CLOSEOUT REPORT

Submitted by the AASHTO TIG Lead States Team for
the following technology:

Linear Referencing Systems (LRS)

Lead States Team Members and Agencies:

Peggi Knight, Chair, Iowa DOT

Oscar Jarquin, California DOT

Thomas Martin, Minnesota DOT

Jonathan DuChateau, Wisconsin DOT

David Blackstone, Ohio DOT

Janet Lowe, North Carolina DOT

Dave Fletcher, Geographic Paradigm Computing, Inc.

Tim Bisch, Bentley Systems, Inc.

Mark Sarmiento, FHWA

Closeout Meeting Date: September 20, 2012

American Association of State Highway and Transportation Officials
AASHTO
The Voice of Transportation

Driving Innovation for Transportation
TIG
AASHTO Technology Implementation Group

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Where the names of products or manufacturers appear herein, their inclusion is considered essential to the objectives of this report. AASHTO does not endorse products or manufacturers.

TABLE OF CONTENTS

Page

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Introduction

The AASHTO Technology Implementation Group (TIG) selected the Iowa Department of Transportation's submission of their Linear Reference System (LRS), developed from the NCHRP 20-27 model, as a TIG Focus Technology. The purpose of the TIG Focus Technologies program is to assist in the distribution of highly beneficial new technologies like LRS to other states. A Lead States Team was formed which included State DOT representatives and private sector members who have a strong understanding of the detail and complexity of this NCHRP model.

Combining information from different data sources within a department of transportation has been an information processing concern. Spatial data, whether in the form of a mile marker, literal description or other location component, have varied in the many different databases used over the years. Since a vast majority of the data collected is referenced to the Earth in some manner, the use of spatial location and Geographic Information System products is the logical choice to accomplish this integration. The Linear Reference System (LRS) aligns the linear reference points in all databases so information from crash statistics, pavement management and other business data can be accurately mapped and data more easily analyzed. Through this alignment, the LRS allows database integration and facilitates data access, improves accuracy, minimizes redundancy in the databases, minimizes data maintenance activities and allows inclusion of all public roads.

The Lead States Team held its kick-off meeting on September 30 and October 1, 2008. See Appendix A for the kick-off meeting agenda. Outcomes from the meeting were a Marketing Analysis (Appendix B), and a Marketing Plan (Appendix C).

Tasks of the Lead States Team have included two state surveys, development and distribution of a brochure, webinars, conference presentations and workshops, web meetings with individual states, and state visits. A value analysis was also performed, showing a 2 to 1 return on investment from implementing the base LRS. A return of 21 to 1 was found for implementing optional LRS functional elements.

This closeout report is divided into five sections:

- Marketing Activities,
- Transition Plan,
- Lessons Learned,
- Performance Measurement, and
- Final Expenditure Summary.

Marketing Activities

The major thrust of the Lead States Team marketing effort involved conducting technical webinars, giving presentations at selected conferences and workshops, and distributing marketing materials and publications in various manners.

Hosted Demonstration Workshops

Date	Workshop Title	Location	Total Attendance
August 10, 2009	Multi-level Linear Referencing Systems: Managing Transportation Data Effectively	Webinar	38
August 11, 2009	Multi-level Linear Referencing Systems: Managing Transportation Data Effectively	Webinar	32
October 8, 2009	Demo for Texas	Webinar	NA
January 28, 2010	Multi-level Linear Referencing Systems: Managing Transportation Data Effectively	Webinar	NA
February 16, 2010	Pennsylvania	Call	
March 16, 2010	Pennsylvania	Webinar	NA
March 24, 2010	Georgia	Webinar	NA
April 11, 2010	GIS-T Conference Workshop	West Virginia	30
July 19-21, 2010	State Visit to Georgia	Atlanta, GA	6
July 29, 2010	California	Call	
August 24, 2010	California	Webinar	NA
October 14, 2010	Michigan	Call	
December 15, 2010	Utah	Webinar	NA
February 2011	State Visit to Minnesota	Minneapolis, MN	10
March 27, 2011	GIS-T Conference Workshop	Hershey, Pennsylvania	15

The Lead States Team found that the workshops were a good forum for fielding questions and provided for better interaction with participants. In addition, the state visits provided the Lead States Team with valuable exposure to the particular infrastructure, politics and team dynamics within a state.

Presentations at Conferences and Meetings

Date	Conference or Meeting Name, Location	Presenter Name, Organization	Presentation Title	Written paper? (Y/N)
Spring 2009	GIS-T Conference Oklahoma	Steve Kadolph, Iowa DOT, J.J. DuChateau, Wisconsin DOT Oscar Jarquin – California DOT Eric Abrams, Iowa DOT	Linear Referencing System (LRS)	No
January 2010	TRB Annual Meeting Committee Meetings	Peggi Knight, Iowa DOT	Iowa LRS	No
July 2010	Mississippi Valley Conference	Eric Abrams, Ryan Wyllie, Steve Kadolph	Exhibit Booth only	No
April 17, 2012	GIS-T	Eric Abrams, Thomas Martin – Minnesota DOT	Costs and Benefits of Implementing and MLLRS	Yes
May 14, 2012	AASHTO IS Traverse City, Michigan	Tom Clemons, Bentley	TIG LRS Value Analysis	Yes

