# The Use of Qualitative Analysis to Compare User Experiences From the GIS TIS/BaseMap System to the Newly Adopted GIS LRS/RCE System at the Minnesota Department of Transportation

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*Keywords:* Geographic Information Systems (GIS), Transportation Systems (TS), Minnesota Department of Transportation (MnDOT), Linear Referencing System (LRS), Roadway Characteristics Editor (RCE), Transportation Information Systems (TIS), BaseMap

## Abstract

The purpose of the project-based case study was to compare and contrast the user experience and software functions of the Transportation Information System (TIS)/BaseMap program and the Linear Referencing System (LRS)/Roadway Characteristics Editor (RCE) GIS bundle. Six research analysts at the Minnesota Department of Transportation were provided an electronic ten question survey. Bar graphs were generated from the survey results to illustrate the various user experiences. The compiled survey results and subsequent analysis indicate various trends in user experience and software capabilities in relation to evolving GIS technologies. Bar graphs of the survey results serve as an instrument to assist, investigate, and understand the diverse functionalities and fluctuating user experiences.

## Introduction

According to the Transportation Research Board (2005), the United States economy and quality of life depend on a transportation system that functions well. Transportation connects people to goods and services, employment opportunities, educational institutions, medical facilities, etc.

According to the U.S. Department of Transportation (2012), transportation systems consist of a number of multimodal transportation strategies to maximize the efficiency, safety, and utility of existing and planned transportation infrastructure. Transportation system strategies encompass many activities, such as traffic incident management, traffic signal coordination, freight management, work zone management, road weather management, congestion, managed lanes, ridesharing and demand management programs, parking management, electronic toll collection, and transit smart cards.

There are a number of transportation system types; some examples include, but are not limited to, flying by air, maritime by sea, and mass transit by road. Transportation systems involve interdependently structured techniques and protocols that transfer travelers as well as merchandise from one location to another.

Transportation systems are

Berhane, Trhas. 2017. The Use of Qualitative Analysis to Compare User Experiences From the GIS TIS/BaseMap System to the Newly Adopted GIS LRS/RCE System at the Minnesota Department of Transportation. Volume 20, Papers in Resource Analysis. 10 pp. Saint Mary's University of Minnesota University Central Services Press. Winona, MN. Retrieved (date) http://www.gis.smumn.edu

crucial to a nation's economic development and financial way of life. Transportation systems connect cities to producers of goods and services and the retailers that distribute them (Transportation Security Administration, 2007). Transportation systems consist of networks of trade that deliver breakthroughs in technology and the creation of consumer goods that are more affordable in a growing economy (Transportation Security Administration, 2007). "The [United States] has made massive investments in building and operating transportation systems, which have connected cities to suburbs, metropolitan areas to one another, factories to markets, and consumers to goods produced all over the world" (Transportation Research Board, 2005). There are "4 million miles of roads and highways, more than 100,000 miles of rail, 600,000 bridges, more than 300 tunnels and numerous sea ports, 2 million miles of pipeline, 500,000 train stations, and 500 public use airports" in the United States (Transportation Security Administration, 2007).

### *A Brief History of the Minnesota Department of Transportation*

According to Katz (2009), the Minnesota Legislature established the Minnesota Department of Transportation (MnDOT) in 1976 to continue the work of the previous Department of Aeronautics. MnDOT continues the work of highways and transportation related areas of the State Planning Agency and of the Public Service Department. Today MnDOT creates and executes approaches, plans, and projects for air transportation, thruways, engine bearers, ports, open travel, and railways.

Once formed, the Legislature decided that MnDOT would be the central organization to create, actualize, manage, unite, and arrange state transportation approaches, plans, and projects. MnDOT endeavors to consider the social, monetary, and ecological impacts of its choices and forcefully advances the effective utilization of vital assets for transportation purposes. Likewise, it maintains close working relationships with numerous types of gatherings and affiliations associated with transportation (Katz, 2009).

