Montana Weigh-in-Motion (WIM) and Automatic Traffic Recorder (ATR) Strategy

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PROBLEM STATEMENT

A critical element in achieving the Montana Department of Transportation’s fundamental goal of providing safe, efficient and sustainable transportation services is the collection of accurate data on how the state’s highways are being used. Such data are necessary to support numerous MDT activities from planning, to infrastructure design, to enforcement of vehicle regulations. Due to limited resources, it is essential that such data are efficiently collected and then put to the best possible uses. The foundations of the data collection program are the permanent weigh-in-motion (WIM) and automatic traffic recorder (ATR) systems deployed across the highway network. These systems must be configured to accurately collect user data across the diverse geographic regions of the state and wide spectrum of goods being transported; further, they need to account for the significant seasonal variations associated with specific commodity hauls. Every WIM/ATR deployment, however, requires resources for installation, maintenance, and data reduction. Thus, a planning strategy is necessary to optimize MDT’s investments in its WIM/ATR program. The proposed research will conduct a comprehensive review of MDT’s WIM program along with a basic review of its ATR data collection program. This review will encompass both basic data collection activities as well as how these data are and can be subsequently used. Recommendations will be made on potential changes to these programs to provide the best possible information in the most cost-effective manner to meet current and future data-user needs. In addition, the statewide traffic adjustment factors currently used by MDT will be reviewed, and regional adjustment factors will be developed that can reflect regional differences in highway use associated with changing demographics, economic conditions, etc.

BACKGROUND SUMMARY

Traffic data collection provides the underpinning for all transportation-engineering activities such as pavement design, infrastructure planning, weight enforcement, and traffic monitoring. Moreover, the Federal Highway Administration (FHWA) has established requirements on the development, establishment, implementation, and continued operation of a traffic monitoring system for highways and public transportation facilities and equipment in each state (Code of Federal Regulations, 2011). As such, states record traffic data as part of their traffic monitoring system to meet the federal traffic data reporting requirements. Traffic data typically collected includes traffic volume, vehicle classification, and vehicle weight data. Data collection techniques and technologies employed range from simple manual devices to ever-evolving sophisticated sensors, detectors, and data recorder and transmission equipment. Two fundamental types of data collection systems are generally employed in continuously monitoring roadway use at permanent (fixed) sites on a highway network, namely, WIM and ATR systems. As of December, 2012, MDT has 33 WIM and 62 ATR systems throughout the state's highway system at the locations shown in Figure 1, with two more WIM systems scheduled for installation in 2013 (MDT, 2013). WIM systems, which are the focus of this research, provide traffic volume, vehicle classification, and weight data. ATR systems are generally less expensive than WIM systems, but they only provide traffic volume and possibly vehicle classification data. Thus, traffic data collection programs typically use both technologies, with data from the two sources being used individually and synergistically to support data needs in a cost effective manner.

Traffic data gathered from permanent WIM/ATR recorders are also important in converting/factoring/seasonally-adjusting short-term traffic counts to estimate Annual Average Daily Traffic (AADT). Permanent WIM/ATR recorders are too expensive to be deployed at every location around a state at which traffic data may be required. Instead, short term counts are done using portable ATRs deployed at a particular location for just a few days. MDT has approximately 5,000 short term count sites. The count cycle for each site is established based on route classification and traffic volume, and varies from annual to every six years. Approximately, 2,600 short term counts are conducted every year (MDT, 2103). Most data users, however, want/need information on annual traffic use (generally, average annual daily traffic), often further broken down by vehicle configuration and weight. These short term counts can be converted to AADT using adjustment factors determined from the permanent, long term WIM and ATR data. Such adjustments are necessary since short term traffic counts (conducted in Montana typically for a 36 hour period (MDT, 2012b)) generally do not yield usable estimates of AADT as they do not encompass all of the temporal variations in traffic flow across a year. The general pattern of traffic across the year, however, can be characterized using traffic data continuously collected from permanent monitoring sites. The results of short term traffic counts can then be matched against the annual pattern determined for routes carrying similar traffic to obtain a useful estimate of AADT at the short term monitoring locations. MDT currently uses a

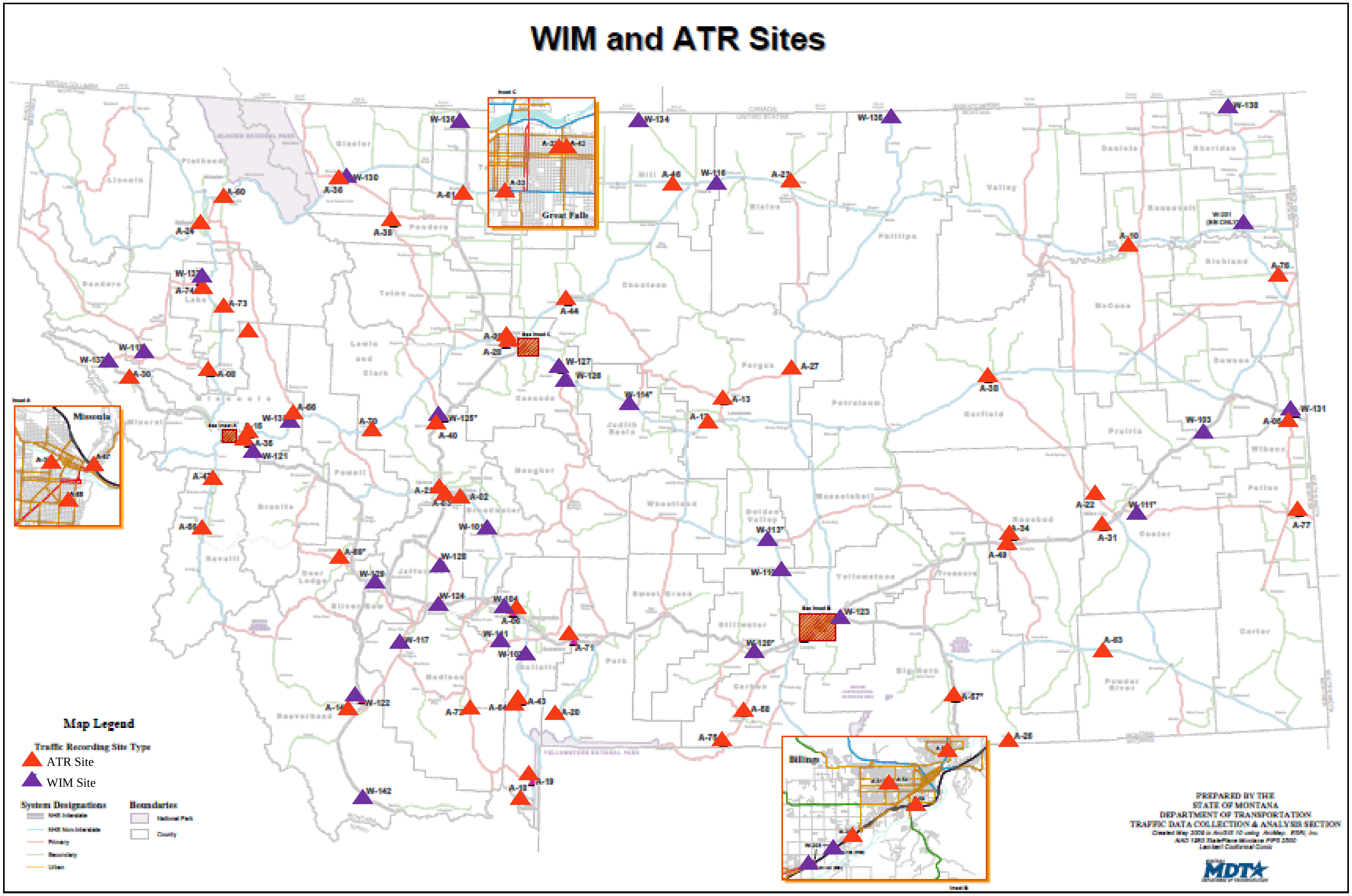

Figure 1. WIM and ATR Sites (MDT, 2012a)

single set of such adjustment factors statewide. The basic nature of traffic operations may vary sufficiently across the state, however, that regional adjustment factors are merited, and development of regional adjustment factors is one objective of this effort.

