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

Report for Task II

MDT Traffic Data Collection Program

Description/Inventory

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ABSTRACT

This task report consists of a comprehensive description and inventory of the traffic data collection program of the Montana Department of Transportation (MDT), as the second task in a project sponsored by MDT to review its traffic data collection program to ensure it provides the best possible traffic information in the most cost effective manner. Based on information provided by the Traffic Data Collection and Analysis (TDCA) Section of MDT, and information available on the MDT website, the research team documented the basic traffic data collection network (with an emphasis on the permanent/continuous automatic traffic recorder (ATR) and weigh-in-motion (WIM) sites), data collection technologies used, program management and operations, organizational structure of the TDCA Section, program cost, and program planning/prioritization methodologies.

The TDCA Section of MDT, responsible for all traffic data collection activities of MDT, collects data continuously at 62 ATR and 32 WIM sites across the state, and additionally conducts approximately 3,000 short term counts annually at various locations statewide. The TDCA Section is responsible for all aspects of short-term and permanent/continuous data collection site installation, maintenance, and field operations, and all data transmission, processing, quality control and analysis, as well as data presentation/display. The TDCA Section has fourteen permanent employees and a supervisor, and annual expenditures of approximately $1.7 million to cover all costs of the traffic data collection program, consisting of labor, equipment, supplies, travel, training and contracted services. In light of growing data needs/requests as design and planning methodologies and processes become increasingly data intensive, the TDCA Section foresees the need, among other things, to a) refine data collection and analysis to better capture regional differences in traffic operations around the state, b) improve physical management of its inventory of data collection equipment/facilities to optimize maintenance and replacement investments, and c) develop a more formal strategy for siting new data collection locations to optimize resource investment across competing priorities.

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Table of Contents

DRAFT

DRAFT

LIST OF TABLES

DRAFT

LIST OF FIGURES

DRAFT

INTRODUCTION

Automatic traffic recorder (ATR) and weigh-in-motion (WIM) systems are the two fundamental types of data collection systems generally employed in continuously monitoring roadway use at permanent sites on a highway network. The 62 ATR and 32 WIM systems that are currently active across Montana's highway network are the major components of the state's traffic data collection system, augmented by traffic counts done at numerous additional sites around the state with portable equipment. With advances in wireless detector, sensor, transmission, and communication technologies, ATR/WIM technologies continue to move forward. The Montana Department of Transportation (MDT) is conducting a project to comprehensively evaluate its existing traffic data collection program and to assist in determining the future direction of this program. The first task of this project was to conduct a systematic and comprehensive literature review on ATR/WIM systems, which was completed and submitted to MDT in October 2013 (Qi, Forsythe, Stephens, & Veneziano, 2013). The second task of this project is to document the structure and operation of MDT's Traffic Data Collection and Analysis (TDCA) program and to inventory the physical equipment being used. The results of this second task are reported herein.

Working with MDT, the composition and organizational structure of the TDCA program was reviewed and characterized, focusing on program

- size, relative to the number and nature of the data collection sites being used;
- data collection technologies, focusing on sensor type, typical installation layout, and data communication technology;
- personnel and administrative structure, relative to the number of employees, management structure and job duties;
- costs, including all site related equipment and activity costs (i.e., installation, maintenance, operation and calibration), and data reduction and dissemination costs as done by in-house and by contracted personnel, and
- planning, encompassing prioritization of future sites and future goals of the overall program.

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SIZE OF TRAFFIC DATA COLLECTION PROGRAM

MDT collects traffic data using a combination of short and long term counts. The short-term count program employs portable equipment to gather traffic data over a duration ranging from 36-hours to several days. The locations at which short-terms counts are done are not fixed, and they significantly outnumber the permanent data collection sites, as short term counts are relatively inexpensive to perform. ATRs and WIMs form the permanent data collection program, which are generally employed to continuously monitor roadway use at fixed sites on the state's highway network. In addition to monitoring the traffic at fixed sites, data gathered from permanent ATR/WIM systems are also important in converting/factoring/seasonally-adjusting short-term traffic counts to estimate traffic flow across the entire year.

Short-Term Counts

MDT uses three approaches to conduct short-term counts, namely road tubes, non-intrusive traffic data collection camera units, and manual counts. There are over 5,000 locations across the state at which short-term counts are collected. The short-term count sites are shown in the statewide traffic count site map (http://www.mdt.mt.gov/publications/datastats/trafficmaps.shtml). Data, however, are not collected at every site each year. Approximately, 2,800 short-term counts are conducted annually. In 2012, 3,252 portable counts were conducted, among which 2,872 were road tube counts, 65 were non-intrusive traffic data collection camera unit counts, and 315 were manual counts. The count cycle varies depending on the location of the short-term sites. Table 1 shows the count cycle for short-term counts on different highway systems.

Table 1 Short-Term Count Cycle

System	Cycle
Interstate	Annual
Non-Interstate NHS	Annual
Primary	Biennial
Urban	Annual
Secondary	Biennial
State Highway	Every three years
Off System	Every three years
Interstate Ramps	a minimum every six years (higher volume ramps get counted on a minimum three year cycle)

Given the usefulness of traffic data and the relatively low cost of installing and operating portable equipment, multiple agencies aside from MDT employ portable devices to collect traffic data. Cities, counties, and Metropolitan Planning Organizations (MPOs) across Montana have and continue to do counts using portable equipment at various sites, especially in urban areas. MDT shares its short-term counts with, and gets data from multiple agencies. Currently, data are shared via email and web link.

ATR/WIM Systems

As of August, 2013, a total of 62 ATRs are operated by MDT across the state's network. The locations of these ATRs are shown in Figure 1, and selected site characteristics are listed in In addition to the volume and class sites, MDT has 15 motorcycle capable sites. The ATR motorcycle sites are an important component in MDT's traffic data collection program, as FHWA requires that each state provide motorcycle vehicle miles of travel (VMT) as part of the Highway Performance Monitoring System (HPMS). In addition to meeting FHWA's requirements, MDT also needs to maintain a sufficient number of ATR motorcycle sites to characterize use of the highway system by this vehicle type (e.g., recreational versus commuter travel). Relative to age/condition, it has been over 10 years since approximately one-third of the permanent ATR sites have received a major equipment upgrade.

According to the latest updated data (November 5, 2013), MDT lists 42 WIM sites in their inventory, of which 37 sites are partially or fully functional and 5 sites are permanently abandoned (these sites were abandoned due to pavement deterioration or urban growth, and data collection needs at these locations are currently covered by another WIM or ATR site in the same vicinity).

The location of the WIM sites (as of August 10, 2013) is shown on Figure 1, and selected site characteristics are presented in **Error! Reference source not found.**. MDT added three new WIM sites in 2013. Relative to the 37 functional sites: 32 sites are fully functional and the remaining five sites are temporarily out of service due to road construction, but they will be restored in the next two years. TDCA has one WIM installation scheduled to be done by an outside contractor in 2014, depending on the completion time of an on-going roadway construction project.

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

Table 2 and Table 3. Referring to In addition to the volume and class sites, MDT has 15 motorcycle capable sites. The ATR motorcycle sites are an important component in MDT's traffic data collection program, as FHWA requires that each state provide motorcycle vehicle miles of travel (VMT) as part of the Highway Performance Monitoring System (HPMS). In addition to meeting FHWA's requirements, MDT also needs to maintain a sufficient number of ATR motorcycle sites to characterize use of the highway system by this vehicle type (e.g., recreational versus commuter travel). Relative to age/condition, it has been over 10 years since approximately one-third of the permanent ATR sites have received a major equipment upgrade.

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

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Table 2 and Table 3, MDT has four types of ATR sites based on the data collected, namely volume only sites (VOLUME), class by length sites (LENGTH), axle classification sites (AXLE), and motorcycle (MC-CLASS) sites.

Table 4 summarizes the number of each type of ATR. The number of length based classification sites is three times of the number of axle based classification sites. All the length based classification sites employ loop technology. MDT intends to upgrade them to axle based classification sites with piezoelectric technology.