According to MnDOT (n.d.a), transportation needs are characterized as either the costs important to meet execution based targets or the costs identified with accomplishing key framework objectives. MnDOT (n.d.a) reported utilizing execution measures, execution markers, and expenses to actualize execution related techniques to build up its data inventory needs, which include the following roadway attribute classifications:

- Pavement Condition
- Bridge Condition
- Traveler Safety
- Twin Cities Mobility
- Interregional Corridor (IRC) Mobility
- Accessible Pedestrian Infrastructure

Planning and infrastructure considerations such as access management, street network layout, and intersection design link transportation systems; some examples include roundabouts, right and left turn lanes, median islands, and four way intersections (U.S. Department of Transportation, 2012). When dealing with transportation systems a number of operators and stakeholders and their needs require consideration, such as:

> "State Departments of Transportation (DOTs), which are often responsible for operations on freeways and major arterials and for programs such as electronic toll collection, incident management, and traveler information services.
>
> Local communities, which are often responsible for local road operations, including traffic signals and signage, local transit services, and municipal parking" (U.S. Department of Transportation, 2012).

### *Implementation of GIS for MnDOT*

MnDOT is the main source of information used in this project and analysis. Various GIS data event layers require certain attributes be available. At a minimum, these attributes include:

- Basic pavement type
- Facility type
- Public status
- Traffic access control
- Street name
- Through lane

### *Term Definitions*

Basic Pavement Type: Currently there are four domain values utilized within the Linear Referencing System describing basic pavement types; these include: Bituminous, Concrete, Gravel, and Dirt/Unimproved

Events: Events are a group of layers containing roadway attribute information that can be edited, queried, and exported. Events are stored in a file geodatabase in the spatial data warehouse. Examples include Basic Pavement Type, Facility Type, Public Status, Traffic Access Control, Street Name, and Through Lanes.

Facility Type: This event consists of one way roadways and two way roadways.

Linear Referencing System (LRS): LRS is a method of spatial referencing, in which the locations of features are described in terms of measurements along a linear element, from a defined starting point (Esri, 2016).

Public Status: The Public Status event layers include the following domain values: public functional road, public conditional road, and nonpublic road.

Roadway Characteristics Editor (RCE): RCE is a map centric web application that supports linear referenced event data editing (Esri, 2016).

Through Lanes: The through lanes event layer describes the number of drivable lanes on any roadway in one direction.

Traffic Access Control: There are three types of traffic access controls. These include: full access control, partial access control, and no access control.

### *What is TIS in MnDOT*

The Transportation Information System (TIS) was introduced as a system automation proposal in 1972, and following its implementation, TIS became a major source of information for Minnesota's roadways network. The TIS also contains pavement information for trunk highways, state aid highways, and local roads (TIS Project Team, 1991).

The TIS Project Team (1991) that developed TIS described that the purpose of the tool was to perform specific tasks relating to transportation data. Since its initial development, the TIS has gone through many changes and modifications in order to satisfy changing demands. The TIS has succeeded in meeting its original goals and in satisfying many new demands.

However, as new demands continue to mount, certain deficiencies in the TIS became apparent. Decisions made when TIS was the department standard did not support the modern age in which we aim for data governance. Part of working within a data governance framework is to treat data as an asset. MnDOT collects and maintains its data in reliable and sustainable ways and promotes sharing these data as much as possible to avoid duplication of efforts and conflicting information.

### *What is LRS in MnDOT*

LRS is a method of spatial referencing, in which the locations of features are described in terms of measurements along a linear element. According to MnDOT's (n.d.b) internal publication, an employee said, "The Linear Referencing System (LRS) is an Esri Suite of tools. The first tool is an ArcGIS Extension called Roads & Highways (R&H) which enables MnDOT to manage multiple linear referencing methods in a single application and tie them to the BaseMap. The second is the Roadway Characteristics Editor (RCE), a web based tool for editing of route related characteristics." Roadway Characteristics Editor (RCE) is a map centric web application that supports linear referenced event data editing (Esri, 2016).

In the past roadway attributes were maintained using the TIS mainframe. The LRS enables the capacity to overlay non-spatial information for analysis, creating an environment for information sharing with MnDOT's state funded and private divisions. The LRS has the temporal ability to display, analyze, create, and maintain roadway information and characteristics in the present, past, and future. The LRS enables users throughout MnDOT to create, edit, and save changes to the transportation network and roadway attributes in the database simultaneously (Minnesota Department of Transportation, n.d.b).

According to MnDOT (n.d.a), the new LRS/RCE is currently in production and they have frozen the old Transportation Information System (TIS) and associated GIS BaseMap thus making them obsolete.