The factors used to adjust short term counts are determined for specific categories of transportation patterns believed to reasonably represent all traffic scenarios across a state's highways. These patterns are referred to as traffic factor groups. Adjustment factors are calculated for each traffic factor group based on the data available from the WIM/ATR sites assigned to that group. FHWA's Traffic Monitoring Guide (TMG, 2012) provides methodologies to help determine the groups to be used, as well as how to calculate the associated adjustment factors. These methodologies have further been commented on and refined by other investigators (Schneider and Tsapai, 2009; Aunet, 2000). The number of traffic factor groups required to adequately represent travel on all of a state's roadways varies based on the underlying variability in traffic patterns around the state. The volume and composition of traffic at a particular location depends on the functional use (classification) of the roadway, the local/regional geography, the socio-economic environment (demographics and economic activity), and temporal factors (time of year, day-of-the-week, time-of-day, etc.). An important consideration in these regards is adequate representation of seasonal variations in traffic flow, which certainly are encountered in Montana as a result of significant economic activity in the areas of agricultural, natural resource extraction and tourism. The TMG recommends a minimum of five traffic factor groups, as listed in Table 1. MDT currently uses nine traffic factor groups (MDT, 2013), generally consistent with the primary functional classifications mandated in the federal Highway Performance Monitoring System (HPMS – FHWA, 2010), which offer some refinements within the groups suggested in the TMG (see Table 1). In practice, MDT combines the two factors groups of Urban Minor Arterial and Urban Collector due to the limited number of data collections sites on urban routes.

In light of changes in traffic patterns over time, it is important to periodically review a) the traffic factor groups being used, b) the assignment of segments along each highway route to a particular traffic factor group, and c) whether regional traffic patterns are being adequately represented (recall, MDT currently uses a single set of adjustment factors statewide, which potentially could mask changes in traffic patterns in a given region). Further, a review of the number and location of WIM and ATR sites being used to support characterization of travel within each factor group (and also on the state's highways in general) is also periodically merited. Several of the state's WIM and ATR systems have been deployed over the years to meet needs other than those of the traffic count program (e.g., to monitor specific aspects of commercial vehicle operations). No formal studies have been conducted to investigate whether the current WIM locations collectively account for the diversity of geographic regions and goods being moved, as well as the seasonal variation in travel on the state's roadways

Turning to uses of the data collected, the traffic data collected through MDT's permanent recorders mainly serve internal users' needs within MDT for the purposes of planning, traffic operations, traffic safety, asset management, highway design, and vehicle weight enforcement. Traffic and data collection information, such as WIM/ATR location, site ID, vehicle classification, annual reports of traffic volume, and monthly comparison reports, is available in PDF file format through the website of MDT's Traffic Data Collection and Analysis (TDCA) Section (MDT, 2012c). Additional traffic data and hard copies of the data can be requested via email. MDT has recently begun to use a cloud based web service, MidWestern Software Solutions (MS2), to improve the data presentation, visualization, and accessibility. In a trial stage, data from 38 permanent recorders are currently uploaded daily and are available to users at any time (MDT, 2013).

Table 1. Traffic Factor Groups (from FHWA, 2001; MDT, 2012b, FHWA, 2012)

Recommended Minimum Traffic Factor Groups, TMG	Groups used in Montana	HPMS Functional Code
Interstate Rural	Rural Interstate (UI)	1
Other Rural	Rural Principal Arterial (RPA) Rural Minor Arterial (RMA) Rural Major Collector (RMC)	3,4,5
Interstate Urban	Urban Interstate (UI)	1
Other Urban	Urban Principal Arterial (UPA) Urban Minor Arterial (UMA) Urban Collector (UC)	3,4,5
Recreational	Recreational (REC)	Any

Specifically considering WIM data, due to the significant impact of commercial vehicles on pavement deterioration and the significant resources required to repair and replace these pavements, there are strong needs for an effective system for commercial vehicle traffic monitoring and data collection. In this regard, WIM has been used worldwide to measure the weights of vehicles (as well as their configuration) as they travel on highways and bridges. Unlike static scales, WIM systems are capable of measuring vehicle weights at normal traffic speeds and do not require vehicles to come to a stop or enter a weigh station. This makes the weighing process more efficient and less biased than using traditional weigh stations.

Most transportation agencies are limited in their use of WIM data to pavement design and vehicle weight enforcement activities (FHWA, 2007). MDT uses WIM data for these purposes, as well as estimating at a regional/statewide level the impacts of vehicle operations on infrastructure condition and service life. In light of their nature (and cost), WIM data might be expected to support other transportation activities, such as bridge structural analysis, geometric design, freight management and operations, facilities planning, policy development, etc. (FHWA, 2007). Thus, over the past decade states (and countries) have increasingly been reviewing their WIM programs with respect to items such as the distribution of their WIM sites, the reliability and cost effectiveness of the hardware being deployed, the form and uses of the data being collected, and the general cost-effectiveness of the overall program (e.g., Koniditsiotis, 2000; PENN DOT, 2002; Regan, et al, 2006; Schultz and Seegmiller, 2006; Zhang, 2007; Pelphrey, et al, 2008; Fernando, et al, 2009; Ishak et al, 2009; Szary and Maher, 2009; Monsere, 2012).

While the above cited and other studies offer useful information and insights on various elements of a WIM program, there is no single model/template for such programs or for their review due to the unique needs of each state/country. Thus, it may be incumbent upon the state of Montana to conduct a WIM program review to determine the adequacy and cost-effectiveness of the existing program and the direction the program should take in the future. No such systematic and comprehensive review has been done before. Specific items that such a review should cover include:

1) Current WIM program: An inventory needs to be done of the structure, facilities and resources of the current WIM program.
2) WIM technologies: WIM technologies continue to move forward with advances in wireless, detector, sensor, transmission, and communication technologies. The latest innovations need to be reviewed relative to their applicability/desirability for use in Montana. Technologies to be focused on in this review include wireless systems to support MDT Motor Carrier Services move towards implementing virtual WIM and low-speed WIM systems for use in urban areas.
3) WIM deployment: The distribution of WIM (and ATR) sites around the state needs to be systematically studied to determine if current traffic patterns and highway use are being adequately captured. If necessary, recommendations are needed on where additional WIM systems should be deployed, and a methodology needs to be developed for prioritizing such deployments that can be readily updated and used into the future. Integral to formulating such recommendations is an assessment of the costs and benefits of current and future deployments.
4) Traffic data users: Currently the traffic data collected through WIM/ATR systems mainly serve internal users in MDT. New uses (and users) need to be identified to ensure full advantage is being taken of the available data, particularly the relative "rich" data from the WIM program.
5) Data formatting and accessibility: Currently, most of the traffic data collected through MDT's WIM/ATR system are accessible in PDF file format through web-links and email

requests. This format can be inconvenient relative to data manipulation and analysis. Users need to be queried about the data formats/presentation that they would find most useful. Information technology (IT), database, and GIS platforms should provide better solutions to present, view, store and share various types of data. Notably, data processing and delivery through the cloud based web service that MDT has begun to work with, MS2, will be fully reviewed. Further, the manner in which traffic data can be incorporated into a comprehensive web-based informational tool (e.g., a tool similar to AASHTO's UPlan web based decision-support mapping and informational tool (AASHTO, 2013)) will be considered.

BENEFITS AND BUSINESS CASE

This project will provide MDT with a comprehensive review and evaluation of the existing WIM program and a basic review of the ATR program. MDT spends approximately $172,350 annually on its WIM program, alone; thus a formal and systematic program review is warranted to assess as possible the costs and benefits of the program. Program costs are generated by the activities required to collect, analyze and distribute/present traffic data. Program benefits are generated by data users working across the spectrum of MDT activities, in the form of improved pavement designs, infrastructure planning, weight enforcement, operations monitoring, etc. As previously stated, traffic data collection provides the underpinning for almost all transportation-engineering activities. This review of MDT's data collection program will provide recommendations on program modifications to ensure essential traffic data is being collected, analyzed, distributed and used in a cost effective manner consistent with MDT's needs and requirements. The results of this review will also provide guidance on the direction of future program development.

OBJECTIVES

The objective of this project is to conduct a comprehensive review of MDT's permanent WIM program along with a basic review of the ATR data collection program to ensure they are providing the best possible traffic information in the most cost effective manner to meet current and future data user needs. After a thorough review of the state-of-the-practice and an inventory of MDT's current programs, questions to be answered include: a) are the right data being collected using the best equipment (including where should new systems be deployed to support development of regional adjustment factors), b) who are current and potential users of these data, c) are/can their data needs be met, d) how can future site deployments be prioritized, and e) what are the costs and benefits of the program, including the staffing resources needed to manage the current and future proposed programs.

RESEARCH PLAN

The research program described in this proposal will provide an in-depth review of and recommendations on the permanent traffic counting equipment element of MDT's traffic data collection program, with a focus on its WIM related elements. Recommendations will be made on potential changes to the program from basic data collection, to the format(s) in which these data are made available to end users, to who these end users are, to where to invest in additional sites in the future. Throughout the review, the costs and benefits of the program will be determined and compared, as appropriate and possible.