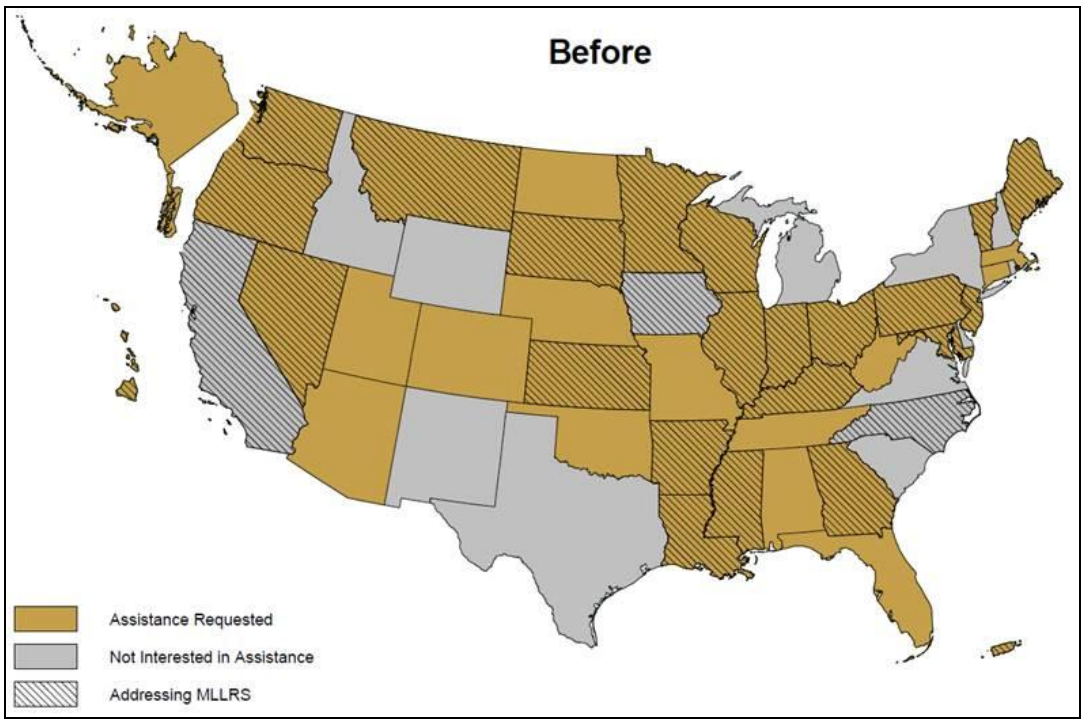
Publications

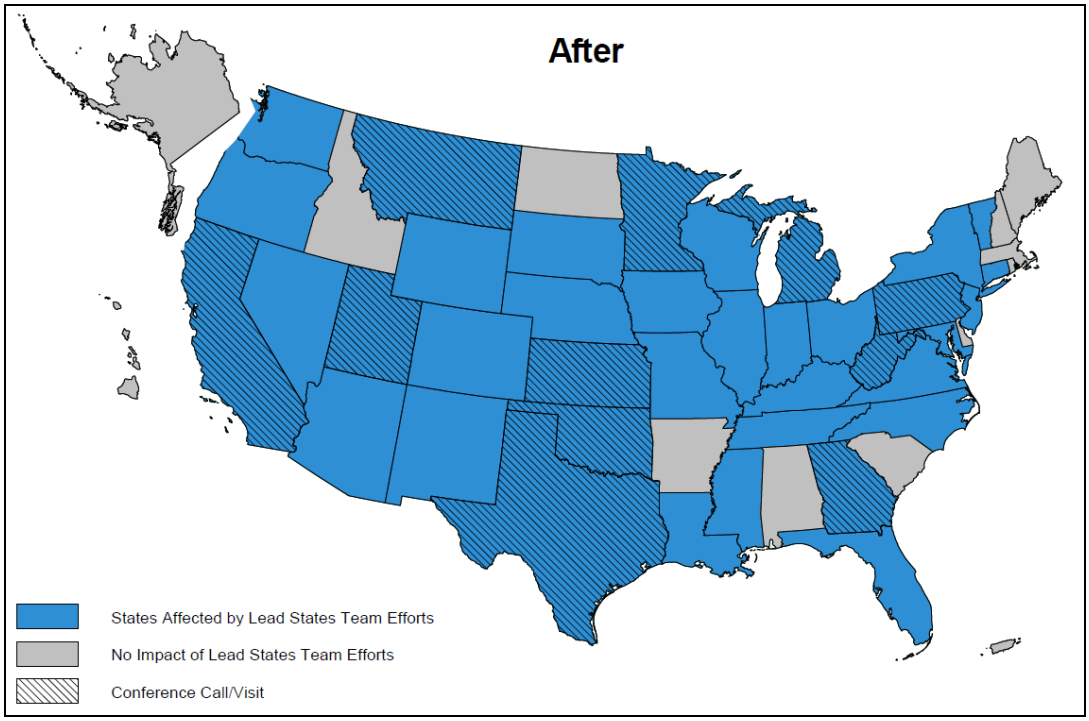
Date Produced	Publication Type	Total Number Produced	Recipients and Distribution Method
February 2009	LRS Brochure	NA	Handouts at Workshops, Meetings, Conferences, and website availability for download.
May 2011	Final Report entitled "Multi-Level Linear Referencing System (MLLRS) Cost/Benefit Value Analysis Study"	NA	LRS Lead States Team and potential LRS implementers. Website download availability.
May 2011	Brochure entitled "Multi-Level Linear Referencing System (MLLRS)"	NA	LRS Lead States Team and potential LRS implementers. Website download availability.
October 2011	Exhibit Banner	1	AASHTO annual meeting, Detroit, MI
July 2010	Exhibit Banner	1	Mississippi Valley Conference, Des Moines, IA

The first three listed items are included in Appendices E, F (Executive Summary only) and G, respectively.

Performance Measurement

The performance of the Lead States Team is best characterized by the following maps which display information gathered prior to Lead States Team activities and at the conclusion of Lead States Team activities.





Lessons Learned

Effective Tools and Methods

State visits were very effective. It was valuable for the team to gain exposure to their politics, infrastructure and team dynamics which in turn could lead to more effective assistance for the state. Discussion was tailored to the state's individual questions and allowed executive decision makers to participate and have their questions addressed. Because this particular Lead States Team was not focused on a computer program but instead on a technology solution, the state visit was valuable in addressing individual state needs.

Workshops provided more detail and were more effective than conference presentations. The workshops proved more effective for fielding questions and allowing for better interaction.

Unique Tools and Methods

A unique approach by this Lead States Team was the request of NCHRP 20-07 funding from AASHTO for the purpose of contracting a formal value analysis of implementing an MLLRS in a State DOT. The Lead State Team made this request because the cost of implementing a new LRS would appear at first look to be prohibitive. The value analysis was to credibly show the return on investment available to a State DOT.

If other Lead States Teams similarly see warrants for a value analysis, they should consider the fact that approval for NCHRP 20-07 funding is competitive and it is generally allocated on an annual basis.

Another unique approach was the stair-step method used in state visits. The team first provided a webinar to introduce the state to LRS. Next, the team had a conference call with representatives from the state to provide the opportunity to clarify and obtain a higher level of understanding. Third, if needed, the team offered an onsite visit that was tailored to the remaining information needs of a particular state.

Transition Plan

Reference Materials

Reference	Publisher	URL (if available on web)
Final Report entitled "Multi-Level Linear Referencing System (MLLRS) Cost/Benefit Value Analysis Study"	RH & Associates, Inc. Glendale, Arizona	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(302)_FR.pdf
Brochure entitled "Multi-Level Linear Referencing System (MLLRS)"	RH & Associates, Inc. Glendale, Arizona	http://tig.transportation.org/Documents/LRS/LRS_NCHRP20-07(302)_brochure.pdf
PowerPoint Presentation entitled "The Costs and Benefits of Implementing an MLLRS"	RH & Associates, Inc. Glendale, Arizona	http://tig.transportation.org/Pages/LinearReferencingSystem.aspx
Brochure entitled "Multi-Level Linear Referencing System"	AASHTO	http://tig.transportation.org/Documents/LRS/TIGBROCHURE.pdf
NCHRP 20-27 NCHRP Report 460 Guidelines for the Implementation of Multimodal Transportation Location Referencing Systems	TRB	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_460.pdf

Technology Transfer

Contact	Office Name, Location	Phone	Email
Mark Sarmiento	FHWA Office of Planning, Washington, DC	(202) 366-4828	Mark.Sarmiento@dot.gov

Primary On-going Implementation Responsibility

Primary on-going implementation responsibility appears to belong to the Finance and Administration Subcommittee on Information Systems and/or the GIS-T Task Force.

Specific Future Actions

Future Activity	Time Frame	Recommended Organization to Perform
Webinar for Kansas	Late October 2012	Iowa and Lead States Team participants
Address interest generated by expansion of LRS requirements for HPMS	Ongoing	All states
GIS-T/ASIS Conference Presentation or Workshop	May 2013	Iowa and Lead States Team participants

On the Web

Information developed by this Lead States Team is available at http://tig.transportation.org/Pages/LinearReferencingSystem.aspx.

Final Expenditure Summary

Total Team Expenditures = $12,082.35

Appendix A: Agenda for Kick-off meeting

AGENDA

Initial Meeting
Linear Referencing System (LRS) Lead States Team

Iowa Department of Transportation
800 Lincoln Way
Ames, Iowa
September 30 – October 1, 2008

Tuesday, September 30: 8:00 P.M. to 4:30 P.M.

Task Assignment **Lead Person**

- Welcome ..... Peggi Knight
- Self Introductions ..... All
- Review Agenda and Goals of the Meeting ..... Peggi Knight and Paul Krugler
- QA about the Process ..... Paul Krugler
- TIG Executive Committee Perspective on the Technology and LST Tasks … Paul Krugler

Develop Market Analysis (See Chapter 3 and appendix E of the Lead States Team guidebook for detailed information about what we will need to develop. The Marketing Analysis is largely in simple tabular format.)

> We hope to be able to expedite development of the market analysis. The plan is for the chair and facilitator to consolidate all pre-meeting question responses from LST members and provide this consolidated information to team members several days prior to the meeting. Each member will also be asked at that time to take a lead role in preparing one of more of the below listed tables or sections of the plan when we meet in Ames. While the consolidated information should go a long way toward establishing the information needed for each part of the plan, time is allowed on the agenda for each member to obtain additional input from other team members.

