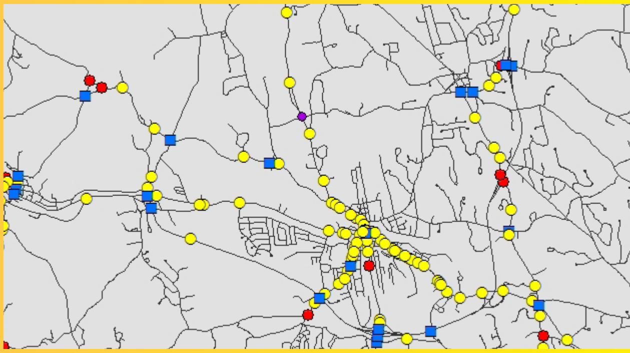
MIRE Fundamental Data Elements Cost-Benefit Estimation



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Quality Assurance Statement

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16. Abstract Quality data are the foundation for making important decisions regarding the design, operation, and safety of roadways. Using roadway and traffic data together with crash data can help agencies make decisions that are fiscally responsible and improve the safety of the roadways for all users. The Federal Highway Administration (FHWA) Office of Safety has established a fundamental set of roadway and traffic data elements that States should collect to support the activities conducted under their Highway Safety Improvement Programs. These data are a subset of the Model Inventory of Roadway Elements (MIRE), and are known as the MIRE Fundamental Data Elements (MIRE FDE). The objective of this effort was to conduct an economic analysis of the cost to States in developing a statewide linear referencing system and collecting the MIRE FDE on all public roadways. This effort also estimated the reduction in fatalities and injuries needed to exceed a 1:1 ratio and a 2:1 ratio of benefits to costs. This report provides the results of this effort.		

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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ACRONYMS

AADT	Annual Average Daily Traffic
FARS	Fatality Analysis Reporting System
FDE	Fundamental Data Elements
FHWA	Federal Highway Administration
GES	General Estimate System
GIS	Geographic Information System
IHSDM	Interactive Highway Safety Design Model
HPMS	Highway Performance Monitoring System
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual
LiDAR	Light Detection and Ranging
LRS	Linear Referencing System
MAIS	Maximum Abbreviated Injury Scale
MAP-21	Moving Ahead for Progress in the 21st Century
MIRE	Model Inventory of Roadway Elements
MIRE FDE	Model Inventory of Roadway Elements Fundamental Data Elements
MIS	Management Information System
NHDOT	New Hampshire Department of Transportation
NHS	National Highway System
OMB	Office of Management and Budget
SHSP	Strategic Highway Safety Plan
UDOT	Utah Department of Transportation
WSDOT	Washington State Department of Transportation

INTRODUCTION

Background

Recognizing that quality data are the foundation for making important decisions regarding the design, operation, and safety of roadways, the Federal Highway Administration (FHWA) has developed guidance for States on implementing their Highway Safety Improvement Programs (HSIPs). By incorporating roadway and traffic data into safety analysis procedures, States can better identify safety problems and prescribe solutions to support and implement their Strategic Highway Safety Plans (SHSPs). Furthermore, new safety analysis tools and methods being developed such as the Highway Safety Manual (HSM) and related software such as AASHTOWare's SafetyAnalyst and FHWA's Interactive Highway Safety Design Model (IHSDM), need quality roadway, traffic, and crash data to achieve the most accurate results. Using roadway and traffic data together with crash data can help agencies make decisions that are fiscally responsible and improve the safety of the roadways for all users.

In the past few years, FHWA has issued several reports and guidelines to address how State and local agencies should be collecting, maintaining, and using safety data to support their HSIPs and SHSPs. These efforts include the FHWA *Model Inventory of Roadway Elements (MIRE) Version 1.0 (1)*, the *Market Analysis of Collecting Fundamental Roadway Data Elements to Support the Highway Safety Improvement Program* report *(2)*, and the *Guidance Memorandum on Fundamental Roadway and Traffic Data Elements to Improve the Highway Safety Improvement Program (3)*.

MIRE Version 1.0 provides a recommended listing of 202 roadway inventory and traffic elements critical to safety management *(1)*. While all of the MIRE elements are important, it may not be feasible for States to collect and integrate all of the elements into their HSIP at the same time. In 2011, FHWA identified a subset of these elements that are critical for safety analysis. These elements, known at the time as the Fundamental Data Elements (FDE), are identified and described in the *Background Report: Guidance for Roadway Safety Data to Support the Highway Safety Improvement Program (4)*. This set is subsequently referred to as the 2011 FDE.

In 2011, FHWA published the *Market Analysis of Collecting Fundamental Roadway Data Elements to Support the Highway Safety Improvement Program (2)*. The report explored the costs of collecting the 2011 FDE. The analysis developed cost estimates for collecting these data in small, medium, and large States. Cost effectiveness analysis was used to determine the number of fatalities and injuries that would need to be reduced as a result of the data collection to justify the costs of the data collection. The report represented the best available information on the cost of collecting these data elements at the time it was developed.

In July of 2012, Moving Ahead for Progress in the 21st Century (MAP-21) was passed. This transportation funding legislation required the identification of a subset of MIRE elements. The *MAP-21 Guidance on State Safety Data Systems (5)* provides information on the set of roadway and traffic data elements States should be collecting on all public roads because they are fundamental to support a State's HSIP. This set of elements is herein referred to as the MIRE Fundamental Data Elements (MIRE FDE). The MIRE FDE include segment, intersection, and ramp data elements and were determined to be the basic set of data elements that an agency would need to conduct enhanced safety analyses to support a State's HSIP. This guidance supersedes the *Guidance Memorandum on Fundamental Roadway and Traffic Data Elements to Improve the Highway Safety Improvement Program (3)* and the 2011 FDE. The MIRE FDE are based on the elements needed to apply the HSM roadway safety management (Part B) procedures using network screening and analytical tools, are a subset of MIRE, and are equivalent to some Highway Performance Monitoring System (HPMS) full extent elements that States submit for Federal-aid highways. The MIRE FDE are divided into a full set of MIRE FDEs and a reduced set of MIRE FDEs for roads with an annual average daily traffic (AADT) less than 400 vehicles per day. Table 1 and Table 2 summarize the MIRE FDE.

Table 1. MIRE FDE for All Public Roads with AADT ≥ 400 Vehicles per Day.

FDE (MIRE Number)^	Definition
Roadway Segment	
Segment Identifier (12)	Unique segment identifier.
Route Number (8)[0]	Signed numeric value for the roadway segment.
Route/Street Name (9)[0]	The route or street name, where different from route number.
Federal-aid/ Route Type (21)*	Federal-aid/National Highway System (NHS) route type.
Rural/Urban Designation (20)*	The rural or urban designation based on Census urban boundary and population.
Surface Type (23)	The surface type of the segment.
Begin Point Segment Descriptor (10)	The location of the starting point of the roadway segment.
End Point Segment Descriptor (11)	The location of the ending point of the roadway segment.
Segment Length (13)	The length of the segment.
Direction of Inventory (18)	Direction of inventory if divided roads are inventoried in each direction.
Functional Class (19)*	The functional class of the segment.
Median Type (54)	The type of median present on the segment.
Access Control (22)†	The degree of access control.
One/Two-Way Operations (91)*	Indication of whether the segment operates as a one- or two-way roadway.
Number of Through Lanes (31)*	The total number of through lanes on the segment. This excludes turn lanes and auxiliary lanes.
Average Annual Daily Traffic (AADT) (79)*	The average number of vehicles passing through a segment from both directions of the mainline route for all days of a specified year.
AADT Year (80)	Year of AADT.
Type of Government Ownership (4)*	Type of governmental ownership.
Intersection	
Unique Junction Identifier (120)	A unique junction identifier.
Location Identifier for Road 1 Crossing Point (122)	Location of the center of the junction on the first intersecting route (e.g. route-milepost).
Location Identifier for Road 2 Crossing Point (123)	Location of the center of the junction on the second intersecting route (e.g. route-milepost). Not applicable if intersecting route is not an inventoried road (i.e., a railroad or bicycle path).
Intersection/Junction Geometry (126)	The type of geometric configuration that best describes the intersection/junction.

FDE (MIRE Number)^	Definition
Intersection/Junction Traffic Control (131)	Traffic control present at intersection/junction.
AADT (79) [for Each Intersecting Road]	The AADT on the approach leg of the intersection/junction.
AADT Year (80) [for Each Intersecting Road]	The year of the AADT on the approach leg of the intersection/junction.
Unique Approach Identifier (139)	A unique identifier for each approach of an intersection.
Interchange/Ramp	
Unique Interchange Identifier (178)	A unique identifier for each interchange.
Location Identifier for Roadway at Beginning Ramp Terminal (197)	Location on the roadway at the beginning ramp terminal (e.g., route-milepost for that roadway) if the ramp connects with a roadway at that point.
Location Identifier for Roadway at Ending Ramp Terminal (201)	Location on the roadway at the ending ramp terminal (e.g. route-milepost for that roadway) if the ramp connects with a roadway at that point.
Ramp Length (187)	Length of ramp.
Roadway Type at Beginning Ramp Terminal (195)	A ramp is described by a beginning and ending ramp terminal in the direction of ramp traffic flow or the direction of inventory. This element describes the type of roadway intersecting with the ramp at the beginning terminal.
Roadway Type at Ending Ramp Terminal (199)	A ramp is described by a beginning and ending ramp terminal in the direction of inventory. This element describes the type of roadway intersecting with the ramp at the ending terminal.
Interchange Type (182)	Type of interchange.
Ramp AADT (191)*	AADT on ramp.
Year of Ramp AADT (192)	Year of AADT on ramp.
Functional Class (19)*	The functional class of the segment.
Type of Government Ownership (4)*	Type of governmental ownership.

^ Model Inventory of Roadway Elements – MIRE Version 1.0 *(1)*.

* HPMS full extent elements required on all Federal-aid highways and ramps located within grade-separated interchanges, i.e., NHS and all functional systems excluding rural minor collectors and locals.

[0] HPMS element required on all NHS, Interstate, Freeway & Expressways, Principal Arterials, and Minor Arterials.

† HPMS element required on all NHS, Interstate, Freeway & Expressways, and Principal Arterials

Table 2. MIRE FDE for All Public Roads with AADT <400 Vehicles per Day.

