department and the Midwest Transportation Center, was conducted by Reginald R. Souleyrette of ISU's Iowa Transportation Center. The missions of the project include:

- assess the need and viability of high-speed computing with GIS for transportation planning, research, and other functions
- establish procedures for integrating high-speed computers and GIS capabilities in transportation modeling
- identify, plan, design, and implement GIS-based tools to facilitate sensitivity analyses, alternatives selection and policy study
- develop guidelines for the developed GIS-based tools to be transferred to the Iowa DOT, other state DOTs, or regional MPO

Deliverables resulting from this project are:

- a working system linking a travel demand model (Tranplan) and a geographic information system (Intergraph MGE/MGA) in a high speed computing environment
- an analysis of transportation network (supply) and land use (demand) scenarios using the system to perform rapid alternatives and sensitivity analysis

3.3.11 Mobile GPS/GIS Pilot Project

A proposal for the Mobile GPS/GIS Pilot Project for the DOT was prepared on May 20, 1994 by Daren Coudriet and Gregg Rosann of American Management Systems, Inc.

This project is to focus on the problem of recording accident location in the field and transferring the data to a GIS. The project is viewed as a stepping stone for other agencies to develop other location-based applications.

The project would have five phases:

- vDetermine the status of GPS and GIS use at the DOT. This phase is further divided up into three components: summarize existing initiatives, assess technological capabilities, and choose evaluation sites.
- vAssess the technology available. This phase is further divided up into three components: mobile GIS capabilities, mobile GPS capabilities, and integration and compatibility issues.
- vDefine options. This phase is further divided up into three components: summary of findings, cost/benefit analysis, and developing options.
- vDesign and develop selected options. Included in this phase is:
  - vProject plan development
  - vSystem design
  - vSystem development
  - vImplement and evaluate the system using a field pilot system.

Recommendation from the Federal Highway Administration call for minimum of eight offices to be involved and a sample size of 960 accident reports.

3.3.12 GIS Pilot Project

In July 1991 the DOT completed the GIS demonstration project and began a GIS pilot project with the Office of Project Planning. The pilot was designed to use GIS to geographically locate information which will be useful in the selection of a route location. The DOT has utilized the procedures developed in the demonstration project to make use of data from DNR and the DOT Cullinet database. Primary road data files were successfully loaded from the base record history file into the GIS Oracle database. This allowed the DOT's GIS access to the vast amount of information maintained on Iowa's primary road network.

The study, in Fremont county for a realignment of Highway 2 was officially started in June of 1991. But the project has gone through many institutional hurdles since that time and is still in progress. Procedures to automate collection of inventory information by integrating Global Positioning Satellite (GPS) technology with videologging data collection activities are currently being developed. Images of roadway data acquired through a multi-camera platform will be referenced with positional data obtained through GPS. This information will be used to determine the practicality of maintaining a database with a geo-referenced coordinate system rather than collecting the data through manual field methods.

GPS technology will also be applied to the environmental analysis of highway corridors and alignments. Positional data will be obtained on environmentally sensitive areas so that a sufficient database is available for the evaluation and comparison of alternative highway corridors or alignments during the project development phase. In the meantime, DOT continues to use the Intergraph workstations for CADD and other GIS work.

3.3.13 County Map Topology

DOT is using the GIS software to make the rest of its county map series topologically correct, so that if the GIS efforts expand to other parts of the state in the future, the maps will be ready.

3.3.14 Secondary Roads

The primary road system portion of the base records database is linked to the DOT digital cartography. Very little additional work is needed to fully utilize GIS here. However, the secondary road database has never been tied to the graphics and this will require considerable effort. DOT is working on a process to make this tie without going in and selecting each graphic segment and matching it with it's appropriate record in the base records database. Nonetheless, this would be a very time intensive process involving 147,000 records.

3.3.15 Pavement Management

The DOT experimented with GIS-type technology in tying the pavement management system into a graphic system and a new pavement management information system was developed. A "user needs" study was conducted, and from this information the system designers chose to use a building block approach to get the system ready for many of the requests that were received. Initially, the new system provided the same type of information as the old system, although some additional information was included. Processing pavement condition ratings was faster and easier and several problem areas were eliminated. The new system was written in SAS. To create the PMIS master file, data were taken from two sources (base record data and test section by milepost data) that were difficult to match previously. With the new system, this problem has been reduced considerably. New data update and viewing screens were incorporated into the new system.

3.3.16 Motor Vehicle Division Oversize/Overweight Permitting

In 1993, the Office of Motor Carrier Services embarked on developing a system to automate the issuance of over-dimensioned and overweight permits. Current procedures require a permit officers to leave their work station to consult five maps mounted on the wall. The permit routing system was being developed with Intergraph hardware, software and consulting. The workstations were to be networked on a local area network (LAN), and the LAN would eventually be connected to the host via the Token Ring network. This project is currently on hold because of problems that surfaced with use of the hardware, software and database.

The system was also to use the base road record information. Information important to the issuance of overweight and/or over-dimensioned permits includes KIP (traffic weight load) maps, surface widths, vertical clearance, bridge embargo maps and detour maps. In certain circumstances there are guidelines for referring approval of permits to the Office of Bridge Design.

The automated system was to allow a permit officer to see a map on the screen and give a beginning point and an ending point for the trip. Based on the information about the load (e.g. how high, wide, heavy, etc.) and the information in the database, the system was to pick a route for the officer. If it were necessary to make more than one stop, a route with multiple points could be set up. The system was also to be able to provide accounting reports, production reports, billing information, and automate other manual procedures.

While few errors are made by DOT personnel in the routing process, the goal of the routing system was to reduce errors as much as possible.

4 PROJECT ACTIVITIES TO DATE

4.1 Review overall Iowa DOT organization

GIS should be viewed as a DOT decision support system. Which decision-making activities it can best support is a key question. To better understand the decision-making structure, the organization of the DOT was first examined. During this phase of GIS strategic planning, the Department was undergoing major reorganization. In addition to reorganization, implementation of ISTEA (management systems, statewide planning), maintenance management, truck routing requirements, and other initiatives were affecting change at the DOT. While these were mostly top-level changes, the full impact at the individual office level was not known at the time this report was being prepared.

4.2 Provide general GIS education for Iowa DOT personnel

One element of the Strategic Plan was to provide a general GIS education for the personnel in the DOT. This gave the personnel in the DOT a sense of what GIS was and how it might be applied in its routine functions. The education was imparted through interviews, presentations, and a NHI short course. The GIS orientation facilitated the interviews, and the steps in the interview process are covered in the remainder of this chapter.

4.3 Identify and describe office-level information-related responsibilities

The first step in defining GIS applications for the Department is to identify office-level tasks or responsibilities that have potential for GIS. It is expected that these would be responsibilities requiring or producing information that is (or can be) stored in (or retrieved from) a database of some kind. Each responsibility can then be defined with regard to the decision that is supported, data used or produced, maps used or produced, computer hardware and software utilized, products generated and impact upon other activities (e.g. corporate database issues, integration with other tasks, redundancy, ...) *(NCGIA , Section 61; Antenucci 1991, step 1-1)*

While more limited, the foregoing parallels the PennDOT study which recommended department staff be interviewed, documents reviewed, and system vendors and other state DOT's be contacted:

> The specific objective of this task was to assess and maximize the utility of existing computer systems for a GIS, identify linkage options among the various systems, and assess the immediate need to enhance existing computer components. In order to make the assessment and determinations, Department staff were interviewed, documents were reviewed, and system vendors and other state DOT's were contacted. (*PennDOT, 1991, Section 1.8.2*)

A survey/interview was conducted of the offices and transportation centers of the Iowa DOT to identify and describe information-related duties and responsibilities. The surveys and interviews were the backbone of the Requirements Definition phase and documented what information was used in the offices and how it was transferred between offices. The survey/interview also provided the information needed to develop a list of potential GIS applications for each office.

All of the offices at the Iowa DOT and all of the Transportation Centers were contacted and invited to share their views concerning the implementation of GIS in the DOT. Then, as recommended in the NCGIA Core Curriculum, surveys concerning GIS were sent out to a large number of divisions in the Iowa DOT. The surveys were followed up by personal interviews with representatives of most of the offices. The interviews and surveys were structured around the following questionnaire:

1. Does the current Policy and Procedures Manual (PPM) accurately represent the mission, responsibilities and organization of the office? If not, please provide updated information and/or organization chart.

2. What tasks are performed to meet office responsibilities? (especially spatial information-related)

3. What data are collected by the office; how (format...)?

4. What data or databases are used by the office?

5. What maps are generated by the office (or by cartography at your request)?

6. What maps are used by your office?

7. If the data currently used/collected in your office are not currently integrated into a department-wide database, what issues could you identify if that were to be requested? (security, labor, timeliness, ...)

8. What stand-alone software or BIS-supported system (besides word-processing) does your office use?

9. How many workstations are in your office (486 or better PCs or Intergraph or other workstation)?

10. Potential GIS applications that the office being interviewed could identify.

The offices, sections, and technical committees that were interviewed or surveyed were:

vProject Development Division:

vDesign

vMaterials

vBridge and Structures

vTransportation Centers (6)

vConstruction

vRight of Way

vContracts

vPlanning and Programming Division:

vPlanning Services

vCartography Section

vSystems Planning

vProgram Management

vRecords Section

vMotor Vehicle Division:

vMotor Carrier

vDriver Services

vTravel Surveys Section

vVehicle Registration

- vEngineering Division:
  - vTraffic Safety
- vMaintenance Division
- vOperations and Finance:
  - vSupport Services
- vCommittees:
  - vPavement Management Technical Committee
  - vBridge Management Technical Committee
- vFormer Rail and Water Division
- vFormer Air and Transit Division

(The notes from the interviews are collected in the Iowa DOT GIS Original Interviews binder and a summary can be found in the Iowa DOT GIS Final Interviews binder.)

Once the preliminary list of potential applications was compiled, the applications list proposed for each office was returned to the office for review and comment. The offices were asked if the applications proposed would enhance or complement the function(s) of the office. This feedback helped prioritize the list and eliminate applications not viewed as particularly useful at this time.

The following sections describe the rationale used by the research team to support each of the survey questions.

4.3.1 Identify the current mission, responsibilities, and goals of the offices

The Policies and Procedures Manual was used before the interviews as a way prepare for the interviews and after the interviews as a reality check on priorities. Each office was asked whether the current Manual accurately represented its present mission, responsibilities and organization to obtain the most accurate and timely information possible. Then the team went through sections applicable to each office to determine what tasks might benefit from the use of a GIS.

4.3.2 Identify the tasks performed by the office (especially spatial and information-related)

Tasks were categorized to identify which were spatially related. The question was framed to supplement the information contained in the Policies and Procedures Manual. Labeling tasks as spatial or information-related helped identify potential GIS applications for the office.

4.3.3 Identify the data collected and the means of data collection used by each office

Questions were asked concerning the specific data collected and the means of collection. The data needs for the office could be type-matched to known GIS applications concerning data collection and methods. Such knowledge of the data collected could also lead to economies in data collection by having data collected in a modified form to satisfy multiple GIS applications.

4.3.4 Identify the data or databases used by each office

The name of each database used was listed for each office. Longer term needs of GIS implementation was derived by focusing on data that will continue to be needed by the offices to carry out future GIS functions. This question also addressed how the offices in the department are related and share data. Data storage requirements were also covered.

4.3.5 Identify the maps generated by each office

The use and production of maps is obviously a spatial task and directly related to potential GIS applications. The maps each office produced, annotated, or updated was recorded.

4.3.6 Identify maps used in each office

This question asked what maps each office refers to in its daily operations. Identifying maps needed for display or reference was another obvious way to identify potential GIS applications for particular offices.

4.3.7 Identify potential problems for the office if the data collected were to be stored in a department-wide database

The purpose was to determine if there were any concerns about incorporating the data collected by each office into one database that could be used by other offices or departments. The main focus was to determine if there were any specific proprietary, security, labor, reliability, or input/output timetable conflicts for any of the offices if the data in the office were incorporated into one database.

4.3.8 Identify stand-alone software or BIS-supported systems used by the office

This question was asked to determine the computer software currently used in each office. The compatibility of GIS software packages to other software packages varies considerably. One goal of GIS implementation is to have the GIS system as compatible as possible with the existing software in the offices.

4.3.9 Identify the computing resources available for the office

This question was asked to determine the computing resources that are currently available in each of the offices. While recognizing that hardware should not call the tune, an appreciation for sunk costs and capital already invested should not be totally ignored when selecting GIS software.

4.3.10 Potential application identified by the office being interviewed

Office personnel were asked to identify potential GIS applications, if they could. The offices were given GIS literature and a short introduction at the beginning of the interview. They were asked to use their knowledge of office operations to suggest GIS applications that might not have surfaced during review of the Policies and Procedures Manual or from the interviews. This proved to be a valuable question for offices that responded to the survey but were not able to be interviewed because of time constraints. It gave them a chance to brainstorm and add to the list of potential applications.

4.4 Identify potential applications

This was the culmination of the surveys/interviews. The methodology of the Pennsylvania Strategic Plan was followed:

> The specific objective of this task was to develop a categorized list of potential applications and recommended priorities. In order to secure the information needed to accomplish this objective, data was gathered through a literature search, surveys, and interviews. (*PennDOT, 1991, Section 1.8.1*)

Using the information about the offices provided in the survey/interview process and knowledge of GIS and GIS usage, the research team was able to identify potential GIS applications for each of the offices. A list of over four hundred (400) potential GIS applications appears in Appendix 4-A. Non-duplicative entries should be added to the list of GIS applications being considered or already under development in the divisions. This combination will ensure that all potential GIS applications are given equal consideration for implementation using a uniform set of selection criteria and weighting factors.

The ISTEA management systems offer an excellent opportunity for utilizing the capabilities of GIS in the Iowa DOT. The AASHTO Pooled Study cited in Chapter 3 lists the management systems that some states are already implementing through GIS.

The ISTEA management systems provide applications where spatial relationship exist among data, e.g. the pavement management system relies on the knowledge about location and the type/condition of pavement at each location. A list of management systems, personnel involved, and how these management systems can incorporate GIS is given in Appendix 4-B.