- Discussions led by each LST member. (Suggest discussions be limited to 5 to 15 minutes.)
    - Defining the Need for and Benefits Provided by the Technology …. LST Member
    - Identifying Broad Target Audiences ..... LST Member
    - Identifying Decision Makers ..... LST Member

- Information Needed by Decision Makers ……. LST Member
- Identifying Perceived and Actual Barriers to Implementation ..…… LST Member
- Identifying Existing Marketing Opportunities ……..… LST Member
- Identifying LST Partners ……LST Member

- Optional Breakout Approach – Individual work time (possibly 30 minutes) to prepare draft tables or paragraph based on group discussions. Provide drafts to facilitator to compile into a first draft Market Analysis document during lunch or break.

- Review of draft document by full team, revise as needed, and approve for submission to the AASHTO TIG Executive Committee ……..…..……..…… Peggi Knight

Develop Marketing Plan (See Chapter 3 and appendices D and F of the Lead States Team guidebook as well as the Marketing Plan template provided in a separate MSWord document.)

- Select Marketing Methods …… Peggi Knight and Paul Krugler
  - Rank probable effectiveness of marketing methods and tools. (Consideration should include but is not limited to the methods described in appendix D of the Lead States Team guidebook.)
  - Compare tentative list of marketing methods to the list of broad target audiences. (Are all audiences adequately addressed using one or more methods?)
  - Compare tentative list of marketing methods to the list of target decision makers. (Do selected marketing methods adequately communicate to all decision makers?)
  - Prioritize perceived and actual barriers to implementation.
  - Prioritize existing marketing opportunities.
  - Compare tentative list of marketing methods to prioritized lists of barriers and opportunities. (Are prioritized barriers adequately addressed by one or more marketing methods, and have marketing methods been selected to take best advantage of existing marketing opportunities?)

- Determine the Message ……..… Peggi Knight and Paul Krugler
  - Review information that was gathered while defining the need for the technology. Determine how each need or benefit can best be communicated, and which marketing methods should emphasize or include each need or benefit.
  - Review list of information needed by decision makers. (Assign each information item to each marketing method where it should be part of the message.)
  - Review prioritized barriers and opportunities. (Attempt to address every prioritized barrier and opportunity with factual information and assign information items to appropriate marketing methods.)
  - Review list of partners. Determine how each partner can best assist with the need and marketing methods.

- Determine the Marketing Activities …… Peggi Knight and Paul Krugler
  - Brainstorm potential marketing activities considering the market analysis, the prioritized barriers and opportunities, the potential marketing methods/tools, and the intended message.
  - Prioritize and select potential marketing activities.
  - Develop the goal and scope of each selected marketing activity.

- For each selected activity, determine promotional tools and information distribution methods.
- Decide which LST member will coordinate each selected activity.
- Show each selected activity as a task in the work plan section of the Marketing Plan. Clearly state the goal and scope of each activity, including planned promotional tools and information distribution methods. Provide adequate detail to substantiate the associated cost estimate in the budget. The last task should be the closeout report. Identify the coordinator for each task.

- Schedule the Marketing Activities …….…….… Peggi Knight and Paul Krugler

    - Determine the length of time required for each task and the relative timeline among tasks for the duration of your LST's activities.
    - Place each task in chronological order on the Activity Schedule in the Marketing Plan. A rearrangement of tasks may be required to achieve an appropriate chronological order of tasks. Consider audience and message priorities and continuity when scheduling.

If time permits, proceed to items on the day two agenda.

Adjourn for the Evening

****

Deluxe continental breakfast provided at the hotel. Mid-morning and mid-afternoon snacks will be provided.

October 1; 8:00 A.M. to noon.

- Prepare the Budget …….…… Peggi Knight and Paul Krugler

    - Estimate expenditures to accomplish each task. Separately tabulate expenses for which the AASHTO TIG will be invoiced and those that the lead states or other organizations will cover. See appendix F of the Lead States Team guidebook for the budget worksheet. The final step in the budgeting process is to determine the individual fiscal year budgets by assigning each task's budget or portions of each task's budget to the AASHTO fiscal year into which the activities are planned to occur.

- Develop the Communications Plan ……..…… Peggi Knight and Paul Krugler

    - Develop the communications plan by completing the table of information shown in the Marketing Plan template separately provided. Show the offices to be contacted within large organizations. For example, under the category of all AASHTO member agencies, show the offices to be contacted, such as the chief engineers, the state bridge engineers, the state materials engineers, etc.

- Develop the Performance Measurement Plan ……..…… Peggi Knight and Paul Krugler

- Select the means by which the LST plans to determine the degree of success achieved at the end of planned activities by completing the table of information shown in the Marketing Plan template separately provided.

Assemble the Marketing Plan

- Assign LST members to prepare each section of the Marketing Plan in final form as may still be needed. ……..….... Peggi Knight

- Individual work time, as needed, to prepare draft sections of the plan based on earlier team discussions. Provide drafts to LST Chair or facilitator to compile into a first draft Market Plan document. ……..…..…… All

- Full LST review, revision, and approval of the proposed Marketing Plan to be submitted to the AASTHO TIG Executive Committee. ……..……..…… Peggi Knight

Travel Claim Submittal Guidance ……..…….. Paul Krugler

Next Steps for the LST Team ……..…… Peggi Knight and Paul Krugler

Adjourn

Appendix B: Marketing Analysis

AASHTO TIG
Lead States Team
Marketing Analysis

for

LINEAR REFERENCING SYSTEM

(Name of Technology)

October 10, 2008

(Date of Analysis)

MARKETING ANALYSIS

What is the need for this technology?

Increasingly business professionals are recognizing that "where" an object is located or an event occurs is an important facet to support business decisions. Transportation agencies have concerned themselves with "where" throughout their existence. For many transportation facilities data, such as those along a roadway, the best location mechanisms constrain the location to the extent of the roadway. A Linear Referencing System* (LRS) that supports multiple Linear Referencing Methods** (LRM) is such a location mechanism. Anyone who describes a location along a roadway relative to another point, such as "I'm at mile marker 100" or "It's located on Main St., 200 feet north of 1st St.", is familiar with the concept of linear referencing.

Nearly every transportation agency uses linear referencing whether or not it is automated or formalized. Legacy systems, and manual systems being automated, often have embedded LRM data. As agencies increasingly utilize multiple data sources for decision support, it becomes apparent that location provides a natural mechanism to integrate these seemingly disparate business data (ie. objects and events). Efficient support of these needs requires an enterprise multi-level LRS.

An enterprise multi-level LRS provides a common, stable framework that is the foundation for managing, transforming and integrating data referenced using various LRMs and other location reference types (eg. GIS or other map-based data, survey data, coordinates). By having an enterprise multi-level LRS, improved decision support is obtained through easier and quicker data integration not previously practical. The common, stable framework that an enterprise multi-level LRS provides allows for faster development of business programs and IT applications which can then immediately integrate with other data, and removes LRS and LRM development and maintenance responsibilities away from each program area. Additionally, business data quality can be improved by automating checks for data gaps, overlap and logical consistency between separate databases. By displaying linear referenced business data on a map, additional tools, such as GIS, can be leveraged for further data integration, analysis and reporting.

As transportation agencies continue to use linear referencing, an enterprise multi-level LRS becomes a logical choice for managing each agency's data and process investments, and for exploiting its business data for new and more complex uses.

* A Linear Referencing System (LRS) is a set of procedures and methods for specifying a location as distance, or offset, along a linear feature, from a point with a known location. An enterprise, multi-level LRS is an integrated part of a larger multi-dimensional location reference framework (eg. survey monuments, legal descriptions, PLSS) that also support the temporal aspect of data.

