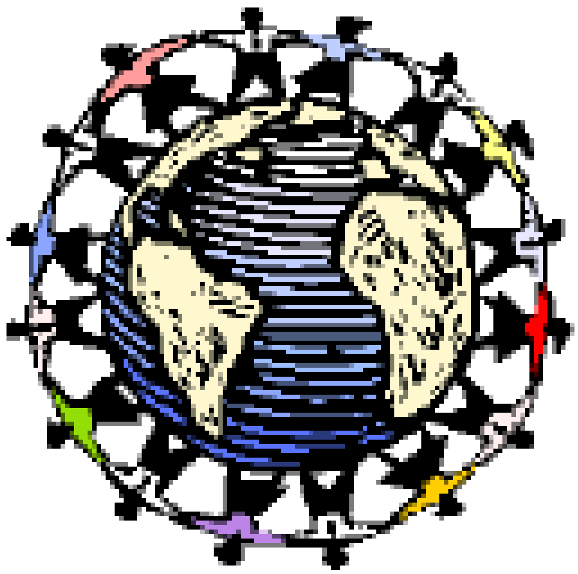
Kansas Department of Transportation

Geospatial Enablement Strategy



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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

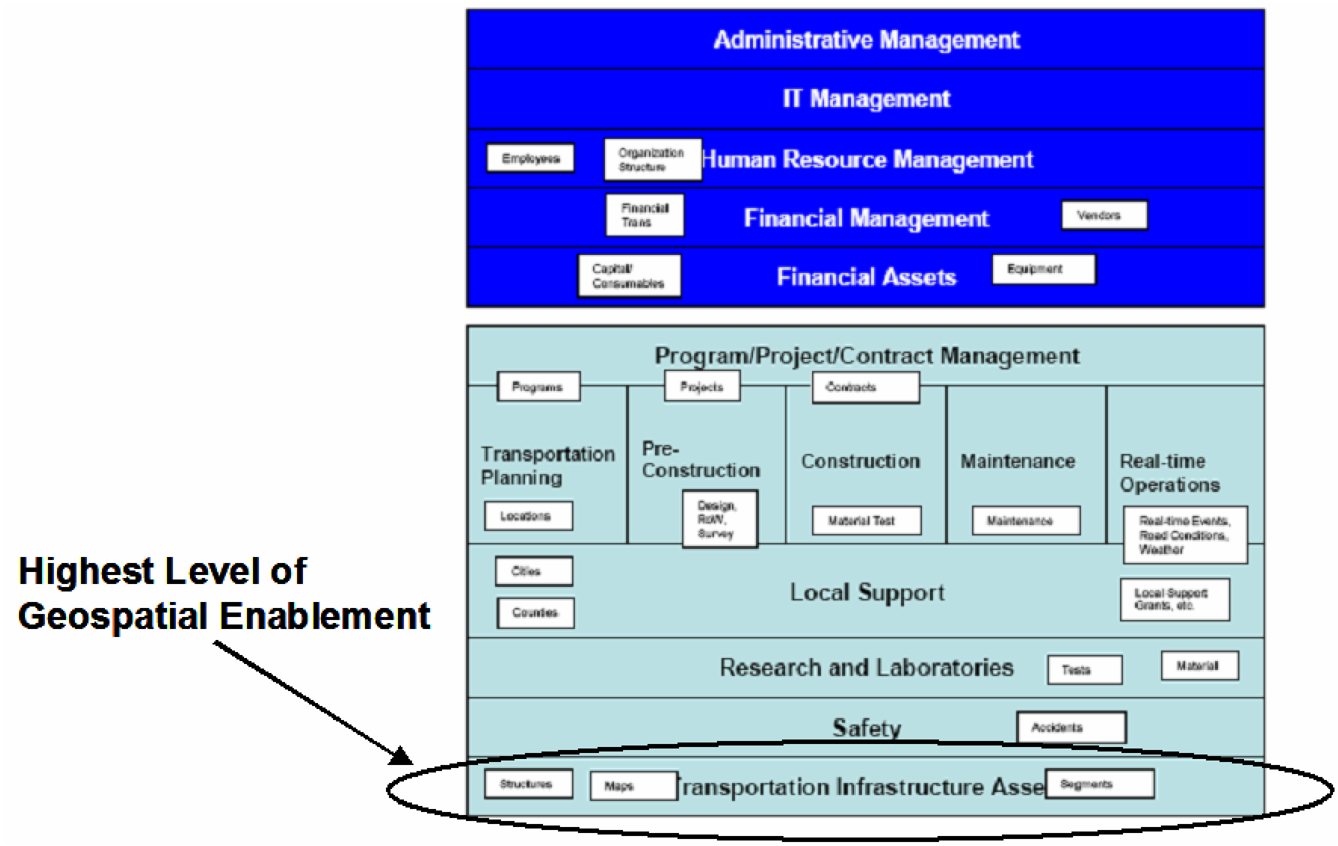


Table 6-1 is based on the Stakeholder Review and KDOT's Information Technology Management and Budget Plan (State FY 2006-2008) and shows geospatial enablement components for KDOT databases (in place or under development). Table 6-1 also shows data elements (that may or may not be