Specific work tasks are:

0) Project management.
1) Review of the state-of-the-practice.
2) Description/inventory of current program and program resources.
3) Description of data collected and factors that influence it.
4) Identification of current and future data uses/users.
5) Assessment of whether data needs are being met.
6) Review of traffic factor groupings.
7) Generation of a methodology for planning/prioritization of future WIM/ATR sites.
8) Preparation of task reports, final report, project summary report and implementation plan.

Task reports will be prepared at the conclusion of Tasks 1-7 documenting the work done on the task and all significant findings.

Task 0: Project Management

The Principal Investigator on this project will be Dr. Jerry Stephens. In addition to directing technical aspects of this project, Dr. Stephens will manage the project budget, schedule, and administrative tasks, and he will serve as the primary point of contact between the WTI research team and the MDT Project Manager. Dr. David Veneziano at WTI/MSU and Dr. Yan Qi at WTI/MT Tech will be Co-Principal Investigators (their specific roles on the project are described in the Staffing section of this proposal). The project will begin with a kick-off meeting with the researchers and MDT to ensure everyone is informed of the contractual obligations and to clarify any technical issues and concerns. During the course of the project, the research team will submit quarterly progress reports to describe the status of the project with respect to schedule and budget. The project team will also submit task reports upon completion of specific tasks (as further commented on below), and final report, project summary report, and implementation plan upon completion of the project.

Task 1: Review of the State-of-the-Practice

While a preliminary review of the state-of-the-practice was done as this proposal was developed, a formal and more thorough review will be conducted at the beginning of the project. This review will document existing WIM/ATR programs and the manner in which the data they collect is and can be used. One element of this review will be a comprehensive literature search to be done through sources such as, but not limited to, the Transport Research International Documentation (TRID) database, the EI Compendex database, Federal Highway Administration (FHWA) websites, Transportation Research Board (TRB) websites, Institute of Transportation Engineers (ITE) websites, American Association of State Highway and Transportation Officials (AASHTO) websites, state DOT websites, and other databases. The literature review will search for peer-reviewed papers and journal articles, agency reports, agency websites, and other relevant documentation and information.

A second element of this review will specifically be an examination of other States' best practices for traffic data collection programs. This review will focus on comparable states, i.e., states with areas of low population density, geographically extensive highway networks, and natural resource based economies. States that are discovered to have especially active data collection programs (and/or data users) will be directly contacted by the research team to learn firsthand about their programs and experience. Such contacts will only be made after informing MDT of who will be contacted and the information that will be solicited.

Both elements of this review will collect information on the latest innovations in WIM/ATR technology (keeping in mind that the focus of this project is on WIM systems, and more specifically on low-speed WIM technologies and wireless communications) and "Best Practices" across the activities of data collection (including site selection), analysis, and presentation/dissemination. Data will be collected on the associated costs of these activities, as well as on any benefit/cost analyses that have been performed. This information will be carefully evaluated with respect to operating conditions within Montana and the customized needs of its traffic data collection (TDC) program.

Task 2: Program Description/Inventory

A comprehensive description and inventory will be conducted of the current program(s) of the TDCA Section. As previously stated, the foundation of these programs is a) the 95 permanent data collection sites operated by TDCA Section, consisting of 33 WIM and 62 ATR installations (MDT 2013) deployed as shown in Figure 1, and b) the 5000 active short term traffic count sites statewide (MDT, 2013). Moreover, two new WIM stations are scheduled to be installed in 2013.

Working with MDT, the composition and organizational structure of the TDCA Section will be reviewed and characterized. The physical WIM/ATR equipment being used by TDCA Section at its permanent sites will be inventoried (including its condition and location), and a detailed assessment will be made of the resources required to maintain this equipment. In addition, MDT's current methodology for planning/prioritization of future WIM/ATR sites will be reviewed and evaluated.

Task 3: Data Collection, Analysis, and Presentation

This task will characterize a) the underlying nature of the data TDCA Section is collecting, b) the analyses being performed on this data, and c) the various delivery formats subsequently being used. Whether the current traffic data collection programs are basically capturing all of the important features of traffic flow on the state's highways can only be determined if these features (and if appropriate, their causative factors) are known. The volume and composition of traffic varies with the functional use (classification) of a roadway, the local/regional geography, socio-economic factors (demographics and economic activity), and temporal factors (time of year, day-of-the-week, time-of-day, etc.). As may be obvious, these factors are often interrelated.

Following Federal Highway Administration guidelines, Montana's highways are classified based on the nature of their use according to the categories shown in Table 2. In recognition of basic differences in the characteristics of urban versus rural travel, routes are first assigned to one of these two broad categories, followed by further sub-assignment to the categories of arterial to collector to local roadway, based on specific function served. For planning and funding purposes, all routes are also assigned to one of five systems, interstate, non –interstate national highway system, primary, secondary, and urban. These systems to some degree also correlate with particular functional classes, as shown in Table 3. In working on this and other project tasks, all five systems will be considered. Patterns of vehicle use on a given route within the state are also typified/represented using nine Traffic Factor Groups, as previously listed in Table 1. Notably, these Traffic Factor Groups are the basis for extrapolating annual traffic volumes from short term monitoring conducted at locations where permanent long term counts are unavailable. The basic nature of the traffic stream for the year for each "Group" is established using the continuous data collected at the permanent WIM/ATR sites. Based on the specific time during the year that short term data is collected at a particular location, it can then be adjusted to generate annual traffic estimates using the traffic patterns of the "Group" to which it is assigned.

Relative to highway users, vehicles are classified following "Scheme F" developed by the Maine DOT in the 1980s and used by FHWA. This classification scheme consists of 13 fundamental vehicle types, with several sub-categories for larger vehicle configurations. These sub-categories have been customized to conditions in Montana (see Figure 2).

Large local/regional fluctuations in traffic volumes and in the composition of the traffic stream are encountered on many of Montana's highways, as the state's economy is agriculture, natural resource extraction and tourism intensive. Ideally the data collection program should be robust enough to capture and/or represent such traffic flows. Such flows include, for example, grain harvests, off-season farm-to-market movements, logging, energy development, ore processing, etc. Such flows can be associated with events within Montana or adjacent states. Working with MDT, any such known events of this type will be identified and documented, and strategies will be discussed, as appropriate and necessary, to monitor them. Specific items that will be considered include traffic impacts of 110-car grain loading facilities and seasonal peak resource extraction activity (i.e., energy and agriculture) by region.

Table 2. Functional Classifications of Montana's Highways (MDT, 2008)

Functional Classification		Characteristics	Montana Examples
Interstate (Principal Arterial)		• Primary through travel route • Longest trip lengths	I 15, I 90, I 94
URBAN (areas with urban boundaries and population > 5,000)	**Principal Arterial**	• Serves major activity centers • Corridors with highest traffic volumes • Longest trip length within city	US 12- Helena
	Minor Arterial	• Interconnects urban principal arterials	
	Collector	• Land access to channel local street traffic to arterial	
	Local	• All remaining streets • Direct land access and link to higher classifications	
RURAL	**Principal Arterial**	• Predominant route between major activity centers • Interstate or Intrastate significance • Long trip lengths • Heavy travel densities • Provide service to most large urban areas	US 93, US 12, US 2, US 87
	Minor Arterial	• Link cities and larger towns (or major resorts) • Spaced at intervals so that all developed areas are within a reasonable distance of an arterial • Interconnects network of arterial highways	US 83, US 89, US 24, US 59
	Major Collector	• Service to travel of primarily intra county importance • Serves important travel generators (i.e. County seats, consolidated schools, mining or logging areas)	S 279, S 241
	Minor Collector	• Land use access and spaced at intervals consistent with population density	
	Local	• Access to adjacent land - short distances • All remaining roads not classified under higher system	

Table 3. Montana Highway System Designations (adapted from MDT, 2008; MDT, 2013)

Montana System Designation	Corresponding Functional Classification
Interstate	Principal Arterial
Non-Interstate - National Highway System (NI-NHS)	Principal Arterial
Primary Highway System	Minor Arterial
Secondary Highway System	Minor Arterial or Major Collector
Urban Highway System	Urban Arterial or Collector

