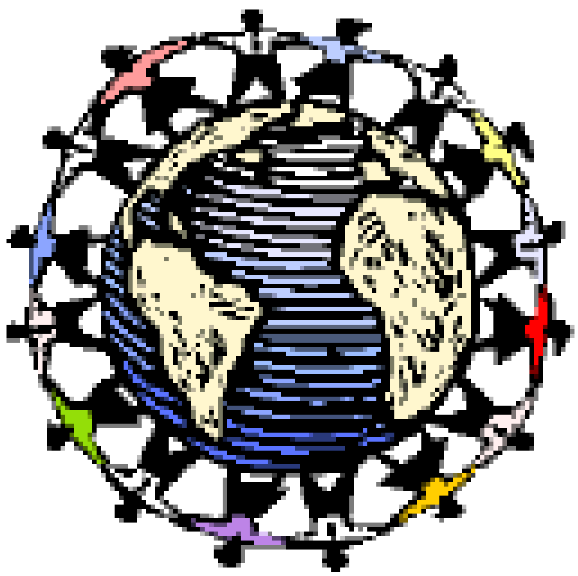
Kansas Department of Transportation

Geospatial Enablement Strategy



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Prepared for KDOT by

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1 Introduction

This document is delivered in response to Work Order Number GISPLAN001. This work order seeks to update the existing GIS Strategic plan with an organic document, which recommends strategies and direction to attain the goal of geospatially enabling the Kansas DOT (KDOT) enterprise, thereby mainstreaming GIS.

The purpose of the GIS Strategic Plan Update is to address the topic of Geospatial Enablement (GE) of KDOT's data assets. A majority of the data collected and stored in the agency is spatially referenced. While GIS emphasizes standard methods with which to graphically display data, the GE effort emphasizes methods to enable the electronic linking, querying, and presentation of data which contains a geospatial component.

The GIS Strategic Plan Update addresses the needs, resources, methods, and expected outcome of Geospatially Enabling KDOT's data assets while embracing the importance of geographic methods with regards to KDOT's business functions. In addition, another goal of the GE initiative will be to culturally and educationally strengthen the existing KDOT spatial initiatives.

Making well-informed, responsible decisions is critical to managing KDOT's 10,000 miles of roadway. Leveraging current and future geospatial investment will be critical for all planning, design, and other operations associated with KDOT's transportation infrastructure.

KDOT currently maintains a vast amount of geospatial data. Geospatial data consists of information that identifies the geographic location, linear location, and characteristics of natural or constructed features on the earth. Historically, this information has been collected from remote sensing, mapping, and surveying technologies. In recent years the ability to extract and transform these data has better equipped decision makers at all transportation agencies to aid in program formation and policy establishment. Ultimately, this improves efficiency in serving the public with regard to maintaining mobility, improving safety, and anticipating and addressing security threats.

In addition, non-geospatial business processes such as budget management or litigation, are becoming increasingly aware of the value of geospatial information. Uniting these areas with traditional consumers of geographic data will allow KDOT to accomplish more with decreasing resources. This provides a more holistic solution to meeting the internal and external needs of KDOT's constituents by replacing existing stovepipes (islands of development) with enterprise-wide access to and delivery of information.

1.1 Geospatial Enablement (GE)—a Definition

Geospatial Enablement (GE) is the method of collecting, storing, integrating, serving, and sharing enterprise business data and processes with location referencing concepts. GE as a method also aggregates metadata (information about the data), which is used to determine geospatial reference, quality, and fitness of the data. GE provides a mechanism to improve data management and distribution, data integration and sharing, and data analysis and presentation. GE also facilitates the streamlining of workflows and allows for better definition and enforcement of business rules.

1.2 Vision Statement

The Geospatial Enablement of the KDOT enterprise will strengthen data flows, workflows, and business flows so that KDOT can efficiently serve stakeholders, partners, and the State of Kansas citizenry.

1.3 Geospatial Enablement (GE) Goals

The following goals were defined for the GE effort as a result of a meeting with the KDOT stakeholders on August 17, 2004.

Goal 1: Augment and add geospatial value to current KDOT initiatives through the incorporation of location referencing and geographic components in KDOT's business functions.

Goal 2: Provide KDOT stakeholders with a clearer and easier path to spatial information that is critical to their business process, thereby improving KDOT's ability to serve the citizens of Kansas.

Goal 3: Ensure KDOT is among the leaders within the state of Kansas for advancing geospatial enablement.

Goal 4: Provide access to KDOT geospatial information to others (public, other agencies, local agencies) through a central point of discovery.

Goal 5: Foster information and resource sharing through the establishment of partnerships to show benefit to the use and inclusion of KDOT information and to the use and inclusion of non-KDOT data.

Goal 6: Enhance awareness of geospatial solutions through education and training.

Goal 7: Record and view information in a geospatial perspective in near real time where appropriate and as accurately as the purpose of the data record necessitates.

1.4 Benefits of Geospatial Enablement (GE)

The following benefits of a GE effort were defined as a result of a meeting with the KDOT stakeholders on August 17, 2004.

Benefit 1: Geospatial enablement (GE) will provide a method of ensuring data access and availability to internal stakeholders within KDOT.

Benefit 2: GE will provide a method of monitoring and improving data quality.

Benefit 3: GE will provide a platform to accurately convey KDOT's goals and objectives to the public.

Benefit 4: GE will aid KDOT in addressing inquiries from peers, legislators, and the public.

Benefit 5: GE will strengthen KDOT's position in litigation.

Benefit 6: GE will aid in integrating or interrelating key business processes.

Benefit 7: GE will provide a foundation on which to more easily build applications which rely on geospatially-enabled data.

Benefit 8: GE will provide a foundation to share data across KDOT and beyond the boundaries of KDOT.

Benefit 9: GE will allow for easier transformation of data based on disparate geo-referencing methods.

Benefit 10: GE will facilitate production of maps and other graphics which have added value and functionality.

Benefit 11: GE will aid in promoting and educating KDOT staff in geographic concepts.

Benefit 12: GE will provide a means by which to exchange information using common location referencing schemes.

Benefit 13: GE will provide a means for sharing data with internal stakeholders at KDOT and external partners such as local, state, and national entities.

Benefit 14: GE will provide a consistent way to access, query, and display data in the context of decision support.

1.5 Justification for the Geospatial Enablement Effort: Existing GeoSpatial Accomplishments and Business Drivers

The justification for Geospatial Enablement throughout the KDOT enterprise is derived from the synergy of existing geospatial accomplishments and business drivers. The GE effort does not require starting over or starting something new; instead the GE effort can call upon work that has already been performed and proven.

Existing geospatial accomplishments at KDOT include, but are not limited to:

1. Base road network modeling;
2. Decision mapping;
3. Adoption of a standard linear referencing method for road models as well as for attribute data;
4. Use of Global Positioning System technology for capture of location data;
5. Imagery data acquisition, management, and distribution; and
6. Website and geospatial web portal development.

These accomplishments can be leveraged with the following business drivers:

Driver 1: Disparate geospatial referencing, inconsistent spatial data stores, and/or outdated technologies do not allow for easy enterprise-wide integration of geospatial information for data management, analysis, reporting, distribution, and presentation.

Driver 2: Duplication of data, lack of spatial and user defined metadata (data about data), and different publishing schedules have given rise to inconsistencies in the use of data used for decision-making and for presentation (maps), resulting in KDOT having more than one version of the official truth.

Driver 3: The requirement for compliance with open geospatial standards and interoperability necessitates the geospatial enablement of KDOT assets.

Driver 4: The increasing demand for accurate geospatial information and the increased visibility and advertising of KDOT products (transportation network models, decision maps, imagery data, and geo-referenced websites and portals) have laid the groundwork for accommodating a broader user audience with expanded needs.

Driver 5: KDOT's representation on the Statewide GIS Policy Board and participation in state and national initiatives have proven that KDOT is a valuable contributor to geospatial endeavors. KDOT's partnership program and other data sharing efforts will facilitate the exchange of geospatial information.

1.6 Strategies for Geospatial Enablement: an Overview

The following high-level strategies for implementation of the geospatial enablement (GE) effort as follows:

Strategy 1: Heighten awareness of and participation in the GE effort via executive support, advertising, public presentations, and personal championing.

Strategy 2: Train staff on how to integrate GE into collection, storage, analysis, distribution, and presentation of information.

Strategy 3: Educate KDOT staff and demonstrate the value of geospatial enablement and geographic thinking for work activities at KDOT.

Strategy 4: Educate KDOT staff on open geospatial standards, metadata standards, and presentation standards for geospatial information.

Strategy 5: Incorporate GE analysis and design into the architecture and process of every IT development and enhancement effort at KDOT. Use existing checklists and processes, such as Information Technology Advisory Committee (ITAC) and Executive Information Technology (EXIT) approval, when required.

Strategy 6: Empower users and data custodians at the operational database level to participate in the GE endeavor in order to spread the responsibility of the GE effort across the KDOT enterprise.

Strategy 7: Provide a service-level clearinghouse and central point of data discovery and access to transportation-related geospatial information to internal and external users.

2 Existing Initiatives Summary

The following documents were reviewed. An Appendix number is shown in parentheses by the category headers and refers to a more detailed review.

2.1 GIS Initiatives (Appendix 1)

The following GIS Strategic plans were reviewed:

1. Kansas DOT GIS Strategic Plan, March 2000 (Section 1.1);
2. Nebraska Department of Roads GIS Strategic Plan Report, January 2001 (Section 1.2);
3. Ohio Department of Transportation Strategic Plan Report, June 2002 (Section 1.3);
4. Pennsylvania Department of Transportation GIS Strategic Plan Executive Summary, 2003 (Section 1.4); and
5. City of Charlotte GIS Strategic Plan, 2002 (Section 1.5).

A peer comparison table of common components can be found in Appendix 1, Section 1.6 that identifies correlations among the analyzed transportation agencies.

2.2 KDOT Initiatives (Appendix 2)

The following internal business initiatives which have influence on or are influenced by the GE effort, were reviewed:

1. KDOT Strategic Information Technology Plan, 2003 (Section 1.1.1;
2. KDOT Strategic Management Plan, 2003 (Section 1.1.2); and
3. Kansas Long Range Transportation Plan, December 2002 (Section 1.1.3).

2.3 State of Kansas Initiatives (Appendix 2)

The state of Kansas has several information management technology strategies in place that may potentially impact the GE effort undertaken at KDOT. Among the strategies reviewed were:

1. State of Kansas Strategic Information Management Plan, January 2002 (Section 1.2.1);
2. State Geographic Information and Related Technology (GI/GIT) Profile (Section 1.2.2); and
3. Strategic Management Plan for Geographic Information Systems Technology 1997, Executive Summary (Section 1.2.3).

3 Management Methodologies and Performance Measures

This section reviews the industry standard management methodologies and performance measures that were analyzed for this study. Detailed descriptions of these methodologies and measures are provided in Appendix 3.

3.1 Management Methodologies

KDOT has studied current management methodologies that will influence the GE effort. These principles are a primary part of the strategic planning fabric of KDOT's IT Architecture strategy. The following were reviewed:

1. Balanced Scorecard (See App. 3, Section 1.1.1);
2. Control Objectives for Information and related Technology (COBIT) (See App. 3, Section 1.1.2);
3. Intellectual Capital (See App. 3, Section 1.1.3); and
4. Performance Measures and Critical Success Indicators (See App. 3, Section 1.1.4.).

3.1.1 Balanced Scorecard

The Balanced Scorecard defines a methodology to measure goals and initiatives and provides a philosophy that assists in translating strategy into action. It provides feedback around both the internal business processes and external outcomes in order to continuously improve strategic performance and results. The Balanced Scorecard transforms strategic planning from a theoretical exercise into the focal point of an enterprise. The Balanced Scorecard assigns all business strategy and vision to four perspectives:

1. Learning and Growth;
2. Business Process;
3. Customer; and
4. Financial.

3.1.2 Control Objectives for Information and related Technology (COBIT)

Control Objectives for Information and related Technology (COBIT) is an open standard for control over information technology developed and promoted by the IT Governance Institute. COBIT helps focus on performance management. This aids IT management in defining key goal indicators to identify and measure outcomes of processes. Key performance indicators are also devised to assess how well processes are performing by measuring the enablement of the process. This establishes a salient relationship between enterprise business goals/measures, and IT's goals/measures.

3.1.3 Intellectual Capital

Intellectual capital is comprised of intangible assets such as employee knowledge, patents, and research. These types of assets are becoming tools to strengthen an agency's position with its constituents. Industry experts have divided intellectual capital into three categories:

1. Human capital;
2. Structural capital; and
3. Customer capital.

KDOT should consider an evaluation of how to empirically define and assign a value to these variables in the context of geospatially enabling the enterprise (see Recommendations section of this document). KDOT currently maintains a high-level of human capital (engineering, planning, cartography, IT) with regards to geospatial science. This knowledge is a valuable repository for the geospatial enablement effort. In addition, these resources should be used to educate KDOT's enterprise to the current usage and value of geospatial information.

3.2 Performance Measures and Critical Success Indicators

The Federal Highway Administration (FHWA) has defined performance measurement as the process of assessing progress toward achieving predetermined goals. Within the DOT community, performance measures are used to monitor the effectiveness of operational strategies and to ascertain the success of achieving agency targets. The FHWA endorses a series of steps to define performance measurement. These consist of:

1. Define mission and goals (include outcome-related goals);
2. Measure performance;
3. Use performance information; and
4. Reinforce performance-based management.

In 2003, KDOT tasked an internal team with defining what would be considered success for the state transportation system. Critical Success Indicators (CSIs) were identified which function as measures that must be satisfied to ensure that KDOT programs are delivering a sufficient transportation system to the State of Kansas. The overarching CSIs defined for KDOT are:

1. Highway maintenance;
2. Highway capacity;
3. Highway safety;
4. Public transportation;
5. Highway construction program;
6. Capital improvement building program;

7. Legal actions;
8. Worker safety;
9. Workforce levels; and
10. Contractors.

These are the vibrant core of KDOT's Strategic Management Plan that will drive KDOT's success in the immediate future. These CSIs utilize systems that are dependent on information from operational databases for analyses. By geospatially enabling KDOT's enterprise in a consistent manner, the business functions utilizing these systems will shorten the time line to making pertinent decisions that will be measured by the aforementioned CSIs. These CSIs are the primary tool by which KDOT will measure itself, to ensure that strategic goals are being achieved.

4 Standards Assessment

Standards affect every aspect of KDOT's business processes. Often inequities exist among KDOT's many geospatial data repositories in terms of how data are collected, stored, formatted, distributed, and presented. Adopting geospatial standards facilitates data sharing, increases interoperability among automated geospatial information system software, and eases interpretation and evaluation of data. In general, standards contribute to making life simpler for KDOT and its customers by increasing the reliability and effectiveness of the products KDOT delivers.

Adoption of geospatial standards provide tangible benefits, such as:

1. Reduction of accuracy problems among geospatial data;
2. Promotion of open format and interoperability, giving rise to less data transformation required among stakeholders;
3. Fewer delays in the decision-making process due to data transformation requirements and interpretation problems;
4. Sending a coordinated message to KDOT's external customers;
5. Lowering training costs with regard to maintaining data; and
6. Simpler application development (time and resources) utilizing geospatial data.

Standards that affect KDOT are both internal and external. Among these are:

1. Location Referencing System (LRS) Key;
2. Open Geospatial Consortium (OGC) Standards;
3. Federal Geographic Data Committee (FGDC) Geospatial Data Standards;
4. Federal Geographic Data Committee (FGDC) Metadata;
5. KDOT Metadata;
6. National Spatial Data Infrastructure (NSDI) Initiative;
7. Global Positioning System (GPS) Standards;
8. Image Data System Standards;
9. Geospatial Information Systems (GIS) Policy Board and State GIS Standards;
10. Cartographic Standards; and
11. The National Map.

These standards are addressed in the following sections.

4.1 Location Reference System (LRS) Key

In August 1995, KDOT implemented an enterprise-wide standard LRS key for representation of the State Highway System network model. This key was revised in March 2000. The key is comprised of a county number and a route identifier, which, when combined, is unique. Adoption of this key, or a means by which to build or join to this key is critical to smooth data flows for attribute, business, and event data that pertain to the state highway system. (Note that the LRS key will accommodate non-state system roadways). The LRS Key structure is as follows:

CCCPRRRRRSUAs

where

- CCC — County Number
- P — Route Prefix
  - C — City classified
  - I — Interstate
  - K — Kansas state route
  - L — Local (rural or city)
  - M — Minor collector
  - R — Major collector
  - U — United States route
  - X — Ramp
- RRRRR — Route Number (padded with leading zeroes if needed)
- S — Route suffix
  - 0 — No suffix (zero)
  - A — Alternate
  - B — Business
  - C — Connector
  - S — Spur
  - Y — Bypass
- U — Unique Identifier
  - Value 0 — Indicates route id (LRS key) is unique (default)
  - Values 1 – 9 — A value added to make route id (LRS key) unique
- A — Administrative Ownership
  - A — U.S. Army Corps of Engineers
  - B — Bureau of Indian Affairs
  - C — U.S. Coast Guard
  - D — U.S. Department of Defense (military reservation)
  - E — U.S. Fossil Energy, Naval Petroleum, and Oil Shale Reserves
  - F — U.S. Fish and Wildlife Service
  - I — U.S. Information Agency
  - L — U.S. Bureau of Land Management
  - M — U.S. Department of the Interior: Minerals and Management Service
  - N — National Parks Service
  - O — National Oceanic and Atmospheric Administration
  - P — Bonneville Power Administration
  - R — U.S. Bureau of Reclamation
  - S — State of Kansas (KDOT) (default value)
  - T — Kansas Turnpike Authority
  - W — City
  - X — County
  - Y — Township
  - Z — Other
- s — Subclass
  - 0 — No subclass (zero)
  - C — Construction
  - R — Resolution
  - U — Unassigned

An inventory of operational databases for the GIS/LRS study of 2003 determined that 14 of the 22 major operational databases either stored or could produce the KDOT LRS key. A user data needs assessment of 103 KDOT stakeholders conducted for this study determined that 57 of them used the KDOT LRS key.

The LRS key provides a foundation for the geospatial enablement of vast amounts of stakeholder data within KDOT for usage across the enterprise. The LRS key can be used to connect business data to the base network. This provides geospatial data that can be used for a multitude of cross-disciplinary analyses. This becomes important as national DOT policy shifts from designing and building the transportation system to maintaining performance levels within the transportation system.

4.2 Temporality

The GIS/LRS Integration study uncovered varying levels of temporality and data requirements. Of the respondents from twenty-two business data areas evaluated, eighteen (82%) stated they manage data temporally. Table 4-1 conveys the various time windows for which KDOT stakeholders manage data temporally.

Table 4-1 Temporal Duration of Data Resources

Time Period	Number of Respondents
0-5 Years	1
5-10 Years	3
10-15 Years	4
15 or more Years	8

Twelve of the 22 respondents stated they date- and time-stamp their data for temporal tracking. In addition, 13 of the 22 respondents stated they take static snapshots of their data. Table 4-2 illustrates the various temporal data management snapshot schemes.

Table 4-2 Temporal Snapshot Schemes

Time Period	Number of Respondents
Quarterly	3
Semi-Annually	0
Annual	3
Other	3

Some of the respondents also stated their data could be made available to other stakeholders via pre-defined queries to their database. In addition, 20 of the 23 respondents stated other stakeholders used their data across the enterprise.

This presents a consistency dilemma in usage of the data for cross-discipline analysis. KDOT should investigate adopting a consistent standard for temporality of data across the enterprise. This will ensure that conclusions that are drawn from analysis of the data will be for congruent time frames.

4.3 Open Geospatial Consortium (OGC) and Open Interoperability

The Open Geospatial Consortium (OGC) is an international not-for-profit organization, comprised of members of the public sector, private sector, and academia, dedicated to open systems (non-proprietary) geoprocessing. OGC envisions the full integration of geospatial data and geoprocessing resources into mainstream computing and the widespread use of interoperable geoprocessing software and geodata products throughout the information infrastructure.

The OGC uses a process of consensus-gathering among its membership in order to achieve specifications. OGC uses the concepts of test beds to test and validate vendor-neutral specifications that result from the consensus-gathering phase. The OGC aggressively identifies markets in need of open spatial interfaces and engages them in development and adoption of specifications.

OGC has the following core values:

1. Meeting the spatial technology interoperability needs of the global community;
2. Delivering programs to develop interfaces to meet the realities of changing technology;
3. Timely delivering market needs at lowest possible cost and highest level of utility;
4. Working by consensus to agree on interfaces while respecting and protecting the intellectual property of its members; and
5. Maintaining spatial technology leadership in the global standards community.

OGC's Technical Committee has developed an architecture (the OpenGIS Abstract Specification) in support of its vision of interoperability for geospatial technology. This specification provides the foundation for most OGC specification development activities. Interfaces built against the Abstract Specification enable interoperability between dissimilar spatial processing systems. A comprehensive listing of specifications adopted by the OGC can be viewed at the following site: http://www.opengeospatial.org/specs/.

As KDOT has discovered, spatial data initiatives and e-government rank near the top of all political agendas. Open interoperability is therefore likely to result in an accelerated acceptance of open standards and further facilitate the integration of geospatial data into core IT systems, mainstream business processes and decision-making.

Open interoperability can enable internal business efficiency and enhance the end user experience, which in turn can positively impact all of KDOT's customers (internal and external). Some of the benefits of open interoperability are:

1. Through open interoperability (Web File System (WFS) and Web Mapping Standard (WMS)), KDOT can use disparate data from multiple sources to publish data in open industry-standard formats to the Web. This will maximize the reuse (internally and externally) of geospatial data, eliminating unnecessary data translation, and reducing integration requirements and associated costs;
2. Reduced human resource dependence for data translation and integration will free resources for more specific development initiatives;
3. Application of the open-standard Web infrastructure gives KDOT access to a large geospatial information pool. This will play a significant role in reducing planning cycles for KDOT initiatives with a geospatial component;
4. A consistent and standard data format for GIS is essential for integration into mainstream IT systems. With open technology being identified as the key enabler in regional, national and global spatial data infrastructure initiatives, open standards are set to become the industry standard; and
5. With open standards guiding the geospatial community, software procurement opportunities are widened. KDOT is not locked into a single vendor because of historic investment or built-in biases.

Open geospatial standards are factors that KDOT should consider for any geospatial/IT projects. This will enhance KDOT's participation in geospatial initiatives and policy-making within the State of Kansas and the DOT community.

4.4 Federal Geographic Data Committee (FGDC) Geospatial Data Standards

The Federal Geographic Data Committee (FGDC) has defined some general guidelines for geospatial data standards. Among these are:

1. Standards must cover the appropriate topical data and processes in order to advance data sharing and minimize duplication of effort;
2. Standards should be intended to remove impedance to data sharing;
3. Standards should be developed and presented in a structured manner that will lead to understandability and usability by consumers. There also should be minimal guidelines for development and documentation of systems;
4. Standards should not be written or implemented in a way that limits any vendor or technology from the use of their own systems;

5. Standards development should be coordinated to eliminate duplicate efforts and to maximize the efforts of the stakeholders contributing to and implementing them;
6. Standards should evolve as technology and institutional mandates change;
7. Standards should be supportable by the geospatial vendor community;
8. Standards should not contain any copyrights or limitations on their use or reproduction. They should be available electronically when possible; and
9. All standards should have a consistent form and format.

There are several tangible benefits to KDOT to participate in FGDC standards formations. Among those are:

1. Collaborative data standards shorten data development times;
2. Positional (spatial) control standards allow participants to more easily obtain, contribute, and register data;
3. Applications are more easily built by using common data development standards; and
4. Analyses, decision-making, and operations can be more easily performed across jurisdictional boundaries. This could be of significance in joint efforts with Missouri DOT in the Kansas City metropolitan area, for example.

KDOT should promote FGDC standards within KDOT and should support the adoption of FGDC standards by the State of Kansas. This should be of particular benefit as KDOT expands the base road network beyond state-maintained highways. Common geospatial standards will provide a level of consistency in disparate road data resources that could be used to complete the expanded base road network.

4.5 FGDC Metadata

Metadata describes the content, quality, condition, and other characteristics of data. The Federal Geographic Data Committee approved the Content Standard for Digital Geospatial Metadata in June 1998.

The Content Standard for Digital Geospatial Metadata was formulated to provide a common set of terminology and definitions for the documentation of digital geospatial data. The standard was developed from the perspective of defining the information required by a prospective user to determine the availability of a set of geospatial data, to determine the fitness of the set of geospatial data for an intended use, to determine the means of accessing the set of geospatial data, and to successfully transfer the set of geospatial data. The standard establishes the names of data elements and compound elements to be used for these purposes, the definitions of these data elements and compound elements, and information about the values that are to be provided for the data elements. The standard does not specify the means by which this information is organized within a given database, GIS, or in a data transfer but does define the means by which the metadata is transmitted, communicated, or presented to the user.

The content standard can be reviewed at the following site: http://www.fgdc.gov/metadata/contstan.html.

4.6 KDOT Metadata and Data Access and Support Center (DASC)

KDOT currently supports the FGDC Content Standard for Digital Geospatial Metadata within certain business areas. KDOT currently has (in production) a product called Spatial Metadata Management System (SMMS) that allows the capture of appropriate metadata in the standard format. The metadata is a critical component to allow effective usage of geospatial data within KDOT. It is imperative for any stakeholder using geospatial data to be able to see the specific parameters associated with the accuracy, date collected and collection methodology. Use of metadata also ensures spatial agreement (a consistent baseline) when layering data.

The Data Access and Support Center (DASC) is a node on the National Spatial Data Infrastructure network. DASC acts as the GIS clearinghouse for FGDC-compliant data for the State of Kansas. DASC publishes and serves geospatial data and associated metadata to users through its Kansas Geospatial Community Commons website.

KDOT has supplied DASC with a copy of the state highway system road network, selected attribute data, and metadata. KDOT is currently working with DASC and others to supply DASC non-state highway system road networks. KDOT is also working with DASC to publish state and local data holdings in a geospatial catalog.

The State of Kansas has defined geospatial metadata standards for all state agencies. This standard can be viewed at the following address: http://da.state.ks.us/itec/Documents/ITECITPolicy5100.htm.

The inclusion of metadata in data management is essential to the understanding of data sources and will foster the best use of the data in applications projects. The publication of metadata then becomes a powerful tool by which to ascertain data integrity, data reliability, data availability, and overall data fitness.

4.7 National Spatial Data Infrastructure (NSDI) Initiative

The National Spatial Data Infrastructure (NSDI), established by executive order, combines technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data. The NSDI supports public and private sector geospatial applications in transportation, community development, agriculture, emergency response, environmental management, and information technology. The goal of the NSDI is to reduce duplication of effort among agencies, improve quality and reduce costs related to geographic information, and to make geographic data more accessible to various public constituencies.

NSDI standards pertain to common layers, or themes, of geospatial data, including administrative boundaries, cadastral (property ownership and taxation), orthoimagery, hydrography, elevation, transportation, and geodetic control. The transportation theme is still in draft form and can be viewed at the following location: http://www.fgdc.gov/standards/documents/standards/fr_trans_id/NSDI-Trans-Public_Review.pdf.