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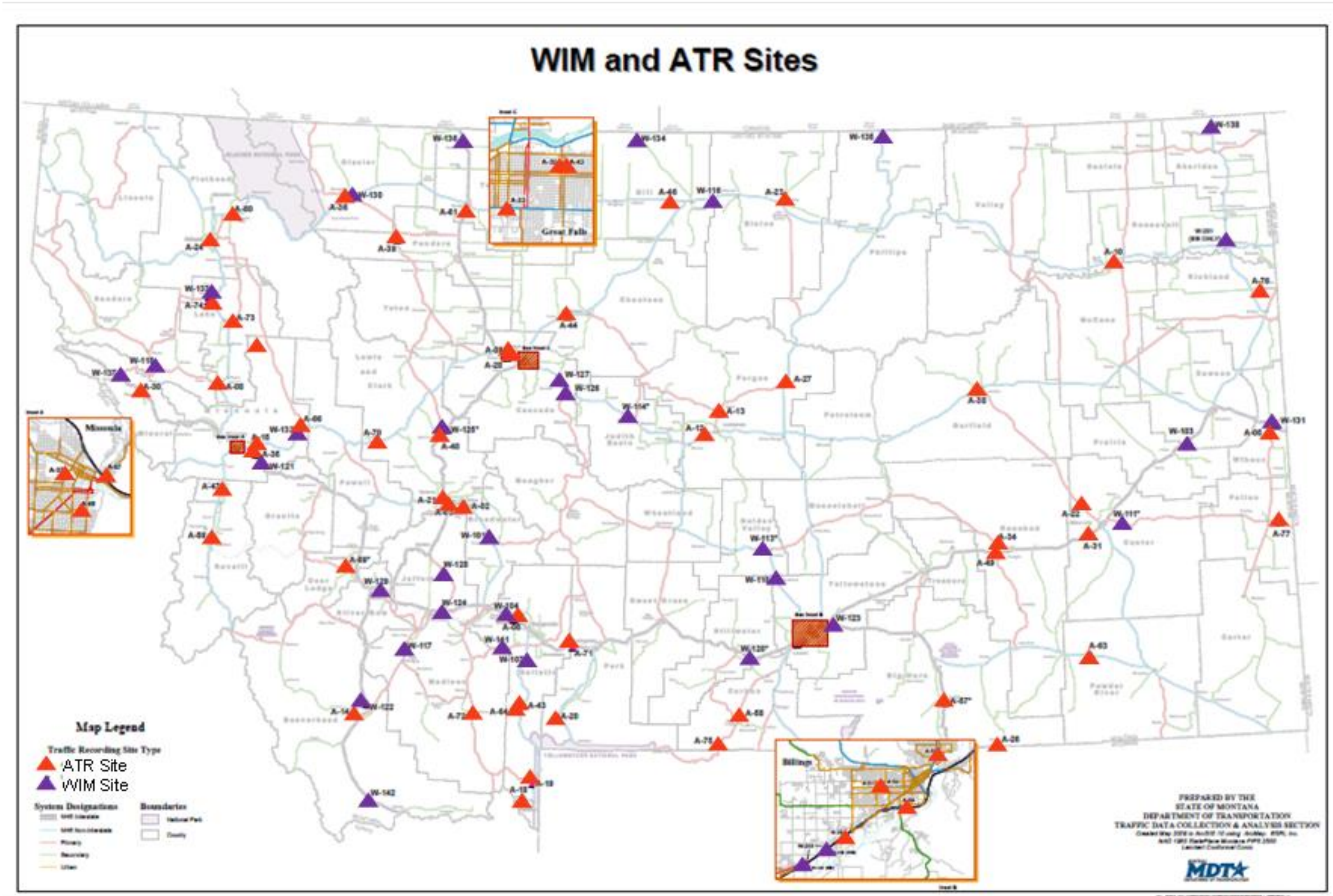

Figure 1 WIM and ATR Sites (MDT, 2012a)

Table 2 ATR Sites (Part I)

SITE ID	Communication Method	Sensor Type	Secondary Sensor Type	Data Collected	Year Established	Last Major Upgrade
A-02	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1961	06/06/13
A-03	Phone	PDVF Piezo	Inductance Loop	AXLE	1988	10 + Yrs
A-05	Cellular Internet	PDVF Piezo	PDVF Piezo	MC-CLASS	1940	8/10/2010
A-06	Phone	Inductance Loop	Inductance Loop	VOLUME	1939	10 + Yrs
A-08	Cellular Internet	PDVF Piezo	PDVF Piezo	MC-CLASS	1961	7/16/08
A-09	Phone	Inductance Loop	Inductance Loop	LENGTH	1940	10 + Yrs
A-10	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1940	9/15/2010
A-12	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1940	6/7/2012
A-13	Phone	Inductance Loop	Inductance Loop	LENGTH	1940	10 + Yrs
A-14	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1940	8/15/2011
A-15	Phone	Inductance Loop	Inductance Loop	LENGTH	1941	10 + Yrs
A-18	Phone	Inductance Loop	Inductance Loop	LENGTH	1970	10 + Yrs
A-19	Phone	Inductance Loop	Inductance Loop	LENGTH	1950	8/10/2006
A-20	Phone	PDVF Piezo	Inductance Loop	LENGTH	1950	2010
A-21	Phone	Inductance Loop	None	VOLUME	1956	11/1/13
A-22	Phone	Inductance Loop	None	VOLUME	1989	10 + Yrs
A-23	Phone	Inductance Loop	Inductance Loop	LENGTH	1957	10 + Yrs
A-24	Phone	Inductance Loop	Inductance Loop	LENGTH	1957	10 + Yrs
A-26	Phone	Inductance Loop	None	VOLUME	2010	1/26/10
A-27	Phone	PDVF Piezo	Inductance Loop	AXLE	1961	10 + Yrs
A-28	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1961	9/7/11
A-29	Phone	Inductance Loop	Inductance Loop	LENGTH	1962	10 + Yrs
A-30	Phone	PDVF Piezo	Inductance Loop	AXLE	1962	2014?
A-31	Phone	PDVF Piezo	Inductance Loop	LENGTH	1963	8/4/2009
A-32	Phone	Inductance Loop	None	VOLUME	1970	10 + Yrs
A-33	Phone	Inductance Loop	None	VOLUME	1965	10 + Yrs
A-34	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1965	2014?
A-35	Phone	Inductance Loop	Inductance Loop	LENGTH	1965	10 + Yrs
A-36	Phone	Inductance Loop	Inductance Loop	LENGTH	1966	10 + Yrs
A-37	Phone	Inductance Loop	None	VOLUME	1966	7/20/2004
A-38	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1967	8/27/2009
A-39	Phone	Inductance Loop	Inductance Loop	LENGTH	1967	10 + Yrs
A-40	Phone	Inductance Loop	Inductance Loop	LENGTH	1968	10 + Yrs
A-42	Phone	Inductance Loop	None	VOLUME	1972	10 + Yrs
A-43	Phone	Inductance Loop	Inductance Loop	MC-CLASS	1972	8/15/2013
A-44	Phone	Inductance Loop	N/A	VOLUME	N/A	2/28/13
A-46	Phone	Inductance Loop	Inductance Loop	MC-CLASS	N/A	5/2/13
A-47	Phone	PDVF Piezo	Inductance Loop	LENGTH	1980	5/1/07
A-49	Phone	Inductance Loop	Inductance Loop	LENGTH	1980	10 + Yrs

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Table 3 ATR Sites (Part II)

SITE ID	Communication Method	Sensor Type	Secondary Sensor Type	Data Collected	Year Established	Last Major Upgrade
A-50	Phone	Inductance Loop	None	VOLUME	1981	4/20/2006
A-51	Phone	Inductance Loop	None	VOLUME	1981	12/30/13
A-54	Phone	Inductance Loop	None	VOLUME	1984	10 + Yrs
A-56	Cellular Internet	PDVF Piezo	Inductance Loop	AXLE	1986	4/26/10
A-57	Phone	PDVF Piezo	Inductance Loop	AXLE	1992	2013
A-58	Phone	Inductance Loop	Inductance Loop	LENGTH	1986	2015?
A-59	Phone	PDVF Piezo	Inductance Loop	AXLE	1990	8/9/10
A-60	Phone	Inductance Loop	Inductance Loop	LENGTH	1982	8/26/04
A-61	Phone	PDVF Piezo	Inductance Loop	AXLE	1991	9/14/2004
A-63	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1992	8/5/09
A-64	Phone	Inductance Loop	Inductance Loop	LENGTH	1992	10 + Yrs
A-66	Phone	PDVF Piezo	PDVF Piezo	MC-CLASS	1992	2014?
A-67	Phone	Inductance Loop	None	VOLUME	1993	10/30/2012
A-68	Phone	Inductance Loop	None	VOLUME	1993	10 + Yrs
A-69	Phone	Inductance Loop	None	VOLUME	1995	2/23/10
A-70	Phone	Inductance Loop	Inductance Loop	LENGTH	1998	2007
A-71	Cellular Internet	PDVF Piezo	Inductance Loop	AXLE	2002	8/21/12
A-72	Cellular Internet	PDVF Piezo	PDVF Piezo	MC-CLASS	2009	2009
A-73	Cellular Internet	PDVF Piezo	PDVF Piezo	MC-CLASS	2009	2009
A-74	Cellular Internet	PDVF Piezo	PDVF Piezo	MC-CLASS	2009	2009
A-75	Manual	PDVF Piezo	PDVF Piezo	MC-CLASS	2011	2011
A-76	Cellular Internet	PDVF Piezo	PDVF Piezo	MC-CLASS	2012	2012
A-77	Cellular Internet	PDVF Piezo	PDVF Piezo	MC-CLASS	2012	2012