spatially enabled) that 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							

	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.

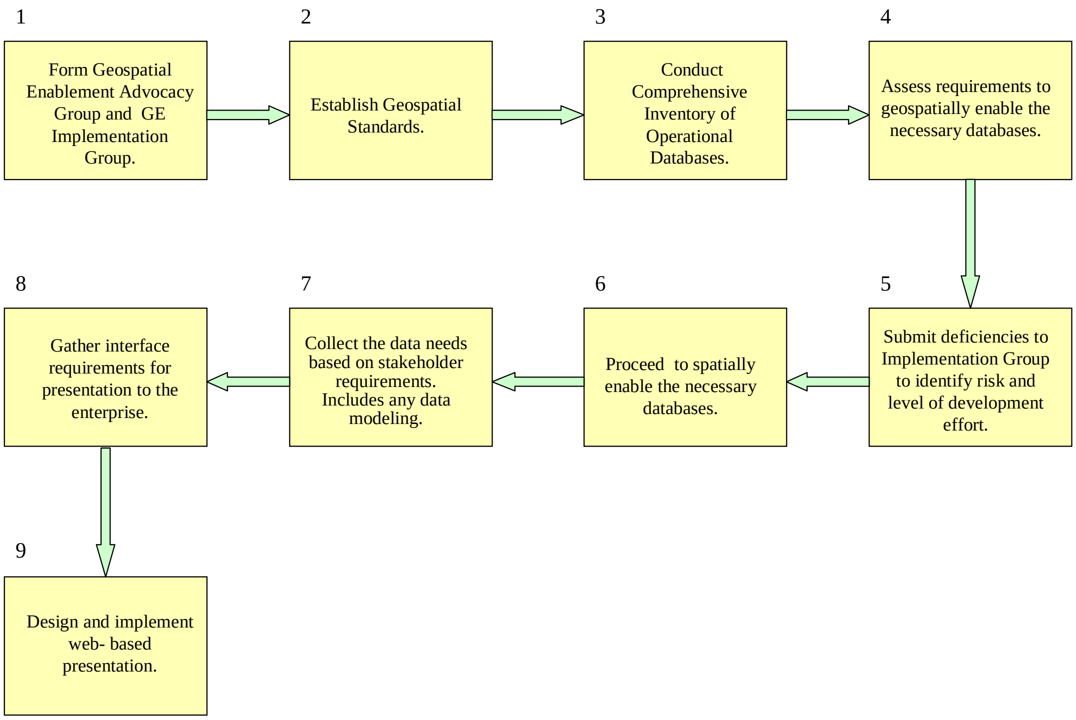
Certain institutional barriers have been overcome through partnering and open discussion and cooperation. KDOT's representation on the GIS Policy Board and technical committees and subcommittees of the Board has opened channels of communication, knowledge sharing, and data sharing. Continuation of these 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.

