GEOANALYTICS, INC.

DEVELOPMENT OF A LINEAR REFERENCING SYSTEM

Submitted to

State of Iowa Department of Transportation

RFP# LT99022

Proposal Date: April 19, 1999

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A Proposal for Professional Services Submitted by

GEOANALYTICS, INC.

To

State of Iowa Department of Transportation

To Provide Consulting Services for

Development of a Linear Referencing System

1 Executive Summary

1.1 Introduction

This proposal is respectfully submitted by GeoAnalytics, Inc., Madison, Wisconsin, (hereinafter "GeoAnalytics") to State of Iowa Department of Transportation (hereinafter "Iowa DOT") in response to a solicitation entitled *State of Iowa Department of Transportation Request for Proposals for the Development of a Linear Referencing System*, RFP LT99022. If accepted by Iowa DOT, a final Professional Services Agreement and Scope of Work will be negotiated and executed by GeoAnalytics and the Iowa DOT. Additional services, if any, will be undertaken by separate agreement. It is understood that this project will require Iowa DOT involvement to be successful. As a result, the Iowa DOT is committed to devote sufficient resources and staff time to ensure timely and fruitful completion of the project.

To address the needs of the Iowa DOT, GeoAnalytics has assembled a team of extraordinary competence, capability, and experience to undertake this linear referencing system ("LRS") project (hereinafter "GeoAnalytics Team"). This team features nationally recognized experts in the transportation and GIS industries. The range of experience and expertise is also extraordinary, including preeminent LRS theorists and authors. The team offers experts in the coordination and integration of information and technology, particularly GIS, information engineering, law, economics, and policy. The following is an Executive Summary which highlights the key components of this proposal. It is organized by the required proposal format.

1.2 Section 2: Introduction and Description of Problem

There are two dimensions to the circumstances giving rise to the project. One is a generalized problem that confronts the transportation industry and state departments of transportation in particular. The second dimension is specific to the Iowa DOT.

1.2.1 Generalized Problem Description

Government agencies, including state departments of transportation, are confronted with the need to accomplish more in a progressively constrained resource environment. At the same time agencies seek to measure performance in terms of efficiency and effectiveness. These measures have shown that information-based solutions and information technology provide many opportunities to enhance efficiency and effectiveness. One source of enhanced performance is the ability to leverage data investments across and within organizations.

Of significant impact to the transportation industry (and many others) is the use of spatial data and technologies as analytical and organizing instruments. Within the spatial framework, however, is the need to accommodate multiple methods of describing, organizing, using and disseminating locational data. The transportation industry as a whole and the Iowa DOT, in particular, have devoted considerable effort in research and planning to develop mechanism for location referencing. Much of that research has created opportunities for agencies by opening up the ability to a single LRS to support multiple functions. For transportation agencies, solving the locational referencing problem will provide great opportunities for performance enhancement.

1.2.2 Iowa DOT Assessment of Need

The GeoAnalytics Team performed a preliminary needs assessment of the LRS. The assessment identified key process, data, technology, organization, and system requirements. These requirements can be used to target areas of the LRS that need attention. The team provided an approach to benchmarking as well as examples.

1.2.3 Iowa DOT Problem Statement

With the backdrop of the industry as a whole, the Iowa DOT is confronted with their own specific version or variation of the generalized problem. While the commonly developed linear referencing models have applicability to Iowa DOT, they must be evaluated and adapted to meet both general and specific needs of DOT agencies. In part, these needs are a function of the unique business processes and mandates of the Iowa DOT. As well, these needs are driven by the practical requirement to preserve existing data and technology investments. Although the Iowa DOT has conducted considerable research and planning into spatial data and technologies and the development of an LRS, this project is intended to design, test, and measure the efficacy of an LRS. The final step of this project, assuming it efficacious to do so, is to develop a comprehensive plan for the development of the LRS that will meet the needs of Iowa DOT agencies.

Although involving spatial data and technology, this effort is very much like a standard Information System (IS) design. IS design literature and methodologies generally recognize a standard set of design components. Throughout this proposal the following design components serve as an analytical and planning framework to ensure the relevancy and robustness of the LRS Design. Each of these components are provided below. Each of these are used to define problem scope in this section:

- **Business Process**. Business processes include mandates and operational processes
- **Data**. The informational component address specific data and information needs to support business process.
- **Technological**. The technological (IT) component deals with the systems architecture that will used once the design has been implemented.
- **Organizational**. The organizational component addresses the implementation of the design in a fashion so that it can be managed and used across organizations by collectors, users, analyzers, and managers. These actors may be scattered geographically and organizationally.
- **Systems**. The system is the combination of all components together. In essence, the LRS. design component addresses the specific tools and applications needed to support business processes and decision making. To be successful, the IS design must comprehend and plan for systems and application.

The final issue in the Iowa DOT problem statement is the need to establish relevant and descriptive performance measures to ensure that the implementation of a LRS will serve the functional and economic needs of the DOT. In this case, this will involve the establishment criteria, measures and performance goals or baselines.

1.3 Section 3: Project Approach

GeoAnalytics has always had a strong process management dimension in its business. GeoAnalytics has developed and currently uses a project management system to monitor, control and manage its work. This system involves a set of people, procedures, data, technology, and reporting mechanisms to ensure the successful management and timely completion of firm projects. This system enables firm management and clients to have access to a wide range of information, including financial status, resource tracking and allocation, and project status. In addition to its internal project management system, GeoAnalytics provides project management services to clients.

1.3.1 Personnel

For this project, GeoAnalytics proposes that its project management system be used. In this system there are five distinct project management roles that are served by GeoAnalytics staff. Peter Thum, M.S., President of GeoAnalytics, will serve as project manager. The project manager has contract level authority to oversee the overall conduct of the project. The project leader, who is responsible for day to day management of the project, will be Thomas Ries M.S., GeoAnalytics Transportation Manager. Heidi Roberts, M.S., serves as the firm's project coordinator. She is responsible for tracking resources, status and budget. The final role is that of project staff. GeoAnalytics has assembled an outstanding project team that includes Alan P. Vonderohe, Ph.D., Nancy von Meyer, Ph.D., Sherry Coatney, M.S., William S. Holland, M.S., J.D., Aaron Cohen, M.S., and others.

1.3.2 Technology

Technology plays a critical role in GeoAnalytics project management system. This technology provides both the means of capture, analysis, and access to project information, including client access. There are three aspects to the technology component of the firm's project management system: Microsoft Project, Wind2 Financial Management System, and Internet Based Project Management. GeoAnalytics strongly urges the use of its Internet Based Project Management System that resides in a secure, password protected space on the GeoAnalytics web site. This system provides both the client and the firm the ability to communicate through e-mail and threaded discussion lists, schedule meetings, track issues, and report project status. This system is entirely customizable to meet client needs

1.4 Section 4: Technical Approach

GeoAnalytics will conduct the LRS Development Project using an information systems design methodology. The phases of this methodology move Iowa DOT's understanding of the LRS from conceptual to specific specifications to actual computer applications. The phases of this approach are consistent with the work areas and deliverables identified in the DOT RFP document (page 8). At each step, the IS design considerations of business process, data, technology, organizations, and systems are taken into account. The following is a high level outline of the system design methodology.

1.4.1 Phase 1: LRS System Design

A. Assessment and Analysis of LRS Needs and Expectations (including development of benchmarks for measuring LRS benefits)

B. LRS Design
   1. Conceptual LRS Design
   2. Logical LRS Design
   3. Physical LRS Design

1.4.2 Phase 2: LRS Prototyping (Pilot Project)

A. Pilot Project Plan Development
B. Pilot Project Execution
    1. Acquisition of System Architecture
    2. Construction of System Components
    3. Field LRS Data Collection and Benchmarking
    4. Office LRS Data Handling and Benchmarking
    5. Documentation
C. LRS Design Revisions (based on Pilot Project findings)
D. LRS Full-scale Implementation Plan Development

During each phase the GeoAnalytics Team will address in more detail the primary needs and issues identified in earlier phases. The Team presents in this section an overview and discussion of several key design issues to illustrate the team's technical competence in LRS, LRS development, and understanding of LRS in context to state departments of transportation.

1.5 Section 5: Project Management

Section 5 details the scope, activities, and products for each phase and task of the design methodology. In addition Section 5 proposes an organizational structure to support the project. The following is a narrative description of that organizational structure.

The success of this project will be determined, in large measure, by the nature and quality of the communication and coordination between the GeoAnalytics team and the Iowa DOT project team. In part, this success is a function of the project management system that is employed. GeoAnalytics proposes an organizational structure for the project that is comprised of GeoAnalytics, its strategic partners, and Iowa DOT and its strategic partners. Within this organizational structure, there are three distinct groups. The first is comprised of select Iowa DOT Senior Managers. This group provides visibility, resources and access to decision makers. Decision makers are, simply, essential to the long term viability and success of the development of a LRS for the Iowa DOT. The second group is the LRS Project Steering Team. This includes both consultant and Iowa DOT staff drawn strategically from areas within the Iowa DOT that are either principal producers of data or that can provide critical expertise to the project. The third level is the Core Project Team which will be comprised of consultants and project support and business function experts

1.6 Section 6: Qualifications and References

1.6.1 Firm Profile

GeoAnalytics, Inc., is an information technology company providing consulting services and applications and software development. The firm specializes in geographic and land information system (GIS/LIS) technology and management. GeoAnalytics is the successor to H_2GEO Consulting which was formed in 1991. Consulting services address the full range of public and private sector GIS/LIS implementation from assessments and requirements analysis to strategic planning to legal analysis and institutional strengthening to technology, system and data design and integration to Internet data publication. GeoAnalytics addresses client needs, resources and priorities using original, independent, rigorous and critical analysis in every engagement. The firm provides GIS/LIS related services including map production, environmental modeling and analysis, business geographics and Internet applications.

GeoAnalytics also develops and resells select software products that enable the adoption and use of these powerful technologies.

1.6.2 Project Team

The GeoAnalytics team offers the Iowa DOT an extraordinary array of expertise and experience. The GeoAnalytics staff has an average of more than 9 years of professional GIS experience, including nationally and internationally recognized experts. The Project Team will be composed of senior GeoAnalytics staff, support staff, select strategic partners, and Iowa DOT personnel. The GeoAnalytics Team will also include Alan Vonderohe with over 20 years of experience in the transportation industry, Sherry Coatney with 16 years of experience in Intergraph systems, and Nancy von Meyer with over 15 years of experience in information technology and consulting.

GeoAnalytics is unique in that it takes an interdisciplinary approach to information system design by bringing process management, legal, organizational, and economic perspectives to its engagements in addition to unparalleled technical expertise. GeoAnalytics works as a team with its clients to create solutions that meet the needs, business functions, resources and priorities of the client. GeoAnalytics' value proposition is that we provide quality, sophisticated consulting and applications development. The GeoAnalytics Team is uniquely qualified to assist the Iowa DOT in this exciting and interesting project.

1.7 Conclusion

On behalf of GeoAnalytics and its project team, thank you for the opportunity to provide this proposal. If you have questions or are in need of other clarification, please feel free to contact us at the address or phone number listed on the cover sheet. GeoAnalytics is willing to negotiate appropriate variations in the scope of work and budget given expectations and/or any constraints. We look forward to working with you in the future.

Respectfully,

GEOANALYTICS, INC.

William S. Holland, CEO		Peter G. Thum, President

2 Introduction and Description of Problem

2.1 Introduction

"Do more with less". While we hear this everyday, most state DOTs are spending time addressing this very real challenge. There are increasing demands for environmental considerations, significant pressures to complete projects in shorter timeframes, and decreasing organizational resources. Yet doing more with less is only half the challenge. Governments must now demonstrate improved performance. Many DOTs have established performance measures as a way of managing this. In an effort to meet performance measure goals, several DOTs have initiated significant efforts to streamline their processes that cross the functional lines of planning, design, construction, operations, and maintenance. Some state DOTs have improved data sharing in order to reduce duplication of effort and to reallocate resources. The bottom line is that DOTs must now be able to show explicit performance gains in the work process changes they make.

Thus, DOTs are seeking data-based solutions to their challenges. As they explore options, they are discovering yet another set of challenges. Data are difficult to access. In many cases, the existing older systems were not designed for the way DOTs want to use them today. If access is possible, the data may not easily integrate because there are no direct relationships among the data. Redesigning these 'legacy' systems is very difficult because of the large investment DOTs have in them. In addition, system redesigns never seem to go quickly. Finally, those who are actually successful in integrating the data have found that the complex data relationships make it very difficult to present the data in simple terms to stakeholders. Where does a DOT go to solve these issues?

Across the nation, DOTs have looked to the use of locational data to address these issues of accountability, data access, data integration, and legacy systems. Since the middle 1980's, DOTs began to recognize that much of their business data and processes have a locational component to them. DOTs believed that if they could leverage this commonality, they could significantly improve their data access, integration, and visualization problems (Briggs and Chatfield (1987); Fletcher (1987)). The growth of Geographic Information Systems for Transportation (GIS-T) in the early 1990's provided a forum to formalize the locational approach (Vonderohe, et al, 1993). During this period it became obvious that transportation location data standards were needed for location to be a successful tool. This was not unlike other national spatial data standards development efforts such as those of FGDC, NSGIC, etc. DOTs used a variety of location formats, many of which were not integrated themselves. Such issues prompted work like the National Cooperative Highway Research Program (NCHRP) Project 20-27(2) that resulted in one of the first nationally developed spatial data models for transportation location referencing (Vonderohe, et al, 1997).

The 20-27(2) model was adopted by the GIS-T Pooled Fund Study (Fletcher, 1995). Vonderohe and Hepworth (1996) sought to analyze specific cases of the 20-27(2) model. In the mean time, some state DOTs began to apply formal location referencing models (e.g., Minnesota, North Carolina, Utah, Wisconsin). Still others seek to find application-specific interpretations of the model (e.g., Siegal et al, 1996). Others are establishing standards (FGDC, 1998)).

While there has been much progress, some general key issues still exist and are relevant here. One issue is how to determine the spatial data accuracy requirements of transportation business functions. NCHRP 20-47 will attempt to provide insight to this. Another is how to establish field collection methodologies to meet accuracy requirements. Some work has been started in this area (Vonderohe and Hepworth, 1998a, 1998b). And finally, how does one capture and apply the time element in addition to space (location) for transportation needs? Work also has been started to address this issue, for example, in NCHRP 20-27(3) "Guidelines for Implementation of Multimodal, Multidimensional Location Referencing Systems for Transportation"(Dr. Vonderohe, a member of this proposal team, is a co-investigator).

2.2 Preliminary Situation (Needs) Assessment

The Iowa DOT faces many of the same business challenges that impact other state transportation agencies across the country. The following is a preliminary assessment of needs. The first section describes general conditions. The next section is an accumulation of key requirements used to compile the general conditions. The last section is a proposed approach to capturing benchmarks. This information was used to help scope the project, which is outlined in the last portion of this section. Also, identification of issues and solution strategies for some of the LRS requirement are detailed in Section 4.

2.2.1 General conditions

Process Conditions. The LRS design should avoid major restructuring of existing data collection processes. Clarification is required on the formal nature of the existing LRM maintenance processes. Data sharing processes between CTRE and Iowa DOT may need to be analyzed. There are no existing processes for the collection, management, and use of the reference datum. These processes are expected to be created in this project.

Data Conditions. In the existing data environment, Iowa DOT maintains digital maps for all counties and incorporated cities; the Iowa DOT is finishing its topological structuring of this data (1:100,000 in most areas, 1:24,000 in some urbanized areas). The Base Record DB has a major amount of existing attribute data relevant to the highway, and this database is directly linked to the spatial data. Other data is maintained in disparate systems around the DOT (highway access, safety features, maintenance locations, material tests, construction information, crashes, wetlands, etc). In this new System, integration between these data must be possible using the LRS. In addition, the new LRS must support temporal and accuracy requirements. Given the information provided, temporal requirements are not formalized and accuracy requirements will need to be clarified.

Technology Conditions. The Iowa DOT has established software standards for GIS and a relational database management system. Intergraph's Modular GIS Environment (MGE) and MGE Segment Manager will be used to provide high level GIS capabilities, including dynamic segmentation. For analysis and end-user application development, the Iowa DOT has selected GeoMedia. Oracle will provide the enterprise database management system, including the GIS database. These standards will provide the basic platform for the technical support of the LRS. For the most part, the established hardware and networking environment appears to be able to support the LRS project. The Iowa DOT has determined that, in general, the selected software and hardware environment should be adequate as a basis for the development of a robust LRS. It will also be necessary to identify any additional software that may need to be developed in order to extend or modify the existing technical environment in order to overcome any limitations to the systems that prevent the successful implementation of the LRS data model.

Organizational Conditions. Six divisions are currently directly involved in the success of the LRS. A strategy to institutionalize the new LRS is required. Some key GIS support staff are in place but more are necessary. An analysis will be needed to determine staff resources for managing the LRS and LRMs. A structure will be needed to ensure the LRS management involves all of the Iowa DOT. The inter-actions regarding LRS with external agencies may need to be more formalized.

Information System Conditions. A limited number of staff can query and create maps from the base record system. CTAMS, ALAS, Pavement Management, Highway Access Management use spatially-referenced data for data access and decision-making. The Base Record and its relation to the Base Map will be improved as a result of this project. The LRS, itself, may become one or more information systems.

2.2.2 Requirements

There are key requirements from which the general conditions will be derived. The requirements will be clarified, prioritized, and appropriate ones targeted for benchmarking. The requirements are grouped by process, data, organization, technology, information systems integration, LRS collection, and LRS Use.