FDE (MIRE Number)^	Definition
Roadway Segment	
Segment Identifier (12)	Unique segment identifier.
Functional Class (19)*	The functional class of the segment.
Surface Type (23)	The surface type of the segment.
Type of Government Ownership (4)*	Type of governmental ownership.
Number of Through Lanes (31)*	The total number of through lanes on the segment. This excludes turn lanes and auxiliary lanes.
Average Annual Daily Traffic (AADT) (79)*	The average number of vehicles passing through a segment from both directions of the mainline route for all days of a specified year.
Begin Point Segment Descriptor (10)	The location of the starting point of the roadway segment.
End Point Segment Descriptor (11)	The location of the ending point of the roadway segment.
Rural/Urban Designation (20)*	The rural or urban designation based on Census urban boundary and population.
Intersection	
Unique Junction Identifier (120)	A unique junction identifier.
Location Identifier for Road 1 Crossing Point (122)	Location of the center of the junction on the first intersecting route (e.g. route-milepost).
Location Identifier for Road 2 Crossing Point (123)	Location of the center of the junction on the second intersecting route (e.g. route-milepost). Not applicable if intersecting route is not an inventoried road (i.e., a railroad or bicycle path).
Intersection/Junction Geometry (126)	The type of geometric configuration that best describes the intersection/junction.
Intersection/Junction Traffic Control (131)	Traffic control present at intersection/junction.

^ Model Inventory of Roadway Elements – MIRE Version 1.0 *(1)*.

* HPMS full extent elements required on all Federal-aid highways and ramps located within grade-separated interchanges, i.e., NHS and all functional systems excluding rural minor collectors and locals.

In addition to collecting the MIRE FDE, States would need to develop a common statewide relational linear referencing system (LRS) on all public roads that is linkable with crash data, as required by 23 CFR 1.5 and described in recent FHWA guidance (6) issued on August 7, 2012. This LRS will enable States to locate high crash locations on all public roads in the State. As States expand their inventories, additional data, such as roadway and traffic data, should be linkable by LRS geolocation.

Objective

The objective of this effort is to estimate the potential cost to States in developing a statewide LRS and collecting the MIRE FDE on all public roadways. The expected benefit is that collecting additional roadway and traffic data and integrating those data into the safety analysis process will improve an agency's ability to locate problem areas and apply appropriate countermeasures, hence improving safety. This report, building upon the market analysis report for the 2011 FDE *(2)*, provides information on efforts conducted since 2011, updates values needed to determine the costs and benefits of collecting the MIRE FDE (slightly revised from the 2011 FDE), revises the methodology used previously to incorporate more recent data and systems, expands the estimates nationally, and adjusts the results accordingly to reflect these changes.

REVIEW OF RECENT DATA COLLECTION EFFORTS

The market analysis report for the 2011 FDE *(2)* relied solely on vendor information to determine data collection costs. Since that time, a number of studies were conducted on evaluating data collection methods in an effort to obtain quality data that are the foundation for making important decisions regarding the design, operation, and safety of roadways. These efforts included the MIRE Management Information System (MIRE MIS) Lead Agency Program intersection inventory collection in New Hampshire and Washington State, a task of the MIRE MIS project *(7)*; and the deployment of light detection and ranging (LiDAR) technology in Utah *(8)*.

MIRE MIS Project and the Intersection Inventory Collection

The objective of the MIRE MIS project was to test the feasibility of converting the MIRE listing into an MIS. This was done through the exploration, development, and documentation of mechanisms for data collection, processes for data handling and storage, details of data file structure, methods to assure the integration of MIRE data with crash data and other data types, and performance metrics to assess and assure MIRE data quality and MIS performance.

The exploration of the mechanism for collecting MIRE data was done through three major tasks including a pilot data collection effort where MIRE data were collected in two States (the MIRE MIS Lead Agency Program intersection inventory collection in New Hampshire and Washington State); a white paper that explores the use of collective information for transportation safety data; and development of a MIRE data collection guidebook. The Lead Agency Program in New Hampshire and Washington State are particularly relevant to this task.

The objective of the Lead Agency Program was to assist volunteer transportation agencies to collect, store, and maintain MIRE data, and to incorporate those data into their safety programs. FHWA chose the New Hampshire Department of Transportation (NHDOT) and the Washington State Department of Transportation (WSDOT) through an application process as Lead Agencies to participate in the MIRE MIS effort. A second objective was to determine the level of effort and resources necessary to achieve these goals.

Both NHDOT and WSDOT requested an intersection inventory for use in AASHTOWare's SafetyAnalyst, but with slightly different variables. Having both agencies select similar elements provided the project team an opportunity to compare different data collection methodologies. The project team developed two different methods to collect these data elements, one set of simplified tools based on a geographic information system (GIS) platform (for NHDOT), and a more complex automated extraction tool based on proprietary software (for WSDOT). The data collection for both States was done in office using information from available sources such as aerials, Google Street View, and video logs to populate the data elements.

The rate of data collection for New Hampshire was approximately nine minutes per intersection compared to three minutes per intersection for Washington State. The New Hampshire rate of collection was higher due to the time it took to collect speed limits on each approach to the intersection. The rate of collection without speed limits is estimated to be approximately two minutes per intersection.

LiDAR Collection in Utah

The Utah Department of Transportation (UDOT) is employing the LiDAR technology on a groundbreaking data collection project. UDOT has recently entered into a contract to gather, identify, and process a wide variety of roadway assets along its entire 6,000+ center lane miles of State route and interstates *(9)*. One of the key goals of the project is to "deploy state of the art collection methods to improve and develop rigorous safety, maintenance, and preservation programs."

The first phase of the project, which involved the data gathering, is complete. The second phase is underway, consisting of post processing and data delivery. The initial data gathering was conducted in 2012, and there are plans for an update of the data to be conducted in 2014.

The data collected include roadway distress data, pavement surfaces, lane miles, signs, right-of-way images, vertical clearances, and more with each of these categories being subdivided further to provide additional detail. The data collection costs associated with collecting roadway conditions was approximately $26 per mile, $30 per mile with geolocating roadways, and $95 per mile with roadway asset data collection *(8)*.

Other Vendors

Many agencies use other non-LiDAR data collection vendors to collect data including traffic volumes. The market analysis report for the 2011 FDE *(2)* summarized cost data provided by 12 data collection vendors from around the country. Costs were obtained from the vendors on a per-mile basis along segments, and a per-location basis for intersections and ramps. The cost for developing an LRS was estimated per mile. For traffic counts on segments, an estimate of one count per mile was used to generate a per mile cost. These costs included data collection and reduction for integration into a State's existing system.

The majority of vendors estimated that they would use digital data collection vans to collect the roadway inventory data. For traffic count data, vendors provided cost estimates based on 48-

hour classification counts for segment and ramp traffic data and peak hour manual counts for intersections.

METHODOLOGY

Overview

The market analysis report for the 2011 FDE included an extensive literature review that uncovered no established methodologies to estimate the benefit of collecting roadway data elements for safety *(2)*. Additionally, no one State was identified that already collects the exact list of MIRE FDE on all public roadways within the State. Therefore, a cost effectiveness analysis was conducted based on estimated costs of collecting data for a small, medium, and large State.

As with the previous analysis, a cost effectiveness analysis approach is used for this effort. However, the general approach is modified to estimate the cost for each State based on the best available estimates for the number of lane miles, intersections, and ramps. The analysis uses costs for data collection from the several sources including the MIRE MIS intersection inventory, Utah's LiDAR experience, and vendors' estimates. These sources represent potential methodologies for data collection, and were selected for this analysis based on the availability of recent cost information. There may be other collection methods, tools, or technologies that States could consider for data collection.

The analysis also considers the extent of data collection already being conducted by the States, and develops a national cost estimate. The cost estimations used in this analysis reflect the additional costs that States would incur based on what is not already being collected through HPMS and through other efforts. During 2011-2012, FHWA conducted a State Data Capabilities Assessment for each State on the collection, management, and use of roadway safety data *(10)*. States provided information about their practices on State and local roads, with most responses for local roads limited to Federal-aid local roads. The analysis uses the results of this assessment to determine the cost to collect the additional MIRE FDEs for each State and the District of Columbia.

The cost estimate also includes the cost to extend existing LRS to all public roads, consistent with the HPMS requirements that States submit their LRS covering all public roadways for their HPMS submittal of 2013 data due June 15, 2014 *(6)*. In addition, 13 of the 37 MIRE FDE for roadways with AADT ≥ 400 vehicles per day are also already collected for the HPMS. For roadways with AADT < 400 vehicles per day, five of the 14 MIRE FDE are HPMS full extent elements for Federal-aid roads. Table 1 and Table 2 indicate which of the 37 MIRE FDE are HPMS elements.

Classification of Roadway Ownership

Each State's roadways, intersections, and ramps are divided into roadway ownership classifications in order to apply the associated costs. To calculate the data collection costs for each State, the roadway mileage, number of intersections, and number of ramps is determined for:

- Federal-aid State roadways.
- Federal-aid non-State roadways.
- Non-Federal-aid State roadways, urban and rural.
- Non-Federal-aid non-State roadways with AADT $\geq$ 400 vehicles per day, urban and rural.
- Non-Federal-aid non-State roadways with AADT $<$ 400 vehicle per day, urban and rural.
- State intersections (State/State and State/local).
- Non-State (local/local) intersections with AADT $\geq$ 400 vehicles per day.
- Non-State (local/local) intersections with AADT $<$ 400 vehicles per day.
- State ramps.
- Non-State ramps.

Roadway Segments

The analysis uses 2011 mileage data from the FHWA Office of Highway Policy Information Highway Statistics Series to determine the Federal-aid and non-Federal-aid roadways for each State, and the urban and rural mileage *(11)*. At the time of this report, the 2011 data did not provide a break-down between State and non-State roadways, so the analysis uses the 2008 data to determine the proportion between State and non-State roads *(12)*. This proportion is applied to the 2011 data.

The MIRE FDE differ for roadways with AADT $\geq$ 400 vehicles per day and those with AADT $<$ 400 vehicles per day. The Highway Statistics Series data do not include this distribution for each State. The analysis uses data provided by Iowa, Missouri, and Minnesota to determine the percent of non-Federal-aid roadways with AADT $<$ 400 vehicles per day. The average of these States, 89.6 percent, is applied for the remaining States.

Intersections

Several States were contacted to determine the number of intersections, including the number of State intersections (i.e., at least one of the crossing roadways is a State road) and the number of non-State intersections (i.e., both crossing roadways are local roads). Missouri, New Hampshire, and Ohio provided the total number of intersections in their States. A partial count of intersections was provided by Colorado, Washington, and Oklahoma.