Table 4 Number of Each Type of ATR

ATR Type	Number	%
MC-CLASS	15	24.2
AXLE	8	12.9
LENGTH	24	38.7
VOLUME	15	24.2

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Table 5 WIM Sites

SITE ID	Communication Method	Sensor Type	Secondary Sensor Type	Year Established
W-101	Wireless Internet	Quartz	Quartz	1996
W-103	Phone	Quartz	Quartz	1997
W-104	Phone	Quartz	Quartz	1996
W-107	Phone	Quartz	Quartz	1997
W-110	Phone	Quartz	Quartz	1997
W-111	Wireless Internet	Quartz	Quartz	1998
W-113	Phone	Quartz	Quartz	1999
W-114	Phone	Quartz	Quartz	1999
W-115	Phone	Quartz	Quartz	1999
W-116	Phone	Quartz	Quartz	1999
W-117	Phone	Quartz	Quartz	1999
W-118	Phone	Quartz	Quartz	1999
W-120	Wireless Internet	Quartz	Quartz	2001
W-121	Wireless Internet	Quartz	Quartz	2001
W-122	Phone	Quartz	Quartz	2001
W-123	Wireless Internet	Quartz	Quartz	2001
W-124	Wireless Internet	Quartz	Quartz	2001
W-125	Phone	Quartz	Quartz	2001
W-126	Wireless Internet	Quartz	Quartz	N/K
W-127	Wireless Internet	Quartz	Quartz	2001
W-128	Wireless Internet	Quartz	Quartz	2005
W-129	Wireless Internet	Quartz	Quartz	2007
W-130	Wireless Internet	Quartz	Quartz	2005
W-131	Wireless Internet	Quartz	Quartz	2006
W-132	Phone	Quartz	Quartz	2006
W-133	Wireless Internet	Quartz	Quartz	2008
W-134	DSL	Quartz	Quartz	2008
W-135	DSL	Quartz	Quartz	2008
W-136	Phone	Quartz	Quartz	2009
W-137	Wireless Internet	Quartz	Quartz	2010
W-138	Wireless Internet	Quartz	Quartz	2011
W-141	Wireless Internet	Quartz	Inductance Loop	2012
W-142	Wireless Internet	Piezoelectric	Inductance Loop	2012
W-143	Wireless Internet	N/K	N/K	N/K
W-144	Phone	N/K	N/K	N/K
W-145	Phone	N/K	N/K	N/K
W-203	Phone	Quartz Piezoelectric	Quartz Piezoelectric	2000

N/K – not known

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The Motor Carriers Service Section of MDT used to operate four bending plate WIM sites for weight enforcement screening purposes only. As the sites deteriorated, the TDCA section replaced the bending plates with Kistler Quartz piezoelectric sensors and assumed responsibility to maintain those sites. To date, there is only one bending plate WIM (Station ID: W-201) that is still functional, and TDCA plans to replace the site with Kistler sensors and include the site in the WIM inventory. MDT has concluded that quartz piezoelectric WIM sensors are more cost effective than bending plate systems in meeting their traffic data collection needs, based in part on the results of two studies they sponsored at Montana State University (MSU) on WIM system performance ((Bylsma & Carson, 2002); (Carson & Stephens, 2004)).

The distribution of ATR and WIM sites across the state highway system by functional class is reported in Table 6. The percent of total VMT on the state highway system that is being directly captured by the permanent ATR and WIM systems was estimated using the volume of traffic passing each ATR and WIM site, the length of highway segment associated with the site, and the projected total VMT on the state highway system. These calculations found that eight percent of total VMT state wide is directly monitored by the current permanent ATR and WIM networks (split approximately evenly between the two systems).

Table 6 Number of ATR and WIM Sites by Functional Class

Functional Class	Number of ATR	Number of WIM
Principal Arterial (Interstate)	9	14
Principal Arterial (Other)	26	16
Minor Arterial	16	6
Collectors – Urban Major Collector - Rural	10	1
Minor Collector	0	0
Local	1	0
Total	62	37

Future Goals

A major future goal of MDT's data collection program is to expand and improve the traffic count exchange program, i.e., - sharing data with local governments/entities. In addition to short term counts, efforts are underway to include data from permanent/continuous counters in the traffic count exchange program. In Missoula, for example, MDT shared the responsibilities of operating three permanent ATR sites with local Missoula agencies. The local agencies (consisting of the City of Missoula and the Missoula MPO) paid for installation of these three ATRs within its urban boundaries. MDT staff maintains the equipment and downloads and processes the data from the ATRs. Missoula is responsible for paying the power and phone bills

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for the sites. Also, if the sites are extensively damaged beyond regular wear and tear (i.e. hit by a car - which has happened numerous times), Missoula is responsible for purchasing new electronic equipment, cabinets, etc. for repairing the sites, while MDT field operation staff will conduct the repair work.

In addition to incorporating both short term and permanent counts in the exchange program, future efforts will also be made to improve and optimize the exchange program. With MDT and local governments/entities working together, both agencies can adjust their traffic data collection systems to reduce redundancy in terms of collected data type and data collection sites, and thus save staff resources at both the state and local levels. Further, opportunities will be pursued to improve MDT's traffic count coverage for lower function class roads through collaboration with local governments. Interactions with local governments and other entities as part of the data exchange program will also be used to increase their awareness and knowledge about traffic data, how they are processed and how they can be used. Moreover, the current data sharing technology needs to be upgraded to improve the efficiency of data sharing. As stated above, current data sharing is done via email and web link. Web-based software needs to be developed to facilitate the data sharing process. The software should be easy to access by multiple agencies and able to accommodate various data formats to accommodate processing software from different vendors.

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DATA COLLECTION TECHNOLOGIES

Various technologies are employed by MDT for portable and permanent traffic data collection in Montana. Compared to portable sites, the technologies used for permanent sites have a higher level of automation and reliability, as more types of data are collected continuously at these sites, and it is expected that these data will be more accurate than those collected at short-term sites. To supplement the automatic methods for short-term data collection, manual methods are employed to collect certain types of data that serve a specific purpose. This section documents the technologies used for portable short term and permanent sites in Montana, along with the future development and needs.

Short-Term Sites

Three types of technologies/methods are employed in Montana to collect short-term data, namely, road tube counters, non-intrusive video equipment, and manual count boards. The portable equipment usually consists of sensors installed on top of the roadway surface or located at the edge of the road and controllers temporarily placed along the edge of the road. There are over 5,000 short term count sites across Montana, however not all counts are taken every year. Counts are taken at approximately 2,800 short-term sites per year.

Road Tube Counters

Road tube counters use road tubes (rubber hoses) as sensors to record axle crossings as tires strike the tube. Data collected includes volume, vehicle classification (FHWA 1-13), and speed. The data collection duration is usually from 36 to 48 hours for vehicle volume and classification counts, respectively. The counter programming and road tube layout determine the type of data that can be collected. **Error! Reference source not found.Error! Reference source not found.** shows a typical layout of a road tube counter capable of collecting classification data. Notably, such a layout typically requires two road tubes in each lane in the direction of travel so that vehicle speed can be determined and used in interpreting the data to infer vehicle configuration. The road tubes are connected to an electronic counter that logs and processes the data generated as vehicles cross the pneumatic tubes. MDT uses a single tube setup for volume counts. MDT has 179 active portable tube counters.

Non-Intrusive Traffic Data Collection Camera Units

Non-intrusive traffic data collection camera units continuously record images of traffic from a fixed field of view. The equipment used in Montana, from Miovision (Ontario, Canada) does not capture images of license plates or of vehicle occupants. Currently, the TDCA Section has nine Miovision Camera units, of which 2 units are 3 years old, 3 units are 2 years old, and 4 units are 1 year old. The equipment is usually mounted on a mast tied to a support pole (e.g. street light or sign post) and is chained /padlocked for security. Figure 3 shows a unit secured to a traffic light pole.

Figure 2 Typical Vehicle Classification Road Tube Setup (Wuertley & Little, 2013)

The video data are processed via a computer program from the vendor to determine volume and vehicle classification. This service is contracted out to the Miovision company. Note that unlike the road tube counters that classify vehicles into the FHWA 1-13 classifications (FHWA, 2012), the non-intrusive traffic data collection camera units classify vehicles based on their length. Vehicle length based classification is not unique to this particular system, but is also typical of other non-intrusive traffic data collection equipment, such as radar and acoustic units. If FHWA classification data are required, they can be obtained through reviewing the raw video and manually classifying the passing vehicles. The count duration for non-intrusive traffic data collection cameras varies from 36 to 48 hours to several days. It is a technology used by multiple agencies (e.g. MDT and MPOs) in Montana to collect short term traffic data.

Cameras are a non-intrusive sensing technology, i.e., sensors do not need to be placed in the roadway. Thus, an advantage of non-intrusive traffic data collection camera units is that they do not require traffic technicians to work in the roadway, which makes them safe to install and operate. Another advantage of using this technology for short term counts is that they are better at classifying motorcycles than road tubes.