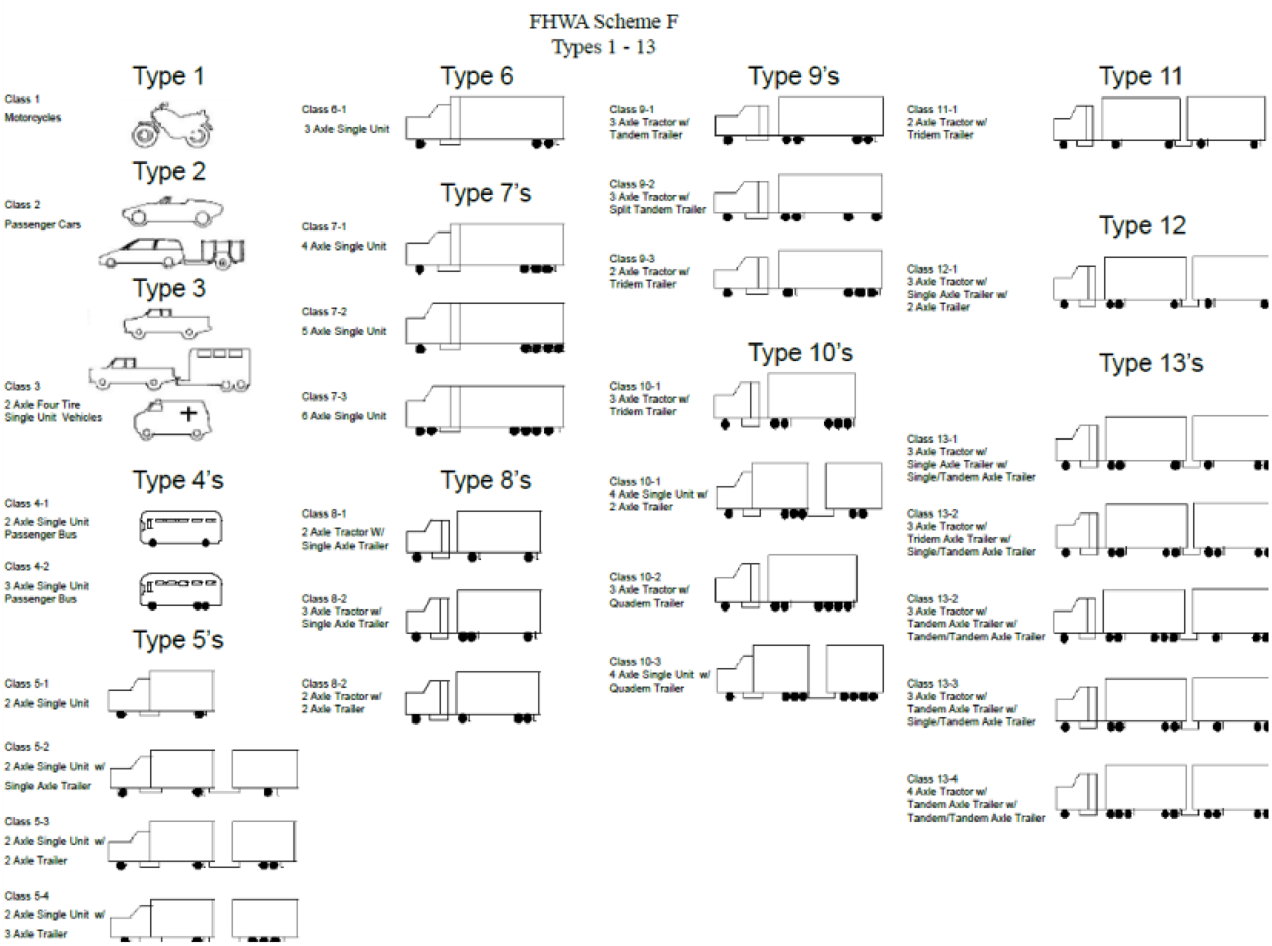

Figure 2. Montana Vehicle Configurations (MDT, 2012c)

Beyond assembling selected items of basic WIM/ATR data to generate various standard state and federal traffic reports, WIM data specifically is further processed to generate parameters for a) pavement design (equivalent single axle loads (ESALs) and load spectra by vehicle configuration) and b) vehicle weight enforcement (by WIM site, vehicle weight, time of day, day of week, and commercial vehicle configuration). MDT has also begun to use the WIM/ATR data reduction, display, and delivery capabilities offered by the Transportation Data Management System programmed by MS2, Midwestern Software Solutions, Ann Arbor, Michigan.

Task 4: Identification of Data Users

Working with the TDCA Section, current and potential users of TDCA Section information within MDT will be identified and contacted by the research team. Current data users will be asked a) what they use the data for, b) what, if any, additional data processing they do to support their end use, c) what impact their use of the data has on the overall transportation program, d) what other traffic data would be useful to them, and e) what data formats and methods of presentation would be useful to them (e.g., interactive maps, GIS interface, etc.). Additionally, they will be introduced to any new data that has become available through the TDCA Section as well as any new data applications identified in the review of the state-of-the-practice that could be pertinent to their operations. Current primary users of TDCA Section data are believed to be involved with planning, pavement design, safety, and vehicle weight enforcement. If any entity has had occasion to request installation of a WIM/ATR site at a specific location, they will be asked how they determined this need.

Going one step further, and in collaboration with the TDCA Section and based on the results of the state-of-the-practice review, potential new traffic data users will be identified and contacted. These potential users will be introduced to the types of information available from the TDCA Section, followed by discussion of how it can possibly be used to support their work and the impact its use can potentially have on the overall transportation program. Potential new users will also be queried about data format/presentation methods they would find most useful (e.g., maps, GIS interface, etc.)

This effort is expected to encompass each division and district of MDT. Further, this effort could be extended outside of MDT if any agencies/entities are identified as using (or potentially using) this data for significant, pertinent, and important purposes (as judged by the project technical panel).

Task 5: Assessment of Adequacy of Data Collection Effort

Based on the information collected in Tasks 1-4, the adequacy of the existing permanent WIM and ATR sites to meet end user data needs will be assessed. This assessment will consider the basic adequacy of the data being collected to fully and accurately characterize vehicular use of the state’s highways, as well as the manner and timeliness of its analysis and distribution. This assessment will address safety, efficiency, and tactical use of resources to optimize return on investment to MDT. The new federal transportation bill (Moving Ahead for Progress in the 21st

Century Act) will also be scrutinized for provisions that could impact the data collection program. In all cases, the required resources and associated nature and value of the benefits to be realized will be addressed. Based on this work, recommendations will be made on potential changes that can be made to provide the best possible information in the most cost effective manner to meet current and future user needs. These recommendations will address the full spectrum of TDCA Section activities, from basic data collection (e.g., monitoring locations and hardware) to the manner in which this data is and could be made available to users, e.g. through spreadsheets, maps, GIS elements, AASHTO Uplan etc., as well as attendant costs and benefits.

Task 6: Review of Traffic Factor Groups

As part of this project, MDT's current traffic factor groupings (previously presented in Table 1) will be reviewed with respect to their accuracy. As part of this review, the distribution of permanent WIMs and ATRs across the state necessary to adequately characterize traffic operations from a "traffic factor group" and roadway functional classification perspective will be evaluated. As previously mentioned, one of the important uses of the continuous traffic data collected by permanent WIM and ATR installations is to provide the data necessary to adjust traffic data collected from short term monitoring events to obtain reasonable estimates of annual traffic. Such adjustments are necessary since short term traffic counts (conducted in Montana typically for a 36 hour period) generally do not yield usable estimates of AADT as they do not encompass all of the temporal variations in traffic flow across a year. The general pattern of traffic across the year, however, can be characterized using traffic data continuously collected from permanent monitoring sites. The results of short term traffic counts can then be matched against the annual pattern determined for routes carrying similar traffic to obtain a useful estimate of AADT at the short term monitoring location.

The TMG presents two approaches for determining factors to adjust short term traffic counts to obtain estimates of annual traffic volumes, namely, roadway-specific factors and traffic factor groups. Following the roadway-specific approach to traffic factors (as developed by the Virginia DOT), a short term count collected at a given location is adjusted to generate an annual traffic estimate based on the nearest permanent recorder on the same route. This approach is relatively simple and direct in its application, but also requires monitoring to be done on every route, often at relatively frequent intervals.

The second approach presented in the TMG for adjusting short term traffic counts to obtain estimates of annual traffic volumes is the "traditional" or traffic group factor method. Following this approach,

1) Seasonal adjustment factors are calculated from each permanent recorder;
2) The permanent recorderss are grouped based on similarities in traffic patterns as determined by their seasonal adjustment factors;
3) The factors determined from each site within a group are averaged;
4) All road/road segments in the state highway network are assigned to a group; and

5) Short term traffic counts obtained for a specific road/road segment are adjusted to obtain annual estimates using the seasonal adjustment factors for the traffic grouping the segment is assigned to.