Process. The design must enhance the efficiency of data access, input and maintenance. The design must provide a LRS that is capable of integrating the many linear referencing methods that are utilized in the Iowa DOT as well as provide improved data integration and access, and minimize redundancy in the database systems.

Data Requirements. The design must have the ability to reference point, linear, polygonal and spatial data. Improve relative and absolute accuracy of the features referenced to the road network. Consideration must also be given to how to model multiple lane highways, such as interstates. The design must accommodate all public roads in the state of Iowa (state, county and municipal) including entrance and exit ramps. The historic or temporal component of the linear data must be considered in the LRS design. The design will include other transportation systems (rail, water, etc.). Relative and absolute accuracy will be initially defined. Structures located along a roadway should be maintained as linear features. The beginning and ending linear extents of such structures should be maintained with respect to the centerline of the roadway.

Organizational Structures, roles and responsibilities (linked to process). The design must propose a strategy for institutionalizing the new LRS and identify the areas where policy and procedure changes are necessary for successful implementation. Adequate staff must be assigned to facilitate intra-agency communication, communicate recommendations to local governmental agencies, partner with local governmental agencies. The design shall not be division specific, but shall be usable by all divisions for referencing data to the road network

Technology. The LRS should be "friendly" to current and emerging technologies (e.g. Geographic Information System (GIS), Global Positioning System (GPS), and Intelligent Transportation System (ITS)), and easily adaptable to future technologies. It must use Iowa DOT standards.

Information System Integration and Use. The LRS must integrate the Coordinated Transportation Analysis and Management System (CTAMS) so that they can query the data referenced to the new LRS. It should provide improved data integration and access capable of integration with the federal aid eligible system. The design must be able to provide processes to simplify the Iowa DOT's reporting requirements to the Federal government.

LRS collection. The design must identify the processes that shall establish the linear referencing system datum in the field. The design must consider the data collection processes and make sure that no process becomes burdensome for the field personnel who collect the data or the data input staff who maintain the databases. The design must enhance the efficiency of data access, input and maintenance. The integration of data external to the Iowa DOT must be considered, especially in relation to data that may not be formatted in the same methods related to divided or undivided roads. The LRS should provide improved data integration and access, minimize redundancy in the database systems, and avoid major restructuring of existing data collection processes.

<u>LRS maintenance.</u> The design must address the processes in which the referencing system shall be maintained. The design must consider the data collection processes and make sure that no process becomes burdensome for the field personnel who collect the data or the data input staff who maintain the databases. The design must enhance the efficiency of data access, input and maintenance. It should minimize the data maintenance needed for any changes in the transportation network as well as minimize redundancy in the database systems

2.2.3 Benchmark Approach

Benchmarks will be linked to an Iowa DOT business purpose and based on improving the effectiveness or efficiency of the Iowa DOT business purpose. This relationship puts the benchmark in context to the business, gives the benchmark purpose, and gives the benchmark priority to other benchmarks. For example, a business function is safety analysis. It may be necessary to improve how effective and efficient data integration is for this function.

It may also be helpful to define what the GeoAnalytics Team interprets *effective* and *efficient* to mean. The team defines effectiveness as meeting business requirements. An example of effective measures may be capability (can we meet this requirement or not), error rate, accuracy, actual to plan (did we meet objectives), demand satisfaction (right product, quantity, place, time), and response time. The GeoAnalytics Team defines efficiency as meeting business requirements with a minimum use of resources. Examples of efficiency measures are cost/transaction, time/activity, asset utilization, output/unit, inventory, and turnaround time (without adding resources). On the safety analysis example, we may want to focus on integrating crash counts and average daily traffic data to create crash rates. The pilot project will compare current integration methods for using the LRMs and the linear datum. In this case, effectiveness may be capability and resulting error in crash rates. An efficiency measure may be staff and computation time necessary to create the integrated data.

2.3 The Problem Statement

Iowa DOT shares similar business challenges to other DOTs and is aware of the value location has to a DOT. They have studied the latest work in location and linear referencing and have evaluated their own location referencing systems and have determined their general needs. They, too, believe improvements in their location referencing can improve their performance.

Given Iowa DOT location formats and related systems (composed of processes, data, organizations, and technology), how should Iowa DOT structure and implement their Linear Reference System, and will Iowa DOT be able to show how such an investment addresses the problems they face?

2.4 Problem scope for this project

This project will clarify the need for, define the management and application requirements of, and demonstrate the purpose and potential benefits of a LRS for the Iowa DOT and its partners. Because the LRS is a complex information system, it will be necessary to decompose the LRS into definable pieces for which scope can be articulated. All information systems have four key components that must be defined, managed, and integrated for successful implementation and long term existence. These elements are data, process, organization, and technology. To define the scope of this project, the scope of each of these components are described below.

2.5 Data

Figure 2-1 illustrates the data and its inter-relationships that the project team assumes comprise the scope for this project. The figure is the conceptual model from the NCHRP 20-27(2) work. The darkened objects are considered in scope. Below is a description of this Figure.

1. The datum and networks (i.e., traversals, or routes) will be defined.
2. The relationship between the datum, networks and targeted Iowa DOT location reference methods will be defined. The location reference methods targeted are:
   - Mileposts
   - Stationing
   - Link-nodes (ALAS)
   - Segmental referencing techniques (Base records)
   - Cartesian coordinates (map projections)
   - Literal descriptions
   - GPS (latitude and longitude, elevation)
   - Milepoints/kilometer points/meter points
3. The relationship between business data and LRMs will be analyzed only to be certain that business locations can be transformed from one format to another.
4. The relationship between the datum and cartography will be defined, with an understanding that it must be defined such that different cartography can be linked to the datum simultaneously.
5. The way the cartography is defined in the Base Record System will be impacted.
6. The geographic extent of this project is limited to selected roadways in Story County, Iowa.
7. Data qualities will be established as part of benchmarks in the assessment phase and detailed in design.
8. Not included:
   - Not all Iowa DOT LRMs are included along those listed above; likewise, no “new” LRMs will be defined.
   - Business data will not be defined, and will be provided in the necessary format required for the pilot.
   - Cartographic data will not be created, and will be provided in the necessary format required for the pilot.

2.6 Process

Figure 2-2 lists the basic elementary processes that are performed in the life cycle of data. This figure illustrates that the project team assumes that not all processes will be evaluated for this project based on the RFP and feedback from submitted questions.

1. Datum collection processes will be performed, but only for a limited area within the pilot area.

2. Existing business data collection processes will be analyzed for impacts only as they relate to the collection and management of linear reference methods, not the business data collection use of linear reference methods.
3. Process effectiveness and efficiencies: these will be established in benchmarks and fine-tuned in design.

2.7 Organization

The following are the team's assumptions regarding the scope of organizational elements in this project:

1. For the functions outlined in the process table, the roles, responsibilities and organizational relationships will be defined for those who will perform the processes for the datum, network, and their inter-relationships with other data objects.
2. For the processes outlined in the process figure, the roles, responsibilities and organizational relationships will be evaluated and impacts determined for those who perform the processes for the cartographic representations, LRMs, and their inter-relationships with other data objects.
3. Organizational effectiveness and efficiency will be established as part of benchmarks in the assessment phase and detailed in design.
4. Organizations included are Iowa DOT and CTRE; other selected state agencies and some local governments may be included.

2.8 Technology

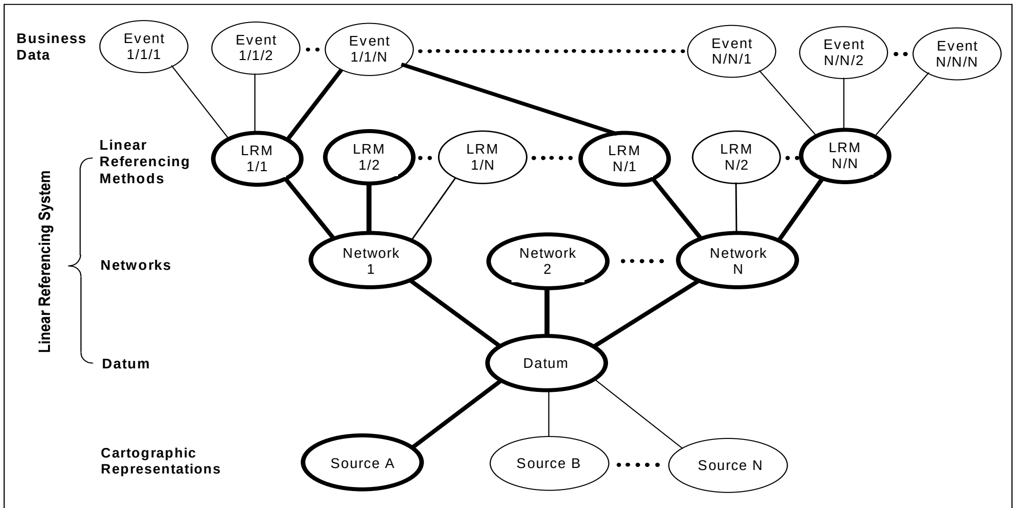
The following are the project team's assumptions regarding the scope of technology elements that will be applied in the project:.

1. Office systems: Intergraph's Modular GIS Environment (MGE), including MGE Segment Manager; GeoMedia, and Oracle Enterprise Relational Database Management System. The database interface may be either ODBC or Intergraph's Relational Interface System.
2. Field systems: GPS, DMIs, videolog van and related technologies, Roadware ™ van and related technologies, field inventory distance measuring devices (.e.g., DMI).
3. Technology effectiveness and efficiency will be established as part of benchmarks in the assessment phase and detailed in design.
4. Not included: DB2-Oracle interfaces, IDMS, GeoPak (for project plan and distance measurements); it is assumed that Iowa DOT staff will provide required data from the information systems that exist in these technologies.

2.9 Information Systems

The GeoAnalytics Team has interpreted the project scope to not include modification of any existing information systems other than how the LRMs relate with the reference datum. The one exception will be to suggest modifications to the Base Record and its relation to the Base Map. The team also understands that all data will be provided by Iowa DOT in the pilot project environment, and that the functions listed in Figure 2-2 will also be performed in the pilot project. For example, the modifications to the following systems are out of scope: CTAMS, ALAS, Pavement Management, and Highway Access Management.

Figure 2-1



Conceptual Overview of Linear Referencing System Data Model
(after Vonderohe, et al, 1997)

Figure 2-2

			Use/Apply				
Data	Collect Data	Update & Manage Data Base	Select & Extract Data for Use	Integrate Data for Use	Analyze Data	Display, Report Results	
Business Data							
Relationship							
Linear Reference Methods							
Relationship							
Networks							
Relationship							
Datum							
Relationship							
Cartographic Representation							
		Legend					
			Develop and Test				
			Develop and Test Impacts				
			Out of Scope				

3 Project Approach

3.1 Overview

GeoAnalytics has always had a strong process management dimension in its business. GeoAnalytics has developed and currently uses a project management system to monitor, control and manage its work. This system involves a set of procedures, data, technology, and reporting mechanisms to ensure the successful management and timely completion of firm projects. This system enables firm management and clients to have access to a wide range of information, including financial status, resource tracking and allocation, and project status. In addition to its internal project management system, GeoAnalytics provides project management services for clients.

In addition to its project management system, the GeoAnalytics staff has extensive experience and expertise in the management of large-scale projects. For example, at the present time, GeoAnalytics is conducting two projects of a similar size, scope, and complexity as the LRS project. One is the Local Road Database Redesign project underway with the State of Wisconsin Department of Transportation. The second is the Wisconsin Electric Power Gas Facilities Database and Maintenance Project, which includes database redesign, maintenance, facilities management, and applications development. Tom Ries, who will serve as project lead, is formally trained in process management and project management and spent four years at the Wisconsin Department of Transportation in that capacity. Until 1995, William Holland served as Executive Director of the Wisconsin Land Information Board where he managed the implementation of the Wisconsin Land Information Program, the nation's premier effort at the development of integrated GIS/LIS on a statewide basis. Nancy von Meyer was the lead on the development of the Federal Geographic Data Committee Cadastral Standard. Other GeoAnalytics project team members have served as principal investigator on numerous projects, including Alan P. Vonderohe (University of Wisconsin-Madison), Peter Thum, and Sherry Coatney (while at Intergraph Consulting).

3.2 GeoAnalytics Project Management System

If selected for this project, GeoAnalytics strongly recommends the use of its project management system. This system leverages the talents and energies of individual project participants by making use of technology to bridge physical distances and to enhance communication. In particular, this system makes use of Internet technologies to provide communication, issue tracking, calendaring, and workgroup management. Making use of a secure, private space on the GeoAnalytics web site, this system enables project participants to access information from anywhere in a technology neutral, thin-client environment. The following provides a brief overview of the firm's project management system.

3.2.1 Personnel

The key to any project management system is communication and the coordination of personnel working on a given exercise. Personnel affected by the project management system include not only the GeoAnalytics team (staff and its subcontractors) but also members of the client team, including its staff and other strategic partners. To facilitate communication and coordination among these diverse parties, GeoAnalytics established a set of four distinct, predefined project management roles.

- **Project Manager.** The Project Manager is an executive level staff member such as a principal or vertical market manager. The Project Manager's role is to ensure that the project is properly planned and completed, including project scoping, phasing, budgeting, client communications, quality control and quality assurance, and project monitoring. The Project Manager has contract level authority in order to meet the changing needs of clients and projects. If GeoAnalytics is chosen to undertake this project, Peter G. Thum, one of the principals of the firm, will serve as Project Manager.

- **Project Leader.** The Project Leader is responsible for day to day management of a given project. This individual serves as the principal point of contact and communication between GeoAnalytics and the client. In addition, the Project Leader provides technical direction, supervision and coordination of assigned staff, and management and deployment of project resources. GeoAnalytics has a very strong preference that the client team includes a counterpart to the Project Leader. If GeoAnalytics is successful in securing this project, Thomas Ries, the firm's Transportation Vertical Market Manager will be assigned as Project Leader.
- **Project Coordinator.** GeoAnalytics employs a full-time Project Coordinator. The Project Coordinator responsibility is to track firm resources, project status and budgets, and assist Project Leaders in the analysis and management of projects from an overall firm perspective. The Project Coordinator uses both Microsoft Project and the Wind2 Financial Management System to accomplish these functions. Heidi Roberts is GeoAnalytics Project Coordinator.
- **Project Staff.** GeoAnalytics uses a team approach to projects that draws on the collective expertise of the firm, its strategic partners and client project participants. Work is assigned in accord with staff availability and expertise. The GeoAnalytics team uses both automated time entry and continuous communication to record and track project status. Coordination among all project staff, both GeoAnalytics and client, is accomplished through a mix of facilitated process and technology.

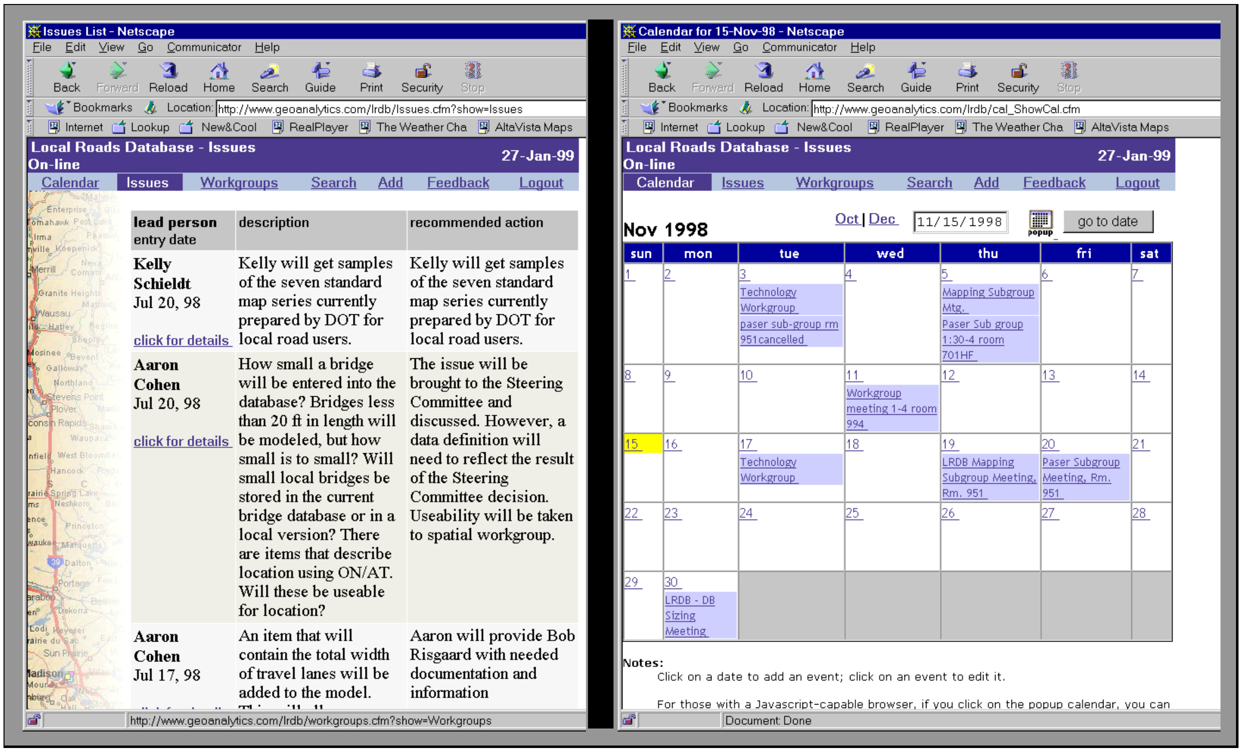
3.2.2 Technology

Technology plays a critical role in GeoAnalytics project management system. This technology provides the means of capture, analysis, and access to project information, including client access. There are three aspects to the technology component of the firm's project management system.