The intersection data from Missouri, New Hampshire, and Ohio were used to determine the average intersections per mile and the portion of non-State intersection. Based on these data, the analysis uses an average of 2.3 intersections per mile to estimate the number of intersections for the remaining States. The data from these three States also show that approximately 78 percent of the intersections are non-State intersections.

To determine the number of non-State intersections with AADT < 400 vehicles per day, the analysis applies the same percentage used for the roadway segments, 89.6 percent.

Ramps

As with the intersection data, several States were contacted to determine the number of ramps in each State. Colorado, Missouri, Ohio, Oklahoma and Washington provided the total number of ramps in their States. These data were compared to the rural and urban interstate miles in these States, resulting in an average of five ramps per rural interstate mile and 9.3 ramps per urban interstate mile. The number of ramps for the remaining States is determined by extrapolating from these averages.

Data Collection Costs

The costs for each State to collect the additional MIRE FDE are aggregated into seven categories:

1. Costs to develop a common LRS.
2. Costs to collect the MIRE FDE elements for roadway segments.
3. Costs to collect the MIRE FDE elements for intersections.
4. Costs to collect the MIRE FDE elements for ramps.
5. Cost to collect volume data.
6. Cost to manage and administer data collection efforts.
7. Cost to maintain the data annually.

Each of the seven categories is described in the following sections. Additionally, Table A1 in the Appendix provides a detailed listing of the specific cost inputs and the source of the inputs for each of the categories.

Linear Referencing System

An LRS is required for all public roadways as part of the States' HPMS submittal of 2013 data, which is due June 15, 2014. Currently, the completeness of the roadway network for each State varies. Only the costs of adding roadways not currently in the network is considered in this analysis. The analysis assumes that all Federal-aid roadways have already been incorporated into the system, and consequently no additional cost will be incurred. For the non-Federal-aid roadways, the percentage of missing roads is based on the State Data Capabilities Assessment *(10)*. The cost per mile to include these additional roads is assumed to be $30/mile based on the Utah LiDAR program *(8)*. Table A2 in the Appendix provides the breakdown of the cost to complete an LRS for each State.

Roadway Segments

The MIRE FDE includes 18 roadway segment elements for roadways with AADT≥ 400 vehicles per day, two of which involve collecting volumes (AADT and AADT year). There are nine MIRE FDE roadway segment elements for those with AADT < 400 vehicles per day, one of which is AADT.

Federal-Aid Roadways

As part of their HPMS reporting for Federal-aid roadways, States already collect many of the MIRE FDE for roadways with AADT ≥ 400 vehicles per day. The additional non-HPMS elements include *surface type*, *direction of inventory, median type, begin point segment descriptor, end point segment descriptor, segment length,* and *AADT year*. Several elements are only reported to HPMS for some functional classes. For example, *access control* is collected on NHS roadways, interstates, freeways and expressways, and principal arterials.

Field data collection is needed for *surface type* and *median type.* Based on the Utah LiDAR project it will cost approximately $30/mile to collect these elements *(8)*. Additionally, a base mobilization fee of $255,000 will be incurred to mobilize the LiDAR equipment in each State. *Access control* can be collected in the office utilizing aerial images or as-built plans. The costs associated with this effort are estimated to be $3 per mile (10 miles per hour at $30 per hour). This also includes the cost to collect the remaining business elements. The analysis considers business elements to be basic location and administrative elements (e.g., *segment identifier*, *direction of inventory*).

The analysis assumes the roadways with AADT < 400 vehicles per day are non-Federal-aid roads. These costs are discussed in the following section.

Non-Federal-Aid Roadways

Some States collect at least a subset of the MIRE FDE on non-Federal-aid roadways, based on the State Data Capabilities Assessment *(10)*. To account only for the additional costs to collect the MIRE FDE, only those elements not currently collected by the States are considered. This was done separately for each State based on their self-reported extent of collection from the State Data Capabilities Assessment. Where a partial number of elements were collected, the cost associated with the missing elements is derived by reducing the overall cost proportionally (missing elements/total elements).

The costs for the remaining roadway segment elements on non-Federal-aid roadways are calculated separately for roadways with AADT ≥ 400 vehicles per day and roadways with AADT < 400 vehicles per day.

<u>Roadways with AADT ≥ 400 Vehicles per Day</u>

The following MIRE FDE roadway segment elements are deemed to require field data collection: *surface type*, *median type*, *one/two way operations*, and *number of through lanes*. Based on the Utah LiDAR project it will cost approximately $38/mile to collect these elements *(8)*. States will not incur the base mobilization fee for the LiDAR van if they already incurred that fee for the data collection on Federal-aid roads.

The remaining non-volume MIRE FDE roadway segment elements can be collected in the office utilizing aerial images or as-built plans. The cost associated with this effort is estimated to be $3 per mile (10 miles per hour at $30 per hour) for State roadways and $6 per mile (five miles per hour at $30 per hour) for local roadways. The higher cost for local roadways is because there are more business elements to collect, and typically there is less existing information for local roads than for State roads.

<u>Roadways with AADT < 400 Vehicles per Day</u>

The MIRE FDE roadway segment elements for roadways with AADT < 400 vehicles per day are significantly less – eight non-volume elements compared to 16. The analysis assumes the *number of through lanes* for all roads in this category is two, based on the low volumes. The analysis also assumes that States will obtain information for these roads through coordination with local agencies. The estimated cost associated with this effort is $0.30/mile (100 miles per hour at $30 per hour), which is lower than the cost for roads with AADT ≥ 400 because there are fewer elements.

Table A3 in the Appendix provides the cost breakdown for roadway data collection on Federal-aid and non-Federal-aid roads for each State.

Intersections

The MIRE FDE includes eight intersection elements for roadways with AADT≥ 400 vehicles per day, two of which involve volumes (AADT and AADT year). There are five MIRE FDE for intersections of two roadways with AADT < 400 vehicles per day.

The MIRE FDE for intersections can be divided into:

- Business elements – *unique junction identifier*, *location identifier for road 1 crossing point*, *location identifier for road 2 crossing point*, and *unique approach identifier*.
- Intersection features – *intersection geometry* and *traffic control*.
- Volume data – the costs of this item are described later in the report.

States will most efficiently achieve the collection of business elements by running a model which imports the intersections' attributes from existing roadway information. The presence of an LRS is a pre-requisite for running the model. While many States already have this system in place, it is assumed that all States will have it by 2014 for their HPMS submittal. Based on the MIRE MIS intersection inventory conducted for New Hampshire, the estimated cost to run this model is a flat fee of $12,000 (120 hours at $100/hour) *(7)*. Since this is not a per element cost, the flat cost is applied to States that are missing any of the intersection business elements on State or non-State roads.

Based on the findings of the MIRE MIS intersection inventory effort, the cost to collect the intersection features is $1 per intersection (2 minutes per intersection at $30 per hour). Similar to the roadway segments, some States already collect MIRE FDE for intersections. In States where data are already available for some elements, the cost associated with the missing elements is derived by reducing the overall cost proportionally (missing elements/total elements).

The analysis assumes 90 percent of the local/local intersections with AADT < 400 vehicles per day will have intersections features collected in office at the rates described above. For the remaining 10 percent of these intersections the analysis assumes States will obtain the data through coordination with local agencies. This cost is estimated to be $0.03 per local intersection (1,000 intersections per hour at $30/hour). Table A4 in the Appendix provides the cost breakdown for intersection data collection for each State.

Ramps

The MIRE FDE includes 11 ramp elements, including two volume-related elements and two elements already collected under HPMS. Similar to intersections, States will most efficiently collect these elements by running a model to import the ramps' business elements from existing roadway data. The business elements for ramps are *unique interchange identifier*, *location identifier for roadway at beginning ramp terminal*, *year of ramp AADT,* and *location identifier for roadway at ending ramp terminal*. The estimated cost to run the model is $8,000 (80 hours at $100/hour) and can only be run once an LRS is in place.

The remaining four elements including *ramp length*, *roadway type* at beginning and ending ramp termini, and *interchange* type, can be collected in the office through aerials and as-built plans. The cost to collect this information is estimated to be $4 per ramp (eight minutes per ramp at $30 per hour). Since this is not a per element cost, the flat cost is applied to States that are missing any of the ramp business elements on State or non-State roads. Table A5 in the Appendix provides the cost breakdown for ramp data collection for each State.

Volume Data

The MIRE FDE includes volumes (AADT), as well as their year, for segments. For roadways with AADT ≥ 400 vehicles per day only, the MIRE FDE includes volume data for ramps and for all intersecting roadways at intersections. Volumes are already collected under HPMS for Federal-aid roadway segments and ramps. Table A6 in the Appendix provides the cost breakdown for volume data collection on roadway segments and intersections for each State.

Roadway Segments

As previously mentioned, HPMS requires AADT reporting on all Federal-aid roadways. Thus, no additional volume collection costs are associated with these roads.

Several States were contacted to determine State practices for volume data collection for non-Federal-aid roads. Colorado, Missouri, and Ohio reported that they collect volume data on all State roads, including non-Federal-aid locations. Based on their responses, the analysis assumes volume data are collected on 99 percent of non-Federal-aid State roadways. This leaves one percent of non-Federal-aid State roadways to collect volume on to account for States that may not have fully complete volume data.

States indicated they have volumes for approximately five percent of all non-Federal-aid, non-State roads with AADT ≥ 400 vehicles per day. For those with AADT < 400 vehicles per day, only one percent had volumes. The analysis assumes that traffic volumes will be estimated for

90 percent of the non-State roads with AADT ≥ 400 vehicles per day, and collected on five percent.

States also indicated they have volumes for approximately one percent of all non-Federal-aid, non-State roads with AADT < 400 vehicles per day. For these low volume roads, the analysis assumes volumes will be estimated for 98 percent, leaving one percent to be counted.

The cost to collect the volume data is based on the vendors' responses in the previous *Market Analysis* report *(2)* at $460 per count. The analysis assumes one count per mile for urban roads, and one count per five miles for rural roads given that these roads tend to have similar volumes for longer stretches due to fewer cross roads. This results in a $460 per mile cost for urban roads and $92 per mile for rural roads.