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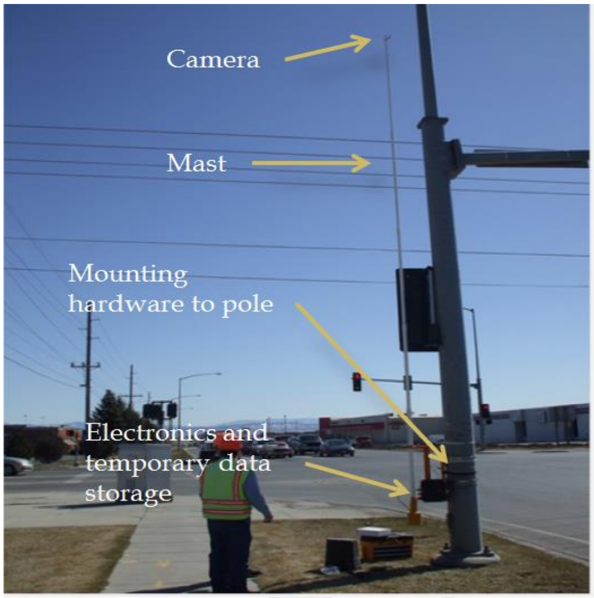

Figure 3 Typical Non-intrusive Traffic Data Collection Camera Unit Setup (Wuertley & Little, 2013)

Manual Count Board

For the manual method, traffic data are collected visually by traffic technicians and entered manually into an electronic count board (Jamar brand boards are used) via push-button controls. In addition to volume and vehicle classification (FHWA 1-13), data collected manually can also include special data such as number of bicycles, pedestrians, and recreational vehicles. The count duration is typically four hours. Manual counts are used as a quality control check on all permanent sites, as well as for intersection studies and special studies as needed by MDT. The four-hour manual counts used for special studies are mainly to provide the vehicle distribution (13 vehicle class) needed to develop project level accumulated vehicle loading forecasts for roadway design. While longer term automated counts (i.e, tube counts) are preferable to manual counts, such automated counts can be difficult to conduct at some locations (mainly urban areas). Miovision camera units can be used in such locations, but Miovision's post-processing only classifies vehicles into three classes, namely, large, small and passenger vehicle. Thus, manual counts need to be conducted on the data collected by the Miovision camera units in order to capture the vehicle distribution based on 13 vehicle classes. Manual counts have been conducted in response to requests for safety improvements relating to noise abatement studies or potential re-routing of traffic.

Permanent Site

ATR and WIM are the two principal types of permanent data collection equipment. A typical permanent site consists of 1) sensors embedded in the pavement for data collection as

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appropriate for the nature of the site; and 2) infrastructure that includes shoulder-mounted pull boxes, conduit (cabinet-to-pull box, pull box-to-pull box under the road where applicable), and a cabinet to hold various electronic components. The cabinet includes an electronic controller, with hard line or wireless communication access.

ATR sites

Piezoelectric sensors and inductive loops are the two major technologies used for ATRs in Montana. The ATR piezoelectric sensors are made by Measurement Specialties, Inc. (MSI), located in Wayne, Pennsylvania and the inductive loops are laid out by TDCA personnel using 14 AWG type 51-3 wire provided by various suppliers. The ATR electronics vendor is Diamond Traffic Products (Oakridge, Oregon).

Based on the data collected, there are four types of ATRs in Montana, namely volume only sites, class by length sites, class by axle sites, and motorcycle sites. The ATR configuration varies depending on the type of the site. For volume and length classifier sites, inductive loops are used. Axle classifier sites use both piezoelectric sensors and inductive loops. Motorcycle capable sites only use piezoelectric sensors (no inductive loops). The piezoelectric sensors used at ATR sites are a BL sensor, a type of PVDF piezoelectric sensor provided by MSI.

Figures 4-7 show the schematic layouts of the four site configurations. Note that for the configuration in **Error! Reference source not found.**, both half-lanes need to be used for collecting motorcycle data; only vehicle counts are collected if just one half-lane is used.

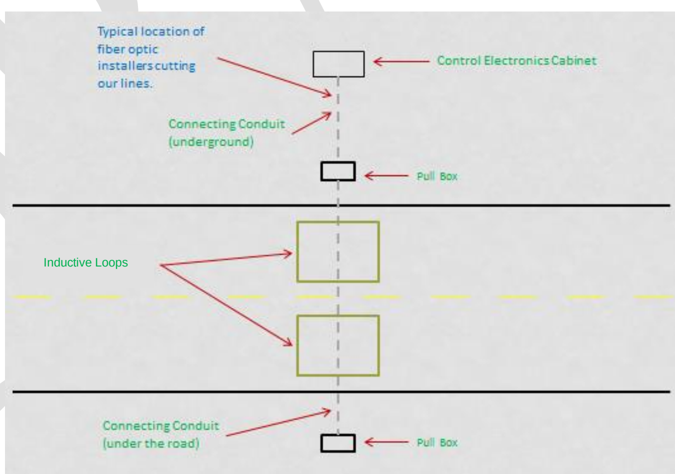

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Figure 4 Schematic Layout of an ATR Site—Volume Configuration (Wuertley & Little, 2013)

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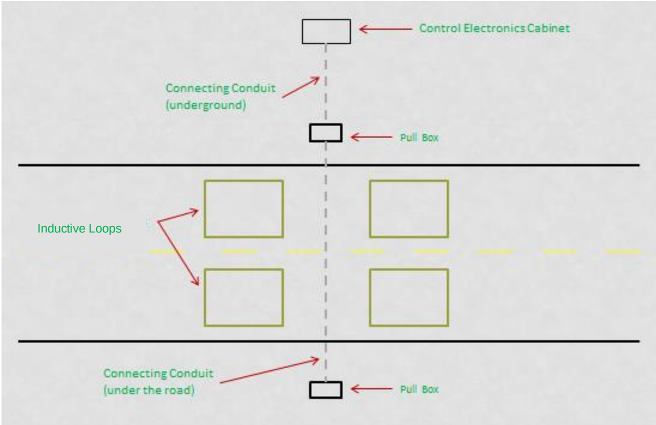

Figure 5 Schematic Layout of an ATR Site--Length Classifier (Wuertley & Little, 2013)

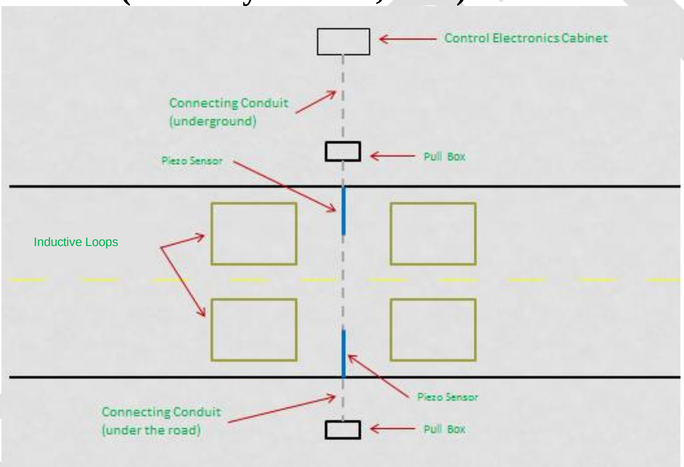

Figure 6 Schematic Layout of an ATR Site--Standard Axle Classifier (Wuertley & Little, 2013)

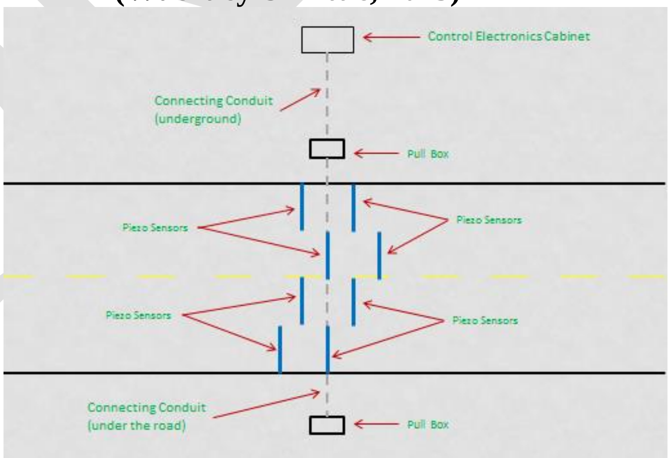

Figure 7 Schematic Layout of an ATR Site—Motorcycle Configuration (Wuertley & Little, 2013)

WIM sites

Error! Reference source not found. presents a typical configuration of a WIM site. Piezoelectric sensors are the main WIM technology used in Montana. Almost all the WIM sites use Kistler quartz piezoelectric sensors. Currently, there are a few sites using ceramic piezoelectric sensors provided by ECM, Inc. (Electronique Contrôle Mesure, Inc.), which will be upgraded to Kistler quartz sensors as schedules, time, and funding permit. Moreover, MDT will use Kistler quartz piezoelectric sensors for all new WIM sites as MDT has found that the quartz piezoelectric technology used in Kistler sensors results in a more accurate, reliable, longer lasting and lower maintenance system compared to other WIM options. Relative to accuracy, the quartz based piezoelectric sensors notably are more inherently stable than other WIM sensor options across the broad range of temperatures experienced in Montana. This inherent temperature stability results in improved performance at the low levels of traffic often encountered in the state.

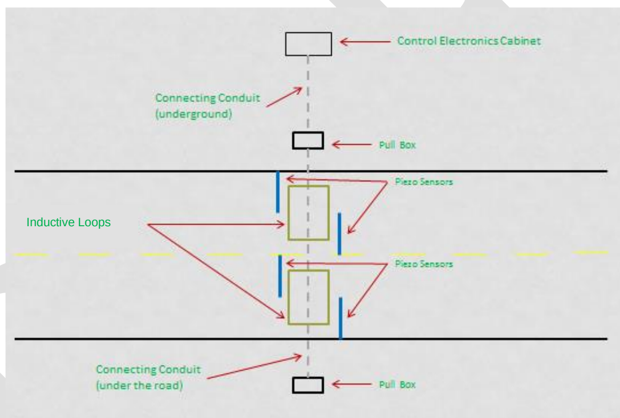

Figure 8 Schematic Layout of WIM Site (Wuertley & Little, 2013)

Communications

Hard line and cellular internet modems (wireless) are the most commonly employed communication technologies used by MDT for permanent data collection sites. In addition, digital subscriber lines (DSL) are used by two WIM sites, while a manual method is used by one ATR site (i.e., data is downloaded by connecting a computer to the system at the site). Table 7**Error! Reference source not found.** presents the number of permanent sites using each type of communication method. Hard line phone is more commonly employed for ATRs, while wireless internet is the most used communication technology for WIM sites. For wireless internet used for ATRs, most of them are for motorcycle capable sites. Cellular broadband has been considered by MDT, but has not been used due to low availability in remote areas.