- **Microsoft Project**. GeoAnalytics uses Microsoft Project to track and manage significant projects. This database-driven software package facilitates the planning and execution of projects by the aggregation and disaggregation of project phases, tasks, and subtasks. In addition, MS Project allows for resource delegation, allocation and leveling, communication and reporting, budget tracking, and critical path modeling and management. MS Project also provides for project tracking, including comparisons of baseline and actual progress, and resource deficiencies.
- **Wind2 Financial Management System**. Wind2 is a database-driven financial management system designed specifically for professional service organizations like GeoAnalytics. GeoAnalytics has created a database design that permits integration of MS Project and Wind2 data. In addition, Wind2 Software, Inc., the manufacturer of Wind2 is scheduled to release a direct link between Wind2 and MS Project early in 1999. Wind2 provides an extensive set of standard and custom reporting options to monitor and manage the financial dimension of projects.
- **Internet-Based Project Management**. GeoAnalytics has developed and implemented a Web-based project management system that resides in a secure, password protected space on the GeoAnalytics web site. This system provides both the client and the firm the ability to communicate through e-mail and threaded discussion lists, schedule meetings, track issues, and report project status (Figure 3-1). This system is entirely customizable to meet client needs. At the present time, GeoAnalytics is using this for two large projects, the State of Wisconsin Department of Transportation Local Roads Database Redesign and the Wisconsin Electric Power Gas Facilities Database and Maintenance projects. If selected for the Iowa DOT LRS project,

GeoAnalytics would implement a customized version of this Web-based project management system. This would provide both client and firm project participants to have access to a wide range of project information.

Figure 3-1 Internet Issue Tracking and Calendar Function



3.3 Needed Iowa DOT Resources

It is expected that the GeoAnalytics team will need only minimal *physical* resources from the Iowa DOT to complete this project. Resources may include meeting space, occasional work space, access to data and perhaps, network resources.

With respect to access to Iowa DOT staff resources, there may be more demands. The success of this project will be dependent, in large measure, on the relevance of the design to affected agencies and individuals. Accordingly, it is expected that some level of Iowa DOT staff commitment must be made to the project. For example, staff must be available for workshops, interviews, project meetings, etc. Section 5-4 details an organization structure for the project. Those individuals closely involved in the project will need to have the sanction to commit staff time to ensure success of the project. In some instances, the level of commitment will be high. For example, it can be reasonably expected that the DOT's principal investigator will be engaged in this project at least 25% of the time. On occasion, some business experts will devote nearly full time for short periods of time. In preparing the project plan, it has been assumed that minimal Iowa DOT staff resources will be available. Nevertheless, as a final scope of work is developed, the exact Iowa DOT staff needs will be clarified.

One area in which it may be advantageous for the Iowa DOT to make more staff commitment will be in the pilot project. This is for two reasons. First, Iowa DOT may be able to save additional financial resources by using its own staff to complete field work and some office work. More importantly, an important part of the pilot will be to engage and educate staff on various aspects of the LRS design and implementation. Typically, GeoAnalytics encourages clients to involve staff in projects as much as possible in order to assure sustainability. A number of technical positions have been identified as needed for the pilot project. While GeoAnalytics is willing to retain others to complete these tasks, it will be advantageous for the Iowa DOT to provide internal staff as well. However, again, the exact extent and scope of Iowa DOT staff commitment can be negotiated if the GeoAnalytics team is selected for this project.

4 Technical Approach

4.1 Overview

GeoAnalytics has assembled a team for this project, made up of internal staff resources coupled with strategic business partner relationships. This team has the expert technical competence necessary to both fully understand and complete the design, development, and benchmark testing of a comprehensive LRS for the Iowa DOT. This technical competence is grounded in an in-depth understanding and experience with the business and information processing requirements of state transportation departments, especially in the context of location reference.

In addition, all team members have experience working on large-scale system and database design projects that require enterprise-wide solutions to interrelated business workflow, data, technology, and organizational problems that are often cross functional in nature. A strong characteristic of the team is its knowledge of the applied integration of various technology and data system types that is often necessary for an organization to preserve (or leverage) existing investments in hardware, software, and data communications while delivering new business driven applications to the employee desktop.

This section first describes how the GeoAnalytics team will approach this project using a systems design methodology. Second, this section provides an overview on how transportation business drives LRS development. The final section describes specific Iowa DOT LRS issues and how the system development approach will help resolve them.

4.2 System Design Methodology

4.2.1 System Components.

The proposed design methodology describes a system as a set of processes, data, technology (tools), and organizations (arrangements). It is important that the project team design for all components of the LRS. A general example of the LRS components is as follows.

- Processes: reference datum collection, management, and use processes
- Data: datum, network, linear reference methods, etc.
- Technology: the information technology used in the field (GPS), data base management systems (Oracle), GIS (Integraph MGE), NT Computers, etc.
- Organization: arrangements between divisions within Iowa DOT and arrangements with other external units of government (county or city to obtain new road plats, CTRE, etc.)

The GeoAnalytics team will design the system so it is fully integrated as part of the overall Iowa DOT enterprise of systems.

4.2.2 Design Methodology

The proposed methodology takes the system through several phases: situation assessment, conceptual design, logical design, physical design, and construction, transition, and production. On this project, we are only going through construction. In each phase, all four system components are analyzed and system requirements or specifications are documented or implemented. This methodology aligns with the RFP project outline as shown in Bidder's Reference Form

Bidder's Reference Form

Nancy von Meyer (Fairview Industries)

Info		
Name of references organization		Michigan
Name of Primary Contact on project (References Project Manager)		n
Contact's Title		
Contact's address	Building 50 Denver Federal Center Denver, CO 80225-0047	h Road #49W Pontiac, MI 48341
Contacts Phone Number		
Contact's FAX Number		
Completion date of project being referenced		
Total project cost		
Amount of cost for which the reference's firm was responsible		

Table 4-1.

Bidder's Reference Form

Bidder’s Reference Form

Bidder’s or Subcontractor’s Name: Nancy von Meyer (Fairview Industries)

Information Requested	Reference 1	Reference 2
Name of references organization	Federal Geographic Data Committee	Oakland County, Michigan
Name of Primary Contact on project (References Project Manager)	Robert Ader	R. Scott Oppmann
Contact’s Title	BLM GeoSciences Team Leader	GIS Manager
Contact’s address	RS 120 Mail Stop Building 50 Denver Federal Center Denver, CO 80225-0047	1200 N. Tlepgraph Road #49W Pontiac, MI 48341
Contacts Phone Number	303/236-3587	248/452-9198
Contact’s FAX Number	303/236-6564	248/452-9126
Completion date of project being referenced	September, 2000	December, 2000
Total project cost	$300,000	$250,000
Amount of cost for which the reference’s firm was responsible	100%	100%

Table 4-1 Project Outline and Design Methodology Phases

Project 1	
	Phase 1 - Linear Referencing System (LRS) Design
Situation Assessment	- Assess needs and establish benchmarks
Conceptual Design	- Develop LRS design
Logical Design	
Physical Design	
	Phase 2 - Pilot LRS Implementation
Construction	- Develop pilot plan
	- Perform and document pilot
	- Revise final LRS design and analyze benchmark criteria
	- develop plan for full-scale implementation
Project 2	
Transition	Full scale LRS Implementation
Production	

4.2.2.1 Situation (Needs) Assessment

The situation assessment will be conducted by the GeoAnalytics team to clearly define expressed or demonstrated need for a comprehensive LRS. The situation assessment will include an inventory and report of existing conditions within the agency with respect to business functions and their related process, data, technology, and organization. In addition, the Iowa DOT and its staff expectations for improved business operations, as a result of more efficient and effective handling of business data, will be identified along with the types of issues and/or challenges associated with accomplishing improvement through the implementation of a LRS.

As part of the situation assessment process, a clear list and definition of benchmarks for measuring the benefits of implementing a LRS within the agency will be identified and defined. These benchmarks, at a high level, will be driven by the need to show improvements in the efficiency and effectiveness (benefits) of agency business functions. At a lower level, benchmarks will be defined operationally, including the type of operation to be tested, by whom and under what conditions, and the measure of change based on current practices that needs to be demonstrated in order to show improvement (benefit) in a particular business area.

The scope of the situation assessment will be broad enough to capture all aspects of enterprise operations potentially impacted by implementation of a LRS. Though the details of many business areas will not be the focus of later design process steps, the team believes it important to capture a complete view of agency functions in order to provide an overall context for design and implementation decisions made later on. For example, it will be important to understand the current Iowa DOT IT infrastructure and planned linkages between different data systems at some level of technical detail even though pilot development and testing of a LRS will ignore many physical IT system dependencies. This is necessary since development of a full-scale LRS implementation plan after pilot benchmarking will require knowing some physical details of existing and future system linkages as part of the agency’s geo-spatial data warehouse rollout.

Mechanisms for completing the situation assessment will include a review of completed agency research coupled with targeted staff interviews. They will provide much of the context for this situation assessment.

4.2.2.2 Conceptual Design

Conceptual design will involve the development of high-level views of each of the four components and their relationships to each other. Additional views will include the LRS system relationships to the overall DOT enterprise of systems. The conceptual design identifies the major system components and their relationship to one another. This design step will be used to develop consensus on a high level view of an acceptable LRS structure that addresses the defined need for better location management and business data integration. The structure will build on existing Iowa DOT work and incorporate work from research efforts across the country. Current and proposed business processes related to LRS creation, management, and use will also be identified and diagrammed.

Like the situation assessment, the scope of the conceptual level design is broad in order to understand the scope of the LRS in context to other relevant business systems of the Iowa DOT.

4.2.2.3 Logical Design

In the logical design step, the team will focus on determining specific LRS requirements. Logical design captures “what” of each of the four components, independent of the “how”. For example, in the case of a LRS datum component, an “anchor point” is what the Iowa DOT needs, regardless of how it is defined in an Oracle database table. The value of this strategy is that logical design can last for 10-30 years. The “how” (determined in physical design) – which includes technology - may last only for 3-7 years. Logical design will capture LRS system names, definitions, qualities, relationships, and also the who, why, when (how often), and quality (data quality or performance). These take the form of entity-relationship diagrams (data), process charts, organizational charts, and technical diagrams, and support documentation.

At this in point in the design process, the main focus will be on LRS component requirements and their relationships. However, the team will also attempt to capture any information about other enterprise systems if they relate to operationalizing benchmarks needed for demonstration of LRS benefits. Also, for benchmarks that include testing performance, the GeoAnalytics team will work with the Iowa DOT staff to clarify current and expected performance. To the extent possible, the GeoAnalytics team will describe current situations (like current processes) and should-be situations (for example, current processes with recommended changes).

Logical data modeling and design will be handled primarily as a group exercise including focused sessions with Iowa transportation business experts. Since the Iowa DOT will be using industry templates (for example, 20-27 (3) work) the team will most likely be able to spend more time on design specifics, such as those outlined in the problem definition (Section 2 of this proposal). Examples include time, resolution, reporting, integration, etc. GeoAnalytics team members are experienced using a variety of data modeling tools. A final decision on the appropriate toolset would be made in conjunction with the Iowa DOT staff to ensure compatibility with agency preferences.

4.2.2.4 Physical Design

Physical design will develop technical specifications in the targeted technologies (MGE, Oracle, etc.) that will implement the requirements captured in logical design. This phase will also require a review of technology options that can provide a physical framework for construction and testing of all system components. This will need to address both in-office and field dimensions of the system design.

The Iowa DOT has identified and is currently implementing a suite of IT infrastructure components, including GIS, as part of an overall modernization of agency information collection and management operations. The GeoAnalytics team will use this as the initial framework for physical design. Final decisions on technology choices will need to be made as part of this design step.

All four components (processes, data, technology, and organization) will have physical implementation specifications (which include procedures) at this step in the process. Specifications will be created for LRS database structures, management tools, field collection, data access, integration, analysis and reporting. Physical data design specifications will be developed by the using appropriate physical data modeling tools that are compatible and/or preferable to the Iowa DOT staff.

4.2.2.5 Construction and Testing

The final phase of design for this project is construction and testing of the prototype LRS system. This includes in-office and field level workflow processes (process), linear and geographic databases (technology and data), and data collection, management, and analysis software tools (technology). The main purpose of this phase is to validate that defined LRS business requirements, agency expectations, and design specifications have been met. The GeoAnalytics team plans to handle this design step as four (4) sub-tasks:

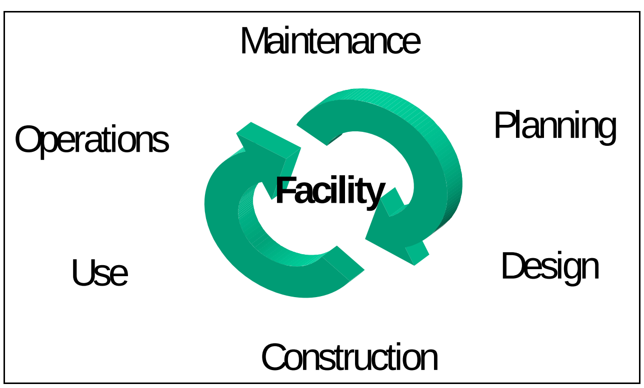
1. Acquisition of LRS System Architecture Environment (data, technology, etc.)
2. Construction of LRS System Components
3. Field LRS Data Collection and Benchmarking
4. Office LRS Data Handling and Benchmarking

Sub-tasks will be conducted in parallel to the extent possible to ensure timely completion of this design step. Lessons learned from this process will be used as feedback to modify any level of LRS design decisions depending upon the results of the benchmark analysis.

4.3 LRS Overview

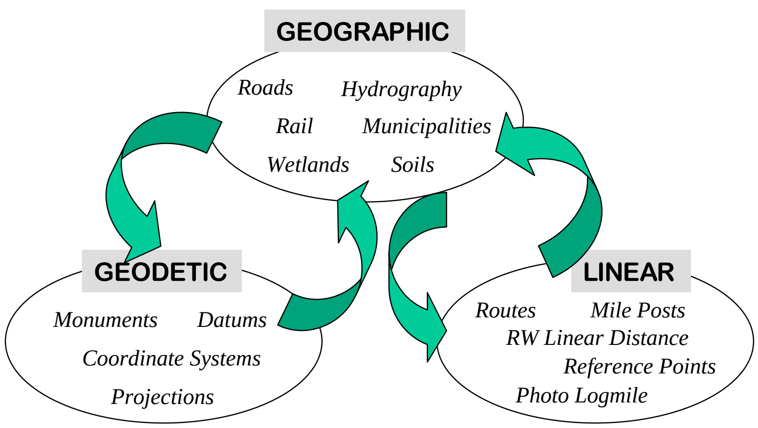
A primary business purpose of state DOTs is to manage transportation facilities. Figure 4-1 shows the relationships of the traditional business functions that state DOTs perform to manage the facility throughout its life (Ries, 1995). Although simplistic, the life cycle graphic illustrates not the department's organization chart but the business processes that must align to provide effective and efficient products and services to the public. A key challenge is making the cycle run smoothly. This cycle is made of processes, and it is information in the form of data that flows through most DOT processes. With location as the common element in most of this data, DOTs are seeking to leverage location referencing to share data and improve data flow.

Figure 4-1 Business function relationships



In order to leverage this commonality, DOTs need to determine their location referencing needs. Wisconsin DOT evaluated their location requirements of the facility life cycle and determined that three types of location referencing must be supported: geodetic, geographic, and linear (Ries, 1993). Figure 4-2 illustrates the inter-relationships of these and provides examples of different forms. Geodetic reference defines location space. Geographic reference defines what exists in the geodetic reference. Linear reference defines the "where" along the geographic reference. In order to use location to improve facility life cycle processes, these references and transformations between them need to be defined. The facility life cycle also helps determine data quality requirements and puts them in context to DOT business processes. Vonderohe, et al (1993) summarized the variance in required levels of accuracy, scale and geographic extent for different business functions in the life cycle as shown in Figure 4-3.