KDOT published a detailed evaluation and analysis of the draft transportation standard in April 2000 and again in December 2001. KDOT used its base network to prototype the standard. It was determined that KDOT could comply with the draft standard but would have to maintain two separate networks to do so. In addition, KDOT has participated in peer reviews of updates to this standard and provided feedback to the FGDC.

4.8 Topologically Integrated Geographic Encoding and Referencing (TIGER) Modernization

The Topologically Integrated Geographic Encoding and Referencing (TIGER) data base was created to support the 1990 Census. Although TIGER files are not considered standards, TIGER files are widely used throughout the United States for street centerline data, particularly at the local jurisdictional level.

The principal data sources for TIGER creation were USGS 1:100,000-scale Digital Line Graphs (DLGs), USGS 1:24,000-scale quadrangles, the U.S. Census Bureau's 1980 Geographic Base File / Dual Independent Map Encoding (GBF/DIME) files, and a variety of maps and aerial photographs. The Census Bureau is currently in the early stages of developing a process to improve the geospatial accuracy of features in the TIGER database and to devise a more effective approach to updating features.

The TIGER modernization initiative is significant to KDOT because many of the local jurisdictions use TIGER data for basic centerline and address information. TIGER data could be used to provide local content (spatial or attribute) to KDOT's expanded base network. The spatial accuracy of this data source will need to be examined to determine if any or all of it is positionally accurate enough to be used.

4.9 Global Positioning System (GPS) Standards

A Global Positioning System (GPS) is a surveying technology comprised of satellites, receiving devices, and corrective tools used to compute a unique position (latitude and longitude) on the surface of the earth. GPS position may be collected by both stationary and mobile (such as in-vehicle) methods for location description, modeling, navigation, land survey, and recreation.

The United States Department of Defense (DOD) developed GPS for the military as a location utility. Today, many industries are leveraging the DOD's massive undertaking, and since GPS has become available to the non-military sector, its use and popularity have grown substantially.

GPS accuracy standards for survey have been developed by the National Geodetic Survey. Because accuracy standards may vary from application to application, the FGDC has also published general guidelines that can be used as reference. The standard can be reviewed at the following address: http://www.fgdc.gov/standards/documents/ standards/accuracy/chapter2.pdf.

KDOT should examine these standards and verify compliance for best practices in data collection. A common positional accuracy baseline will provide great benefit in spatially enabling the enterprise and will be crucial for overlay analysis in homeland security initiatives.

4.10 Image Data Standards

Imagery data come in many types, sizes, and specifications. The most common image data type used at KDOT is the Digital Orthophoto Quadrangle (DOQ). These quadrangles are often divided into quarters, and the DOQs are then referred to as Digital Orthophoto Quarter Quadrangles (DOQQs).

A DOQ is a computer-generated image of an aerial photograph that has been orthorectified (horizontal and vertical distortions removed) so that it has the geometric properties of a map but looks like a photograph. DOQs have their own metadata standard and also meet federal map accuracy standards.

DOQ production begins with an aerial photograph and requires four elements:

1. At least three ground positions that can be identified within the photograph;
2. Camera calibration specifications, such as focal length;
3. A digital elevation model (DEM) of the area covered by the photograph;
4. A high-resolution digital image of the photograph, produced by scanning.

The photograph is processed pixel by pixel to produce an image with features in true geographic positions. USGS DOQs meet national map accuracy standards at 1:12,000 scale for 3.75-minute quarter quadrangles and at 1:24,000 scale for 7.5-minute quadrangles (corresponding to standard, 7.5-minute USGS topographic maps).

4.11 GIS Policy Board and State GIS Standards

The Kansas GIS Policy Board is responsible for the development of standards and for coordination among agencies and organizations who exchange geospatial data in the

State of Kansas. One of the major policy goals of the Board is to maximize the cost-effectiveness of GIS through public and private partnerships throughout Kansas.

The board consists of 27 members appointed by the Governor from state and local government / public agencies, private sector, and academia. The Board reviews, coordinates and makes recommendations which impact GIS programs and investments in Kansas.

KDOT is represented on the GIS Policy Board, which enables KDOT to contribute to the formulation and adoption of GIS policies and standards for Kansas. More information on the GIS Policy Board and its policies and standards can be viewed at the following site: http://gisdasc.kgs.ku.edu/kgcc/docs/index.cfm#stand.

4.12 Cartographic Standards

The Bureau of Transportation Planning is responsible for maintaining high standards of quality and accuracy in the design and production of the Kansas Official Transportation Map. This map is an example of how KDOT employs cartographic standards for map products. Below is a summary of how a cartographic standard has been implemented for various components of the official transportation map:

1. Highways and Roads shown - with distances (mileage) provided between major cities or state highway junctions;
2. Incorporated cities and towns and unincorporated places;
3. Drainage features;
4. Commercial, municipal airports and military bases;
5. Main track lines (including carrier name) for operating railroads will be shown; and
6. Reprinting of the map every two years.

The standard implemented by KDOT is designed around the example which FHWA recommended in its Guide for Highway Planning Map Manual, which promotes uniformity of general mapping practices among the states. KDOT is also an advocate of the federal mapping standard promoted by the United State Geological Survey. (USGS). The USGS has published documentation detailing standards for map sets which can be viewed at the following address: http://search.usgs.gov/query.html?rq=0&col=faq&col=usgs&col=top2000&col=internal&qt=+Mapping+Standards&charset=iso-8859-1.

4.13 National Map

The National Map is a United States Geological Survey (USGS) partnership program and initiative which will produce a framework for sharing and presentation of geographic information for the United States. The National Map will provide public access to geospatial data and information from multiple sources to help support decision-making in both the public and private sectors.

The National Map is the product of a consortium of federal, state, and local partners who provide geospatial data for access, integration, and applications at the global, national, state, and local scales. The USGS and its partners are committed to providing accurate, consistent, and current digital geospatial base data and maps.

USGS is committed to providing several products and services under the umbrella of this initiative. See http://geography.usgs.gov/products.html for a list of the products and http://geography.usgs.gov/services.html for the various services provided.

The National Map is an initiative that requires dependable data from reliable sources. KDOT should be the provider of state maintained roads for this initiative. In addition, KDOT should seek to encourage local partners in the state of Kansas to contribute their resources to this endeavor.

4.14 Software Version Reconciliation

As with many large enterprise organizations KDOT is forced to deal with software packages from many different vendors, each releasing upgraded versions at different schedules. Even if the softwares themselves are compatible, often the versions among compatible softwares are not compatible. Version control and rigorous scheduling of installation of upgrades becomes a critical issue in terms of minimizing work down times. For geospatial application developers and power users, KDOT should investigate a strategy to incorporate geospatial applications installations and upgrades into a standard workstation build at regularly scheduled intervals. The Ohio Department of Transportation utilizes a semi-annual standard build to ensure that there are no incompatibilities among versions or applications.

5 Stakeholder Review

This section provides an overview of stakeholder data needs and data holdings that pertain to geospatially enabling the enterprise. Stakeholder information was gathered from KDOT employee interviews for the GIS/LRS Integration study (February 2003), from CPMS Architecture Review Interviews and Surveys, from those who participated in the on-site stakeholder meeting (August 2004), and from results tabulated from the "Stakeholder Survey: GIS Strategic Plan Update." Follow-up interviews were also conducted for currency and for clarification. An Appendix number is shown in parentheses by the category headers and refers to more detailed information.

5.1 GIS/LRS Stakeholder Participant Data Holdings Inventory from GIS/LRS Integration Study of 2003 (Appendix 5, Section 1.2.2)

The data elements examined in the GIS/LRS Integration Study of February 2003 are as follows:

1. Data Collection and Structure;
2. Metadata;
3. Location Reference System;
4. Enterprise Data Dissemination;
5. Enterprise Data Access and Provision; and
6. Software Profile.

This assessment was performed in 2003 and included participants from all KDOT Bureaus and Offices at Headquarters who were stakeholders in state system geometrics data. A complete list of the participants is provided in Appendix 5.

The GIS/LRS study asked a host of questions pertaining to the collection, post processing, structure and dissemination of each operational database and its relationship to state system geometrics data held in the CANSYS and CANSYS2 (EXOR Highways) databases.

Note that 76% of the stakeholders in the GIS/LRS study stated that they required access to data from other business areas compared to 93% tabulated from the Stakeholder Survey: GIS Strategic Plan Update. Thus, there is an implied heightened awareness and requirement for usage of enterprise wide data from February 2003 to November 2004.

5.2 CPMS Architecture Review Interviews and Surveys

The Comprehensive Program Management System (CPMS) is KDOT's project management system. CPMS provides for project and fund planning, monitoring, and closure. It is used to manage all construction projects and selected non-construction projects. The non-construction projects were established so that progress and funding could be monitored using CPMS.

In May 2004 KDOT began a CPMS architecture study. In late 2004, twenty surveys pertaining to CPMS usage and design recommendations (from the CPMS study) were reviewed to identify common components that would have a potential impact on the geospatial enablement effort.

In the stakeholder data needs assessment conducted for the CPMS study, construction project information was the one data element that was most requested. CPMS has the ability to generate the LRS Key, which is imperative for linearly locating project data against KDOT's Base Network. In addition, CPMS contains the duration of each project (begin and end county logmile). This provides all the necessary components to extend CPMS data into the geospatial realm.

CPMS data (or any other database with the LRS key or LRS key components) can possibly be joined, for example, using another common key (like contract number or project number), to the Contract Management System (CMS) or to any other database with no LRS key or LRS key components. In this example, however, care must be taken to ensure that the contract numbers or the project numbers have the same meaning and the same format in order to execute the join. These types of joins (on common keys) have the potential to extend geospatial enablement to specific business data that is not currently geospatially enabled with minimal impact at the operational database level.

5.3 KDOT Stakeholder Meeting

On August 18th, 2003 a stakeholder meeting was conducted following the kickoff presentation for the geospatial enablement initiative (GIS Strategic plan update). During this meeting an open discussion was conducted with approximately 35 employees of KDOT (from five of six districts and headquarters) and representatives from the Federal Highway Administration, the Kansas Information Technology Office (State GIS Coordinator), and Intergraph Corporation, the consulting firm conducting the plan update.

Several salient points came from this meeting. The group asked for an enterprise definition of geospatial enablement. The definition should address what the components are and how this could be deployed throughout KDOT. Also, comments arose pertaining to the establishment of spatial data standards and how these would impact the effort. Another concern was how this initiative would seamlessly blend with KDOT's enterprise architecture. Many stakeholders raised the issue of how data would be accessed, queried, and presented (exploited) throughout the KDOT enterprise, with KGATE (KDOT's georeferenced web portal) offered as a viable solution to many data consumers.

5.4 Stakeholder Data Needs Survey (Appendix 5, Section 1.1)

In November 2004, a survey entitled "Stakeholder Survey: GIS Strategic Plan Update" was distributed to KDOT geospatial enablement stakeholders. One hundred three (103) surveys were returned. This survey was administered to determine levels of usage of KDOT data elements to designate and set priorities for data elements to be targeted for the geospatial enablement process. Questions are categorized as shown below:

1. Intensity of use of KDOT data;
2. Use of data outside of immediate business area;
3. Specific types of data required for business functions;
4. Use of KDOT's LRS key for state highway system data; and
5. LRS key use of other Linear Referencing Methods (LRMs) for state highway system data.

NOTE: The inventory findings from the sources mentioned above should not be a substitute for a comprehensive inventory of the current operational databases at KDOT.

5.5 KDOT Traditional Inventory Process and Inventory Assessment (Appendix 5, Section 1.2.1)

The most current inventory assessment of data that could be geospatially enabled was performed for the GIS/LRS integration study that concluded in February 2003. As stated, this is not a substitute for a comprehensive inventory review. The caretaker of each respective data source should perform an inventory review and post it to a central point of discovery.

KDOT manages many different repositories of data, spread across multiple business areas. This fact can have an effect on the accuracy of data used for analysis and on maintaining and publishing the official version of the truth based on varying data sources.

The general process for data inventory at KDOT often follows this course:

1. Data custodian conducts inventory or hires transportation consultant to assist;
2. Questions are formulated which pertain only to to data holdings meaningful to the subject or the study at hand, such as the GIS/LRS study or CPMS review.

The questions answered reflect what is needed for the study and not what data resides at KDOT;

3. Often only those data custodians and users within a given business area are consulted for the subject or the study at hand; and
4. These findings may be published but are not well-read. The resultant inventory is not an actual inventory but a series of answers to specific questions pertaining to specific data holdings. Questions asked are often not all-encompassing and can be provincial.

Within any organization that contains multiple business areas, the process of how the inventory is conducted and what it hopes to document is usually specific to those conducting the inventory. This provides an assessment of what is needed by those asking the questions making the subsequent inventory localized.

In an enterprise setting where there are dependent analysis relationships (perceived or not perceived) among different business areas, it becomes more important that guiding principles or standards for data collection and inventory be established. Having data inventory guidelines or standards, such as data collection accuracy and format, naming conventions, data types, required attributes, and publishing venues will improve workflows by providing consistency and availability of data holdings. Establishing guidelines for maintenance schedules and the creation of metadata are also critical to data inventory practices.

A consistent methodology must be established to govern the inventory process. There will always be variance among business units, but a measure of consistency will make decision-making and report building at KDOT more efficient. Ultimately, KDOT will be able to provide salient information to those who shape the transportation policy for the State of Kansas.

6 Geospatial Enablement Components

Components that allow data from KDOT's major operational databases to be geospatially enabled are analyzed in this section. Information forwarded in this section is based on the Stakeholder Review (Section 5 above). This will provide a reasonable assessment of the level of effort and strategic resources that will be impacted the by the GE effort. The components analyzed are:

1. Operational databases;
2. Spatial and user-defined metadata; and
3. Location reference component.

6.1 Operational Database Enablement Profile (Appendix 5, Section 1.3.1)

Most of the official state highway system databases KDOT uses for policy and decision-making are geospatially enabled or partially geospatially enabled. Many other databases that are not geospatially enabled can possibly be joined to other databases to obtain the geospatial reference (see Section 5.2 above).

The GIS/LRS study of February 2003 identified the presence of the following geospatial components in selected state system-related databases:

1. Geometry (Spatial structure such as Oracle SDO_Geometry format or proprietary GIS format – the geometry is the means by which to create the graphic, or map piece, for both the base and for selected attributes to be displayed as a map feature or layer over the base layer);
2. Storage of the KDOT LRS key as an attribute;
3. The ability of each database to produce the LRS key;
4. Other linear referencing methods used besides the LRS key; and
5. Any other relevant information pertaining to these geospatial components.

Note that 14 of the 22 respondents either store or can produce the KDOT LRS key. In addition, eight of the operational databases contain a spatial geometry, and five of the databases have both geometry storage and the LRS key as a component in their databases.

Figure 6-1 depicts KDOT's Value Chain. As illustrated, most of the current geospatial enablement efforts have been concentrated in one area of the chain, the state highway system network.

Figure 6-1 Current Concentration of Geospatial Enablement

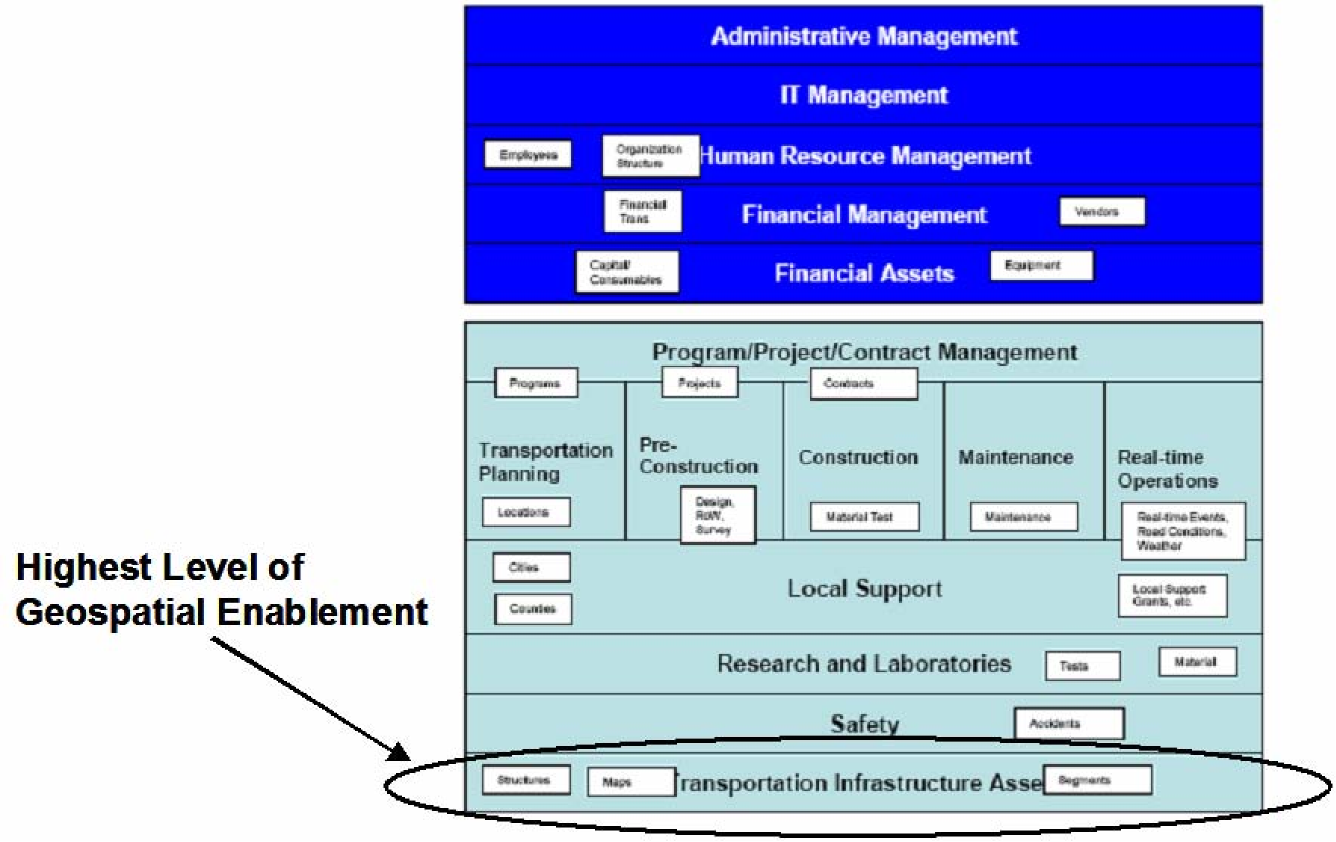

Table 6-1 is based on the Stakeholder Review and KDOT's Information Technology Management and Budget Plan (State FY 2006-2008) and shows geospatial enablement components for KDOT databases (in place or under development). Table 6-1 also shows data elements (that may or may not be spatially enabled) that were deemed critical to KDOT business, functions, workflow, and / or data flows. This table is not complete and will be used to assess current levels of geospatial enablement and to gauge progress on the geospatial enablement effort at KDOT. Appendix 6 contains samples of detailed descriptions of KDOT's existing business systems.

For the State highway system, the LRS key is present in most operational databases. The adoption of the LRS key eases the geospatial enablement of critical data which can be joined to databases which have also adopted the LRS key. In addition, many of the operational databases without the LRS key have other common keys which can be used to join to databases which have the LRS key data (see Section 5.2).

Certain business areas of KDOT are beginning to embrace geospatial concepts and to understand the importance of geospatial enablement of critical data that lies off of the state highway system. For example, KDOT facilities locations, test materials locations, non-state system road network, and non-state bridge locations have been identified as critical data elements to business functions. Likewise, non-state system accident locations and non-state system portions of Road Safety Audits, and particular features of KDOT's capital inventory may also become candidate data sources for geospatial enablement (See Appendix 5 for more detailed information).

Table 6-1 Geospatial Assessments

	Database / data element	Acronym	LRS	Build LRS key	Join to LRS	Lat/Long	Other LRM	Off state system network
1	AASHTO: PONTIS – see PONTIS							
2	City agreements							
3	City connecting link projects							
4	AASHTO: Vertis – see VERTIS							
5	Access permits		Y					
6	Accident locations	KARS	Y					Y
7	Advanced Public Transportation Management System*							
8	Advanced Traveler Information System	ATIS	Y					
9	All rural Roads Network*		Y*					Y
10	Automated Budget System	ABS						
11	Automated Traffic Management Sys	ATMS						
12	Automated Traffic Recorder System	ATRS						
13	Bid Analysis And Management System	BAMS					RM	
14	Bridge	BOPRS						
15	Bridge Office Management System	BROMS						
16	Bridge Reporting Analysis System	BRAS						
17	Budget System							
18	Capital Inventory							
19	Cash receipts							
20	City maps							Y
21	City street centerlines							Y

	Database / data element	Acronym	LRS	Build LRS key	Join to LRS	Lat/Long	Other LRM	Off state system network
22	Comprehensive Program Management System	CPMS		Y		Y	LL	
23	Comprehensive Transportation Program Comparison Report System	CTP report						
24	Computer Aided Drafting and Design	CADD						
25	Computer Aided Mapping	CAM						
26	Congestion Management System							
27	Construction Management System Materials Inspection							
28	Consumable Inventory Management	CIMS						
29	Continuous Coverage Counts	CVRG						
30	Contract Management System	CMS			Y			
31	Control Section Analysis System	CANSYS	Y	Y				
32	Cost Center Feedback	CCFB						
33	County maps							
34	Crew Card Reporting*							
35	Crossing Inventory Information Management System	CIIMS						
36	Customer Relationship Management*							
37	Digital Elevation Models*							
38	Digital Terrain Models*							
39	District Employee Database							
40	Electronic Accident Data Collection and Reporting System	EADCR						
41	Electronic Surveying							

	Database / data element	Acronym	LRS	Build LRS key	Join to LRS	Lat/Long	Other LRM	Off state system network
42	Employee Time Reporting System	ETS						
43	Enhanced Radio System*							
44	Equipment Management System	EMS						
45	Fatal Accident Reporting System	FARS						
46	Features Inventory							
47	Federal Aid Billing System	FABS						
48	Fiber Optics Infrastructure							
49	Financial Model							
50	Fuel Tracking System	TRAKS						
51	GIS Data Warehouse	GIS/DW	Y	Y				
52	High Accident Locations	HAL’s	Y					
53	Highway Maintenance Management System	HMMS						
54	Highway Performance Monitoring System	HPMS						
55	Highway Performance Monitoring System	HPMS	Y	Y				
56	Integrated Financial Management System	IFIS						
57	Intelligent Transportation System --statewide	ITS TOC		Y				
58	Intelligent Transportation System --Wichita	ITS TOC		Y				
59	ITS devices (cameras, etc.)	ITS						
60	KanRoad	KANROAD	Y					
61	Kansas Accident Records System	KARS	Y					Y
62	KCScout	KCScout		Y				
63	KGATE	KGATE	Y					
64	L PILE Plus							
65	Laboratory Information Management System	LIMS	Y	Y				

	Database / data element	Acronym	LRS	Build LRS key	Join to LRS	Lat/Long	Other LRM	Off state system network
66	LEAP							
67	Learning Management System	LMS						
68	Legislative Bill Tracking							
69	Local roads -- rural		Y*					Y
70	Long Term Pavement Performance							
71	Maintenance Management Stud*							
72	Materials locations							Y
73	National Bridge Inspection Program	NBIP						Y
74	Network Optimization System – part of PMIS	NOS-SEE PMS						
75	Non-sys – city classified non-state							
76	OPIS							
77	Orthophotography Production							
78	Orthophotography*							
79	Pavement Management System	PMS						
80	Pavement Optimization System—part of PMIS	POS						
81	Personnel and Position Management System							
82	Photogrammetry							
83	PONTIS							
84	Priority formula							
85	Priority Formula*							
86	Program Development Model							
87	Public info portals							
88	Public Involvement Database							

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	Database / data element	Acronym	LRS	Build LRS key	Join to LRS	Lat/Long	Other LRM	Off state system network
89	Radio Business Plan*							
90	Railroad crossing							
91	Reinforced Concrete Box							
92	Re-use of Survey data							
93	Right of Way Beautification System							
94	Right of Way Tract Tracking							
95	Road and Weather Information System	RWIS						
96	Road safety audits							
97	SHAFT							
98	Shop Management System							
99	Snow and Ice Removal Reporting System							
100	State Highway System Base Network							
101	State maps							
102	Strategic Management Plan							
103	Substantial Maintenance Program Development*							
104	TerraShare Image and other raster data management and distribution	TERRASHARE						
105	Topologically Integrated Geographic Encoding and Referencing data	TIGER data						
106	Traffic Data System	TRADAS						
107	Traffic Forecasts							
108	Traffic Safety Information Management System							
109	Treasury Management Spreadsheet							

	Database / data element	Acronym	LRS	Build LRS key	Join to LRS	Lat/Long	Other LRM	Off state system network
110	Truck Routing Information System							
111	US Census Socioeconomic data							
112	VIRTIS							
113	Voucher Entry System	VES						

LRM's: **Clm-**county route logmile, **Slm-**state route logmile, **Clk-** county route logkilo, **Slk-**state route logkilo, **Rm-**reference marker, **LL-**Longitude/Latitude, **EN-**Easting/Northing, **St-**stationing, **XY-**x, y coordinates, **Int-**intersection reference

6.2 Spatial and User-Defined Metadata (Appendix 5, Section 1.3.2)

Spatial metadata refers to characteristics of the spatial component of the data, such as datum, map projection, and reference coordinates that explain how the 3-dimensional model of Earth was transformed into 2-dimensional model for 2-D presentation or mapping. As examples, spatial metadata is imbedded in imagery data served through TerraShare or in GIS applications. With spatial metadata, information layers which exist in alternate map projections, for example, can be transformed in order to properly layer the information (so the bridge goes over the water, so to speak). The metadata should also be published to assist the consumer in understanding data quality and fitness.

Additional user-defined metadata can tell the user about data collection techniques, data audience, data maintenance, data age, data distribution, data cost, and overall data fitness. Metadata creation has become a necessary component to standard business rules for inventory and for data exchange, but metadata creation remains in its infancy at KDOT.

Spatial metadata will be a critical factor for a uniform geospatial enablement effort. Understanding the basic framework of the data is critical for consistency in the development of enterprise applications by KDOT. In addition, as KDOT continues to provide and exchange data with external entities, metadata, both spatial and user-defined, will be critical not only for seamless usage of the data but also for acceptance of the data in the first place.

6.3 KDOT LRS Key and Location Reference Methods (Appendix 5, 1.3.3)

The KDOT LRS key usage was analyzed in the GIS/LRS 2003 study. This study showed that 67% of those interviewed had adopted KDOT's LRS key as a standard for linear referencing. From the "Stakeholder Survey: GIS Strategic Plan Update" it was found that 56% of those asked had adopted the LRS key. The LRS key is a very vital component to geospatially enabling the enterprise from the state system base network standpoint.