** A Linear Referencing Method (LRM) is a specific method for measuring linear locations. (eg. Reference Post, Mile point, Stationing, Address range)

Who are the broad target audiences for the LST?
The target audience of this technology would be the State Transportation agencies. There are three general roles within the target audience for this marketing plan:

- Business champion - understands the technology and is able to articulate why its implementation is important to the rest of the business functions of the organization.
- Technical champion - understands the technology and how to implement the solution.
- Sponsor - organizes and commits resources of the organization to implementing the technology.

By targeting the marketing plan to these roles (instead of titles), it allows the plan to be adaptable to the cultural organization of each DOT. In some DOTs, these roles are found within steering or governance committees. In other DOTs these roles are assumed by one or two people within the organization. These three roles can also be distributed throughout the DOT organization.

The LST believes that the decision-makers within the organization are primarily defined by those individuals or groups who fill the roles mentioned above. If those three roles are "on board", then the decision to implement the technology will be relatively simple.

Who are the decision makers in the targeted agencies?

- Upper Level Managers (Division and Office directors and CIO)
- GIS Coordinators
- Data Managers
- Safety Community
- Asset Managers
- Design, Operations and Maintenance personnel
- Intelligent Transportation Systems Staff
- Planners
- Oversized vehicle permitting staff

What information will decision makers want to know to reach a conclusion about trying or adopting this technology?

The following table represents the information and detail the LST determined that decision makers would likely require before considering and /or implementing any enterprise LRS technology. Our message must highlight the real benefits of such a system (e.g. improved uses of data, reduced agency resources, etc.). It is our belief that implementing an enterprise LRS system will ultimately allow participating agencies to move from an information-poor state to an information-rich state, and as a promised result, will make better decisions and ultimately save taxpayer money.

Information	Interest Level	
	Critical	Desirable
How much will it cost?	x	
Why do we need it?	x	
How is this different than what we are doing now?	x	
How will it save taxpayer money (e.g. staff reduction, process improvement?	x	
What are the risks of implementing it?	x	
What are the risks of not doing it?	x	
What will be the initial investment—staff, data, time, etc.?	x	
Who will maintain it (DOT, local government, etc.)?		x
How long will it take to implement?		x
How is this different than GIS or other related technology?		x
Will it work with existing systems in place (ESRI, Oracle, IBM DB2, etc.) and processes (HPMS)?		x
Which states have implemented it versus those who have not?		x

What are actual and perceived barriers to be overcome to do a trial or to adopt this technology as a standard?

Barrier	Type	
	Actual	Perceived
Agency is entrenched in technology incompatible with Multilevel LRS		X
Internal and external political perception that implementing a Multilevel LRS would waste time and resources		X
View that LRS is not an engineering solution, but only a personal productivity tool		X
Perception that LRS is an enterprise solution unable to deliver on a project basis		X
Resistance to enterprise and visionary thinking		X
Inter-political perception that too much control would be given to or lost by a “group”		X
LRS can not be delivered without an increase in overhead costs		X
LRS comes with a high cost	X	

LRS data is planning data, historically inaccurate and previously found to be useless on actual projects		X
Location information doesn't have the same legitimacy as financial information		X
Responsibility for the governance of the LRS is unclear and therefore unmanageable	X	
Lack of understanding the advantage of using an LRS over other location techniques i.e. Google maps, GPS	X	
Commercial off-the-shelf solutions are limited and inflexible to individual State's needs	X	X

What marketing opportunities already exist?

Marketing for the LST findings and products will be at national level conferences. The three primary conferences are: GIS-T, TRB, and AASHTO-IS. At GIS-T the primary audience is the GIS practitioners and technical champions. At TRB it is the senior management and decision makers or potential sponsors. At AASHTO-IS outreach will be to the IT management.

Other potential conferences are the Traffic Records Forum, the Association of Traffic Safety Information Professionals, regional AASHTO conferences, regional GIS conferences, Local Technology Assistance Program, HEEP, and NENA.

The LST recognizes the need to reach out to the vendor community to communicate the needs of the DOT's for COTS solutions. Vendor conferences are also potential marketing opportunities.

National initiatives such as the HPMS reassessment and asset management tool development are also opportunities to market the technology.

Who are our potential partners in marketing this technology?

- State DOTs that have implemented LRSs
- Vendors
- NSGIC – National States Geographic Information Council
- Safety Groups
- FHWA
- Systems Integration Consulting Firms
- Open Geospatial Consortium
- FEMA
- Homeland Security

Appendix C: Marketing Plan

AASHTO TIG
Lead States Team
Marketing Plan

for

LINEAR REFERENCING SYSTEM

(Name of Technology)

Lead States Team:

Peggi Knight , Chair, Iowa DOT
David Blackstone , Ohio DOT
John Farley , North Carolina DOT
Oscar Jarquin , California DOT
Thomas Martin , Minnesota DOT
Jonathan DuChateau , Wisconsin DOT
Dave Fletcher , Geographic Paradigm Computing, Inc.
Tim Bisch , Bentley Systems, Inc.
Mark Sarmiento , FHWA

October 10, 2008

(Date of Plan)

WORK PLAN

Task 1.	Title: **Assess LRS Needs and Contacts in Each State**

Task Description:

Each LST member will contact assigned states to notify them of Lead States Team existence and purpose and to determine:

1. Are differing location referencing methods in legacy databases a current area of concern in your state?
2. Do you have a current effort on-going to address this concern?
3. Is your state aware of the LRS model developed through NCHRP work and the work of several lead states who have implemented variations of this model?
4. Would you be interested in receiving additional information via webinar about best practices from other states and the benefits they have seen?
5. Might your state have interest in several LST members visiting your state to share their experiences in implementing LRS or to review your state's situation and offer suggestions for your state's consideration?
6. Is there some other type of assistance from the LST that would be beneficial to your state?
7. Who are the potential business and technical champions in your state? Who is the sponsor or high level decision-maker with authority to allocate budget and direct an enterprise-level program?

An email introduction is planned prior to the telephone contact. Task requires development of message and specific questions to be used by all. Message should include purpose and objectives of the LRS Lead States Team.

Task 2.	Title: **Develop PowerPoint Presentation, Brochure and Posters Appropriate for State Visits and Use at Conferences**

Task Description:

PowerPoint presentation is to summarize LRS's in lead states and lessons learned during development of each. Information will be divided into modules or sections intended for specific target audiences. Target audience is primarily states being visited by Lead States Team members. Brochure is to describe the problem and solution provided by LRS and anecdotal information demonstrating LRS value. Target audience is generally higher level decision makers.

The Lead States Team will stay vendor neutral, focusing on functional needs of platforms and software rather than on preferences for specific software. Lead States Team members will share their experiences with specific products as it pertains to communicating their experiences.

Task 3.	Title: **Develop Value Analysis Document (Contractor)**

Task Description:

The Lead States Team will pursue AASHTO 20-07 funding and prepare a brief document describing desired contract work. Document to be submitted to AASHTO 20-07 committee through the AASHTO TIG Program Manager. If approved for funding, team members will provide information to the contractor as needed for development of the analysis. Purpose of the value analysis document to be produced is to clearly and credibly show that substantial benefits can be anticipated from implementing LRS. The document will be distributed to all states indicating in task one that integrating data in legacy databases is an area of concern. It will also be distributed as

a handout during task 5 presentation(s) and workshop(s) if available.

Task 4. Title: **Develop and Host Webinar(s).**

Task Description:

As the need is determined during task one, develop and host webinar(s) with individual states to communicate value and basic methods of implementing LRS. Webinars are anticipated to range from one to two hours in most cases. AASHTOWare will be kept advised of Lead States Team activities.

