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

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

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July 2015

ABSTRACT

This task report presents a process to systematically prioritize deployment of traffic data collection sites (specifically permanent Weigh in Motion (WIM) and Automatic Traffic Recorder (ATR) sites) using a weighted sum model (WSM) acting on various criteria critical to such decisions. This work was executed as part of a comprehensive project being done to assess the efficacy of the Montana Department of Transportation's (MDT's) traffic data collection program (i.e., Task 7 of this project).

Prioritization of the deployment of WIM and ATR sites is an important element of any traffic data collection program, as typically the number of candidate sites exceeds the available resources to deploy and maintain them. In such cases, the merits of each site must be carefully and systematically weighed to ensure the best solution is realized.

Presently, the approach used by MDT in prioritizing/selecting WIM/ATR sites could be characterized as subjective in nature. Features of potential sites are systematically listed, but these features are then subjectively discussed in determining priorities for deployment. This process does not necessarily follow a replicable framework in which each criterion is consistently applied with the same degree of importance across all alternate sites. Following the approach proposed herein, the importance of each criterion (its weight) is first established based on agency priorities. The degree to which each site meets each criteria is then estimated. These values are multiplied by the weights, and the results are summed to obtain a score for each proposed site.

Site prioritization decisions are not necessarily expected to be made based only on the scores generated by this process. Rather, these scores will provide a relatively quantitative and consistent evaluation of each site to be considered in further discussion of their comparative priority.

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INTRODUCTION

Prioritizing the deployment of Weigh in Motion (WIM) and Automatic Traffic Recorder (ATR) systems is an important aspect of any traffic data collection program. Agencies are typically faced with limited resources and the need to select only a subset of the total number of proposed sites. Ideally, adequate resources would be available to deploy and maintain a large number of permanent data collection sites over an entire region to capture the wide variety of seasonal, economic and other traffic trends that are present. In reality, it is possible to only deploy and maintain a limited number of continuous, permanent traffic monitoring sites throughout a state. Thus, when numerous candidate locations have been identified for consideration, the merits of these sites must be comparatively evaluated. Parameters considered in this evaluation include whether acknowledged gaps in data collection needs will be filled and what capital costs are involved.

The approach presently employed by the Montana Department of Transportation (MDT) in prioritizing/selecting WIM/ATR deployments uses a formal list of evaluation criteria which includes such items as traffic factor group data needs, physical pavement and roadway conditions at proposed sites, commercial vehicle weight enforcement data needs, etc. Based on this information, the proposed sites are ranked by MDT staff using their collective professional judgment. This prioritization approach has subjective elements in its execution, and thus it can be difficult to ensure that a) the various evaluation criteria have been consistently applied and b) the outcomes have been realized in a replicable framework.

In light of these potential limitations in their current process, MDT elected to explore more objective methodologies to prioritize selection of permanent traffic data collection sites. The following sections of this report discuss the factors to consider in prioritization and the proposed prioritization/ranking scheme that has been developed in this effort. This work is part of a comprehensive evaluation being conducted by MDT of its traffic data collection program to assist in determining the future direction of the program. Other work being done as part of this project can be seen at http://www.mdt.mt.gov/research/projects/planning/wim.shtml.

WIM AND ATR SITE SELECTION

This section provides an overview of the most important needs and criteria that are commonly (or should be) considered in the WIM/ATR prioritization process. Following this overview, the site prioritization process currently used by MDT is described. Note that in reviewing available literature from across the country on traffic data collection programs, no existing methodologies were found for objectively/quantitatively considering the various factors that influence site selection as part of the decision-making process.

WIM and ATR Site Selection Criteria

Key in prioritizing and ranking proposed WIM and ATR sites is understanding what activities the collected data will be used to support. Various uses of traffic data cited by the Traffic Monitoring Guide (TMG - FHWA, 2013) include pavement, bridge, and geometric design; pavement maintenance; design of traffic control systems; vehicle weight enforcement; vehicle speed enforcement; and local and network level planning activities. Essential to providing data for many of these tasks is the ability to estimate at any given location around the state annual traffic demands based on short term traffic counts (i.e., counts performed for just a few days) conducted at that location. Short-term traffic counts are modified to obtain year around traffic demands using seasonal traffic adjustment factors developed from continuous traffic counts conducted at permanent WIM/ATR sites. Thus, WIM/ATR sites need to be located to support accurate development of these factors. Further, and very pragmatically, additional siting considerations can include a) the degree to which specific roadway features at a proposed site are conducive to system installation and data collection, and b) if system installation can be synergistically done during a coincident construction activity planned at the intended site. These criteria are discussed in more detail below.