KDOT has traditionally used multiple Location Referencing Methods (LRMs). In the GIS/LRS study of 2003, County-Route Logmile and Longitude/Latitude were the most frequently used LRMs, and the most commonly used LRMs from the Stakeholder Survey: GIS Strategic Plan Update were:

1. State Route Logmile (63%)
2. Reference Post (61%)
3. County Route Logmile (54%)
4. Longitude/Latitude (46%)

A technical note deserves mention here. KDOT stakeholders have expressed a need to be able to convert or transform between the above-mentioned LRMs. There are several approaches to doing this. Currently, GeoMedia Transportation contains and Event Conversion utility that allows transformation from one LRM to another. In addition, there is a utility that will assign an LRS Key to a coordinate (longitude/latitude or easting/northing) event that does not contain the LRS Key. Once this is done the Event Conversion utility can be used to convert between LRMs. Another approach is to register event data to a linear datum as opposed to an LRM. The actual LRM itself is built on top of the datum. This allows location to be seamlessly converted from one LRM to another. The support of a linear datum model will be fully functional in GeoMedia Transportation 6.0.

7 Barriers to Geospatial Enablement

This section summarizes obvious and perceived barriers that impact the geospatial enablement effort at KDOT. Several of these barriers are interrelated.

7.1 Cultural Barriers

Cultural barriers center around common misconceptions of geospatial enablement:

1. Geospatial enablement (GE) is perceived as another system or another application;
2. Geospatial enablement (GE) will cause another "stovepipe" (island of development) to be erected;
3. Geospatial enablement (GE) will require the creation of another database or will require major changes to existing operational databases;

A common cultural misconception of the geospatial enablement effort is that it is another system or application. This is quite contrary to the truth. One of the premises of geospatial enablement is to go a "level below" any system utilized by KDOT. The goal is to geospatially enable the major operational databases that are used to make policy and project decisions and to produce reports. This detaches the spatial component from any application and allows for any and all maintenance to be performed at the operational database level without duplication of effort or the need for additional maintenance "downstream."

Because the geospatial enablement effort is perceived by many as another system, the natural inclination is that this will add another "stovepipe" that precludes enterprise-wide usage of information in an open capacity. If the geospatial enablement effort is based on adopted KDOT standards (such as KDOT standard LRS key, county route logmile, latitude and longitude, as examples), then data are more easily integrated at the operational level so that data and applications built on those data can be shared across the enterprise.

Another cultural misconception is that the GE effort will require the creation of additional GIS databases or extreme makeovers to current operational databases. First, GIS has been mislabled as a database when, in fact, GIS is not a database but a method or approach which *uses* geospatially enabled data *from* a database and/or inside of GIS (and some CADD) application software. Major changes would not be required to geospatially enable operational databases, as illustrated in the example in Section 5.2. In other cases, by recommending that geospatial enablement (GE) occur at the operational database level, only additional attributes (that store the location/geospatial reference) need to be added. No new databases need be built.

Geospatial enablement is conducive to data sharing. Work culture barriers which center around data sharing also exist:

4. Ownership and territorialism may impede the GE effort;
5. There is fear associated with sharing data which may be used in a misrepresentative way or may be used out of context;
6. There is fear associated with sharing data because errors in the data may be discovered; and
7. Provincialism regarding data development and the reuse of data is not uncommon. (“Who would ever want my data?” or “No one understands my data like I do.”)

Overcoming the barriers mentioned above come about as a result of strong communication and education and having common, well-expressed goals about the GE effort and subsequent data sharing. Creation of user defined metadata adds strength to data fitness and can leave little room for the use of data out of context. Finding errors in data results in the fixing of errors and results in cleaner data. Regarding reuse of data, it is becoming a common, practical practice to let data consumers be in charge of their own discovery.

7.2 Operational Barriers

Any organization deals with internal operational barriers or misconceptions when undertaking new initiatives. Many of the barriers listed below interrelate and cross over into cultural barriers:

1. Budgetary/Resource factors;
2. Educational and training issues;
3. Implementation concerns;
4. Technical barriers;
5. Institutional barriers; and
6. Security barriers.

Budgetary/Resource issues can take many different forms. Among the perceived factors that could have an impact are funding, personnel and time. Most of the funding impacts will occur at the operational database level. In few cases the geospatial enablement components will have to be added to the database (state system only). This will consist of deriving location and adding it via an automated process. In another case this could consist of a change in field data collection methodology to add location as a managed attribute.

Educational and training issues will need to be addressed. Many individuals at KDOT are in the beginning stages of working with geospatial information. Some are already working with geospatially-enabled data (CPMS) but are not aware of it. There will be a process beginning with the presentation of the findings for this study that will make KDOT stakeholders aware of what geospatial enablement is and where it currently is in place within the enterprise.

Training is another factor to consider. Training will focus on field data collection and the methodologies to fully enable partially enabled databases. Once the processes are defined then training the appropriate people will have to take place. This should be a collaborative effort between each data custodian and the appropriate GIS and IT personnel, if needed. Training of specific software for selected data custodians will also need to occur.

Education and training barriers are best overcome through open channels of communication. Creativity and innovation also need to be embraced to carry out education and training, particularly in light of diminishing resources.

There are a few implementation concerns that should be addressed. The issue of proprietary systems and open interoperability for state system base network maintenance was addressed in the GIS/LRS study but must be revisited. KDOT currently has implemented open GIS web development tools (GeoMedia WebMap Professional) that have the ability to assimilate data from dissimilar formats for decision support and presentation. This will factor into the implementation approach KDOT takes in presenting the operational databases to the enterprise. This technology allows a read-only connection to dissimilar data sources that are required for usage in the workflows and work processes at KDOT.

Most technical barriers pertain to software and formatting and can be overcome. Compliance to OGC and metadata standards will make these and any additional barriers easier to overcome.

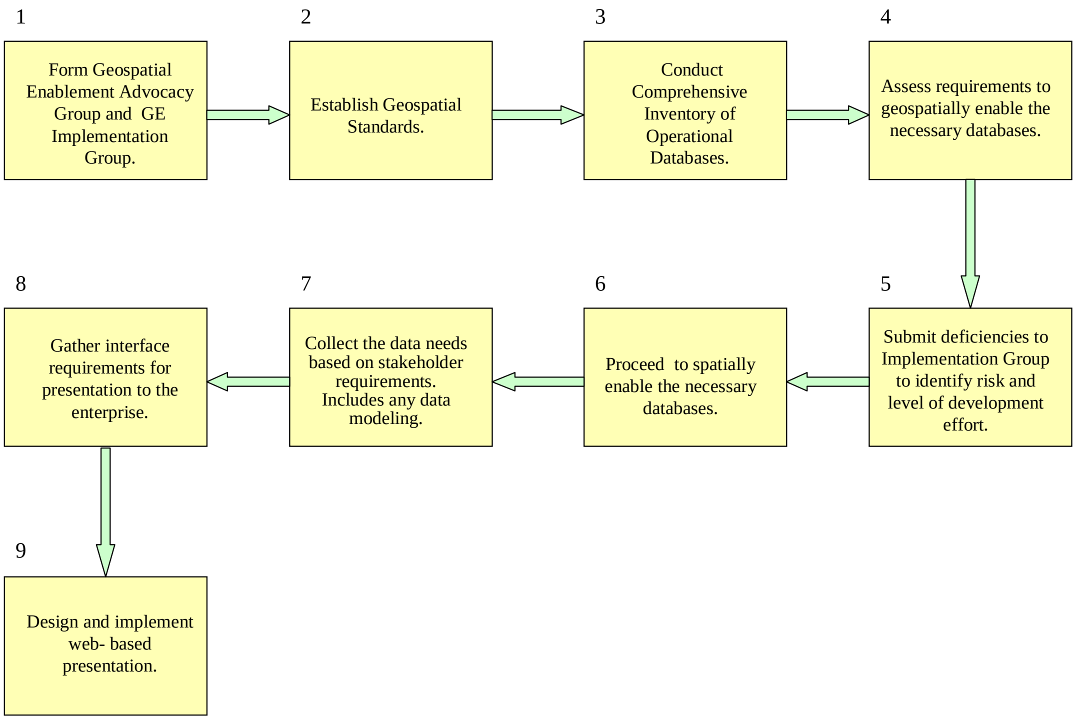
Certain institutional barriers have been overcome through partnering and open discussion and cooperation. KDOT's representation on the GIS Policy Board and technical committees and subcommittees of the Board has opened channels of communication, knowledge sharing, and data sharing. Continuation of these common sense practices will certainly assist in the breaking down of barriers that have impeded data sharing and contributed to duplication.

As technical and institutional barriers are breaking down, security barriers, which may be another type of technical barrier, have become a concern. These barriers can be broken down through continued communication among partners and documentation of common goals with respect to sharing and presentation of geospatial information.

8 Enablement Process

This section outlines the process for the geospatial enablement effort. Figure 8-1 provides a general roadmap of how this can be accomplished. Figure 8-2 illustrates a simplified decision flow for geospatial enablement of selected data.

Figure 8-1 Geospatial Enablement Process



1. The process will begin with creation of the Geospatial Enablement (GE) Advocacy Group and the GE Implementation Task Group. The Advocacy Group will be responsible for creating policy for the collection and dissemination of geospatial data. The Implementation Task Group will provide support and consultation for any subject matter that requires automation or usage of GIS and IT technology (See Recommendations 14 and 15 below).

2. The next step would be to establish formal geospatial standards to govern the management of geospatial data. The Advocacy Group will be responsible for assembling existing standards and creating standards where none exist. The standards will seek to limit basic data structure and locational discrepancies that typically plague large enterprise organizations that share data. Examples of standards that could be adopted pertain to data accuracy, naming conventions, linear referencing methods and naming, and metadata standards.

This step should take 2-3 months with weekly or bi-weekly scheduled meetings of the group.

3. A comprehensive inventory of all the operational databases to identify which ones are geospatially enabled should be conducted, guided by the GE Advocacy Group. The GIS/LRS data holding survey of 2003 provided an incomplete survey but is a place to start (see App. 5, Table 6). The custodian of each operational database should complete the inventory. The geospatial enablement components are the geodetic coordinate system, the KDOT LRS key, other LRM, and spatial and other user-defined metadata, such as the data collection methodology, accuracy, and the date the data was collected. This process should take 3-4 months to complete. Inventory should be published to a central point of discovery.

4. After the inventory is completed an assessment of what will be required to geospatially enable the deficient operational databases will be conducted. The data custodian simply will evaluate which missing pieces of information are required to spatially enable the database. For instance, are the components of the KDOT LRS key available on the data? If they are, should a new attribute be created concatenating the parts so the LRS key is managed as one attribute? Is there coordinate information resident with the data? If so, is it projected coordinates that will need to be converted to geographic coordinates or a county-route logmile LRM? This step should take 2-3 months to complete.

5. Any noted deficiencies that are not correctable by the data custodian should be submitted to the Technical Committee. The Committee will identify if there are current IT or GIS software tools in usage that can provide value to enable the deficient database. For instance, the GIS department at KDOT uses a tool named SMMS to create FGDC compliant spatial metadata. Other departments could use SMMS to create metadata for their operational databases. The Technical Committee should have a list of all the GIS and IT tools available to them that could be matched to various deficiencies that may exist in the operational databases. This process should take 3-4 months.

6. The next stage would be to commence with the enabling of locationally deficient data. This is bringing together the identified tool (off the shelf or user developed) and the data. This process should take 4-6 months.

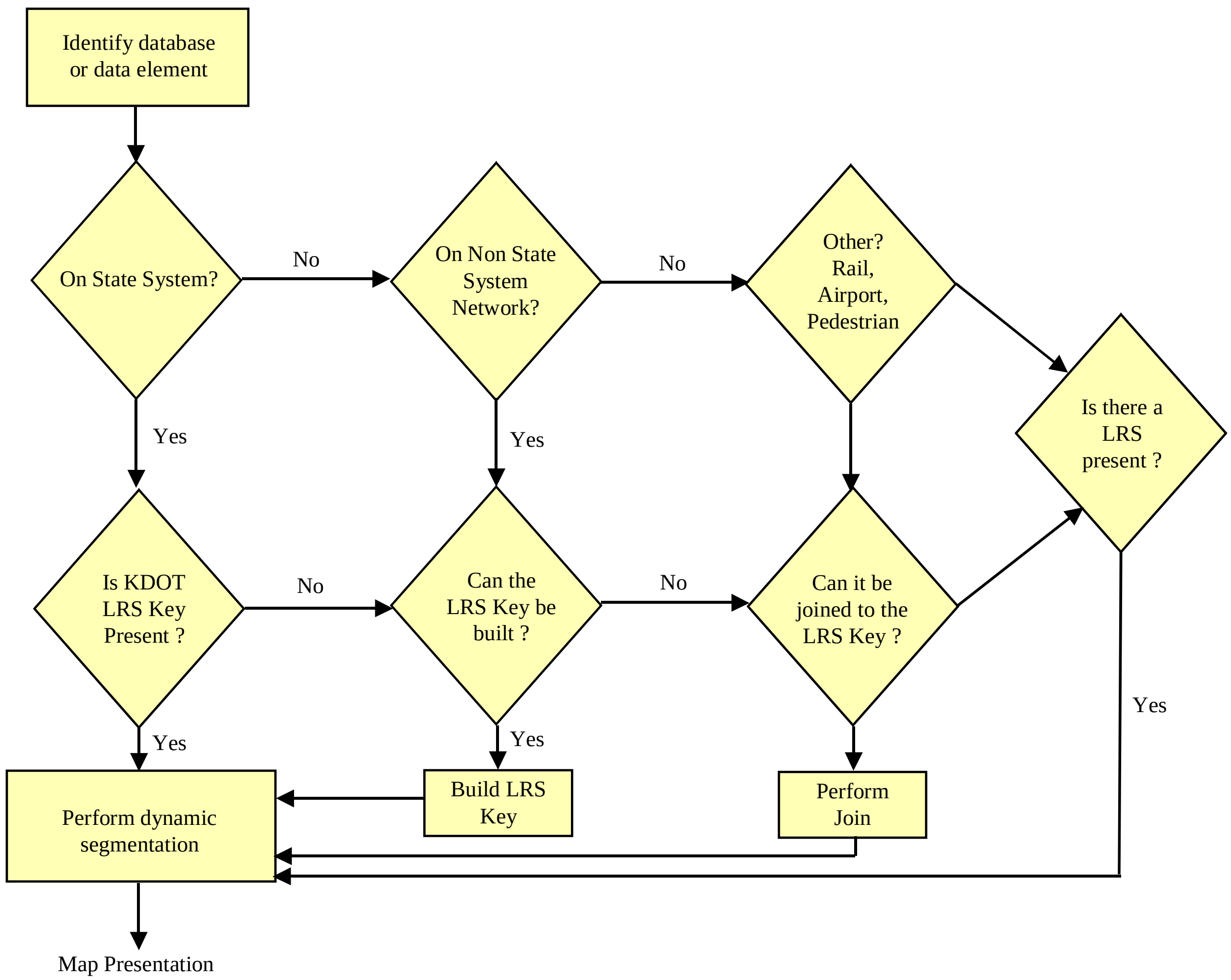
7. The next phase moves into the realm of user data needs across the enterprise. The Geospatial Enablement Advocacy Group should lead this. It will consist of defining stakeholder needs from the operational databases. This would help determine which specific pieces of information are most salient to decision making. This may involve some data modeling for presentation purposes. This should take 3-4 months.

8. Finally, the dissemination mechanism to present the data to the enterprise must go through requirements gathering. Currently there are two initiatives that are underway at KDOT that could be of benefit. The GIS/DW and KGATE are currently serving as an enterprise wide repository of spatial data and enterprise decision support mechanism. These efforts should be leveraged to simplify and shorten the design cycle for the presentation logic to the enterprise. All of the stakeholders that participated in the above mentioned efforts and new stakeholders involved in the GE initiative would submit requirements for the presentation environment

9. The last step would be to design, test and implement the web based analysis environment. After the requirements have been collected the Advocacy Group would prioritize the essential functions based on value scheme. The prototype would be built and selectively tested by a team chosen by the Advocacy Group. Refinement to the prototype would be made based on user input and then the final design would be completed. The system would then be rolled out to the enterprise.

A conceptual process flow for databases or elements to verify geospatially enablement could resemble Figure 8-2 below.

Figure 8-2 Database/element enablement flow



In all phases of the GE process, Quality Assurance and Quality Control are critical to the success of any geospatial enablement effort. The importance of an effective QA/QC data validation process is evident as KDOT stakeholders recognize that geospatial database resources become the foundation for business applications and analyses. The role of data validation inside software applications, the role of data validation through visualization, and the role of metadata creation and inclusion provide the means by which to support the QA/QC process to ensure and maintain data integrity.

9 Facts and Findings

This section will identify the overall findings of the study that were derived from peer and literature reviews, personal interviews and surveys of KDOT stakeholders.

1. KDOT GIS Plan of 2000 was analyzed against a peer group of DOT's GIS plans, within comparable time frames, to determine if there were any inequities of goals and objectives, data warehousing and management philosophies, and strategic technical direction among the transportation community. It was found that KDOT's GIS Strategic Plan was consistent and at a competitive level with regards to goals and objectives, implementation of GIS technology, and application needs. Furthermore, KDOT was at a comparable progression point with respect to the development of spatial databases to be used for mapping and linear analysis.

2. The analysis of KDOT's GIS Plan of 2000 with other transportation peers revealed the focus was on non-integrated, stovepipe applications designed to solve a specific business problems. The most common components were:
    a. Recommendation for a GIS Steering Committee;
    b. Staff evaluation considerations;
    c. Employee training;
    d. Database evaluation;
    e. Data distribution methodology;
    f. Review of data quality and process analysis; and
    g. Identification of priority applications.

3. It was necessary to evaluate several internal KDOT initiatives for strategic synchronization. Those initiatives were:
    a. KDOT Strategic Information Technology Plan (SITP), 2003;
    b. KDOT Strategic Management Plan, 2003;
    c. Kansas Long Range Transportation Plan, December 2002;
    d. GIS/LRS Integration and Needs Assessment, February 2003;
    e. GIS/Data Warehouse Project, August 2004; and
    f. CPMS Architecture Review Surveys, August 2004.

4. The KDOT SITP mentioned two salient points that would directly influence the GE effort:
    a. IT's role in the collection, storage and retrieval of data. This could impact where the geospatial enablement process of candidate data sets would occur.
    b. Consolidation of databases to an enterprise view. This is significant with regards to how and what geospatially enabled data is made available to the enterprise.

5. The KDOT SITP created a value chain with data structures mapped to it. In analyzing the value chain, with the applicable data structures, most of the current spatial enablement efforts have been concentrated in one area of the chain, specifically the state highway system network.

6. At KDOT, very little geospatial enablement or location referencing occurs beyond the Kansas state highway system network geometrics (pavement and bridges). The desire to geospatially enable non-traditional asset information (e.g., financial, budget, human resources) has not been articulated.

7. The KDOT Strategic Management Plan (SMP) 2003 outlined several goals with which the GE effort must integrate:
    a. Maximizing the effectiveness of the workforce through elimination of redundant data;
    b. Aid in the integration of application by providing common spatial components that streamline development and information exchange.
    c. Ensuring that KDOT projects are in conformance with various federal standards.
    d. Ensure the most current and accurate data is available for stakeholders in the decision process.
    e. Utilize the most efficient technology to meet strategic objectives. This will be important with regards to methods used to spatially enable data.
    f. Provide optimal methods and techniques to analyze information for the long-range transportation needs. Among these are:
        i. Preserve SHS or improve the condition.
        ii. Effective Right-Of-Way clearance for project letting.

8. The GIS/LRS Integration and Needs Assessment Study of 2003 identified the following factors:
    a. Production level maintenance of LRS/network data still takes place in two different environments:
        i. EXOR Highways (GAD Unit)
        ii. GeoMedia/GeoMedia Transportation (Cartography/GIS).
    b. The GPS-Based centerline maintenance workflow is still utilizing the spatial centerline from the GPS collected data into the GIS Network, but loading the logmile from CANSYS2. The result of this is the logmile from CANSYS2 may not be as current as the measure collected by the GPS-based centerline.
    c. Business data that was needed for decision support was being maintained in both the GAD Unit and Cartography/GIS.
    d. This study recommended that EXOR Highways create a network representation and event table with the appropriate linear referencing method and make it available to the enterprise. This

recommendation was accepted by the KDOT evaluation team but has not yet been implemented.

9. The Comprehensive Program Management System (CPMS) is KDOT's project management system. CPMS provides for project and fund planning, monitoring and closure, not only for construction projects, but also for all projects which the agency chooses to establish for the purpose of planning and monitoring work.

10. The CPMS system is currently in the requirements definition stage to be re-designed.

11. Nine of the 19 respondents to the CPMS Architecture Review Survey expressed interest in having a geospatial and mapping component.

12. The current CPMS system contains all the components to build KDOT's standard LRS key. This will allow the LRS key to be easily constructed. This will extend the geospatial enablement effort to the realm of decision support.

13. The current CPMS also contains begin and end points (logmile) of the construction projects being managed in addition to the components to build KDOT's standard LRS key. This provides a foundation to geospatially enable construction project data.

14. The primary tracking mechanism for projects in CPMS is the project ID number. This could create an avenue for joining into other systems, but project definition and formatting issues will need to be resolved.

15. The Contract Management System (CMS) follows all processes associated with contract-related functions. Most (70-80%) are construction contracts, but other contracts have been allowed into the system. CMS handles change orders. The primary key is a KDOT-assigned contract number. CMS carries associated project numbers (the primary key in CPMS) but CMS must first have a contract number.

16. CPMS data (or any other database with the LRS key or LRS key components) can possibly be joined, for example, using another common key (like contract number or project number), to the Contract Management System (CMS) or to any other database with no LRS key or no LRS key components. In this example, however, care must be taken to ensure that the contract numbers or the project numbers have the same meaning and the same format in order to execute the join. These types of joins (on common keys) have the potential to extend geospatial enablement to specific business data that is not currently geospatially enabled with minimal impact at the operational database level.

17. The state of Kansas Strategic Information Management Plan (SIMP) has as an objective to create a Truck Routing portal. KDOT has implemented the Truck Routing Information System (TRIS).

18. The SIMP states that the State of Kansas would like to build a GIS interface into an orthoimagery repository. In addition, the SIMP states that the State would like to designate "Centers of Expertise" within certain technology and project domains.

19. KDOT's Bureau of Computer Services (BCS) has incorporated Control Objectives for Information and related Technology (COBIT) principles into IT strategies. These principles are synchronized into enterprise-wide KDOT goals that have been established in the SMP. The primary areas of focus are:
    a. Technology Usage
    b. Workforce Optimization

    The GE effort will seek to leverage technology usage to spatially enable stakeholder business data and deploy it to the enterprise. This will have a significant impact on optimizing the workforce by eliminating duplication of data, and providing easier access to spatial data needed for enterprise-wide decision-making.

20. FHWA has established general performance measures that KDOT has utilized to establish Critical Success Indicators. Most of these indicators utilize data that has a spatial or linear component. Some of the indicators that could be directly impacted by the GE effort are:
    a. Highway Capacity
    b. Highway Safety
    c. Public Transportation

21. The GIS/LRS study of 2003 revealed that 15 of the 21 respondents to the survey stated they used an Oracle database. The level of usage has not decreased since this study.

22. Oracle is the chosen database for KDOT. This provides a spatial/geometry component for data that is stored and then subsequently rendered through a web site or GIS environment.

23. Oracle is a partner in the Open GIS Consortium, which establishes geospatial standards for government and private sector participants.

24. KDOT has built an internal GIS based web portal (KGATE) to connect numerous KDOT geospatially enabled databases and other data. KGATE can be accessed throughout the agency. KGATE provides the ability to dynamically display, as examples, accident locations, traffic volumes, and

video log, with digital imagery as background. This provides a baseline system for enterprise-wide data access for decision-making.

25. KDOT has under design a GIS spatial data warehouse that will serve as a repository of frequently accessed data from operational databases. It was determined the data in this warehouse is to be published at pre-defined temporal intervals that are static, and thus dynamic access to these operational databases is not required for enterprise-wide decision support. This will provide more consistent performance from an enterprise vantage point.

26. KDOT has a major investment in acquiring and maintaining aerial image and rasterized map data covering the state of Kansas. Image acquisition and orthophotography production of second generation DOQQs was completed in 2004. KDOT's image and raster repository contains Years 1991 and 2002 one-meter (black and white) DOQQs, 2003 and 2004 2-meter color imagery, 0.6 meter color imagery for selected areas, 3 scales of Digital Raster Graphics (DRGs), and miscellaneous high-resolution photos and oblique photos.

27. KDOT currently uses an LRS key that was designed in 1995 and revised in 2000. This key functions as a standard to locate linear data against the road network.

28. In the GIS/LRS study of 2003, fourteen (67%) of the 21 respondents stated they have adopted the standard LRS key to manage the data holdings. In addition, from the data needs assessment conducted for this effort, 57 (55%) of 103 respondents stated they use the KDOT LRS key.

29. KDOT has analyzed the NSDI Framework Transportation draft standard. This is a transportation segment identification scheme authored by the Federal Geographic Data Committee (FGDC). KDOT attempted to see if it was feasible to use the framework in production network maintenance and mapping. This was done because of KDOT's relationship with DASC, which serves as an FGDC clearinghouse. DASC looks to KDOT to provide the transportation related data to the clearinghouse.

30. Planning/Cartography department at KDOT are currently collecting FGDC compliant metadata for its databases. KDOT stakeholders have not universally adopted this standard.

31. KDOT's operational databases maintain varying durations of temporality. Some databases are date- and time-stamped, based on event or transaction. Other databases are "frozen" (snapshots taken) at scheduled intervals, such as quarterly, semi-annually, or annually).

10 Recommendations

This section will present a list of recommendations to help move KDOT forward in the geospatial enablement (GE) effort.

1. The Secretary of Transportation shall provide published executive endorsement of the GE effort so that all KDOT divisions, bureaus, offices, and districts will participate in the GE effort.

2. The GIS Plan Update Steering Committee shall be the designated champion of the GE effort throughout the enterprise and outside of KDOT.

3. The GIS Plan update Steering Committee shall revisit the plan, which is an organic document, in terms of content, progress, pertinence, and relevance, at regularly scheduled intervals as agreed upon by the Steering Committee.

4. All software development endeavors which require support or approval from KDOT's ITAC or EXIT shall be required to have a GE component.

5. KDOT shall educate its staff and its contracted and other partners in terms of its GE effort and associated requirements, such as data collection using GPS, LRS creation, and metadata.

6. All legacy systems shall be required to have a geospatial component based on user audience, upgrade schedule, or on a case-by-case basis, as approved by ITAC/EXIT.

7. KDOT shall provide adequate resources to ensure adequate support for the GE effort. KDOT's ITAC and EXIT will be instrumental in decisions governing priority for resources and organizational commitment to the GE effort.