(See also: Ant. Step 1-4; NCGIA 61B2)

4.5 Obtain Information on Benefits and Costs of Potential GIS Applications from Offices

Once the list of potential GIS applications for each office was developed, it was returned to obtain estimates of benefits and costs. This initial feedback will be used to prioritize the applications and amalgamate them with the applications previously identified by the divisions using their internal identification procedure.

> The requirements definition must establish priorities for application development. These priorities, in turn, establish the initial data architecture and continuing strategy for spatial database development. Applications also establish the required software functionality in terms of the necessary spatial operators, location-referencing method support, data management characteristics, reporting and cartographic output capabilities, user interface, and so forth. (*NCHRP 1993a, Section 3.3*)

The offices rated each application with respect to potential benefit and cost:

vH = high

vL = low

vN = none

v? = don't understand what this application is vI = insufficient information for determining benefit or cost.

The offices identified applications that fell in the high benefit and either high or low cost as the first applications to be examined and implemented. The applications that fell in the low benefit and high cost category will be deferred and implemented at a time when they have a better cost/benefit ratio.

4.6 Formation of GIS Coordination Committee [GIS-CC]

Efficient, integrated and effective implementation of Department-wide GIS requires support and leadership within the Department. Often, support for cross-divisional activities such as information systems is provided by a "policy" committee which acts upon the recommendations proposed by a "technical" committee. At the Iowa DOT, a single GIS Coordination Committee (GIS-CC) was designed to provide both functions. DOT experience with the Pavement Management Information System suggested that a single committee would facilitate more rapid, effective implementation of geographic information processing technology. The Committee provides a forum for discussion of GIS issues and is responsive to all divisions of the DOT. The NCHRP GIS-T project reported:

> The key to successful implementation of GIS-T is the support of top management. Because GIS-T will have agency wide impacts, the management team must include top managers from all agency divisions. If GIS-T is viewed as only as a MIS activity, then the full power of GIS-T to integrate information across agency lines will be less likely to be achieved and the speed of implementation will be slowed. The management team must include a Sponsor- an individual who at least initially is committed to exploring the feasibility of GIS-T and ultimately will be committed to securing the resources required for successful GIS-T implementation.
>
> The second and equally important organizational requirement is the technical team. The technical team is composed of technical managers who will be responsible for planning and implementing GIS-T. As with the management team, all agency divisions should be represented. *(NCHRP 1993a, Section 4.2)*

The DOT developed the GIS-CC consisting of employees who have an interest in GIS implementation and are willing to working toward implementation. The Coordination Committee is responsible for representing the entire DOT and is therefore made up of members who represent all divisions of the department.

The GIS-CC duties are to recommend the establishment (and revision) of GIS policies, develop goals and objectives, define staffing requirements for GIS support, evaluate and recommend software, provide for general GIS familiarization for personnel, identify future trends in GIS, and monitor GIS activity from other areas. Divisions will select and prioritize their own GIS applications and establish/execute specific training requirements for specific applications.

5 IMPLEMENTATION PLAN

The goal of this Strategic Plan is to evaluate GIS and provide a methodology for implementing the technology in Department activities as a means to improve transportation in Iowa. This chapter is intended to serve as a guide for future GIS implementation at the Department. It is presented as a set of 23 recommended activities to be conducted by various units of the Department. These activities or "plan elements" are to be updated regularly.

> Information technology planning never ends - it must be a continuous, ongoing process, attending to a regularly reviewed and updated product. At any given time, the current plan must be recognized as time sensitive. Only thus can an organization deal with rapidly changing technology and requirements.
>
> Any good information technology plan must address a range of time horizons, say 10 years, 5 years, and 1 year. The longer-term horizons are necessary to set context and to assure that the organization is not planning itself into dead ends. The shorter-term ones are necessary to assure relevance to current conditions and responsiveness to unanticipated constraints or opportunities (e.g., financial exigencies or appearance of new software). (*NCHRP 1993a*, *Section 3.1.3*)

Responsibility for each of the elements identified in this plan is listed below and lies with:

- va GIS coordinator (and core staff), to be designated
- va GIS Coordination Committee (GIS-CC), to be formed
- vapplications developers/users (division staff)

The Strategic Plan elements include:

[Elements marked with an asterisk (*) are related to applications development and must approximately follow the listed order.]

- vselect GIS coordinator (*)
- vestablish GIS goals and objectives
- vdefine staffing requirements (identify resources)
- vchoose applications (*)
- videntify/designate key personnel (*)
- vperform functional requirements analysis (*)
- videntify database issues (*)
- vevaluate software (*)
- vperform cost/benefit-based GIS justification (*)
- vselect hardware/software (*)
- vdevelop/convert GIS database(s) (*)

- develop applications and measures of effectiveness [MOE] (*)
- document applications (*)
- provide GIS training (*)
- implement GIS applications (*)
- post-implementation qualitative evaluation (*)
- post-implementation C/B analysis (*)
- revise objectives
- provide GIS education
- foster external GIS coordination
- recognize and capitalize on trends
- monitor other state GIS activities
- communicate with decision makers.

Schedule: No definite schedule is placed on any of the plan elements at this time. Timing will depend upon the needs of the DOT to access rapidly expanding GIS technology and to a large extent upon the needs of the various management systems now being developed for the DOT. Development of a Master Schedule should be an early activity of the GIS-CC in cooperation with the ISTEA management system committee(s) and other DOT staff.

This GIS Strategic Plan and Master Schedule must be updated as applications are developed and lessons are learned.

5.1 Select GIS Coordinator

Responsibility: Information Processing Steering Committee and GIS-CC

Along with the GIS-CC, there should also be a GIS coordinator selected for the Department. This GIS coordinator is responsible for participating in the state-wide cooperative approach, identify future directions in GIS, monitor GIS activities/technology in other centers, and foster communications between users, developers, and the GIS-CC. The GIS coordinator could be responsible for managing (or co-managing with Operations and Finance management) a technical staff (GIS support staff).

(see also: PennDOT, 1991, Sec. 2.2.2)

5.2 Develop goals and objectives, and Measures Of Effectiveness for objectives

Responsibility: GIS Coordination Committee

The GIS Coordination Committee [GIS-CC] will address the goals, objectives and measures of effectiveness (MOE) for the development of GIS in the Department. The GIS coordinator (and technical staff, where needed) will assist the GIS-CC in the development of specific goals, objectives, and MOE's for the objectives.

> Development of goals and objectives for GIS-T planning and implementation follows directly from the assessment of agency needs and resources. The goals provide the broad policy framework within which GIS-T will be planned and implemented. The objectives are more specific statements of how each goal is to be achieved including guidance as to scope, timing, and duration. As the goals and objectives are developed and refined, more information on agency needs and resources may be required resulting in an iterative process. for each objective one or more measures of effectiveness (MOEs) should be developed. (*NCHRP, 1993a, Section 4.4*)

The goals, objectives, and measures of effectiveness developed by the GIS-CC and coordinator (with input of DOT staff), establish the general direction for future GIS implementation within the DOT. The goals should be clearly defined to avoid ambiguity which could lead to confusion and lack of focus. Objectives should be specific statements which guide personnel in implementation tasks. Objectives include scope of projects, timing concerning implementation of different applications (in general), and the amount of time to implement different applications. Measures of effectiveness that are developed by the GIS-CC and DOT staff are the tools for evaluating implementation of different GIS applications. Goals, objectives and measures of effectiveness will likely vary for different divisions.

Two important features of the goals and measures identification process are:

- Goals, objectives and measures defined by the committee are to be regarded as *recommendations* to the Divisions, and
- The goals, objectives and MOEs should *continuously* be revisited and updated, as required.

The national GIS-T study reports:

> Goals and objectives should include the critical success factors. For example, the GIS-T should (1) maximize the level of integration with the corporate information systems strategy, (2) minimize the staff requirements, (3) facilitate education and training, (4) provide the widest range of functionality, and (5) provide the highest degree of flexibility in the data architecture. Cost-related goals and objectives should also be included. (*NCHRP, 1993a, Section 4.4*)

The critical success factors identified in Chapter 2 of this report will be important to the GIS coordinator and Committee when developing goals, objectives, and MOE's. These factors will be especially relevant to coordination of cross-divisional applications. The GIS-CC should monitor the development of GIS for the department to determine if the technology is being fully utilized. An early committee activity could be to establish its mission, role and responsibilities, subject to input of the Divisions and approval of the IP Steering Committee.

5.3 Define Requirements and Identify Resources for the GIS Support Staff

Responsibility: GIS Coordination Committee

As mentioned in Chapter 2, there will be the need to develop specific positions within the Iowa DOT to deal with GIS application implementation and usage. The GIS-CC will be responsible for addressing and defining any additional staffing requirements for the department that implementation of GIS programs might incur.

As identified in NCHRP 359, these positions can be classified into three groups: core, master, and other users. Whether the Iowa DOT develops these positions should be examined by the GIS Coordination Committee.

> In an organization-wide implementation, there are likely to be three levels of GIS-T staff and users:
>
> 1. Core staff who are responsible for spatial database design and development, establishment of standards, training, low-level programming and application development. The core staff is often within the MIS division.
> 2. "Master" users who participate with the core staff in application design and who do high-level (macro language) application development. Master users are attached to user divisions.
> 3. Other users who are trained only in the use of fully developed applications. These are most of an organization's employees, from entry level planners and engineers to top management. (*NCHRP, 1993a, Section 3.2, 5.3*)

We suggest the Department employ terminology such as "GIS support staff", "GIS Applications Developers", and "GIS Users" with the same definitions and locations as the NCHRP report suggests.

The GIS-CC will assist in preparing the job descriptions of GIS staff positions and make recommendations for filling these positions with persons who possess the skills and necessary geographic reasoning and aptitude. The GIS-CC might also be consulted when and if existing GIS staff are reassigned or reclassified within the divisions.

5.4 Choose Applications for Further Study with High Payoff Potential

Responsibility: Divisions

Each Division will decide upon the GIS applications to be developed for its own use. This decision can be made using the existing policies for GIS applications development along with input from the GIS-CC, GIS coordinator, and support staff. Division staff are encouraged to examine the list of potential GIS activities identified during development through the methodology described in Chapter 4-A and contained in Appendix A . The list is not meant to be exhaustive, rather, it is suggestive of the opportunities presented by the technology. Management systems present an especially promising opportunity.

Divisions need to be aware that a large number of potentially cost effective GIS applications may be identified and that some prioritization methodology must be applied. The divisions can be assisted in this by using an applications definition method of GIS implementation since it presumes serial implementation (Croswell, 1988) This can reduce a potentially overwhelming task to manageable proportions.

With the resources available at the Iowa DOT through the GIS-CC and outside assistance, the research team believes that development of applications within the divisions will be possible. Selected applications should have a high benefit/cost ratio and whenever possible, contribute to a modular, building block concept (integrated).

5.5 Identify Key Personnel for Selected Application(s)

Responsibility: Divisions

After the divisions select the applications that they will be examining for the future year, the key personnel to be associate with each GIS application should be specified. The Divisions will identify applications developers who will work with the GIS-CC and support staff. Prospective users should also be identified.

5.5.1 GIS Applications Developers

Each of the Divisions will be responsible for developing GIS applications. The applications developer will work closely with the GIS coordinator and the support staff. The applications developer should be computer and programming literate and be willing to learn (highly motivated). (*NCHRP, 1993a, Section 3.2*)

5.5.2 Users (Within the Divisions)

It is key to identify end users early in the process of applications development. This will enable developers to design software and user-friendly interfaces. This will also facilitate the smoothest transition from existing procedures and processes. Users will require varying levels of training depending upon computer literacy and experience. (*NCHRP 1993a, Section 3.2*)

5.6 Perform Functional Requirements Study for Potential Application(s)

Responsibility: Divisions w/GIS Support Unit

A Functional Requirements Study (FRS) is the primary planning process for implementing a GIS application. The FRS lays out what data are needed and how they must be processed to make the necessary products and reports. The FRS should include an identification of the decisions to be supported, a description of the data required and the data availability, and a list of the GIS functions required. (*NCGIA, 1991, Section 61*) Also included in the FRS is the staffing requirements needed to support the GIS for the application.

A Functional Requirements Study should attempt to establish hardware and software needs, define support requirements, identify database issues, and if needed, evaluate software alternatives through initial screening.

Applications developers with the assistance of the support staff can conduct the FRS. For identified applications, the FRS could begin with the data collected during the surveys and interviews. (See Chapter 4 and Appendix 4-A.)

5.6.1 Identify decision to be supported

A Functional Requirements Study initially focuses upon the decisions made by division staff in the routine performance of their assigned duties. The documentation should show which decisions attend each responsibility. (*NCGIA, 1991, Section 61B*)

This information can be obtained by the applications developer through an examination of the Policy and Procedure Manual and/or by following and using the results of the survey process covered in Chapter 4.

5.6.2 Describe data requirements/availability

There are many items to examine when estimating data requirements and availability. This step involves identifying those data sets which must be processed to create the required product. (*NCGIA, 1991, Section 61B*). Antenucci, 1991, lists some of the parameters that need to be considered:

- data content
- map features
- graphical data required
- non-graphical data required
- current map descriptions
- data standards and characteristics
- scale/precision/accuracy
- data volume. (*Antenucci, 1991, Step 1*)

Other data descriptors include:

- filename/location
- format/media
- who maintains the data.

Cataloging these factors on data requirements and availability help the applications developer understand the ingredients required for a given product and the associated costs for data can be estimated.

(see also: NCHRP 1993a Section 3.3; NCGIA, 1991, 61B)

5.6.3 Define software requirements/match with current software/hardware capabilities

During the Functional Requirements Study, divisions will define the software requirements for their specific applications.

> A number of vendors provide GIS-T software likely to meet many of a DOT's goals for implementing a wide variety of GIS-T applications. The capabilities of current GIS-T software are changing fairly rapidly. Thus, the best source of information on the potential functionality of each software product is the vendor. This information should be supplemented where possible by independent validation by current GIS-T software users via technical reports and informal communication. The specific information that must be collected for each alternative depends on the objectives and the MOEs that were developed in the prior setup. (*NCHRP 1993a, Section 4.5*)

Once the data requirements and availability are defined, the next step in the FRS is to examine different software packages to determine which package will best fit the data needs. To reduce implementation costs, compatibility with software, hardware and communications currently used at the DOT is equally important .