The analysis assumes States will use existing volume and roadway data to estimate volumes on the roads where counts are not conducted. This can be done using geospatial analysis that assigns volumes based on roadway and location characteristics. Similar to the model run for segment and intersection business elements, the analysis assumes a flat cost of $16,000 (160 hours at $100/hour) for estimation of volumes. This cost is applied twice – once to estimate volumes on the non-Federal-aid, non-State roads with AADT ≥ 400 vehicles per day, and once for the non-Federal-aid, non-State roads with AADT < 400 vehicles per day. States will likely need to create two models for each of the roadway classes, which is why the estimation cost is applied twice.

Intersections

The MIRE FDE includes volumes for intersections of roadways with volumes over AADT ≥ 400 vehicles per day for both intersecting roadways. This analysis assumes that separate intersection volumes will not be counted. Instead, volumes will be assigned to the intersection based on the AADT of the intersecting roads. Based on the MIRE MIS intersection inventory effort, the cost to assign the volumes to an intersection is approximately $0.50 per intersection (100 hours per 10,000 intersections at $50 per hour) *(7)*.

Ramps

HPMS reporting includes volume data for ramps; therefore no additional cost is incurred to collect these data for ramps.

Management and Administration of Data Collection Efforts

The efforts to collect the roadway segment, intersection, and ramp data will require costs for management and administration, particularly if the data are collected by vendors or contractors.

The analysis includes management and administration costs equal to five percent of the total data collection costs, up to $250,000 maximum for each State.

Data Maintenance

In addition to the costs of initial data collection, the costs to maintain the data are also calculated (e.g., the costs to update the data as conditions change). For roadway segment data, the analysis assumes that two percent of the roadway mileage will be updated annually. The analysis approximates that updating the segment data will cost $6 per mile (five miles per hour at $30/hour). The cost of updating the segment data is more than the initial cost of collecting segment data since these updates will most likely not be done by re-collecting the data on a large-scale, but rather by updating individual segments based on updates from construction/design plans, aerials, and other technological advances. More time will be needed to update segments individually (e.g., higher unit price for collection) than the large scale initial collection effort.

For intersections, the analysis assumes two percent of intersections with an AADT ≥ 400 vehicles per day will be updated annually. Similar to segments, these will be based on updates from construction/design plans and aerials. The analysis estimates that updating the intersection data will cost $2.50 per intersection (five minutes per intersection at $30/hour). Similar to segments, this assumes that more time will be needed for each intersection that is updated.

The analysis assumes two percent of ramps will be updated annually. The cost for updating ramps is $5 per ramp (10 minutes per ramp at $30/hour). As with segments and intersections, the analysis assumes more time is need per ramp for the data updates.

For updating volumes, the analysis assumes volumes on non-Federal-aid State roads will be updated on a three-year cycle (i.e., 33 percent of volumes updated annually). The volumes on non-Federal-aid non-State roads with an AADT ≥ 400 vehicles per day will be updated on a six-year cycle. This is only for those roads that have existing counts (five percent of total) and roads with new counts from the data collection (five percent of total). This equates to approximately two percent of the non-Federal-aid non-State roads annually. The same rate of collection and cost per count used for the data collection is applied for the updates, for both urban and rural roads.

These assumptions on data collection cycles and maintenance were based on standard practices obtained through discussions with several States. Table A7 in the Appendix summarizes the maintenance costs for each State.

Disaggregated Annual Costs

The annual base cost for segments, intersections, and ramps is disaggregated for each State. The analysis assumes a start date of October 1, 2013 for the development of the LRS and the data collection. The analysis also assumes that all States will have an LRS by June 15, 2014, and that this is the end date for development of the LRS. The analysis assumes the MIRE FDE data collection will be complete by September 30, 2019, for a total time period of six years. The costs are disaggregated annually at an equal rate for the duration of the data collection period.

The analysis employs a real discount rate of 0.50 percent based on a rate for 16 years, extrapolated from the December 2012 real interest rates on treasury notes and bonds for 7, 10, 20, and 30 years from the White House Office of Management and Budget (OMB) *(13)*. A real discount rate is a forecast of real interest rates from which the inflation premium has been removed. This rate is appropriate for calculating the net present value for cost-effectiveness analysis.

The data collection and maintenance costs are disaggregated over the entire analysis period, 2013 to 2029. This timeframe allows for the total six year data collection period and an additional 10 years of implementation. The discount rate of 0.50 percent, per OMB guidance, is used to calculate the present value of the collection and maintenance costs for each year in 2013 dollars *(13)*. The present value cost for each year is summed to determine the net present value cost for the total analysis period, including maintenance of the data. Table A8 in the Appendix summarizes the net present value costs for each State.

Benefits

The benefits of collecting the MIRE FDE can have a significant impact on improving safety on our Nation's roads, because collecting this roadway and traffic data and integrating those data into the safety analysis process would improve an agency's ability to locate problem areas and apply appropriate countermeasures, hence improving safety. The benefits in this analysis are calculated by estimating the reduction in fatalities and injuries needed to exceed a 1:1 ratio and a 2:1 ratio of benefits to costs. That is, the assumed benefit of collecting the MIRE FDE is ultimately a reduction in fatalities and injuries. The 2012 comprehensive cost of a fatality is $9,100,000 and $107,438 for an injury, based on the value of a statistical life *(14)*. The injury cost reflects the average injury costs based on the national distribution of injuries in the General Estimate System (GES) using a Maximum Abbreviated Injury Scale (MAIS). MAIS injuries are on a scale of zero to five, with five being the most severe non-fatal injury.

The future cost of a fatality and injury is forecasted out for each year of the analysis period, and then discounted to reflect 2013 dollar values using a discount rate of 0.50 percent. The calculation of benefits assumes a yearly accumulation of benefits beginning after the data collection start date of October 1, 2013. The analysis assumes a portion of benefits will be accumulated while data are collected, with the full realization of benefits after data collection is complete. Table 3 shows the rate of accumulation of the benefits.

Table 3. Accumulation of Benefits.

Year End	Value of Data in Decision-Making	Comment
9/30/2014	0%	No value in first full year of collection; data are not readily available for analysis.
9/30/2015	20%	LRS is available for use and increases ability for analysis.
9/30/2016	40%	LRS and high priority data are available for analysis.
9/30/2017	60%	LRS and high priority data are available for analysis.
9/30/2018	70%	LRS, high priority data, and some lower priority data are available for analysis.
9/30/2019	80%	Data collection is complete but not all data are available for analysis.
9/30/2020	90%	All data are available for analysis; data are incorporated into safety program and used in decision-making process for improvements to roadways.
9/30/2021	100%	Full value of data realized after one full year of incorporation into safety program.
9/30/2022	100%	Value of investment continues.
9/30/2023	100%	Value of investment continues.
9/30/2024	100%	Value of investment continues.
9/30/2025	100%	Value of investment continues.
9/30/2026	100%	Value of investment continues.
9/30/2027	100%	Value of investment continues.
9/30/2028	100%	Value of investment continues.
9/30/2029	100%	Value of investment continues.

The average cost of a fatality and injury is calculated for the analysis period. This calculation accounts for the portion of the fatality and injury costs during the data collection period.

The analysis uses a five-year average of fatalities in each State as report in the Fatality Analysis Reporting System (FARS) from 2007 to 2011 *(15)*. The ratio of the number of fatalities to injuries for each State is calculated using the national five-year average of fatalities to injuries. During this five-year period, there were an average of 35,476 total fatalities per year and 2,302,000 total injuries per year, equating to a fatality to injury ratio of approximately 1:65. Using that ratio, the number of fatalities and injuries needed to exceed a 1:1 ratio and a 2:1 ratio of benefits to costs is developed for each State.

RESULTS

Costs of Data Collection and Maintenance

The costs for each State to collect the additional MIRE FDE are compiled into seven categories:

1. Costs to develop a common LRS.
2. Costs to collect the MIRE FDE elements for roadway segments.
3. Costs to collect the MIRE FDE elements for intersections.
4. Costs to collect the MIRE FDE elements for ramps.
5. Cost to collect volume data.
6. Cost to manage and administer data collection efforts.
7. Cost to maintain the data annually.

Table 4 lists the net present value (in 2013 dollars) of the total costs to complete the data collection and maintain the data for the entire 16-year analysis period.

Table 4. Net Present Value of MIRE FDE Data Collection and Maintenance Costs for the 2013-2029 Analysis Period (2013 Dollars).

Data	US Average per State	US Total
LRS	$336,900	$17,180,600
Segments	$732,000	$37,332,500
Intersections	$159,800	$8,151,700
Ramps	$16,100	$819,400
Volumes	$118,000	$6,016,100
Management & Administration	$66,600	$3,394,500
Maintenance	$2,896,100	$147,701,100
Total	**$4,325,400**	**$220,595,900**

The total cost of data collection is less than the costs reported in the 2011 *Market Analysis (2)*. This analysis incorporates new data and information that became available since the publication of the previous analysis. The State Data Capabilities Assessment provided more insight on current State practices and the extent and coverage of data already collected. Where the previous analysis made global assumptions on the extent of data coverage nationally, this analysis used the State's self-reported extent and coverage from the Capabilities Assessment. Also, the analysis incorporates updated costs from recently deployed data collection methods (e.g., Utah's LiDAR experience and the intersection inventory collection in New Hampshire), which were not available at the time of the previous market analysis.

Another factor contributing to the change in costs is the difference in the analysis approach. The 2011 market analysis calculated costs for a hypothetical small, medium, and large State using data from a few sample States. With the recent availability of information on individual States, this analysis calculates the costs for each of the 50 States and the District of Columbia individually, which are used to determine a national average.

Benefit-Cost Analysis

The summary of the average annual costs and required benefits to collect the above information are shown in Table 5. On average, nationally, 0.38 fatalities and 24.77 injuries would need to be reduced over the entire analysis period to achieve a greater than 1:1 benefit to cost ratio. This increases to 0.76 fatalities and 49.54 injuries that would need to be reduced to achieve a greater than 2:1 benefit to cost ratio.

Table 5. Summary of US Average Cost and Needed Benefit for the 2013-2029 Analysis Period (2013 Dollars).

Benefit Scenario	Net Present Value Cost	Cost of a Fatality	Cost of an Injury	Needed Fatalities	Needed Injuries
Benefit ≥ 1:1	$4,325,400	$6,416,233	$75,753	0.38	24.77
Benefit ≥ 2:1	$4,325,400	$6,416,233	$75,753	0.76	49.54

SUMMARY

The purpose of this effort was to conduct an economic analysis of the development of a statewide common LRS and the collection of the MIRE FDE on all public roads. Collecting additional roadway and traffic data, and integrating those data into the safety analysis process, will improve an agency's ability to locate problem areas and apply appropriate countermeasures, hence improving safety.