Task 5. Title: **Give Presentation(s) and/or Workshop(s) at TRB, GIST and AASHTO IS Conferences**

Task Description:

Selected team members will pursue agenda acceptance and present the benefits of implementing LRS at the conferences shown below.

Conference	Date - Location	Comments
2009 GIST	April 5-8, 2009 – Oklahoma City	Approval to have a 2-hour panel discussion will be pursued.
2009 AASHTO IS	May 3-6, 2009 - Seattle	Presentation to be focused on value of LRS at enterprise level.
2010 TRB	January 10-14, 2010 – Washington D.C.	Work through GIS Committee and possibly other committees. Possibly joint session.
2010 Conference 1	2010 - TBD	TBD
2010 Conference 2	2010 - TBD	TBD

AASHTOWare will be kept advised of Lead States Team activities.

Task 6. Title: **Visit States Offering Invitation**

Task Description:

Budget includes visits to approximately 10 states with generally three LST members participating in each visit. Length of visit estimated at 1.5 days on site. Purpose of the visit will be to provide tailored assistance to individual states. Team members to make specific visits will be determined based on the expressed areas of interest from the host state. All visits will be approved and assigned by the LST chair.

Task 7. Title: **Assess LRS Level of Knowledge Transfer and Implementation Success**

Task Description:

As necessary, contact states to determine the extent of success of Lead States Team efforts. Focus will be to develop performance measurement information. Survey states receiving assistance to determine satisfaction.

Task 8.	Title: **Prepare and Submit Closeout Report**
Task Description: Prepare Closeout Report as described in the Guidebook for Lead States Teams of the AASHTO TIG. Report will be generated during a closeout meeting of the Lead States Team.	

Activity Schedule

O	Original Schedule	Revision Date:
R	Work Completed	
X	Revised Schedule	

Activity	FY 2009												FY 2010												FY 2011											
	J	*A*	*S*	*O*	*N*	*D*	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*J*	*F*	*M*	*A*	*M*	*J*
Task 1.				O	O	O																														
Task 2.							O	O	O	O																										
Task 3.							O	O	O	O						O	O	O	O	O	O	O	O	O	O	O	O	O								
Task 4.							O		O		O		O		O		O		O		O															
Task 5.										O	O								O			O	O													
Task 6.								O		O		O		O		O		O		O		O		O		O										
Task 7.																								O	O	O	O	O								
Task 8.																													O							

COMMUNICATIONS PLAN

Communication Targets	Method(s)	Purpose
GIS counterparts in all AASHTO member agencies	Email and Telephone	Assess current LRS status (task 1) and final LRS status (task 7)
Business and technical champions in all AASHTO member agencies which express interest	Webinar	To provide basic information to state DOTs desiring some additional information prior to deciding if they should explore LRS potential in a deeper manner.
Business and technical champions and sponsors within agencies expressing interest in meeting with Lead States Team members during state visits.	State Visits	To provide advice and information tailored to the specific needs and questions of the agency considering pursing LRS.
All attendees of GIS and AASHTO IS conferences, and TRB	Presentations and possible booths	Secondary method of finding champions within states.
AASHTO Website surfers	Website	

PERFORMANCE MEASUREMENT PLAN

Performance Measure	Measurement Method
Number of additional agencies that have begun development of an LRS during the period of Lead States Team activity.	Initial and final surveys of all AASHTO agencies.
Number of additional agencies that are currently considering initiation of efforts to implement LRS as of the date of the closeout report.	Initial and final surveys of all AASHTO agencies.
Number of agencies receiving assistance from the Lead States Teams in evaluating LRS for possible new or expanded implementation in their state.	Review team activities to determine number of states requesting and participating in webinars and Lead States Team member visits.

ANNUAL BUDGETS

Annual Lead States Team Budget

(To be prepared for each fiscal year* of Marketing Plan activity)

Focus Technology: Linear Referencing System

Budget Period: October 1, 2008 through June 30, 2009

Cost Type / Description	Estimated Non-reimbursed Costs to Lead States	Costs to be Reimbursed by AASHTO	Additional Description	Subtotals of Costs to AASHTO
Labor				
Lead States Team Members				
Others from Lead States				
Other				
Total Labor	$ -			
Expendable Goods & Supplies				
Total Expendable Goods & Supplies	$ -			$ -
Operating and Other Expenses				
Travel for Task # 5 - Conferences		$ 8,000		
Travel for Task # 6 - estimated 3 State Visits		$ 13,500		
Travel for Task #				
Long Distance Telephone Charges				
Reproduction				
Shipping				
Equipment Rental				
Total Operating and Other Expenses	$ -			$ 21,500
Equipment Purchases				
Total Equipment Purchases	$ -			$ -
Subcontracts**				
Brochure/presentation preparation assistance		$ 6,000		
Poster preparation - Iowa DOT	$ 2,000			
Total Subcontracts	$ 2,000			$ 6,000
TOTAL LEAD STATES CONTRIBUTION	**$ 2,000**			
TOTAL AASHTO BUDGET REQUEST FOR THIS FISCAL YEAR				**$ 27,500**

* AASHTO's fiscal year is July 1 through June 30.

** Subcontracts should be established directly with AASHTO. Contact the AASHTO TIG Program Manager for assistance.

Notes:

1. The proposed AASHTO reimbursed budget is not to include salary and fringe benefits for lead states team members providing services.

2. Travel expenses for lead states team members representating industry are not reimbursable by AASHTO.

3. Appropriate indirect charges may be included in the individual cost estimates above.

Annual Lead States Team Budget

(To be prepared for each fiscal year* of Marketing Plan activity)

Focus Technology: Linear Referencing System

Budget Period: July 1, 2009 through June 30, 2010

Cost Type / Description	Estimated Non-reimbursed Costs to Lead States	Costs to be Reimbursed by AASHTO	Additional Description	Subtotals of Costs to AASHTO
Labor				
Lead States Team Members				
Others from Lead States				
Other				
Total Labor	$ -			
Expendable Goods & Supplies				
Total Expendable Goods & Supplies	$ -			$ -
Operating and Other Expenses				
Travel for Task # 5 - Conferences		$ 6,000		
Travel for Task # 6 - estimated 5 state visits		$ 22,500		
Travel for Task #				
Long Distance Telephone Charges				
Reproduction				
Shipping				
Equipment Rental				
Total Operating and Other Expenses	$ -			$ 28,500
Equipment Purchases				
Total Equipment Purchases	$ -			$ -
Subcontracts**				
Value Analysis - AASHTO 20-07 Funding	$ 50,000			
Total Subcontracts	$ 50,000			$ -
TOTAL LEAD STATES CONTRIBUTION	**$ 50,000**			
TOTAL AASHTO BUDGET REQUEST FOR THIS FISCAL YEAR				**$ 28,500**

* AASHTO's fiscal year is July 1 through June 30.

** Subcontracts should be established directly with AASHTO. Contact the AASHTO TIG Program Manager for assistance.

Notes:

1. The proposed AASHTO reimbursed budget is not to include salary and fringe benefits for lead states team members providing services.

2. Travel expenses for lead states team members representating industry are not reimbursable by AASHTO.

3. Appropriate indirect charges may be included in the individual cost estimates above.

Annual Lead States Team Budget

(To be prepared for each fiscal year* of Marketing Plan activity)

Focus Technology: Linear Referencing System

Budget Period: July 1, 2010 through June 30, 2011

Cost Type / Description	Estimated Non-reimbursed Costs to Lead States	Costs to be Reimbursed by AASHTO	Additional Description	Subtotals of Costs to AASHTO
Labor				
Lead States Team Members				
Others from Lead States				
Other				
Total Labor	$ -			
Expendable Goods & Supplies				
Total Expendable Goods & Supplies	$ -			$ -
Operating and Other Expenses				
Travel for Task # 6 - visit estimated 2 states		$ 9,000		
Travel for Task # 8 - Closeout LST Meeting		$ 10,000		
Travel for Task #				
Long Distance Telephone Charges				
Reproduction				
Shipping				
Equipment Rental				
Total Operating and Other Expenses	$ -			$ 19,000
Equipment Purchases				
Total Equipment Purchases	$ -			$ -
Subcontracts**				
Total Subcontracts	$ -			$ -
TOTAL LEAD STATES CONTRIBUTION	$ -			
TOTAL AASHTO BUDGET REQUEST FOR THIS FISCAL YEAR				$ 19,000

* AASHTO's fiscal year is July 1 through June 30.