(See : NCGIA, 1991 61b5, 62d, 66d; PennDOT Sec 2.4)

5.6.3.1 Software functionality

The most effective and efficient software will perform the application without numerous data conversions and/or the purchase of additional software. (*Antenucci, 1991*)

5.6.3.2 Data entry, processing, retrieval and display functions required

The software must perform data entry, data processing, data retrieval as well as the production/display of products. It will work with current data at the DOT and incorporate the data into the software with minimal effort. The software also needs the ability to move data rapidly to other database(s) as needed. Finally, it needs to display the data in meaningful ways to support/provide maps, enter and answer queries, and perform searches and sorts over a wide range of criteria. (*Antenucci, 1991*)

5.6.3.3 Hardware devices and capabilities

The software selected needs to be as compatible as possible with the existing hardware at the DOT. This can produce significant savings for the development of the application; and while hardware costs have declined dramatically in recent years and will continue to decline, hardware should be selected to support the software and applications not the reverse. (*NCHRP 1993a*)

5.6.3.4 Communications Facilities

The software must be compatible with the existing communications systems in the department. Because the application may be shared throughout the department, the software needs to be accessible to authorized external users. Having a software system that is compatible with the existing communication system will facilitate the sharing of data across offices at the department. (*Antenucci, 1991*)

5.6.4 Define support requirements (within the divisions)

Although not given as a step in the NCGIA report, determining the support personnel requirements for each application should be included in the Functional Requirements Study. It includes the person-hours needed in the implementation stage and the person-hours needed in the education and operating stage. Thus it will cover support personnel requirements from the initial stages of implementation through the transition to the operations phase where the GIS application replaces the existing system for producing the work of the division.

5.7 Identify Database Issues.

Responsibility: GIS Coordination Committee

The GIS-CC is responsible for examining database issues and determining the policies that the department will follow to handle issues. The GIS-CC will also identify database issues that arise in cross-divisional applications. The GIS coordinator will request that specific database issues within the divisions be examined in a timely manner and will work with the GIS-CC in resolving database issues.

Database issues include linking mainframe database workstations to digital maps, stand-alone systems verses network systems, data transfer standards, location referencing, developing/compiling graphic and non-graphic standards, privacy and security concerns, defining the required relation among data, establishing the frequency and timeliness of data updates (data maintenance), data conversion issues, standards in storage media, and database software options.

5.7.1 Linking a mainframe database to a workstation graphic computer

A report published by the Oregon DOT entitled, "Linking a Mainframe DB2 to Workstation Graphics at the Oregon Department of Transportation" by Chris A. Levy of the Oregon DOT examines this topic. It was presented at the AASHTO GIS for Transportation Symposium 1991 and includes the Oregon DOT's use of an application which will link highway and milepost numbers such that analysis done on the mainframe doesn't interfere with computing speed on the graphic computer. (*Levy, 1991*)

5.7.2 Stand-alone systems verses networks

Stand-alone systems often result when application areas are responsible for their own computing. Stand-alone systems offer autonomy to individual or small groups of users. But individual users in large organizations often must interact. They share data and have common computing needs. Stand-alone systems forgo the synergy of networks, and also exacerbate the integrity and redundancy problems inherent in multiple copies (or versions) of the same data scattered throughout an organization. (*NCHRP 1993a, Section 4.2*)

The GIS-CC needs to examine the use of the stand-alone versus centralized and distributed server/user network systems to determine which is best suited for the divisions. (See also: NCGIA, 1991, 66C)

5.7.3 Identify data transfer standards

Data transfer standards and formats must be defined for data exchange between DOT systems and between DOT and other agency systems. Data exchange formats should be examined with regard to their efficiency for Department GIS use. Available standards include SIF (standard interchange format), DLG (digital line graph), and DXF (drawing interchange format), although these are standards for graphics exchange only. Several of the GIS vendors are working toward standards and tools that will facilitate exchange of data and graphics alike. Furthermore, the Department must stay abreast of national efforts toward development of graphic data transfer standards (SDTS, etc.).

> As a rule, state agencies do not have common GIS hardware and software. A number of data exchange format standards have been used - all with some

> limitations. Problems arise from the incompatibilities of proprietary data models. Typically, either information is lost or spurious information appears when translating among various vendors' exchange formats. Implementation of neutral, robust standards, such as the Spatial Data Transfer Standard (SDTS) is vital to efficient data sharing efforts. (*NCHRP 1993a, Section 7.2*)

5.7.4 Examine location referencing

A set of referencing systems should be defined for the GIS. For example, the PennDOT implementation plan specified:

- State plane
- NAD 27 or NAD 83
- Latitide/longitude
- State route/segment/offset (this is PennDOT roadway location referencing system)
- County and municipal codes

(*PennDOT, 1991, Section 2.5.2*)

A comprehensive review of referencing systems for the Iowa DOT was conducted by Peggi Knight. (See Knight, 1994). This document will provide a good resource for the GIS-CC and support staff as a central GIS database is designed.

5.7.5 Identify graphic data standards

Various applications require various graphical standards for accuracy and precision. These may range from 1:100,000 scale for statewide planning to centimeter-level accuracy for design and engineering work. GIS technology allows for the integration of data of different standards while retaining information (metadata) about the accuracy and precision of each element or layer. While a combination of data with different levels of accuracy produces accuracy no better than the worst input, as data are improved later, they may be substituted.

5.7.6 Identify non-graphic data standards

Following the PennDOT implementation plan, non-graphic data standards to be defined for the GIS-T include:

v Data definitions (data dictionary)

v Physical storage plan

v Data access strategy

vMaintenance/enhancement (*PennDOT, 1991, Section 2.5.4*)

5.7.7 Identify security/safeguard concerns

Security issues exist for all databases to protect data/system integrity and to confine access to legitimate and authorized users. (*NCGIA, 1991, 66C*)

To protect their GIS investment, the PennDOT implementation plan suggested safeguards be implemented to control access to the GIS and its data. System security measures must consider:

v System access within the DOT

v System access by other agencies

vSystem access by the public

v Read/write access for data protection (*PennDOT, 1991, Section 2.5.5*)

5.7.8 Required relation among data

There is a need to determine the relation among data to determine which data need to be used together and precisely how data sets interact. Some data sets are derived from others. Still others may be combined to form yet another. There is always a danger of redundancy in data which on the surface appear to be different. However, collection criteria can often be reformulated to make more efficient use of data collection and processing functions. (*Antenucci, 1991*)

5.7.9 Frequency of update/timeliness

As GIS becomes more pervasive, more data sets will be developed. It is important to consider, when developing new applications, the mechanism and frequency required for updating the data. When will data be updated and who will be responsible? If this step is ignored, new data may not be placed into the system in a timely manner (or not at all). Applications may only be used once. Data can come from internal sources or external sources. They may be collected routinely or require a special effort. Life cycle costs of applications, including training, support and especially data update must be carefully examined. Further, a user unaware of the age/timeliness of data could produce items that do not reflect current conditions or problems. (NCGIA, *1991*, *Section 66C*)

5.7.10 Identify data conversion issues

The data conversion process is the process of manipulating data from various sources into the form required for a particular application. The four main conversion issues are scale, accuracy, scheduling priorities, and cost. Much GIS data exists at other state (Iowa) and federal agencies. The GIS demonstration project described in Chapter 3 of this report is an excellent example of the issues and techniques involving transfer of data from the DNR to the DOT. While many of the GIS vendors provide data conversion tools, many have bugs (at this date) and are difficult to use. The trend, however, is toward simplification of the conversion process. (*NCGIA, 1991, Section 66G*)

5.7.11 What storage media to use

This decision depends on the size and growth rate expected for the database, the access speed required, and the database format for the various media. (NCGIA, 1991, 66C)

5.7.12 Evaluate Database Software Options

The DOT currently has extensive experience with several database software packages. Among these are DB2 and IDMS. There has been limited experience with Oracle and some others. There are other database packages available to support GIS. While it would be desirable to select software which is compatible with existing DOT software, programs, and experience, the software must possess the flexibility to efficiently support GIS and provide for future expandability.

5.8 Evaluate Software Alternatives: initial screening (If needed)

Responsibility: Divisions/GIS Coordination Committee

Software alternatives must be examined to determine which best meets the needs of the application. Initial screening of a set of alternatives may be needed to reduce the number of candidates for in-house testing to a manageable size. The evaluation of software should involve the divisions (and the GIS-CC, especially if the choice affects other divisions). The division's applications developer will be responsible for screening software which will best satisfy the needs of the division. The GIS-CC will determine how the software will fit into overall GIS implementation and development.

> Full evaluation of the GIS-T software alternatives requires in-house "hands-on" testing of the most promising alternatives. There simply is no other way to demonstrate that the software ... is compatible with the office operating environment, and meets the primary DOT functionality requirements.
>
> The in-house testing of two or more promising software alternatives ideally would be conducted with current DOT hardware and operating systems and actual DOT databases. The testing should cover the full range of required GIS-T functionality. Evaluation criteria should be included for user interfaces, database creation, database management, data manipulation and analysis, data display and map generation as well as transportation-specific functions such as dynamic segmentation and route generation. One or more prototype applications should be demonstrated. (*NCHRP 1993a, Section 4.6*)

The testing process in the department needs to be a full function test that includes all the features and all the division personnel expected to perform the application in the future. The software should be tested against criteria decided upon prior to the test. The testing process should be overseen by both the applications developer and GIS-CC.

The applications developer and the GIS-CC should employ qualitative and quantitative benchmarking in evaluating software alternatives to minimizing risk in the selection process. Qualitative benchmarks ask "are the functions actually present?", "do they live up to expectations?", and "are they easy to use?". Quantitative benchmarks ask "does the proposed configuration have sufficient capacity for the planned workload?". (NCGIA, 1991, 63)

5.9 Perform initial cost benefit analysis for applications - Decide whether or not to proceed.

Responsibility: Divisions w/GIS Support Unit

Once the Functional Requirements Study is completed and the database issues and software alternatives are narrowed down, the implementation process needs to be examined to decide whether further development of this specific application is warranted. Before more resources are committed, the divisions (represented by the applications developer, with the help of the support unit) should present evidence showing that the application will provide a pay-off in the long run. The applications developer will be analyzing the application on a technical level and will be concerned with the efficiency of the application. The GIS-CC will analyze the applications on an institutional level and will be concerned with the effectiveness and compatibility of the application for the entire DOT.

The first step is to determine the benefits of implementing a particular application. Five classes of benefits are listed by Antenucci's:

> Type 1 - Quantifiable efficiencies in current practices, or benefits that reflect improvements in existing practices.
> Type 2 - Quantifiable expanded capabilities, or benefits that offer added capabilities.
> Type 3 - Quantifiable unpredictable events, or benefits that result from the flexibility of the software to accommodate non-routine [perturbations].
> Type 4 - Intangible benefits, or benefits that produce intangible advantages.
> Type 5 - Quantifiable sale of information, or benefits that result from the sale of information services. (*Antenucci, 1991, Page 66-77*)

If the justification process only looked at the benefits of implementing a GIS there would always be reason to justify the system. The cost also must be considered. The four implementation costs identified by Antenucci are:

> Cost 1 - Capital and operating cost.
> Cost 2 - Database cost.
> Cost 3 - Hardware and software cost.
> Cost 4 - Personnel cost. (*Antenucci, 1991, Page 66-77*)

> Justification arguments for GIS-T are similar to those used initially for automation in general and later for CAD. GIS concepts are at the heart of new strategies for comprehensive information systems design and planning. As a result, the potential benefits of GIS-T are both organization-wide and profound. A number of studies have shown that the return on an investment for GIS is substantial given that a critical level of investment is reached. For example, Gillespie reported that, as a result of 40 case studies at the federal level, efficiency benefits alone justified the cost of GIS and that effectiveness benefits were many times larger. Efficiency benefits are those that result from completion of the same tasks at reduced costs. Effectiveness benefits are those that result from completion of tasks that could not or would not be done otherwise.
>
> A well developed justification strategy can do more than provide arguments for GIS-T. It will [encourage] decision makers to consider all factors, including those that are quantifiable, those that are non-quantifiable, and those that are intangible (53). (*NCHRP 1993a, Section 6.1*)

The GIS justification procedure is similar to those already in place at the DOT. Because of this, decision makers already have a familiarity with justification processes proposed for GIS implementation.

Qualitative and quantitative benefits and costs are listed on page 83.

5.10 Select Software (followed by selecting hardware)

Responsibility: Divisions/GIS Coordination Committee

The implementation of a GIS application must await software selection by the divisions and the GIS-CC. The choice of the best software for the division is based on cost, speed and capacity, quality and cost of support, and the supplier's background. However, the choice of software also has an impact on Department-wide support functions where a smaller set of software packages would be preferred. (*NCGIA, 1991, 66E*)

	BENEFITS	COSTS
QUALITATIVE	Doing new things Improved departmental relationships Improved decision-making Data integration Improved security of data Improved organization of data Reduced redundancy Improved report presentation Easier to manage large volumes of data Increased ability to meet deadlines & expectations More spontaneity (creativity) Ability to discover data inter-relationships Ability to perform iterative planning Better documentation of data/systems Easier to justify needs Improved worker moral? (empowered, high tech)	Institutional opposition to change Tendency toward inappropriate use of technology (overkill) Disruption of normal work activities and potential of missing important deadlines Delay of production (esp. first applications) Difficulty in dealing with large volume data sets (getting started) More spontaneity (less control over quality) Decrease in worker moral? (intimidation; feeling that they haven't been doing a good job)
QUANTITATIVE	Doing old things better Improved efficiency - easier/faster revision of maps and data - faster searches - improved analysis Improved accuracy Increased productivity Cost reduction Cost avoidance Revenue from sale of information	Hardware purchase and maintenance Software purchase and maintenance Training Data collection/input Database maintenance Systems analysis and support Purchase of data

(See also: NCGIA, 1991, Section 65 b, c)

> Completion of GIS-T software evaluation leads logically to the development of the final system design and detailed specifications. The specifications form the basis for the Request for Proposal (RFP) and the competitive bid process. Procurement of GIS-T software is merely the beginning of a long implementation process. The procurement process itself should include a provision for operational testing of the software and formal acceptance based on clearly defined evaluation criteria. Further testing of the software with a pilot project is highly recommended. Only at this point should full agency-wide applications be initiated. The final step in the implementation process is "application enabling." A systematic process for identifying and implementing promising applications across the agency should be institutionalized so that the full power of GIS-T is realized. (*NCHRP 1993a, Section 4.7*)

Following the evaluation of the bids and the selection of the best software for the application, the division needs to select a procurement approach (usually via RFP, unless the software already exists at the Department) and to design a pilot test program for the application software.