The approach used to conduct the economic analysis is a hybrid of a benefit-cost analysis and a cost effectiveness analysis. The costs for data collection were provided from several sources including the MIRE MIS Lead Agency Program intersection inventory effort, Utah's LiDAR experience, and vendors' estimates. For benefits, an estimate of how many fatalities and injuries would need to be reduced in order exceed the costs (for a 1:1 and 2:1 ratio) are developed. That is, this analysis identified the benefit required to obtain cost effectiveness.

The analysis calculates the costs for each State to collect the MIRE FDE that they do not already collect for HPMS, or for other reasons, as reported in the State Data Capabilities Assessment *(10)*. The costs are broken down for the development of an LRS, collection of segment, intersection, ramp, and volume data, and annual maintenance of data.

The analysis period is from 2013 to 2029. This includes a 10-year period after data collection is complete to fully realize the benefits. The calculation of benefits assumes a yearly accumulation of benefits beginning after the data collection start date of October 1, 2013. The analysis assumes a portion of benefits will be accumulated while data are collected, with the full realization of benefits after data collection is complete.

The estimated reduction in fatalities and injuries were determined based on the costs. The national average for the total cost of data collection and maintenance over the entire analysis period is $4.33 million per State and the District of Columbia (in 2013 U.S. dollars). A reduction of 0.38 fatalities and 24.77 injuries over the analysis period is required to achieve a greater than 1:1 benefit to cost ratio.

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APPENDIX – DATA COLLECTION COSTS PER STATE

Table A1. Cost Inputs and Source.

OWNERSHIP	VARIABLE	RATE	UNIT	COMMENT
LRS				
All	Cost to collect	$30.00	per mile	Cost is based on Utah LiDAR project and reinforced by previous market analysis.
SEGMENTS				
All	Field collection, LiDAR mobilization	$255,000.00	base cost	Based on Utah LiDAR base mobilization cost.
Federal-aid, State	Field collection, LiDAR cost for elements	$30.00	per mile	Based on Utah LiDAR costs. Surface type ($26/mi), median type ($4/mi).
Federal-aid, State	In office, rate of collection	10	miles per hour	Access control can be collected from aerials, plus any additional business elements (minimal).
Federal-aid, State	In office, cost	$30.00	per hour	
Federal-aid, Non-State	Field collection, LiDAR cost for elements	$30.00	per mile	Based on Utah LiDAR costs. Surface type ($26/mi), median type ($4/mi).
Federal-aid, Non-State	In office, rate of collection	10	miles per hour	Access control can be collected from aerials, plus any additional business elements (minimal).
Federal-aid, Non-State	In office, cost	$30.00	per hour	
Non-Federal-aid, State	Field collection, LiDAR cost for elements	$38.00	per mile	Based on Utah LiDAR costs. Surface type ($26/mi), median type ($4/mi), one/two-way operations ($1/mi), number of lanes ($7/mi)
Non-Federal-aid, State	In office, rate of collection	10	miles per hour	Access control can be collected from aerials, plus any additional business elements (minimal).
Non-Federal-aid, State	In office, cost	$30.00	per hour	
Non-Federal-aid, Non-State, over 400 ADT	Field collection, LiDAR cost for elements	$38.00	per mile	Based on Utah LiDAR costs. Surface type ($26/mi), median type ($4/mi), one/two-way operations ($1/mi), number of lanes ($7/mi)
Non-Federal-aid, Non-State, over 400 ADT	In office, rate of collection	5	miles per hour	Lower rate of collection due to more business elements to collect and less existing information.
Non-Federal-aid, Non-State, over 400 ADT	In office, cost	$30.00	per hour	
Non-Federal-aid, Non-State, under 400 ADT	Portion of roadways under 400 ADT	89.6%	percent	Extrapolation based on data obtained from States. See *StateData_Road* tab.
Non-Federal-aid, Non-State, under 400 ADT	In office, rate of collection	100	miles per hour	Obtain information through coordination with local agencies. Rate based on average miles in a NH town. Assume number of through lanes is 2.
Non-Federal-aid, Non-State, under 400 ADT	In office, cost	$30.00	per hour	
RAMPS				
All	Number of ramps, rural	5	ramps per mile	Extrapolation based on data obtained from States. See *StateData_Ramp* tab.
All	Number of ramps, urban	9.3	ramps per mile	Extrapolation based on data obtained from States. See *StateData_Ramp* tab.
All	Identification of ramps and business elements, rate	80	hours	This is a model that is run; setup time is the same regardless of the size of the State. Requires LRS to be in place; this portion occurs after 2014 for most States.
All	Identification of ramps and business elements, cost	$100.00	per hour	
All	In office, rate of collection	0.13	hours per ramp	Rate equivalent to 8 minutes per ramp.
All	In office, cost	$30.00	per hour	

Table A1. Cost Inputs and Source.

OWNERSHIP	VARIABLE	RATE	UNIT	COMMENT
INTERSECTIONS				
All	Number of intersections, all roads	2.3	intersections per mile	Extrapolation based on data obtained from States. See *StateData_Int* tab.
Non-State	Portion of intersections that are Local/Local	78%	percent	Extrapolation based on data obtained from States. See *StateData_Int* tab.
All	Identification of intersections and business elements, rate	120	hours	This is a model that is run; setup time is the same regardless of the size of the State. Requires LRS to be in place; this portion occurs after 2014 for most States.
All	Identification of intersections and business elements, cost	$100.00	per hour	
State (S/S and S/L)	In office, rate of collection	0.03	hours per intersection	Rate equivalent to 2 minutes per intersection. Geometry and traffic control can be collected from aerials.
State (S/S and S/L)	In office, cost	$30.00	per hour	Base on NH intersection inventory costs.
Non-State (L/L), over 400 ADT	In office, rate of collection	0.03	hours per intersection	Rate equivalent to 2 minutes per intersection. Geometry and traffic control can be collected from aerials.
Non-State (L/L), over 400 ADT	In office, cost	$30.00	per hour	Base on NH intersection inventory costs.
Non-State (L/L), under 400 ADT	Intersections populated by in-office data collection	90%	percent	Assume portion of intersections will have intersection features collected in office using aerials.
Non-State (L/L), under 400 ADT	In office, rate of collection	0.03	hours per intersection	Rate equivalent to 2 minutes per intersection. Geometry and traffic control can be collected from aerials.
Non-State (L/L), under 400 ADT	In office, cost	$30.00	per hour	Base on NH intersection inventory costs.
Non-State (L/L), under 400 ADT	Intersections populated by local agency coordination	10%	percent	Assume portion of intersections will have intersection features collected through coordination with local agencies.
Non-State (L/L), under 400 ADT	In office, rate of collection	1000	intersections per hour	Obtain information through coordination with local agencies. Assume number of through lanes is 2.
Non-State (L/L), under 400 ADT	In office, cost	$30.00	per hour	

Table A1. Cost Inputs and Source.

OWNERSHIP	VARIABLE	RATE	UNIT	COMMENT
VOLUME				
Non-Federal-aid, State	Percent of roads with volume	99%	percent	Based on three States reporting having 100% of roads with volumes. Assume some States would fall just under 100%.
Non-Federal-aid, State	Percent of roads to collect volume	1%	percent	
Non-Federal-aid, State	ADT on segment, urban, rate of collection	1	count per mile	
Non-Federal-aid, State	ADT on segment, urban, cost	$460.00	per count	
Non-Federal-aid, State	ADT on segment, rural, rate of collection	0.2	count per mile	Rate is equivalent to 1 count every 5 miles.
Non-Federal-aid, State	ADT on segment, rural, cost	$460.00	per count	
Non-Federal-aid, Non-State, over 400 ADT	Percent of roads with volume	5%	percent	
Non-Federal-aid, Non-State, over 400 ADT	Percent of roads to estimate volume	90%	percent	
Non-Federal-aid, Non-State, over 400 ADT	Estimation of volumes, rate	160	hours	Assume estimations are based on exiting roadway information (e.g., functional class, area type) and existing volumes.
Non-Federal-aid, Non-State, over 400 ADT	Estimation of volumes, cost	$100.00	per hour	
Non-Federal-aid, Non-State, over 400 ADT	Percent of roads to collect volume	5%	percent	
Non-Federal-aid, Non-State, over 400 ADT	ADT on segment, urban, rate of collection	1	count per mile	
Non-Federal-aid, Non-State, over 400 ADT	ADT on segment, urban, cost	$460.00	per count	
Non-Federal-aid, Non-State, over 400 ADT	ADT on segment, rural, rate of collection	0.2	count per mile	Rate is equivalent to 1 count every 5 miles.
Non-Federal-aid, Non-State, over 400 ADT	ADT on segment, rural, cost	$460.00	per count	
Non-Federal-aid, Non-State, under 400 ADT	Percent of roads with volume	1%	percent	
Non-Federal-aid, Non-State, under 400 ADT	Percent of roads to estimate volume	99%	percent	
Non-Federal-aid, Non-State, under 400 ADT	Estimation of volumes, rate	160	hours	Assume estimations are based on exiting roadway information (e.g., functional class, area type) and existing volumes.
Non-Federal-aid, Non-State, under 400 ADT	Estimation of volumes, cost	$100.00	per hour	
Non-Federal-aid, Non-State, under 400 ADT	Percent of roads to collect volume	0%	percent	
Non-Federal-aid, Non-State, under 400 ADT	ADT on segment, urban, rate of collection	1	count per mile	
Non-Federal-aid, Non-State, under 400 ADT	ADT on segment, urban, cost	$460.00	per count	
Non-Federal-aid, Non-State, under 400 ADT	ADT on segment, rural, rate of collection	0.2	count per mile	Rate is equivalent to 1 count every 5 miles.
Non-Federal-aid, Non-State, under 400 ADT	ADT on segment, rural, cost	$460.00	per count	
Intersections over 400 ADT	Assignment of volumes, rate	0.01	hours per intersection	Rate is equivalent to 100 hours per 10,000 intersections. This is based on the NH intersection inventory effort.
Intersections over 400 ADT	Assignment of volumes, cost	$50.00	per hour	

Table A1. Cost Inputs and Source.