Two major challenges in using the traffic group factor method are determining the nature/number of groups to be used and appropriately assigning road/road segments to a group. As previously noted and presented in Table 1, Montana currently uses nine traffic factor groups, with two of the groups being combined due to the low number of data collection sites within them (i.e., Urban Minor Arterial and Urban Collector). Thus, all traffic flows on Montana's highways are viewed as represented by one of the eight traffic patterns embodied by these groups. As might be expected, these groups reflect to some extent the functional classifications used to categorize the state's highways. However, functional classifications were not intended to indicate the specific pattern of traffic on a roadway (i.e., specific vehicle configurations using the roadway and temporal variations in their use during the year), but rather the general nature of its use. Thus, while functional classifications enter into the identification of appropriate traffic factor groups, vehicle configuration and seasonal traffic flow must also be considered.

In establishing traffic factor groups there is a tradeoff between having enough groups to accurately represent all traffic patterns, and having more groups than can be analytically supported by the underlying permanent traffic recorders. To some extent, this issue can be addressed by statistically comparing the adjustment factors from different permanent recorders in assigning them to a traffic factor group, as well as assessing the variability in the adjustment factors across the recorders within a group. In the latter case, for example, if the variability in the adjustment factors within a group is too high, there can be uncertainties in assigning a particular roads/road segment to a specific group. This uncertainty can be somewhat addressed by performing some statistical comparisons of the features of the short term traffic count along a specific road segment with coincident features from the permanent traffic counts used to create the traffic factor group of interest. In accomplishing the tasks described above, i.e., determining the number of traffic factor groups to be used, assigning individual road segments to these groups and developing associated seasonal adjustment factors, the quantitative analyses being performed are often complemented by professional judgment.

In this project, the accuracy of the current traffic factor groups used by MDT will be assessed. Recommendations will be made as possible and appropriate on changes to these groups and the grouping scheme. Further, the underlying distribution and number of WIMs and ATRs necessary across the state to characterize travel on the state's highways and to support calculation of regional adjustment factors for the traffic factor groups will be investigated. This investigation will consider the trade-off between the desired accuracy of the traffic volume estimates being generated and the attendant number and distribution of data collection sites required. Various options will be discussed in this regard, with due consideration of their cost versus the benefit provided. This work will be done following the procedures outlined in the TMG (FHWA, 2012).

Task 7: Methodology for Future Planning/Prioritization of WIM/ATR Sites

Based on the work in Tasks 1 -7, a methodology will be developed to help the TDC program plan/prioritize future WIM/ATR deployments to best support the collective needs of data users. Priorities to be addressed in this process will include, as appropriate, improving a) the accuracy of the traffic factor grouping analyses, b) the capture of regional and temporal fluctuations in commodity flows, and c) weight and speed enforcement.

Based on the limited literature review completed to-date, little published information is available on how agencies do (or could) plan/prioritize deployment of WIM/ATR sites. That being said, as part of the direct agency contacts made during Task 1 of this project (Review of the State-of the-Practice), information on such procedures will be solicited. The literature that is available on WIM site prioritization appears to focus on locating sites to optimize weight enforcement (e.g. Besinovic, Markovic, and Schonfeld, 2013), which is only one use for WIM data. The work done in Tasks 2 through 7 will provide a) better definition of the criteria that should be used in the prioritization process and their relative importance and b) information on quantitative tools that can be used in evaluating these criteria. While basically the cost-to-benefit ratios associated with specific deployments to support various purposes should drive these decisions, these ratios may be difficult to quantitatively evaluate for some WIM uses, notably with respect to quantifying the benefits to be realized. For example, the reduction in pavement damage from overweight vehicles due to improved compliance with vehicle weight regulations resulting from WIM deployment at a specific location may be reasonably determined, while the benefits of WIM deployment at another site with the intent of improving the quality of traffic data collected for planning and other purposes may be more difficulty to quantify.

Ideally, the prioritization methodology to be used needs to be simple to execute with respect to the required inputs and attendant analyses, and robust enough to appropriately accommodate both quantitative and qualitative based assessments of associated benefits. The first step in the prioritization process could be the selection of candidate sites to support a particular purpose based on quantitative (e.g., expected decrease in overweight vehicle operations, expected improvement in traffic data quality) or qualitative (e.g., expert opinion on expected growth in an area) considerations. Some form of prioritization matrix could then be used to compare the desirability of competing sites based on the nature, magnitude, importance and certainty of realizing the expected benefit. Roles of prioritization matrices vary based on the nature of the problem being addressed, from primarily ensuring that important factors in the prioritization decision are discussed, to providing a numerical “score” that significantly drives the decision. In this case, based on the information reviewed to-date, the methodology to be developed in this project would provide and use both quantitative and qualitative information on costs and benefits of potential WIM locations to assist MDT with final site selection.

Task 8: Reporting

The research team will prepare task reports at the conclusion of Tasks 1 through 7 documenting the work done and significant findings/conclusions from each task. These task reports will form the basis for a comprehensive final report fully documenting the methodologies used, information collected, and conclusions reached. All reports will be prepared following MDT guidelines and submitted following MDT schedule requirements.

A final project meeting will be held with the Technical Panel to discuss the results of the project and their implementation. An implementation plan will be prepared based on this meeting.

MDT INVOLVEMENT

MDT will be directly involved in the execution of all tasks on this project. More specifically, on a task-by-task basis this involvement is expected to consist of:

0) Project management:

MDT will be expected to review and comment on quarterly progress reports.

1) Review of the state-of-the-practice.

MDT will be asked to identify any states they believe have successful WIM programs pertinent to Montana, and any individuals in these states that the research team should contact. MDT will review any contacts that the research team intends to make with other states, as well as the nature of the questions to be asked.

2) Description/inventory of current program and program resources.

MDT will provide information on a) the composition and organizational structure of the TDCA Section, b) the physical WIM/ATR equipment being used at its permanent sites (including condition and location), and c) the resources required to maintain this equipment. Further, MDT will be asked to comment on the efficiency and adequacy of the current TDC systems and for suggestions on possible changes to the systems.

3) Description of data collected and factors that influence it.

MDT will be asked to provide examples of current data products, as well as describe and provide information on any general trends/traffic patterns they are aware of both geographically and temporally (seasonally) around the state.

4) Identification of current and future data uses/users.

MDT will assist in identifying current and potential future data users to be interviewed by the research team. MDT personnel will help the research team arrange and conduct any subsequent interviews with these entities.

5) Assessment of if data needs are being met.

MDT will provide input on their assessment of how well data needs are being met based on their participation in Task 4. MDT will provide input on any new data formats requested/required by data users.

6) Review of traffic factor groups and adjustment factors.

MDT will describe the methodology used to generate the current traffic adjustment factors. MDT will provide traffic data as necessary and available to develop and analyze new traffic factor groups and adjustment factors. This data will consist of WIM and ATR records variously aggregated by day, month and year, for at least the past three years. The intent is to scope and execute this task using data readily available from MDT. MDT will offer expert opinions on proposed changes to the traffic factor groups, the assignment of highway segments to these groups, and the development of regional seasonal adjustment factors.

7) **Generation of a methodology for planning/prioritization of future WIM/ATR sites.**
MDT will offer any suggestions they have on planning/prioritization methodologies for deploying WIM/ATR systems and will review the process developed by the research team. MDT will offer input on any criteria and their importance considered by this process.

8) **Preparation of task reports, final report, project summary report and implementation plan.**
MDT will provide final review of all deliverables. MDT will discuss with the research team the implementation of the project findings, which will form the basis for the implementation plan.

PRODUCTS

The following will be produced during the course of this project:

1. Quarterly progress reports;
2. Task reports submitted at the conclusion of Tasks 1-7;
3. Final report documenting all work done, results obtained in executing Tasks 1-7, and recommendations;
4. Final report cover page photo (JPG format);
5. Project summary report;
6. Final presentation/implementation meeting; and
7. Implementation plan.

Reports will follow MDT's guidelines, will be edited by an independent reviewer, and will be submitted in MS Word and Adobe PDF formats. Reports will be submitted according to MDT's standard reporting requirements. Basic submittal times are indicated in the Schedule section of this proposal.

Additionally, it is anticipated that after MDT approves the final report, various presentations and papers will be prepared on the project findings (with full acknowledgement of MDT sponsorship).

IMPLEMENTATION

This research will provide MDT with valuable information and recommendations addressing the full spectrum of traffic data collection activities, from raw data collection, to the way this data is analyzed, to the manner in which these data are made available to the user,. The methodology developed in the research will provide a guideline for MDT to review existing practices and to plan/prioritize future WIM/ATR deployments to best support the collective needs of the traffic data users.

SCHEDULE

This project will require approximately 18 months to complete. The anticipated project schedule by task is presented in Figure 3. This schedule assumes a start date of approximately May 1, 2013 and an associated end date of October 31, 2014.