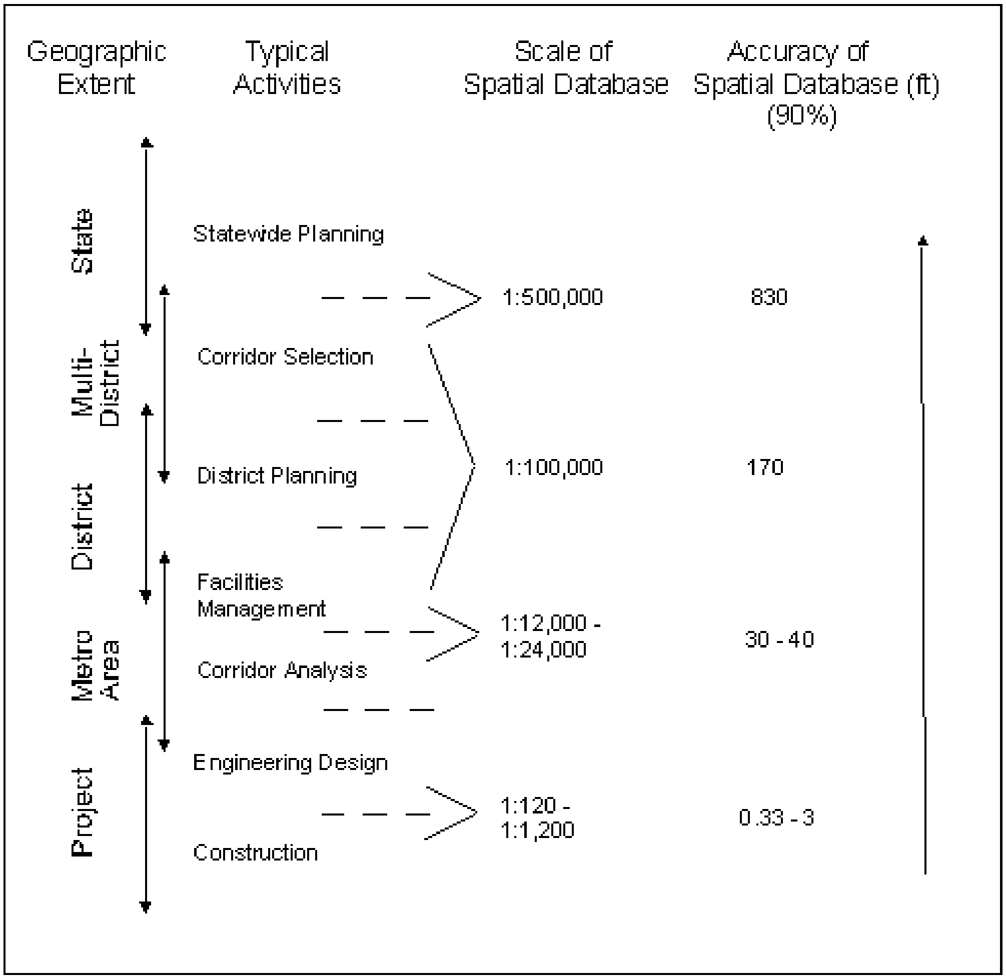
Figure 4-2 Location reference relationships



To use location to support the business processes of the facility life cycle requires not one location format, but several managed through a location referencing system. This location referencing system should collect and manage the geodetic, geographic, and linear reference types and the relationships between these. The system should support the variance in quality requirements that are found along the facility life cycle.

Iowa DOT's Location Reference System team also reached such findings in their research. From this work, the Iowa DOT established this project to develop a subset of the overall location referencing system: the linear referencing system and its relationships to the geographic and geodetic reference types for the entire facility life cycle.

Figure 4-3 Degree of accuracy in business functions



4.4 LRS Design

The linear referencing system (LRS) is a combination of processes, data, people and policies (organization), and technology. As the LRS development moves from the conceptual, to the logical, and then to the physical design it is critical to address the needs of each of these components. The GeoAnalytics team will describe general design issues regarding the data, organization, and technology LRS components. Then the team will discuss design issues regarding the LRS processes of collection, management, and use.

4.4.1 Data Design

Data design is by far the most nationally researched and developed component of LRS. The Iowa DOT is leveraging this investment by including as part of this project the need to incorporate industry data model templates like 20-27(2) to have a common standard on which to build and to jump start their design effort. While there is much to leverage, there are some outstanding issues. Some of these issues are technological, but they are mostly business-driven. This means the issues should be resolved based on the business needs of the Iowa DOT, not the targeted technology environment. The GeoAnalytics team provides a discussion of several of these issues and potential strategies for addressing them.

4.4.1.1 Datum Issues

These issues are related to the basic 20-27(2) model. The diagram in the RFP, page 12, implies that the 20-27(2) network object (‘(Link/Node Model)) is collapsed with the Reference Datum Representation. The GeoAnalytics team suggests that most DOTs have more than one basic network where this collapse might cause integration difficulties. It is recommended that the Iowa DOT determine whether other network representations exist within the organization and the impacts this may cause.

4.4.1.2 Complex Object Issues

Merging Roadway Anchor Point Locations. This issue is where to place the anchor point on converging and diverging roadways (e.g., ramps). One strategy is to remain true to the 20-27(2) model and place the anchor point at the projected intersection of the two traveled ways, and then create some permanent physical indicator in the field for ease of use. Another strategy is to use the gore point, which does not meet some of the basic criteria of the 20-27(2) anchor point. The GeoAnalytics team proposes that business requirements and rules determine the best strategy.

Divided Highways and One-Way Road Pairs. The GeoAnalytics team interprets this to be either the classification of traversals (routes) or the ability to determine the position in one roadway that complements the position in the roadway going the opposite direction. While these both challenge the linear models created so far, determination of the best solution is based on what business processes drive the need for such business requirements.

Concurrent Routes. How to work with concurrent routes (multiple routes at federal, state, and local levels traverse the same roadway) and aliases (e.g., Highway 12 is routinely called the “Beltline”). The GeoAnalytics team believes this is a physical design issue, because a fully normalized data structure would provide this capability.

4.4.1.3 Overall Data Design Issues

Time. The GeoAnalytics team is well aware of the issues surrounding time and space. Wisconsin DOT stores both real world change and data base change dates. They also create an explicit relationship between the retired and new datums object. Fletcher developed a time component to object models for seven transportation management systems (Fletcher, 1995). NCHRP 20-27(3) is also gathering temporal requirements from many transportation business functions. The GeoAnalytics team suggests including these as key sources for temporal requirement development.

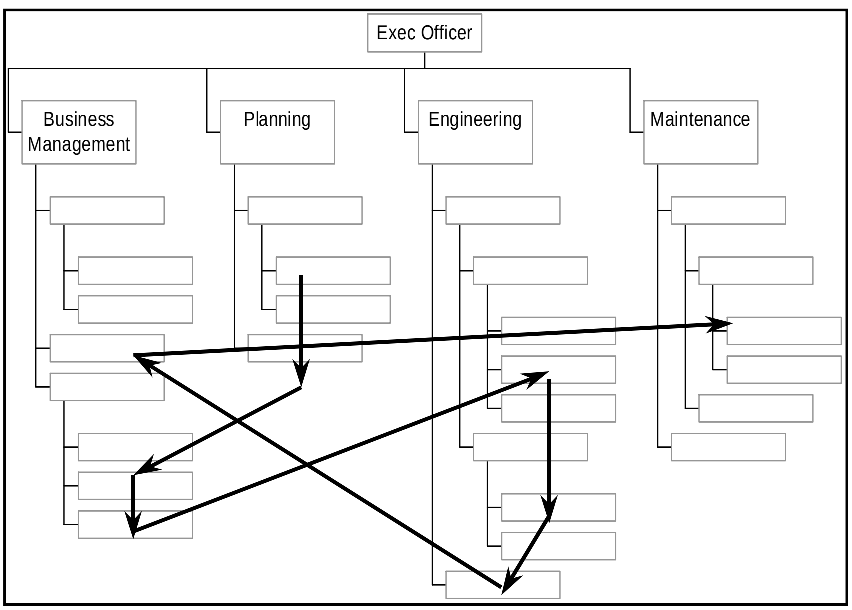
Accuracy. Accuracy in spatial data can be thought of as representing nearness to true locations. Accuracy is typically affected by two types of errors in measurements: 1) systematic errors that can be modeled and removed and 2) random errors that are inherent in data and cannot be removed, only managed in such ways as to minimize their effects. The randomness of these unavoidable errors injects statistical properties and uncertainty into the concept of accuracy. Anything that is measured can never be known exactly. Our knowledge of location, as a result of measurement, is subject to the laws of probability. In other words, we can never know for certain that we know the coordinates of a point to within 10 centimeters. We might know them to within 10 centimeters with 95% certainty, but we cannot know within 100% certainty. The desired level of certainty is critical in the statement of accuracy specifications. There are economic implications. That is, we can be 68% certain for less cost that we can be 90% certain.

4.4.2 Organizational Design

An important characteristic of the LRS is it's broad impact on the Department. The business functions that have a stake in the LRS span the organization. A very real issue is how to successfully manage the LRS when collectors, data managers, and data users may all be from different places in the organization. The priorities, perspectives, missions, and available resources of the different units can often cause conflict and sometimes separation of efforts. The GeoAnalytics team proposes evaluating an organizational structure that manages the LRS by process, not by traditional bureaucratic structure (Figure 4-4). This process management approach has all parties involved in the LRS collection, management, and use processes focused on the overall delivery of the LRS to DOT users as opposed to their own individual scope of the LRS (Schlesiona, 1988).

Another issue arises from the Iowa DOT looking to share data with local governments. These entities may have their own linear referencing formats or use cartography that is not the same as the Iowa DOT's to link to their attribute data. A challenge exists to determine how to integrate with perhaps hundreds of different location referencing formats. While a rigorous analysis cannot be done in this project, the GeoAnalytics team proposes that the issues and potential strategies for addressing the issues be laid out.

Figure 4-4 Organization structure



4.4.3 Technology Design

It is important that any technical design for an LRS for the Iowa DOT integrate well with the DOT's existing systems. It is equally important that the technical solutions proposed during this project not preclude the use of new technologies as they mature. Therefore, the Project Team will develop an LRS for the Iowa DOT that accommodates, and builds on, the Iowa DOT's experience with its selected geographic information system, relational database management system, and automation infrastructure.

Existing Systems. The Iowa DOT has standardized on Intergraph's Modular GIS Environment (MGE) as the primary GIS platform. The Iowa DOT has selected MGE Segment Manager to provide dynamic segmentation functionality. For analysis and application development, the Iowa DOT standard is GeoMedia. The Iowa DOT is implementing Oracle as the relational database management system. The Iowa DOT has implemented network and Internet connectivity between the various locations of DOT offices around the state, providing a backbone for data sharing.

LRS Integration with Existing Systems. The Project Team believes that the GIS and database platforms selected by the Iowa DOT can be used as a foundation to support a robust LRS design. MGE provides a viable toolset for updating and maintaining the cartographic representation of the LRS, and Segment Manager can provide some of the analytical and visualization capabilities for the LRS. Specifically, Segment Manager's abilities to integrate multiple linear referencing methods, accommodate loops and gaps in routes, and model concurrent and divided routes will be assets in the development of a physical implementation of the LRS. On the other hand, there are limitations to the capabilities of MGE and Segment Manager that will need to be overcome in the physical design of the system. Temporal data management is one issue that will require additional consideration. The LRS technical design will need to develop strategies to incorporate time within the data structures of MGE, Segment Manager, and Oracle. Issues to be resolved include decisions about whether there should there be multiple MGE features to represent the status of roadways, and/or whether multiple Segment Manager coordinate files will need to be available for analysis within Segment Manager or GeoMedia. It is likely that custom software will need to be developed to extend the current data model and data structures of the standard GIS platform.

The technical design of the LRS must incorporate the developing spatial capabilities of the relational database management system. Oracle provides robust enterprise data management, security, and retrieval, and Oracle is tightly integrated with the GIS. Oracle's Spatial Cartridge provides a method for spatial data management that may help integrate the LRS into general enterprise data managed by the Iowa DOT.

As the automation infrastructure of the Iowa DOT develops, it is likely that the impact of the Internet/Intranet will increase. The technical design of the LRS will need to examine the effect that web access will have on the design.

Finally, the LRS technical design must not be tied so closely to a particular existing system that incorporating new technologies will require significant redesign or data manipulation. It is the intention of the Project Team to examine new GIS, database, and system technologies during the project to see how they will impact the LRS technical design. Specifically, the Project Team will incorporate information about future development for products where significant transportation research and development efforts are underway.

Integration with Existing Geodata. The Iowa DOT has several existing datasets that will need to be incorporated into the physical design of the LRS. Geographic data include cartographic, planning, and engineering datasets currently being built and maintained in MGE, MicroStation, and other GIS.
It is expected that the primary integration with these data sets will involve making the data "smart", "clean", and topologically related using existing GIS tools and custom software. It is understood that some of this preparatory work will be completed by the Iowa DOT. For integrating other GIS data, data server software may be used to access the data in its native format. Where data servers for particular formats are unavailable, data translation methodologies will need to be developed.

Part of the process for integrating existing geodata will include an assessment of the accuracy, currency, and suitability of the existing geodata. An examination of the metadata for each candidate data set will need to be done, and additional metadata may need to be developed so that the quality of subsequent analytical results may be assessed.

Other sources of geodata that will need to be incorporated into the LRS will include GPS data, video logs, and possibly raster imagery. While tools for incorporating such data exist within GIS, some custom tools for streamlining the incorporation of such data may need to be developed.

Integration with Existing Databases. Oracle data may be used directly in the selected GIS, including any data that may be built with the Oracle Spatial Cartridge. Other database information may be accessible via ODBC, or ASCII database download and transfer into Oracle.

Providing Data to Users Outside Iowa DOT. It is important that any LRS design take into consideration organizations outside the Iowa DOT that will request access to data managed within the LRS. These potential data users may not have the same systems as the Iowa DOT, so it is necessary to provide methods for producing data that may be accessed via other systems. For example, the GeoMedia Professional's capability to produce an ArcView shape file from an existing data warehouse could provide data to ESRI users. It is also possible that the Iowa DOT could provide a copy of database information in the Oracle warehouse as an ASCII file and provide graphic data in standard exchange formats for uploading to other systems. Providing direct access to original data across the Internet is another possibility to be explored.

4.4.4 LRS Data Collection

Datum Collection. Data must be collected in the field for the two classes of linear datum objects: anchor points and anchor sections.

Anchor Points. The most fundamental characteristic of an anchor point is that it must be unambiguously identifiable and recoverable in the field. The data that are collected for anchor points must, therefore, ensure that this criterion is met. For purely linear referencing purposes, this does not necessarily require that accurate coordinates (absolute mathematical positions) be established for anchor points. For example, it might be sufficient to provide a verbal description, referring to easily identifiable landmarks, much in the form of the "to reach" descriptions used for finding geodetic control points. In turn, this does not necessarily mean that anchor points must be permanently marked with nearly indestructible buried concrete posts, as are geodetic control points. It might be sufficient to visit a site, select an anchor point, and describe its location simply as "the intersection of the pavement centerlines (as determined from edge of pavement) of Elm Street and Oak Street in Ames, Iowa". Of course, rules would be required for deriving and checking of descriptions of this sort.

Determination of accurate coordinates for anchor points could serve the purpose of identifying and recovering them in the field. Particularly, if coordinates are determined to the necessary level of accuracy, they could be used to re-establish locations of anchor points that might become obscured or ambiguous due to disturbances or destruction of landmarks and physical features used to otherwise reference their locations. In this case, kinematic differential GPS is a technology that could be used to establish coordinates of anchor points well within the recommended accuracy of one meter in the location referencing system team report.

We proposed to develop, in conjunction with the Iowa DOT field personnel, rules for anchor point location description collection and to demonstrate the use of kinematic differential GPS for determination of anchor point coordinate values during the pilot project. The one-meter coordinate accuracy recommendation in the location referencing system team report will be clarified as to level of uncertainty (statistical aspect) during the early stages of the situation assessment.

Anchor Sections. The accuracies of the lengths of the anchor sections in the linear datum establish the upper limit on the overall accuracy of the full linear referencing system. These accuracies are, therefore, perhaps the most critical factor in establishing the datum. The necessary accuracies in anchor section length measurement are derived from end-user requirements for accuracy in business data. Once business data accuracy requirements are determined, they can be used to reverse engineer the linear referencing system and the underlying linear datum by applying geodetic engineering principles for location referencing system design (Vonderohe and Hepworth, 1998b). This reverse engineering yields the appropriate configuration of the system in the field, including the measurements to make, and the accuracies with which to make them. Once the required accuracies of anchor section lengths are known, then appropriate technologies can be selected for making the measurements.

The datum must be more accurate than the most stringent accuracy required for business data. This is because business data are located in the field by measurements to reference points that are, in turn, tied to the datum by other measurements. All these measurements contain errors that propagate. Of course, required accuracies in business data vary with applications. It is also true that required accuracies might vary with geographic location. That is, data near and within urban areas probably have higher accuracy requirements than the same kinds of data in more remote, rural areas.

The optimal design for the linear datum is the one that establishes the datum at the necessary level of accuracy for the least cost. We propose to clarify, with regard to the level of uncertainty (statistical aspect), the ten-meter relative accuracy recommendation in the location referencing system team report in the early stages of needs assessment. We will then work with the Iowa DOT field and office personnel to ascertain their assessment of the capabilities and accuracies of the following technologies or methods for obtaining anchor section lengths: videolog van GPS coordinates, videolog van distance measurements, Roadware van GPS coordinates, Roadware van distance measurements, field inventory distance measurements, cartographic representations of roadways, plan (project) controls and distance measurements, and / or any of these techniques in conjunction with one another.

These technologies will then be evaluated during the pilot project to determine least-cost methods for achieving the required accuracies of anchor section lengths. One of the criteria for selection of pilot project roadways within the pilot project county will be diversity in accuracy requirements, if such diversity is determined to exist. Experience with the various measurement approaches during the pilot project will result not only in determination of the appropriate technology or technologies to use but also assist with development of guidelines for specific procedures in application of the technology or technologies to the problem of anchor section length determination.

Linear Reference Methods. The Iowa DOT requires the LRS support several linear referencing methods (LRM). This is a very legitimate business requirement. There are at least two types of linear referencing methods: 1) discrete and 2) continuous (Ries, 1993). Each offers different advantages during data collection and use. The reference point is a localized feature-based scheme, appropriate for collecting discrete objects and events such as culverts, intersections, accidents, etc. The milepoint is a continuous scheme appropriate for collecting continuous objects and events such as photolog images, pavement, ride statistics, etc. Milepost and light pole schemes are frequent and consistent, popular for either discrete or continuous data collection, especially in urban areas. Given the advantages of various schemes, multiple linear referencing schemes should be allowed.