OWNERSHIP	VARIABLE	RATE	UNIT	COMMENT
INVENTORY MAINTENANCE COSTS				
Segments, >400 ADT	Roadways updated annually	2%	percent	Update annually. Based on inputs FHWA and knowledge of State practices.
Segments, >400 ADT	In office, rate of collection	5	miles per hour	
Segments, >400 ADT	In office, cost	$30.00	per hour	
Intersections, >400 ADT	Intersections updated annually.	2%	percent	Update annually. Based on inputs FHWA and knowledge of State practices.
Intersections, >400 ADT	In office, rate of collection	0.08	hours per intersection	Rate equivalent to 5 minutes per intersection. Assume more individual attention needed for each intersection.
Intersections, >400 ADT	In office, cost	$30.00	per hour	
Ramps	Ramps updated annually	2%	percent	Update annually. Based on inputs FHWA and knowledge of State practices.
Ramps	In office, rate of collection	0.17	hours per ramp	Rate equivalent to 10 minutes per ramp. Assume more individual attention needed for each ramp.
Ramps	In office, cost	$30.00	per hour	
Volume, Non-Federal-aid, State	Volumes updated annually, urban	33%	percent	Update on a three-year cycle.
Volume, Non-Federal-aid, State	ADT on segment, urban, rate of collection	1	count per mile	
Volume, Non-Federal-aid, State	ADT on segment, urban, cost	$460.00	per count	
Volume, Non-Federal-aid, State	Volumes updated annually, rural	33%	percent	Update on a three-year cycle.
Volume, Non-Federal-aid, State	ADT on segment, rural, rate of collection	0.2	count per mile	Rate is equivalent to 1 count every 5 miles.
Volume, Non-Federal-aid, State	ADT on segment, rural, cost	$460.00	per count	
Volume, Non-Federal-aid, Non-State, over 400 ADT	Volumes updated annually	1.7%	percent	Update only the roads with volumes on a six-year cycle.
Volume, Non-Federal-aid, Non-State, over 400 ADT	ADT on segment, urban, rate of collection	1	count per mile	
Volume, Non-Federal-aid, Non-State, over 400 ADT	ADT on segment, urban, cost	$460.00	per count	
Volume, Non-Federal-aid, Non-State, over 400 ADT	ADT on segment, rural, rate of collection	0.2	count per mile	Rate is equivalent to 1 count every 5 miles.
Volume, Non-Federal-aid, Non-State, over 400 ADT	ADT on segment, rural, cost	$460.00	per count	
Volume, Non-Federal-aid, Non-State, under 400 ADT	Volumes updated annually	0%	percent	

Table A1. Cost Inputs and Source.

OWNERSHIP	VARIABLE	RATE	UNIT	COMMENT
MISCELLANEOUS INPUTS				
All	Discount Rate	0.50%	percent	Source: *Office of Management and Budget Circular A-94*, http://www.whitehouse.gov/omb/circulars_a094/a94_appx-c
All	Inflation Rate	0.00%	percent	
All	Value of a Statistical Life (VSL)	$9,100,000.00	per fatality	Source: Office of the Secretary of Transportation, Memorandum on Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses, February 28, 2013. http://www.dot.gov/regulations/economic-values-used-in-analysis.
All	Data collection M&A, percent of costs	5%	percent	Management and administration costs for data collection.
All	Data collection M&A, maximum	$250,000.00	maximum	

Table A2. Cost of Completing a Linear Referencing System by State.

State	State[1]	Local[2]	Total
Alabama	$0	$227,484	$227,484
Alaska	$5,034	$272,357	$277,391
Arizona	$0	$533,523	$533,523
Arkansas	$0	$1,909,326	$1,909,326
California	$0	$3,494,533	$3,494,533
Colorado	$0	$0	$0
Connecticut	$0	$434,371	$434,371
Delaware	$0	$0	$0
Dist. of Columbia	$0	$0	$0
Florida	$0	$0	$0
Georgia	$0	$0	$0
Hawaii	$0	$0	$0
Idaho	$0	$948,626	$948,626
Illinois	$0	$0	$0
Indiana	$0	$0	$0
Iowa	$0	$0	$0
Kansas	$0	$0	$0
Kentucky	$0	$0	$0
Louisiana	$0	$0	$0
Maine	$0	$0	$0
Maryland	$0	$0	$0
Massachusetts	$0	$0	$0
Michigan	$0	$0	$0
Minnesota	$0	$0	$0
Mississippi	$0	$1,118,447	$1,118,447
Missouri	$0	$0	$0
Montana	$0	$0	$0
Nebraska	$0	$1,641,906	$1,641,906
Nevada	$0	$87,161	$87,161
New Hampshire	$0	$0	$0
New Jersey	$0	$0	$0
New Mexico	$0	$892,000	$892,000
New York	$0	$0	$0
North Carolina	$355,431	$737,637	$1,093,067
North Dakota	$0	$2,051,927	$2,051,927
Ohio	$0	$0	$0
Oklahoma	$0	$0	$0
Oregon	$0	$0	$0
Pennsylvania	$0	$0	$0
Rhode Island	$0	$0	$0
South Carolina	$0	$727,026	$727,026
South Dakota	$0	$0	$0
Tennessee	$0	$349,427	$349,427
Texas	$0	$0	$0
Utah	$0	$0	$0
Vermont	$0	$0	$0
Virginia	$12,083	$0	$12,083
Washington	$0	$1,340,014	$1,340,014
West Virginia	$0	$100,961	$100,961
Wisconsin	$0	$0	$0
Wyoming	$0	$0	$0
US Total	$372,548	$16,866,728	$17,239,277
US Average	$7,305	$330,720	$338,025

Notes:

1. Assume that the State roads that do not have an LRS are Non-Federal-aid, State roadways.

2. Assume that the local roads that do not have an LRS are Non-Federal-aid, non-State roadways.

Table A3. Cost of Roadway Segment Data Collection by State.

State	Federal-aid		Non-Federal-aid			Total
	State	Non-State	State	Non-State		
				<400	>400	
Alabama	$0	$28,194	$0	$20,383	$601,989	$650,565
Alaska	$0	$266,837	$0	$2,711	$46,160	$315,708
Arizona	$0	$364,945	$0	$13,658	$232,515	$611,118
Arkansas	$13,594	$7,416	$263	$20,863	$610,166	$652,302
California	$0	$1,762,282	$475	$31,311	$533,033	$2,327,100
Colorado	$0	$382,801	$0	$19,029	$323,950	$725,780
Connecticut	$0	$304,646	$0	$4,097	$69,743	$378,486
Delaware	$0	$0	$0	$255	$259,346	$259,601
Dist. of Columbia	$0	$255,944	$0	$24	$405	$256,373
Florida	$0	$755,780	$0	$25,665	$436,910	$1,218,355
Georgia	$0	$752,145	$0	$24,837	$422,822	$1,199,804
Hawaii	$0	$0	$0	$762	$267,980	$268,743
Idaho	$0	$417,138	$2	$7,500	$168,297	$592,937
Illinois	$0	$0	$0	$27,787	$728,046	$755,833
Indiana	$0	$0	$8	$19,822	$592,438	$612,267
Iowa	$0	$0	$0	$24,595	$562,721	$587,317
Kansas	$0	$731,107	$0	$28,374	$483,029	$1,242,509
Kentucky	$0	$0	$0	$13,609	$486,671	$500,280
Louisiana	$0	$8,290	$0	$11,455	$450,016	$469,761
Maine	$0	$0	$549	$3,860	$320,714	$325,123
Maryland	$0	$0	$0	$6,387	$363,728	$370,114
Massachusetts	$0	$0	$0	$6,753	$369,959	$376,712
Michigan	$588,589	$1,019,289	$535	$23,018	$391,854	$2,023,284
Minnesota	$13,441	$1,065,562	$21	$25,359	$932,464	$2,036,847
Mississippi	$0	$0	$0	$14,316	$498,715	$513,031
Missouri	$0	$367,206	$0	$26,877	$135,340	$529,423
Montana	$0	$324,141	$0	$15,986	$272,148	$612,275
Nebraska	$9,968	$0	$5	$19,615	$588,927	$618,516
Nevada	$334,260	$27,709	$6,217	$7,810	$132,950	$508,945
New Hampshire	$0	$0	$0	$3,071	$307,282	$310,354
New Jersey	$0	$551,185	$132	$7,766	$132,208	$691,291
New Mexico	$39,383	$342,130	$4,836	$14,531	$247,381	$648,262
New York	$14,387	$10,646	$142	$23,265	$651,059	$699,498
North Carolina	$36,267	$301,625	$622,004	$6,609	$112,514	$1,079,020
North Dakota	$376,938	$428,886	$857	$18,385	$312,987	$1,138,053
Ohio	$0	$418,701	$0	$25,012	$425,792	$869,505
Oklahoma	$33,474	$998,584	$0	$21,810	$371,284	$1,425,151
Oregon	$0	$0	$0	$11,006	$442,366	$453,373
Pennsylvania	$0	$399,463	$0	$20,520	$349,331	$769,314
Rhode Island	$278,153	$16,721	$843	$1,256	$21,388	$318,361
South Carolina	$0	$272,330	$0	$6,514	$110,896	$389,740
South Dakota	$0	$470,304	$1	$16,837	$286,636	$773,779
Tennessee	$0	$398,378	$0	$20,872	$355,329	$774,579
Texas	$0	$906,465	$0	$57,649	$981,412	$1,945,527
Utah	$0	$370,747	$0	$9,835	$167,427	$548,008
Vermont	$294,287	$47,879	$96	$2,800	$47,662	$392,725
Virginia	$0	$375,454	$0	$3,323	$56,572	$435,349
Washington	$0	$698,609	$0	$17,152	$291,995	$1,007,756
West Virginia	$406,297	$13,572	$238,425	$1,005	$17,111	$676,410
Wisconsin	$0	$0	$0	$23,312	$651,858	$675,170
Wyoming	$0	$284,209	$0	$5,359	$91,231	$380,799
US Total	$2,439,038	$16,147,318	$875,410	$764,609	$17,714,759	$37,941,135
US Average	$47,824	$316,614	$17,165	$14,992	$347,348	$743,944

Table A4. Cost of Intersection Data Collection by State.