8. KDOT shall set an aggressive internal and external marketing/educational program surrounding the GE effort. A chief communication coordinator of these efforts should be designated from the GIS Plan update Steering Committee.
    a. External efforts can be geared toward participation in professional associations or conferences such as:
        1. GIS for Transportation (GIS-T);
        2. Highway Engineering Exchange Program (HEEP;
        3. National State Geographic Information Council (NSGIC);
        4. National Association of State Chief Information Officers (NASCIO);
        5. Association of American Geographers (AAG);

6. Urban and Regional Information Systems Association (URISA);
7. American Society of Photogrammetry and Remote Sensing (ASPRS);
8. Transportation Research Board (TRB);
9. American Association of State Highway and Transportation Officials (AASHTO);
10. American Society of Civil Engineers (ASCE);
11. American Institute of Certified Planners (AICP);
12. Mid-American GIS Consortium (MAGIC);
13. State of Kansas GIS Policy Board;
14. Kansas Society of Professional Engineers;
15. Kansas Highway Association;
16. Kansas Association of Counties;
17. League of Kansas Municipalities;
18. Information Technology Leadership Council;
19. Local governmental and/or planning entities (cities, counties, Metropolitan Planning Organizations);
20. Local Chambers of Commerce;
21. Private sector partnership groups; and
22. Vendor-specific venues.

b. Internal efforts can be in the form of participation in:
    1. Brown Bag Luncheons;
    2. Net Meetings/Web demonstrations;
    3. Division, Bureau, Office, District, Area, and Subarea meetings;
    4. Status presentations to ITAC and EXIT;
    5. Operations meeting presentation;
    6. Operations Computer Advisory Group (OCAG);
    7. Internal newsletter / Other internal correspondence; and
    8. Creation of a GE Advocacy Group.

9. KDOT shall maintain an active role on the GIS Policy Board and on its technical advisory committee and subcommittees. This is essential to help formulate statewide geospatial policy and to set direction that will benefit KDOT.

10. A designated GE point of contact will lead the Geospatial Enablement effort. This point of contact will guide GE efforts for KDOT and will act as liaison for GE efforts outside of KDOT.

11. KDOT shall participate with user groups that help to guide software development and release schedules.

12. KDOT's internal stakeholders shall be encouraged to use Oracle as the tool for maintenance and sharing of their operational, geospatially-enabled databases. This should be done for the following reasons:

    a. Oracle would help to provide a standard database development platform throughout the enterprise.
    b. This will aid BCS with schema standards for the proposed enterprise architecture.
    c. Oracle contains a spatial data geometry type inside of Oracle Spatial that can be used across geospatial and GIS applications. This provides a "built-in" mechanism that will aid the spatial enablement of KDOT's enterprise by securing a common format for the geospatial data geometry where applicable.
    d. Training can be simplified for database users enterprise-wide.

13. GE efforts shall begin with data collection methods in the field. This will empower the users and data custodians alike, will be of the least impact to the agency, and will expedite the mainstreaming and acceptance of GIS throughout KDOT.
    Two different sets of geo-referencing for the GE effort (one for linear data and one for non-linear data) shall be required.
    The requirements for LINEAR data collection (data which will be applied to a linear transportation network) are:
    a. The LRS key (County-route identifier which adheres to KDOT's LRS key standard) or data by which to create the standard LRS key (road network only); and
    b. Longitude/latitude (with metadata regarding data collection).
    The requirements for NON-LINEAR data collection (data which will NOT be applied to a linear transportation network OR is areal (polygonal) in nature, such as quarry sample locations) are:
    c. Longitude/latitude (with metadata regarding data collection)
    d. Public Land Survey System (PLSS) reference (legal description) (with metadata regarding level of granularity).
    These location reference methods WOULD NOT replace the existing methods but would augment them and provide the means by which to easily integrate, share, and graphically display data. This would require a policy (ITAC/EXIT) to ensure all new projects or system enhancements are required to have a spatial component adhering to these data collection methods in addition to metadata creation.

14. The Steering Committee will help to formulate a Geospatial Enablement Advocacy Group which will also guide the GE effort. The group will consist of representatives from the various business areas within KDOT. Members of the group will be data content and/or data use experts for data from their respective areas. This group will have authority to accomplish GE efforts, will be accountable, and will provide technical and

administrative support.

15. The Steering Committee shall assign a Geospatial enablement Implementation Task Group to assist in the coordination, schedule, and technicalities associated with the GE effort. This group shall be comprised of, but not limited to, stakeholders from the following business areas: State system assets, base network maintenance, Cartography, GIS, GPS collection, Survey, Remote Sensing, and photogrammetry. It is possible that more than one Implementation Task Group will be established. This task group will determine what attributes will be presented to the enterprise, replete with core metadata (subject to approval by ITAC/EXIT).

16. KDOT shall investigate establishing a standard for temporality of data. The GIS Strategic Plan Update Steering Committee should drive this. This would allow KDOT to ensure decisions are based on a common time period of data. This would require metadata to accurately convey the temporality of the data.

17. A comprehensive inventory shall be conducted and published (to the enterprise) to determine which operational databases are geospatially enabled. Each Division, Bureau, Office, and District at KDOT shall publish their data holdings, including, but not limited to, metadata, data dictionary, Entity Relationship Diagrams, a documented data maintenance workflow, and the level of geospatial enablement (spatial location, LRS key and/or LRM). Each business area shall be responsible for geospatially enabling its existing data with guidance provided by the working group(s) defined above (see Rec. 14 and Rec. 15). Figure 8-1 shall be used as a guide.

18. GE efforts of existing data shall occur at the operational database or data system level. The GE effort will be carried out through a committee of data custodians. This term refers to the person or persons with direct responsibility of collecting and maintaining data assets for their respective business unit (Division, Bureau, Office, District.) The data custodians will perform the majority of the work of identifying data sets, describing their current state of GE, estimating the resources needed to GE the dataset, estimating the benefit, and making recommendations to the Steering Committee and to the GE Coordinator. This ensures that the "locus of control" for geospatial enablement occurs at the operational database level, which has the least impact on existing resources.

19. KDOT shall closely examine duplication of data with respect to geospatial enablement, maintenance, distribution, and presentation. This will ensure that most current data will be available for decision support thus taking any dependent applications as close as possible to real time data for

decision-making.

20. Business data that references the LRS throughout the enterprise shall adopt KDOT's standard LRS key implemented in August 1995 (revised March 2000), or have a means by which to create the LRS key or to join to the LRS key in a table in another database. (If the business data does not have the necessary attributes to build the LRS key but has an attribute to join it to another database that contains the key, this will be sufficient.) This will accelerate the geospatial enablement of legacy systems. In addition, all internal stakeholders continue to collect measurements with the LRS key. These measurements can then be transformed to a County-Route Logpoint Linear Referencing Method (LRM). The LRS key shall be captured as part of data collection requirements where possible.

21. Core metadata shall be defined for all geospatially enabled data sources. This would include all data that references a modeled transportation network (linear network) and any other spatial data not dependent on a network location (point data off of the network polygonal data). This includes acceptable levels of accuracy based on data type and functional attributes of the data. The collectors and maintainers of the operational databases should build the metadata. There should be a consistent and agreed upon metadata standard, preferably compliant with the Federal Geographic Data Committee standards, and endorsed by ITAC and EXIT. Information shared should not be disseminated or accepted for dissemination without core metadata.

22. There shall be a primary mechanism to disseminate key information as identified by the Stakeholder Survey: GIS Strategic Plan Update and from personal interviews conducted as part of information gathering for recent studies conducted at KDOT. This mechanism will act as a central point of discovery for KDOT data holdings and will contain required metadata as determined in Recommendation 20.

23. There shall be a central point of discovery for graphic (map) presentation of KDOT data holdings. This mechanism will contain required metadata as determined in Recommendation 20.

24. KDOT will establish and document a quality assurance/quality control workflow for cartographic products and data posted to KGATE. This will ensure a level of consistency among data and information used by stakeholders throughout the enterprise. Among the quality process to be performed would be:

    a. Verification of properly defined LRS Key;
    b. Validation of properly formatted location reference method; and
    c. Inclusion of proper metadata with the data.

25. KDOT shall leverage its investment in remotely-sensed image and other raster data by using this image data for geospatial enablement of data holdings where accuracy levels are acceptable, such as for digitizing road and rail networks, geospatial enablement of non-state system bridges or maintenance agreement areas (delineations), or airport locations, to mention a few.

26. KDOT shall investigate a strategy to incorporate a "standard build" for work stations with GIS applications and versions and associated database versions on a semi-annual basis. This will help to ensure that a consistent platform is used for business and geospatial applications. In addition, this will aid KDOT in ensuring there are no incompatibilities between various application software packages that would cause significant downtime while the problems are being identified and remediated.

27. KDOT shall continue to actively participate in data sharing activities relating to image data acquisition.

28. KDOT shall leverage its investment in Intelligent Transportation Systems against geospatial enablement, data sharing and consolidation, and data maintenance to support the ITS effort. It is recommended that data from KDOT's web-enabled applications, such as KanRoad, TRIS, and 511 be integrated with ITS information from KCScout, the Wichita ITS project, and statewide ITS efforts.

29. The GIS Plan update Steering Committee shall delegate a representative to aid the CPMS redesign. This individual can make data modeling recommendations that will support the GE effort.

30. KDOT shall design and develop a central decision support environment for power users who require ad hoc query and/or complex spatial query functionality. Analysis workflows would be defined to generate specific menus tailored to meet requirements associated with ad hoc query functionality for spatial analysis and for graphic presentation of select information. In addition, basic training could be provided for core commands that are common throughout the majority of the analysis business processes. Results would be posted to the enterprise for all viewers and queries would be shared among power users.

31. KDOT shall provide knowledge or skills transfer to the State of Kansas in Enterprise geospatially-referenced Image Management. KDOT should take a proactive role in advising or allowing the stakeholder access to the DOQQs, other imagery, and other raster data repository set up and administered through TerraShare. This is one of the objectives in the State of Kansas Strategic Information Plan.

32. KDOT shall provide knowledge or skills transfer to the State of Kansas for Geospatial web development and Internet (Web) mapping services. KDOT has successfully deployed enterprise web portals (KanRoad, TRIS, 511, KGATE) and can provide assistance to other agencies in the state.

33. KDOT shall continue to be proactive in promoting openness for geospatial data standards set forth by the Open Geospatial Consortium. KDOT should apply appropriate influence to the State GIS Policy Board to ensure that open geospatial standards are respected.

34. KDOT shall continue to comment on the creation and adoption of NSDI transportation standards and other NSDI initiatives which impact transportation.

35. KDOT shall consider an evaluation of how to empirically define and assign a value to measure intellectual capital variables in the context of geospatially enabling the enterprise.

36. KDOT shall leverage its investments and relationships with software companies that are members of the Open Geospatial Consortium in order to influence these companies' development directions in standards that benefit KDOT.

37. KDOT shall publish an inventory of its data holdings to a central point of discovery. Each Division, Bureau, Office, District, Area, or Subarea is responsible for its part in the publishing of this inventory. Requirements for publishing (e.g., metadata, data dictionary) shall be subject to the approval of ITAC/EXIT.

38. KDOT shall participate with DASC to publish an inventory of what data elements are available and sharable from federal, state, and local governments, other planning entities, and private sector.

39. KDOT shall support DASC's efforts with respect to the growth of its website, the Kansas Geospatial Community Commons.

40. KDOT shall participate with DASC and members of the Technical Advisory Committee to the GIS Policy Board and local jurisdictions to collect and maintain street centerline data.

41. KDOT shall participate in the USGS National Map initiative.

42. KDOT shall participate in the TIGER modernization initiative.

43. The Steering Committee or a group designated by Steering Committee shall examine ways to bridge the gap between GIS/Planning and survey in terms of geospatial enablement and accuracy issues as well as in reuse of survey data for discovery or planning purposes.

44. KDOT shall geospatially enable its non-state system local and rural road line network through the adoption of KDOT's LRS standard key. This provides a framework to distribute existing data along this linear network model.

45. At KDOT, very little geospatial enablement or location referencing occurs beyond the Kansas state highway system. The desire to geospatially enable asset information beyond the Kansas state highway system has not been articulated. The Steering Committee or a group designated by the Steering Committee shall examine ways to articulate the value of agency-wide and all-encompassing asset management and the critical role that geospatial enablement could play in asset management.

46. KDOT shall adopt cartographic standards for presentation and publication. KDOT shall publish guidelines for internal and external cartographic presentation and publication.

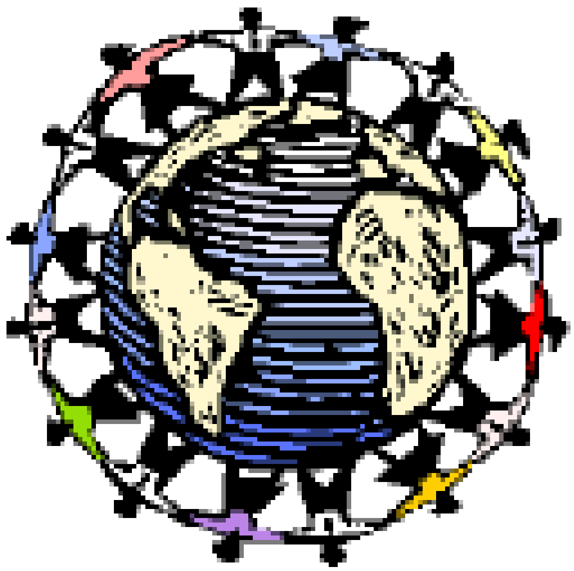
47. KDOT shall add GPS data collection devices to its capital inventory program to ensure that these devices are in the replacement cycle.

48. KDOT shall identify workflows and data flows and set schedule for moving from CADD-based cartography to GIS. This will allow for data-driven workflows and avoidance of duplication of effort from planning through design and construction:
    a. County inventory
    b. Functional classifications updates
    c. All (rural) roads network maintenance
    d. City streets mapping and maintenance
    e. Strip mapping
    f. State system maintenance (automating the determination of official alignment and official mileages).

Kansas Department of Transportation

Kansas Department of Transportation

GeoSpatial Enablement Strategy Appendix 1 – Peer Initiatives



February 18, 2005

Prepared for KDOT by

Intergraph Mapping and GeoSpatial Solutions

INTERGRAPH

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Appendix 1 – Detailed Review of Peer Initiatives

Appendix 1 contains a review of peer Transportation agencies GIS strategic initiatives. The following GIS Strategic plans were reviewed for this study:

1. Kansas DOT GIS Strategic Plan, March 2000
2. Nebraska Department of Roads GIS Strategic Plan Report, January 2001
3. Ohio Department of Transportation Strategic Plan Report, June 2002
4. Pennsylvania Department of Transportation GIS Strategic Plan Executive Summary, 2003
5. City of Charlotte GIS Strategic Plan, 2002
6. State of Kansas GIS Strategic plan (This plan's update is under development and consequently was not reviewed)

1.1 Kansas DOT GIS Strategic Plan, March 2000

This document was written as a follow up to the GIS Directions report done in 1995. A strategy was laid out to guide KDOT's GIS direction between the years 2001 through 2003. In this plan the following components were established:

1. GIS Mission
2. GIS Vision
3. GIS Strategic Goals
4. GIS Management Strategic Goals
5. Identification of Critical Issues
6. Identification of Priority GIS Projects

One of the key attributes of this document was creating a greater awareness of GIS throughout the KDOT enterprise. KDOT has been using some form of GIS system since the latter part of the 1980's but this initiative helped to define a concrete course for future development. Several critical factors were identified for KDOT to address. Among these concerns were organizational constraints, basemap structure, and technology platforms.

1.1.1 Priority GIS Applications

There were 29 proposed GIS applications identified in the plan. These applications were evaluated and rated on series of variables such as level of effort to develop, data that would have to be collected, potential usage of the application, level of importance and the overall Transportation Program Needs. These were prioritized from 1-29. The consultant that prepared the plan costed the applications. In addition, there was a list of 5 priority projects that were to be completed between the years 2001 – 2003. These are listed below:

1. Decision maps (Program Management)
2. High accident location maps (Local Projects/Transportation Planning)

3. Construction and detour web application (Construction and Maintenance / GIS)
4. Network Optimization Maps (Pavement Management—Materials and Research Center (MRC)
5. Recompiled GIS basemap (base network) at a scale of 1:12,000 (Cartography/GIS).

Of these projects the following has occurred:

1. Decision maps – This was in place on the MGE platform and the business processes were successfully moved to the GeoMedia environment. Planning produces these for Program Management.
2. High accident location maps – KDOT currently can plot accidents on the state system only. The ability to plot accidents on the non-state system is still not available; the skills set needs to be realized but the tool are available in-house.
3. Construction and detours web application – This is part of the KanRoad application.
4. Network Optimization Maps – The Materials and Research Center has developed these maps. There decision support structure will eventually be linked into KGATE.
5. Recompiled GIS basemap at a scale of 1:12,000 – The base network has been re-calibrated based on lat/long collected using GPS technology. There is still not a seamless integration with the network created and maintained in EXOR Highways. A GIS/LRS integration study was completed in February of 2003. This research recommended the base network be produced by EXOR Highways and published for the KDOT enterprise to use by dependent applications. This recommendation was made to help eliminate duplication of the same process. The network generated from EXOR Highways is the official network representation for KDOT. It is essential for enterprise wide accuracy and consistency that this recommendation from the prior study be implemented.

6. In addition, there was an accelerated schedule that included five additional applications. The following applications were ranked 6 through 10.

7. GIS-Maintenance Management System (MMS) integration (Construction and Maintenance).
8. Non-state system bridge inventory georeferencing and data integration (Local Projects)
9. GIS-Pavement Management Information System (PMIS) integration (Pavement Management)
10. GIS-traffic models integration (Statewide Planning)
11. Environmental use of GIS (Environmental Services)

Of these projects the following have been completed:

1. GIS-MMS integration – The linear data reference structure (mile markers/ reference posts) has been linked to the enterprise LRS Key so that decision support can be performed. This business process will be integrated into KGATE.
2. Non-state system bridge inventory georeferencing and data integration (Local Projects) – The data must be prepared for enterprise dissemination. The tools are currently resident in house to geospatially enable this data.
3. GIS-Pavement Management Information System integration – This system is in place and KGATE will potentially be used to provide pavement data to the KDOT enterprise.
4. GIS-traffic models integration (Statewide Planning) KGATE will help to serve this to the enterprise
5. Environmental use of GIS – Their data is provided by outside agencies from KDOT. They utilize the 2003 2-meter color imagery, which is critical to their analysis processes. Access to their analysis products will be provided to the enterprise via an interface to KGATE.

In addition, there are several other applications that did not have a high priority but that have been enabled:

1. Traffic and Field Operations view of traffic counts – These are currently broadcast to the enterprise via KGATE.
2. The Bureau of Local Projects' viewer for maintenance agreements – The data is available but not enabled for dissemination. The decision support structure for the enterprise would reside in KGATE.
3. A maintenance viewer application – This would allow Local projects to view the maintenance agreement areas (roadway segments) in a map. This is still in conceptual design and dialog is on going between planning and local projects.
4. Cellular coverage maps for the State of Kansas. Although this was not a GIS application, it was listed in the March 2000 plan. Several maps of the ITS infrastructure have been produced and distributed.
5. Base network support for the Kansas City Scout project, which is an Advanced Traffic Management service to the Kansas City metropolitan area. A separate state system road network was developed (by the contractor) for the KCScout project. Recent dialogue has been established among KCScout staff, KDOT GIS staff, Missouri DOT GIS staff, and others regarding the maintenance of this network and regarding the addition of non-state system arterials to the network to support Operation Greenlight.
6. The Project Optimization System should build on the efforts of the NOS and PMIS programs as part of a phased approach to a full PMIS. This will be integrated with the other PMIS underway within KGATE.
7. Wichita Traffic Operations Center base network. Work is in the preliminary phases. The KDOT GIS team assembled for KCScout project will most likely be involved with the TOC endeavor in Wichita
8. The Construction and Maintenance Unit's QA application should build on the MMS application developed earlier in the cycle.

9. The ability to access legacy data (Bureau of Construction and Maintenance) with a GIS interface received a high importance score, and this application would be especially useful to district offices.
10. The ability to get the strip maps into a GIS-ready form for wider and timely distribution – The strip map represents a design file that conveys the engineering centerline. This file is then drawn and provided to CANSYS for definition of their centerline. This has not completed.
11. The collection of accident data for local projects – This has not been accomplished. The data is not in place to map local road accidents.
12. A maintenance activity reporting database application – A crew report system is currently under development.
13. A new process for updating the county map series - This process is currently under development. There are several issues that are being investigated to allow quality cartographical output to be produced.
14. The development of non-state system road layer for the GIS base network – The digitizing of the rural non-state system roads is completed and has been graphically tied to the state system network. KDOT is currently evaluating which attributes to carry on the non-state system portion of the network. In addition, the decision to create a local LRS is under evaluation (Wichita Prototype for City non-state network).
15. Driveway/access permit application – This currently has been completed.
16. A telecommunications infrastructure database – This is in the planning and implementation stages.
17. A cellular coverage database – See above.
18. A snowplow routing application – No work has been performed in this area.
19. A sign inventory management system – Requirements definition for the sign inventory system is scheduled to begin in the fiscal year 2006.

1.1.2 Critical Issues

There were several other critical issues defined to guide KDOT's future GIS direction. Among these are organizational issues, concerns with the current basemap and the choice of technology platforms to produce the deliverables from the GIS plan. Performance measures were defined for these critical factors. These factors will be discussed in the following paragraphs.

Staffing Support and Skills Set

There were several objectives relevant to GIS staffing in the 2000 plan. KDOT's GIS department was able to fill 6 positions during the 2001-2002 fiscal years. In addition, management continued to maintain a contractor support mechanism that allowed programming support to be acquired outside of the internal KDOT skill set. Instead of an intern system the GIS department uses temporary employees. One of these employees has become a full-time member of the GIS staff. Each of these actions was defined as performance measure in the 2000 plan.

GIS Distribution

One key objective in the plan was to provide widespread hands-on access to GIS functionality, maps, and data throughout KDOT. Several performance measures were established to achieve this. KDOT met the initial measure of evaluating Intergraph's GeoMedia and GeoMedia WebMap version 3.0 in the year 2000 KDOT has continually evaluated and deployed the most recent versions of these products to the enterprise. Currently, version 5.2 of both has been deployed. In addition, KDOT had set a strategic action to disseminate geospatial data to the district offices. This has been achieved by providing web access via KGATE to various geospatial databases. A design plan was never drafted for desktop deployment of GIS to KDOT's enterprise. The KGATE intranet site in part has addressed this. It provides a more cost effective means to disseminate geospatial data.

KGATE provides enterprise wide access to critical business data in a read-only mode. It is structured to provide viewers within the enterprise the ability to execute pre-defined queries of various operational databases that are available for decision support. KGATE does not provide the ability to perform the ad-hoc queries that are required of power users within the enterprise. This type of query would be performed as the SQL or GIS level.

Several strategies and performance measures were established for enterprise-wide education on GIS and KDOT personnel skill refinement. Among the targeted actions to address these objectives were:

1. Conduct one non-technical GIS seminar for KDOT departmental managers by Fourth Quarter 2000.
2. Provide software training for new GIS personnel by Third Quarter 2000.
3. Three technical GIS training seminars at KDOT's Central Office and at one pilot district office by the end of 2000.
4. Participation at least one national/regional/state GIS conference a year.
5. Develop and publish a regular GIS status report/newsletter with a First Quarter 2000 startup date; develop Intranet site by Third Quarter 2000; prepare various GIS presentations by Fourth Quarter 2000. GIS updates could also be featured in the KDOT and BCS newsletters.
6. Prepare and distribute GIS capabilities and services brochures and similar materials by end of 2000.

These were accomplished by the following actions:

1. GeoMedia and GeoMedia Professional training – July 2000
2. MGE training – Jan., Feb. 2001
3. GeoMedia Web Map training – Oct 2001
4. Spatial indexing – June 2003
5. Online GIS (intro to GeoSpatial Theory) class – 10 week online class, Nov. 2003 – Feb 2004
6. ITS classes:
    - Software acquisition – Dec 2000
    - Introduction to Systems Engineering – Dec 2001
7. TerraShare:
    - Pilot (initial skills transfer—overview, metadata, system requirements) – Jan. through April 2003
    - Implementation plan – June through Oct. 2003
    - TerraShare administration (skills transfer - metadata) – Jan. through June 2004
    - Skills transfer for ingesting of line scan data – June through Sept. 2004

Significant investment has been made in properly equipping KDOT personnel for success.

1.1.3 Data Access and Sharing Improvements

The 2000 plan identified the need to improve GIS access to KDOT transportation databases for decision support, visualization, analysis, and data validation purposes. Among the established performance measures were:

1. A design plan for GIS database structures and accessing of the database by Q3, 2000.
2. GIS access to CANSYS II when the latter system is implemented.
3. GIS access to at least one additional data source annually beginning in 2000.
4. Design and deploy at least one GIS tool to promote data error detection and correction by Fourth Quarter 2000.

These objectives were accomplished by:

1. A GIS/LRS integration study dated February 2003 recommended that EXOR Highways publish the network and event tables for linear analysis and GIS exploitation.
2. Additional data sources are continually added to KGATE to extend the enterprise decision support environment.
3. KDOT implemented the GeoMedia Transportation environment. The dynamic segmentation command provides error-checking capability that allows validation of any event data used for linear analysis.

4. A design plan for GIS database structure is under investigation. The network table and major event tables were documented in February 2000.

1.1.4 GIS Management Structure

Another strategic objective of the 2000 plan was to strengthen the KDOT GIS management structure. This was to be done by the following actions:

1. Develop a GIS management plan and organizational structure by Q1 2000.
2. Establish a regular GIS Subcommittee meeting schedule by Q1 2000.
3. Develop a GIS tracking product mechanism/report by Q1 2000.

These performance requirements were met by the following actions:

1. The organizational structure of the GIS department was clearly established in 2001.
2. The GIS subcommittee was established in Q4 2000 and met regularly. It still has active membership but is currently inactive.
3. The GIS management plan has been structured within the KDOT IT Architecture plan.

1.1.5 Development of Realistic, Measurable Goals

Another objective of the 2000 plan was to determine and document realistic, measurable goals for GIS operations through 2002. Several of the measurable means to accomplish this were:

1. Receive guidance and direction from the GIS Subcommittee on GIS action plan.
2. Develop small, affordable "modules" for GIS projects.
3. Have GIS Subcommittee review/revise GIS action plan at least quarterly.

The GIS action plan is still under consideration and currently the GIS Subcommittee is inactive. However, with the geospatial plan update and in keeping with the Kansas IT Project Management Methodology, a plan update Steering Committee has been established with a project sponsor and executive endorsement. Status reports to KDOT ITAC and EXIT committees will also be given. In addition, a task force will be established to help mainstream GIS throughout the agency.

1.1.6 Basemap/Base Network Resolution

Another critical issue defined in the 2000 plan was to construct a revised "standard" GIS basemap layer at 1:12,000 scale for general KDOT application use. The basemap refers to the production network used for linear decision support. The basemap was subsequently renamed the base network. Among the actions and performance measures defined to reach this objective were:

1. An in-house evaluation to define characteristics of the standard network layer by Q2, 2000.
2. Analyze the implications of network conversion between Intergraph format and other formats (i.e. ArcView and TransCAD) by Q4, 2000.
3. Investigate sources for the addition of non-state system roads into the base network by Q1, 2001.
4. Complete base network by Q2, 2002.