(See also: NCGIA, 1991, 62 E; PennDOT, 1991, Sec. 2.4)

5.10.1 Develop a Request for Proposal (RFP)

The NCHRP report suggests a process for developing an RFP:

> 1. Invitation to bid - a summary of the project and bid procedures.
> 2. Instructions to bidders - a detailed description of how bids are to be prepared and the format for submission. Permitted exclusions and substitutions are identified.
> 3. Bid proposal - the actual response by the bidder in the format specified in the "instructions to bidders," includes a budget for completing the work and commitment to complete the work if selected.
> 4. Bonds - may include bid bond, performance bond, or labor and materials payment bond.
> 5. Agreement - a legal document that identifies the parties, the work to be performed, the time allowed, the amount of the award, and signatures binding the parties.
> 6. Conditions - definition of general contractual relationships and procedures.
> 7. Contractor qualifications - identification of the minimum experience and qualifications necessary to submit a bid and instructions for submitting specific data on qualifications. (*NCHRP 1993a, Section 4.7.3*)

Divisions need to develop a software procurement approach similar to the RFP currently used for obtaining new equipment. The items listed by NCHRP might not be required in the specific DOT RFP. Conversely, the items listed by NCHRP might overlook critical items needed in an

RFP from the Department. Either way, the applications developers should be familiar with and be able to assist in the preparation of an acceptable document for procuring GIS software and hardware for the division.

5.10.2 Run a pilot project

The division should run a pilot project with the selected software using data authorized by the department to facilitate implementation. The pilot project will be useful in discovering implementation problems that could arise in the operation stage of development. "The pilot project provides the first physical results from a GIS project and provides a range of reduction of risks associated with a project before the final commitment to full implementation is made." (NCGIA, 1991, 64)

> The problems of making GIS-T operational can most easily be addressed in a pilot project. A pilot project minimizes the risks inherent in implementing any new technology. The project should be large enough so that meaningful results are obtained, but small enough so that alternative approaches and solutions can be tested without excessive commitments of staff time and other resources.
>
> The best candidates for pilot projects are high priority applications that were identified in the initial needs assessment. These applications have the highest potential benefits compared with development and operational requirements A successful pilot project should lead directly to agency-wide application once the benefits and costs of implementation are demonstrated. (*NCHRP 1993a*, *Section 4.7.6*)

Following a successful pilot project, the application then enters the phase of full database design prior to implementation.

The Iowa DOT has already conducted one demonstration and one pilot project utilizing GIS, presented in Chapter 3 of this document. American Management Systems, Inc. is currently under contract to develop and test a mobile GPS/GIS system for accident reporting. This project is viewed by some as a proof of concept.

(See also: NCGIA, 1991, 64)

5.11 Develop or Convert GIS Database

Responsibility: Divisions/GIS Coordination Committee

The task of database development and/or modification is one of the most important and expensive items required for implementing a GIS. It can take several years to complete and cost four to five times as much as the hardware and software. It is important to note that since the benefits of the GIS are derived from the products produced, the database development must be scheduled so the system can produce a limited number of products and support different applications as quickly as possible. The total benefits to be derived from the GIS will not be obtained until database development is complete. (*NCGIA, 1991, 66H*)

The task of developing and converting the database falls within the duties of the individual divisions developing the applications and the support staff. When examining the different database issues presented earlier in this document, the applications developer and the support staff require input from the GIS-CC so that the needs of the different divisions are included. The GIS-CC will compare the applications desired by the divisions to identify those with similar structures/functions, and common/compatible database requirements.

5.12 Develop Application(s)

Responsibility: Divisions w/GIS Support Unit

The applications developer is responsible for developing the applications within the division with assistance provided by the GIS-CC and support staff to select hardware, software, and develop procedures. Allocations of adequate time and resources within the divisions should be made using current procedures. Time and resources allocated to GIS support staff must be made at the Department level.

5.13 Develop Documentation, Quality Control Process

Responsibility: Divisions

The division applications developer will prepare documentation and quality control procedures and can receive guidance from the GIS-CC and support staff if desired. Specific documentation on standards and implementation procedures is required for each application. A complete data dictionary is a must. The GIS-CC should maintain Department guidelines for the data dictionary which could be similar to national or other state agency models (e.g. DNR). The applications developer will also be required to develop a quality control process that will be used to evaluate and maintain performance standards, especially those needed to monitor milestones for the Measures of Effectiveness. Chapter 2 presents some of the items mentioned in the

NCHRP study that are required in a quality control process. The applications developer should review Chapter 2 when developing application documentation of procedures.

5.14 Provide GIS Training

Responsibility: GIS Support Unit

The Department should recognize that continued education in GIS and geographic reasoning are required. Training on a Department-wide GIS and use of databases should be provided by the support staff. The support staff and the applications developer will be responsible for training the users on specific applications. Similar training is recommended by the PennDOT study where a central staff is trained to operate the GIS which is then responsible for training the remote users of the GIS. (PennDOT, 1991, Sec. 4.1)

5.15 Implement the applications

Responsibility: Divisions w/GIS Support Unit

Divisions implement and integrate the applications into the Department using the knowledge gained in the FRS and by executing the procedures and other steps outlined in this Strategic Plan.

The applications developer recommends when the application is ready to be implemented, who will be using the application when it is developed, who will collect data to support the application before, during and after development (transition), and how the application will be integrated into the routine operation and work of the division.

5.16 Perform Post-Development Qualitative Evaluation

Responsibility: Divisions

The divisions will be responsible for post-development qualitative evaluation of applications. The actual implementation process should be compared to the planned implementation process. User satisfaction with the process and the operation of the application should be documented along with lessons learned.

> Periodic evaluation of a GIS-T implementation is necessary to ensure efficiency and effectiveness in meeting goals under changing circumstances such as new demands for applications; turnover, increases, or reductions in personnel; and changes in funding and organizational structure. Monitoring

> the performance of GIS-T might be necessary to sustain funding and institutional support. Possible evaluation methods include the following:
>
> 1. Comparison to plan. The following questions should be addressed: a) Is implementation on schedule-have planned milestones been met? b) Have planned goals and objectives been met? c) Have there been unexpected benefits? d) Have there been unexpected costs?
>
> The GIS-T implementation plan should be updated following each evaluation.
>
> 2. Determination of user satisfaction. The following questions should be addressed: a) How many active users are there of GIS-T in the organization? How does this compare to the number that have been trained? b) What is the extent of the organization's application portfolio? c) Have the users' confidence in data and decision making increased? d) Is there a higher morale? (*NCHRP 1993a, Section 6.2*)

This post-development qualitative evaluation will help the divisions determine the intrinsic value of the application that was just implemented. The knowledge of the value placed on the application might lead the divisions to alter priorities and division goals and objectives for future GIS-T applications.

5.17 Perform Post-Development B/C Analysis

Responsibility: Divisions

> Quantitative benefit-cost analysis. System evaluation can have a larger impact than the initial justification. Accurate determination of resources expended is now possible. (*NCHRP 1993a, Section 6.2*)

> ... testing will provide DOT staff with a greater understanding of GIS-T software capabilities and the extent to which the software alternatives are likely to meet DOT application needs. The testing and subsequent performance evaluation should lead to further refinement of DOT needs, which should be reflected in a revised statement of goals and objectives. (*NCHRP 1993a, Section 4.6*)

The B/C analysis will be developed by the division and will be required for each application implemented. This information will help the divisions revise and restructure the priorities for future GIS implementation. Methods can be similar to those utilized in Functional Requirements Study.

(See also: NCGIA, 1991, 65 D; Antenucci, 1991, Sec. B.3)

5.18 Revise GIS objectives

Responsibility: GIS Coordination Committee/Divisions

The implementation and evaluation of GIS applications will lead to new questions about the future applications and the process of implementing the applications. The questions will require that the GIS-CC and the Divisions revise initial GIS goals, objectives and measures of effectiveness for applications. The revision of the objectives for the GIS applications will be an iterative process that will lead to the best possible development of applications in the department.

5.19 Continue General GIS Education for Iowa DOT Personnel

Responsibility: GIS-CC and Support Staff

Educating personnel in the department about the capabilities of GIS is extremely important. GIS is a technology, or tool that can only produce results if personnel know what it can do and how to use it. To date, an introduction to GIS principles has been provided through interviews, presentations, and a NHI short course.

Additional opportunities for DOT personnel to learn more about GIS:

> An introductory short course in GIS-T has recently been developed for the Federal Highway Administration (FHWA) and is being offered on a regular basis through 1992. Some universities offer introductory continuing education short courses on GIS-T. Training services (introductory through advanced) can be obtained from consultants and software vendors. Such services can be provided either on-site (if demand is high enough) or at remote central locations of the provider's choosing. (*NCHRP 1993a, Section 3.5*)
>
> For organization-wide implementation, there will be some need for training on a continuing basis when there is personnel turnover, when new applications are being introduced, and when new release of the core GIS software become available. Large transportation agencies should consider developing internal training services, in which case there should be staff whose job it is to provide GIS-T training for other staff.. (*NCHRP 1993a, Section 3.5*)

It is important to note that in a dynamic environment, both at the Department and in the GIS hardware and software markets, there will be the need to provide additional and continuing education for the existing employees as new applications are developed and/or new GISs come into use. There is also a need to supply GIS education and orientation to new employees of the department. The department might also want to consider developing an internal GIS training center whose responsibilities would include educating personnel about new GIS capabilities.

5.20 Foster and Participate in State-Wide Cooperative Approach

Responsibility: GIS Coordinator

The GIS coordinator will be responsible for participating in a state-wide cooperative approach. The coordinator should work with other government agencies, such as RPAs and MPOs as they develop GIS applications and data sets that can be used state-wide. The GIS-CC will also collaborate with the Iowa Geographic Information Council (IGIC) to foster GIS coordination in the state.

> An integral part of a DOT's information technology and GIS plans must be coordination with other state agencies. There is significant potential for sharing of at least some spatial database construction and maintenance cost. Recognizing this, every state has some GIS coordination activity among state agencies (some extend the activity to include local governments, the Federal Government, and even the private sector) (4).
>
> Typically, each state agency agrees to be the responsible "custodian" of the spatial data that is primary to its mission, to maintain that data according to agreed-upon standards, and to make it available to other participants. In this way, DOTs become the custodians of transportation data, Departments of Natural Resources become the custodians of hydrography and wetlands data, and so forth.
>
> A data clearinghouse can be either a source of data (the actual data is on hand) or a source of information on how to obtain data (users are directed to appropriate agency contacts). And some states have used consultants to develop statewide GIS strategic plans (e.g., Minnesota). (*NCHRP 1993a, Section 7.1*)

5.20.1 Develop standards for state-wide approach

The GIS coordinator will be responsible for participating in the development of standards for state-wide GIS applications. These standards should be related to the GIS standards developed for use within DOT.

> In many cases, quality and maintenance standards for data sharing are those that are or would be used internally by the agencies anyway. So the requirement to conform to such standards imposes no additional burden on internal GIS efforts. However, concern over liability appears to be hindering

some data-sharing efforts. The concepts of "truth in labeling" on the part of data providers, and the corresponding judgment of "fitness for use" on the part of data users that stand behind the Quality section of the Spatial Data Transfer Standard (21, Part 1, pp. 21-24), represent current thinking concerning the risks of data sharing.

5.20.2 Identify DOT's role in state-wide cooperative effort

DOTs often have primary roles in statewide GIS efforts. There appear to be at least three reasons for this:

1. DOTs have a tradition of map making and geographic data management.
2. Many other agencies need transportation data; highway and road networks are often used as reference systems by others.
3. DOTs have always worked closely with local governments (e.g., with MPOs in transportation planning and with engineering offices in geodetic control, aerial photography, and large-scale mapping).

DOT roles seem to revolve around these concepts. DOTs are often looked to for leadership and technical knowledge. DOTs are the custodians of transportation information. And they are often important players in local government land information system (LIS) development efforts, particularly with regard to geodetic control. (*NCHRP 1993a, Section 7.3*)

5.21 Identify Trends and Future Applications and Potential Impact on DOT

Responsibility: GIS Coordinator/GIS Coordination Committee

The GIS coordinator and the GIS-CC will have the responsibility to identify trends and future applications and the potential impact of the trends and applications on the department. In so doing, the department will stay informed of the latest GIS issues and technology. The GIS-CC will be the channel for information sharing between the applications developers and the GIS industry.

(see NCHRP, 1993a, sec. 8)

5.22 Continue to Monitor GIS-T Activities in other States

Responsibility: GIS Coordinator/GIS Coordination Committee

The GIS coordinator and the GIS-CC will be required to keep track of GIS activities that are occurring on other states. By monitoring GIS-T activities in other states the coordinator and the GIS-CC can keep the divisions advised of similar applications being implemented elsewhere. The

GIS coordinator and members of the GIS-CC should attend national GIS-T conferences to keep up with these activities.

5.23 Foster Communication on the Status of GIS-T between Users, Developers, GIS-CC Members, Sponsor, Champion and Management

Responsibility: GIS Coordinator

The GIS coordinator will also be responsible to foster communications between the users of the GIS, the developers of the applications, and the management in the Department. Even if many effective GIS applications are developed which result in savings and better provision of transportation services, if these successes are not effectively communicated, the entire program will be at risk.