State	Identify Intersections and Business Elements[1]	Data Collection			Total
		State	Non-State <400	Non-State >400	
Alabama	$12,000	$51,444	$147,571	$18,969	$229,984
Alaska	$12,000	$8,437	$24,203	$3,111	$47,752
Arizona	$12,000	$32,936	$94,481	$12,145	$151,562
Arkansas	$12,000	$50,641	$145,269	$18,673	$226,584
California	$12,000	$0	$249,951	$32,129	$294,080
Colorado	$12,000	$0	$128,334	$16,496	$156,830
Connecticut	$12,000	$10,851	$31,128	$4,001	$57,980
Delaware	$12,000	$0	$4,614	$593	$17,207
Dist. of Columbia	$12,000	$759	$2,178	$280	$15,217
Florida	$12,000	$61,610	$176,733	$22,717	$273,061
Georgia	$12,000	$0	$179,327	$23,051	$214,378
Hawaii	$12,000	$2,229	$6,394	$822	$21,445
Idaho	$12,000	$24,568	$70,474	$9,059	$116,101
Illinois	$12,000	$35,293	$151,862	$19,520	$218,675
Indiana	$12,000	$49,115	$140,892	$18,110	$220,117
Iowa	$12,000	$58,175	$166,880	$21,451	$258,505
Kansas	$12,000	$0	$152,966	$19,662	$184,628
Kentucky	$12,000	$40,085	$114,988	$14,781	$181,854
Louisiana	$12,000	$15,594	$89,463	$11,500	$128,556
Maine	$12,000	$11,574	$33,201	$4,268	$61,043
Maryland	$12,000	$16,354	$46,914	$6,030	$81,299
Massachusetts	$12,000	$18,369	$52,694	$6,773	$89,836
Michigan	$12,000	$61,775	$177,208	$22,778	$273,761
Minnesota	$12,000	$0	$201,321	$25,878	$239,199
Mississippi	$12,000	$38,010	$109,035	$14,015	$173,060
Missouri	$12,000	$30,000	$127,431	$16,380	$185,811
Montana	$12,000	$18,945	$81,517	$10,478	$122,939
Nebraska	$12,000	$47,362	$135,861	$17,463	$212,686
Nevada	$12,000	$18,641	$53,473	$6,873	$90,987
New Hampshire	$12,000	$0	$24,879	$3,198	$40,077
New Jersey	$12,000	$0	$56,917	$7,316	$76,233
New Mexico	$12,000	$34,602	$99,260	$12,759	$158,621
New York	$12,000	$57,984	$166,331	$21,380	$257,694
North Carolina	$12,000	$53,570	$153,670	$19,753	$238,992
North Dakota	$12,000	$43,946	$126,064	$16,204	$198,215
Ohio	$12,000	$46,934	$182,864	$23,505	$265,303
Oklahoma	$12,000	$57,081	$163,741	$21,047	$253,869
Oregon	$12,000	$0	$64,391	$8,277	$84,667
Pennsylvania	$12,000	$60,604	$173,848	$22,346	$268,799
Rhode Island	$12,000	$2,789	$8,707	$1,119	$24,615
South Carolina	$12,000	$16,697	$95,795	$12,314	$136,806
South Dakota	$12,000	$0	$119,690	$15,385	$147,075
Tennessee	$12,000	$48,319	$138,607	$17,817	$216,743
Texas	$12,000	$79,166	$454,191	$58,382	$603,739
Utah	$12,000	$23,091	$66,239	$8,514	$109,844
Vermont	$12,000	$0	$20,742	$2,666	$35,408
Virginia	$12,000	$18,839	$108,081	$13,893	$152,812
Washington	$12,000	$0	$121,553	$15,624	$149,177
West Virginia	$12,000	$19,555	$56,094	$7,210	$94,859
Wisconsin	$12,000	$0	$125,212	$16,095	$153,307
Wyoming	$12,000	$14,296	$41,009	$5,271	$72,577
US Total	$612,000	$1,280,242	$5,664,249	$728,081	$8,284,572
US Average	$12,000	$25,103	$111,064	$14,276	$162,443

Notes:

1. If State is missing any of the intersection business elements (State or local), apply base cost to run model.

Table A5. Cost of Ramp Data Collection by State.

State	Identify Ramps and Business Elements[1]	Data Collection			Total
		State	Non-State	Total	
Alabama	$8,000	$12,231	$0	$12,231	$20,231
Alaska	$8,000	$11,515	$0	$11,515	$19,515
Arizona	$8,000	$3,324	$0	$3,324	$11,324
Arkansas	$8,000	$6,298	$0	$6,298	$14,298
California	$8,000	$34,623	$0	$34,623	$42,623
Colorado	$8,000	$2,499	$0	$2,499	$10,499
Connecticut	$8,000	$3,033	$0	$3,033	$11,033
Delaware	$0	$189	$0	$189	$189
Dist. of Columbia	$8,000	$178	$0	$178	$8,178
Florida	$8,000	$10,688	$0	$10,688	$18,688
Georgia	$8,000	$17,051	$0	$17,051	$25,051
Hawaii	$8,000	$242	$0	$242	$8,242
Idaho	$8,000	$6,891	$0	$6,891	$14,891
Illinois	$8,000	$18,783	$2,912	$21,695	$29,695
Indiana	$8,000	$11,748	$0	$11,748	$19,748
Iowa	$8,000	$2,286	$0	$2,286	$10,286
Kansas	$8,000	$5,792	$2,167	$7,960	$15,960
Kentucky	$8,000	$7,321	$0	$7,321	$15,321
Louisiana	$8,000	$9,085	$0	$9,085	$17,085
Maine	$8,000	$4,283	$0	$4,283	$12,283
Maryland	$0	$4,606	$919	$5,525	$5,525
Massachusetts	$8,000	$7,472	$2,416	$9,888	$17,888
Michigan	$8,000	$17,904	$0	$17,904	$25,904
Minnesota	$8,000	$8,651	$50	$8,701	$16,701
Mississippi	$8,000	$8,747	$0	$8,747	$16,747
Missouri	$0	$3,677	$0	$3,677	$3,677
Montana	$8,000	$6,231	$0	$6,231	$14,231
Nebraska	$0	$0	$0	$0	$0
Nevada	$8,000	$1,667	$21	$1,687	$9,687
New Hampshire	$8,000	$2,905	$0	$2,905	$10,905
New Jersey	$8,000	$5,628	$1,836	$7,463	$15,463
New Mexico	$8,000	$11,309	$0	$11,309	$19,309
New York	$0	$7,996	$4,209	$12,205	$12,205
North Carolina	$8,000	$17,174	$0	$17,174	$25,174
North Dakota	$8,000	$6,155	$0	$6,155	$14,155
Ohio	$8,000	$14,764	$5,361	$20,124	$28,124
Oklahoma	$8,000	$7,022	$3,617	$10,639	$18,639
Oregon	$8,000	$6,610	$0	$6,610	$14,610
Pennsylvania	$8,000	$18,312	$6,567	$24,879	$32,879
Rhode Island	$8,000	$1,137	$0	$1,137	$9,137
South Carolina	$8,000	$0	$0	$0	$8,000
South Dakota	$8,000	$5,585	$0	$5,585	$13,585
Tennessee	$8,000	$14,631	$0	$14,631	$22,631
Texas	$8,000	$42,587	$0	$42,587	$50,587
Utah	$8,000	$11,200	$0	$11,200	$19,200
Vermont	$8,000	$2,662	$0	$2,662	$10,662
Virginia	$8,000	$7,586	$0	$7,586	$15,586
Washington	$8,000	$2,452	$0	$2,452	$10,452
West Virginia	$8,000	$6,040	$1,110	$7,150	$15,150
Wisconsin	$8,000	$7,276	$0	$7,276	$15,276
Wyoming	$8,000	$7,504	$0	$7,504	$15,504
US Total	$368,000	$433,549	$31,185	$464,734	$832,734
US Average	$7,216	$8,501	$611	$9,112	$16,328

Notes:

1. If State is missing any of the ramp business elements (State or local), apply base cost to run model. Assume no ramps on local, non-Federal-aid roads.

Table A6. Cost of Volume Data Collection by State.

State	Non-Federal-aid Segments									Intersections >400 ADT[1]	Total
	State		Non-State, >400 ADT			Non-State, <400 ADT			Segment Total		
	Rural	Urban	Rural	Urban	Estimation	Rural	Urban	Estimation			
Alabama	$31	$0	$28,290	$39,929	$16,000	$0	$0	$16,000	$100,251	$35,206	$135,457
Alaska	$1,478	$331	$4,007	$4,096	$16,000	$0	$0	$16,000	$41,911	$5,774	$47,685
Arizona	$756	$930	$15,145	$45,815	$16,000	$0	$0	$16,000	$94,647	$22,540	$117,187
Arkansas	$424	$299	$32,868	$21,314	$16,000	$0	$0	$16,000	$86,906	$34,657	$121,563
California	$44	$5	$28,241	$137,427	$16,000	$0	$0	$16,000	$197,716	$59,631	$257,348
Colorado	$129	$0	$27,097	$33,855	$16,000	$0	$0	$16,000	$93,081	$30,617	$123,698
Connecticut	$30	$65	$2,302	$24,949	$16,000	$0	$0	$16,000	$59,345	$7,426	$66,771
Delaware	$2,199	$6,817	$108	$1,732	$16,000	$0	$0	$16,000	$42,856	$2,202	$45,058
Dist. of Columbia	$0	$4,406	$0	$212	$16,000	$0	$0	$16,000	$36,618	$520	$37,137
Florida	$0	$9	$14,468	$156,044	$16,000	$0	$0	$16,000	$202,522	$42,164	$244,685
Georgia	$14	$75	$30,085	$70,597	$16,000	$0	$0	$16,000	$132,770	$42,782	$175,553
Hawaii	$1	$80	$640	$3,586	$16,000	$0	$0	$16,000	$36,306	$1,525	$37,832
Idaho	$7	$0	$15,908	$9,443	$16,000	$0	$0	$16,000	$57,358	$16,813	$74,171
Illinois	$348	$1,018	$36,091	$66,818	$16,000	$0	$0	$16,000	$136,275	$48,307	$184,582
Indiana	$27	$5	$27,328	$39,748	$16,000	$0	$0	$16,000	$99,107	$33,613	$132,720
Iowa	$5	$0	$29,351	$14,098	$16,000	$0	$0	$16,000	$75,454	$39,813	$115,267
Kansas	$13	$0	$46,334	$20,823	$16,000	$0	$0	$16,000	$99,170	$48,658	$147,828
Kentucky	$13,286	$647	$19,726	$22,468	$16,000	$0	$0	$16,000	$88,128	$27,433	$115,561
Louisiana	$5,052	$646	$15,250	$25,690	$16,000	$0	$0	$16,000	$78,638	$21,343	$99,981
Maine	$2,018	$9	$5,911	$4,794	$16,000	$0	$0	$16,000	$44,733	$7,921	$52,653
Maryland	$511	$482	$5,219	$30,742	$16,000	$0	$0	$16,000	$68,953	$11,192	$80,146
Massachusetts	$29	$181	$2,966	$45,260	$16,000	$0	$0	$16,000	$80,436	$12,571	$93,008
Michigan	$10	$9	$29,307	$58,298	$16,000	$0	$0	$16,000	$119,625	$42,277	$161,901
Minnesota	$19	$32	$83,913	$67,860	$16,000	$0	$0	$16,000	$183,825	$48,030	$231,854
Mississippi	$176	$406	$22,025	$17,273	$16,000	$0	$0	$16,000	$71,880	$26,013	$97,893
Missouri	$6,492	$259	$11,593	$12,783	$16,000	$0	$0	$16,000	$63,126	$40,920	$104,046
Montana	$730	$33	$27,373	$5,394	$16,000	$0	$0	$16,000	$65,529	$25,930	$91,459
Nebraska	$10	$0	$32,747	$10,817	$16,000	$0	$0	$16,000	$75,574	$32,413	$107,987

Table A6. Cost of Volume Data Collection by State.