These objectives were met by the following actions:

1. Approaches to Improve GIS Base Map Accuracy. Evaluated LRM's, workflows, spatial enablement, and GPS, Nov. 1999 - Feb 2000.
2. GPS Integration Workshop – Incorporation of lat/log into state system centerline model, March-May 2000.
3. Base Map Accuracy pilot. Recalibration of the state system centerline, June 2000 -May 2001, revised Sept 2001.
4. LRS/Base map maintenance workshop. June 2001 – August 2001.
5. Implications of network conversion to other formats addressed by standard export capabilities of GeoMedia Professional 4.0, May 2001.
6. NSDI Transportation Data Model Impacts Nov. 1999 - April 2000.
7. NSDI Framework Transportation Update Jun. 2001- Aug 2001.
8. Participation in the statewide acquisition of second generation Digital Orthophoto Quarter Quadrangles (DOQQs).
9. Purchase of image data management and distribution software (TerraShare).
10. Base network updated (with addition of non-state network using DOQQs for digitizing and data validation) in Q4, 2002.
11. The GIS/LRS study of February 2003 recommended the network be maintained by EXOR Highways and published to the enterprise for decision support analysis.

1.1.7 Data/LRS/Route System Translators

Another objective listed in the 2000 plan was to translate location references seamlessly between multiple LRM's and among multiple database formats. This was measurable by the following criteria:

1. Inventory and document the various LRM's in use at KDOT by Q1, 2000.

2. Document needed databases and formats that have a location reference component by Q3, 2000.
3. Evaluate object-oriented database software by Q4, 2000.
4. Complete LRS/LRM data translation project by Q2, 2001.

The following steps accomplished these actions:

1. The inventory of LRM's and databases was concluded in the GIS/LRS Integration study during Q1, 2003.
2. The implementation of Oracle Spatial as the object-oriented database occurred in Q3, 2003.
3. The LRS/LRM translation project was accomplished through two mechanisms. The first was to build four separate LRM's unto the base network segments to facilitate locating linear data. The second was the implementation of the EXOR Highways system that allows analysis in different LRM's, such as mile markers and lat/long values.

1.1.8 GPS Accommodation

Another objective stated in the 2000 plan was to accommodate the ability to translate between GPS-collected field data formats and GIS linear referencing and base network formats. Strategic actions to accomplish this were:

1. Identify potential GPS uses for field data collection at KDOT by Q1, 2000.
2. Test GPS/GIS data conversions through a pilot project by Q4, 2000.

These were both accomplished through the base network centerline project mentioned earlier. The centerline was collected via GPS devices and brought into a geospatial warehouse and used for decision support.

KDOT needs to publish a standard for GPS data collection and associated metadata required for data collection.

1.1.9 Historical and Temporal Data Management

Another objective of the 2000 plan was to support, manage, retrieve, and analyze historical/temporal GIS data. There were several measurable actions defined to achieve this. Among these are:

1. Identify and document historical/temporal data sources by Q4, 2000.
2. Complete historical/temporal management design plan by Q1, 2001.
3. Deploy GIS temporal analysis tools by Q3, 2001.

These objectives have been met in a limited capacity. The data sources with a temporal requirement were identified in the GIS/LRS Integration study of February 2003.

1.1.10 Software Choice

As part of the 2000 plan KDOT was to evaluate software for relevance in making improvements to existing GIS operations. To this end several actions were taken. These are listed below:

1. Evaluate GIS software to determine course of action for upgrading or changing software.
2. Evaluate object-oriented spatial database products by Q4, 2000.

KDOT concluded the Intergraph's GeoMedia suite of GIS tools would allow for the greatest future growth capacity. The software supports open industry standards set forth by the Open GIS Consortium (OGC) and also provides data server technology to read other GIS vendor's proprietary formats. In addition, KDOT concluded Oracle Spatial would be the spatial data storage that would best serve enterprise requirements.

1.1.11 Data Migration to RDBMS

In the 2000 plan there was an action to review and database conversion projects that are being converted to RDBMS format as part of other KDOT management systems initiatives. This would ensure consistency and usability with any GIS application that required the data. KDOT and the State of Kansas have adopted Oracle as the database standard. KDOT also implemented Oracle Spatial in 2003.

1.1.12 Development of GIS Pilot Projects

Another objective was to identify and deploy three GIS pilot projects annually, commencing in the year 2000. Candidate projects include a GIS interface to viewing the CTP, a project tracking map/visualization tool and a web accessible application for a district office. These were met by the following initiatives:

1. KanRoad is a combination of the Construction Detour Reporting System (CDRS) data entry and the Road Condition Reporting System (RCRS).
2. KGATE is an internal GIS-based web portal designed to connect numerous KDOT databases. The web site provides access to KDOT data throughout the agency that could not previously be shared efficiently. The site provides capabilities to dynamically show geospatially-enabled data like accidents, land use, video log, fiscal, and image data accessed through TerraShare.
3. The Truck Routing Information System (TRIS).

1.1.13 Internet Access to GIS Data

Another objective was to provide Internet to GIS data for by KDOT and external users. The KanRoad application is Internet based. Currently, KDOT is evaluating extra-net access to KGATE. The targeted audience would be KDOT business partners, such as Metropolitan Planning Organizations.

1.1.14 Intranet Access to GIS Data

Another objective was an access-controlled, secure Intranet GIS application for internal KDOT use. This was accomplished with the deployment of KGATE. The KGATE initiative has aligned KDOT with other peer DOT's for enterprise dissemination of decision support information. The KGATE web portal is comparable to GRIP at Oklahoma DOT, NECTAR at the Nebraska Department of Roads and the web portal at Hawaii DOT.

1.2 Nebraska DOR GIS Strategic Plan Report, January 2001

This report is similar in scope to KDOT. It was written by the same consulting firm that did KDOT's 2000 GIS Strategic Plan. It provided a comprehensive Needs Assessment for the usage and promotion of GIS within the Nebraska Department of Roads (NDOR). The plan addresses the following topics:

1. GIS Benefits
2. GIS Strategic Objectives
3. GIS within the NDOR Enterprise
    - GIS interaction with other business units
    - GIS Committee and responsibilities
4. Success Factors
5. Applications Recommendations

There were 29 application modules recommended to NDOR. The needs/applications were grouped under the three defined Strategic Objective for NDOR. The objective categories were: Organizational (1), Data Management and Access (2), and Methods, Standards, and Procedures (3). The applications recommended are listed below:

1. Establish GIS Steering Committee Structure (1)
2. Strengthen GIS Core Group Staff Structure (1)
3. Hire GIS Core Group staff (1)
4. Intranet-based video logging interface (2)
5. Prepare Design Document and Add Phase I elements to basemap (2)
6. Add Phase II elements to basemap (2)
7. Develop a Data Model and Conceptual Design for Data Repository (2)
8. Pilot of Data Repository (2)
9. Full implementation of Data Repository (2)
10. Design and implement web interface to the Data Repository (2)
11. Expand web interface to the Data Repository (2)
12. Design Document for Pavement Management System (PMS) - GIS Application. This includes program interface, data access/display, and analysis tools for testing and implementation in Central Office (2)

13. Deploy PMS-GIS interface in a single district office as a pilot (2)
14. Implement PMS-GIS interface in all district offices (2)
15. Link Bridge Analysis System (BAS) with MGE project (2)
16. Create BAS-GIS interface for Deployment in Central Office (2)
17. BAS-GIS interface pilot in a district office (2)
18. BAS-GIS interface to all district offices (2)
19. Design intranet Road Closure web application (2)
20. Design internet Road Closure web application (2)
21. Develop GIS Safety Analysis System for deployment in both Central Office and Districts (2)
22. Document road network maintenance workflows (3)
23. Document existing GIS processes and procedures (3)
24. Develop metadata for GIS data (3)
25. Define GIS server filenames and directory characteristics (3)
26. Develop metadata for data repository (3)
27. Design and document standards for GUI's utilized by GIS applications (3)
28. Design and document general operational standards for GIS (3)
29. Design and document standards for web-based development (3)

While some of the resultant applications were different this strategic plan was similar to the KDOT plan of 2000 in that it sought to:

1. Set obtainable goals and objectives relevant for GIS
2. Address the strengthening of the GIS organization
3. Attempt to educate the DOT culture of the value of GIS
4. Categorize and prioritize the most critical needs/application based on stakeholder interviews
5. Move applications to a web based environment where applicable.

1.3 Ohio DOT Strategic Plan Report, June 2002

Another peer DOT GIS strategic plan that was reviewed was from the state of Ohio. The same consulting firm that authored the Kansas and Nebraska plans did the Ohio DOT plan. This report was structured somewhat differently from the prior two. The strategic plan process was divided into 3 distinct task domains. They are as follows:

1. Review Existing Systems - Task 1
2. Identify User Needs – Task 2
3. Development of Strategic Plan – Task 3

1.3.1 Review of Existing Systems

The first task was to perform a comprehensive review of systems with the Division of Information Technology (DoIT), Technical Services, and district offices. An analysis of the following areas was performed:

1. **Databases –** The database management systems used.
2. **Applications –** The application development and implemented programs.
3. **Infrastructure –** The servers, networks, and other technology used for information to flow.
4. **Workstations –** The desktop, user, or client personal computers used for GIS activities.
5. **Districts –** The GIS-related information technologies in the ODOT districts.
6. **Technical Services –** The GIS unit is located within this environment and is responsible for GIS development, system support, and training.

1.3.2 Interview and Needs Summary

This document attempted to collect stakeholder requirements and devise a prioritized list of applications. Three different modes of data collection were used. The first was a workshop, the second was direct interviews, and the third was an on-line electronic survey.

Twenty-nine department and districts were interviewed. In the interviews a description of the stakeholder function, implemented technologies, current usage of GIS, GIS vision and perceived application needs were defined. In addition, a summation of the pertinent issues that were derived from the interviews was provided. Among the key factors uncovered were:

1. Management Issues:
    - ODOT's vision and mission in forefront of GIS actions.
    - GIS coordination through a GIS committee.
    - Custom GIS interface development should be included in IT projects.
    - Expanded GIS skill sets must be developed.
    - Asset management (GASB 34).
    - Sustained marketing of GIS to upper management and legislators.
2. Data Standards:
    - Data Description Catalog is necessary.
    - Linear referencing use is consistent within ODOT.
    - Linear features versus polygons; Intergraph versus ESRI.
    - Adoption of fundamental mapping standards.
3. Data Quality:
    - Data quality throughout ODOT is good.
    - A few problems with the currency of data.
    - Continued investment in Base Transportation Referencing System (BTRS) reliability.
4. Data Uses and Integration:
    - ODOT needs a better method to track construction projects from concept to completion.
    - ODOT is transitioning from data islands to data integration.
    - District offices can be receive great value from integration efforts.

  - There are multiple applications that can benefit from real-time data acquisition.
5. Education and Training
   - Continued enterprise wide GIS education.
   - ODOT should investigate multiple modes of GIS training.
   - Immediate project assignment is necessary to enforce and provide the return on investment for training.
   - Conceptual training on geography and GIS concepts are required to move outside of the realm of software.
   - ODOT needs analytical workflow training for business problems.
6. Funding will by tied to upper management "buy in."
7. Staffing:
   - Staffing levels must be appropriate to keep central and district offices synchronized.
   - District "buy" in for GIS is essential to equipping staff for success.
8. GIS Customer Services is generally well respected across the enterprise.
9. System Issues:
   - Oracle Spatial or investigate spatially enabling Sybase.
   - Hardware upgrades problems in District and County Offices.
   - Simpler GIS interface required for the enterprise instead of the "out of the box" GeoMedia.
   - ODOT's Corel Office Suite standard is generally inconvenient for sharing files with the outside world.

1.3.3 Development of Strategic Plan

The actual strategic plan is an encapsulation of the prior two documents. It was written for a 5-year time window. A list of recommended actions were identified for Ohio DOT. Among those are the following:

1. Evaluate Sybase and GIS integration
2. Evaluate GeoMedia Transportation
3. Implementation of database and GeoMedia changes
4. Constitute a permanent GIS Users Group
5. Establish a GIS Steering Committee
6. Develop a GIS career path
7. A formal GIS training/education plan
8. Standardize of coordinate systems
9. Continue updating data description catalog
10. Continue upgrading/standardizing GIS workstations
11. Evaluate upgrades to ODOT's network bandwidth capacities
12. Evaluation of improving cartographic viewing and production interfaces, tools, and output.

In addition, priority applications were identified and recommended for implementation within the 5-year period. Among the highest priority applications were:

1. ELLIS Integration
2. Pavement Management Application
3. Work Plan/OPI/Sufficiency Processes
4. Maintenance Quality System Deficiencies Viewer
5. Congestion Management System
6. Safety Analysis System
7. Enhanced Roadway Inventory System
8. Bridge Inspection
9. Traffic Data Viewing and Analysis Application
10. Basemap Enhancement
11. Bridge Information System
12. Environmental Analysis System
13. GIS Intranet Viewer
14. Public Access Information Viewer
15. Videolog Integration

In addition, there were 12 other applications identified within the 5-year strategic plan window. These were given a lower priority for implementation.

1.4 Pennsylvania DOT

The next peer DOT to be evaluated is Pennsylvania. Penn DOT provided an update to a previous GIS Strategic plan that had been done. The time window the update covers is 1998 – 2003. This plan update provide costing and development time in the following areas:

1. GIS Management:
   - Procedural development
   - Knowledge transfer
   - Cartographic integration
   - Future development tools
2. GIS Distribution:
   - Data sharing
   - Desktop GIS
   - Development tools
3. GIS Applications:
   - Application management
   - Video/Image transfer:
     - Link GIS and video logging
     - Investigate various raster storage solutions
     - GIS and real-time streaming video
     - Acquire digital ortho/satellite imagery

- Data management tools:
  - Analyze multimodal support
  - Study real-time analysis applications
  - Intelligent intersection tools
  - Integration of highway design functions
  - Incorporation of historical data for GIS analysis
  - Incorporate landmark references in GIS
  - Integration of document management with GIS
  - GIS/HPMS data manipulation tools
  - Integration of auto traffic system
  - Integrate ITS data with GIS
- New technology directions:
  - Integrate GPS and GIS
  - Investigation of environmental GIS applications
  - 3D visualization tools
  - GIS and straight line diagram integration
- Future application development

4. Systems:
   - Current system management
   - Knowledge transfer:
     - System administration training
   - Network communications:
     - Incorporation of Lotus notes
     - Implement NT domain access/CADD
     - Remote monitoring/maintenance software
     - Any additional hardware purchases
   - Database management:
     - Database modeling
     - Data maintenance
     - Relational graphics database
     - Data refresh/synchronization tools
     - Select database posting tools
   - System administration:
     - Improve network
     - GIS debugging software
     - Centralize data files
     - Coordination of web server maintenance and support
     - Standardization workstation configurations/software
   - Future system enhancement and development

1.4.1 Future Considerations

An analysis of future trends that would have a potential impact on Penn DOT was also conducted. With consideration to the timeframe this report was written the following is a list of future trends that would impact Penn DOT's GIS strategic objectives:

1. Web-based technology to disseminate GIS data internally and to the general public.
2. Technology to incorporate of detailed photo and satellite images with GIS maps.
3. Advances in Client-Server Technology.
4. Advances in Data Storage Technology.
5. Availability of Large Quantities of Data.
6. Use of GPS.

1.5 City of Charlotte, NC, April 2002

The City of Charlotte was included in this study for several reasons. First, the entire format of the GIS Strategic Plan was completely different from the other peers. Second, the same vendor that did KDOT, OHIO DOT, NDOR and Penn DOT's Strategic Plans did not do City of Charlotte's plan. Third, it had a component for Charlotte DOT that dealt with similar issues on a micro scale that a state DOT addresses on a macro level. Fourth, it was attempting to implement and enterprise GIS architecture similar to a state DOT. Finally, it illustrates there is more to geospatial solutions than the transportation layer, and that geospatial solutions for transportation always rely on non-transportation data as part of the solution.

Below are some of the key components of the enterprise GIS model devised for Charlotte:

1. Executive level involvement and support for GIS technology.
   - Focus Area Strategy Plans
   - KBU Business Plans
2. Direct connection between GIS and the City's strategic objectives.
3. GIS coordination between City departments and other agencies.
4. Effective improvements and cost avoidance by shared applications, hardware, software, personnel resources, and data.
5. Use of GIS technology to improve business processes that span across the organizations.
6. Communication and education among users.

References to Enterprise GIS therefore speak to all City departments, encompassing their interests collectively versus individually. Some key logistical goals that were established for the enterprise strategic plan are as follows:

1. Data
   - Implement spatial data warehouse for enterprise GIS data
   - Data standards for spatial data warehouse
   - Policy for data security, distribution, and other legal issues
   - Establish data stewards/custodians
   - Develop Address Plan

- o Establish regional data partnerships
- o Establish Land Use QA/QC data
- o Develop and implement digital submittal standards with County

2. Applications
   - o Apply "Use Case" or modular development for enterprise applications
   - o Develop a rapid application development methodology
   - o Presents alternatives for prioritizing enterprise applications

3. Organization
   - o Framework for City/County GIS working relationship
   - o Establishes GIS Enterprise Team responsible for:
     - Collaborating to achieve the best interest of the City
     - Overseeing implementation of the GIS Strategic Plan recommendations
     - Prioritizing enterprise applications
     - Developing data policies and procedures
     - Providing GIS budget recommendations
     - Oversee activities of other GIS committees
     - Communicating with Key Businesses
   - o Establishes GIS Infrastructure Committee
   - o Establishes GIS Data Framework Committee responsible for the City's GIS data, including data architecture, addressing, data modeling, metadata, symbology standards, and data maintenance agreements
   - o Recommends GIS representative on TMT
   - o Establishes Office of Enterprise GIS (4 person team)
   - o Participates on County Integrated Land Records project

4. Training and Support
   - o Develop & implement GIS Training Plan
   - o Formalize partnership with TLC
   - o Refine user support system, including Help Desk
   - o Develop intranet information web portal

A list of primary applications for the City of Charlotte was identified. These applications are identified below:

1. Asset inventory – the basis for all other applications.
2. Integrated project management and information access – track improvements, changes, expansions, etc.
3. Incident and complaint analysis.
4. Forecasting, analysis, and planning.
5. Citizen information access (web based analysis).
6. Intranet application to assist staff in responding to citizen calls for information.

1.6 *Peer Comparison*

This section will provide a comparison of the peer DOT's. Each of the peer DOT's plan has unique characteristics in and of itself but there are common characteristics among all of them. Variables to be paralleled will be staffing logistics, GIS steering committee and internal promotion strategies, application development, whether the standard GIS software was evaluated, and if an evaluation of the enterprise spatial database occurred. Table 1 compares some of the chief logistical components of the peer review.

Table 1 Plan Logistical Comparisons

Components	**KDOT**	**ODOT**	**NDOR**	**PeDOT**	**Charlotte**
Steering Committee	X	X	X		X
Staff Evaluation					
1. Management	X		X	X	X
2. Additional Staff	X	X	X		
3. Career Path Definition		X	X		
4. Decentralized Staff	X	X	X		
GIS Training Program	X	X	X	X	X
Internal GIS Marketing	X	X	X		
Hardware Analysis					
1. Central Office		X	X	X	X
2. Districts		X	X		
Database Evaluation					
1. Enterprise	X	X	X	X	X
2. Spatial	X	X	X	X	X
3. Migration	X	X			
Data Modeling			X	X	X
Software Evaluation	X	X	X		
Data Distribution Evaluation					
1. Desktop	X		X	X	X
2. Web	X	X	X	X	X
Data/System Integration	X	X		X	X
Data Quality/Process Analysis	X	X	X	X	X

Table 2 presents a summary of comparable GIS applications identified from the DOT peer analysis.

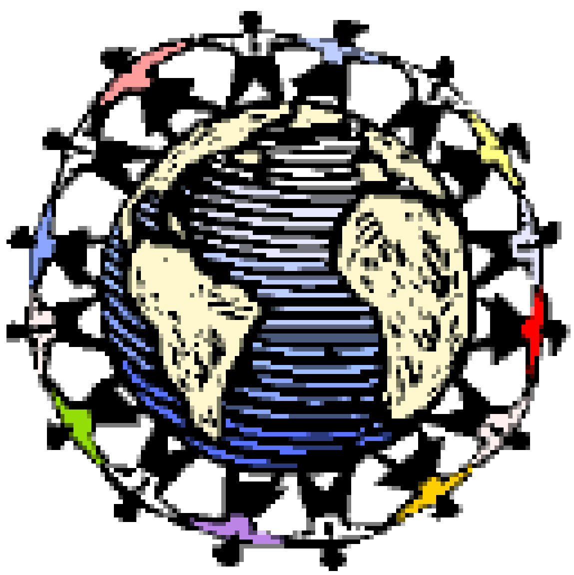
Table 2 Common GIS Applications Identified

Applications	KDOT	ODOT	NDOR	PennDOT	Charlotte
Safety/Accident analysis	X	X	X		X
Asset Management Inventory					X
Construction and Detour System (road closings)	X		X		
GIS Pavement Management interface	X	X	X		
Basemap-Base network improvement	X	X	X		X
GIS Maintenance Management System interface	X	X			X
GIS Bridge Management System	X		X		
Environmental GIS	X	X			
Pavement Optimization System	X				
GIS Traffic Model integration (Travel Demand)	X				X
Traffic Data Viewing and Analysis System	X	X		X	
Videolog System		X	X	X	
Web based decision support interface			X	X	X
Work Plan/Sufficiency Process		X			
Congestion Management System - ITS		X			
Roadway Inventory System		X			
GIS-HPMS Interface				X	
Integration of ITS data with GIS				X	
Straight Line Diagrams				X	
Project Management					X
Web based Citizen Information Access System					X

There were several applications not listed on this matrix. The reason is they were specific to a single DOT and did not represent common characteristics across the peer group. It is also worth noting that Penn DOT's plan was an update to a strategic plan done in the mid 1990's. This signifies a different paradigm of how the update to their GIS plan was done. Penn DOT and Ohio DOT are a little more advanced in the deployment of GIS. In addition, both of these DOT's have had a fairly well defined integration process between the LRS and the GIS in place for sometime.

Kansas Department of Transportation

GeoSpatial Enablement Strategy Appendix 2 – KDOT and State of Kansas Initiatives



February 18, 2005

Prepared for KDOT by

Intergraph Mapping and GeoSpatial Solutions

INTERGRAPH

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Appendix 2 – Detailed Review of KDOT and State of Kansas Initiatives

This section will detail several categories of initiatives that will impact the GE of KDOT's enterprise. Among the initiatives reviewed were efforts by KDOT and the State of Kansas.

1.1 KDOT Initiatives

This section will highlight other KDOT initiatives and initiatives undertaken by the State of Kansas that will impact GE effort.

Among these factors are:

1. KDOT Strategic Information Technology Plan, 2003
2. KDOT Strategic Management Plan, 2003
3. Kansas Long Range Transportation Plan, December 2002

1.1.1 KDOT Strategic Information Technology Plan (SITP), 2003

This section will provide a synopsis of the KDOT SITP. Focus areas will be those that directly impact the GE effort.

KDOT's IT department provides 5 major products to the enterprise. These are listed below:

1. **Infrastructure –** telecommunications and network connectivity to all KDOT employees.
2. **Data –** collection, storage and retrieval of critical KDOT data.
3. **Applications –** the systems and programs that are used by KDOT.
4. **Support –** support for the hardware, network and software used by KDOT personnel, KDOT's business partners and traveling public.
5. **Expertise –** staff to support the specification, development and maintenance of KDOT applications.

There are several major strategies in the SITP. The following are some of the strategies that have been identified to meet the IT objectives:

1. Move closer to real time.
2. Move workflow out to all end users.
3. Design in ability to change components.
4. Phase out obsolete or inefficient technologies.
5. Consolidate databases to enterprise view - KDOT estimates at least 30-50% of this data across the enterprise is redundant. Making copies of data that exists in one of the operational databases creates too many user applications.

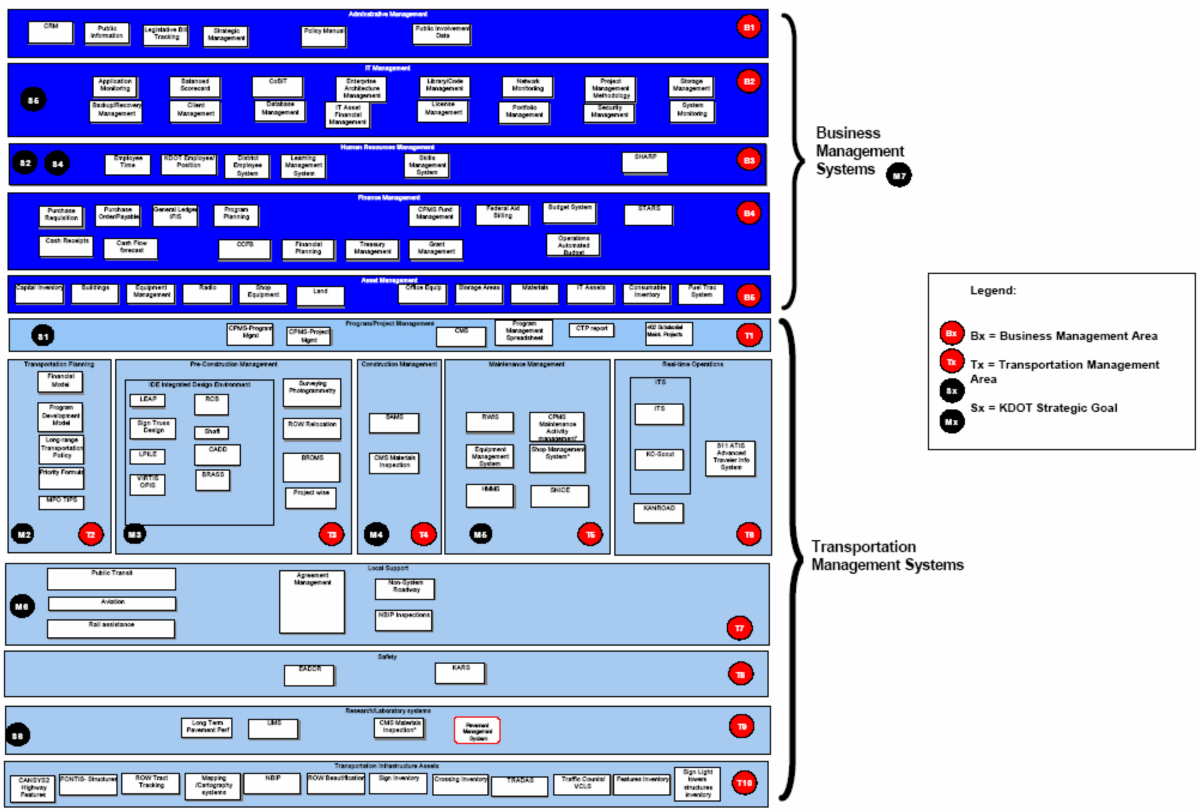
6. Support self-service access to information.
7. Fully utilize infrastructure capabilities.

These strategies become foundational in evaluating the current and future technology initiatives KDOT undertakes.

KDOT has 110 applications that were identified by IT as being 'most critical'. These represent the most critical applications identified by IT. Several of these applications contain multiple programs and others are simply a spreadsheet. These are the applications that are primarily used in the deployment of the Comprehensive Transportation Program (CTP).

As mentioned earlier, KDOT's IT department went through an exhaustive inventory of the most pertinent business applications. KDOT's IT department has constructed a "value chain" to classify the various systems and data structures. This projects these elements onto the major business processes undertaken by KDOT. Figure 1 conveys the KDOT Value Chain with application assignment.