### *Purpose*

The main objective of this project was to analyze the differences between user experiences and software capabilities of the TIS/BaseMap software compared to the LRS/RCE GIS package. This project serves as an instrument to further explore and understand the different functionalities and varying user experiences involved in migrating from one GIS software package to another. It is particularly relevant to compare these two systems. Many DOT's across the United States are interested in adopting the new Linear Referencing System and Roadway Characteristics Editor from Esri. The analysis may help determine the appropriate direction for other DOT's.

## Methodology

### *Data Acquisition*

Two web based surveys with a total of ten questions each were designed and a comparative analysis was conducted. The first survey collected information on the old system, the TIS/BaseMap. The second survey collected data regarding the present LRS/RCE system.

The electronic surveys were facilitated by SurveyMonkey. The SurveyMonkey survey system allowed a web link to be sent by email to the research analysts that were selected to complete the surveys. The survey results were collected over a two-month period.

The questionnaire assessed two components of the LRS/RCE and the TIS/BaseMap platforms: user experience and system capability. The first component, user experience, included the following questions in the survey:

- How intuitive is the design of the LRS/RCE website?
- How easy is it to interpret the results of a query in RCE?
- Is the LRS\RCE tools easy to navigate?
- Rate the LRS\RCE software on ease of use?
- How aesthetically appealing is the RCE interface website?

The second component, assessing capabilities, used the following questions:

- Overall, how well does the LRS software help update roadway attributes?
- How satisfied are you with the reliability of the LRS software?
- How satisfied are you with the ability to integrate other data types with the LRS\RCE interface?
- How intuitive is the design of the TIS/BaseMap?
- Is the TIS/BaseMap system easy to navigate?

Likert Scale

"A Likert scale is a psychological measurement device that is used to gauge attitudes, values, and opinions. It functions by having a person complete a questionnaire" (Williams, n.d.). According to Vanek (2012), the Likert scale is a useful question type when one wants to get an overall measurement of sentiment around a particular topic, opinion, or experience. It is also suitable for collecting specific data on factors that contribute to that sentiment.

The Likert scale rating system contains individual measures to contribute knowledge towards a whole assessment, demeanor, or mental capacity of a survey participant. A Likert scale may consist of answers ranging from "Strongly Disagree" to "Strongly Agree" (Harpe, 2015).

Questionnaire Content

The survey was designed using the Likert scaling system. Ten questions were administered. The questions contained at least four standardized responses, ranging from extremely dissatisfied to extremely satisfied. These responses were intended to help collect data to show the various trends in user experience when comparing one GIS software package to another.

Six research analysts at MnDOT completed the questionnaire surveys and their responses were used to detect trends and differences for this case study. Due to a limited number of research analysts that have experience with both software systems, the sample size for the case study was small. The objective of the two surveys was to identify important user experiences in the new LRS/RCE system as well as the old TIS/BaseMap system. The web survey results were exported for supplementary analysis.

Survey responses could reveal trends by focusing on questions which had to do with user experience and functionalities in relation to both the TIS/BaseMap and LRS/RCE systems.

*Data Preparation and Analysis*

Microsoft Excel was utilized in creating bar graphs and tables to compare the old TIS/BaseMap system with the new LRS/RCE. The bar graphs and tables created in Microsoft Excel were used to evaluate the user experiences and system capabilities.

In addition, a table was created to display a checklist of the various capabilities and functionalities that any GIS system should be able to perform at the very least. These capabilities and functionalities were determined by MnDOT as a minimum requirement that any implemented system should be able to perform. The table was populated by comparing the capabilities of functionalities of the two different systems.

**Results**

Table 1 illustrates that both the LRS/RCE and TIS/BaseMap systems are capable of integrating data. The data used in external systems have sharing capabilities with edits made to the LRS. Editing across the web is a function of the new LRS/RCE system and was not a part of the older TIS/BaseMap system.

With the LRS/RCE software, the capabilities of creating and editing event data are available. Both systems have the functionality to coordinate and track work throughout organizations. Both systems are able to produce a history of job completion log. Simplifying the LRS updates is a functionality of the new LRS/RCE software. It allows the organization to define how measures and route associations should react to changes in the LRS.

According to (MnDOT, n.d.b), analyzing and reporting data is part of the LRS software capabilities. It allows the system to generate reports and produce maps, which is something the old TIS/BaseMap system did not have the capability to do. Furthermore, the new LRS/RCE system has the capability to automate quality control measures.