** Subcontracts should be established directly with AASHTO. Contact the AASHTO TIG Program Manager for assistance.

Notes:

1. The proposed AASHTO reimbursed budget is not to include salary and fringe benefits for lead states team members providing services.

2. Travel expenses for lead states team members representating industry are not reimbursable by AASHTO.

3. Appropriate indirect charges may be included in the individual cost estimates above.

Appendix D: State Survey

1) Are differing location referencing methods in legacy databases a current area of concern in your state?
2) Do you have a current effort on-going to address this concern?
3) Is your state aware of the LRS model developed through NCHRP 20-27 and the work of several lead states who have implemented variations of this model?
4) Would you be interested in receiving additional information via webinar about best practices from LST states and the benefits they have seen?
5) Might there be an interest in several LST members visiting your state to share their experiences in implementing an LRS or to review your situation and offer suggestions for your consideration?
6) Is there some other type of assistance from the LST that would be beneficial to your state?
7) Who are the potential business and technical champions in your state? Who is the sponsor or high level decision-maker with authority to allocate budget and direct an enterprise-level program?

Appendix E: Initial MLLRS Brochure

ABOUT TIG

TECHNOLOGY IMPLEMENTATION GROUP

Dedicated to sharing high-payoff, market-ready technologies among transportation agencies across the United States, TIG promotes technological advancements in transportation, sponsors technology transfer efforts, and encourages implementation of those advancements.

For more information visit

www.aashtotig.org

Publication Date: February 2009

WHAT DOES THE LEAD STATES TEAM OFFER?

- Knowledge and experience related to LRS implementation.
- Customized state visits, as time and money permit.
- Webinars to share experiences and educate others
- Iowa's LRS Maintenance Tool at no charge

LEAD STATES TEAM

TIG's Lead States Team on the Multi-Level Linear Referencing System includes DOT and FHWA representatives who can help you evaluate the use of the technology in your agency. Turn to team members for insight, expertise, and advice.

LEAD STATES TEAM

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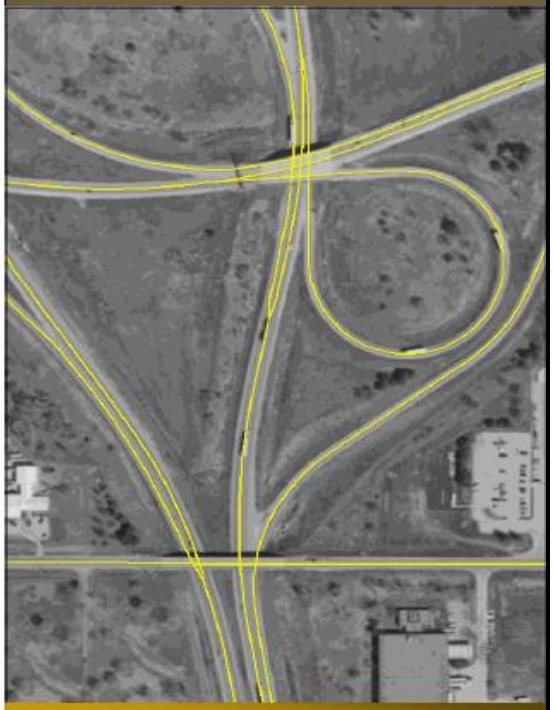
MULTI-LEVEL LINEAR REFERENCING SYSTEM



MANAGING TRANSPORTATION DATA EFFECTIVELY

NCHRP 20-27 (2) LRS Model

"The NCHRP 20-27(2) linear referencing system data model was developed in response to a growing awareness of the need to integrate increasing amounts of linearly referenced data used by the transportation community . The 20-27(2) data model includes multiple linear referencing methods, multiple cartographic representations, and multiple network representations. Data integration is supported through transformations among methods, networks, and cartographic representations by associating with a central object referred to as a "linear datum."" [1]

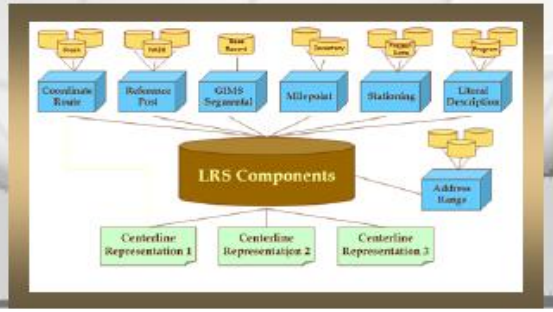
[1] Adams, T. M.; Koncz, N. A.; Vonderohe, A. P. (2001) "Guidelines for the Implementation of Multimodal Transportation Location Referencing Systems" NATIONAL ACADEMY PRESS WASHINGTON, D.C.

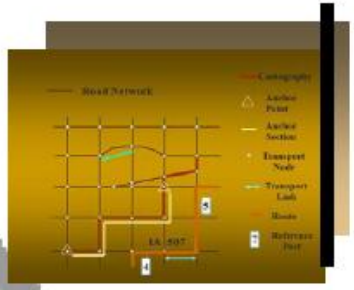
WHY ADD COMPLEXITY?

Why add the complexity required by the "linear datum"? Because it is the most stable part of the linear referencing system. Route paths and names change, and new network links are built, modified and combined over time. As long as the transportation systems location remains the same regardless of modifications to routes, network links or changes to business data the datum location remains stable

WHAT DOES THE NCHRP 20-27 (2) SYSTEM CONTAIN?

1. Spatial representations of transportation system
   - Accurate Centerline
   - Multiple cartographic abstraction layers
2. Datum layer (stable over time)
3. Network layer
   - Links and nodes that define the network
4. Location Referencing Methods (LRM)
   - Data required for these methods
   - Programs and interfaces to supply a LRS cartographic location to business data that uses a supported LRM.





WHAT THE NCHRP 20-27 (2) SYSTEM DOES NOT CONTAIN?

Business data is separated from the NCHRP 20-27 (2) model in order to minimize the systems impact on existing business data. The only items required are those needed by the LRM's. Typically enough information to specify a route and any data specifically required by the supported LRM, such as milepost and offset for the Milepost LRM.

WHY DO IT?

1. A single source for spatial location for transportation systems is provided.
2. Metadata and business rules for spatial locations are managed in a central location.
3. A navigable network is included.
4. As many cartographies and routes as needed can be included.
5. Supports multiple transportation systems—roads, pipelines, rail, navigable rivers, etc.
6. Minimizes changes to existing business data.

Appendix F: Executive Summary of Final Report - Multi-Level Linear Referencing System Cost/Benefit Value Analysis Study

MULTI-LEVEL LINEAR REFERENCING SYSTEM (MLLRS) COST/BENEFIT VALUE ANALYSIS STUDY

Requested by:

American Association of State Highway
and Transportation Officials (AASHTO)

Standing Committee on Highways

Prepared by:

Renee L. Hoekstra, CVS
RH & Associates, Inc.
Glendale, Arizona

May 2011

The information contained in this report was prepared as part of NCHRP Project 20-07, Task 302, National Cooperative Highway Research Program, Transportation Research Board.

SPECIAL NOTE: This report **IS NOT** an official publication of the National Cooperative Highway Research Program, Transportation Research Board, National Research Council, or The National Academies.