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Table 7 ATR/WIM Communication Methods

Type	ATR	WIM	Total
Phone	52	17	69
Wireless Internet	9	18	27
DSL	0	2	2
Manual	1	0	1

Future Goals

Collecting traffic data in urban areas is generally problematic, and improving data collection in these areas is a major goal of MDT's traffic data collection program. Outside of urban areas, the currently employed data collection technologies generally meet the needs of MDT, especially the Kistler quartz piezoelectric sensors, which have been found to be very accurate, easy to maintain, and relatively insensitive to Montana's weather conditions. As sensors are replaced at existing WIM sites, MDT intends to transition to using all Kistler quartz piezoelectric sensors, and to use Kistler sensors at all new WIM sites. That being said, most available traffic data collection technologies have issues when deployed in urban environments where stop and go traffic, pavement conditions, and complex traffic movements generally degrade their performance. MDT continues to seek ways to improve collection of vehicle classification data within cities and urban areas that are capable of collecting accurate vehicle classification data under stop and go, and congested traffic conditions.

MDT is looking for a new type of sensor that is capable of collecting volume data on one-lane ramps in interchanges. The sensors and loops currently being used elsewhere could possibly work on such ramps, but their installation could get very complicated and expensive due to the manner in which the sensors/loops need to be hard-wired to the electronic equipment. Real estate in and around an interchange is much more restrictive than it is out on the open road, so physical wiring is much more difficult in interchange areas.

MDT has looked into micro loops for use as ramp sensors and in high volume urban areas. Micro loops are a passive sensing system (not electrically driven) that detect vehicles by noting the disturbance in the Earth's magnetic field as vehicles pass over the loops. This type of technology is more suited to interchange environments/urban areas than currently used sensors and standard inductance loops. However, since ramps are typically only one lane wide, closing down a ramp for several hours to install sensors/loops in the travel lane is not practical. The same problem with lane closure issues applies to high volume urban areas. Therefore, it would be better to use a non-intrusive sensor that could be installed next to, but not in, the lane of travel, and have that sensor connected wirelessly to a single controller that could simultaneously monitor all of the ramps of one interchange.

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COMPOSITION AND ORGANIZATIONAL STRUCTURE OF THE TRAFFIC DATA COLLECTION UNIT

The traffic data collection unit in MDT is the TDCA Section, which is one of two sections under the Data and Statistics Bureau along with the Road Inventory and Mapping Section. The TDCA Section has fourteen permanent employees and a supervisor. In addition, three temporary staff positions are available as needed. Figure 9 shows the staffing, organizational structure, and duties of the TDCA Section within MDT.

The TDCA Section is responsible for short-term and permanent traffic data collection, traffic data processing, and data QA/QC and analysis, as well as data presentation/display. The short-term count program within the TDCA Section has five full time equivalent (FTE) positions, with the program manager located in Helena, and four traffic technicians located one each in Great Falls, Glasgow, Missoula, and Billings. The short-term count program is responsible for the deployment, maintenance, and operation of short-term counts, and the collection and analysis of the attendant short-term data. Up to three seasonal traffic technicians can be hired based on the needs of the manual/short-term count program and to support special studies.

The ATR/WIM installation and maintenance program within the TDCA Section has four FTEs, with one electronic engineer, and three electronic repair technologists, all located in Helena. Even when WIM installations are contracted out, the ATR/WIM installation and maintenance program still assigns personnel to oversee the installation. In addition, the electronic engineer is involved in ATR/WIM site selection and budgeting, and the three electronic repair technologists perform equipment calibration and purchasing.

The TDCA Section has four FTE's for data download, processing and dissemination/display. One FTE is assigned for ATR/WIM data processing to download, process, and perform quality control (QC) on ATR and WIM data. The FTE for WIM data processing is also responsible for portable WIM/WIM-ATR installation. In addition, the section has one FTE assigned for traffic data analysis (such as developing adjustment factors, AADT for off system roadways, etc.) and one FTE particularly for WIM data analysis and reporting. Moreover, there is one FTE who has the responsibility to incorporate the traffic data into a Geographic Information System (GIS) and is also in charge of data requests. All the data processing staff is located in Helena.

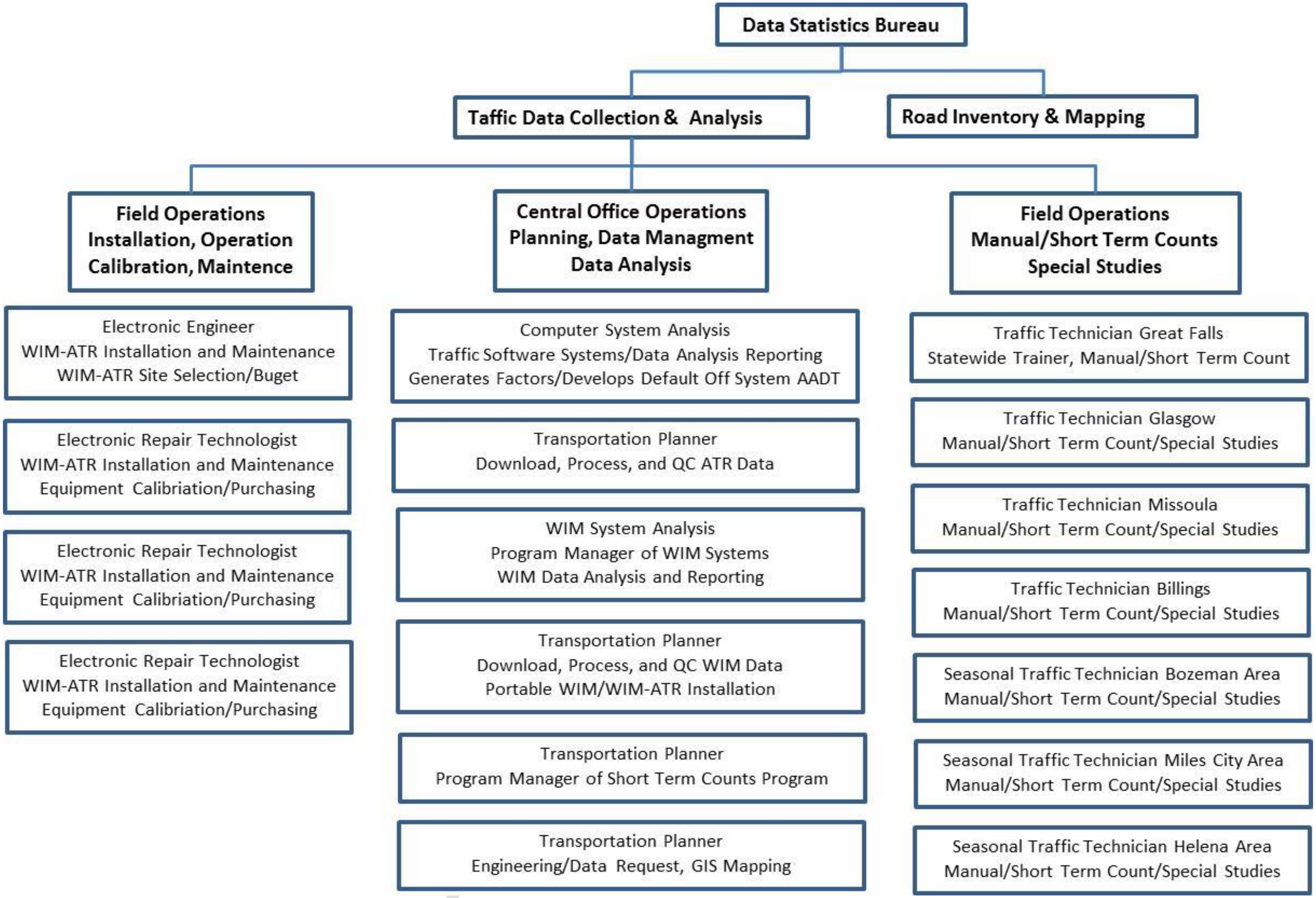

Figure 9 Organizational Chart of TDCA Section

MANAGEMENT AND OPERATIONS OF TRAFFIC DATA COLLECTION PROGRAMS

Traffic data collection sites, especially the permanent/continuous sites, involve expensive and sophisticated electronic equipment, which are a major capital investment for state departments of transportation (DOTs). After initial installation, proper maintenance, operation, and management of all this equipment is essential to ensure it functions at its full potential and hence maximizes the outcome of the capital investment. The TDCA Section of MDT is responsible for these critical tasks for MDT's data collection systems.

Short-Term Count Field Operations

The TDCA Section performs installation, removal, calibration, maintenance, repair, and data retrieval functions for short-term data counts. Only video camera image processing is contracted out (to the equipment vendor), as the video camera vendor controls the processing program. Maintenance for short term sites mainly consists of repair/replacement of road tubes. Calibration/diagnostics of road tubes is done in the shop with a device that simulates the air puffs generated when vehicles compress the tubes on the roadway. Further, when counts are being taken, MDT personnel routinely check to see if the tubes have come loose.