Table 1. Capabilities of the LRS/RCE and TIS Systems.

| Key Information | LRS/RCE | TIS/ BaseMap |
|---|---|---|
| **Integrate Data** | Yes | Yes |
| **Edit Across the Web** | Yes | No |
| **Coordinate and Track Work Through an Organization** | Yes | Yes |
| **Simplify LRS Updates** | Yes | No |
| **Analyze & Report Data** | Yes | No |
| **Automate Quality Control** | Yes | No |

***Survey Results***

The bar chart in Figure 1 illustrates that 83.33 percent of the respondents stated the design of the LRS/RCE website is somewhat engaging. 16.67 percent found the website design to be not so engaging.

Figure 2 illustrates 50 percent of the respondents believed the new LRS/RCE tools were easy to navigate. 33.33 percent of the respondents indicated the LRS/RCE tools were somewhat easy to navigate, given the adaptation of a new system. Figure 3 shows that, compared to its successor, 50 percent of respondents believe the TIS/BaseMap system is not so engaging.

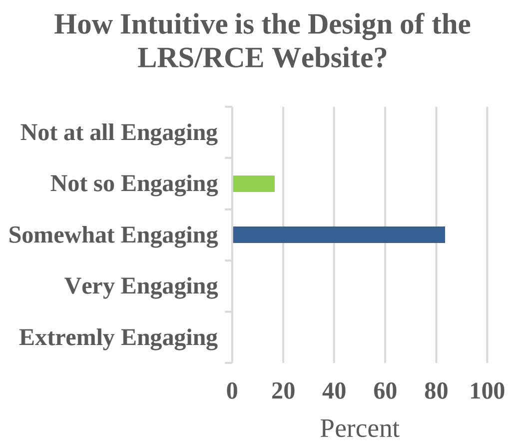


Figure 1. Results illustrating respondents feelings the intuitive nature of the LRS/RCE website.

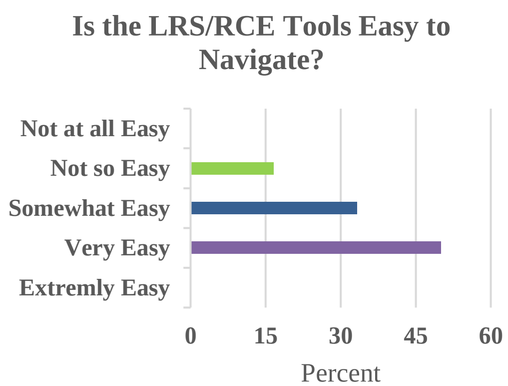


Figure 2. Results of how easy the LRS/RCE tools are to navigate.

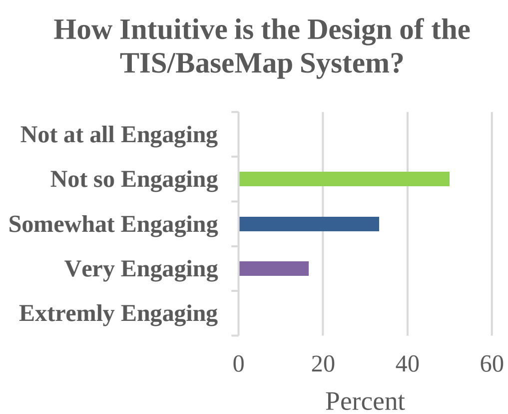


Figure 3. Results of how intuitive the design of the TIS/BaseMap system is.

As seen in Figure 4, 66.66 percent of respondents indicate the old TIS/BaseMap was either not so easy or somewhat easy.

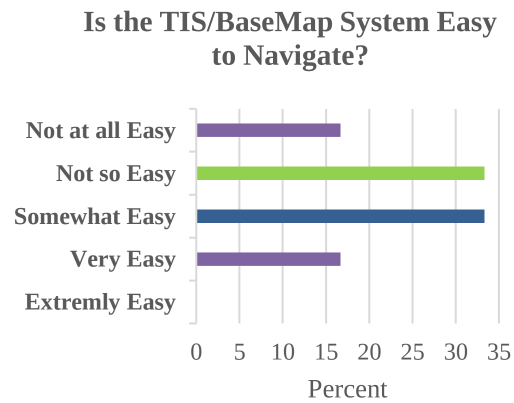


Figure 4. Results of how easy the TIS/BaseMap system is to navigate.

The bar graph below indicates respondents were split equally between being very satisfied and somewhat satisfied in regards to how the TIS/BaseMap system integrates with other data types (Figure 5).