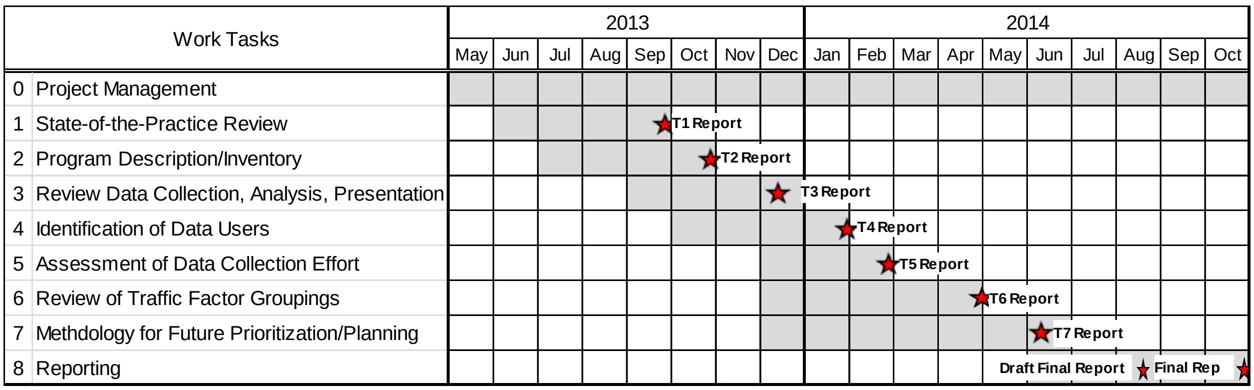

Figure 3. Schedule

BUDGET

The cost of this project will be $204,779 as summarized in Table 4. This cost includes all allocated research and support staff time, and other anticipated expenses. The subaward listed in Table 4 consists of the work to be done by WTI-MT Tech. A further itemization of MT Tech's budget is presented in Table 5. Pay and benefit rates are shown in Table 6. Projected expenditures by task are shown in Table 7. Projected expenditures by state and federal fiscal years are shown in Table 8 and Table 9, respectively. Within Task 8 (Reporting), the specific costs of the Project Summary Report and the final project presentation are $1,088 and $2,541, respectively. All indicated travel costs are for trips to MDT to work on various project tasks; by its very nature this project requires that the project team work closely with MDT personnel on several tasks.

Table 4. Summary of Cost by Budget Category

Item	Amount
Salaries	$86,041
Benefits	$22,581
In-State Travel	$1,120
Out-of-State Travel	$0
Expendable Supplies, Minor Eqpmnt, Repair and Maint	$100
Subaward	$47,985
Participant Costs - RA Tuition	$5,998
Total Direct Costs	$163,823
Overhead - 25%	$40,956
Total Project Cost	$204,779

Table 5. MT Tech Budget

Item	Amount
Salaries	$29,941
Benefits	$7,558
In-State Travel	$788
Out-of-State Travel	$0
Expendable Supplies, Minor Equipment, Repair and Maintenance	$100
Contracted Services	$0
Participant Costs	$0
Total Direct Costs	$38,388
Overhead - 25%	$9,597
MT Tech Project Cost	$47,985

Table 6. Hourly and Benefit Rates

Staff Person	Hourly Rate	Benefit Rate
Jerry Stephens	$57.89	30%
Yan Qi	$42.64	25%
David Veneziano	$34.41	30%
Ahmed Al-Kaisy	$50.45	30%
Graduate Student	$14.00	10%
Bus. Administrator	$21.68	46%
Business Manager	$35.00	33%
Support Staff	$20.00	33%

Table 7. Cost by Task

Task	Cost	% of Total Cost
0 - Project Mgmt	$19,072	9
1 - Review State-of-the-Practice	$14,864	7
2 - Describe/Inventory Program	$6,564	3
3 - Review Data Collection/Analysis	$22,004	11
4 - Identification of Data Users	$20,326	10
5 - Assess Data Collection Effort	$17,422	9
6 - Review Traffic Factor Groups	$37,026	18
7 - Methodology Future Deployments	$24,969	12
8 - Reporting	$42,531	21
Total	$204,779	100

Table 8. Expenditures by State Fiscal Year

Item	Total Amount	State Fiscal Year		
		2013	2014	2015
Salaries	$86,041	$2,452	$76,702	$6,886
Benefits	$22,581	$643	$20,130	$1,807
In-State Travel	$1,120	$32	$998	$90
Out-of-State Travel	$0	$0	$0	$0
Expendable Supplies, Minor Eqpmnt, Repair and Maint	$100	$3	$89	$8
Subaward	$47,985	$1,367	$42,777	$3,841
Participant Costs - RA Tuition	$5,998	$171	$5,347	$480
Total Direct Costs	$163,823	$4,668	$146,043	$13,112
Overhead - 25%	$40,956	$1,167	$36,511	$3,278
Total Project Cost	$204,779	$5,835	$182,554	$16,390

Table 9. Expenditures by Federal Fiscal Year

Item	Total Amount	Federal Fiscal Year		
		2013	2014	2015
Salaries	$86,041	$14,128	$70,191	$1,722
Benefits	$22,581	$3,708	$18,421	$452
In-State Travel	$1,120	$184	$914	$22
Out-of-State Travel	$0	$0	$0	$0
Expendable Supplies, Minor Eqpmnt, Repair and Maint	$100	$16	$82	$2
Subaward	$47,985	$7,879	$39,146	$960
Participant Costs - RA Tuition	$5,998	$985	$4,893	$120
Total Direct Costs	$163,823	$26,899	$133,646	$3,278
Overhead - 25%	$40,956	$6,725	$33,411	$819
Total Project Cost	$204,779	$33,624	$167,057	$4,097

STAFFING

The research team is composed of three faculty members from WTI-MSU and one faculty member from WTI-MT Tech along with a graduate student researcher from WTI-MSU. The primary role of the research team members are delineated by task in Table 10. The Principal Investigator for the project will be Dr. Jerry Stephens at WTI-MSU. Dr. Stephens has previously worked with MDT on several traffic data intensive projects, including a project that investigated WIM based vehicle weight enforcement and a project that studied the comparative performance of different WIM technologies. Dr. Yan Qi and Dr. David Veneziano at WTI- MT Tech and WTI-MSU, respectively, will be Co-Principal Investigators on the project. Dr. Yan Qi recently joined the faculty at MT Tech and has a background in traffic operations and safety, transportation planning, and pavement management systems. Dr. Yan Qi worked on a project for the Louisiana Department of Transportation developing truck load spectra for pavement design. Dr. David Veneziano at WTI-MSU, with expertise in traffic operations and safety, has worked on several MDT projects, including a project that collected extensive traffic data statewide for a project on rest area usage. Dr. Ahmed Al-Kaisy at WTI-MSU also has an extensive background in traffic operations and safety, and worked on the rest area project with Dr. Veneziano. Both Drs. Veneziano and Al-Kaisy have collected and analyzed traffic data for various research projects. Projected level of effort by individual and project task is summarized in Table 11. Resumes for these individuals are presented at the end of this proposal. The Principal Investigators can commit the time necessary to complete this work in a timely and deliberate manner as shown in Table 12

Lead members of the research team will not be changed without written consent of MDT.

Table 10. Summary of Project Roles

Task	Lead	Secondary	Review/Advise
Project Management	Stephens	Qi, Veneziano	-
State-of-the-Practice Review	Qi	Stephens, Veneziano	Al-Kaisy
Description/Inventory of Program	Qi	Stephens, Veneziano	-
Review Data Collection, Analysis, Presentation	Qi	Stephens, Veneziano	Al-Kaisy
Identification of Data Users	Stephens	Qi, Veneziano	Al-Kaisy
Assessment of Data Collection Effort	Qi	Stephens, Qi, Veneziano	Al-Kaisy
Review of Traffic Factor Groupings	Veneziano	Al-Kaisy	Stephens, Qi
Methodology for Future Prioritization/Planning	Veneziano	Al-Kaisy	Stephens, Qi
Reporting	Stephens	Qi, Veneziano	Al-Kaisy

Table 11. Level of Effort by Individual and Task

Individual		Role in Study	Task									
			0	1	2	3	4	5	6	7	8	Total
Jerry Stephens	MSU	Principal Investigator	120	24	16	64	60	32	48	40	100	504
Yan Qi	MT Tech	Co-Principal Investigator	36	80	40	98	96	80	40	40	184	694
David Veneziano	MSU	Co-Principal Investigator	36	32	16	40	32	60	160	220	120	716
Ahmed Al-Kaisy	MSU	Researcher/Reviewer	0	16	0	32	16	16	40	120	32	272
Graduate Student	MSU	Researcher	16	120	40	120	120	120	160	240	240	1176
Bus. Administrator	MT Tech	Admin Support	16	0	0	0	0	0	0	0	0	16
Business Manager	MSU	Administrative Support	8	0	0	0	0	0	0	0	0	8
Support Staff	MSU	Graphics/Report Editing	8	0	0	0	0	0	0	0	80	88
		Total	240	272	112	354	324	308	448	660	756	3474