Data from portable count devices are transferred in the field to computers (typically laptops) via a wired interface using vendor-provided software. The data are typically transferred to the office by email or are uploaded to a shared drive. The data are checked for quality and accuracy before being incorporated into the traffic data system and made public. Also, as mentioned in previous sections, many cities, counties, and MPOs across Montana collect short term traffic data using portable equipment at various sites, especially in urban areas. Through its traffic count exchange program, MDT shares short-term counts with, and gets data from multiple agencies across the state.

Continuous ATR/WIM Site Field Operations

ATR sites are installed by field operations personnel within the TDCA Section, while WIM systems are installed by TDCA Section personnel or outside contractors. In the case of new WIM sites that are incorporated into a road construction project and are funded by the project, installation is contracted out. The TDCA Section additionally has its own funds that are sufficient to support installation of approximately one new WIM site every year, with this installation also being contracted out. Equipment necessary to restore existing WIM sites that are removed as part of road construction projects is paid for by those construction projects, and TDCA Section field operations personnel rebuild the installations. Note that in the case of contracted installations, MDT still must assign personnel to oversee contractor operations.

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Annual routine winter maintenance is done on all ATR/WIM sites starting in early fall and continuing into December. TDCA Section field personnel visit each site at least once a year and conduct a thorough on-site inspection and perform maintenance/repair activities as necessary. During these on-site inspections, field personnel conduct equipment tests and check all the system components, including sensor condition, site condition, batteries, etc. A detailed check list for ATR winter maintenance activities is attached in Appendix A. In addition to checking the equipment, field operations personnel also record the pavement condition at each site, since pavement condition has significant impact on site function. No quantitative measurements of the pavement surface condition are made, only qualitative observations are noted on the maintenance sheet.

Calibration of ATRs is performed during the winter maintenance cycle. Not all the ATR sites can or need to be calibrated. Volume only sites are not calibrated, since volume ATR sites use only one sensor per lane. The sensor loop either works (detecting the presence of a vehicle), or it does not work. Most of the volume only sites are in urban areas, where calibration runs would be difficult to make due to the continuous presence of traffic. To calibrate ATR sites collecting speed and length data, a service truck of known length is driven through the sites at a known speed (verified with a radar gun), and the measurements made by the site equipment are then compared to these known vehicle length and speed values. Equipment parameters are adjusted until the systems report accurate values.

As stated previously, manual counts are done as a quality control check on all permanent ATR and WIM sites. These counts are used to evaluate the accuracy of the number of vehicles detected and vehicle classification. These manual counts, however, cannot determine the accuracy of the speed or length data being collected. Manual counts are done a minimum of four times per year (once each quarter) and are four hours in duration. Manual counts are also conducted if major changes in calibration parameters are made to correct previously reported problems.

The WIM winter maintenance activities are essentially the same as are done for the ATRs, only calibration is not performed on the WIM sites during the winter maintenance activities. WIM calibrations are done typically in the spring and late summer/early fall, with every site being evaluated at least once per year. New sites are calibrated twice a year for the first two years, since the deformation of new pavement in the initial one or two years affects the WIM sensors; usually the pavement settlement stabilizes after two years. Generally WIM calibration is done in accordance with ASTM E1318, but MDT has its own criteria on measurement tolerances, which is much tighter than the criteria in the ASTM standard. A Class 9 truck weighing 78,000 lbs. is used for calibration as shown in Figure 10. The sites with Kistler quartz piezoelectric sensors are calibrated within ±3% of the gross weight, except for one or two

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sites with rough pavement surface conditions that result in a lower accuracy of ±8% of the gross weight. The ASTM standard criterion for Type II WIM systems is ±15% of gross weight. For the sites using ECM sensors, the accuracy is around ±10% of the gross weight, sometimes reaching ±7%.

Figure 10 WIM Calibration Truck

In addition to routine annual maintenance, special maintenance or repair work is needed when the ATR/WIM equipment fails or has functional errors. Replacement of equipment parts and repair work are scheduled as needed, which also depends on weather, personnel availability, and any on-going pavement construction projects.

All of the tasks mentioned above are best performed during favorable weather conditions. That being said, Montana has a short construction season coupled with harsh winters often characterized by long uninterrupted periods of protracted cold and/or snow. This situation has a significant impact on the field operations of the TDCA Section, with a major amount of work being compressed into the short field/construction season, and scheduled maintenance and necessary repair work throughout the rest of year often having to be deferred due to severe weather conditions. MDT keeps records of all the repair work done, but the data are not in a readily queried database format. To improve this situation, MDT is developing an Equipment Maintenance Module as part of the department’s new Traffic Data Management System (TDMS).

Relative to data retrieval, the ATR/WIM data are stored locally at the point of collection and polled daily via computers controlled by the central office. The data are downloaded directly to these computers, and then custom software programs distribute and process the files semi-automatically.

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System Management

MDT maintains a description record for all permanent traffic data collection sites. As the name implies, these records describe the characteristics/properties of a site, and include station ID, year station established, method of data collection, method of data retrieval, location, etc. Table 8 presents a full list of the data items included in the station description record.

Table 8 Station Description Record Items (FHWA, 2012)

Field	Description	Field	Description
1	Record Type	22	Type of Sensor
2	FIPS State Code	23	Second Type of Sensor
3	Station ID	24	Primary Purpose - *NEW*
4	Direction of Travel Code	25	LRS Identification - *NEW*
5	Lane of Travel	26	LRS Location Point - *NEW*
6	Year of Data	27	Latitude - *NEW*
7	Functional Classification Code	28	Longitude - *NEW*
8	Number of Lanes in Direction Indicated	29	SHRP Site Identification - *NEW*
9	Sample Type for Traffic Volume	30	Previous Station ID
10	Number of Lanes Monitored for Traffic Volume	31	Year Station Established
11	Method of Traffic Volume Counting	32	Year Station Discontinued
12	Sample Type for Vehicle Classification	33	FIPS County Code
13	Number of Lanes Monitored for Vehicle Class	34	HPMS Sample Type
14	Method of Vehicle Classification	35	HPMS Sample Identifier
15	Algorithm for Vehicle Classification	36	National Highway System - *NEW*
16	Classification System for Vehicle Classification	37	Posted Route Signing
17	Sample Type for Truck Weight	38	Posted Signed Route Number
18	Number of Lanes Monitored for Truck Weight	39	Concurrent Route Signing
19	Method of Truck Weighing	40	Concurrent Signed Route Number
20	Calibration of Weighing System	41	Station Location
21	Method of Data Retrieval		

Evaluation of the Current System and Future Goals

Currently, TDCA Section field operations personnel perform the installation, maintenance, calibration, and repair of the portable and permanent sites, only the new WIM site installations are contracted out. This approach generally meets current operational needs, but resources are strained, particularly in completing winter maintenance activities. As the number of sites increases, more staff will be needed to maintain the program, especially for field operations. In addition, more automatic processes will be needed to reduce the work load and enhance the efficiency of the entire program. For example, currently data retrieval and transfer from short-term counts are done manually via computer, either by email or uploading files to a shared drive. A program/technology that is capable of polling the data from short-term counts and transferring them into the data system will greatly reduce the work load of field personnel.

Pavement condition and pavement projects have significant impacts on the operation and accuracy of data collection sites, especially the permanent sites, and reciprocally elements of pavement restoration and preservation projects may be affected if an ATR/WIM site is within the project area. Currently, the TDCA Section gets notified by the Pavement Analysis Division when they recognize road projects that may affect an ATR/WIM site. The TDCA Section also monitors the scheduled project lists and project status reports to determine project status to check for projects impacts on ATR/WIM sites. That being said, there are no official procedures in place to notify the TDCA Section of impending pavement projects that could affect data collection activities. A better process is needed for notification and coordinating the activities of TDCA and the Pavement Analysis Division.

The station description record is the major source for information on MDT's inventory of permanent sites. The TDCA Section field operations personnel also maintain a record of the maintenance activities at each site. While system assets are well documented through this inventory and maintenance data, this information is not incorporated into a database management system. Such a system, populated with updated data on a regular basis, would be useful in proactively managing these data collection assets. Such a system would have to be easy to access, use, and maintain for TDCA field and office personnel. Quantitative measurements of ATR/WIM site pavement conditions need to be developed to more objectively characterize site condition, and so that these data can be readily incorporated into the system management database.

Currently, ATR/WIM site condition is basically represented by its age (i.e., years in service). This single index cannot fully describe the site's physical and functional conditions. Using the framework of the above mentioned database management system, a systematic assessment approach/method needs to be developed to evaluate and determine ATR/WIM site condition. The method should consider the site service years, maintenance history, calibration records, as well as site pavement condition to yield a composite index to describe the site's condition. Ideally, based on the assessed site condition, a guide/process can be developed to determine the optimal replacement cycle of ATR/WIM equipment to achieve the desired level of performance.

RESOURCES REQUIRED FOR THE DATA COLLECTION PROGRAM

Traffic data collection programs require considerable resources for system installation, maintenance, and data reduction, especially for the permanent ATR/WIM systems. Initial capital investment and ongoing field and office operations costs are the major expenses of the traffic data collection program. This section summarizes the costs of MDT's data collection program, with an emphasis on ATR/WIM systems (all cost information is the approximate average of the last five fiscal years and is adapted from (Wuertley & Little, 2013)).