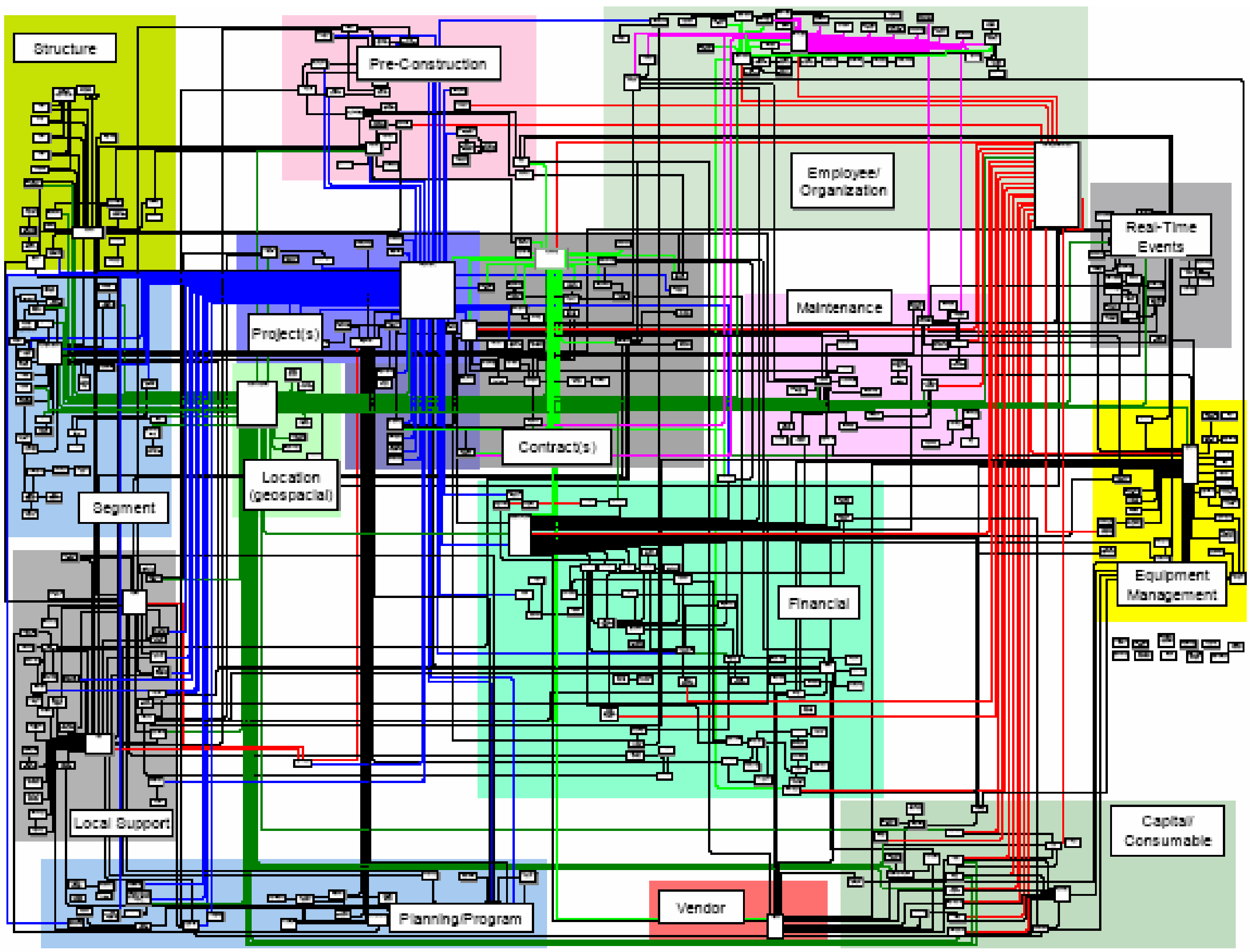
Figure 1 The KDOT Value Chain with Applications



This graphic helps to strategically locate where the most critical applications lie within the major categorical business layers within the KDOT enterprise. In addition, the value chain allows each application to be distinguished as either a business management or transportation system process.

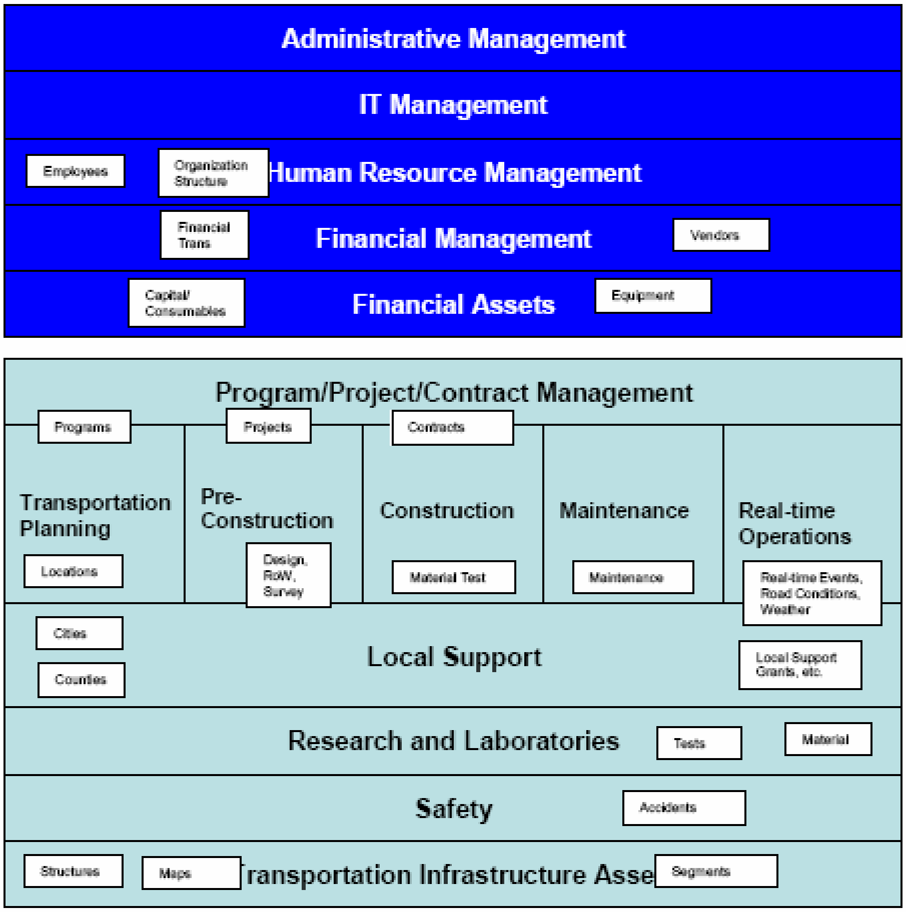
While KDOT maintains an extremely large amount of data there are a few major classifications critical to the central business processes. Figure 2 illustrates KDOT's Enterprise data architecture.

Figure 2 KDOT's Enterprise Data Architecture



Over the course of time KDOT should to consolidate a good percentage of these applications. KDOT's IT department have overlain these major data categories onto the KDOT Value Chain (Figure 3). This illustrates the correlation between data classes and business process.

Figure 3 Data Classes to Value Chain



These are critical factors that can help identify the opportunities to geospatially enable KDOT's enterprise.

1.1.2 KDOT Strategic Management Plan, 2003

The KDOT Strategic Management Plan (SMP) was also reviewed to have a fundamental understanding of how high-level management policies can impact the geospatial enablement effort. This document consists of KDOT's Strategic Plan and Management Plan.

The SMP is designed to function as a directional tool for KDOT. It attempts to answer the following relevant questions pertaining to KDOT:

1. Where is KDOT now?
2. Where does KDOT want to be?
3. When does it want to be there?
4. How does KDOT get to where it wants to be?

5. How does KDOT tell if it's getting where it wants to be?

Overviews of both the Strategic and Management Plan will be provided in the following subsections.

1.1.2.1 Strategic Plan

The Strategic Plan establishes the direction KDOT is moving toward. It consists of the following goals:

1. **Completion of the Comprehensive Transportation Program (CTP) on time and within budget.** Objectives to include:
   - CTP Implementation - Develop the programs, schedules, and performance measures required for achieving success of the CTP. Strategies to include:
     1. Define Success Indicators.
     2. Establish transportation Revolving Fund.
     3. Local Railroad Crossing for non-state system.
     4. Enhance public transit.
     5. Establish aviation program.
   - CTP Completion – Identify program deficiencies and progress variance that would prohibit completion of CTP. Strategies to include:
     1. Success indicator review.
     2. Annual review of SMP.
     3. Review of project noise abatement procedures.
   - CTP Revenues – Properly plan and manage financial resources needed to complete CTP. Strategies to include:
     1. Issue 20-year bonds for CTP.
     2. Seek legislation to maximize federal aid.
     3. Ensure adequate funding from State General Fund.
     4. Maximize revenue from future federal transportation programs.

2. **KDOT will continually improve as an organization.** Objectives to include:
   - Managers Core Values – Identify improvement areas from 2000 internal survey. Strategies to include:
     1. Managers must implement core value initiatives.
     2. Management must evaluate core values.
     3. Identify and implement department-wide core value initiatives.
   - Manager Leadership Priorities – Improvement of KDOT's organization culture. Strategies to include:
     1. Implement leadership initiatives that improve overall leadership.
     2. Evaluate leadership initiatives to communicate successful efforts department wide.
     3. Implement specific successful leadership initiatives department wide.
   - Improve organizational effectiveness. Strategies to include:
     1. Review of SMP with department managers.
     2. Publish SMP throughout the department.

3. Periodic review of Strategic and Management goals, objectives and strategies to ensure compliance.
4. Review key issues to determine new actions.

3. **KDOT will build relationships with all of its nongovernmental customers and partners.** Objectives to include:
   - o Determine external customer expectations. Strategies to include:
     1. Management will strive to implement external customer initiatives.
     2. Communicate external customer initiatives department wide.
     3. Successful external customer initiatives will be implemented department wide.
   - o Cultivate public trust through external communications. Strategy includes:
     1. Public involvement liaison to each district
   - o Develop business relationships with KDOT's private sector partners. Strategies to include:
     1. Initiatives that foster more coordinated relationships with business partners.
   - o Develop and promote initiatives to reduce fatalities and injuries on Kansas's roadways. Strategy includes:
     1. Legislative measures to support safety initiatives.

4. **KDOT will maximize the effectiveness of its workforce.** Objectives to include:
   - o Develop strategy to replace experienced personnel losses. This includes:
     1. Establishment of career ladder.
   - o Stimulate efforts to hire qualified personnel. Strategies include:
     1. Enhance recruiting at campuses, tech schools and job fairs.
     2. Improve minority and female hiring and retention.
   - o Privatization where necessary to effectively utilize state resources. To include:
     1. Development of SOP's for privatizing decisions.
   - o Improve workforce by Headquarters consolidation into one location. To include:
     1. Preparation of new facility.
     2. Facility relocation by December 2003.
   - o Disaster recovery plan with department specific elements.

5. **KDOT will optimize technology to improve overall department operations.** Objectives to include:
   - o Strengthen the information infrastructure. This includes:
     1. Update all telecommunications media.
     2. Enhance statewide 800 Megahertz radio system.
     3. IT contingency plans to minimize service disruptions.
   - o Develop specific infrastructure solutions. To include:

1. Investigate new financial management process – state accounting system.
2. Standard record and workflow management system.
3. Develop information warehousing system.
4. Update GIS Strategic Plan.
5. Roll out integrated design environment to the districts.

- Integrate applications. To include:
  1. Enhancement of CPMS.
  2. Enhancement of CANSYS.
  3. Enhancement of PMS.
  4. Conversion of CMS to a new platform.
  5. Develop and enhance TRIS.
  6. Develop an access permit database.
  7. Develop LIMS.
  8. Develop and enhance a Right of Way tracking system.
  9. Design a strategy for internet/intranet usage.
  10. Enhance TSIMS.
- Continue to research and develop new technologies to strengthen KDOT.

6. **KDOT will enhance its relationship with all of its intergovernmental customers and partners.** Objectives to include:
   - Influence national transportation issues via participation in outside associations.

1.1.2.2 Management Plan

The Management Plan provides the rationale for day-to-day operations by management at KDOT. It furnishes performance measures to gauge KDOT's progress to reaching management objectives. The following section provides an overview of the objectives.

1. **To provide the direction, planning, coordination, communication, and administrative support that fosters an integrated, multimodal transportation system meeting the needs of Kansas.** To be done through:
   - To provide strategic direction through the Comparison Report/CTP. Strategies include:
     1. The Strategic management planning elements are completed.
     2. A sound Agency Budget for financial framework for expenditure decisions.
     3. Support policies to guide KDOT toward its mission.
   - Provide a vital information link between KDOT and its customers. To be done through:
     1. Two-way communication with employees.
     2. Effective dissemination of information to the public and media.
     3. Accurate and effective communication with government partners.

4. Clear communication with business partners.

- Ensure projects are managed to maximize KDOT's resources. Achieved through:
  1. Project control and system monitoring.
  2. Ensure compliance with federal guidelines.
- Accurately analyze information needed to determine Kansas's long-range transportation needs. To be done through:
  1. Long range plan based on public needs, transportation data and future projections.
  2. Gather and maintain accurate data on traffic and roadway conditions.
  3. Report system need findings via plans, reports and maps.
  4. Coordinate development of technologies that enhance safety management.
  5. Utilize GIS technology to achieve KDOT's mission.
- Use the most accurate highway data to identify priority construction and maintenance needs.
- Attract, train and develop a quality workforce. Done through:
  1. Effective human resource plan.
  2. Solid employee relations.
  3. Strengthened recruiting process.
  4. Facilitate employee development to maximize performance.
  5. Evaluate compensation classifications.
  6. Ensure positions properly classified.
- Provide financial services support to KDOT's objectives. This includes:
  1. A Strategic Financial Plan.
  2. An Accounting Transaction process.
  3. Produce GAAP basis financial statements to internal and external participants.
  4. An effective procurement process that produces goods and services at the lowest possible cost.
  5. Manage financial instruments for maximum return without unreasonable risk.
  6. Effective deployment of the Transportation Revolving Fund to provide needed assistance to local governments.
- Provide optimal information technology to effectively help KDOT achieve objectives. Done through:
  1. Strategic IT Plan.
  2. Strengthened Information Infrastructure.
  3. Integration of KDOT information systems.
  4. Standards for application development.
- Strengthen support services needed to achieve objectives of the CTP. To include:
  1. Quality production of presentations and reports.
  2. High quality photographs for reporting.
  3. Streamline and effective material duplication.
  4. Adequate facilities to material generation.

- Effective resource management to support construction and maintenance. Achieved through:
  1. Proper inventory levels of people and equipment.
  2. A Capital Improvement Program that provides the needed facilities.
  3. Ensure new technologies are utilized in the construction and maintenance processes.
- Ensure transportation plans meet the highest modal needs. To be accomplished through:
  1. Incorporation of public input into Public Transportation strategies.
  2. Distribute available federal funding and provide technical assistance for safety projects.
  3. Provide urban planning assistance and funds as needed.
  4. Improve reliability and safety of public-use airports.
  5. Incorporate rail into state modal plans.

2. **To provide assistance for safe, efficient and reliable local multimodal transportation system.** This will be supported by the following objectives:
   - Assist local entities in developing road construction projects that maximize state and federal aid. To include:
     1. Development of a 5-year plan for cities and counties to leverage available funding.
     2. Deploy a strategy to aid local engineers in maximizing financial aid.
   - KDOT will work with local entities to help them develop a comprehensive transportation system. This includes:
     1. Define programs to help local government provide adequate public transportation to all Kansas citizens.
     2. Utilize National Highway Traffic Safety Administration funds to ensure safety of local road systems.
     3. Assist local government with city connecting links, geometric improvements and economic development projects.
     4. Provide support for airport safety inspections and adequate runways.
     5. State Rail Plan that utilizes federal and state loans for new projects and rehabilitation efforts.

3. **Preserve the State Highway System as built or in an improved condition.** To be accomplished through the following objectives:
   - Identify areas to perform proper maintenance of the State System. To include:
     1. Road Maintenance Plan to address comprehensive and routine maintenance needs of the system.
     2. Bridge Management Plan that includes inspection of bridges on the State System to identify maintenance needs.
     3. Traffic Management Plan to ensure proper traffic control on the State System.

4. **Develop and construct projects that provide a quality state highway network to meet the needs of the public.** This will be done by the following objectives:
   - o Develop specific scope, schedule and plan for construction and rehabilitation projects. This includes:
     1. Collection of appropriate background data to form project plans.
     2. Preparation of proper plans for projects.
   - o Ensure projects are ready for construction letting. To be done by:
     1. Effective Right-Of-Way clearance strategy.
     2. Ensure utility related concerns are settled prior to construction.
   - o Award cost effective bids for highway projects. To include:
     1. Ensure contractors have clear contract specifications.
     2. Conduct constructability reviews to ensure accurate proposals.
     3. Evaluation of project costs through comparison of bids to KDOT's estimates.
   - o An effective Construction Project Administration Plan to ensure projects are completed on time and according to specifications. This includes:
     1. Address change orders so that changes are cost effective.
     2. Construction cycle inspections of projects to ensure compliance with KDOT standards.
     3. Final approval processes to ensure projects are completed according to contract.

The Strategic Management Plan is the wrapper around all of the other initiatives undertaken by KDOT Stakeholders. Several of the objectives have a direct impact on lower level IT and Planning initiatives. These over-riding objectives must frame the GE effort. The GE effort will add value to all of the state transportation system's life cycle.

1.1.3 Kansas Long Range Transportation Plan (LRTP), December 2002

The LRTP is a policy document that functions as a basis for the State of Kansas transportation planning process. It provides direction for the future. The Plan encompasses a 20-year planning horizon. It encompasses all modes of transportation in Kansas. The LRTP was written with the cooperation of local, state, and federal agencies and the Indian Nations of Kansas. The LRTP reviews trends in demographics, travel, and transportation funding to provide a vision for transportation in Kansas. In addition to the road network the plan attempts to look at all modes of transportation within the state of Kansas that are required to deliver a complete transportation system. The needs of rail, airport services and public transit are addressed in the plan.

The major categorical areas the plan addresses are as follows:

1. KDOT's Decision Making Process
2. Trends Affecting Transportation
3. Road, Streets and Highways—Conditions and Needs. To include:

   - State Highway
   - Kansas Turnpike
   - Local Road and Bridges
4. Other Transportation Modes. Including:
   - Aviation
   - Bicycle and Pedestrian
   - Rail
   - Public
   - Water
   - Intermodal
5. Integration of Transportation Modes and Technologies. To include:
   - KDOT's Role and Partners
   - Transportation and Land Use Correlation
   - Making Things Work Together
6. Other Factors for Consideration. These includes:
   - Safety
   - Research
   - Security and Emergency Response
   - Social Impacts
   - Air Quality Standards
   - Environmental Issues
   - Advances in Alternative Fuels
   - Transportation and Tourism

These are the overall areas the plan addresses in significant detail. Almost every element of this plan deals with data that is spatially enabled in one form or another. The largest technology content in the plan deals with the integration of ITS into KDOT's mainstream business practices.

1.2 State of Kansas Initiatives

The state of Kansas has several information management technology plans in place that will impact the GE effort undertaken at KDOT. Among those are:

1. State of Kansas Strategic Information Management Plan, January 2002
2. State Geographic Information and Related Technology (GI/GIT) Profile
3. Strategic Management Plan for Geographic Information Systems Technology 1997, Executive Summary

1.2.1 Kansas Strategic Information Management Plan (SIMP), January 2002

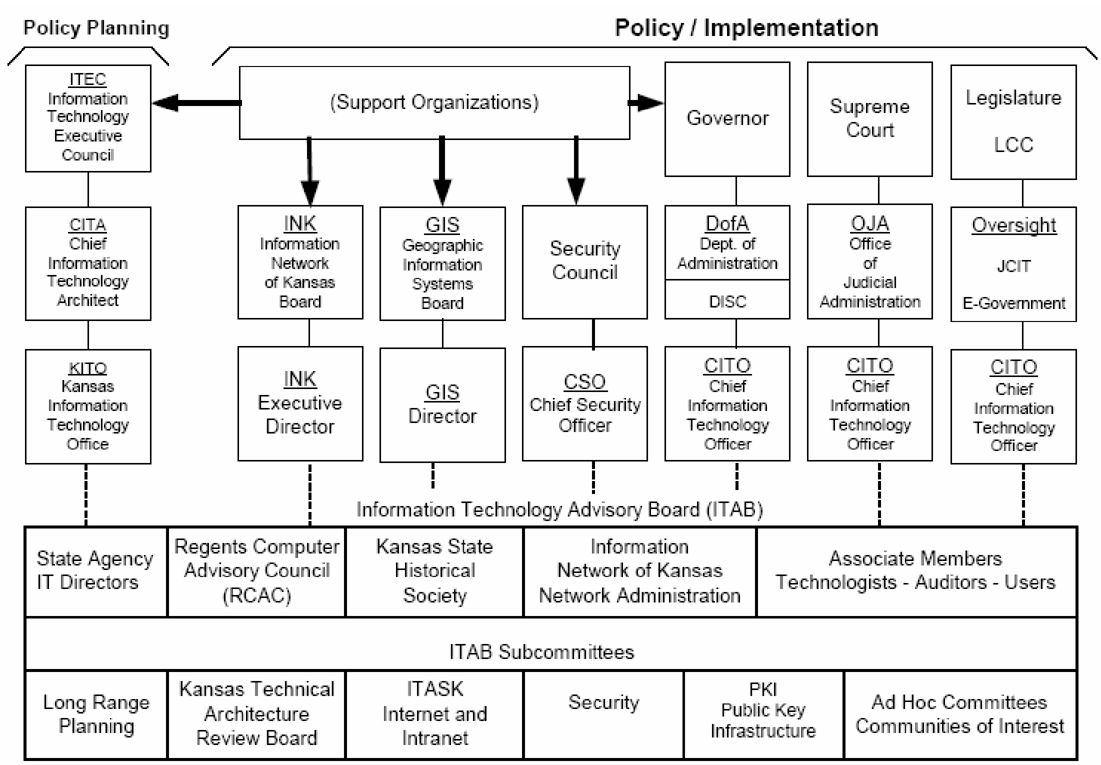
The SIMP was reviewed because of KDOT's participation in statewide IT initiatives. The state of Kansas has an Information Technology Advisory Board (ITAB) that all Kansas Agency IT Directors participate on. This board is an integral piece of the

Kansas Consolidated IT Governance Model. Policy planning under this model is overseen by:

1. Information Technology Council (ITEC)
2. Chief Information Technology Architect (CITA)
3. Kansas Information Technology Office (KITO)

The overall structure of the Governance Model is illustrated in Figure 4. This figure is courtesy of the Kansas SIMP.

Figure 4 Kansas IT Governance Model



The overriding goals with particular objectives of the SIMP that influence KDOT's GE initiative are as follows:

1. **(Customer Perspective): Provide broad access to public information and services.**
   - **Initiative #1-A-2**: Develop an integrated **one-stop Trucking portal** for the state of Kansas incorporating services from the Kansas Corporation Commission, the Kansas Department of Revenue, and the Kansas Department of Transportation.
   - **Initiative #1-A-3**: Publish standards for Website development for integration into the Kansas Statewide Technical Architecture.

- **Initiative #1-C-1:** Survey existing locator services and search engines to identify "best of breed" for implementation of a Kansas Government Information Locator Service (KGILS).
- **Initiative #1-C-2:** Define metadata standards for a KGILS.

KDOT currently has a Truck Routing Information System (TRIS) for the routing of oversize/overweight vehicles. This initiative should be leveraged by the State of Kansas. KDOT has already performed the design and testing of this type of system and this would give KDOT the opportunity to provide technical leadership to the state of Kansas. KDOT should play a key role in the formulation of standards for website development. KDOT has invested a great deal of funding and developed domain expertise the state of Kansas could benefit from. The existing locator service correlates to the ability to identify good information sources. KDOT has expertise in this realm via the design of the KGATE. In addition, KDOT should play a central role in the development of metadata standards based on the research and acceptance of FGDC metadata.

2. **(Financial Perspective): Use public and private resources effectively and efficiently.**
   - **Initiative #2-C-6**: Implement Geographic Information System (GIS) interface capability for state agencies' applications, to allow ortho-imagery displays of geo-referenced application data.

KDOT's should take an active role in this initiative. KDOT has already established a framework the state of Kansas can leverage in meeting this objective. KDOT should take advantage of the opportunity to drive policy with regards to GIS applications within the state of Kansas.

3. **(Internal Business Perspective): Manage government IT resources effectively and efficiently.**
   - **Initiative #3-B-3**: Designate lead agencies for multi-agency system development projects; lead agencies shall retain responsibility and authority for project management and cross-agency coordination.
   - **Initiative #3-B-4**: Designate specific agencies as Centers of Expertise for particular technologies with widespread use in state government, or labeled as an "emerging technology".

This is a perfect initiative to market and leverage all the TerraShare work that has been done at KDOT to the State as well as its web design knowledge (KGATE, KanRoad, TRIS).

4. **(Learning and Growth Perspective): Promote economic development and citizen awareness in Kansas, and IT proficiency within Kansas state government.**

- **Initiative #4-B-1**: Provide network connectivity to Kansas schools, libraries and hospitals through the KAN-ED network.
- **Initiative #4-B-2**: Expand the KAN-REN network among institutions of post-secondary education to provide Internet2 access by KAN-ED network nodes.

KDOT will need to tie into this initiative to get a larger presence in the education system. This will allow KDOT to have greater influence over the skill sets that are developed at the post-secondary educational level.

These are the major salient points of the SIMP that KDOT should attempt to exploit.

1.2.2 State Geographic Information and Related Technology (GI/GIT) Profile, February 2000.

The state maintains a fulltime State GIS Director to provide staff support to the GIS Policy Board. Additional support is provided by the Data Access and Support Center (DASC), a state-funded center located at the Kansas Geological Survey with the purpose of providing archival and distribution services for digital GI to many users of GI/GIT in Kansas.

The GIS Policy Board is tasked to:

1. Establish a strategic management plan to guide the development and implementation of GIS technology to benefit the citizens of Kansas, and update the plan biennially.
2. Develop and maintain policies, standards, guidelines, and strategies, which emphasize cooperation and coordination among government entities developing and implementing GIS in order to maximize the cost effectiveness and value of GIS to the state.
3. Establish public and private partnerships throughout Kansas to maximize value, minimize cost, and avoid redundant activities in the development and implementation of GIS.
4. Coordinate, review, and provide recommendations on GIS programs and investments and provide assistance with dispute resolution among GIS partners.

In 2000 the policy board undertook the following initiatives:

1. Spatial data standards development, implementation, and maintenance
2. Development and coordination of foundational data for use with GIS
3. Metadata development, implementation, and discovery support
4. Geodetic Control Densification
5. 4,000 Scale National Hydrologic Database Development
6. Educational Activities through the MidAmerican Geographic Information Systems Consortium (MAGIC), the National States Geographic Information Council (NSGIC), and the K-12 Kansas Collaborative Research Network (KanCRN).

The GIS Policy Board annually funds database development projects of statewide importance, which become of part of the state's "core" database holdings, and then become available for distribution through DASC. KDOT should seek to influence any statewide database schema and policy statements that emanate from the policy board.