A primary consideration when selecting a data collection LRM choice is the LRM formats required by the customers of the data. Data collection is done for one purpose only: to apply it in making business decisions. Data collection should not place undue burden on the data users. In the past this was a significant organizational issue. The GeoAnalytics team believes that, with the datum concept and LRM transformation requirements, collectors will be able to use what is most effective for them regardless of what the data user desires.

4.4.5 LRS Data Management

The linear datum concept was driven by the frustrations DOTs have felt about their linear reference systems not being stable enough over time. Several cases exist where route name changes or alignment changes have required significant re-coding efforts of their data. Stability was a primary business rule when people across the nation started to data model their location data needs. In fact, data modeling is how the basic datum elements of anchor section and anchor point – as well as the other basic elements of a linear reference system - were determined. Data modeling uses a technique called normalization, where modelers decompose data into its smallest levels. Data modeling also helped show that linear reference methods have some association to the linear datum. When you apply this association from LRM to datum, location becomes the most basic format. This is why the linear datum was determined to be analogous to datums defined in other spatial dimensions as illustrated in Table 4-1 (Vonderohe and Hepworth, 1998a). Like the other datums, its purpose is to provide the basic framework on which all other locations in that dimension are referenced and transformed.

Table 4-1 Characteristics of Location Reference Systems (from Vonderohe and Hepworth (1996))

Name	Dimension	Datum Object	Reference Object	Location Specification	Transformation
WGS84	3 D	3D Cartesian Axes	GPS Satellite	X,Y,Z	X,Y,Z ⇔ ϕ,λ,h
NAD83	2 D (Horizontal)	Ellipsoid	Horizontal Control Station	ϕ,λ	ϕ,λ ⇔ x,y ϕ,λ ⇔ N,E
PLSS	2 D (Non-Mathematical)	Section Corner	Cadastral Survey Monument	Township, Range, Section, Aliquot Part	None
NAVD88	1 D (Vertical)	Geoid	Benchmark	Elevation	None
LRS	*1 D (Linear)*	*Anchor Point / Anchor Section*	*Traversal Reference Point*	*Offset along Anchor Section*	$LRM_i \Leftrightarrow LRM_j$

Because the linear datum is the most stable representation of linear space it can be used to store transportation linear data over time. Most linear referencing methods are composed of routes, and routes in many cases are less stable than the data referenced to them. A data management issue for many DOTs is if and when to store their business data locations in datum format versus a linear reference format. The

DOTs have to weigh the conversion costs and time against developing tools to update business data location values when ever LRM elements changes (e.g., a route name, or a milepoint value now changes because of a realignment). The GeoAnalytics team assumes from the preliminary needs assessment the Iowa DOT will option for tool development on systems that will not be redesigned soon.

4.4.6 LRS Data Use

Applying the LRS means accessing, updating integrating, displaying, analyzing, and reporting on business data. Ease of access is the key element of the system based on the preliminary situation assessment. Typically, strong data management systems are not conducive to easy of use. Data management systems are designed for efficiently maintaining data that has high quality and integrity. In fact, data management and data use are typically polar views. The GeoAnalytics team will work in the logical and physical design phases to determine the specific performance expectations that will drive how best to structure data to accommodate both management and use.

Dynamic segmentation is a typical strategy for how data users have grown accustomed to integrating, displaying and analyzing their data. Decisions will be required to determine whether these basic location processes should involve the datum or be performed directly with the LRMs. The GeoAnalytics team will work in the logical and physical design phases to determine the best strategy.

4.5 Summary of Technology Needs

At this time, the GeoAnalytics team does not foresee any administrative or project support software needs (please see Section 3 for a list of capabilities GeoAnalytics offers its clients). The exception would be any particular software requirement the Iowa DOT has that was not mentioned in the RFP or subsequent bidder question responses.

5 Project Management

The overall success of this project should be measured not only by the delivery of a technically sound linear reference system design and implementation plan but also by the procedures and methods that are employed to achieve this end. As a company, GeoAnalytics believes strongly in a well-managed and structured approach to project execution. This type of approach includes a clear definition of project scope and of consultant and client roles and responsibilities. Based on our experiences, we have learned that an organized approach to project management helps to ensure:

- Timely completion of individual tasks and deliverables;
- Properly documented decisions regarding key issues and actions;
- Good communications within and between consultant and client staff; and
- Managed expectations for interim and final project outcomes.

Given the complexity of the proposed Iowa DOT LRS Development Project, the GeoAnalytics team intends to provide both overall leadership for project management working in conjunction with assigned Iowa DOT counterparts and to provide a high level of technical expertise relevant to the linear referencing system design, prototyping, and implementation.

This section of the RFP response seeks to accomplish two things. First, to outline the proposed approach to the execution of individual project phases and tasks that will provide the logistical framework for the Technical Approach to the project as proposed in Section 4. Second, this section provides a detailed description of the proposed project management procedures and an overall organizational structure for project execution. The organizational structure defines a team approach to project decision-making including targeted participation by both the GeoAnalytics team and the Iowa DOT staff. The intent of this team structure is to improve the quality and efficiency of decisions. In addition, this structure is designed to provide a mechanism for the Iowa DOT staff to be engaged in a learning process throughout the project in order to support implementation and maintenance of the LRS. The project management description includes a summary of key GeoAnalytics team resources and their anticipated project roles.

5.1 Summary Description of Project Phases and Tasks

GeoAnalytics will conduct the LRS Development Project using a series of sequential and closely interrelated phases and tasks. These phases and tasks are consistent with the work areas and deliverables identified in the DOT RFP document (page 8) and are also based on standard Information System (IS) design components. These components include: Business Process; Informational (Data); Technological (IT); Organizational; and Systems (Applications). At each step these IS design components are addressed. The proposed phases and tasks in basic sequence include:

Phase 1: LRS System Design

C. Assessment and Analysis of LRS Needs and Expectations (including development of benchmarks for measuring LRS benefits)

D. LRS Design

   1. Conceptual LRS Design
   2. Logical LRS Design
   3. Physical LRS Design

Phase 2: LRS Prototyping (Pilot Project)

E. Pilot Project Plan Development
F. Pilot Project Execution
    1. Acquisition of System Architecture
    2. Construction of System Components
    3. Field LRS Data Collection and Benchmarking
    4. Office LRS Data Handling and Benchmarking
    5. Documentation
G. LRS Design Revisions (based on Pilot Project findings)
H. LRS Full-scale Implementation Plan Development

5.2 Detailed Description of Project Phases and Tasks

The following details the scope, activities, and products proposed for each project phase and work task. Table 5-1 contains a summary list of project task deliverables.

5.2.1 PHASE 1: Task 1 - Situation (Needs) Assessment

5.2.1.1 Scope

Phase 1 of the project will focus on completing an assessment of current agency conditions, needs, and expectations for LRS development and deployment. GeoAnalytics will undertake a broad approach to the situation assessment in that it will review the agency from an enterprise perspective while focusing on the process, organizational, data and technology dimensions of critical business functions. A review of completed agency research coupled with targeted staff interviews will provide much of the context for this assessment. In addition, benchmarks for measuring the benefits of implementing a LRS within the agency will be identified and defined. These benchmarks, at a high level, will be driven by the need to show improvements in the efficiency and effectiveness (benefits) of agency business functions. At a lower level, benchmarks will be defined operationally by including the type of operation to be tested, by whom and under what conditions, and the measure of change based on current practices that needs to be demonstrated in order to show improvement (benefit) in a particular business area.

5.2.1.2 Activities

The following are a proposed series of work activities necessary to complete this first task:

a. Familiarization. GeoAnalytics will review previous planning, organizational charts, agency mandates, and other materials provided by the DOT. The Iowa DOT has accomplished much with past research related to the development of a LRS, the deployment of GIS and related spatial information technologies. Accordingly, it is our intention to build on and supplement this work rather than to repeat known findings and conclusions.
b. Workshop. This facilitated workshop will be directed to key Iowa DOT project participants. The purpose of this workshop is threefold. First, we will acquaint participants to project and process. Second, to provide basic education and information on the LRS concepts and issues to define the nomenclature of the project and to establish a baseline understanding for all project participants. The third purpose of the workshop is to engage participants in a facilitated discussion to build consensus around key LRS issues and opportunities.
c. Executive Briefing. As a kick-off to this project, a short executive briefing will be held to acquaint decision-makers with the project and its intended outcomes. In addition to its

educational value, the purpose of this executive briefing will be to build support with decision makers for the LRS implementation project overall.

d. Interviews. The GeoAnalytics team will conduct a series of interviews with key individuals and agencies within the Iowa DOT. The purpose of these interviews will be to identify and document issues related to the five IS design components and to develop the functional needs to be addressed by the LRS design.

e. Interim Task 1 Report Development. An interim report will be developed that will document the results of the preceding fact investigation and research. This report will also detail key issues and needs that must be addressed by the LRS design. This report will also detail relevant "benefit" benchmarks for the establishment of the LRS.

f. Interim Task 1 Report Presentation and Feedback. Interim Task Report 1 will be provided and presented to the Iowa DOT project team for review and comments. The presentation will take the form of a facilitated workshop. The report document will be provided to the project team prior to the workshop.

g. Final Situation Assessment Report Production. Based on the comments received through the review process and workshop, a final Situation Assessment Report will be delivered. This document will be used to help guide the balance of LRS project and will provide a framework for benchmarking the efficiency and effectiveness of the LRS. This report will constitute a component/chapter of the Phase 1 report.

5.2.1.3 Products

The situation assessment task will produce the following products…

a. Education.
b. Fact Investigation.
c. Final Situation Assessment Report.

5.2.2 PHASE 1: Task 2 - Linear Reference System (LRS) Design

The second major task under Phase 1 will involve the development of a LRS design for the agency. The design process will involve three sequential sub-tasks called conceptual design, logical design, and physical design. The GeoAnalytics team believes that it is important to follow this process as it permits high level design, conceptually and logically, that is closest in intent to the NCHRP 20-27 transportation modeling research. This process also addresses the organizational, data, and technology constraint realities inherent in the physical design. Within each one of these sub-tasks the Business Process, Data, Technology, and Organizational architectures of the Iowa DOT LRS enterprise will be modeled.

5.2.3 LRS Conceptual Design Sub-Task 1

5.2.3.1 Scope

Under the conceptual design sub-task we will develop high-level model views of proposing the Iowa DOT LRS. These model views will be driven by the Needs Assessment findings that will include articulated goals and objectives for improved business operations and decision-making through more efficient and effective data collection, integration, management, analysis, and output.

5.2.3.2 Activities

a. Workshop. The GeoAnalytics team will conduct an onsite workshop that will be designed to identify and build consensus regarding the necessary features of the LRS. This workshop will be directed to a more focused set of Iowa DOT project participants. If necessary, additional fact investigation and research will be conducted if gaps are discovered as part of the workshop process.

b. Interim Conceptual Design Report. Based on the results of the workshop and additional fact investigation and research, the GeoAnalytics team will prepare an interim LRS conceptual design report detailing a high-level model for the Iowa DOT LRS architecture. This will include the development of entity relationship diagrams and other conceptual models and diagrams.
c. Interim Task 2 Report Presentation and Feedback. An interim Task 2 report will be provided and presented to the Iowa DOT project team for review and comments. The GeoAnalytics team will then facilitate an onsite workshop on this report.
d. Final Conceptual Design Report Production. Based on the comments received through the review process and workshop, a final conceptual design report will be delivered.

5.2.3.3 Products

The LRS conceptual design task will produce the following products.

a. Consensus Development.
b. Final Conceptual Design Report. This will include conceptual diagrams and models.

5.2.4 LRS Logical Design Sub-Task 2

5.2.4.1 Scope

Under the logical design sub-task, the GeoAnalytics team, working with Iowa DOT staff, will determine specific LRS requirements. The sub-task focuses on the “what” of Iowa DOT needs with data, process, organization and technologies, independent of the “how”. For this project, the GeoAnalytics team will focus on getting significant details on the areas to be benchmarked as well as attempt to capture information about the entire enterprise. For benchmarks that include testing performance, measures will be established and current and expected performance will be determined.

5.2.4.2 Activities

a. Workshop/Meetings. The GeoAnalytics team will conduct an onsite workshop and a series of individual meetings with key Iowa DOT staff. These efforts are intended to establish requirements and relevant benchmark information. If necessary, additional fact investigation and research will be conducted if gaps are discovered as part of this process.
b. Interim Task 2 Logical Design Report. A report, including a series of diagrams, will be developed to document the logical design. This documentation will serve not only project needs, but also as an ongoing reference.
c. Interim Task 2 Report Presentation and Feedback. An Interim Task 2 Logical Report will be provided and presented to the Iowa DOT project team for review and comments. The GeoAnalytics team will facilitate a workshop on this report.
d. Final Logical Design Report Production. Based on the comments received through the review process and workshop, a final conceptual design report will be delivered.

5.2.4.3 Products

Based on the comments received through the review process and workshop, a final logical design report will be delivered. Specific aspects to be described or diagramed include:

a. Process Model. This will include linear datum and LRM collection and management, access, analysis, and integration.
b. Data Model. This will include specifications, benchmarks, etc.
c. Technology Model. This will include an assessment of the current and proposed technology environments and potential technology gaps.
d. Organizational Model. The organizational model will address management processes and potential gaps.
e. Systems/Applications Modeling. This model will identify key applications needs and gaps.

5.2.5 LRS Physical Design Sub-Task 3

5.2.5.1 Scope

Under the physical design sub-task the GeoAnalytics team will develop technical specifications, including full data design, technology framework, software and applications design, business process design, and organizational model. The result of this task will be the development of a blueprint for implementation to support the prototype testing activities under Phase 2.

5.2.5.2 Activities

a. Workshop/Meetings. The GeoAnalytics team will conduct at least one onsite workshop as well as a series of individual meetings with key Iowa DOT staff. These meetings are intended to facilitate the development of set of technical specifications that meet the needs of the entire Iowa DOT as well as individual agencies within the DOT.
b. Interim Task 3 Physical Design Report. This report will propose the full compliment of technical specifications to support the pilot project. In addition, this report will provide relevant benchmarks, measures and target goals for the evaluation of the LRS.
c. Interim Task 3 Report Presentation and Feedback. An interim Task 3 physical design report will be provided and presented to the Iowa DOT project team for review and comments. The presentation will take the form of a facilitated workshop. The report document will be provided to the project team prior to the workshop.
d. Final Physical Design Report Production. Based on the comments received through the review process and workshop, a final conceptual design report will be delivered.

5.2.5.3 Products

a. Physical Design Report. This report will provide detailed specifications for business process, data/information, technology, organization interaction, and applications.
b. Benchmarks. This task will establish specific benchmarks, measures, and target goals for evaluation of the efficacy of the LRS design.

5.2.6 PHASE 2: Task 1 - Develop LRS Pilot Project Plan

Phase 2 of the project will focus on the planning and execution of a pilot project designed to prototype and benchmark the physical LRS design developed under Phase 1. The first task under Phase 2 will be developing of a pilot project plan that outlines prototyping activities and related resource requirements, timelines for completion, and personnel assignments for both GeoAnalytics and Iowa DOT staff.

5.2.6.1 Scope

GeoAnalytics proposes to prepare a detailed pilot project plan that will include a full scope of activities for determining the LRS components.

5.2.6.2 Activities

The following are a proposed series of work activities necessary to complete this task:

a. Workshop. The GeoAnalytics team will conduct a workshop directed primarily to those individuals and agencies within the Iowa DOT who will be involved in the pilot project. The purpose of this workshop will be to develop consensus on the scope, extent, and architectural components of the pilot project.

b. Draft Development. GeoAnalytics will generate the draft pilot project plan covering the architectural components described above. It will detail a scope of work agreed upon as appropriate for the pilot project.

c. Presentation and Feedback. Following completion of the draft pilot project plan, it will be transmitted for review and feedback. A workshop will be conducted and, if necessary, individual meetings will be held to present the plan and generate consensus.

d. Modifications and Final Plan. The pilot plan will be modified based on feedback from the Iowa DOT and a final plan will be prepared and transmitted to the Iowa DOT for approval.

5.2.6.3 Products

The LRS Pilot Project Plan Development task will produce an Iowa DOT approved pilot project plan. The plan will be the blueprint for the activities to occur under the pilot project. The pilot plan will address the following system architectural components:

a. Process. GeoAnalytics will describe the processes and methodologies required to implement the LRS within a defined pilot project area. The plan will describe how functions necessary to achieve a successful pilot completion will be arranged, managed and executed.

b. Data. The pilot plan will describe what data will be required to complete the pilot. This data includes all components germane to implementing the proposed LRS. The data potentially includes existing cartography and business data, as well as, the new datum and other LRS components created under the pilot project.

c. Technology. GeoAnalytics will detail the necessary hardware and software components for the field and office portions of the pilot project. A successful pilot will reveal any additional technology necessary for the LRS pilot.

d. Organizational. The pilot plan will describe which organizational arrangements may need to be modified. These organizational arrangements include both office and field operations. It is understood that minimal impact on field personnel and their collection activities is a stated goal of the project.