Acknowledgements

This study was requested by the American Association of State Highway and Transportation Officials (AASHTO), and conducted as part of National Cooperative Highway Research Program (NCHRP) Project 08-36. The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Project 08-36 is intended to fund quick response studies on behalf of the AASHTO Standing Committee on Planning. The report was prepared by Renee L. Hoekstra, CVS, President of RH & Associates, Inc. The work was guided by a task group chaired by Peggi Knight (Iowa DOT) which included Jonathan J. DuChateau (Wisconsin DOT); John Farley (North Carolina DOT), Oscar E. Jarquin (California DOT); Matt Koukol (Ramsey County GIS); Paul E. Krugler (Texas A&M University); Greg Slater (Maryland SHA); Reginald Souleyrette (Iowa State University); Robert "Bob" Pollack (FHWA) and Keith Platte (AASHTO). The project was managed by Nanda Srinivasan, NCHRP Senior Program Officer.

The Value Analysis Study, which provided the information for this report, required the use of the SAVE International Value Analysis 6-Step Job Plan and was administered by Renee L. Hoekstra, a Certified Value Specialist. The VA Study Team providing the information in this document included the following members; Jerome "Joe" Breyer, Works Consulting, LLC, Gilbert, Arizona, is identified as a technical expert and also represented the Arizona Department of Transportation, Multimodal Planning Division; Jun Wu, North Carolina Department of Transportation, IT-GIS Division; Michael Ney Sheffer, Maryland State Highway Administration; Thomas Martin, Minnesota Department of Transportation; Peggi Knight, Iowa Department of Transportation; Eric Abrams, Iowa Department of Transportation; Michael Clement, Iowa Department of Transportation; Karen Carroll, Iowa Department of Transportation; Ryan Wyllie, Iowa Department of Transportation; Oscar Jarquin, Caltrans IT Department; Reg Souleyrette, Iowa State University; Bruce Aquila, Intergraph; and Gary Waters, ESRI.

Disclaimer

MULTI-LEVEL LINEAR REFERENCING SYSTEM (MLLRS) COST/BENEFIT VALUE ANALYSIS STUDY

Requested by:

American Association of State Highway
and Transportation Officials (AASHTO)

Standing Committee on Highways

Authors: Renee L. Hoekstra, CVS, RH & Associates, Inc.,
Glendale, Arizona
Jerome P. Breyer, Works Consulting LLC,
Gilbert, Arizona

TABLE OF CONTENTS

ABSTRACT

This report documents the outcome of the Value Analysis (VA) Study which was conducted at the Iowa Department of Transportation in Ames Iowa on April 6-8, 2011. The purpose of the VA Study was to identify the costs and benefits of implementing and maintaining a statewide Multi-Level Linear Referencing System (MLLRS). The VA Study followed the SAVE International 6-step job plan which helped to identify the various aspects of a statewide MLLRS including; System Needs, Constraints, Performance Attributes, Qualitative and Quantitative Benefits, Defined Users/Business Units, System Functions, Alignment with the 10 Functional Requirements of Report 20-27, Costs for Developing and Maintaining a Baseline MLLRS and Implementation Considerations. The findings of the study represent a 5-year breakeven point for the baseline and the optional functional elements with potential overall cost/benefit savings of $12.6 million for a state with 25,000 miles of road network.

Chapter 1 - Executive Summary

Introduction

Many technical reports have been completed about developing and integrating a Linear Referencing System (LRS) within a state transportation agency. The magnitude of costs related to the development of a LRS and the commitment required by an agency can be overwhelming, especially if there are no data to support the costs or expected benefits. This report will help the state by providing credible quantitative and qualitative benefits obtained from a state's investment as well as sample costs and requirements for implementing and maintaining a Multi-Level Linear Referencing System (MLLRS). The use of the word *"baseline system"* throughout this report represents the minimum requirements for a fully functioning MLLRS. The use of the term *"optional functional elements"* refers to supplemental elements that will improve the baseline MLLRS.

Definition of Multi-Level Linear Referencing System (MLLRS)

Efficient planning, design, construction, and maintenance operations require accurate, dependable and electronically based methods of positioning and locating specific facilities, operations, and needs. These methods must be logically linked with other organizational electronic management systems to optimize overall operational efficiency. The MLLRS is essentially the multi-dimensional LRS (MDLRS) defined in the NCHRP Report 460 as follows:

"The NCHRP 20-27(2) linear referencing system data model was developed in response to a growing awareness of the need to integrate increasing amounts of linearly referenced data used by the transportation community (*1*). The 20-27(2) data model includes multiple linear referencing methods, multiple cartographic representations, and multiple network representations. Data integration is supported through transformations among methods, networks, and cartographic representations by associating with a central object referred to as a linear datum."

While the above definition uses the "multiple" adjective with three separate characteristics, this study relates specifically to the linear referencing methods, or LRMs, as the key aspect that differentiates a MLLRS from a LRS. This does not diminish the importance of cartographic representations and network representations in MLLRS – but instead allows the study team to address perhaps the most significant existing deterrent in efficient data sharing – the inability to cross-relate information from different data stores.

NCHRP 20-07 Value Analysis for MLLRS

Research Approach and Study Objectives

The research for this paper was completed during a 3-day Value Analysis (VA) Study using the SAVE International 6-Step Job Plan. The Job Plan included the following Phases: Information,

Function Analysis, Creativity, Evaluation, and Development; the 6th phase, Presentation, was not performed. A complete description of the process can be found in Chapter 2.

A VA Study approach was used to bring together several state DOTs to discuss the merits, benefits, constraints, impacts and the implementation of a MLLRS. This also allowed this research to be conducted in a team approach allowing for integration of data and the sharing of information in real time. The VA approach enabled the team to discuss approaches and reach consensus in a very short time. The objectives included:

- Providing a definition for what is required in a baseline MLLRS, which means, what are the minimum requirements versus supplemental or supporting functions
- Providing a definition of Multi-Level in the context of a LRS
- Identifying all costs associated with both a baseline MLLRS and any potential additive functional features in the system
- Understanding all benefits – including quantitative and qualitative – with implementing a MLLRS
- Identifying the current and potential uses of a MLLRS
- Providing the potential impacts of not implementing a MLLRS
- Providing implementation considerations for both the initial system development as well as maintaining a MLLRS

Basic Assumption

It is necessary to first identify that this study and the findings are predicated on a basic assumption. This assumption is that "each state implementing a MLLRS already has 25,000 miles of road and some type of an existing LRS – including multiple LRMs that do not share a common linear datum". This is important as the costs and efforts identified to establish an initial LRS is not included.

Why It is Important to Implement ML into LRS

1) Data and information are more readily available from different sources which reference the same linear datum,
2) Improvements are made related to quality, timeliness, and the efficiency in many reports which are often required to meet a state's internal mission and/or needs as well as external requests and mandates,
3) Improve analysis leading to more data-driven decision support which will also lead to more consistency in the decision-making process within the agency over time,
4) Improve communication within the agency across departments and greater involvement with other agency partners and stakeholders by sharing information,
5) The ability to improve customer service by allowing information and data to be more readily accessed and disseminated in a more timely manner,

6) Able to integrate with legacy systems and ultimately eliminate dependencies on obsolete technology,
7) Establish standards to increase LRS consistency throughout the agency and industry-wide, and
8) Lower the life cycle cost impacts of system ownership.

Although many of the items stated above represent benefits of a MLLRS, the team also identified both quantitative and qualitative benefits to implementing a MLLRS. Other benefits were also identified by the study team. These benefits are identified in detail, including the definition, rating and ranking, within Chapter 3.