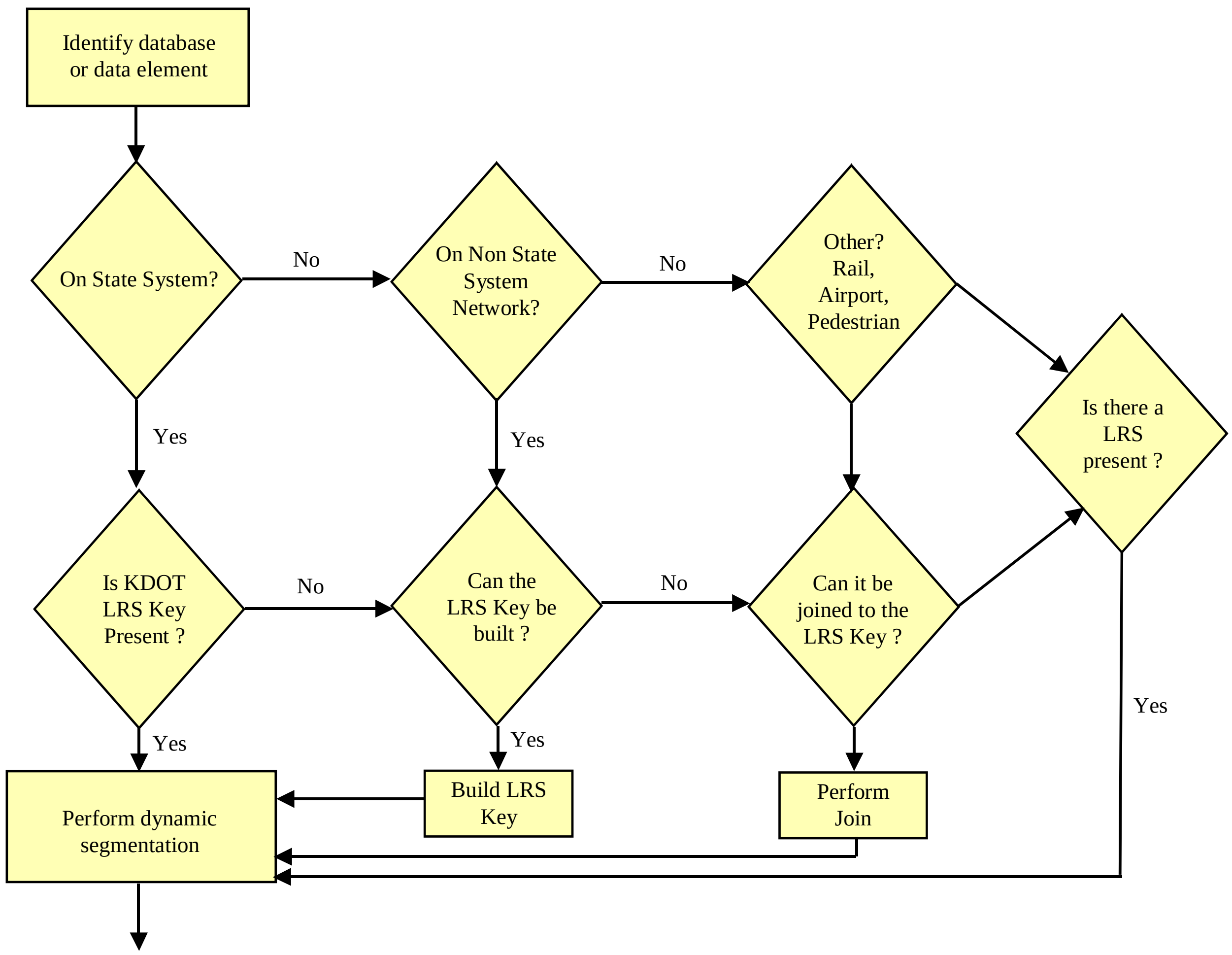
7. The next phase moves into the realm of user data needs across the enterprise. The Geospatial Enablement Advocacy Group should lead this. It will consist of defining stakeholder needs from the operational databases. This would help determine which specific pieces of information are most salient to 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).