5.2.7 PHASE 2: Task 2 - Perform and Document LRS Pilot Project

The second major task under Phase 2 will involve the actual execution of the pilot project. Separate teams will be used to coordinate field versus in-office LRS design benchmark testing and documentation.

5.2.7.1 Scope

The GeoAnalytics team proposes to complete work as detailed in the pilot plan that will allow the Iowa DOT to identify how the proposed LRS Design can be implemented successfully. This task will be done as a collection of sub-tasks run, to some degree in parallel, for the acquisition and construction of LRS prototype environment components (hardware, software, database structure, and application tools), field and office-based LRS data collection and database entry, and execution of targeted benchmark tests.

5.2.7.2 Activities

The following are a proposed series of work activities necessary to complete the pilot project:

a. Setup Technical Environment. GeoAnalytics and the Iowa DOT will establish a development environment of both field and office technologies appropriate for the pilot as specified in the pilot plan. The technical environment will be compatible with existing Iowa DOT technology or an extension there of.

b. Develop Benchmark Environment. GeoAnalytics will endeavor to create an environment that most closely approximates the actual (or proposed) working conditions of the Iowa DOT under the new LRS. This environment will be one in which the validity of benchmark data is of the highest priority.

c. Collect and Organize Pilot Data. Those functions selected for benchmarking under the pilot will be performed. Data will be collected and benchmarks generated for comparison. The data collection effort will be designed to make the analysis of benchmarks as efficient, yet as rigorous as possible.

d. Perform Benchmark Analyses. The analysis of benchmark data will produce the quantitative and qualitative measures of whether the system design, as piloted, is meeting functional requirements and whether the design is appropriate for the Iowa DOT.

e. Document and Present Results. Analysis results will be documented and presented the to Iowa DOT within the Pilot Plan Documentation. The documentation will cover all aspects of the design as they relate to data, technology, organization and processes.

f. Obtain and Document Feedback. Iowa DOT will review pilot documentation and, with GeoAnalytics participation, prepare adjustments to the pilot design for inclusion in the revised LRS Design.

5.2.7.3 Products

The LRS Pilot Project task will produce functional pilot project and LRS pilot documentation. The documentation will contain recommendations for adjusting the LRS design to meet the needs of the Iowa DOT. The documentation will list both successes and deficiencies of the original LRS design. It will also describe where modifications were made to the design to improve the outcome of benchmark analysis.

5.2.8 PHASE 2: Task 3 - Revise Final LRS Design

5.2.8.1 Scope

The third task under Phase 2 involves revision to the LRS design based on lessons learned from the pilot. The purpose of this task is to take the results of the LRS pilot, including the relative strengths and weaknesses of the initial design, and develop a final LRS design. The product will be a final design that will meet the business function needs of multiple Iowa DOT agencies. In addition to the foregoing, this task will also involve the analysis of the benchmark data to forecast the benefits of a full LRS implementation.

5.2.8.2 Activities

The following are a proposed series of work activities necessary to complete this task:

a. Evaluation. Working with the Iowa DOT staff, the GeoAnalytics team will inventory and analyze the results of the pilot project exercise, including benchmarks. This activity will be accomplished through a series of workshops/meetings.

b. Reassess Benchmarks. As part of the evaluation, benchmark data will be reviewed and analyzed by the full project team.

c. Documentation. There will be three distinct reports under this task. Each report will be provided to the Iowa DOT for review and comments:

   i. *LRS Design (Revised)*. Following the evaluation of the pilot project, the GeoAnalytics team will provide a proposed set of modifications to the physical design documentation. In addition, a brief narrative report will be developed that will describe the modifications and the rationale supporting the changes.

   ii. *LRS Implementation Strategy Report*. This report will provide an operational blueprint for the LRS implementation.

   iii. *LRS Implementation Benefits Report*. The result of the benchmark reassessment exercise will be to finalize and document the benefits to the LRS implementation.

d. Workshop/Executive Briefings. A final workshop will be conducted to present the results of the pilot project and final design. This workshop will be targeted to a broader audience of interested Iowa DOT staff. In addition to a workshop, Executive Briefings will be conducted for decision-makers to provide them results of this phase of the project and to build support for the overall LRS implementation.

5.2.8.3 Products

A final LRS design document and a LRS physical implementation strategy report that describes all of the data, technology, and organizational components will be delivered.

a. LRS Design (Revised) Report. The LRS Design Report will provide a detailed blueprint for the technical implementation of the LRS. This report will be used as a framework for the implementation plan and will address all of the IS design components necessary to operationalize the tested LRS design, including business process, data, technology, organizations, and applications.

b. LRS Implementation Plan Strategy. This document will provide a practical blueprint for implementation of the LRS. This document will include step by step activity descriptions and project management documentation (Gantt Charts, Critical Path diagrams, etc.).

c. LRS Implementation Benefits. Benchmark test results will be presented in the form of identified LRS benefits.

d. Education. The executive briefings will provide education to decision makers and will be used to build political support for the LRS implementation.

5.2.9 PHASE 2: Task 3 - Develop Plan for Full-scale LRS Implementation

5.2.9.1 Scope

The final work task under Phase 2 will involve the development of a full-scale LRS Implementation Plan for the Iowa DOT that builds on the implementation strategy report by providing a detailed accounting of LRS deployment activities, timelines for completion, costs, and human resource requirements.

5.2.9.2 Activities

a. Resource Requirements Definition. The GeoAnalytics team will research and analyze a wide range of resource requirements to accomplish a full LRS implementation. Resources requirements will include data, technology, personnel, etc.

b. Presentation and Feedback. Resource requirements will be added to the implementation strategy report. Iowa DOT staff will be given an opportunity to review and comment on this report prior to a final workshop.

c. Final Plan Modifications and Delivery. Based on comments and the results of the workshop, a final implementation plan, including costs and resource requirements will be prepared and delivered to the Iowa DOT.

5.2.9.3 Products

A final Scope and Plan for the Full Scale Implementation will be delivered.

5.3 Project Deliverables and Timeline

The following is a summary list of project task products that will be delivered by the GeoAnalytics team as part of contract obligations. Products are identified by project phase and task and include an estimate of calendar time for completion.

Table 5-1 Project Overview and Estimated Time Frame

Project Phases/Tasks	Deliverables	Estimated Elapsed Time-Frame
PHASE 1: LRS System Design		
1) Situation Assessment and Benchmarks Development	▪ Education ▪ Fact Investigation ▪ Final Situation Assessment Report	4 Weeks
2) LRS Design		
▪ Conceptual LRS Design	▪ Consensus Development ▪ Final Conceptual Design Report	3 Weeks
▪ Logical LRS Design	▪ Process Model ▪ Data Model ▪ Technology Model ▪ Systems Application Model	6 Weeks
▪ Physical LRS Design	▪ Process Model ▪ Data Model ▪ Technology Model ▪ Systems Application Model	4 Weeks
PHASE 2: LRS Prototyping		
3) Pilot Project Plan Development	▪ Pilot Project Plan Document	2 Weeks
4) Pilot Project Execution	▪ Pilot Project Completion ▪ Pilot Project Report	
▪ Acquisition of System Architecture		3 Weeks
▪ Construction of System Components		4 Weeks
▪ Field LRS Data Collection and Benchmarking		12 Weeks
▪ Office LRS Data Handling and Benchmarking		8 Weeks

Table 5-1 Project Overview and Estimated Time Frame

Project Phases/Tasks	Deliverables	Estimated Elapsed Time-Frame
5) LRS Design Revisions	▪ LRS Revised Design Report ▪ LRS Implementation Plan Strategy Report ▪ LRS Implementation Benefits Report ▪ Education	7 Weeks
6) LRS Full-scale Implementation Plan Development	▪ Project 2 Cost Estimate Report ▪ Final Implementation Plan Strategy Report	3 Weeks

5.4 Project Organizational Structure

The success of this project will be determined, in large measure, by the nature and quality of the communication and coordination between the GeoAnalytics team and the Iowa DOT project team. In part, this success is a function of the project management system that is employed. Ultimately, the function of the project management system is dependent on the organizational structure on both the consultant and the client side. The following proposes an organizational structure for this project.

Figure 5-1 and Table 5-2 provide an overview of this organizational structure. The key feature of the model defined by Figure 5-1 shows the structure of an overall project team comprised of GeoAnalytics, including its strategic partners, and the Iowa DOT, its strategic partners and select interested parties. Within this organizational structure, there are three distinct groups. The first is comprised of select Iowa DOT Senior Managers. This group provides visibility, resources and access to decision-makers. Decision-makers are, simply, essential to the long term viability and success of the development of a LRS for the Iowa DOT. The second group is the LRS Project Steering Team. This includes both consultant and Iowa DOT staff drawn strategically from areas within the Iowa DOT that are either principal producers of data or that can provide critical expertise to the project. The LRS Steering Team will be led by the principal investigator drawn from the Iowa DOT. It is hoped that this individual will also serve as the client corollary to GeoAnalytics Project Manager, Peter Thum, President. The third level is the Core Project Team. GeoAnalytics Project Leader, Tom Ries, will lead this group. This group will be comprised of consultants, project support and business function experts.

Table 5-2 Organization Structure and Responsibilities

Team and Responsibility	Resource
Iowa DOT Senior Managers (5-7 members) - Prioritizes project with other IS and Business initiatives - Ensures proper resources are assigned - Removes barriers to success	**Sponsor:**
Project Steering Team (5-7 members) - Can authorize a certain level of resources - Removes barriers to success - Communicates with divisions - Accepts/rejects project recommendations • Cross-functional representation • Includes one Iowa DOT IS representative	**Chair:** DOT LRS Primary Project Manager - Co-Project Manager - Iowa DOT Division Reps - CTRE Rep - Local Gov't Rep

Table 5-2 Organization Structure and Responsibilities

Team and Responsibility	Resource
Core Project Team (3-5 members) - Perform the work or directly lead those who do the work - Work throughout the project • Information Systems development expertise • Information Technology expertise • Business expertise • Project Management expertise	**Chair:** Project Leader (Tom Ries) - Sherry Coatney - Iowa DOT LRS Manager - CTRE Rep
Project Support Experts (as needed) - Perform work or provide advice to the project - Work only on project phases or tasks within the project, but most likely not the entire project. • Programming expertise • Needs Assessment and Requirements Analysis (data and process modelers) • Business analysts (industry experts, theories, case examples, trends) • Other DOT's	**Experts:** - Nancy von Meyer - Alan Vonderohe - William Holland - Jeff Laird - Aaron Cohen - Tom LeMahieu - Jim Cory
Iowa Business Experts (15-20 key members) - Supplies experience from the benchmark areas - Provide and validate current situation, requirements and specifications - Provide advice and feedback from minutes, drafts, etc - May perform some work on certain phases or tasks - Liaison with the general population	**Experts:** - Iowa DOT Functional Areas - CTRE Reps - Local Governments - MIS Office - GIS Comm. Rep
Iowa Transportation Population - Kept informed via intranet, mail, bulletins, newsletters, conferences - Provides issues, recommendations, and general feedback on project tasks and deliverables.	**Organizations:** - Iowa DOT - Local Governments - GIS Committee - CTRE

5.5 GeoAnalytics Team Members

GeoAnalytics has assembled a team of extraordinary competence, capability, and experience to undertake this project. This team features nationally recognized experts in the transportation and GIS industries. The range of experience and expertise is also extraordinary, including leading LRS theorists and authors. The team offers experts in the coordination and integration of information and technology, particularly GIS, information engineering, law, economics, and policy. In addition, many members of the GeoAnalytics Team are frequent professional collaborators. Table 5-3 provides a brief overview of the GeoAnalytics Project Team and their proposed roles. More detailed biographical information is available in Section 6.

Figure 5-1

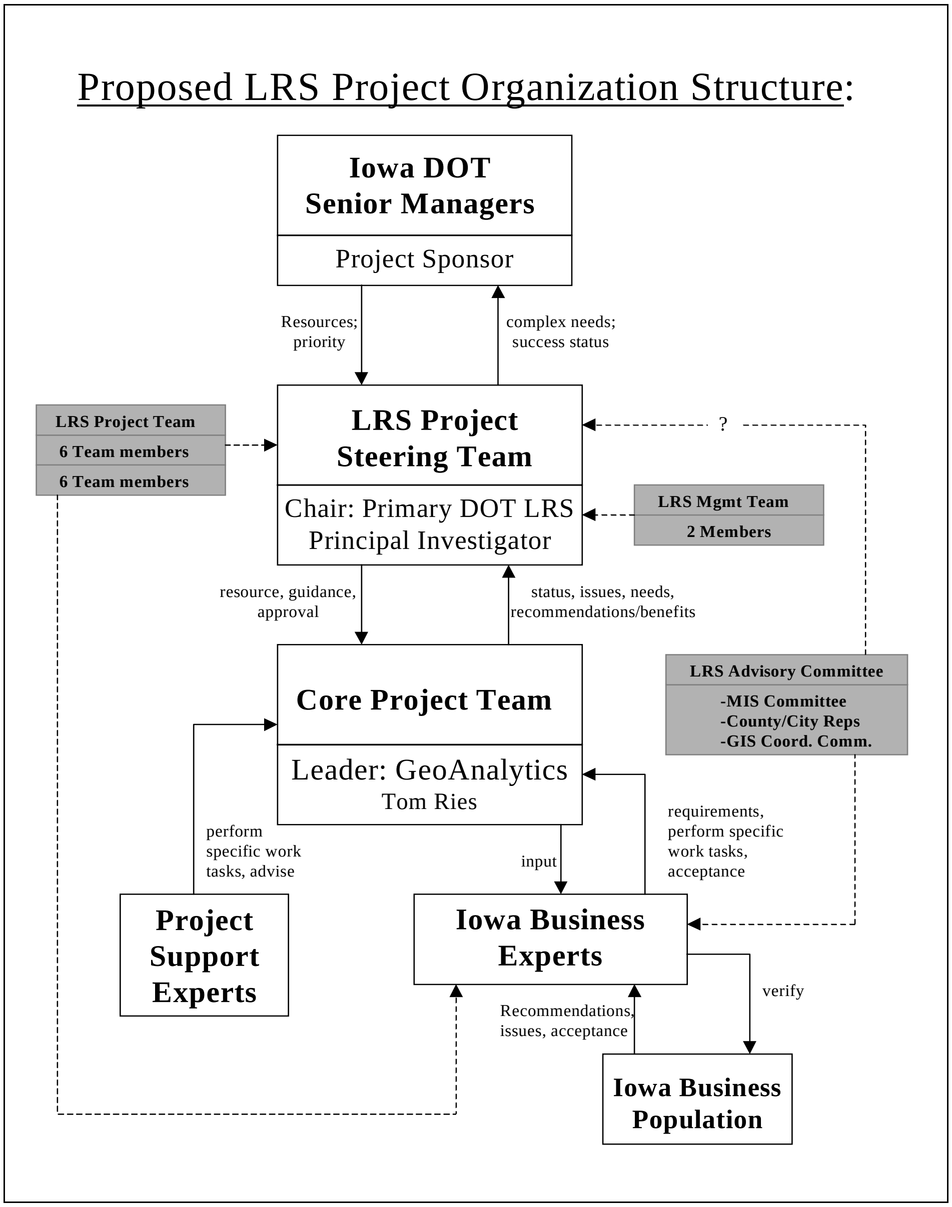


Table 5-3 Project Team and Proposed Role

TEAM MEMBER	ANTICIPATED PROJECT ROLE
Peter G. Thum, M.S., President, GeoAnalytics	• Project Manager • GIS/IT Integration
Thomas Ries, M.S., Transportation Manager, GeoAnalytics	• Project Leader • Situation Assessment • LRS Design and Prototyping • LRS Pilot and Implementation Plan Development

Table 5-3 Project Team and Proposed Role

TEAM MEMBER	ANTICIPATED PROJECT ROLE
Sherry Coatney, M.S. Intergraph Technology Specialist Safe Harbor Group	• GIS/IT Technology Specialist • Technology Situation Assessment • LRS Technology Design and Prototyping • LRS Pilot and Implementation Plan Development
Alan P. Vonderohe, Ph.D. LRS Development Specialist, University of Wisconsin-Madison	• LRS Development Specialist • Technical consultant • Linear referencing systems specialist
Nancy von Meyer, Ph.D. Vice-President, Fairview Industries	• Project staff • Technical consultant • Data design specialist
Aaron Cohen, M.S. Senior GIS Analyst, GeoAnalytics	• Project Staff • Technical consultant
William S. Holland, M.S., J.D. CEO, GeoAnalytics	• Project Management • Situation Assessment
Jeff Laird, B.A.. Vice-President, Bluegrass GIS, Inc.	• MGE/Segment Manager and GeoMedia Programming • LRS Design
James A. Cory, B. A., GIS/IT Analyst, GeoAnalytics	• Applications Development Programmer • Database Administration • Oracle/Spatial Cartridge
Heidi Roberts, M.S. Project Coordinator, GeoAnalytics	• Project Management and Support • Resource Allocation
Anita Temple, B.S. GIS Analyst, GeoAnalytics	• Technical Writing • IS Design Documentation
Steve Allenstein, M.S. Programmer / Analyst, GeoAnalytics	• Technical Project Implementation • GIS Applications Programming
Tom LeMahieu, M.S. Programmer / Analyst, GeoAnalytics	• Technical Project Implementation • GIS Applications Programming

In addition to the positions above, GeoAnalytics will acquire specific technical staff primarily to conduct the pilot project. These positions will include a photo-log specialist, field GPS specialists, benchmarking staff, Field DMI specialists, and Field Literal Description specialists.