Table 12. Summary of Commitments

Individual	Available Time %	Existing Commitments	
		Commitment	Time, %
Jerry Stephens	15	Teaching	20
		Administration	45
		Caltrans Bridge Deck Project	5
		NSF REU Project	5
		MDT Prestress Project	5
		Other	5
Yan Qi	30	Teaching	50
		NSF REU Project	10
		Service	10
David Veneziano	20	MDT Roundabout Project	25
		CDOT B/C Analysis Auto Spray Tech	10
		IDT Effectiveness of Winter Chemicals	10
		CALTRANS COATS Phase V	25
		FHWA Traffic Calming Rural Roads	10

FACILITIES

Given the nature of the research study, most of the work will be data/information acquiring, analysis, and assessment. The research will be conducted on pc/workstations using software available at WTI-MSU and WTI-Montana Tech. Exploration of alternative approaches to analyze and present traffic data may require additional specialized software packages. The research team will request trial versions of any such software at no cost to the project.

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Schultz, G. and Seegmiller (2006), *Utah Commercial Motor Vehicle Weigh-in-Motion Data Analysis and Calibration Methodology*, prepared by Brigham Young University, Department of Civil and Environmental Engineering, for the Utah Department of Transportation.

Szary, P., and Maher, A. (2009), *Implementation of Weigh-In-Motion (WIM) Systems*, prepared by the Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University for the New Jersey Department of Transportation.

Zhang, L. (2007), *An Evaluation of the Technical and Economic Performance of Weigh-in-Motion Sensing Technology*, thesis submitted to the University of Waterloo.

Jerry E. Stephens, Ph.D., P.E.
Professor and Acting Department Head,
Civil Engineering Department
Montana State University, Bozeman, MT
406-994-6113/jerrys@ce.montana.edu

Education

University of New Hampshire	Civil Engineering	B.S.C.E., 1975
Purdue University	Civil Engineering	M.S.C.E., 1976
Purdue University	Civil Engineering (Structures)	Ph.D., 1985

Appointments

Acting Department Head, Civil Engineering Department, Montana State University, Bozeman, MT, July 2012 to present.

Research Director, Western Transportation Institute (WTI), Montana State University, Bozeman, MT, May 2006 to June 2012.

Full/Associate/Assistant Professor, Civil Engineering Department, Montana State University, Bozeman, MT, August 1989 to present.

Associate Professor, Civil Engineering Department, West Virginia University, Morgantown, WV, August 1988 to August 1989.

Senior Research Engineer, New Mexico Engineering Research Ins., Albuquerque, NM, June 1985 to July 1988.

Research Instructor, Purdue University, Department of Civil Engineering, West Lafayette, IN, August 1982 to May 1985.

Research Engineer, New Mexico Engineering Research Ins., Albuquerque, NM, June 1976 to July 1982.

Selected Presentations/Publications

Kappes, L., Berry, M., and Stephens, J. (2012), “Concrete Filled Steel Tube Piles to Concrete Pile-Cap Connections,” presented at the ASCE/SEI Structures Congress, Spring 2012.

Berry, M., Stephens, J., and Cross, D., (2011), Performance of 100% Fly Ash Concrete with 100% Recycled Glass Aggregate, ACI Materials Journal, July 2011.

Berry, M., Schroeder, D., Larabee, B., and Stephens, J. (2010), Building Green: Development and Evaluation of an Environmentally Friendly Concrete, American Concrete Institute, Annual Convention, Pittsburgh, PA, October 2010.

Berry, M., Cross*, D., and Stephens, J. (2009), “Performance of 100% Fly Ash Concrete with 100% Recycled Glass Aggregate”, Proceedings, 2009 Annual Meeting of the Transportation Research Board, Washington, D.C., January 2009.

Ogard, L., Stephens, J., and Cole, M. (2008), “Container/Trailer on Flatcar in Intermodal Service on Montana Railway Mainlines,” Final Report FHWA/MT-08-009/8191 prepared for the Montana Department of Transportation by Prime Focus LLC and Montana State University, Bozeman, MT.

Cole, M., Ogard, L., and Stephens, J. (2008), “Prospects for Intermodal Containerized Freight Transport in Montana,” Presentation at the 2009 Annual Meeting of the Institute for Operations Research and Management, Washington, D.C., October 2008.

Stephens, J., Cuelho, E., Johnson*, J. and Smolenski*, P. (2006), “Uncommon Methods of Analyzing Strain and Temperature Data to Reveal the Presence of Distress in Bridge Decks,” Presentation at 2006 NDE Conference on Civil Engineering, St.Louis, MO, August 15-18, 2006.

Stephens, J., Carson, J., Hult, D., and Bisom, D. (2005), "Coming into Focus: Montana's State Truck Activities Reporting System", invited presentation at the 2005 Annual Meeting of the Transportation Research Board, January, 2005, Washington, D.C.

Clark. D.J., Stephens, J, and Carson, J. (2004), "A Field Evaluation of Piezoelectric and Bending Plate Weigh-in-Motion Systems," Final Report prepared for the Montana Department of Transportation by Montana State University, Bozeman, MT.

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Hewit, J., Stephens, J., Smith*, K., and Menuez*, N. (1999), "Infrastructure and Economic Impacts of Changes in Truck Weight Regulations in Montana, Transportation Research Record 1653, Transportation Research Board, National Research Council, Washington, D.C.

Stephens, J.E., and Menuez*, N. (1999), "Cost Allocation Study for the Montana State Highway System: 1999 Update", Final Report prepared for the Montana Department of Transportation by Montana State University, Bozeman, MT.

Folwell, M., and Stephens, J. (1997), "System for Processing and Analyzing WIM and AVC Data", Final Report prepared for the Montana Department of Transportation by Montana State University, Bozeman, MT.

Stephens, J., Scoles, J., Patterson, S., and Schillings, P. (1996), Impact of Adopting Canadian Interprovincial and Canamex Limits on Vehicle Size and Weight on the Montana State Highway System", Final Report prepared for the Montana Department of Transportation by Montana State University, Bozeman, MT.

National Committee Activity

Making Sense of Sensors Used to Monitor Bridges, Workshop Organizer/Moderator with Eli Cuelho, Transportation Research Board Annual Meeting, 2007

Member and Paper Reviewer, Transportation Research Board, Truck Size and Weight Committee, 1996 – 2007, current friend of committee

Member, National Cooperative Highway Research Program Project Panels (four projects)

Member, Transportation Research Board, Committee to Review the Federal Cost Allocation Study, 1996-1997

Session Moderator, Federal Highway Administration Workshop on Highway Cost Allocation, May, 2000, Irvine, California

Honors/Awards

Alumni/Chamber of Commerce Award for Excellence, MSU (7 awards)
Outstanding Instructor – CE/BREN, College of Engineering, MSU (5 awards)
Outstanding Instructor, Civil Engineering Dept., MSU (3 awards)

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Education

May 2010: ***Ph.D.***, Civil Engineering (Transportation), ***Louisiana State University***

May 2008: ***M.S.***, Applied Statistics, Department of Experimental Statistics, ***Louisiana State University***

July 1999: ***M.S.***, Civil Engineering (Transportation), ***Southeast University***, Nanjing, China

July 1996: ***B.S.***, Civil Engineering, ***Shandong Polytechnic University (now Shandong University)***, Jinan, China

Appointments

August 2012-present: ***Assistant Professor***, General Engineering Department, Montana Tech

June 2010-June 2012: ***Technical Manager,*** Institute for Multimodal Transportation, Jackson State University, Jackson, MS

January 2004- August 2004: ***Engineer***, Koch Materials Company (China), Beijing, China

January 2001- December 2002: ***Engineer***, Highway Department, Ministry of Transportation, Beijing, China

May 1999-December 2000: ***Assistant Research Fellow*****,** China Transportation Research Institute, Beijing, China

Selected Journal Publications

Qi, Y. and S. Ishak, "Stochastic Approach for Short-Term Freeway Traffic Prediction during Peak Periods", the IEEE Journal of Intelligent Transportation Systems, in press, 2012.