1.2.3 Strategic Management Plan for Geographic Information Systems Technology 1997.

This plan was comprised of four separate strategic tracks. The four tracks consist of Database, Services, Management, and Information Access. All of these tracks consist of a series of task for successful deployment. The tracks will be discussed in the following paragraphs.

Database Track

The objectives of the database track are:

1. Develop clear and accepted data standards.
2. Involve end users in the technical standards process.
3. Develop a well-defined geospatial data framework.

These objectives will be met in the following manner:

1. GIS users will adopt standards related to the characteristics for geographic data sets, their maintenance, and the transfer of it among users.
2. Kansas GIS community will accept the geospatial data framework, which identifies the essential geographic databases and attributes necessary for the development of new databases. This will allow the seamless integration of databases for exchange and analysis of spatial data.

KDOT has been an active participant in carrying out these objectives. It makes available the major transportation content to the state clearinghouse. The non-state rural network will be posted to DASC when available (Q1, 2005).

Services Track

The objectives of this track are:

1. Support the application of GIS technologies by state agencies and local governments.
2. Continue DASC's clearinghouse role for "core" (framework) databases, expand its role to include Kansas' framework databases, and provide metadata and locational pointers for other spatial databases.
3. Monitor and report standards including metadata standards.
4. Define and establish mechanisms for user support.
5. Encourage the implementation of GIS technologies and the sharing of spatial data by all users.

These objectives will be will be supported by the following strategies:

1. DASC will serve as a clearinghouse for core (framework) databases and selected databases within the Kansas Geospatial Data Framework. DASC will also provide metadata information for other geospatial data from all Kansas sectors.
2. GIS databases will be shared at a minimal cost to the user.
3. DASC will provide support services for the application of GIS technologies for the geospatial community.
4. GIS technologies will increase in use within state, local, and private agencies. State and local government agencies will be exposed to the activities of the Policy Board.

Management Track

The objectives of this track will be to:

1. Spur the definition of responsibilities for government and private entities in the development of geospatial databases.
2. Establish procedures for partnerships among government and the private sector.
3. Encourage government and the private sector to include GIS funding as a budget item.

The following strategies will be applied to meet the management track objectives:

1. The Policy Board and spatial data developers will partner to delineate roles and responsibilities for data development. This will assure the adherence to standards, no duplication of data, promote the efficient use of financial and human resources, and assure the sharing of the developed GIS databases.
2. The State GIS Coordinator will lead efforts to expand, develop, and maintain GIS technologies and data themes.
3. The state GIS management structure will become institutionalized in Kansas.

KDOT has actively participated in partnerships with private sector and other state agencies. KDOT is represented on the GIS policy board to aid in shaping of policies that govern partner relationships.

Information Access Track

The objectives of the information access track are:

1. Provide guidance on the legal issues regarding the creation and the release of spatial data.
2. Begin the process of modernizing laws and regulations relating to digital information.

The following strategies will be applied to meet the information track objectives:

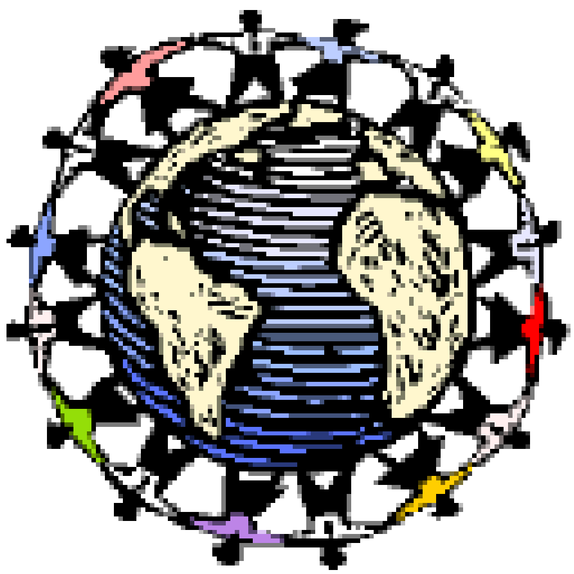
1. Citizens' privacy rights and information relating to endangered species, historical sites, archeological finds, and other sensitive information, will be protected from unauthorized, unscrupulous and/or commercial abuse of spatial databases through legal restrictions and GIS community norms.
2. Developers of geospatial data will not have legal liability for unintentional human errors in their databases. Providers of the data will not have legal liability for the distribution of data with errors.
3. The GIS community will abide by laws and norms regarding the protection of privacy and sensitive information.

KDOT should play an active role in any legislation governing the legal climate surrounding spatial data.

In concluding, the State GIS Strategic plan is in the process of being revised. KDOT should seek to aid the GIS Policy Board in directional strategies for the revised plan.

Kansas Department of Transportation

GeoSpatial Enablement Strategy Appendix 3- Management Methodologies and Performance Measures



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Appendix 3 – Management Methodologies and Performance Measures

This appendix will describe the management methodologies and performance measure techniques KDOT has evaluated for various technology governance principles.

1.1 Management Methodologies

The following industry management methodologies were analyzed to determine if there was intrinsic value to the geospatial enablement effort.

1. Balanced Scorecard
2. COBIT
3. Intellectual Capital

1.1.1 Balanced Scorecard

The Balanced Scorecard defines a methodology to measure goals and initiatives, and a philosophy that assists in translating strategy into action. It provides feedback around both the internal business processes and external outcomes in order to continuously improve strategic performance and results. When fully deployed, the balanced scorecard transforms strategic planning from an academic exercise into the nerve center of an enterprise.

The basic tenets of The Balanced Scorecard include assigning all business strategy and vision with respect to four perspectives. Those perspectives are:

1. Learning and Growth
2. Business Process
3. Customer
4. Financial

A brief overview of each of these will be discussed in the following paragraphs.

The Learning and Growth perspective includes employee training and corporate cultural attitudes related to both individual and corporate self-improvement. Due to rapid technological change, it is necessary for workers to constantly increase their knowledge foundation because ultimately the employees are the source of what drives how the technology is administered.. Government agencies deal with hiring restrictions that limit their ability to recruit new technical workers. This factor, in combination with a decline in training of existing employees, has eroded techical skill sets. Metrics can be implemented to allow managers to devise strategies to properly allocate training funds where they will be of the greatest benefit. Learning and growth are essential building blocks for creating a knowledgeable work force.

The Business Process Perspective refers to internal business processes. Performance measures relating to this perspective allows companies to determine how well a business is functioning, and whether its goods and services are meeting customer expectations. These measures must be designed by those who have the most in-depth knowdege of their company's business processes and customer expectations. In addition to the strategic management process, mission-oriented processes, and support processes must be defined and analyzed.

The Customer Perspective deals with customer focus and satisfaction. This is very simplistic to measure, if ones customers are not satisfied they will find other suppliers more in line with helping them meet their objectives. In developing performance measures for satisfaction, customers should profile and their business processes studied.

The Financial Perspective centers around developing funding data as a priority. Steps must be taken to secure it. A centralize database should provide easier access to funding information. To much emphasis on financials leads to the unbalanced scorecard with respect to other perspectives.

KDOT has strategically analyzed this management methodology. In the KDOT Value Chain these perspectives are factored in the KDOT Strategic Information Technology Plan. In addition, the State of Kanasas Strategic Information Technology Plan has embraced the philosophy of balancing these key business management components. This helps to align KDOT's IT and the State's IT management philosophies and policies.

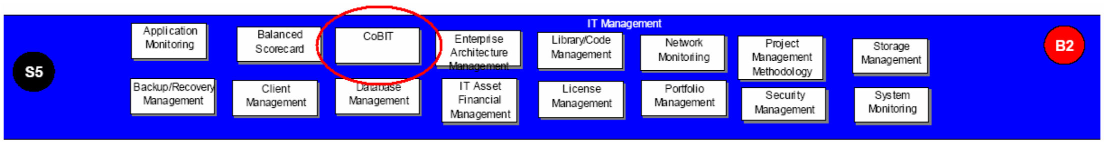
1.1.2 COBIT

COBIT stands for Control Objectives for Information and related Technology. It is an open standard for control over information technology developed and promoted by the IT Governance Institute.

COBIT identifies 34 IT processes, a high-level approach to control over these processes, as well as 318 detailed control objectives and audit guidelines to assess the identified IT processes. COBIT defines general standards for reasonable IT security and control practices. These practices will support management needs in determining and monitoring the appropriate level of IT security for their organizations.

COBIT helps focus on performance management. It integrates principles of the Balanced Scorecard. This assists IT management in defining Key Goal Indicators to identify and measure outcomes of processes. In addition, Key Performance Indicators are formulated to assess how well processes are performing by measuring the enablers of the process. In many companies today, IT has become the major enabler of the e-business environment. This identifies a salient relationship between business goals with their measures, and IT with its goals and measures. Figure 1 illustrates KDOT's incorporation of this paradigm into its IT governance decision making.

Figure 1 COBIT as a KDOT IT Management Principle



KDOT has effectively evaluated this IT management methodology and grafted in its best practices. This is also reflected in how BCS has aligned its goals with that of KDOT's in general. Table 1 provides a summary.

Table 1 KDOT - BCS Goal Parallel

	KDOT	**BCS**
Goal		
CTP	To provide a statewide transportation system to meet the needs of Kansas.	Work to align IT with KDOT's core business processes.
Private Sector Partners	KDOT will build relationships with all of its non-government customers and partners.	Assume business partners and the public use our systems.
Intergovernmental Partners	KDOT will enhance its relationship with all of its intergovernmental customers and partners.	To provide systems that are easy for business partner use of our systems.
Technology Usage	KDOT will optimize technology to improve overall department operations.	Work to help KDOT innovate through the effective use of technology and process improvement.
Workforce Optimization	KDOT will maximize the effectiveness of its workforce.	Ensure information is available to all who should have it.

1.1.3 Intellectual Capital

Intellectual capital can be comprised of intangible assets such as employee knowledge, patents, and research. These types of assets are entering usage as tools to strengthen an agencies position with their constituents. Various research initiatives estimate that spending on intangible assets like research and development and employee education can result in a return eight times greater than an equal investment in equipment and facilities.

Knowledge is useful information about things that are essential to any Company. These can consist of variables such as its customers, competitors, and product business strategies. Knowledge management entails capturing and leveraging valuable information and disseminating it for use by other people throughout the company. Knowledge management also addresses aggregating information into "components" which when combined and modified. These components can then be used in other departments within a company in a totally different context.

In addition, how does KDOT define and measure success with regards to intellectual capital? What can be defined as viable measures of KDOT's intellectual capital? Let's revisit some of the aforementioned components. David Skyrme has devised an increasingly popular classification divides intellectual assets into three categories:

1. **Human Capital** - that in the minds of individuals: knowledge, competences, experience, and know-how.
2. **Structural Capital** - "that which is left after employees go home for the night": processes, information systems, and databases.
3. **Relationship (or Customer) Capital** - customer relationships, brands, trademarks.

These classifications schemes may vary from organization to organization but provide a framework for KDOT and other companies to categorize intellectual capital investment. Also, there is a paradigm of thought that separates out assets protected by law. Many companies, Intergraph included, have formed Intellectual Property divisions. These areas would deal with the protection trademarks, patents, copyrights, and licenses. KDOT may seek to ensure proper protection of published works within the transportation industry. This would be an example of "intellectual property."

Performance measure for intellectual capital should not be static. These measures should help managers identify the underlying cause and effect. Scorecards should be devised to help an organization to understand its intellectual capital.

Skyrme has identified several success stories in devising strategies and scorecards to measure and manage intellectual capital. Among these that have successfully applied enhanced measures are:

1. Skandia AFS - use its Navigator (90 measures in 5 groups) and other tools to set management goals and drive the business forward. It published ***Intellectual Capital Supplements*** alongside its twice-yearly financial reports from 1994-1999.
2. Dow Chemical - has focused specifically on understanding the value in their patent portfolio. Using the Technical Factor method of Arthur D. Little, alongside their own management model, they have generated over $125m new revenues from their patents.

3. Austrian Research Centers, Seibersdorf - developed an IC report to provide better information to its stakeholders that also revealed greater insights into its internal knowledge processes.
4. Systematic Software Engineering, Denmark – stated its IC report helped raise the organization's profile, attracting more customers and highly skilled employees.

These organizations have found it gives them a better understanding of the drivers of value and it also improves management and growth of these vital assets. KDOT should consider any technique to strengthen the dissemination of knowledge process throughout the enterprise. In addition, techniques or strategies to enhance the ability to recruit the level of skill necessary for KDOT to meet enterprise goals should be considered.

1.2 Performance Measures and Success Indicators

This section will address the following:

1. FHWA Performance Measures
2. KDOT Critical Success Indicators

1.2.1 FHWA Performance Measures

FHWA has defined performance measurement as the process of assessing progress toward achieving predetermined goals, including information on the efficiency with which resources are transformed into goods and services (outputs), the quality of those outputs (how well they are delivered to clients and the extent to which clients are satisfied) and outcomes (the results of a program activity compared to its intended purpose), and the effectiveness of government operations in terms of their specific contributions to program objectives.

Performance measures being universally embraced for highway systems to monitor the effectiveness of operational strategies and to evaluate the success of achieving agency targets. Performance measures of operational effectiveness are used in the planning and systems engineering to prioritize projects, convey feedback on how effective long-term strategies have been, tune goals and objectives, and improve processes for the delivery of transportation services. Performance measures in planning are used in reporting trends, conditions, and outcomes resulting from improvements to the transportation system.

Pickrell and Neumann stated at the TRB 2000 meeting some of the reasons for adopting performance measures are:

1. Accountability - They provide means of determining whether resources are being allocated to the priority needs that have been identified.

2. Efficiency - They focus actions and resources on organizational outputs and the process of delivery.
3. Effectiveness - In regards to goals achievement, they provide a linkage between ultimate outcomes of policy decisions and actions of a transportation agency.
4. Communications – They allow better information to customers and stakeholders on progress toward goals and objectives or system performance problems.
5. Clarity - They lend clarity to the purpose of an agency's actions and expenditures.
6. Improvement – They aid in periodically refining programs and service delivery based on system monitoring.

The Office of Management and Budget has constructed some criteria for defining performance measures. Among those are:

1. They must be tied to a specific goal or objective.
2. Data requirements such as the population and the metric will include the frequency of measurement and data sources.
3. The calculation methodology will include required equations and definition of key terms.
4. A clear data collection plan that helps streamline the data collection processes.

Table 2 presents some common performance measures for measuring effectiveness of a highway system:

Table 2 Common Performance Measure for a Highway System

#	Performance Measure	Definition
1	Commercial vehicle safety violations	Number of violations issued by law enforcement based on vehicle weight, size, or safety.
2	Congestion cost per capita	Annual "tax" per capita
3	Congestion cost per eligible driver	Annual "tax" per driver
4	Delay caused by incidents	Increase in travel time caused by incidents.
5	Delay per capita	Annual time per person
6	Delay per eligible driver	Annual time per driver
7	Density	Passenger cars per hour per lane
8	Duration of congestion	Period of congestion
9	Evacuation clearance time	Reaction and travel time for evacuees to leave an area at risk
10	Incidents	Traffic interruption caused by a crash or unscheduled event

#	Performance Measure	Definition
11	Level of service (LOS)	Qualitative assessment of highway point, segment, or system using “A” (best) to “F” (worst) based on effectiveness.
12	Percent of system congested	Percent of miles congested (usually based on LOS E or F).
13	Percent of travel congested	Percent of vehicle-miles or person-miles traveled.
14	Rail crossing incidents	Traffic crashes that occur at highway–rail grade crossings.
15	Recurring delay	Travel time increases from congestion, but does not consider incidents.
16	Response time to weather-related incidents	Period required for an incident to be identified/verified and for action to alleviate the delay to traffic to at the scene.
17	Roadway congestion index	Cars per road space
18	Security for highway and transit	Number of violations issued by law enforcement for acts of violence against traveler.
19	Speed	Distance divided by travel time.
20	Toll revenue	Dollars generated from tolls.
21	Traffic volume	Annual ADT, peak-hour traffic, or peak-period traffic.
22	Travel costs	Value of driver’s time for a trip and expenses incurred during the trip (ownership, operating expenses, tolls, or tariffs).
23	Travel rate index	Amount of extra travel time
24	Travel time	Distance divided by speed
25	Travel time reliability	Definitions include: 1) variability of travel times, 2) % of travelers arriving at destination in acceptable time, 3) range of travel times.
26	Vehicle-miles traveled	Volume times length
27	Vehicle occupancy	Persons per vehicle
28	Wasted fuel per capita	Extra fuel due to congestion
29	Wasted fuel per eligible driver	Extra fuel due to congestion
30	Weather-related traffic incidents	Traffic interruptions caused by inclement weather

The FHWA recently endorsed a series of steps to define performance measure. These steps originated from research by the U.S. General Accounting Office. The steps consist of:

1. Define mission and goals (include outcome-related goals):
    - Involve key stakeholders in defining missions and goals.
    - Identify key factors that could significantly affect the achievement of the goals.

   - Align activities, core processes, and resources to help achieve the goals.
2. Measure performance:
   - Measures at organizational levels that demonstrate results based on a vital indicators for each goal at that level,
   - The measures should respond to multiple priorities, link to responsible programs, and not be costly.
   - Collect complete and consistent data to document performance. It must support decision-making at various organizational levels.
   - Report performance information in a useful way.
3. Use performance information:
   - Use performance information for managing the agency or program to achieve goals.
   - Communicate performance information to key stakeholders and the public.
   - Demonstrate program performance.
   - Support resource allocation and other policy decision-making.
4. Reinforce performance-based management:
   - Devolve decision making with accountability for results.
   - Create incentives for improved performance.
   - Build expertise in strategic planning, performance measurement, and use of performance information in decision-making.
   - Integrate performance-based management into the agency culture and activities.

1.2.2 KDOT Critical Success Indicators

KDOT tasked an internal team during 2003 to define enterprise wide critical success indicators (CSI) for the state transportation system. These indicators functions as conditions or measures that must be satisfied to ensure KDOT programs are delivering a sufficient transportation system to the citizens of the state of Kansas.

The overarching CSI's that were defined for KDOT are as follows:

1. **Provide a statewide transportation system to meet the needs of Kansas.** This is judged a success when:
   - The overall condition of the State Highway System (SHS) improves or remains at a favorable condition.
   - Added traffic demands on the SHS are managed without a decrease in the service level.
   - Crash and/or fatality rates decrease or remain constant on the SHS.
   - The physical condition of public use airports shows improvement.
   - The physical condition of short-line rail infrastructure supports safe and efficient movement of goods throughout Kansas.
2. **Organizationally KDOT is successful when:**

- Schedules and budgets are met for construction programs.
- Department operation costs remain at or below current level (factored inflation).
- When legal actions against KDOT decrease.
- Employees are productive and have a sense of fulfillment.

3. **KDOT successfully satisfies our customers when:**
   - The public is satisfied with the level of service of the system.
   - Business partners and KDOT have a mutually beneficial relationship.
   - The public believes KDOT is providing proper services for their tax dollars.

KDOT has established specific success indicators to support the enterprise wide performance measures mentioned above. These indicators address the following operational aspects of KDOT's business processes:

1. **Highway Maintenance.** This consists of success factors for:
   - Pavement Management – Performance levels for the SHS
   - Maintenance Quality Assurance - Measures the overall impact of cumulative maintenance activities on the LOS being provided to the traveling public.
   - Bridge Health Index - A 0-100 ranking system that functions as a performance measure to communicate the condition of a bridge. In 2002 KDOT used the this index as a performance measure for GASB34 reporting.
2. **Highway Capacity.** KDOT has established the following criteria for LOS to measure success:
   - Density, in terms of passenger cars per mile per lane;
   - Speed, in terms of mean passenger car speed;
   - Volume to capacity ratio.
3. **Highway Safety.** Measures have been established for the following areas:
   - Work Zone/Work Zone Accident Statistics – Methods used to enhance work zone safety include public education and awareness programs.
   - Highway Rail Crossings/Crossing Accident Rates – KDOT is involved with several public education programs that have seen a dramatic decrease since 1999 in the crash rate for at-grade crossings. Among these are:
     1. Operation Lifesaver
     2. Positive Enforcement
     3. Partnership with Northern Santa Fe and Union Pacific Railroads.
   - State Highway/Injury and Fatal Crash Rates – KDOT tracks crashes that involve injuries and fatalities that occur on the SHS. The Injury Crash rate conveys the overall number of injury crashes per million miles traveled by people on the SHS. The Fatal Crash rate is the number of crashes with fatalities per hundred million miles traveled by people on the SHS.

4. **Public Transportation.** Success indicators were established for the following modes:
    - o Transit Ridership - Under the CTP, funding for the Coordinated Public Transportation Assistance Fund program was increased from $1 million per year to $6 million per year. The funding targeted underserved areas of the State in order to provide vehicles for medical transportation, expand and enhance future public transit needs.
    - o Airports - The Runway Pavement Condition Index is an overall average condition index of public-use runways in Kansas. The index starts with 0 - failed rating, to 100 - excellent rating. A good rating (from 56 to 70) is acceptable.
    - o Rail - The State Rail Service Improvement Fund (SRSIF) provide short-line railroads operating in Kansas with low-interest, 10-year revolving loans. This program resulted in the following:
        4. 2000 – 2002: Thirteen rehabilitation projects and one acquisition project.
        5. 2003: Ten infrastructure rehabilitation projects and one acquisition.
5. **Highway Construction Program.** Success indicators were established to evaluate the following:
    - o State Highway Program - Is evaluated by four specific indicators:
        1. Total Program Beginning Estimate,
        2. Total Program Current Estimate,
        3. Cumulative-to-date Beginning Estimate,
        4. Cumulative-to-date Actual.
    - o Projects Scheduled vs Actual Lets. Classification criteria as follows:
        1. Program type:
            - Substantial Maintenance,
            - Major Modification,
            - Priority Bridge,
            - System Enhancement,
            - Total Program.
        2. Projects are classified each quarter as:
            - Let early,
            - Let on time,
            - Number of months late (1-3 months, 4-6 months, or greater than 7).
    - o Change Orders - This is a very significant factor for determining how successful KDOT has been throughout a highway project's life cycle (design through construction).
        1. Percentages measured for:
            - The total program,
            - Substantial Maintenance,
            - Major Modification,

- Priority Bridge.

2. KDOT has established a measure of 2% of all projects potentially will have an unexpected change.

- Federal Fund Usage. KDOT's goal is to get actual federal funding obligations as close to planned obligations as possible. Performance goals for several categories of highway are evaluated accordingly:
  1. Actual Obligation as a Percent of Original Planned Obligation (close to 100.0 % as is possible).
  2. Planned Obligation versus the Actual Obligation of Federal Funds.
  3. Construction Engineering costs as a % of total construction costs (7.5%).
  4. Cumulative Construction Engineering Percentage.
  5. Preliminary Engineering (PE) costs.
  6. Cumulative Preliminary Engineering Percent.

6. **Capital Improvement Building Program.** Success indicators were established to evaluate the following:
   - Building Improvement Program - Is designed to depict the results of KDOT's Building Improvement Program (BIP).
   - Dollars Appropriated.
7. **Legal Actions.** Categories that indicators were devised for are:
   - Legal Activities and Costs - Indicators for these two categories are:
     1. The number of tort claims filed against KDOT and those still pending,
     2. The dollar loss resulting from settlement of those claims,
     3. The costs of private legal counsel,
     4. The costs of the Office of Chief Counsel.
   - Trends of Legal Actions.

8. **Worker Safety.** Success indicators established as follows:
   - Work-Related Accidents includes the following measures:
     1. The total number of accidents reported and the dollars accumulated-to-date.
     2. The lost time due to accidents in districts.
9. **Workforce Levels.** Success factors that are measured and analyzed are as follows:
   - Leave Usage by Area - Indicators for measured are:
     1. Number of full-time employees in each office/bureau/district.
     2. Average vacation leave taken per person in the office/bureau/district .
     3. Average sick leave taken per person in the office/bureau/district.
   - Turnover Rate – The % of employees terminated, retired, or transferred from an organization to the number of employed workers.
10. **Contractors.** Disputes occassionaly arise with its highway construction contractors.

Kansas Department of Transportation

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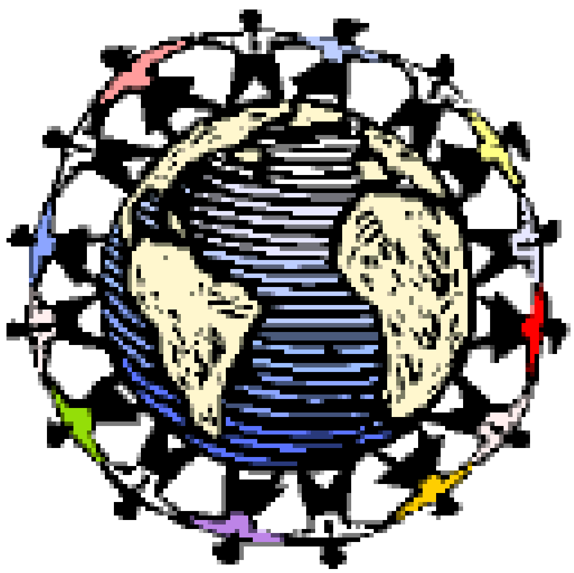
GeoSpatial Enablement Strategy Appendix 4 - Stakeholder Survey
Geospatial Information System (GIS) Strategic Plan Update



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Stakeholder Survey Geospatial Information System (GIS) Strategic Plan Update

Name
Division, Bureau, or Office OR
District, Area or Subarea
Business Function(s)

1. Your level of use of KDOT data: (check one)

___Viewer (read or view only—never make updates to the data)
___User (limited query creation, make updates to the data regularly)
___Power user/developer of applications
___Data administrator

2. Do you require other stakeholders' data for your business function?

___Yes
___ No

3. What are the types of data you require? (Check all that apply.)

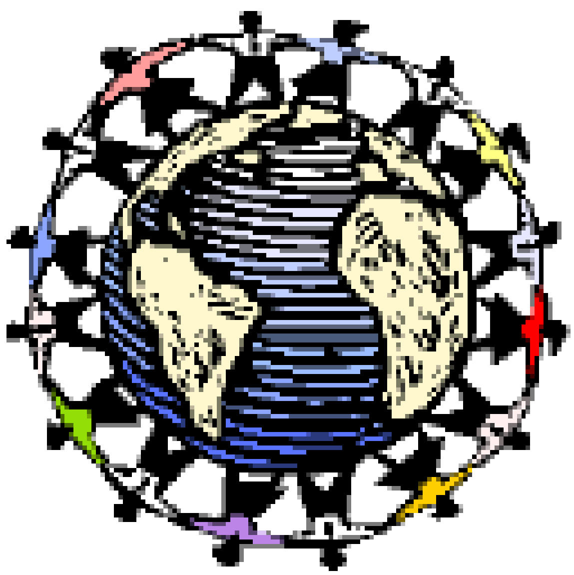
___State System Network
___State System Access points
___Local (non-state) Bridges
___City streets
___Traffic Counts
___Functional Classification
___Signing
___Pavement
___Maintenance projects
___Financial
___Railroad network
___Pedestrian/Pedalcycle
___Trails
___Landmarks
___Utilities
___Imagery
___Air quality
___Rest areas
___Digital elevation models
___State System Bridges
___Local Road Network (rural)
___Culverts
___Motor vehicle accidents (crashes)
___Truck counts
___Weigh-in-Motion
___Guard fence
___Construction projects
___Contracts
___At-Grade Railroad Crossings
___Aviation
___Transit
___Scenic byways
___Parcel/ROW
___Hydrography
___Environmental (T&E species)
___KDOT Facilities
___Educational Facilities
___Digital terrain models (project)

4. Which reference methods do you use? (Check all that apply.)

___KDOT's Location Reference System key
___State Route Logmile
___Longitude/Latitude
___Easting/northing
___Other (specify
___County Route Logmile
___Reference Post
___Stationing
___x, y coordinates

Kansas Department of Transportation

GeoSpatial Enablement Strategy Appendix 5- Stakeholder Review



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Appendix 5 – Stakeholder Review

Appendix 5 provides an overview of stakeholder data needs and data holdings that pertain to geospatially enabling the enterprise. Stakeholder information was gathered from KDOT employee interviews for the GIS/LRS Integration study (February 2003), from those who participated in the on-site stakeholder meeting (August 2004) and associated follow-up interviews, and from results tabulated from the "Stakeholder Survey for the GIS Strategic Plan Update." Most stakeholders are internal to KDOT.