5.6 Project GANTT Chart

Follows

6 Qualifications and References

The GeoAnalytics team offers the Iowa DOT an extraordinary array of expertise and experience. The GeoAnalytics staff has an average of more than 9 years of professional GIS experience, including nationally and internationally recognized experts. The Project Team will be composed of senior GeoAnalytics staff, support staff and, where appropriate, outside technical advisors and Iowa DOT personnel. The GeoAnalytics team will also include Alan Vonderohe with over 20 years of experience in the transportation industry, Sherry Coatney with 16 years of experience in Intergraph systems, and Nancy von Meyer with over 15 years of experience in information technology and consulting.

GeoAnalytics is unique in that it takes an interdisciplinary approach to information system design by bringing process management, legal, organizational, and economic perspectives to its engagements in addition to unparalleled technical expertise. GeoAnalytics works as a team with its clients to create solutions that meet the needs, business functions, resources and priorities of the client. GeoAnalytics' value proposition is that we provide quality, sophisticated consulting and applications development. Moreover, this team has a record of significant accomplishments in the GIS/LIS industry.

WILLIAM SHEPHARD HOLLAND

Professional Experience

Chief Executive Officer, GeoAnalytics, Inc.

Principal and co-founder of GeoAnalytics, Inc. In addition to executive management, Mr. Holland's work involves the legal, policy, financial, and economic dimensions of information technology. In addition, he conducts organizational and requirements assessments, process management, business function analysis, strategic planning, education and executive briefings. Key areas include information policy, business geographics, institutional strengthening, and decision support in management information systems.

Executive Director

Prior to co-founding GeoAnalytics, Inc., Mr. Holland was the first Executive Director of the State of Wisconsin Land Information Board from November 1989 to August 1995. He was responsible for implementing the nation's premier program for the coordinated development of integrated data for geographic and land information systems across local, state and federal agencies, and the private sector.

Attorney

Mr. Holland has been a private attorney in Madison, Wisconsin since 1985. Practice experience includes intellectual property, technical litigation, real estate, business, agricultural law, debtor-creditor, insurance, products liability, personal injury, and tax. Mr. Holland is licensed to practice in the state and federal courts of Illinois and Wisconsin.

Other Professional Accomplishments

Mr. Holland is Past-President, founding member, and Member of Board of Directors (1991-1996) of the National States Geographic Information Council (NSGIC). Mr. Holland provided leadership with NSGIC in its development and formulation of key policy instruments underlying the development of the National Spatial Data Infrastructure. He is a nationally recognized lecturer on information and technology policy and intergovernmental coordination, including engagements in Germany, Australia, numerous national, state and regional conferences. In addition, Mr. Holland has authored several articles and publications.

Education

In May 1985, Mr. Holland was conferred, cum laude, a Juris Doctor from the Northern Illinois University College of Law, DeKalb, Illinois. Mr. Holland has a Master of Science (1984), and a Bachelor of Science (1981) from the University of Illinois, Urbana-Champaign. He majored in Agricultural Economics, and his areas of study included policy, economic theory, finance, real estate, quantitative and financial analysis. Mr. Holland was a Hunter Graduate Fellow, graduated with academic honors, and received the award of merit from the Gamma Sigma Delta Honor Society.

Professional Affiliations

State Bar of Wisconsin, the Wisconsin Land Information Association (past member of the Board of Directors), the National States Geographic Information Council, and the Urban and Regional Information Systems Association (URISA).

PETER G. THUM

Professional Experience

President, GeoAnalytics, Inc.

Principal and co-founder of GeoAnalytics, Inc., Mr. Thum's work involves the technological dimensions of geographic information systems. He provides enterprise-wide organizational user needs assessments, GIS/LIS hardware and software system designs, geographic and tabular database designs and implementation, and acquisition implementation for GIS.

President, H_2GEO Consulting

Prior to founding GeoAnalytics, Inc., Mr. Thum was the sole proprietor of H_2Geo Consulting, Madison, Wisconsin from January 1991 to August 1995. The firm provided geographic and land information consulting and management services to government and the private sector. Conducted environmental and hydrologic studies using GIS technology.

LICGF Manager

Mr. Thum was the Facility Manager of the University of Wisconsin-Madison Land Information & Computer Graphics Facility (LICGF) from September 1987 to December 1992. Mr. Thum provided hardware and software systems technical support and assisted in projects focused on the application of GIS for local government land records automation. He managed Project LOCALIS (a consortium of seven Wisconsin and Illinois counties, IBM, ERDAS and ESRI), which evaluated and recommended alternative strategies for local government GIS database design, automation, and applications development. He managed workstation and microcomputer hardware, modeled water quality and non-point pollution applications, provided general consulting to county and municipal officials in LIS/GIS implementation and provided instructional/educational support when needed.

Water Resources Planner

From October 1984 to September 1986, Mr. Thum was a Water Resources Planner with Lake County, Illinois Department of Planning, Zoning, and Environmental Quality. He managed county stormwater management program activities that included designing an organizational framework, evaluating hydrologic impacts of local land use changes, technical writing and development of applications.

Education

Mr. Thum graduated with a Master of Science (1989) in Water Resources Management, Watershed Planning and Water Resources Policy, from the University of Wisconsin-Madison.
He has a Bachelor of Arts (1986) from Northeastern Illinois University, Chicago, Illinois, with a major in Geography and Environmental Studies. He also has additional training in surface water modeling, stormwater management, land use planning, and geographic information systems.

Other Professional Accomplishments

Mr. Thum has over 13 years experience in information technology. He has given numerous lectures and workshops in local, regional and national conferences. He also authored several articles and publications.

Professional Affiliations

Mr. Thum's professional affiliations include the Urban & Regional Information Systems Association (URISA), American Water Resources Association (AWRA), American Congress on Surveying and Mapping (ACSM), and the Wisconsin Land Information Association.

THOMAS G. RIES

Professional Experience

Transportation Services Manager, GeoAnalytics, Inc.

Mr. Ries manages the firm's transportation consulting and development services. His areas of expertise are enterprise transportation systems analysis and design specializing in spatial needs, process management, organizational development, and information technology planning. He is responsible for project management and leadership, senior consulting, strategic and business planning, marketing and sales.

Chief, Performance and Process Management Services, Wisconsin DOT

Mr. Ries was manager and senior consultant for department consulting services in quality principles, performance measures, process improvement, process re-engineering, and customer and business assessments for 1994-1998. He was the consultant for improving access for executive and senior mangers to management information for the highway project development process, improving WisDOT customer support/contact interfaces, improving data quality and data access to the Local road inventory and certification process that included spatial data and process requirements analysis, improving methods to performance specifications for roadway subgrade design and construction.

Senior Analyst, Geographic Information Services, Wisconsin DOT

Mr. Ries was the spatial database development manger for the Wisconsin DOT for almost 10 years. He modeled, designed, developed, and implemented several statewide roadway and multi-layered databases. His focus was in linear spatial data, spatial data quality assurance and control, and applying spatial data quality and methods to data maintenance and management procedures. Included in his database work is one of the first transportation location reference database management systems that contains a linear datum, multiple linear reference methods, and multiple-scaled cartographic databases. He developed location control policies and standards, spatial data access roles and geographic data access services for the department as well as IT visioning and IT planning. He was been project lead on a data architecture plan development.

Other Professional Accomplishments

Mr. Ries is author and co-author of several articles and research reports in the field of transportation spatial database development. He has participated in numerous national initiatives and workshop presentations on spatial data development and implementation for transportation, including the National Spatial Data Infrastructure transportation data model, 1996; national workshop on Integrated Transportation Information Systems, 1996; and the NCHRP 20-27(2) linear reference data modeling project, 1994-95. Mr. Ries has also been instructor and presenter with many audiences at conference workshops, professional associations, international governments, and all levels of US government

Education & Training

M.S., Cartography, University of Wisconsin-Madison; 1987 and GIS/LIS. B.S., Mathematics, Illinois State University; 1983. He has additional training in re-engineering and process improvement, facilitation, organizational development, information engineering and data modeling, application development methodologies, project management, and strategic planning.

Professional Affiliations

Member, National Cooperative Highway Research Program 20-27(3) Project Panel; American Congress on Surveying Mapping, Cartography and Geographic Information Society, North American Cartographic Information Society.

DR. ALAN P. VONDEROHE

Professional Experience

Professor of Civil and Environmental Engineering, Univ. of Wis. - Madison

Dr. Vonderohe has been on the faculty at UW-Madison for the past 20 years. He was promoted to full professor in 1989. He chairs the Geospatial Information Engineering Group within Civil and Environmental Engineering and has also chaired the campus-wide Spatial Information and Analysis Consortium. He has taught more than 20 different courses ranging from basic surveying, to advanced analytical photogrammetry. Most recently, his courses have included spatial reference systems, engineering applications of GIS, and intelligent transportation systems. His research has ranged from applications of the Global Positioning System, to design and development of local land information systems, to analysis of accuracy's of methods for constructing digital parcel maps, to applications of digital photogrammetry.

Dr. Vonderohe's most significant research has been in Geographic Information Systems for Transportation (GIS-T), where he has been PI on two nationally prominent projects with the National Cooperative Highway Research Program (NCHRP 20-27 and NCHRP 20-27(2)). The results of this research included a conceptual model for linear referencing systems that addresses the problem of data sharing and integration through development of a common linear datum. Most recently, he was PI on a project, funded by Sandia National Laboratories, that developed a methodology for design of the field components of the linear datum, based upon the accuracy requirements of end users.

Other Professional Accomplishments

Dr. Vonderohe has been keynote speaker at a number of annual meetings of the Land Surveyors' Society in various states and at the annual AASHTO Symposium on GIS-T. He has given invited lectures, seminars, and short courses on topics ranging from the multipurpose cadastre to institutional considerations for implementation of GIS-T, in venues ranging from URISA, to ACSM, to AASHTO, to TRB, to the Wisconsin Land Information Association. Dr. Vonderohe has served as a consultant to local and state government, power utilities, the Society of Automotive Engineers, and Oak Ridge National Laboratories. He is author of over 150 publications on research and education. In 1994, he received the Earle J. Fennell Award for outstanding contributions to surveying education from the American Congress on Surveying on Mapping. Dr. Vonderohe is a registered land surveyor in Wisconsin and Illinois.

Education

Dr. Vonderohe received his BSCE, MS, and Ph.D. degrees, with majors in Photogrammetry and geodetic science, from the University of Illinois at Urbana-Champaign. As an undergraduate, he was presented with the W.H Rayner Award as outstanding student of surveying. As a graduate student, he received the W.H. Eldridge Award for best contributed paper from the Illinois Registered Land Surveyors Association. He is a member of the Chi Epsilon National Honor Society.

Professional Affiliations

Transportation Research Board (Task Force on GIS-T), American Congress on Surveying Mapping (Editorial Review Board), American Society for Photogrammetry and Remote Sensing (Past President, Western Great Lakes Region), American Society of Civil Engineers (past member of Publications Committee), Wisconsin Society of Land Surveyors (Past Chair, Land Information Systems Committee), and the Urban and Regional Information Systems Association.

SHERRY K. COATNEY

Professional Experience

GIS Consultant, Safe Harbor Group, Inc.

Ms. Coatney is a GIS consultant affiliated with the Safe Harbor Group, Inc. Her areas of expertise include GIS project management, assessment, implementation, and training. She provides consulting services primarily to local government and state agencies using Intergraph GIS software products.

GIS Consulting Manager, Intergraph Corporation

Ms. Coatney was the Central US GIS Consulting Manager for Intergraph Corporation from September 1998 to November 1998. She was responsible for managing a team of GIS consultants for transportation and local government custom software development and project implementation. She also provided project management for large GIS consulting contracts. From December 1997 to September 1998, Ms. Coatney was the Midwest GIS/Civil Engineering Technical Support Manager for Intergraph Corporation. In this position, she provided project management for short-term consulting projects, supported trade shows, demonstrated software and consulted with transportation and government customers in GIS implementation.

GIS/Mapping Application Specialist, Intergraph Corporation

Also with Intergraph Corporation, Ms. Coatney provided pre-sales technical, demonstration, and post-sales implementation support for GIS and mapping application software for the Midwest region from July 1994 to December 1997. She specialized in transportation, local government, business and cartographic application support.

GIS Sales Representative, DataMap, Inc.

From November 1992 to July 1994, Ms. Coatney used direct sales techniques to market geographic and demographic databases, GIS software, and custom mapping services for DataMap, Inc. She also developed value-added reseller relationships with other GIS firms and conducted studies of vertical markets for geographic products and services.

Cartographer, University of Wisconsin-Madison

While attending graduate school at the University of Wisconsin-Madison from August 1989 to September 1992, Ms. Coatney was a cartographer with Mapping Specialists, Ltd., and with the Wisconsin Department of Transportation. She was responsible for updating, designing and producing the digital state highway map of Wisconsin for WisDOT.

Other Professional Accomplishments

Ms. Coatney has sixteen years experience in Intergraph systems, and is a certified MGE instructor. She is experienced in MGE (including Segment Manager, Network, and other advanced modules), GeoMedia, Oracle, SQLServer, and MicroStation, on Windows NT and UNIX platforms. She has served on the Standards Committee of the Governor's Council on Geographic Information for the state of Minnesota.

Education

Ms. Coatney has a Master of Science (1992) and a Bachelor of Arts (1982) from the University of Wisconsin-Madison. She majored in cartography, and her thesis research was in the marketing of GIS and cartographic services. Ms. Coatney was awarded Sophomore Honors and the Order of the Omega as an undergraduate.

DR. NANCY VON MEYER

Professional Experience

Vice President, Fairview Industries, Inc.

Vice President and co-founder of Fairview Industries, Inc. Fairview Industries is an information technology service and consulting firm based in Blue Mounds, Wisconsin. A Wisconsin Corporation since 1983, Fairview Industries provides information modeling, user needs and situation assessment reports, implementation assistance, and product development services to local, state and federal agencies and utilities. Fairview Industries is vendor independent with working experience on the major GIS platforms, document imaging systems, and most Computer Aided Software Engineering (CASE) tools. Nancy's activities at Fairview Industries include

Organizational, workflow, and situation assessments

Institutional design, re-organization, and change management

Database and System Design

Geodetic Issues, Coordinate Systems and Survey Designs

Standards development, standards maintenance, and standards implementation

Quality assurance, technology procurement and contract administration.

Engineering Systems and GIS design and specifications

Other Professional Accomplishments

Dr. von Meyer is Past-President of the Wisconsin Land Information Association and a former member of the Board of Directors of the Urban and Regional Information Systems Association. She is currently the Editor of the Surveying and Land Information Systems Journal and on the Editorial Advisory Board of Geo Info Systems Magazine. Dr. von Meyer has served on National Academy of Sciences committees and panels. She has authored several articles and publications.

Education

Dr. von Meyer graduated with a Ph.D. (1989) in Civil and Environmental Engineering, from the University of Wisconsin-Madison. She has a Masters of Science (1982), also from the University of Wisconsin-Madison in Mining Engineering, as well as a Bachelor of Science in Mining Engineering (1977) from the University of Wisconsin-Platteville.

Professional Affiliations

Dr. von Meyer’s professional affiliations include the American Congress of Surveying and Mapping (ACSM), American Society of Photogrammetry and Remote Sensing (ASPRS), GIS/LIS Conference – Conference Committee (1992-1994 and 1998-present), International Geographic Information Foundation (IGIF) Board of Trustees (1991-1994), National Research Council – Mapping Sciences Committee (1992-1997), Registered Professional Engineer, Urban & Regional Information Systems Association (URISA), Wisconsin Land Information Association (WLIA), Wisconsin Society of Land Surveyors (WSLS)

AARON COHEN

Professional Experience

Senior GIS Analyst/Programmer, GeoAnalytics, Inc.

Senior technical consultant, providing support for GIS system analysis, database design and technical applications. Develop technical specifications and procedures for Arc/Info and ArcView based applications and data automation procedures. Provide support for hardware/software installation and UNIX/AIX and Windows NT system administration.

Associate Planner, Marathon County Planning Department

Administered and implemented a GIS for Marathon County using ARC/INFO 7.04 and ARCVIEW 3.0 on UNIX workstations and PCs via a network. Duties included data acquisition and QA/QC, application development using AML and AVENUE, preparation of State of Wisconsin Land Information Plans and successful grant application development. Staff to the Marathon County Land Information Committee and a member of the DP Management Group.

Personally developed one of only three countywide ward plans using GIS in the State of Wisconsin for legislative redistricting in 1991.

Successfully managed the installation of a E9-1-1 system for Marathon County. Project included development of RFPs and implementation plan, development of Master Street Address Guide (MSAG), negotiation of contracts with utilities and vendors, and coordination with the State of Wisconsin Public Service Commission.

Planning and Research Associate, Seneca Associates

Lead staff member for a community research and planning firm specializing in services to non-profits and government agencies. Specific responsibilities included the design and implementation of surveys, program evaluations, and needs assessments. Database design, statistical analysis, and computer presentation of results were areas of concentration.

Education

Mr. Cohen graduated with a Master of Science (1987) in Urban Affairs from the University of Wisconsin-Milwaukee. He has a Bachelor of Arts (1983) from the University of Wisconsin-Milwaukee. He majored in Anthropology. Other areas of study include economic development, research methodology, urban planning, computerized research applications, urban anthropology, architecture, cultural anthropology and computer science.