Initial Capital Investment

The ATR/WIM setup costs cover the acquisition and installation of sensors, electronics, and infrastructure. Equipment costs vary for different types, brands, and layouts of systems. Usually, the sensors include epoxy materials and cabling; the electronic equipment includes controllers, modems, batteries, solar panels (if used), regulators, surge suppressors, etc.; and the infrastructure includes pull boxes, conduit, cabinets, and concrete (if used). Table 9 presents the average costs of these three major equipment components and the estimated total installation costs of ATR and WIM systems. Referring to Table 7, the setup costs are approximately six times greater for WIM compared to ATR installations. As might be expected, four-lane configurations cost more than two-lane configurations. Note that among all types of ATRs, motorcycle configurations are the most expensive.

Table 9 ATR/WIM Setup Costs

System	Component Cost ($)			Total Project Cost ($)	
	Sensors	Electronic Equipment (including communications)	Infrastructure	2-lane	4-lane
ATR	2,500/lane	2,000	1,700	8,700 (Motorcycle Config)	15,700 (Motorcycle Config)
WIM	15,000/lane	20,000	3,000	53,000	86,600

Annual Field Operations Expenses

While the initial setup cost for a portable counter is almost negligible compared to that of a permanent ATR/WIM, the annual operating costs of the short-term count program in Montana are still considerable, as almost 3,000 such counts are performed each year. The total annual cost of the short-term count program, consisting of operating (labor, equipment, and travel) and supply costs, is $321,370, as detailed in Table 10. The latest data show that MDT conducted a total of 3,252 short-term counts in 2012, including 2,872 portable unit counts, 315 manual counts, and 65 Miovision counts. Based on these figures, the average approximate cost for each short-term count was $100.

Table 10 Annual Operations Costs of Short-term Count and ATR/WIM Programs

Item		Portable Program($)	ATR/WIM ($)
Operating Costs	Labor	152,900	194,393
	Equipment	116,970	105,826
	Travel	31,500	13,500
	Sum	301,370	313,719
Supply Costs		20,000	113,000
Contracting Costs		N/A	105,000 (WIMs only)
Communication Costs		N/A	32,000
Total Costs		321,370	563,719
Approximate Average Cost per Counter/Site		100	5,581

Table 10 also presents the annual operations costs for MDT's ATR/WIM program itemized by type of cost and unit cost per site. The indicated equipment costs for the ATR/WIM programs are for equipment associated with WIM calibration activities. In addition to the regular operating and supply costs, annual costs of the ATR/WIM programs also include communication and contracting costs, since MDT contracts out WIM installation. Based on a total of 101 ATR/WIM sites (63 ATR sites and 38 WIM sites), the annual field operation costs per site is approximately $5,500.

Office Operations Costs

The major part of the office operation costs is the salaries of the office staff in the TDCA Section. This estimated cost is $356,000 annually. In addition, the office operation costs also include $104,107 per year in external contracted services (primarily for data processing). Thus the total office operation costs of MDT's traffic data collection program is $460,107 annually.

Summary of Program Costs

Total annual expenditures of the traffic data collection program are estimated to be approximately 1.7 million dollars, consisting of the approximately 1.3 million detailed above, and associated expenditures of 0.4 million dollars on personnel training, traffic data visualization and presentation, etc. That being said, due to weather and resource related constraints, necessary work to sustain the program (i.e., maintenance and repair) has had to be deferred; thus, program resource needs actually exceed the expenditures presented above.

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PROGRAM PLANNING/PRIORITIZATION

MDT generally follows the procedure described in the Traffic Monitoring Guide (TMG) (FHWA, 2012) in prioritizing and selecting new traffic data collection sites. In addition, rules and criteria have been developed by MDT over time to supplement the TMG procedures and address specific needs and requirements in Montana. Various factors are considered for ATR/WIM program planning, among which the most important is satisfying traffic data needs.

New Site Selection

Traffic data needs are the primary driving factor in selecting new permanent data collection sites. One important use of permanent sites is to characterize the traffic pattern for each function class and help determine the factors to adjust short-term counts to project annual levels of use. MDT determines the required number of permanent sites for each function class according to the method provided in the TMG. Changes in traffic patterns in one function class and/or the need for improved accuracy in adjustment factors can create a need for new permanent sites. Permanent traffic monitoring sites are also located to capture specific seasonal and spatially varying traffic flows encountered in the state as a result of significant economic activity in the areas of agriculture, natural resource extraction and tourism. In addition, new site selection also addresses the data needs of cooperative programs. For instance, new WIM sites can be and have been added to facilitate weight monitoring, enforcement, and other activities of Motor Carrier Services (MCS). The Montana Highway Patrol is another cooperative program that influences decisions on new site selection, since traffic data can be helpful in scheduling patrol activities. All such sites, however, still have to fit in some manner within the basic traffic data collection program and its objectives and needs.

The type of new permanent site, i.e., ATR or WIM, is usually determined by the nature of the traffic data needed to support the underlying activity that will use the data collected. Despite this general philosophy, most data users and MDT customers desire WIMs over ATRs, given that WIMs collect data encompassing all the data items collected by ATRs, and more. After a preliminary location is selected for a new site along a road section, MDT personnel are sent to the road section to evaluate if the road section and pavement condition are suitable for site installation. Condition items checked include roadway topography, utility availability, pavement conditions, and equipment specific criteria. The ATR/WIM site selection criteria are presented in more detail in Appendix B. Site upgrades from ATR to WIM are prioritized using similar criteria as for new site selection. In areas where motorcycle data are required, the upgrade of ATR to WIM is restricted, since the current WIM systems are not able to collect motorcycle data.

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MDT follows the method provided by the TMG for short-term site selection. Generally speaking, each on-system road traffic section (generally demarcated by changes in traffic control and or geometric alignment along a route) has at least one designated short-term count site. If road traffic sections change, new short-term sites are added. If a new interchange is built, for example, short-term sites will be added to monitor the associated changes in traffic flow. Currently, short-term traffic counts on off-system routes (i.e., routes that are not part of the highway network under MDT jurisdiction) are not a major concern to MDT.

System Planning/Prioritization

As with most public agencies, resource constraints dictate that careful program planning/prioritization are engaged in to ensure available resources are optimally used in meeting program objectives. Relative to installing/upgrading ATR and WIM sites, a meeting is held once a year to discuss the ranking of possible alternatives and select projects for installation/upgrade for the next fiscal year within the available budget. Project possibilities are identified throughout the year by TDCA Section staff and include those requested by various data users, and they are prioritized at the meeting based on how well they support 1) improvements in determining the adjustment factors used to project short-term counts to year around traffic flows, 2) data needs for pavement design, 3) weight enforcement, 4) collection of speed data, and 5) other objectives pertinent to a specific proposed project, judged in importance relative to the preceding criteria. Note that WIM sites that are temporarily downgraded to ATRs or out of service and need to be restored are also identified and considered during the meeting on new sites planning/prioritization. Usually, restoration of existing sites is given higher priority over new site installations.

Meeting participants are mainly personnel from the TDCA Section. However, it has been noticed that attendance of pavement engineers is of great help in project selection. Usually, funds are available to support one WIM installation per year. If roadway condition or other features of the top priority sites are not suitable for system installation/upgrade, consideration moves down the list until a viable site is found. It has happened in the past that the candidate project ranked 12th down the list was chosen for WIM installation. Another case when a candidate site ranked down the list is chosen for installation is when roadway construction is scheduled at the proposed site location of for the next fiscal year. Such sites are chosen for execution regardless of their ranking to synchronize installation with road construction to save resources.

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Evaluation of Current Methodology and Future Goals

Currently, MDT employs nine traffic factor groups and follows the TMG to determine the appropriate number of permanent traffic collection sites required to characterize each factor group. These groups are used with temporal adjustment factors to obtain annual traffic flows from short-term counts. At the present time, MDT uses a single set of adjustment factors statewide. Given Montana's geographically extensive highway network and the social-economic variance across different regions of the state, the TDCA Section has long recognized the need to develop regional traffic group factors, and further study and development of such regional factors is a forthcoming task on this project. Further, to better support future work of this kind, new ATRs/WIMs need to be appropriately sited to better capture significant seasonal and geographic traffic patterns by region.

Relative to selecting/prioritizing new data collection sites, while MDT follows TMG methods and applies several customized criteria in this regard, the decision making process ultimately is subjectively driven. While this approach has generally fulfilled the needs of the past, the landscape is changing with increasing traffic data demands from various users within and beyond MDT, the social-economic development in the state, the evolution of ATR/WIM technologies, as well as ongoing budget constraints. A hybrid approach incorporating subjective and objective criteria in site planning/prioritization will result in more optimum resource allocation. Mathematical algorithms are available to develop a more objective approach assigning weight to various influential factors in optimizing the deployment of ATR/WIM systems within budget and resource constraints. Taking informed professional opinion into consideration and employing suitable mathematical algorithms, a system planning/prioritization scheme that is appropriate to the situation in Montana can be developed, which is a major focus of Task 7 of this project.