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Division	Office/ Function	Ref. #	Potential GIS Application	Benefits	Costs	Duplicate Ref. #
Project Development	Materials	1	Access the location of material pits and the type of material available from each material pit	H	L	10, 211, 423,
Project Dev.	Materials	2	Access and store line and road samples from projects	?	?	
Project Dev.	Materials	3	Access and store pavement analysis and design (job location, data collected/not yet collected)	?	?	140
Project Dev.	Materials	4	Store project documentation on which materials are used in which projects	L-H	H	29, 66, 70, 117, 419, 421
Project Dev.	Materials	5	Produce and access maps of pavement test information	H	L	
Project Dev.	Materials	6	Access maps of blow ups and rutting	L	L	
Project Dev.	Materials	7	Identify location of new material for evaluation	?		
Project Dev.	Materials	8	Determine the condition of pavement by location	H	L	153, 164, 415
Project Dev.	Materials	9	Handle PMIS data	H	L	40, 118, 236, 439
Project Dev.	Materials	10	Access the location of aggregate sites, pit sites (distance and availability)	H	L	1, 211, 423
Project Dev.	Materials	11	Access the location of ready mix plants and asphalt plants	L	L	446, 488, 489
Project Dev.	Materials	12	Access the friction number of each roadway	?		424, 475
Project Dev.	Materials	13	Access location and availability of equipment/vehicles for testing	L	?	114, 515
Project Dev.	Materials	14	Produce detour maps to show where a primary road was routed to a secondary or city road and pavement tests need to be performed	L	?	
Project Dev.	Materials	15	Display the results of pavement tests	L	?	
Project Dev.	Materials	16	Communicate and share information with other offices	?		
Project Dev.	Bridge Design	17	Store and access bridge deck condition	L	H	
Project Dev.	Bridge Design	18	Store bridge inspection information	L	H	128,160
Project Dev.	Bridge Design	19	Store and access structural section views of bridges	L	H	
Project Dev.	Bridge Design	20	Handle bridge management	L	H	
Project Dev.	Bridge Design	21	Store and access video records of bridge condition	N	H	
Project Dev.	Bridge Design	22	Determine load capacity of bridges	N	I	36
Project Dev.	Bridge Design	23	Route heavy loads and transfer information to driver services	I	I	

Project Dev.	Bridge Design	24	Store plans, pictures, reports of bridges	H	H	370, 430, 466, 493
Project Dev.	Bridge Design	25	Access information from Bridge Management System (map/data)	H	L	
Project Dev.	Bridge Design	26	Identify types of permits required when submitting bridge plans (wetlands, jurisdiction, ...)	L	L	
Project Dev.	Bridge Design	27	Use GIS to model stream and river flows for hydrologic analysis	I	I	
Project Dev.	Bridge Design	28	GIS map of proposed structures to maintain liaison with county officials	L	L	
Project Dev.	Road Design	29	Access pavement history (when, what aggregate)	H	I	4, 66, 70, 419, 421
Project Dev.	Road Design	30	Access and produce location maps for projects	L	L	
Project Dev.	Road Design	31	Access survey data maps	H	I	72
Project Dev.	Road Design	32	Access and store soil information maps	H	I	65
Project Dev.	Road Design	33	Access wetland location	H	I	67, 89, 205
Project Dev.	Road Design	34	Produce plans for traffic control in workzones	N	I	61
Project Dev.	Road Design	35	Produce plans for urban and rural road design	N	I	
Project Dev.	Road Design	36	Access bridge rating and bridge locations	H	L	22
Project Dev.	Road Design	37	Transfer data from the DNR, FHWA, cities and counties	H	I	
Project Dev.	Road Design	38	Provide information on property ownership for the signing of documents authorizing legal right of entry on private property to perform surveys and soil investigations	L	I	85, 435, 479
Project Dev.	Road Design	39	Access survey information and cross-reference to real world coordinates	L	I	
Project Dev.	Road Design	40	Facilitate exchange of information with PMIS	H	I	9, 118, 236, 439
Project Dev.	Road Design	41	Facilitate the support activities of the primary survey and photogrammetry, roadside development, soil design, and predesign sections.	L	I	
Project Dev.	Road Design	42	Facilitate the review of project concepts, soil engineering design, photogrammetry and survey data, and roadside development plans to assure accuracy and compliance with design policies	L	I	
Project Dev.	Road Design	43	Maintain inventory of comparable paving sections and alternative designs for cost analysis	L	I	162
Project Dev.	Road Design	44	Access information about parks and institutional road projects	L	I	
Project Dev.	Road Design	45	Track proposed railroad abandonments to determine possible impact on highway design	L	I	204
Project Dev.	Road Design	46	Store information about vertical clearances in construction plans of highway and airports when a flight path crosses a primary or interstate highway	L	I	324

Project Dev.	Road Design	47	Access traffic and accident data from other offices or bureaus	H	I	235, 353
Project Dev.	Road Design	48	Plan, model and inventory plans for erosion control, landscaping, and safety rest areas	L	I	
Project Dev.	Road Design	49	Plan a viewshed for appropriate aesthetics and construction measures	?	?	
Project Dev.	Road Design	50	Inventory, allocation and planning of rest areas	N	I	
Project Dev.	Road Design	51	Prepare a map of which scenic areas are in violation of use	H	I	
Project Dev.	Road Design	52	Inventory and produce landscape plans for rest areas along highway right of ways, for department-owned property, and for windbreaks off highway right of ways	L	I	
Project Dev.	Road Design	53	Develop and access plans for roadway lighting on the interstate and other primary roads	L	I	
Project Dev.	Road Design	54	Review roadway lighting plans and make recommendations to other government agencies	L	I	
Project Dev.	Road Design	55	Maintain person-power control systems for the efficient scheduling and management of design projects	L	I	
Project Dev.	Road Design	56	Assist the office director with budget preparation and management, project progress monitoring, target reviews, plan storage, office presentations, and other assigned duties	L	I	
Project Dev.	Road Design	57	Maintain and provide access to the project development file	L	I	
Project Dev.	Road Design	58	Locate project borrow locations, review with soils geologist and incorporate soils into design plans	L	I	
Project Dev.	Construction	59	Handle construction management	I	I	
Project Dev.	Construction	60	Handle information about construction planning	H	L	
Project Dev.	Construction	61	Produce plans for detour/workzone traffic control	H	L	34
Project Dev.	Construction	62	Access culvert location and offset	L	I	133, 375, 494
Project Dev.	Construction	63	Store and access location of underground storage tanks	L	I	
Project Dev.	Construction	64	Produce haul roads maps, detour maps, and embargo maps	H	L	149, 337, 427, 476, 504
Project Dev.	Construction	65	Access soil information maps	L	I	32
Project Dev.	Construction	66	Store and access the total quantities that went in each project by location	I	I	4, 29, 70, 117, 419, 421
Project Dev.	Construction	67	Access map of state wetlands			32, 89, 205
Project Dev.	Construction	68	Store and access utilities located in the right of way	H	I	134, 215, 418, 426, 471
Project Dev.	Construction	69	Access map of current project locations and project locations for the upcoming year	H	L	290, 329

Project Dev.	Construction	70	Store and access the quality of the aggregate used in each project	L	L	4, 29, 66, 117, 419, 421
Project Dev.	Construction	71	Access right of way location and ownership information	H	H	85, 86, 219, 416, 435, 479,
Project Dev.	Construction	72	Access survey maps	I	I	31
Project Dev.	Construction	73	Access map of ATR locations	L	L	240, 287
Project Dev.	Construction	74	Provide maps that can assist in the coordination and assignment of permanent and temporary field personnel	L	I	
Project Dev.	Construction	75	Facilitate direction and consultation to field offices, including counties and cities, on normal, special or complex construction problems	I	I	
Project Dev.	Construction	76	Facilitate in the advising the contracts engineer concerning contractor performance and qualifications	I	I	
Project Dev.	Right of Way	77	Access and display federal lands inventory			
Project Dev.	Right of Way	78	Store engineering calculations			
Project Dev.	Right of Way	79	Access and display mapping files			
Project Dev.	Right of Way	80	Access billboard statue maps			
Project Dev.	Right of Way	81	Store maps to assist in right of way litigation			
Project Dev.	Right of Way	82	Handle real estate management			
Project Dev.	Right of Way	83	Display maps of right of way acquisition			
Project Dev.	Right of Way	84	Access and display maps of vacant lands			
Project Dev.	Right of Way	85	Access and automate title search, dimensions, relationship, subdivision, address, phone number			71, 86, 219, 416, 435, 479
Project Dev.	Right of Way	86	Develop map of right of way			71, 85, 219, 416, 435, 479
Project Dev.	Right of Way	87	Access map of property plats DOT will be buying			
Project Dev.	Right of Way	88	Access strip maps			
Project Dev.	Right of Way	89	Access maps of state wetlands			32, 67, 205
Project Dev.	Right of Way	90	Access maps of all lakes and streams in the state			447, 454
Project Dev.	Right of Way	91	Automate coordination with property management section			
Project Dev.	Right of Way	92	Determine the amount of right of way needed for a given project			

Project Dev.	Right of Way	93	Access topographical information for borrow pits			
Project Dev.	Right of Way	94	Store individual parcel files containing scale property plats, title information, pertinent computations and other necessary data pertaining to the parcel			
Project Dev.	Right of Way	95	Transfer information with other offices regarding recommended design changes, borrow areas, access and the effect of proposed right of way projects			
Project Dev.	Right of Way	96	Store official right of way plans for the purpose of acquisition and as the record of right of way acquired			
Project Dev.	Right of Way	97	Store detailed cost estimates for future rural right of way acquisitions			
Project Dev.	Right of Way	98	Store plans provided by utility companies and cost estimates			
Project Dev.	Right of Way	99	Access multiple listing to provide relocation assistance			
Project Dev.	Right of Way	100	Coordinate with support services on management of property owned by the department			470, 513
Project Dev.	Right of Way	101	Coordinate with project planning on the notification of properties effected by a proposed route			
Project Dev.	Right of Way	102	Maintain an inventory of outdoor advertising signs and junkyards visible along the freeways and primary and interstate highways			
Project Dev.	Right of Way	103	Maintain outdoor advertising through the issuance of permits			
Project Dev.	Right of Way	104	Store motorist logo information signing within highway right of way			
Project Dev.	Right of Way	105	Access the location of junkyards to select for relocation or removal as needed			
Project Dev.	Right of Way	106	Assist in allocating funds for outdoor advertising and junkyard control programs			
Project Dev.	Right of Way	107	Coordinate the removal of junkyards on the interstate and primary systems			
Project Dev.	Contracts	108	Store and track contract summaries and project monitoring	?	I	463
Project Dev.	Contracts	109	Produce project cost maps	?	I	
Project Dev.	Contracts	110	Store and reference latitude and longitude of project	H	L	
Project Dev.	Contracts	111	Cross-referencing system for projects for use by other offices	H	I	
Project Dev.	Contracts	112	Produce and store a map of contractors by location and information about which services are supplied by each contractor	L	L	516
Project Dev.	Contracts	113	Produce map of construction funds available for further letting by county	L	L	
Maintenance		114	Access Equipment/material location			13, 515
Maintenance		115	Handle maintenance management			
Maintenance		116	Access contracts/pavement age map			

Maintenance		117	Access and store pavement history information			4, 29, 66, 70, 419, 421
Maintenance		118	Handle PMIS file			9, 40, 236, 439
Maintenance		119	Access the location of traffic signal controls			
Maintenance		120	Freeway ramp metering			
Maintenance		121	Produce mile post location maps			
Maintenance		122	Handle port management			203, 306
Maintenance		123	Display when various types of work are required and scheduled to maximize efficiency			
Maintenance		124	Identify areas of continued maintenance that may need to be replaced			495
Maintenance		125	Monitor stockpiles and display quantities of materials at various sites			
Maintenance		126	Display the roadway conditions			
Maintenance		127	Display locations where work has or hasn't been performed recently			
Maintenance		128	Access the location and type of bridge for bridge inspection			160
Maintenance		129	Store and access sign location and sign inventory			412, 428, 465, 514
Maintenance		130	Store information about salt stockpiles (location and amount)			
Maintenance		131	Perform flood detour routing			
Maintenance		132	Access the location and type of guardrail			365, 414, 432, 467
Maintenance		133	Access the location and dimensions of culverts and other drainage structures			62, 375, 494
Maintenance		134	Access the location of utilities			68, 215, 418, 426, 471
Maintenance		135	Handle the MMS data (maintenance management system)			
Maintenance		136	Access the location of intersection lighting			
Maintenance		137	Produce signing plan maps (for construction and emergencies)			
Maintenance		138	Access the location of deer kills			411, 464
Maintenance		139	Access maps showing the level of service of each roadway			
Maintenance		140	Access the location of different types of pavement - tied to PMIS			3
Maintenance		141	Access the location and operation of pavement sensors			

Maintenance		142	Produce and access vehicle count maps			188, 256, 278, 336, 382, 482, 501
Maintenance		143	Access railroad maps			288, 408, 491
Maintenance		144	Access state highway maps			284, 318
Maintenance		145	Track equipment by location			506
Maintenance		146	Maintain current areas of responsibilities maps			168, 172, 201, 293, 444, 486
Maintenance		147	Transfer location information about areas where railroad crossings are in need of maintenance			
Maintenance		148	Store the highway lighting maintenance program			
Maintenance		149	Produce detour and bridge embargo maps and haul maps			64, 337, 427, 476, 504
Maintenance		150	Produce consolidated summaries of weather forecasts and road conditions during the winter months			347, 398
Maintenance		151	Produce maps showing the location where chemical weed control was performed and the location where containers where disposed			
Maintenance		152	Develop and maintain the snow and ice control program			
Maintenance		153	Produce maps of road surface and shoulder condition			8, 164, 415
Maintenance		154	Store maps of detour routes to resolve controversies between jurisdictions concerning compensation			
Maintenance		155	Store results of annual maintenance quality inspections and prepare reports on findings			
Maintenance		156	Store information and use GIS to conduct a sign inventory management system			
Maintenance		157	Access map of speed zone in the state			244
Maintenance		158	Access map of all line marking in the state			
Maintenance	Bridge Man. System	159	Tie PONTIS into a GIS to produce graphical output	L	L	
Maintenance	Bridge M.S.	160	Access the locations of bridges to be inspected	L	L	128
Maintenance	PMIS	161	Track how much money was spent in each location			
Maintenance	PMIS	162	Store and track how much success has the pavement had by location			43
Maintenance	PMIS	163	Develop network cutoffs for paving			