Professional Affiliations

Board of Directors, Wisconsin Land Information Association (WLIA), 1994 to 1996.
Co-Chair WLIA Education Committee (1994-95) and Technical Committee (1995-96).
Member of WLIA since 1992. Member of the American Planning Association (APA) since 1989.

JEFFREY M. LAIRD

Professional Experience

Vice President, Bluegrass GIS

Responsible for all aspects of GIS consulting for all clients, and for applications development for clients requiring work on Bentley, Intergraph MGE, GeoMedia, AutoCAD, ArcView, MapInfo, or MapObjects product lines. Provide customized applications and programming using Visual Basic, MDL, UCM, MicroStation Basic, Avenue, and MapBasic. Also assist clients in the establishment of CAD standards and digital mapping processes.

Senior Systems Analyst, PlanGraphics, Inc.

Prior to Bluegrass GIS, Mr. Laird was Project manager and applications developer responsible for geographic information systems hardware, software, and database design and implementation in Frankfort, KY from 1991-1997. Also responsible for the analysis of clients' GIS requirements. Provide assistance to clients in the specification, evaluation, and procurement of GIS products and data conversion services. Provide technical support to clients and projects ranging from comprehensive project management, including schedule, budget, and resources, to detailed software engineering, program design, and coding.

Education

Mr. Laird graduated with a Bachelor of Arts (1984) in Geography from George Mason University, Fairfax, VA. He is a certified Cartographer (1984, GMU), as well as a certified Mapping Specialist (1997, ASPRS).

Additional Professional Experience

Minnesota Department of Transportation, St. Paul, MN – as a subcontractor to Intergraph Corporation, performed a GIS assessment for the Right of Way unit of the Office of Land Management. Interviewed over 120 persons in five Districts, compiled and evaluated the information, and developed a GIS Situation Analysis, Needs Assessment, and Detailed Implementation plan for the management of DOT ROW properties, acquisitions, and reconveyances statewide.

Additional Experience - *U.S. Army, Fort McCoy, WI* – GIS needs assessment, system design, project planning, and implementation for facilities management involving multi-agency data sharing - Intergraph MGE GIS,. *San Jose Water Company* – development & on-call applications development resource of elevation determination and inline pressurization calculator applications using Visual Basic, GeoMedia, Access, and MGE Terrain Analyst. *EG&G Mound* – Project Manager – assisted in situation analysis and implementation plan design for hazardous materials cleanup activities. Developed & implemented an Environmental Remediation GIS on the MGE platform.

Additional Specialized Training

GeoMedia Customization, Intergraph GeoMedia Workshop, Microstation MDL Programming, Intergraph GeoVoxel Workshop, UNISYS Spatialware, Real Time Kinematic GPS, Differential GPS, Microstation Geographics, MGE for NT Intergraph, ORACLE v.7 for NT.

JAMES A. CORY

Professional Experience

GIS/IT Analyst, GeoAnalytics, Inc.

Information System design, integration and administration, spatial and tabular database design. Technical: ARC/INFO, SDE, ArcView, and MapObjects GIS - AML, Avenue, Visual Basic, C programming - UNIX (Ultrix/OSF) OS - Oracle RDBMS.

Worked as technical consultant on Gas Company installation of ArcFM. Responsible for setup and integration of Oracle, SDE, ArcFM, and network interfaces. Worked with customer to develop data conversion process from legacy GIS into ArcFM structure. Developed Oracle and SDE routines to load and configure converted data into the new system.

Team leader and programmer on project to develop a prototype Arcview application to evaluate proposed DNR hydrographic data model. Building data structure based on model. Creation of routines for associating user tabular data, containing XY locations with hydro routes and regions.

GIS Programmer Analyst

July 1991 to June 1998 - Bureau of Information Management, Department of Natural Resources, State of Wisconsin, Madison, Wisconsin. Responsible for developing spatial databases, user applications and information system designs. Researched and implemented various methods for integrating spatial and tabular databases.

Developed the statewide Deer Management Unit layer as a subset of many DLG layers. Made presentation quality maps and linked the units to the DNR's extensive deer database.

Completed work on a protraction program written in Fortran and then applied it to the conversion of Oracle records containing PLSS location descriptions into Arc/Info point coverages. Applied this methodology to the creation and maintenance of a statewide well layer.

Responsible for evaluating and testing the Database Integrator functions linking Arc to the Oracle database residing on a VAX. Connections were developed for both DECNet and TCP/IP protocols. Verified and tested Arcview - Oracle connectivity for the Unix systems and for PC's. Using the point locations stored in the Oracle database, I created an Avenue application that set up an event theme and linked it to the appropriate tabular data.

Worked with the Property Management team as GIS Analyst and I am responsible for the overall design and development strategy for the Property Boundary layer. Records of ownership are stored in Oracle and their areal descriptions are noted down to the PLSS Quarter Quarter Section.

Education

Mr. Cory undertook 2 yrs of graduate studies (1979) in Soil Science and the geography of soils, from the University of Wisconsin-Madison. He has a Bachelor of Arts (1977) from Sonona State College, Rohnert Park, CA in Geography. He also has much supplemental training in Visual Basic, Oracle DBA/SQL, Powerbuilder, Computer Aided Drafting (AutoCad).

Bidder's Reference Form

Bidder’s Reference Form

Bidder’s or Subcontractor’s Name: Sherry K. Coatney

Information Requested	Reference 1	Reference 2
Name of references organization	Minnesota Department of Transportation	Ohio Department of Transportation
Name of Primary Contact on project (References Project Manager)	Mike Schadauer	Dave Blackstone
Contact’s Title	Project Manager	GIS Manager
Contact’s address	395 John Ireland Blvd. St. Paul, MN 55155	25 S. Front Street Columbus, OH 43215
Contacts Phone Number	651/582-1764	614/466-3124
Contact’s FAX Number	651/582-1004	614/752-8646
Completion date of project being referenced	April, 1998	January, 1997
Total project cost	$50,000	$34,000
Amount of cost for which the reference’s firm was responsible	30%	100%

Bidder's Reference Form

Bidder's or Subcontractor's Name: Dr. Alan P. Vonderohe

Information Requested	Reference 1	Reference 2
Name of references organization	National Cooperative Highway Research Program – Transportation Research Board	Sandia National Laboratories - Software Systems Surety Dept.
Name of Primary Contact on project (References Project Manager)	Dr. Ken Opiela	John Espinoza Jr., SMTS
Contact's Title	Senior Project Coordinator	SMTS
Contact's address	2101 Constitution Avenue, NW Washington, D.C. 20418	P.O. Box 5800 / MS 0449 Albuquerque, NM 87185-0449
Contacts Phone Number	202/334-3237	505/844-6887
Contact's FAX Number	202/334-2006 email: kopiela@nas.edu	505/844-9641 email: jespino@sandia.gov
Completion date of project being referenced	August, 1997	December, 1996
Total project cost	$200,000	$15,000
Amount of cost for which the reference's firm was responsible	100%	100%

Bidder's Reference Form

Bidder's or Subcontractor's Name: GeoAnalytics, Inc. (Tom Ries)

Information Requested	Reference 1	Reference 2
Name of references organization	Wisconsin Department of Transportation	Wisconsin Department of Administration
Name of Primary Contact on project (References Project Manager)	Mike Krueger	Loren Hoffman
Contact's Title	Supervisor, Geographic Information Services	State Redistricting Project Manager
Contact's address	4802 Sheboygan Avenue, Rm. 201B Madison, WI 53707	Office of Land Information Services PO Box 952 Madison, WI 53701-0952
Contacts Phone Number	608/261-6275	608/261-6633
Contact's FAX Number	608/267-0294	608/266-5519
Completion date of project being referenced	September 1996	January 1992
Total project cost	Information not available from DOT.	$1.25 million
Amount of cost for which the reference's firm was responsible	Information not available from DOT (see description)	$300,000

Bidder's Reference Form

Bidder's or Subcontractor's Name: GeoAnalytics, Inc. (Peter Thum)

Information Requested	Reference 1	Reference 2
Name of references organization	Wisconsin Department of Transportation	
Name of Primary Contact on project (References Project Manager)	Ruben Anthony	
Contact's Title	Bureau Chief – Bureau of Transit and Local Roads	
Contact's address	4802 Sheboygan Avenue PO Box 7915 Madison, WI 53707-7915	
Contacts Phone Number	608/266-2249	
Contact's FAX Number	608/267-0294	
Completion date of project being referenced	December 1999	
Total project cost	$270,000	
Amount of cost for which the reference's firm was responsible	100%	

Bidder's Reference Form

Bidder's Reference Form

Bidder's or Subcontractor's Name: Nancy von Meyer

Information Requested	Reference 1	Reference 2
Name of references organization	Federal Geographic Data Committee	Oakland County, Michigan
Name of Primary Contact on project (References Project Manager)	Robert Ader	R. Scott Oppmann
Contact's Title	BLM GeoSciences Team Leader	GIS Manager
Contact's address	RS 120 Mail Stop Building 50 Denver Federal Center Denver, CO 80225-0047	1200 N. Tlepgraph Road #49W Pontiac, MI 48341
Contacts Phone Number	303/236-3587	248/452-9198
Contact's FAX Number	303/236-6564	248/452-9126
Completion date of project being referenced	September, 2000	December, 2000
Total project cost	$300,000	$250,000
Amount of cost for which the reference's firm was responsible	100%	100%

Sherry K. Coatney

Reference 1:

The Minnesota DOT Right-of-Way Plan and Assessment project provided assessments of the current state of GIS use, the need for GIS technology, and a plan for the development of GIS capabilities within the Right-of-Way division of Minnesota DOT. The project research was based on a review of previous department reports and interviews with
personnel involved in all Right-of-Way processes. Interviews were conducted with personnel in MnDOT's Central Office, Metro Division, and three District Offices. The results of the interviews were summarized in a report, which was approved by MnDOT. A secondary report was then prepared that included a plan for the implementation of GIS within MnDOT
Right-of-Way. Issues covered in the report included how current work processes would be affected by GIS, application development, staffing requirements, training, software, hardware, and technical support. The final plan was accepted and approved by MnDOT.

Reference 2:

The Ohio DOT GIS Conversion project provided a methodology for moving the Ohio DOT's existing VAX-based GIS to a Windows NT environment. The project included an assessment of custom software built upon Intergraph's IGDS-DMRS environment on the VAX, as well as development of custom tools for translating the existing graphic and database portions of the GIS from IGDS-DMSR to MGE, Segment Manager and Oracle. An attempt was made to duplicate the custom software in the MGE environment, and effort that was eventually abandoned in favor of using the off-the-shelf capabilities of MGE. The project included the development of a user's manual, system training, and GIS software/Oracle scripting.

Alan P. Vonderohe

Reference 1:

Dr. Vonderohe served as Principal Investigator on continuation of his initial GIS-T work with the National Cooperative Highway Research Program. The continuation project was referred to as NCHRP 20-27(2): "Development of System and Application Architectures for GIS-T". This research resulted in two primary products:

The linear referencing system data model that helps form the conceptual basis for the proposed Iowa DOT LRS. This data model arose from a workshop, in August 1994, of more than 40 transportation professionals, drawn together to address the problem of data sharing and integration within and across agencies having multiple linear referencing methods, multiple network databases, and multiple cartographic representations. The key component of the data model is a linear "datum" that provides a common reference space for transformation among the various methods and representations. The data model has generated extended interest in formal modeling of location referencing systems within the transportation community and is being adopted by states such as Wisconsin, Minnesota, and Iowa.

Generic data, functional, and business systems architectures, synthesized from formal models of same from eight state and provincial DOTs. The synthesized architectures are expected to provide significant benefits to DOTs that use information-engineering methods to develop information strategy plans.

The results of this work have been published by the NCHRP as Research Results Digests 218 and 221, respectively.

Reference 2:

The NCHRP 20-27(2) model is conceptual in nature and does not address in-the-field-aspects of linear referencing systems, including how to select datum objects (i.e., anchor points and anchor sections), accuracy requirements for positioning and measuring datum objects, and how to achieve those accuracy requirements. These aspects of the linear referencing datum were addressed during follow-on research, funded by Sandia National Laboratories, with Dr. Vonderohe as PI. The project was entitled AT-45767 "A Methodology for Design of a Linear Referencing System for Transportation".

Within the research, linear referencing systems were viewed as similar to other location referencing such as those used for mapping. Such location referencing systems have datum's (e.g., NAD83, NGVD88) and consist of collections of redundant systems of measurements that are self-checking and rigorously designed to meet the accuracy requirements of users. Geodetic engineering principles used to design these more traditional referencing systems were applied to the linear problem to produce a methodology that reverse engineers the accuracy requirements of users and the capabilities of measurement technologies to produce optimal configurations of datum objects and field measurements. By "optimal", we mean the least-cost configuration of anchor points, anchor sections, and measurements, guaranteed within specified levels of certainty, to meet the accuracy requirements of users. The research included guidelines on selection of points in the field, measurement methods, and choices to be made in special circumstances (e.g., ramps, cul-de-sacs).

This research was published in full as a report by Sandia Laboratories and excerpts have recently appeared in two papers in the Spring 1998 issue of the Journal of the Urban and Regional Information Systems Association, (Vol. 10, No.1).

GeoAnalytics, Inc. (Thomas G. Ries)

Reference 1:

The following projects were part of a large effort, of several projects, to design and implement the Wisconsin DOT's locational reference systems. This effort followed a high-level system analysis on WiDOT location reference needs. Mr. Ries worked on two key projects under this effort. The first project (1989-1992) was the design and implementation of the department's linear reference system, its field collection procedures, and corresponding data base management system. Mr. Ries was a senior consultant to this project, assisting in the requirements analysis, data modeling, and systems and procedures development. The second project (1992-1995) was the design and implementation of the department's geographic reference system (cartography) and its relationship to the linear reference system, and the corresponding data base management system.

Both systems include historical data, data maintenance and access tools. This system supports the ability to tie a linear datum to multiple cartographies, tracks the variable data sources used, and tracks editor resource use. This system was used as a basis for the development of the NCHRP 20-27(2) model.

Mr. Ries spent 10-15% of his time working on the linear reference system project (most of this time in the modeling stage), and 80-100% of his time working on the geographic reference system.

Reference 2:

This project was one effort under the State of Wisconsin's Redistricting Effort based on the 1990 Census. The effort included a multi-government cooperative approach to create spatial and tabular data that could be used by all governments in the state of Wisconsin after redistricting. Wisconsin DOT was contracted to create the spatial database because of their skills in the development and management in spatial database systems. Mr. Ries was project leader for this effort. This project was to create a data maintenance system to update the US Census Bureau TIGER data base for general use by state governments and local governments. Updates came from local governments in various forms. Project deadlines were critical to match the redistricting schedule. Rigorous data quality control and assurance processes and procedures were developed to meet the requirements to produce detailed data auditing (lineage) information.   Another primary objective of the system was to create a database and for documentation to prevent the data from being held up in court regarding redistricting. The objective was met.

GeoAnalytics, Inc. (Peter G. Thum)

Reference 1:

GeoAnalytics has been supporting the Division of Transportation Investment Management - Bureau of Transit and Local Roads within WDOT since May 1997. Assistance has focused on the design and implementation of a statewide, geospatial database on local road information and the development of specific GIS applications to be used for data input, maintenance, query and analysis, and output. This project involves the migration of existing local roads information from a mainframe flat file structure to a GIS based relational database warehouse that will be managed for internal WDOT personnel access as well as access by other state and local units of government. Additionally, the project is moving attribute data from a statically segmented view to a dynamic view were each set of related attributes varies independently of one another. Integration of data sets is achieved through the development of an in-house LRS based on link-node structures.

A variety of technology types are being designed and/or will be used to support implementation of the project. These include: workstation ARC/INFO for GIS data management, Oracle and DB2 RDBMS for business data storage and management, ESRI's MapObjects, ArcView, and Internet Map Server (IMS) solutions for data query, analysis, and publication, and an intranet and extranet network infrastructure for data warehouse access by both producers and users of local roads information. In addition, geospatial data transfer standards are being developed to facilitate the exchange of GIS data between WDOT and many local units of government throughout Wisconsin.

The Local Roads Database redesign initiative is being completed in a staged fashion, the status and results of which will be described in the presentation. These stages include a User Needs Assessment, Logical Data and Process Model Development, Physical Database Development and Prototyping, and Implementation. Currently the project is in system design, readying for prototyping.

Dr. Nancy von Meyer

Reference 1:

Dr von Meyer served as the project leader and facilitator for the development and continued maintenance of the Federal Geographic Data Committee’s Cadastral Data Content Standard for the National Spatial Data Infrastructure, December 1996. This standard is a compilation and reconciliation of land records and land ownership information from eleven federal agencies. It is a vendor independent logical data model that provides a semantic data standard for land and survey related information. von Meyer continues to work with the FGDC Cadastral Subcommittee on standard maintenance, education, and implementation topics. Additional information, including an online educational package can be accessed on the World Wide Web at: http://www.fairview-industries.com/fgdc-cad.html

Reference 2:

The Oakland County, MI project involved establishing a GIS Data Utility for the County that will serve as a focus for the distribution, access, and maintenance of GIS data, including parcel information, transportation and drainage networks, and digital orthophotography. Dr. von Meyer's work on this project included: conducting a user needs study, writing a request for proposal for software, assisting with the selection of the software, designing data coverages for GIS, assisting with data design for elements in the data warehouse, assisting with the organizational changes required to support the GIS county-wide, and assisting with public access through a one-stop shop design. Documents related to this project can be found on the World Wide Web at: http://www.co.oakland.mi.us/c_serv/gis