State	Non-Federal-aid Segments									Intersections >400 ADT[1]	Total
	State		Non-State, >400 ADT			Non-State, <400 ADT			Segment Total		
	Rural	Urban	Rural	Urban	Estimation	Rural	Urban	Estimation			
Nevada	$570	$159	$11,128	$13,856	$16,000	$0	$0	$16,000	$57,713	$12,757	$70,470
New Hampshire	$1,090	$259	$3,779	$8,434	$16,000	$0	$0	$16,000	$45,562	$6,749	$52,311
New Jersey	$9	$14	$2,767	$55,274	$16,000	$0	$0	$16,000	$90,064	$13,579	$103,643
New Mexico	$2,533	$46	$23,472	$11,953	$16,000	$0	$0	$16,000	$70,003	$23,681	$93,684
New York	$491	$152	$25,731	$78,377	$16,000	$0	$0	$16,000	$136,751	$39,682	$176,433
North Carolina	$46,385	$40,573	$4,113	$38,251	$16,000	$0	$0	$16,000	$161,322	$36,661	$197,983
North Dakota	$38	$14	$32,201	$2,601	$16,000	$0	$0	$16,000	$66,854	$30,075	$96,929
Ohio	$1,044	$0	$28,989	$77,627	$16,000	$0	$0	$16,000	$139,660	$35,220	$174,880
Oklahoma	$0	$0	$33,413	$27,014	$16,000	$0	$0	$16,000	$92,427	$39,064	$131,491
Oregon	$71	$5	$15,303	$21,428	$16,000	$0	$0	$16,000	$68,806	$20,482	$89,289
Pennsylvania	$13,098	$4,541	$22,055	$72,330	$16,000	$0	$0	$16,000	$144,024	$41,475	$185,499
Rhode Island	$43	$66	$432	$9,019	$16,000	$0	$0	$16,000	$41,560	$2,246	$43,806
South Carolina	$13,532	$27,781	$9,227	$11,835	$16,000	$0	$0	$16,000	$94,375	$22,854	$117,229
South Dakota	$4	$0	$28,985	$4,906	$16,000	$0	$0	$16,000	$65,895	$28,555	$94,450
Tennessee	$0	$0	$29,341	$39,033	$16,000	$0	$0	$16,000	$100,375	$33,068	$133,443
Texas	$13,082	$1,076	$71,188	$157,073	$16,000	$0	$0	$16,000	$274,419	$108,357	$382,776
Utah	$40	$75	$13,235	$21,345	$16,000	$0	$0	$16,000	$66,695	$15,803	$82,497
Vermont	$9	$0	$4,546	$2,185	$16,000	$0	$0	$16,000	$38,740	$4,948	$43,689
Virginia	$30,748	$31,541	$1,068	$24,233	$16,000	$0	$0	$16,000	$119,590	$25,785	$145,375
Washington	$0	$0	$23,009	$37,588	$16,000	$0	$0	$16,000	$92,598	$28,999	$121,597
West Virginia	$21,231	$6,335	$843	$4,728	$16,000	$0	$0	$16,000	$65,137	$13,383	$78,520
Wisconsin	$21	$0	$34,304	$35,930	$16,000	$0	$0	$16,000	$102,255	$39,829	$142,084
Wyoming	$454	$74	$8,728	$4,048	$16,000	$0	$0	$16,000	$45,305	$9,784	$55,088
US Total	$178,331	$129,455	$1,022,149	$1,750,935	$816,000	$0	$0	$816,000	$4,712,870	$1,401,327	$6,114,197
US Average	$3,497	$2,538	$20,042	$34,332	$16,000	$0	$0	$16,000	$92,409	$27,477	$119,886

Notes:

1. Assumed all State intersections are >400 ADT.

Table A7. Annual Data Maintenance Cost by State.

State	Segments >400 ADT	Intersections >400 ADT[1]	Ramps	Volumes	Total
Alabama	$3,636	$3,521	$306	$23,787	$31,250
Alaska	$501	$577	$288	$62,988	$64,354
Arizona	$2,144	$2,254	$332	$76,530	$81,261
Arkansas	$2,936	$3,466	$210	$42,180	$48,791
California	$7,677	$5,963	$866	$56,838	$71,343
Colorado	$2,579	$3,062	$250	$24,619	$30,510
Connecticut	$925	$743	$152	$12,225	$14,044
Delaware	$243	$220	$19	$301,154	$301,636
Dist. of Columbia	$67	$52	$6	$146,923	$147,048
Florida	$4,309	$4,216	$534	$57,144	$66,204
Georgia	$4,478	$4,278	$426	$36,519	$45,702
Hawaii	$219	$153	$24	$4,091	$4,486
Idaho	$1,449	$1,681	$172	$8,669	$11,971
Illinois	$4,963	$4,831	$723	$79,843	$90,359
Indiana	$3,584	$3,361	$392	$23,412	$30,749
Iowa	$3,252	$3,981	$229	$14,638	$22,100
Kansas	$3,378	$4,866	$265	$22,814	$31,324
Kentucky	$2,486	$2,743	$244	$478,500	$483,973
Louisiana	$2,175	$2,134	$303	$203,587	$208,199
Maine	$945	$792	$107	$71,148	$72,992
Maryland	$1,247	$1,119	$184	$45,070	$47,621
Massachusetts	$1,608	$1,257	$247	$23,061	$26,173
Michigan	$4,960	$4,228	$448	$29,848	$39,483
Minnesota	$5,673	$4,803	$290	$52,316	$63,081
Mississippi	$2,709	$2,601	$219	$32,512	$38,040
Missouri	$3,231	$4,092	$368	$233,151	$240,841
Montana	$1,752	$2,593	$312	$36,342	$40,999
Nebraska	$2,334	$3,241	$134	$14,858	$20,568
Nevada	$1,025	$1,276	$169	$32,643	$35,113
New Hampshire	$564	$675	$73	$49,036	$50,348
New Jersey	$1,592	$1,358	$187	$20,126	$23,263
New Mexico	$1,856	$2,368	$283	$97,771	$102,278
New York	$4,351	$3,968	$610	$56,145	$65,075
North Carolina	$3,645	$3,666	$429	$2,912,727	$2,920,468
North Dakota	$1,788	$3,008	$154	$13,315	$18,265
Ohio	$4,540	$3,522	$872	$70,341	$79,275
Oklahoma	$3,399	$3,906	$325	$20,142	$27,772
Oregon	$2,011	$2,048	$220	$14,778	$19,058
Pennsylvania	$4,389	$4,148	$622	$619,419	$628,578
Rhode Island	$268	$225	$28	$6,774	$7,295
South Carolina	$2,789	$2,285	$271	$1,384,120	$1,389,465
South Dakota	$1,785	$2,855	$186	$11,420	$16,247
Tennessee	$3,021	$3,307	$366	$22,792	$29,485
Texas	$10,940	$10,836	$1,065	$548,032	$570,872
Utah	$1,293	$1,580	$280	$15,366	$18,519
Vermont	$573	$495	$89	$2,547	$3,703
Virginia	$3,019	$2,579	$379	$2,084,737	$2,090,714
Washington	$2,786	$2,900	$245	$20,199	$26,130
West Virginia	$1,420	$1,338	$179	$920,714	$923,651
Wisconsin	$4,297	$3,983	$243	$24,118	$32,640
Wyoming	$1,032	$978	$250	$21,878	$24,138
US Total	$137,844	$140,133	$15,572	$11,183,908	$11,477,456
US Average	$2,703	$2,748	$305	$219,292	$225,048

Notes:

1. Assumes all State intersections are >400 ADT.

Table A8. Net Present Value of Total Data Collection and Maintenance Costs by State, 2013-2029 (2013 Dollars).

State	Net Present Value (2013$)
Alabama	$1,710,646
Alaska	$1,563,196
Arizona	$2,524,421
Arkansas	$3,673,041
California	$7,521,017
Colorado	$1,443,152
Connecticut	$1,166,314
Delaware	$4,214,423
Dist. of Columbia	$2,219,748
Florida	$2,664,937
Georgia	$2,256,461
Hawaii	$405,146
Idaho	$1,970,682
Illinois	$2,391,017
Indiana	$1,413,216
Iowa	$1,287,978
Kansas	$2,046,779
Kentucky	$7,068,124
Louisiana	$3,418,377
Maine	$1,405,383
Maryland	$1,167,713
Massachusetts	$933,408
Michigan	$3,075,341
Minnesota	$3,420,092
Mississippi	$2,486,481
Missouri	$3,949,584
Montana	$1,396,389
Nebraska	$2,952,113
Nevada	$1,245,659
New Hampshire	$1,075,283
New Jersey	$1,215,398
New Mexico	$3,199,418
New York	$2,021,263
North Carolina	$40,318,314
North Dakota	$3,876,285
Ohio	$2,402,340
Oklahoma	$2,247,197
Oregon	$908,471
Pennsylvania	$9,387,192
Rhode Island	$502,918
South Carolina	$19,314,453
South Dakota	$1,272,084
Tennessee	$1,930,305
Texas	$10,427,967
Utah	$1,023,058
Vermont	$546,133
Virginia	$27,691,589
Washington	$3,069,362
West Virginia	$12,885,487
Wisconsin	$1,438,566
Wyoming	$851,970
US Total	$220,595,892
US Average	$4,325,410

For More Information:

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