Maintenance	PMIS	164	Store condition analysis rating			8, 153, 415
Maintenance	PMIS	165	Store pavement sufficiency information by location			174, 187, 295
Maintenance	PMIS	166	Produce and access maps of different highway systems			
Maintenance	PMIS	167	Tie PMIS into MMS			
Maintenance	PMIS	168	Produce and access maps of federal classification of highways			146, 172, 201, 293, 444, 486
Maintenance	PMIS	169	Store data that is used by other offices			
Planning & Programming	Systems Planning	170	Store data for transportation modeling, urban planning, travel forecasting	H		
Plan. & Prog.	Systems Plan.	171	Store data for census transportation planning package	L		
Plan. & Prog.	Systems Plan.	172	Produce and access functional classification maps	H		146, 168, 201, 293, 444, 486
Plan. & Prog.	Systems Plan.	173	Produce maps to show transportation improvement programs in urban counties	H		
Plan. & Prog.	Systems Plan.	174	Produce maps to show roadway sufficiencies	H		165, 187, 295
Plan. & Prog.	Systems Plan.	175	Store data for needs studies	H		
Plan. & Prog.	Systems Plan.	176	Store data for special studies	L		
Plan. & Prog.	Systems Plan.	177	Produce and access maps of the commercial network	H		
Plan. & Prog.	Systems Plan.	178	Produce maps to determine access control assessment	H		
Plan. & Prog.	Systems Plan.	179	Store data for multimodal planning and system design	H		
Plan. & Prog.	Systems Plan.	180	Store data for rail alternative analysis	L		
Plan. & Prog.	Systems Plan.	181	Produce map showing transit accessibility and sketch planning	L		
Plan. & Prog.	Systems Plan.	182	Produce maps and store data for economic development	L		
Plan. & Prog.	Systems Plan.	183	Produce freight route maps	L		334
Plan. & Prog.	Systems Plan.	184	Produce maps for passenger transport	L		
Plan. & Prog.	Systems Plan.	185	Store data for ridership demographic and service analysis	L		
Plan. & Prog.	Systems Plan.	186	Produce maps of bike paths in the state	L		
Plan. & Prog.	Systems Plan.	187	Store highway sufficiency by location	H		165, 174, 295
Plan. & Prog.	Systems Plan.	188	Access and produce vehicle count maps			142, 256, 278, 336, 382, 482, 501

Plan. & Prog.	Systems Plan.	189	Access and produce railroad maps, pipeline maps, aviation inventory maps	H		
Plan. & Prog.	Systems Plan.	190	Store and transfer data needed for regional planning (location specific)	N		
Plan. & Prog.	Systems Plan.	191	Produce and access system plans	H		
Plan. & Prog.	Systems Plan.	192	Produce and access forecasting maps	L		
Plan. & Prog.	Systems Plan.	193	Produce maps of intersection turning movements	L		383
Plan. & Prog.	Systems Plan.	194	Produce maps of vehicle miles of travel by system classification	L		296
Plan. & Prog.	Systems Plan.	195	Produce maps for state wide travel forecasts	H		
Plan. & Prog.	Systems Plan.	196	Produce maps of the geographic areas for the continuing transportation study	H		
Plan. & Prog.	Systems Plan.	197	Produce maps of alternative transportation networks	H		
Plan. & Prog.	Systems Plan.	198	GIS applications to support transportation activities in cities over 25,000 people	H		
Plan. & Prog.	Systems Plan.	199	GIS applications to support regional planning agencies in the preparation of regional transit development plans	L		400
Plan. & Prog.	Systems Plan.	200	Produce maps to show the locations of potential RISE projects on the primary system	N		
Plan. & Prog.	Systems Plan.	201	Produce maps to show the changes in the state's functional classification system	H		146, 168, 172, 293, 444, 486
Plan. & Prog.	Systems Plan.	202	Produce maps of the state wide aviation system plan which inventories all airports	L		308
Plan. & Prog.	Systems Plan.	203	Produce maps of river terminals facilities and ports	H		122, 306
Plan. & Prog.	Systems Plan.	204	Produce maps of rail plans and railroad abandonments	H		45
Plan. & Prog.	Project Planning	205	Access the location of wetlands	H		32, 67, 89
Plan. & Prog.	Project Plan.	206	Access the location of endangered species	H		
Plan. & Prog.	Project Plan.	207	Access the Location of prehistoric sites, National Register sites, mapping sites	H		
Plan. & Prog.	Project Plan.	208	Access the Location of noise, sound wall, airport noise analysis	N		
Plan. & Prog.	Project Plan.	209	Access the location of flood plains	H		437, 442, 481
Plan. & Prog.	Project Plan.	210	Access the location of hazardous waste sites	H		
Plan. & Prog.	Project Plan.	211	access the Location of material pit sites	L		1, 10, 423
Plan. & Prog.	Project Plan.	212	Access and display land use maps	L		441, 484
Plan. & Prog.	Project Plan.	213	Environmental impact monitoring and management	L		
Plan. & Prog.	Project Plan.	214	Perform air quality analysis	N		

Plan. & Prog.	Project Plan.	215	Access energy line location and access the location of utilities	L		68, 134, 418, 426, 471
Plan. & Prog.	Project Plan.	216	Display maps for site selection	H		
Plan. & Prog.	Project Plan.	217	Display maps for corridor selection / route planning	H		409, 462
Plan. & Prog.	Project Plan.	218	Display maps for alternatives analysis	L		
Plan. & Prog.	Project Plan.	219	Access maps of ROW and property ownership	L		71, 85, 86, 416, 435, 479
Plan. & Prog.	Project Plan.	220	Store plans inventory	N		
Plan. & Prog.	Project Plan.	221	Store data about population and employment within various transportation corridors	N		
Plan. & Prog.	Project Plan.	222	Store data to handle construction impact mitigation	L		
Plan. & Prog.	Project Plan.	223	Produce maps for route concept analysis and reports	L		
Plan. & Prog.	Project Plan.	224	Store data for engineers estimates	L		
Plan. & Prog.	Project Plan.	225	Produce maps for public presentation	L		390
Plan. & Prog.	Project Plan.	226	Access the location of recreational trails	L		456
Plan. & Prog.	Project Plan.	227	Perform route optimization	H		
Plan. & Prog.	Project Plan.	228	Perform project tracking	L		
Plan. & Prog.	Project Plan.	229	Produce maps for land use planning	H		
Plan. & Prog.	Project Plan.	230	Store data for policy and standards development	L		
Plan. & Prog.	Project Plan.	231	Access maps of environmentally sensitive areas	H		
Plan. & Prog.	Project Plan.	232	Transfer data with other departments	L		
Plan. & Prog.	Project Plan.	233	Access maps of cemeteries	L		
Plan. & Prog.	Project Plan.	234	Access the location of cultural resource information	H		
Plan. & Prog.	Project Plan.	235	Access and display ALAS information	L		47, 353
Plan. & Prog.	Project Plan.	236	Display PMIS data	L		9, 40, 118, 439
Plan. & Prog.	Project Plan.	237	Access maps for counties, cities, commercial and industrial networks, vehicle counts			
Plan. & Prog.	Project Plan.	238	Display USGS contour maps, field measurements and stereoplotter	L		
Plan. & Prog.	Traffic Survey	239	Produce annual traffic map/key	L	L	
Plan. & Prog.	Traffic Survey	240	Produce maps showing AADTs and count/ATR locations	L	L	73, 287
Plan. & Prog.	Traffic Survey	241	Access truck weight maps	L	L	313, 328

Plan. & Prog.	Traffic Survey	242	Access annual vehicle occupancy estimation maps	?	?	
Plan. & Prog.	Traffic Survey	243	Store manual classification data and access site maps	H	H	
Plan. & Prog.	Traffic Survey	244	Produce speed maps for the state	?	?	157
Plan. & Prog.	Traffic Survey	245	Access county maps	?	?	271, 438
Plan. & Prog.	Traffic Survey	246	Display and analysis of aviation counter activities and inventories	?	?	
Plan. & Prog.	Traffic Survey	247	Perform origin/destination mapping	L	L	
Plan. & Prog.	Traffic Survey	248	Produce weight-in-motion maps	H	L	
Plan. & Prog.	Traffic Survey	249	Perform highway inventory query and reporting	?	?	
Plan. & Prog.	Traffic Survey	250	Perform traffic request and investigation	L	L	
Plan. & Prog.	Traffic Survey	251	Handle highway performance monitoring system	?	?	
Plan. & Prog.	Traffic Survey	252	Display and analyze locations and view traffic counts for a series of years	H	H	
Plan. & Prog.	Traffic Survey	253	Enter and store traffic count data for secondary roads (reduce the 75 days per year)	H	H	
Plan. & Prog.	Traffic Survey	254	Tie and display data to actual locations instead of closest nodes	H	H	
Plan. & Prog.	Traffic Survey	255	Overlay traffic count data with other roadway features	H	H	
Plan. & Prog.	Traffic Survey	256	Access and produce state, county and city traffic count maps	H	L	142, 188, 278, 336, 382, 482, 501
Plan. & Prog.	Traffic Survey	257	Generate new traffic books	H	H	
Plan. & Prog.	Traffic Survey	258	Generate maps based on classification	?	?	298
Plan. & Prog.	Traffic Survey	259	Generate vehicle occupancy maps	?	?	
Plan. & Prog.	Traffic Survey	260	Generate speed surveys	?	?	
Plan. & Prog.	Cartography	261	Develop routines for annual update of maps	H	L	
Plan. & Prog.	Cartography	262	Convert current maps to metric	L	H	
Plan. & Prog.	Cartography	263	Access and produce maps for the 5 year transportation improvements	H	L	323
Plan. & Prog.	Cartography	264	Store geodesy control files	?	?	
Plan. & Prog.	Cartography	265	Store CADD reference maps	?	?	
Plan. & Prog.	Cartography	266	Produce a complete new set of FAS/FAUS maps	N	H	
Plan. & Prog.	Cartography	267	Store and access tourism maps and statistics	?	L	
Plan. & Prog.	Cartography	268	Perform urban area mapping	H	L	

Plan. & Prog.	Cartography	269	Maps that can be produced by GIS	H	L	
Plan. & Prog.	Cartography	270	City maps	H	H	381
Plan. & Prog.	Cartography	271	County maps	H	H	245, 438
Plan. & Prog.	Cartography	272	State maps	H	L	499
Plan. & Prog.	Cartography	273	Quad Maps	L	H	
Plan. & Prog.	Cartography	274	Primary road maps	H	L	
Plan. & Prog.	Cartography	275	Maps showing annexations	L	L	
Plan. & Prog.	Cartography	276	Maps showing new roads	H	L	
Plan. & Prog.	Cartography	277	Maps showing corporate line changes	L	L	297, 443, 485
Plan. & Prog.	Cartography	278	Traffic maps	H	H	142, 188, 256, 336, 382, 482, 501
Plan. & Prog.	Cartography	279	State park maps	L	H	
Plan. & Prog.	Cartography	280	State institutional maps	L	H	
Plan. & Prog.	Cartography	281	Interstate strip maps	L	H	
Plan. & Prog.	Cartography	282	Interchange diagrams	L	H	338
Plan. & Prog.	Cartography	283	State pipeline maps	L	L	
Plan. & Prog.	Cartography	284	State highway maps	H	L	144, 318
Plan. & Prog.	Cartography	285	Maps of primary road surface and vehicle clearance maps	H	L	500
Plan. & Prog.	Cartography	286	DOT district maps	L	L	
Plan. & Prog.	Cartography	287	ATR location maps	L	L	73, 240
Plan. & Prog.	Cartography	288	Railroad maps	H	L	143, 408, 491
Plan. & Prog.	Cartography	289	Maps with the placement of ALAS nodes	H	H	
Plan. & Prog.	Cartography	290	Location of construction areas in the state	H	L	69, 329
Plan. & Prog.	Cartography	291	Many other special maps that are requested by the other departments	H	L	
Plan. & Prog.	Base Records	292	Produce route maps, county maps, township plats			
Plan. & Prog.	Base Records	293	Produce maps showing the transfer of jurisdiction for the FHWA			146, 168, 172, 201, 444, 486

Plan. & Prog.	Base Records	294	Store and access images on laser disk for sign inventory, ROW, train data collectors, PMIS data			
Plan. & Prog.	Base Records	295	Produce and access roadway sufficiency maps			165, 174, 187
Plan. & Prog.	Base Records	296	Access to total miles of public roads in Iowa by county and road type			194
Plan. & Prog.	Base Records	297	Produce corp. limit maps			277, 443, 485
Plan. & Prog.	Base Records	298	Produce roadway functional classification map			258
Plan. & Prog.	Base Records	299	Determine distance between hospitals and determine which hospital is closest to a particular address			
Plan. & Prog.	Base Records	300	Produce maps for state troopers to show the mileage between roads on the primary system			
Plan. & Prog.	Program Man.	301	Intermodal management			
Plan. & Prog.	Prog. Man.	302	Transit management			399
Plan. & Prog.	Prog. Man.	303	Airport management			395
Plan. & Prog.	Prog. Man.	304	Parks and institutional management			
Plan. & Prog.	Prog. Man.	305	Railroad infrastructure management			405
Plan. & Prog.	Prog. Man.	306	Rivers and ports			122, 203
Plan. & Prog.	Prog. Man.	307	Airport landside planning			
Plan. & Prog.	Prog. Man.	308	Airport facilities inventory			202
Plan. & Prog.	Prog. Man.	309	Airport access			
Plan. & Prog.	Planning Services	310	Store data on vehicle registration, population, licensed drivers, average income, fuel sales	L	L	361
Plan. & Prog.	Plan. Services	311	Store data to perform revenue forecast by area	L	I	
Plan. & Prog.	Plan. Services	312	Store data to determine the economic impact on a region	?		
Plan. & Prog.	Plan. Services	313	Develop and access truck route maps			241, 328
Plan. & Prog.	Plan. Services	314	Store vehicle registration by county	L	L	
Plan. & Prog.	Plan. Services	315	Access location of traffic generators (plants, trucking companies, ...)	I	I	
Plan. & Prog.	Plan. Services	316	Store fuel sales and price of fuel data	L	I	
Plan. & Prog.	Plan. Services	317	Store data for travel demand used by advanced planning	I	I	
Plan. & Prog.	Plan. Services	318	Generate traffic maps and general highway maps	L	I	144, 284