1.1 Stakeholder Data Needs Survey

A questionnaire was given to KDOT stakeholders pertaining to their data usage and needs on November 2, 2004. There were over 100 respondents to the questionnaire. The questionnaire is shown in Appendix 4.

There were 103 surveys completed. This survey was administered to determine which data sets the majority of stakeholders at KDOT utilize. This in turn will allow these data sources to be designated as primary targets for geospatial enablement.

The first question asked in the survey was what level of user of KDOT data did each respondent consider themselves. This question was asked to determine the level of interaction each stakeholder has with the various databases available throughout the enterprise. Each respondent was asked to choose one category but some respondents fell into multiple categories and marked them accordingly on the survey. Table 1 conveys the results of this question.

Table 1 Level of User of Data

Category of User	Number of Responses	Percentage of Total Respondents
Viewer (Read only, Never updates data)	48	47 %
User (Limited query creation, Updates data regularly)	35	34%
Power User (Developer of applications)	18	17%
Data Administrator	5	5%

The majority of data consumers at KDOT need data in a read only capacity to complete their specific business processes. Thirty-four percent of the respondents stated they have write access to data used by various stakeholders throughout the enterprise. This is important because these people have the ability to populate the geospatial component of the various types of data utilized by various personnel at KDOT.

The next question the respondents were asked was if they require the usage of other stakeholders' data to complete their business function. Table 2 illustrates the results.

Table 2 Uses of Other Stakeholder Data

Use of Other Stakeholders' Data	Number of Responses	Percentage of Total Respondents
Yes	96	93 %
No	7	7%

The overwhelming majority of respondents require usage of the various data sources managed by others at KDOT. This is critical to understand because once the data is geospatially enabled analysis can be extended to include overlay analysis to derive more accurate conclusions. An example would be ROW owned by the DOT that housed equipment when a road was being built. It will be necessary to locate those parcels and then find out the proximity to various types of land uses to see what is permitted.

The next question asked to the respondents was what are the other types of data you require to complete your business process. This was asked for to determine which data sets would be of the highest priority to geospatially enable.

A brief profile of who the respondents are shows the depth of the survey. Table 3 shows the representative departments and number of respondents.

Table 3 Respondent Profiles

Department	Number of Responses
District 1	8
District 2	6
District 3	3
District 4	5
District 5	6
District 6	2
Aviation	1
BCS	3
Bridge	2
Construction & Maintenance	6
Design	8
Environmental	1

Department	Number of Responses
Human Resources	2
Legal	3
Local Projects	4
Materials & Research	6
Planning	20
Project Management	1
Public Information	1
ROW	6
Safety	2
Traffic Engineering	6
Videolog	2

There were 23 respondent work areas. The average number of responses per department was roughly 4. Planning had the most respondents with 20 and there were four departments that had 1 respondent. This provides a representative cross-section of the agency.

There were 38 types of data the respondents were asked if they used. Table 4 conveys the results.

Table 4 Stakeholders Data Requirements

Data Source	Number of Responses	Percentage of Total Respondents
State System Network	66	64%
State System Access Points	42	40%
Local (Non-State) Bridges	30	29%
City Streets	50	49%
Traffic Counts	57	55%
Functional Classification	45	44%
Signing	51	50%
Pavement	51	50%
Maintenance Projects	51	50%
Financial	16	16%
Railroad Network	30	29%
Pedestrian/Pedalcycle	18	17%
Trails	16	16%
Landmarks	22	21%

Data Source	Number of Responses	Percentage of Total Respondents
Utilities	42	41%
Imagery	40	39%
Air Quality	7	7%
Rest Areas	30	29%
Digital Elevation Models	19	18%
State System Bridges	55	53%
Local Road Network (Rural)	51	50%
Culverts	36	35%
Motor Vehicle Accidents (Crashes)	37	36%
Truck Counts	47	46%
Weigh-In-Motion	15	15%
Guard Fence	35	34%
Construction Projects	67	65%
Contracts	37	36%
At-Grade-Railroad Crossings	40	39%
Aviation	14	14%
Transit	11	11%
Scenic Byways	24	23%
Parcel/ROW	39	38%
Hydrography	21	20%
Environmental (T&E Species)	14	14%
KDOT Facilities	34	33%
Educational Facilities	11	11%
Digital Terrain Models	16	16%

The average number of data sources used by the respondents above was approximately 13 of the 38. One respondent said they used all 38 data sources and 2 respondents said they did not use any of them. The average number of data sources used for all respondents was approximately 13. The top 5 data sources are listed below:

1. Construction Projects (65%)
2. State System Network (64%)
3. Traffic Counts (55%)
4. State System Bridges (53%)
5. Signing, Pavement, Maintenance Projects and Local Road Network – Rural (50%)

The most significant fact in the list above is the State System Network is used 64% of the respondents. The network is already geospatially enabled and several of the data sources above reference the network. In addition, Construction Projects was the most used data source identified by the respondents. The Construction Project data has the ability to generate the LRS key used by KDOT and also contains the longitude and latitude durations of each project. This provides a basis to give a geospatial context for construction project data. In addition, 40% or more of the respondents on the survey used 13 of the data sources. This says that 1/3 of those data sources are used by a large percentage of the respondents.

The least used data sources are as follows:

1. Air Quality (7%)
2. Educational Facilities and Transit (11%)
3. Environmental - T&E Species (14%)

The last variable that was measured by the survey was the types of linear reference methods (LRM) used by the respondents. Table 5 shows the usage among the respondents.

Table 5 Stakeholder LRM Requirements

LRS Key or LRM	# Of Responses	% Total Respondents
KDOT LRS Key	57	55%
State Route Logmile	65	63%
Longitude/Latitude	47	46%
Easting/Northing	14	14%
County Route Logmile	56	54%
Reference Post	63	61%
Stationing	42	41%
X, Y Coordinates	18	17%
Other	8	8%

Fifty five percent of the respondents stated they were using KDOT's LRS key. This is imperative for linear referencing. Linear referencing is a methodology to provide spatial context to data that is locationally referenced. The LRM's that were used the most are as follows:

1. State Route Logmile (63%)
2. Reference Post (61%)
3. County Route Logmile (54%)
4. Longitude/Latitude (46%)

Eighty-one (79%) of the 103 respondents stated they use two or more LRM's to locate data. This is a pertinent fact with regard to completing the spatially enablement process. KDOT may want to consider adopting a universal LRM for analysis. There is a utility within GeoMedia Transportation that allows conversion between coordinate LRM's (longitude-latitude and easting-northing) and route-measure LRM's (State Logmile, County Logmile and Reference Post). The conversion would take place in the form of query thus the base data would not need to be appended or edited.

1.2 Inventory Assessment

The most current inventory assessment of data that could be geospatially enabled was performed for the GIS/LRS integration study that concluded in February 2003. This is not a substitute for a comprehensive inventory review. The caretaker of each respective data source should perform this and post to a central point of discovery.

1.2.1 KDOT Traditional Inventory Process

KDOT maintains an exhaustive repository of data. In many instances the same data exists across the enterprise in multiple databases. This creates inconsistency in identifying the most accurate and up to date data required for decision-making. This can potentially have disastrous ramifications when performing analysis.

A general process followed for data inventory at KDOT resembles the following steps:

1. Each data custodian will attempt to conduct the inventory or hire consultant with transportation expertise to assist.
2. Formulate questions that need to be answered about data holdings (not an actual inventory).
3. Attempt to identify throughout everyone within a given bureau that maybe a caretaker of information.
4. Publish findings to all agency departments.

A pre-defined and consistent methodology must be devised to conduct any inventory process. This is necessary for uniformity across all representative groups at KDOT.

1.2.2 GIS/LRS Stakeholder Participant Data Holdings Inventory from 2003

This section will list the elements and participants in the Stakeholder data-holding inventory performed for the GIS/LRS Integration study of 2003. The data elements examined in that study are as follows:

1. Data Collection and Structure

2. Metadata
3. Location Reference System
4. Enterprise Data Dissemination
5. Enterprise Data Access and Provision
6. Software Profile

KDOT personnel stated during the course of this study the components above have remained unchanged since the GIS/LRS Integration study of 2003. With that in mind these elements have used as a baseline to determine what the current level of geospatial enablement is for the major operational databases. This is not meant to serve as a substitute for a detailed inventory by each custodian of the operational databases.

The respondents to that study are listed below:

1. Office of Engineering Support - Program/Project Management Support
2. Bureau of Transportation Planning - Decision mapping and GIS applications
3. Bureau of Transportation Planning – Base Network Maintenance
4. Bureau of Transportation Planning – Kanroad (formerly CDRS and RCRS)
5. Bureau of Transportation Planning – GPS Centerline recalibration
6. Bureau of Transportation Planning - Reference Posts on state highway system
7. Bureau of Transportation Planning - Videolog
8. Bureau of Transportation Planning – Traffic Volume
9. Bureau of Transportation Planning - CANSYS2, state system bridges, and public at-grade railroad crossings data
10. Bureau of Transportation Planning - KARS
11. Bureau of Transportation Planning - ITS
12. Bureau of Construction and Maintenance - CDRS/RCRS, Rest Area Inventory, and Paint Striping Inventory
13. Bureau of Design Environmental Services Section - Environmental GIS-based project review and reporting
14. Bureau of Materials and Research Pavement Management Section - Substantial Maintenance Program and maintenance of the PIMS
15. Bureau of Transportation Information - Advanced Traveler Information System
16. Bureau of Local Projects - Data management of local bridge inventory
17. Bureau of Local Projects - KDOT's improvement program for roads and bridges
18. Bureau of Design Coordinating Section - Highway/Railroad crossing safety, utility adjustments, and preliminary design surveys
19. Bureau of Traffic Engineering Corridor Management Unit - Highway Access Permit System
20. Bureau of Public Involvement
21. Bureau of Computer Services - TRIS

In the GIS/LRS study the respondents were asked if they required access to other stakeholders data. Seventy-six percent stated they required access to other business unit's data. In the current survey 93% stated they needed access to other departments data within KDOT. This is significant because to use it in integrated spatial/linear analysis components such as the LRS key and a recognized LRM will be necessary.

These were the key corollary components of the two studies that were worth noting. Again, it should be reiterated the GIS/LRS data holding survey should not be substituted for a comprehensive analysis of the current business environment at KDOT.

1.3 Geospatial Enablement Components

There are several data and system components that allow data to be geospatially enabled. These will be analyzed using stakeholder interviews (CPMS, GIS/LRS 2003, and direct) in the following subsections to provide a preliminary indication of geospatial enablement among the major operational databases at KDOT. This will provide a reasonable assessment of the level of effort and strategic sources that will be impacted the GE effort. The components analyzed are:

1. Databases – This consists of the operational databases that are used by KDOT stakeholders. In addition, this also considers whether the database supports the storage of geospatial data.
2. Spatial and User-Defined Metadata – This consists of information describing who, when and how the data was collected, the geographic characteristics of the data and spatial extents.
3. Location Reference Component – This consists of the data containing the LRS key or a means by which to create the key or join to other data which has the LRS key.

1.3.1 Operational Database Enablement Profile

Of the above-mentioned stakeholders several maintain the official databases KDOT uses for policy and decision-making. These databases contain various levels of geospatial components. Most of them are partially geospatially enabled and some can be linked to other databases they have a relevant relationship to for decision making.

Table 6-1 in the main document illustrates the presence of geospatial components in the major KDOT operational databases.

There is incomplete data in this assessment. Most of this is due to nothing being provided by the respondents. Fourteen of the 22 respondents either store or can produce the KDOT LRSKey. This is a necessary in order to perform dynamic segmentation of tabular data containing an LRM that references the network. In addition, eight of the operational databases contain a spatial geometry type that allows spatial data to be graphically displayed in a GIS environment or database.

Five of the operational databases have both geometry storage and the LRSKey as a component of their database.

In addition, many of the operational databases have common relationships that have been defined in the Enterprise Architecture data model. These should be leveraged to utilize common fields that can be joined to form analytical relationships.

1.3.2 Spatial and User-Defined Metadata

Metadata refers to characteristics of the spatial component of the data, that is, datum, map projection, and reference coordinates that the data have been tied to in a cartographic sense. Metadata can also be created and published at the item, attribute, or event level. Metadata can tell the user about data collection techniques, data audience, data maintenance, data distribution, data age, and overall data fitness. Metadata can also help the user to identify usable or reliable data and can provide assumptions necessary when performing statistical or other analyses.

Table 6 shows the whether metadata is resident in the operational databases that were surveyed in the GIS/LRS Integration study of 2003.

Table 6 Metadata in operational databases

Database	Metadata
CPMS	N
GIS - Mapping	Y
GIS – Base Network	Y
KanRoad	Y
GPS Centerline	Y
Reference Posts	N
Videolog	N
Traffic Volume	N
Bridge	N
At-Grade Crossings	Y
Accident	N
ITS	
Rest Area	
Striping	
Environmental	N
Pavement	N
ATIS	N
Local Bridge	N
Local Roads	N
Access Permit	N
Public Affairs	N

Database	Metadata
TRIS	Y

Six (27%) of the 22 respondents stated they create metadata for their operational databases. Twelve (55%) of the 22 respondents stated they do not maintain any metadata for their operational databases. There was no information provided by three respondents.

Metadata will be a critical factor for uniform spatial enablement effort. Understanding the basic framework of the data is critical for consistency in the development of enterprise applications by KDOT. In addition, as KDOT continues to provide and exchange data with external agencies metadata will be critical for seamless usage of the data.

1.3.3 KDOT LRS Key and Location Reference Methods

The KDOT LRS key usage was also analyzed in the GIS/LRS study. Sixty-seven percent of the respondents in that study stated they have adopted the standard LRS key to manage the data holdings. Fifty-five percent of the respondents to the current study stated they have adopted the LRS key.

There were 11 different LRM's in use. Seventy-six percent of the respondents stated they used multiple LRM's. The most prevalent LRM's are county-route logmile and the Longitude/latitude LRM's. Of the 21 respondents, 57% used the county-route logmile LRM. This was the most used LRM is the GIS/LRS study. This is a contrast with the current survey that showed 63% of the current stakeholders use State Route Logmile and that is the most used LRM. In the GIS/LRS study 52% used the longitude/latitude LRM and that was the second most used LRM. In the current survey 46% used longitude/latitude. In both studies it was the second most frequently used LRM.

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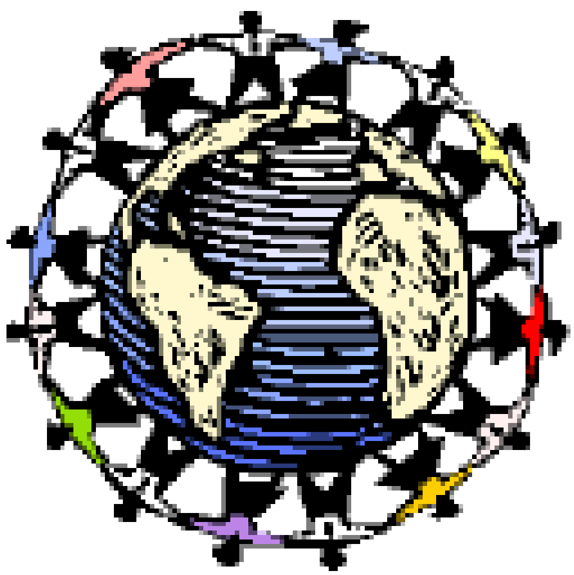
GeoSpatial Enablement Strategy Appendix 6 – Existing Business Systems and Workflows



February 18, 2005

Prepared for KDOT by

Intergraph Mapping and GeoSpatial Solutions

INTERGRAPH

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Appendix 6 Existing Business Systems and Workflows

Appendix 6 contains a comprehensive review of the business systems that will be involved or affected by the geospatial enablement initiative. The systems are:

1. Comprehensive Program Management System (CPMS)
2. Contract Management System (CMS)
3. CANSYS II/Exor Highways
4. Pavement Management Information System (PMIS)
5. Network Optimization System (NOS)
6. GIS Data Warehouse (GIS/DW)
7. KGATE
8. Kansas Accident Records System (KARS)
9. KANROAD
10. Truck Routing Information System (TRIS)
11. TerraShare
12. KCScout
13. ATIS

1.1 Comprehensive Project/Program Management System (CPMS)

The Comprehensive Project/Program Management System (CPMS) provides project and fund planning, monitoring and closure information for construction projects and for all projects, which the agency chooses to establish for the purpose of planning and monitoring KDOT's work. CPMS replaced KDOT's previous project management system, the Resource Management System (RMS), in 1992. Since the initial start-up date in May of 1992, CPMS has continued to evolve as the agency has established business practices and procedures for using CPMS and identified necessary modifications and refinements.

The CPMS User Manual contains instructional and operational material about CPMS. It reflects all CPMS modifications since the initial start-up of CPMS, including the latest work package implemented September 26, 1997. The manual does include the background, reference and base material that a user needs to know in order to successfully navigate CPMS and understand the information presented.

During August through September of 2004 a series of interviews were conducted with various KDOT users of CPMS. In these interviews respondents were asked a series of questions pertaining to their business process, customers, and the CPMS system. While there is a wealth of information provided in these surveys only a portion of it is relevant to the GE initiative. Table 1 provides a synopsis of the most salient points obtained from the surveys.

Table 1 CPMS Review Summary

Respondent	What do you supply CPMS?	What do you receive from CPMS?	Future req. for CPMS	Business objects used outside of CPMS	Interface into CPMS	Tracking Mechanism
Local Projects	All proj info	Proj sched info	GIS/Spatial	Schedules from RUPUS		
Eng. Supp.	Letting date changes			Excel Sprd., Access DB	None	
Const.and Maint.	Status & date plans received	Proj activ. for time charges	Map of road w/proj	BAMS, CMS, Access DB		Proj #
Design	Prel estim of time & cost, Proj milestones	Proj data – sched/status	Remote wireless conn	BROMS, CANSYS, CICS, CMS, PONTIS	Time Sheet, Task data	
Transp. Plan.	None	Gen proj status	Assoc proj data with coordinates for mapping	CANSYS, KARS, Bridge DB, Rail Cross, Traffic data,	From bus object systems	
Fiscal Services	Obligation, expenditures, Percentages,	Billing reports		Fed Aid Excel Sprd.	From bus object systems	Proj #
FHWA	FHWA gives proj info to KDOT to enter into CPMS	Final vouchers from Fiscal	GIS viewing and LRS enabled	Excel Sprd. to track proj status	None	Proj #
Personnel		Estim. hours on proj	None	SHARP, CICS	CICS	Proj #
Traff. Safety	Work phases, funding split	Notice when proj is let, fund info reports	Ref beg/end of proj, Legal desc. of proj, Grant and multi proj tracking,	CANSYS, KANROAD	None	Proj #
Mat. & Res.	Jurisd proj, Track pub, Pool Funds, Cash Flow	Resp parties, Dates, Proj Info, Funding	Custom & Ad-hoc reports, DMS for reports	Excel Sprd	PMS via Oracle Gateway	Proj #

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Respondent	What do you supply CPMS?	What do you receive from CPMS?	Future req. for CPMS	Business objects used outside of CPMS	Interface into CPMS	Tracking Mechanism
Supp. Services	None	Grant dollars, Funding info, Proj milestone		STARS, CCFB, IFIS, CMS	None	
Comp. Ser.		Report info	Wireless conf. room			
Traff Eng.	**Admin:** Hist. and forecasting **Signing:** Perm. signing **General:** lighting, pave. markings, signals	Hist. info, Proj. Man., Activity dates, Proj status, Charge time	Link to GIS, Accid. data	Excel Sprd. for funding	None	
ROW	Sched. Info	Workload info,	Link to GIS, 4000 Smart Maps tied to legal descr.	ROW Access Program	SAS	
Pub. Inv.	None	Proj sched., scope, loc., cost, length	GIS link to the PIP to show proj info, Tie proj together that cross county line	PIP, PID	PIP, PID	
Prog. Man.	Proj updates	All proj man. related info	CTP info, Proj level costs, GIS tie in, Map info from DB2	None	None	
Operations	Const. dates,	Contract info, Sched. Letting		CMS, General Ledger	None	Proj #
Man. & Budg.	Revenue and estimate info	Eng. cost, Util. reloc, ROW cost	Hist. tracking of proj	Excel Sprd. of cash flow	None	
IT Architect			Data WH, GIS tie in			Proj #

In addition, CPMS currently maintains begin and end logmile of each project. The elements are also in place to generate KDOT's standard LRS key. These critical pieces of information are what are needed to provide a location reference component to project data. In turn, decision support mapping can then be performed. This provides a spatial component to the data in CPMS.

1.2 GIS/Data Warehouse Project, August 2004

The Bureau of Computer Services (BCS) is currently gathering requirements for a GIS/Data Warehouse. This warehouse will function as an information database to support decision-making. The design of this warehouse will be structured for querying, analysis, and to maximize performance. This initiative is currently in the conceptual design phase. Requirements have been collected and a preliminary draft document has been written.

Preliminary plans are to populate the warehouse from operational databases. The update interval had not been defined at the time of the preliminary draft. This provides stable data in the warehouse. Business as usual can occur in the operational databases without the threat of corruption from an external source. The primary content of this warehouse will be business data from various operational units across the enterprise. The warehouse will also contain metadata pertaining to the data structure. The metadata will also describe the methods of data collection, and the accuracy of the data.

The warehouse will attempt to spatially enable the KDOT's current data model. The warehouse will be used with the base network produced by Bureau of Transportation Planning. Conceptually, data added to this warehouse will have a spatial component that allows it to be used with the LRM's used by the GIS Unit for the KDOT's base network. The dominant LRM is county-route-logmile. The route features that reside in the base network include an LRS key. The data in the warehouse will either already contain the LRS key or will have the necessary pieces to construct it. This will allow the data to be used for analysis and will overlay the base network.

Table 2 provides a table of the data classification and attributes to be built into the warehouse. This was derived from a larger table from the requirements document. The LRS key was not added to the list of attributes in the table because it is required of each data classification.

Table 2 Data Classification for GIS/Data warehouse

Data Classification	Attributes
AADT and Truck Traffic Counts for State System	AADT, Truck Counts, Traffic Count Year
AADT for State System	AADT, Traffic Count Year, Route Classification (I, U, K), Growth Factor, K Factor, Land Use (Rural/Urban), State Logmile, County Logmile
Statewide historical traffic counts	Traffic, Sequence ID, Location Description, County, City, Index Number (interchange), Route Classification (I, U, K), Leg, Raw Count, Adjusted Count
Statewide historical vehicle classification sites	Traffic, Sequence ID, Date, Vehicle Classification Count, Hour, Lane, Direction, Location, Location Description, Route Classification (I, U, K)
Traffic counts and other data from the ATRS Database	Location, # of Lanes, AADT, AADT Date, 30th Highest Hourly Volume, Peak Hour
Multiple attributes with offsets	Speed Limit, AADT, Access Control, Surface Type, Land Use, Shoulder Width, Shoulder Type
Accidents	Accident Key, RCRP, Accident Year, Deer Involvement, Speed, Alcohol Involvement, Total Fatalities, Work Zone
Bridges Data	Bridge Serial, Bridge Serial Number, Bridge Log Info, Culvert Info, Railroad Crossing Info, Reference Post Info
Surface Data	Surface Type, Surface Year, Surface Width
Accident Map by Roadway Type	Shoulder Width, Accident Key, Accident Year, County, Route Classification (I, U, K), Lane Class, Accident Severity, Construction Zone, Alcohol Involvement

There are several general requirements for the warehouse that will have an impact on the GE effort. Among those are:

1. Ability to view digital Orthophotography.
2. View files from KDOT's Document Management System.
3. Built on Oracle 9i (Utilize Oracle Spatial).
4. Use same linear referencing as is used by KDOT's base network.
5. Store the LRS key attributes.

1.3 Contract Management System (CMS)

1.4 Cansys2/EXOR Highways

EXOR Highways stores LRS related data in an Oracle relational database. The system is database-driven. It is a two-fold system that consists of network data and event/business data. The network uses a datum concept. The datum is a series of connected segments that provide the domain for transformations among linear referencing methods KDOT utilizes. The datum consists of segments that have attribute values associated with it. One of the attributes is a route identifier. This is crucial in grouping the segments together into routes. Each of the segments has a calculated length in meters. This is used by the grouping mechanism to generate different LRM's for a collection of network segments. There is a jurisdictional attribute (rse_agency) that equates to a county code that allows the segments to be grouped into jurisdictions.

Event data is registered to the datum segments as opposed to a route. This means each event is located as an offset distance in meters from the beginning of a segment. EXOR Highways has a process that allows the event registration function to occur. The benefit of locating an event as an offset distance from the beginning of a datum segment is when the network changes only the events on the effected segments have to be changed. This is a critical component in saving time in maintenance workflows for event data. If there is a datum level change a trigger is kicked off that time-stamps and retires the necessary records in event tables that have been registered to the impacted segments within the datum.

A series of views are created based on user requirements for access to data that references the network. The *road_segs* table functions as a datum component in building various types of LRM subsystems used for linear analysis and decision support mapping. These subsystems are known as groups to EXOR Highways.

Because EXOR Highways is proprietary, no published data dictionary is available. However, the primary structure of KDOT's implementation is as follows:

- The *road_segs* table contains a record for each road segment as well as each road grouping. Currently, the road segments are broken at intersections defined in the previous CANSYS system.
- The *road_seg_membs_all* table identifies the road segments within each road grouping. The primary columns in this table are *in_group_id,* and *of_segment_id.* Each road grouping is represented in this table by a set of records; in each record of the set, the *in_group_id* column contains the *road_segs* identifier of the road grouping, and the *of_segment_id* column contains the *road_segs* identifier if the individual segment.
- Asset (Event) tables contain the location of each asset item on the road network.

No additions or modifications may be made to the structure of the tables.

1.5 KGATE

1.6 TerraShare

1.7 Kansas Accident Records System (KARS)

1.8 KanRoad

1.9 Truck Routing Information System (TRIS)

1.10 Pavement Management Information System (PMIS)

1.11 Network Optimization System (NOS)

1.12 ATIS