Relative to maintaining existing data collection sites, an asset management plan needs to be adopted that optimizes the nature and timing of equipment maintenance, repair and replacement activities with the objective of collecting the best possible data at the lowest possible cost. Similarly, and as is obvious, in purchasing sensor systems for new data collection sites, life cycle costs should be considered in addition to initial capital investment costs.

Relative to very immediate actions, an official procedure may be merited to ensure the TDCA Section is notified regarding proposed pavement design, construction and maintenance activities. Ideally, the TDCA Section would have the opportunity to coordinate their plans with such activities to allow for more cost effective deployment/restoration of data collection sites.

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SUMMARY

A comprehensive description and inventory of the traffic data collection program at MDT was conducted as the second task in a project sponsored by MDT to review its traffic data collection program to ensure it provides the best possible traffic information in the most cost effective manner. Based on information provided by the TDCA Section and information available on MDT's website, the research team reviewed and documented

- the layout and characteristics of the basic traffic data collection network,
- the data collection technologies used,
- program management and operations,
- the organizational structure of the TDCA Section, program costs, and
- program planning/prioritization methodologies.

While considering both short-term counts and permanent sites, this task focused on permanent/continuous sites (ATR and WIM programs).

The TDCA Section of MDT is responsible for the traffic data program for the state highway system, and its activities include basic data collection at short term and continuous/permanent sites located around the state; installation, maintenance, and operation of all equipment required for this data collection; transmission, processing (including QA/QC), analysis; and presentation/display of the data that is collected. Currently the primary components of the data collection program are the permanent ATR and WIM sites deployed across the state at which continuous traffic monitoring is performed (62 ATR and 37 WIM sites), and the over 5,000 locations across the state at which short-term counts are done, with approximately 3,000 such counts being conducted each year. The continuous sites primarily use inductive loops and quartz-piezoelectric sensors for ATR and WIM data collection, respectively. Short-term counts are done with road tube counters and non-intrusive traffic data collection cameras, with some manual counts also being performed. TDCA Section field operations personnel (9 FTE) perform the installation, maintenance, calibration, and repair of the portable and permanent sites, only the new WIM site installations are contracted out. Data download, analysis and presentation/display processing is also done by TDCA Section personnel (4 FTE). Total annual program cost (labor, equipment, supplies, travel, contracted services, personnel training, etc.) is approximately 1.7 million dollars.

While MDT's traffic data needs have been generally met by the current traffic data collection program, the TDCA Section foresees the need for some changes in the future. In light of growing data needs/requests as design and planning methodologies and processes become increasingly data intensive, potential changes include among other things,

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a) expanding the traffic count exchange program with local entities to increase the data collection coverage across the state and optimize the allocation of limited resources;
b) tackling technical barriers to collecting traffic data in urban areas and on motorcycle operations;
c) refining data collection and analysis to better capture regional differences in traffic operations around the state, in part to support developing traffic group factors by region of the state;
d) seeking adequate resources needed to properly manage and maintain the ever growing short-term and permanent data collection systems;
e) improving physical management of the inventory of data collection equipment/facilities to optimize maintenance and replacement investments; and
f) developing a more formal strategy for siting new data collection locations to optimize resource investment across competing priorities.

Of a more immediate nature, an official procedure may be merited to ensure the TDCA Section is notified regarding proposed pavement design, construction and maintenance activities, relative to better managing data collection assets (both existing and proposed) that could be affected by such activities.

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Works Cited

Bylsma, R., & Carson, J. (2002). *Evaluation of Low-cost Weigh-in-motion (WIM) at Armington Junction Weigh Station.* prepared by Montana State University for the Montana Department of Transportation.

Carson, J., & Stephens, J. (2004). *A Comparison of Bending Plate and Piezoelectric Weigh-in-motion (WIM) Systems.* prepared by Montana State University for the Montana Department of Transportation.

FHWA. (2012). *Highway Performance Monitoring System: Field Manual.*

FHWA. (2012). *Traffic Monitoring Guide.* FHWA-PL-01-021, Washington D.C.

Qi, Y., Forsythe, S., Stephens, J., & Veneziano, D. (2013). *Report for Task 1 of Montana Weigh-in-Motion (WIM) and Automatic Traffic Record (ATR) Strategy.*

Wuertley, R., & Little, T. (2013). Traffic Data Collection and Processing.

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APPENDIX A

ATR Site Winter Maintenance

- Take GPS reading of site if needed
- Check Road Sensor Condition. (Piezos, Loops, Pull Boxes)
- Check General Site Condition
- Break and make terminal connections
- Record serial #'s for Modem and ATR
- Board versions
- Check batteries for corrosion, record voltages and do battery capacity test
- Check internal battery, record voltages and do battery capacity test
- If conditions are acceptable check output of:
    - Solar panel (Approx. 2 volts above battery given good sun)
    - Regulator output no load, also regulators with dual voltage outputs-14.2v and 7.5v
    - Note these values on ATR maintenance sheet
- Check for general wear and tear
- As needed:
    - Silicone / Tar cracks
    - Paint cabinets
    - Oil hinges
- Sensor Maintenance
    - Measure L, R, Q of loops and record results
    - Meg and Cap piezos and record results
- ATR Maintenance
    - Open box
    - Check Battery
    - Pull cards apart
    - Pull battery from card and drain caps
    - Replace cards
    - The unit should do a cold hard restart upon power-up.
    - Perform config and setup.
    - Call office to finish programming
- Run Calibration runs appropriate for site settings with office on phone

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APPENDIX B

ATR & WIM Site Basic Selection Criteria

General site selection criteria applicable to both ATR and WIM locations:

- **Roadway topography**:
  - Roadway should be as level as possible.
    - No hills or sharp curves within ¼ mile of either end of the proposed site.
  - Need at least 600 feet of straight, flat pavement at proposed location. (300 feet minimum upstream and downstream of the proposed sensor location).
  - Available right-of-way must allow cabinet to be placed outside of the clear zone, typically a minimum of 30 feet from the edge of the nearest lane of travel. (Clear zone distances depend on traffic volume, posted speed, road topography, and shoulder slope characteristics, so the actual distance can vary.)
  - Available right-of-way must be accessible by service vehicles for installation and maintenance purposes.
- **Utility availability:**
  - Electrical power:
    - *For solar sites:*
      - Exposure to the sun must be adequate to accommodate solar panel requirements in all seasons. Southern exposure should not have any obstructions more than 15 degrees above the horizon from 110 degrees to 250 degrees (east to west) if possible to accommodate the track of the sun during the winter months.
    - *For A/C powered sites:*
      - A/C power must be accessible via power lines located within 150 feet of right-of-way fence on the side of the road where the cabinet is to be located. We do not want overhead power lines to be placed over the highway near our sites as they interfere electrically with the sensors in the road.
      - Power should be able to be delivered to the cabinet via underground service. Utility easements from adjacent private landowners must be obtainable in order to run underground serve to the cabinet.

- Communications:
    - *Cellular phone service:*
        - This is the preferred communications service if it is available. Signal type and strength is measured at the proposed cabinet location to determine the feasibility of cell service.
    - *Land-line phone service:*
        - Only used if cell service is not available. Land-line service access must be within the provider's specified hook-up range (varies by provider) so that no installation charges are applicable in order to keep costs down. Line quality must be able to handle data transmissions. DSL service is acceptable (and is becoming preferable).

- **Pavement conditions:**
    - *Rutting:*
        - Cannot be more than ¼ inch deep for WIM sensor installation.
        - Can be more than ¼ inch deep but should not exceed ½ inch deep for ATR sensor installation.
    - *Cracking:*
        - Transverse cracking is acceptable if the cracks are no more than ½ inch in width and have enough space between them to accommodate the sensor array. It is preferable to avoid pavement with transverse cracks as crack width varies with the seasons and new cracks can form at any time, including in the middle of the sensor array.
        - Longitudinal cracking is not acceptable at all as this means the cracks must be crossed by the sensors/sensor leads, and seasonal changes in crack sizes will damages sensors/sensor leads.
    - *Spalling:*
        - Pavement that is spalling (or scaling, chipping, flaking or generally breaking up) is not acceptable as the surface deterioration will lead to sensor damage.
    - *Lift adhesion issues:*
        - Any signs of overlay lift adhesion issues are unacceptable as the loose lifts will move with traffic and tear the sensors out of pavement.
    - *Chip seal adhesion issues:*
        - Loose or missing chip seal should be avoided if possible as it will continue to come loose over time and drive a need for more sensor maintenance than is normally necessary. Excessive grinding on sensor surfaces due to missing chip seal leads to premature sensor failure.

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- **WIM specific criteria:**
    - *Calibration truck turn-around locations:*
        - For 4 lane installations, normal interstate exits are used. Exits should be at least 1 mile from the proposed site location and no more than 5 miles away if possible.
        - For 2 lane installations, turn-arounds should be at least 1 mile away and no more than 5 miles away if possible. 2 Lane turn-around locations have to be able to accommodate the size of the calibration truck, and have to provide adequate space to allow the truck to be driven safely out of the lanes of travel. Additionally, there has to be good visibility in both directions to allow the driver to safely return the truck to the lanes of travel. Unpaved turn-arounds are acceptable, but these have the limitation of being usable only in dry conditions as they typically will not support the weight of the calibration truck when wet. It is also highly preferable that all 2 lane truck turn-arounds are located within the highway right-of-way so as not to occur any liability issues when using private property.

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