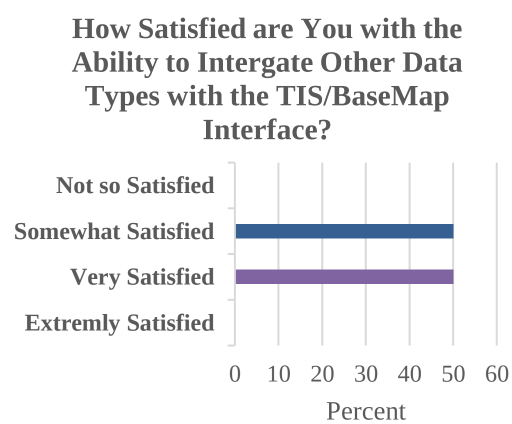


Figure 5. Results of how satisfied respondents felt in relation to the ability to integrate data in the TIS/BaseMap interface.

Figure 6 illustrates 50 percent of the survey takers agree that the TIS/BaseMap software was easy to use.

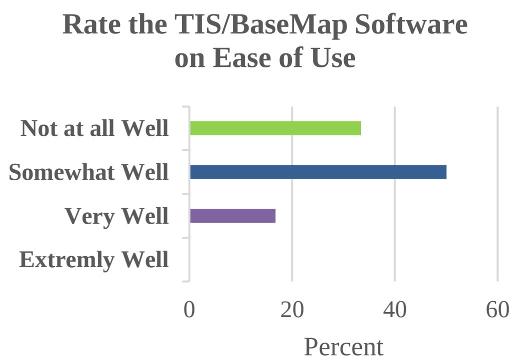


Figure 6. Respondents feeling towards the ease of use with the TIS/BaseMap software.

Figure 7 illustrates 66.67 percent of respondents using the LRS/RCE interface were somewhat satisfied with how the new system integrates with other data types.

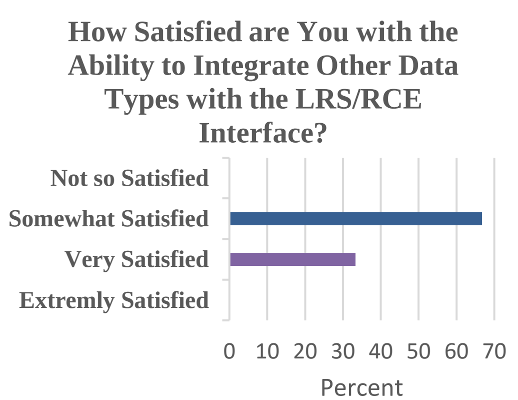


Figure 7. Results of how satisfied respondents were in relation to the ability to integrate data in the LRS/RCE interface.

Figure 8 illustrates 66.67 percent of the survey takers agree the LRS/RCE software was very well easy to use. Figure 9 illustrates 50 percent of respondents agree interpreting queries in RCE was somewhat easy. According to Figure 10, 66.66 percent of respondents agree in interpreting queries in the TIS/BaseMap was very or somewhat easy to execute.

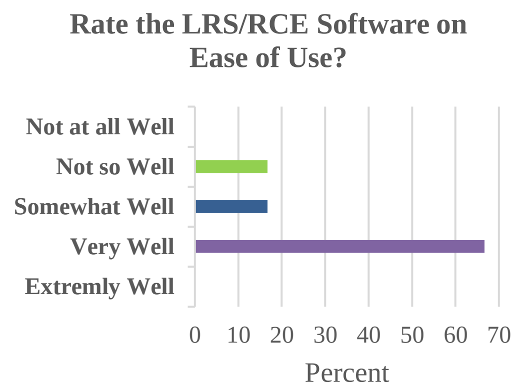


Figure 8. The ease of use with the LRS/RCE software.

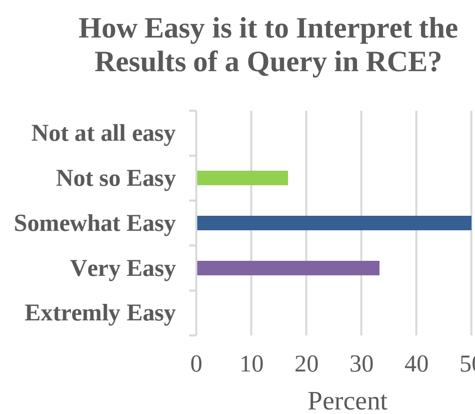


Figure 9. Results on ease of interpreting results of a query in RCE.