Plan. & Prog.	Plan. Services	319	Administer the process of designating highway routes for use by trucks of exceptional size (share information with driver services)			326
Plan. & Prog.	Plan. Services	320	Maintain maps of river toll bridges	L	L	
Plan. & Prog.	Plan. Services	321	Store information to act as a public information system to respond to inquiries made by legislators, officials or state federal agencies, and private citizens	L	L	
Plan. & Prog.	Plan. Services	322	Produce maps to support reports required by the FHWA (motor fuel consumption, state motor fuel tax collected, state motor vehicle registrations, state operator-chauffeur licenses, state motor vehicle registration fees, receipts from motor vehicles operated for hire)	I	I	
Plan. & Prog.	Plan. Services	323	Produce maps for transportation plans, 5 year construction plans and 20 year studies	I	I	263
Motor Vehicle	Motor Carrier Services	324	Access and display vertical clearances at specific locations			46
Motor Vehicle	M.C. Services	325	Produce map to show commodity flow analysis			
Motor Vehicle	M.C. Services	326	Handle permit routing for oversized/overweight			319
Motor Vehicle	M.C. Services	327	Store truck weight data			
Motor Vehicle	M.C. Services	328	Perform routing of trucks (especially, oversized / overweight)	H		241, 313
Motor Vehicle	M.C. Services	329	Access maps showing the location of construction areas			69, 290
Motor Vehicle	M.C. Services	330	Access maps showing speed limits, roadway widths, bridge weight restrictions, bridge vertical clearance restrictions	H		
Motor Vehicle	M.C. Services	331	Access maps of road closures due to emergency situations	H		436
Motor Vehicle	M.C. Services	332	Track the number of miles driven by each carrier and fuel usage	L		
Motor Vehicle	M.C. Services	333	Store data about the owners / operators (address, #of vehicles, vehicle description, miles traveled)	L		
Motor Vehicle	M.C. Services	334	Generate map of route to give to carriers	L		183
Motor Vehicle	M.C. Services	335	Identify and analyze the location of high accident areas	M		385
Motor Vehicle	M.C. Services	336	Produce and access traffic count maps, population maps, and truck traffic maps	M		142, 188, 256, 278, 382, 482, 501
Motor Vehicle	M.C. Services	337	Produce Iowa bridge embargo maps and detour and road embargo maps	H		64, 149, 427, 476, 504
Motor Vehicle	M.C. Services	338	Produce and access intersection layout maps	H		282

Motor Vehicle	M.C. Services	339	Assist in public information system to consult with persons both the public and private sectors			
Motor Vehicle	M.C. Services	340	Use GIS and GPS for use tax (IFTA, IRP)			
Motor Vehicle	M.C. Services	341	Access maps of truck registrations by IRP jurisdiction			
Motor Vehicle	M.C. Services	342	Access map of the flow of IRP funds			
Motor Vehicle	M.C. Services	343	Store information used for permit routing (see 10-29-93)			
Motor Vehicle	M.C. Services	344	Produce US maps of permits issued and information by state			363
Motor Vehicle	Driver Services	345	Store driver information system			
Motor Vehicle	Driver Serv.	346	Store customer information system			
Motor Vehicle	Driver Serv.	347	Store and handle winter storm management			150, 398
Motor Vehicle	Driver Serv.	348	Produce maps to show accident locations (breakdown by type of accident and county or licensing district)			420, 483
Motor Vehicle	Driver Serv.	349	Produce maps to show the location of driver licensing stations and operating hours and services offered			
Motor Vehicle	Driver Serv.	350	Produce maps to show the number of licenses issued by location			
Motor Vehicle	Driver Serv.	351	Store and access data for the Fatal Accident Reporting System (FARS)			
Motor Vehicle	Driver Serv.	352	Enter and edit ALAS information			
Motor Vehicle	Driver Serv.	353	Store accident data that is entered into the accident statistics system			47, 235
Motor Vehicle	Driver Serv.	354	Store the computerized master file of all persons licensed to operate a motor vehicle and any persons who possess a non-operator identification cards			
Motor Vehicle	Driver Serv.	355	Store driver records of all suspensions, revocations, cancellations, convictions, reinstatements, and other driver-related actions			
Motor Vehicle	Driver Serv.	356	Analyze data from motor vehicle accident records			
Motor Vehicle	Driver Serv.	357	Store and access accurate state data on motor vehicle accidents, including annual accident reports			
Motor Vehicle	Driver Serv.	358	Store geocoded database and map of vehicle registrations			
Motor Vehicle	Driver Serv.	359	Coordinate the expenditures of federal 402 traffic safety funds for this office (child restraint only) and ensure that they are used effectively and timely			
Motor Vehicle	Driver Serv.	360	Produce maps for Accident Fact Book such as the accident statistics by city or county, accidents by road type, alcohol related accidents by city or county			393

Motor Vehicle	Vehicle Registration	361	Vehicle registration data	L	L	310
Motor Vehicle	Vehicle Reg.	362	Recoverable permit integration	?		
Motor Vehicle	Vehicle Reg.	363	Truck permit integration	?		344
Motor Vehicle	Vehicle Reg.	364	Vehicle dealer requirements	L	L	
Engineering	Safety	365	Access and display guardrail/fence inventory	L	H	132, 414, 432, 467
Engineering	Safety	366	Handle accident database	H	H	
Engineering	Safety	367	Handle railroad safety program	H	L	407
Engineering	Safety	368	Handle railroad grade crossing management			
Engineering	Safety	369	Store and access roadside obstacle inventory	I	H	
Engineering	Safety	370	Store and access location of narrow bridge approaches	H	L	24, 430, 466, 493
Engineering	Safety	371	Freeway incident detection and management	M	H	
Engineering	Safety	372	Handle safety management	H	H	
Engineering	Safety	373	Store and access traffic restrictions	?	?	
Engineering	Safety	374	Store AAR crossing inventory			
Engineering	Safety	375	Access and store culvert location and information	L	M	62, 133, 494
Engineering	Safety	376	Access and store curve location and data	H	H	
Engineering	Safety	377	Access physical features of the roadway for specific locations	I	I	448, 449, 455
Engineering	Safety	378	Tie accident and accident causes to specific locations (ALAS)	H	H	
Engineering	Safety	379	Determine and view roadway features (0.3 miles for rural; 0.1 miles for urban)	H	M	
Engineering	Safety	380	Tie accidents to curves and relevant curve data	H	H	
Engineering	Safety	381	Access city and county maps	L	L	270
Engineering	Safety	382	Access traffic and road maps	L	L	142, 188, 256, 278, 336, 482, 501
Engineering	Safety	383	Access turn movements at intersections	H	L	193
Engineering	Safety	384	Access plans from road design for safety review	H	L	
Engineering	Safety	385	Produce and send maps of high accident locations to cities	L	M	335

Engineering	Safety	386	Produce map of safety improvements	L	M	
Engineering	Safety	387	Track, manage and display a list of locations on the primary road system which are candidate safety locations	?	?	
Engineering	Safety	388	Access, select and review construction plans so that the current design practices are followed in the plan	H	L	
Engineering	Safety	389	Access, select and review highway maintenance instructional memoranda so that operational concerns are addressed	N	L	
Engineering	Safety	390	Assist in preparation of responses to public inquiries	?	?	225
Engineering	Safety	391	Maintain records of claims filed against the department	H	L	
Engineering	Safety	392	Maintain up-to-data documentation for claims, such as police reports, court files, plans, maps, photographs, statements, specifications, name of witnesses, etc.			
Engineering	Safety	393	Statistical analysis of accident locations	H	I	360
Air & Transit (Former)		394	Access and produce maps of airport layout	H	M	
A/T (Former)		395	Incorporate airport master records database	M	L	303
A/T (Former)		396	Develop GIS based pavement management system	M	L	
A/T (Former)		397	Store and access aircraft registration data (type of aircraft, owner, # of miles, ...)	L	L	
A/T (Former)		398	Weather information around the state of Iowa	L	L	150, 347
A/T (Former)		399	Develop transit route maps	L(M)	L	302
A/T (Former)		400	Develop transit paths	?	?	199
A/T (Former)		401	Access location of airplane and transit accidents	L	L(M)	
A/T (Former)		402	Store and access transit statistics (rides, miles, cost, operating ratio, ...)	L(M)	L	
A/T (Former)		403	Develop layers of zoning for both structural/terrain and noise that can then be overlaid on aerial photos	M	L	
A/T (Former)		404	Prepare a map of the state airport system with the ability to show approach slopes as they relate to terrain and obstructions	H	M	
Rail & Water (Former)		405	Access the location and year track was built or replaced			305
R/W (Former)		406	Determine the gross ton miles over each section of track			
R/W (Former)		407	Access the location of accidents and derailments			367

R/W (Former)		408	Access and produce track maps			143, 288, 491
Field Services	CIATC	409	Access maps for planning and plan development	H		217, 462
Field Services	CIATC	410	Access maps for post contract work	?		
Field Services	CIATC	411	Identify location of deer kills	H		138, 464
Field Services	CIATC	412	Access location and inventory of signs	H		129, 428, 465, 514
Field Services	CIATC	413	Identify location of bridges under 20 '	L		
Field Services	CIATC	414	Identify location of guardrail and pipes	L		132, 365, 432, 467
Field Services	CIATC	415	Access and identify crack and patch paving location	?		8, 153, 164
Field Services	CIATC	416	Access and identify right of way and fencing	H?		
Field Services	CIATC	417	Access property owned by the IADOT	H		71, 85, 86, 219, 435, 479
Field Services	CIATC	418	Access and identify utility locations	H		68, 134, 215, 426, 471
Field Services	CIATC	419	Access pavement history (when, what aggregates)	H		4, 29, 66, 70, 117, 421
Field Services	CIATC	420	Accident locations	H		348, 483
Field Services	NEIATC	421	Store plans of as-built information (including material quantities and qualities)	H	H	4, 29, 66, 70, 117, 419
Field Services	NEIATC	422	Access the location of specific pavement mixes	?	?	
Field Services	NEIATC	423	Access quarry and pit locations and types of aggregate available	M	L	1, 10, 211
Field Services	NEIATC	424	Display friction factor data by location	H	L	12, 475
Field Services	NEIATC	425	Display drainage structure and water pipe dimensions and locations	M	H	468
Field Services	NEIATC	426	Access the location of utilities	H	L	68, 134, 215, 418, 471
Field Services	NEIATC	427	Develop and produce maps for detour routes and haul routes	L	L	64, 149, 337, 476, 504
Field Services	NEIATC	428	Track sign location and inventory	H	H	129, 412, 465, 514
Field Services	NEIATC	429	Display speed zone by location and pavement markings	M	M	477

Field Services	NEIATC	430	Access bridge location and clearances	H	L	24, 370, 466, 493
Field Services	NEIATC	431	Access adopt-a-highway locations and present owners	L	L	498
Field Services	NEIATC	432	Access the location of guardrail and type of guardrail	L	L	132, 365, 414, 467
Field Services	NEIATC	433	Access the location of no passing zones	M	H	
Field Services	NEIATC	434	Display crack and patch surveys and locations	L	L	469, 478
Field Services	NEIATC	435	Access maps of ROW and property ownership	H	H	71, 85, 86, 219, 416, 479
Field Services	NEIATC	436	Access and produce maps for the closure of roads (special events)	L	L	331
Field Services	NEIATC	437	Produce watershed and drainage maps	L	M	209, 442, 481
Field Services	NEIATC	438	Access county base maps	H	L	245, 271
Field Services	NEIATC	439	Store and handle PMIS data	H	H	9, 40, 118, 236
Field Services	NEIATC	440	Display vehicle counts and accident history	H	H	
Field Services	NEIATC	441	Access maps of present and future land use	M	H	212, 484
Field Services	NEIATC	442	Access maps of drainage districts	L	M	209, 437, 481
Field Services	NEIATC	443	Access maps of corp. limits	L	L	277, 297, 485
Field Services	NEIATC	444	Access Jurisdiction maps	L	L	146, 168, 172, 201, 293, 486
Field Services	NEIATC	445	Route maintenance vehicles for improved efficiency	?	?	487
Field Services	NEIATC	446	Access the location of ready mix plants	L	L	11
Field Services	SEIATC	447	Access and display stream bed location and elevation	L	H	90, 454
Field Services	SEIATC	448	Store and access natural features inventory	H	L	377, 449, 455
Field Services	SEIATC	449	Store and access man-made features inventory	H	L	377, 448, 455
Field Services	SEIATC	450	Store and access topographical data for specific sites	H	H	458
Field Services	ECIATC	451	Store quarry log	H	I	459
Field Services	ECIATC	452	Store T-203 information	H	I	460
Field Services	ECIATC	453	Store test results	H	L	461
Field Services	NWIATC	454	Stream bed location and elevation	H	L	90, 447
Field Services	NWIATC	455	Natural features inventory	H	L	377, 448, 449

Field Services	NWIATC	456	Trail location	H	L	226
Field Services	NWIATC	457	Maintain features inventory	H	L	497
Field Services	NWIATC	458	Topographical data	H	H	450
Field Services	NWIATC	459	Store quarry log	H		451
Field Services	NWIATC	460	T-203 information	?	?	452
Field Services	NWIATC	461	Test results	L	L	453
Field Services	NWIATC	462	Plan and planning development	H	H	217, 409
Field Services	NWIATC	463	Post contract work	H	L	108
Field Services	NWIATC	464	Deer kill location	L	L	138, 411
Field Services	NWIATC	465	Sign inventory and location	H	H	129, 412, 428, 514
Field Services	NWIATC	466	Bridge location, type and size	H	L	24, 370, 430, 493
Field Services	NWIATC	467	Guardrail location and type	H	L	132, 365, 414, 432
Field Services	NWIATC	468	Pipe location and pipe	H	H	425
Field Services	NWIATC	469	Crack and patch paving locations	H	H	434, 478
Field Services	NWIATC	470	Property owned by the DOT	H	L	100, 513
Field Services	NWIATC	471	Utility information and location	H	H	68, 134, 215, 418, 426
Field Services	NWIATC	472	Paving history	H	L	
Field Services	NWIATC	473	As built information	H	H	
Field Services	NWIATC	474	Location of specific pavement mixtures	H	H	
Field Services	NWIATC	475	Friction data	I	I	12, 424
Field Services	NWIATC	476	Detour routes and haul roads	H	L	64, 149, 337, 427, 504
Field Services	NWIATC	477	Location of speed zones and pavement markings	H	H	429
Field Services	NWIATC	478	Patch locations	H	H	434, 469
Field Services	NWIATC	479	Right of way and ownership	H	H	71, 85, 86, 219, 416, 435
Field Services	NWIATC	480	Map of road closures	H	L	