Quantitative Benefits

The quantitative benefits identified for a MLLRS are related to saving time and costs for the agency. Time and cost savings are defined as a reduction in staff hours, operational hours, and hours associated with other departments. Additionally, there will be an improved stewardship of data and business/ operational unit improvements. Sample business/operational units were used for this study to show improvement savings and they were defined as safety improvements, reduced risk for litigation, reduced impacts to the project, and reduced impacts to maintenance. A complete definition and the savings associated with each of these benefits are provided within Chapter 3.

The overall annual quantitative savings for the benefits as described above can be summarized as follows:

Baseline System

- $10,000 per FTE for a reduction in staff hours
- $20,000 per FTE for a reduction in operational hours
- $2,000 per FTE for a reduction in staff hours for other departments

Optional Functional Elements – These are described as additional elements which will increase the functionality of the baseline system including Managing Change and Modeling Connectivity.

Manage Change

- $10,000 FTE for a reduction in staff hours
- $20,000 per FTE for a reduction in operational hours
- $2,000 per FTE for a reduction in staff hours for other Departments

Model Connectivity

- $10,000 FTE for a reduction in staff hours
- $20,000 per FTE for a reduction in operational hours
- $2,000 per FTE for a reduction in staff hours for other departments

Business/Operational Unit Improvements – Each of the benefits identified above provides a different level of savings. This team identified several business/operational units as a representation of potential savings and established a sample budget for each of the business/operational units. The annual savings calculation used the sample budget to determine the overall savings as a percentage of the identified budget. Using the four business/operational units; safety improvements, reduced level of risk for litigation, reduced impacts to projects, and reduced maintenance, the estimated annual savings for the agency for the baseline and the optional functional elements can be summarized as:

- Baseline - $1,168,000
- Manage Change - $1,208,000
- Model Connectivity - $1,220,000

Qualitative Benefits

Qualitative benefits are much more difficult to measure, however of equal importance to the DOT. The study team identified the following qualitative benefits:

- Ease of use and accessibility
- Flexibility and integration
- Quality of data
- Internal and external collaboration
- Data-driven decision making

A full description of each of these benefits can be found in Chapter 3.

Implementation Considerations

Cost to Implement a MLLRS

The basic assumption made by this team, as expressed on the previous page, is "that a LRS already exists" within the agency wanting to implement a MLLRS. A complete listing of the associated costs is included in Chapter 5 and includes both capital and annual maintenance costs. The costs shown are exclusive of what is already available within the agency, including hardware. Additionally, in order to develop the overall costs, labor rates are represented by an integrated agency and consultant rate as well as a singular civil service rate.

The baseline costs are also based on 25,000 miles of centerline per state, a good existing primary road network, includes a spatial representation, hardware, software, and assumes the agency uses some LRM already. The baseline development cost is approximately $2 million.

There are additional functional elements that can be added to the baseline to add value to the MLLRS. These additional total costs, including labor and as needed, software and hardware, required to establish the MLLRS is as follows:

- Managing Change - $31,650
- Modeling Connectivity - $793,400
- LRM Development - $40,000 each

Maintenance Costs

Maintenance annual costs including labor, hardware and software, will vary, but on an average for the baseline system, considering the 25,000 miles of centerline assumption, are $251,700.

Maintenance costs for the optional functional elements are very minor and will have very little impact on the overall annual budget.

A breakeven timeframe that can be expected is approximately five (5) years after the installation of a complete system. The schedule for implementation is estimated at (2) years after a contract, as needed, has been let with a selected consultant.

Benefit Cost Analysis to Implement and Maintain a MLLRS

The study team realized other benefits to having an agency-wide MLLRS. This includes a life cycle cost savings over the life of the system. However, in this instance, a 5-year breakeven period was used to show the estimated cost benefit. If a DOT wanted to understand the full life cycle/cost benefit savings, these numbers can be multiplied out to the life of the system, the total savings can be very beneficial to the DOT. There is on-going maintenance that will be required, but with the adoption of a MLLRS, a savings can be calculated for both the baseline system and the additional elements. The savings was calculated over a 5-year period with an escalation rate of 3%.

The overall cost-to-benefit (C/B) savings is as shown:

- *Baseline - $2,437,874*
- *Optional Functional Elements - $10,120,428*

When expressed as a C/B ratio, the baseline effort yields a C/B ratio of 1.8:1 while the optional functional elements yield an aggregate 21.4:1 ratio of benefits to cost. These figures were generated from empirical values generated by several of the participating states as workshop participants. These aggregate C/B ratios are bound to be different when each particular state is analyzed separately for their own costs versus benefits using their individual operating conditions.

Critical Implementation Considerations

Critical implementation considerations as well as the potential impacts to not implementing a MLLRS need to be considered by each DOT. This is a critical step for the agency as they consider taking the next steps into developing a MLLRS. The agency should be fully prepared to address each of the considerations to ensure success of a MLLRS. A complete listing of these considerations can be found in Chapter 6.

Appendix G: Brochure from MLLRS Cost/Benefit Value Analysis Study

Cost to Implement a MLLRS

Capital Costs

- Baseline System - $2 million
- Optional Functional Elements
  - * Manage Change - $2K
  - * Model Connectivity - $493K
  - * LRM Development - $40K each
- Maintenance Costs
  - * Baseline - $252K
  - * Optional Functional Elements
    - * Minor adjustments only

Cost/Benefit Analysis

- Based on a 5-year period 3% escalation rate, constant dollar approach
  - * Baseline System - $2.5 million in savings
    - * Cost/Benefit Ratio = 2:1
  - * Optional Functional Elements - $10 million in savings
    - * Benefit/Cost Ratio = 21:1

Benefits & Cost Savings

Quantitative Benefits

- Ease of use and accessibility
- Flexibility and integration
- Quality of data
- Internal and external collaboration
- Data-driven decision support

Cost Savings

- Business/Operational Unit Improvements
  - * Sample Business Units Used
    - * Safety improvements
    - * Reduced level of risk for litigation
    - * Reduced impacts to projects
    - * Reduced maintenance
- Baseline Savings
  - * $1.1 million
- Optional Functional Elements Savings
  - * $2.5 million

Multi-Level Linear Referencing System (MLLRS)

The Costs & Benefits of Implementing a MLLRS
(Synopsis from the NCHRP Project 20-07, Task 302 Report)

ACKNOWLEDGEMENT OF SPONSORSHIP *Work was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program, which is administered by the Transportation Research Board of the National Academies.* **DISCLAIMER** *The opinions and conclusions expressed or implied in reports are those of the research agencies. They are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors.*

What is a MLLRS?

Efficient planning, design, construction, and maintenance operations requires accurate, dependable and electronically based methods of positioning and locating specific facilities, operations, and needs. These methods must be logically linked with other organizational electronic management systems to optimize overall operational efficiency. The MLLRS is essentially the multi-dimensional LRS (MDLRS) defined in the NCHRP Report 460. To sum it up it:

- Meets the NCHRP 20-27 data model
- Meets the needs of integrating increasing amounts of linearly referenced data
- Logically links with other organizational electronic management systems
- Includes multiple linear referencing methods, multiple cartographic representations and multiple network representations
- Associates through a central object referred to as a "linear datum"

Why Implement ML into LRS?

- More readily available data and information from different sources
- Improvements in quality, timeliness, and efficiency for reporting
- Improved analysis leading to more data-driven decision support
- Improved communication by being able to more readily share information in a timely manner
- Desire to improve customer service
- Integrates with legacy systems and ultimately eliminates dependencies on obsolete technology
- Establishes standards to increase LRS consistency throughout the agency and industry-wide
- Lowers the life cycle cost impacts of system ownership

Assumptions

- A LRS already exists with at least one LRM
- A good existing primary road network exists
- Includes a spatial representation
- 25,000 miles of centerline roadway
- Base hardware and software currently exists
- Baseline = The minimum requirements to implement and maintain a MLLRS
- Optional Functional Elements = Additional elements added to the baseline to improve the overall function of the MLLRS