Ishak, S., Y. Qi, and P. Rayaprolu, "Safety Evaluation of Joint and Conventional Lane Merge Configurations for Freeway Work Zones", Traffic Injury Prevention, 13(2): 199-208, 2012

Qi, Y., S. Ishak, B. Wolshon, and C. Alecsandru, "Traffic Behavior and Compliance to Truck Restriction Policies on Four Lane Rural Freeways", Journal of Transportation Safety & Security, 4:160-177, 2012

Rayaprolu, P., S. Ishak, Y. Qi, and B. Wolshon, "Operational Assessment of Joint and Conventional Lane Merge Configurations for Freeway Work Zones", Journal of Intelligent Transportation Systems: Technology, Planning, and Operations, in press, 2012.

Mamidala, C., S. Ishak, and Y. Qi, "Stochastic Characteristics of Freeway Traffic Speed during Breakdown and Recovery Periods", the Journal of the Transportation Research Board, No. 2178,pp. 79-89, 2010.

Wolshon, B., S. Ishak, Y. Qi, M. Korkut, X. Sun, and C. Alecsandru, "Trucker Perceptions of Lane Restriction and Differential Speed Limit Policies on Freeways", Journal of Transportation Safety & Security,1:101-120, 2009.

Selected Project Experience

Utilized the cutting-edge technologies of remote censoring, GPS, GIS, and image processing to gather highway network inventory data - "State-of-Practice Approaches and Technologies for Inventory Data Collection of Public Road System" sponsored by Mississippi Department of Transportation;

Evaluated various automated pavement distress data collection techniques and compared them with the manual method - "Assessment of Pavement Infrastructure for Use in a Pavement Management System" sponsored by U.S Department of Transportation.

Simulated and compared various evacuation scenarios - "Emergency Evacuation Study for the Great Jackson Area: DYNASMART-P Deployment in Mississippi DOT" sponsored by Mississippi Department of Transportation.

Developed the histograms of pavement distresses over time and compared them with the threshold values - "Evaluation of MDOT's Distress Thresholds for Maintained Pavement Projects" sponsored by Mississippi Department of Transportation.

Conducted before and after study to investigate the effectiveness of ramp metering on I-12 - "Measuring Effectiveness of Ramp Metering Strategies on I-12" sponsored by Louisiana Department of Transportation and Development.

Conducted statistical and economic analysis to compare the performance and costs of warranty and traditional pavement contracting procedures and assessed the cost-effectiveness of warranty projects – "Cost-Effectiveness Study of the Pavement Warranty Program in Mississippi" sponsored by Mississippi Department of Transportation.

Assessed traffic safety benefits of a lower speed limit and restriction of trucks to use right lane only on the elevated segment of Interstate -10 over the Atchafalaya basin.

Developed the truck load spectra in Louisiana for the future implementation of MEPDG for Louisiana Department of Transportation and Development.

Evaluated pavement performance using field rutting data of the lanes under repeated loading at Louisiana Department of Transportation & Development pavement research facility.

National Committee Activity

2009 - Present: Member of American Society of Civil Engineers

2009 - Present: Member of Institute of Transportation Engineer

2009 - Present: Paper reviewer, Transportation Research Board

Friend of AHB20: Committee on Freeway Operations

Friend of ABJ35: Committee on Highway Traffic Monitoring

Friend of ANB70: Committee on Truck and Bus Safety

2009 - Present: American Society for Testing and Materials (ASTM)

Member of E17.52: Subcommittee on Traffic Monitoring, which is part of the Committee on Pavement Roughness, Pavement Management, and ITS Data Archiving,

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Western Transportation Institute
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Education

St. Joseph's College (Indiana)	Management	B.S.,	2000
Iowa State University	Transportation Planning	M.S.,	2002
Iowa State University	Civil Engineering (Transportation)	Ph.D.,	2006

Appointments

Research Scientist II, Western Transportation Institute. Bozeman, MT, August 2012 to Present.

Research Scientist, Western Transportation Institute. Bozeman, MT, September 2006 to August 2012.

Research Assistant, Center for Transportation Research and Education. Ames, IA, July 2000 to August 2006.

Selected Presentations/Publications

Shi, Xianming, David Veneziano, Ning Xie and Jing Gong. (2012) "Use of Chloride-Based Ice Control Products for Sustainable Winter Maintenance: A Balanced Perspective". Cold Regions Science and Technology, In Press, 2012.

Ye, Zhirui, David Veneziano and Ian Turnbull. (2012) "Safety Effects of Icy Curve Warning Systems." Accepted for Publication in Transportation Research Record, Journal of the Transportation Research Board, In Press, 2012.

Al-Kaisy, Ahmed, David Veneziano, Zachary Kirkemo and Christopher Dorrington. (2012) "Usage Estimation at Rest Areas on Rural Interstate and Arterial Highways: Practical Guidelines." Accepted for Publication in Transportation Research Record, Journal of the Transportation Research Board, In Press, 2012.

Al-Kaisy, Ahmed, Sommer Roefaro and David Veneziano. (2012) "Effectiveness of Signal Control at Channelized Right-Turning Lanes: An Empirical Study". Journal of Transportation Safety & Security, Vol. 4, No. 1, pp. 19-34, 2012.

Al-Kaisy, Ahmed, Brian Church, David Veneziano, and Christopher Dorrington. (2011) "Investigation of Parking Dwell Time at Rest Areas on Rural Highways." Transportation Research Record, Journal of the Transportation Research Board, No 2255, pp. 156-164, 2011.

Al-Kaisy, Ahmed, Zachary Kirkemo, David Veneziano, and Christopher Dorrington. (2011) "Traffic Usage of Rest Areas on Rural Highways: A Recent Empirical Study." Transportation Research Record, Journal of the Transportation Research Board, No 2255, pp. 146-155, 2011.

Ye, Zhirui, David Veneziano and Dominique Lord. (2011) "Safety Impact of Gateway Monuments." Accident Analysis & Prevention, Vol. 43, No. 1, pp. 290-300, 2011.

Fay, Laura, David Veneziano, Zhirui Ye, Dan Williams and Xianming Shi. (2010)"Cost-Benefits of Winter Road Maintenance Tools: A Renewed Perspective Based on Recent Research." Transportation Research Record, Journal of the Transportation Research Board, No 2169, pp. 174-186, 2010.

Veneziano, David, Shaowei Wang and Xianming Shi. (2009) "Precipitation Variation and the Identification of High-risk Wet Accident Locations in the State of California." Transportation Research Record, Journal of the Transportation Research Board, No 2107, pp. 123-133, 2009.

Lassacher, Suzanne, David Veneziano, Steven Albert, and Zhirui Ye. (2009) "Special Event Traffic Management in Small Communities." Transportation Research Record, Journal of the Transportation Research Board, No 2099, pp. 85-93, 2009.

Hallmark, Shauna, David Veneziano, Scott Falb, Michael Pawlovich, and Deborah Witt. (2008) "Evaluation of Iowa's Graduated Driver's Licensing Program." Accident Analysis & Prevention, Vol. 40, No. 4, pp. 1401-1405, 2008.

Veneziano, David, Shauna L. Hallmark and Reginald R. Souleyrette. (2004) "Accuracy Evaluation of LIDAR-Derived Terrain Data for Highway Location." Computer-Aided Civil and Infrastructure Engineering Vol. 19. No 2. pp. 147-160, 2004.

Veneziano, David, Reginald Souleyrette, and Shauna Hallmark. (2003) "Integration of Light Detection and Ranging Technology with Photogrammetry in Highway Location and Design." Transportation Research Record, Journal of the Transportation Research Board, No 1836, pp. 1-6, 2003.

National Committee Activity

2011-present: Transportation Research Board Committee AHD65, Committee on Winter Maintenance: "Friend" of committee.

2007-present: Transportation Research Board Committee ANB30(1), Teen Driving Subcommittee: "Friend" of committee.

2004-present: Transportation Research Board Committee ANB20, Safety Data, Analysis, and Evaluation: "Friend" of committee.

Member - Institute of Transportation Engineers.

Reviewer – Journal of Transportation Safety & Security, 2012 – Present.

Reviewer – TRB Subcommittee on Surrogate Measures of Safety ANB20(3), 2011-present.

Reviewer – Computer Aided Civil and Infrastructure Engineering, 2008-present.

Honors/Awards

Federal Highway Administration Dwight David Eisenhower Transportation Fellowship 2003 – 2006.

Iowa State University Engineering Student Council Leadership Award, 2003.

Eno Transportation Foundation Fellow, 2002.

Midwest Transportation Consortium (University Transportation Center Region 7) Outstanding Student of the Year, 2002.

Midwest Transportation Consortium (University Transportation Center Region 7) Outstanding Graduate Student Paper, 2001 and 2002.