Field Services	NWIATC	481	Watershed and drainage maps	H	H	209, 437, 442
Field Services	NWIATC	482	Vehicle counts	H	H	142, 188, 256, 278, 336, 382, 501
Field Services	NWIATC	483	Accident information	H	H	348, 420
Field Services	NWIATC	484	Present and future land use	H	H	212, 441
Field Services	NWIATC	485	Corporate limits	H	L	277, 297, 443
Field Services	NWIATC	486	Jurisdiction maps	H	L	146, 168, 172, 201, 293, 444
Field Services	NWIATC	487	Maintenance vehicle routes	L	L	445
Field Services	NWIATC	488	Permanent ready mix plant location w/data	L	L	11
Field Services	NWIATC	489	Permanent A/C plant locations	L	L	11
Field Services	NWIATC	490	Aggregate supply intermediate storage locations	L	L	
Field Services	NWIATC	491	Rail line locations	H	L	143, 288, 408
Field Services	SWIATC	492	Location and inventory of signs	H/H/H/H	H/I/I/L	507
Field Services	SWIATC	493	Location and inventory of bridges	H/L/H/H	H/I/I/L	24, 370, 430, 466
Field Services	SWIATC	494	Location and inventory of culverts	H/L/H/H	H/I/I/L	62, 133, 375
Field Services	SWIATC	495	Location of annual problems	H/H/H/H	L/I/I/L	124
Field Services	SWIATC	496	Store equipment inventories	H/H/H/H	L/I/I/L	505
Field Services	SWIATC	497	Store maintenance features inventories	?/H/?/H	?/I/I/L	457
Field Services	SWIATC	498	Store adopt-a-highway ownership information	I/L/H/H	I/I/I/L	431
Field Services	SWIATC	499	Produce state highway maps	H/L/H/L	L/I/I/H	272
Field Services	SWIATC	500	Produce vertical clearance maps	H/L/H/H	L/I/I/L	285
Field Services	SWIATC	501	Produce traffic count maps	H/L/H/L	H/I/I/H	142, 188, 256, 278, 336, 382, 482
Field Services	SWIATC	502	Produce maintenance level service maps	H/L/H/L	L/I/I/H	
Field Services	SWIATC	503	Produce maintenance area responsibility map	H/L/H/L	L/I/I/H	
Field Services	SWIATC	504	Produce detour and embargo maps	H/L/H/L	H/I/I/H	64, 149, 337, 426, 476

Operations & Finance	Support Services	505	Handle equipment services			496
Op. & Fin.	Sup. Serv.	506	Handle and store equipment inventory, use/control			145
Op. & Fin.	Sup. Serv.	507	Handle inventory at the sign shop			492
Op. & Fin.	Sup. Serv.	508	Handle fleet management			
Op. & Fin.	Sup. Serv.	509	Handle facilities management			
Op. & Fin.	Sup. Serv.	510	Access information concerning purchasing and inventory			
Op. & Fin.	Sup. Serv.	511	Manage inventory of telephone/radio by location			
Op. & Fin.	Sup. Serv.	512	Access the location and amount of road salt, sand and fuel used			
Op. & Fin.	Sup. Serv.	513	Access the location of land owned by the IADOT (buildings that are leased)			100, 470
Op. & Fin.	Sup. Serv.	514	Access sign and post location			129, 412, 428, 465
Op. & Fin.	Sup. Serv.	515	Handle garage and equipment inventories			13, 114
Op. & Fin.	Sup. Serv.	516	Access a geographic list of contractors (electricians, plumbers, carpenters,...)			112

H = high
L = low
N = none
? = don't understand what this application is
I = insufficient information for determining benefit or cost

Appendix 4-B

Implications of ISTEA Management Systems

The Office of Program Management, within the Planning and Research Division, is responsible for coordinating all management systems at the Iowa DOT. Data are gathered and assimilated by the operating jurisdiction and then utilized by the Office of Program Management to develop the statewide planning activities.

A section in the Policy and Procedure Manual has been established which describes the purpose, objectives, processes, and management of the six required management systems. A policy committee has been formed which consists of the directors of the divisions affected by the management systems. Technical committees (originally subcommittees of the Policy Committee), have also been formed for each management system. The offices affected by the management systems may be represented on the technical committees. The responsibilities of these technical committees include:

A. Define the general requirements of the management systems and identify the technical steps necessary to meet these requirements. This will be inclusive of management system objectives, guidelines and work plan.
B. Perform technical implementation steps.
C. Using performance-based criteria, evaluate the effectiveness of the management system.
D. Continually update and refine the management system to meet the Department's needs.
E. Provide certification information as required by federal regulations.

The DOT is currently in the process of implementing an in-house pavement management system, a PONTIS-based system for bridge management, and all other management systems. The implementation process is being accomplished through the technical committees.

DOT Offices represented on each technical committee follows:

<u>Pavement Management Technical Committee</u>
Office of Materials
Office of Design
Office of Local Systems
Office of Program Management
Maintenance Division
Office of Systems Planning

Bureau of Information Services
Engineering Division
Iowa County Engineers Association (ICEA)
American Public Works Association (APWA)
Iowa Association of Regional Councils (IARC)
Federal Highway Administration (FHWA) - ex officio

Bridge Management
Office of Bridge Design
Maintenance Division
Office of Local Systems
Office of Program Management
Office of Systems Planning
Bureau of Information Services
Engineering Division
Iowa County Engineers Association (ICEA)
American Public Works Association (APWA)
Iowa Association of Regional Councils (IARC)
Federal Highway Administration (FHWA) - ex officio

Safety Management Technical Committee (partial list):
Engineering Division
Planning and Programming Division
Maintenance Division
Operations and Finance Division
Development Division
Governor's Traffic Safety Bureau (GTSB)
Motor Vehicle Division
Iowa State Patrol
Emergency Medical Services (EMS)
Iowa County Engineers Association (ICEA)
Iowa Association of County Sheriffs (IACS)
American Public Works Association (APWA)
Iowa Association of Chiefs of Police (IACP)
Iowa Association of Regional Councils (IARC) (RPAs and MPOs)
Federal Highway Administration (FHWA) - ex officio
National Highway Traffic Safety Administration (NHTSA) - ex officio
Motor Carriers (US DOT) - ex officio

Congestion Management
Office of Systems Planning
Maintenance Division
Office of Traffic Engineering
Office of Program Management
Motor Vehicle Division

Bureau of Information Services
Representative of Large City (chosen by the League of Iowa Municipalities)
Representative of MPOs
Iowa Association of Regional Councils (IARC)
Representative of each TMA (chosen by the TMAs)
Transit Operator (chosen by IPTA)
IPTA Representative
Federal Highway Administration (FHWA)/Federal Transit Administration (FTA) - ex officio
Office of Local Systems
Department of Public Safety

<u>Intermodal Transportation Facilities and Equipment Systems</u>
Office of Systems Planning
Office of Program Management
Bureau of Information Services
Motor Vehicle Division
Office of Local Systems
Intercity Bus Carrier (person from statewide advisory committee)
Urban Transit Operator (chosen by IPTA)
Regional Transit Operator (chosen by IPTA)
MPO representative (chosen by IARC)
Regional planning representative (chosen by IARC)
Large Airport Operator - Des Moines or Cedar Rapids - (person from statewide advisory committee)
Rail Carrier representative (person from statewide advisory committee)
Intermodal transportation representative (person from statewide advisory committee)
Motor Carrier representative (person from statewide advisory committee)
Barge terminal operator/broker (person from statewide advisory committee)
Federal Highway Administration (FHWA)/Federal Transit Administration (FTA) - ex officio

<u>Public Transportation Facilities and Equipment System</u>
Office of Local Systems
Bureau of Information Services
Office of Systems Planning
Regional Transit Operator (chosen by IPTA)
Small Urban Transit Operator (chosen by IPTA)
Large Urban Transit Operator (chosen by IPTA)
MPO representative (chosen by IARC)
Regional planning representative (chosen by IARC)
Federal Highway Administration (FHWA)/Federal Transit Administration (FTA) - ex officio
Department of Elder Affairs
Office of Program Management

The following describes the ISTEA requirements and status of the Iowa Bridge Management System:

(source: Document: Federal Register - March 2, 1993 - 23 CFR Part 500, Subpart C)

1. BMS required for bridges on all highways -- Iowa DOT's leadership is committed to the concept of a BMS.

2. State shall take lead in establishing agreements regarding BMS with local bridge owners -- Iowa DOT has not yet taken any steps to formally establish such agreements. Office of Local Systems will, in the near future, discuss the BMS concept and ISTEA requirements with the County Engineers' Design Committee.

3. Minimum standards for BMS

(a) Computerized database and program for collecting data -

A database and a collection program exist. Needed modifications are being discussed by the BMS Technical Committee.

(b) Computer model for network level analysis -- Iowa DOT has participated in FHWA's BMS project which developed a computer model -- PONTIS. This included conducting a beta test of the model using Iowa DOT structures in two counties. The BMS Technical Committee has recommended that PONTIS be used for Iowa's DOT.

(c) System for monitoring actions recommended by the BMS and for updating the database when actions are taken -- This has not yet been addressed.

4. Compliance schedule

(a) BMS objectives are to be formally established and system design completes or underway by October 1, 1994 -- Iowa DOT intends to meet this deadline. It intends to adopt PONTIS as the system design.

(b) In fiscal years after FY 1995, system design and testing must be completed and full-scale data collected must be underway -- Iowa DOT intends to meet this requirement.

(c) Within four years of the effective date of the regulation, a BMS shall be fully implemented -- Iowa DOT intends to meet this requirement.

The following excerpts from DOT internal memos highlight issues surrounding the data requirements for the ISTEA Management Systems.

To: Office of Program Management September 12, 1994

From: Director, Office of Transportation Data (formerly, Office of Transportation Inventory)

Re: Management Systems

Four of the six transportation management systems identified under ISTEA must be operational by October 1996. Since you have the responsibility for coordinating the development of the management systems, there are several items relating to the information base(s) needed to support these systems that you should ensure are properly addressed and resolved early on:

> What data are needed? As each management system is being developed, the data items needed to support the system need to be identified.
>
> What is the sensitivity of the data items? There is always a tendency to identify as "needed", a wide array of data items. Quite frequently during application, only a select few factors make any significant difference in the decision making process. Data items that have very little or no affect on decision making should not be identified as "needed" for the management system.
>
> Which data items are new? Which of the data items that are truly needed are not currently collected and maintained by someone?
>
> How can data be obtained? Where and how could the new data items be gathered? Along with this goes the issue of cost to collect the data both in monetary terms and staff time.
>
> Who will collect the data? Once needed data is identified, a responsibility for collecting the data needs to be established. This again could have staffing and budgeting implications. Both of these need lead time to prepare for.
>
> Who will maintain the data? Once data starts being collected, it triggers a need to maintain it in an organized fashion to ensure integrity and currency. Where will this function be housed?
>
> Who will ensure compatibility? This usually becomes the responsibility of the group responsible for maintaining the data. However, data compatibility should be established before anything is collected. This area includes everything from data file formats,

exchange standards, data definitions, reference systems, access systems, and the rest of the meta data features.

Common reference system. Entering, accessing, and linking data among data bases is going to be vital to establishing workable management systems.

Although there is frequent referral to the need for a "common reference system", it is doubtful very many people have the same definition of what "common reference system" means. To some, this means a single reference system that everyone would use. Examples of this are the route/milepost and coordinate approaches. Others make no distinction between reference system and access methods. Others refer to GPS as a reference system rather than a method of obtaining locational reference data. This is unfortunate because GPS has a great potential for aiding in obtaining locational information but at the same time should not detract from resolving locational referencing issues.

There will be a continual need to integrate multiple data files, often with files coming from outside sources over which the DOT has no control and probably limited influence towards the underlying reference system.

The Office of Transportation Data has a project currently underway to link the DOT Base Record information system with Cartography's graphic files. This linkage will make it possible to directly associate Base Record information with map linework for analysis and display purposes such as the truck routing Motor Vehicle Division is undertaking.

For the management system to be operational by October 1996, the supporting data bases must be in place ahead of that date. Some of the data items identified may be in place ahead of that date. Some of the data items identified may take several years to collect on a statewide basis if incorporated into existing data collection programs. For these reasons, it is important to resolve as many of the above issues as possible in a timely manner.

cc: Director, Planning and Programming Division
Director, Office of Program Management

To: Director, Project Development Division September 29, 1994

From: Director, Office Transportation Data (Inventory)

Re: Management Systems Support Data

At the September 19th Management Systems Meeting, you requested input from those in attendance as to what some of the related issues are.

To me, a major issue is the data needed to support the six management systems plus the Traffic Monitoring System for Highways.

There were several comments during the meeting relating to contracting for various inventory items and data base designs. The issue is how to ensure data collected to maintain each of the systems is collected in an efficient manner, only collected once, stored in a format that allows for sharing information among systems and other users, has term definitions that are clear and have consistent meaning among systems, and has an established mechanism to collect and maintain the necessary data over a long period of time.

Part of this insurance relates to the system of referencing data stored in various data bases. There will be a combination of linear and spatial data that might be collected by different entities and which changes over time. The DOT needs to ensure management system support data can be integrated with other DOT data and transportation related data obtained from other agencies that the DOT needs in its operation. It also needs to ensure historical data can be adequately related to current and future data.

The monetary and/or staff costs to collect, manage, and maintain current, all this data will be very sizable. Some thought needs to go into how much of this is contracted out versus done in-house and how this vast pool of data will be organized and managed.

I have attached a September 12th memo to the Office of Program Management highlighting some of the data issues.

cc: Director, Planning and Programming Division

Appendix 4-C

Iowa DOT GIS Implementation Plan Date:
Office Applications Interview
Office/Division:

The objective of this interview is to begin identifying potential GIS applications for the office. The information will also be used in an effort to identify high-payoff, low cost applications for prioritization.

1. Does the current Policy and Procedures Manual (PPM) accurately represent the mission, responsibilities and organization of the office? If not, please provide updated information and/or organization chart.

2. What tasks are performed to meet office responsibilities? (especially spatial information-related)

3. What data are collected by the office; how (format...)?

4. What data or databases are used by the office?

5. What maps are generated by the office (or by cartography at your request?)

6. What maps are used by your office?

7. If the data currently used/collected in your office are not currently integrated into a department-wide database, what issues could you identify if that were to be requested? (security, labor, timeliness, ...)

8. What stand-alone software or BIS-supported system (besides word-processing) does your office use?

9. How many workstations are in your office (486 or better PCs or Intergraph or other workstation)?