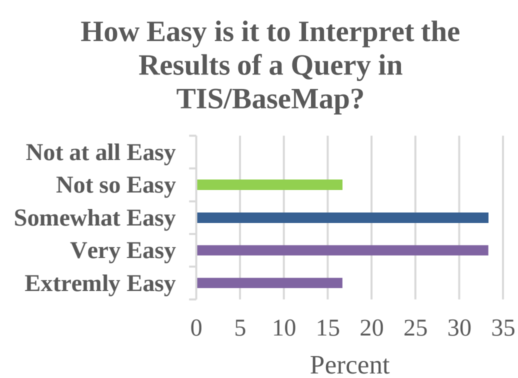


Figure 10. Results on ease of interpreting results of a query in RCE.

## Conclusions

The primary objective of this case study was to identify the contrasts between various user experiences with the TIS/BaseMap platform compared to the LRS/RCE GIS bundle. Results discovered the LRS/RCE design is more intuitive than the design of the TIS/BaseMap system. Fifty percent of the research analysts agree the new LRS/RCE tools was easier to navigate than the old TIS/BaseMap tools. Survey respondents agreed the ability to integrate other data types with the LRS/RCE interface was more satisfying than using the old TIS/BaseMap system. 66.7 percent of survey respondents agree the LRS/RCE software was easier to use than the TIS/BaseMap software. Fifty percent of the survey respondents agree it was somewhat easy to interpret the results of a query in RCE compared to 33.33 percent in the TIS/BaseMap system.

In summary, results indicate a majority of respondents strongly lean towards the adaption of the new LRS/RCE system based on their experiences when using both software packages. A clear trend begins to develop when one examines the survey data more closely. It is apparent the new LRS/RCE software package is a winner over its predecessor. The new LRS/RCE software wins in both categories of user experience and software capabilities.

In addition, this case study application was rooted in a purposive sample uniquely identified for this study. While the sample size was not ideal to assume trends expected in larger, more generalizable populations, the focus of the study was unique to this setting. Further examination of longitudinal impacts may also be helpful to determine how effective new software applications are after periods of time have passed.

## Acknowledgements

I would like to thank staff at Saint Mary's University and Nana Yaw Owusu-Amponsah who encouraged, challenged, and provided guidance to me during my time at Saint Mary's University of Minnesota. Important thanks to my family for their unconditional love and support.

## References

Esri. 2016. Esri Roads and Highways. Retrieved 2016 from http://www.esri.com/software/arcgis/extensions/roads-and-highways/features.

Harpe, S. E. 2015. How to Analyze Likert and Other Rating Scale Data. *Currents in Pharmacy Teaching and Learning* 7: 836-850. Retrieved 2016 from EBSCO*host* database.

Katz, J. 2009. From Footpaths to Freeways: A Survey of Roads and Highways in Minnesota. MN. Retrieved 2016 from https://www.lrrb.org/pdf/FootpathsFreeways.pdf.

Minnesota Department of Transportation. n.d.a. Minnesota State Highway Investment Plan: 2014-2033. Retrieved 2016 from http://www.dot.state.mn.us/planning/mnship/index.html.

Minnesota Department of Transportation. n.d.b. Linear Referencing System. Retrieved 2016 from http://ihub.dot.state.mn.us/gis/lrs_index.html.

Transportation Research Board. 2005. Critical Issues in Transportation. Retrieved 2016 from www.TRB.org.

Transportation Security Administration. 2007. Transportation Systems: Critical Infrastructure and Key Resources Sector-pecific Plan as input to the National Infrastructure Protection Plan. 1-87. Retrieved 2016, from www.tsa.gov.

TIS Project Team. 1991. Transportation Information System Feasibility Study.

U.S. Department of Transportation. 2012. The Role of Transportation Systems Management & Operations in Supporting

Livability and Sustainability. Retrieved 2016 from http://www.ops.fhwa.dot.gov/publications/fhwahop12004/index.htm.

Vanek, C. 2012. Likert Scale- What is it? When to Use it? How to Analyze it? Retrieved 2016 from https://www.surveygizmo.com/survey-blog/likert-scale-what-is-it-how-to-analyze-it-and-when-to-use-it/.

Williams, Y. n.d. Likert Scale: Definition, Examples and Analysis - Video & Lesson Transcript. Study.com. Retrieved 2016 from http://study.com/academy/lesson/likert-scale-definition-examples-analysis.html.