General Data Quality/System Coverage Considerations

As mentioned above, one of the most important uses of continuously collected WIM/ATR data is in the development of traffic adjustment factors. Following the traffic adjustment factor approach, the general pattern of traffic throughout the year is characterized using traffic data continuously collected from a finite number of permanent monitoring sites. The results of a short term traffic count (often performed in Montana for only 36 hours) can then be temporally matched against the annual pattern determined for routes carrying similar traffic - i.e., for a traffic factor group - to obtain a useful estimate of Annual Average Daily Traffic (AADT) at the short term monitoring location. Further, average daily traffic for other months and days of the year can be obtained for the short term site using daily and monthly adjustment factors available for the traffic factor group to which it is assigned.

Currently, MDT uses nine traffic factor groups, generally consistent with the primary functional classifications mandated in the Federal Highway Performance Monitoring System (HPMS – FHWA, 2012). These groups are:

1) Interstate - Rural
2) Interstate - Urban
3) Principal Arterial - Rural
4) Principal Arterial - Urban
5) Minor Arterial - Rural
6) Minor Arterial - Urban
7) Major Collector - Rural
8) Collector - Urban
9) Recreational

Two of these groups are typically combined due to the low number of data collection sites within them, i.e., Minor Arterial - Urban and Collector - Urban, resulting in eight traffic factor groups. Thus, all traffic flows on Montana’s highways are viewed as represented by one of the eight traffic patterns embodied by these groups.

Using the data continuously recorded by permanent WIM/ATR sites located on routes in each group, adjustment factors are determined to be used with short term data counts conducted at any point on any route included within the group. The accuracy at which these adjustment factors is determined for a given traffic factor group is a function of the inherent variability in the traffic patterns on the routes included in the group, and the number of sites at which these traffic patterns are monitored. Statistical procedures are presented in the TMG to determine the number of data collection sites necessary within a given factor group to obtain the desired level of precision for the attendant adjustment factors. The TMG recommends that factors be determined with 10 percent precision with 95 percent confidence for each individual group, excluding recreational groups (these groups tend to be subjective in their composition, and no recommended precision is specified). While these calculations can be reasonably performed, the TMG indicates that when these reliability levels are applied, usually five to eight continuous monitoring sites are required per factor group. The TMG goes on to comment that for most factor groups, at least six continuous counters should be included within each factor group, with due consideration of a few additional sites in the event of counter malfunction.

Note that the TMG also comments specifically on having an adequate number of WIM systems appropriately distributed across the state to characterize the weight related demands being placed on the highway infrastructure. Similar to traffic factor groups, weight groups are established to represent distinctive weight related characteristics of the vehicles using various elements of the highway system. A major use of weight related information is in pavement design, where a measure of the structural demand a vehicle places on the highway often is expressed in terms of equivalent single axle loads (ESALs), which reflect both the weight as well as the axle configuration of a vehicle. For project level work, MDT generates average ESAL factors by vehicle configuration and weight, by system. For network level work, this information generally is aggregated for the route classifications of interstate, and minor and major arterials (three weight groups). The TMG indicates that there should be at least two WIM sites per weight group, with a typical target of six WIM sites per weight group.

The number of WIM and ATR sites located on each functional class of highways is reported in Table 1. Referring to this table, relative to supporting calculation of traffic adjustment factors by functional classification (effectively, the traffic factor groups currently used by MDT), the highway classes with the most data collection sites are Interstate – Rural, Principal Arterial - Rural, Minor Arterial – Rural, and Major Collector – Rural, with at least six collection sites per system. The highway classes with the fewest data collection sites (three sites or less) are Minor Arterial – Urban, Collector Urban, Minor Collector – Rural, and Recreational. Relative to supporting vehicle weight related analyses, the highway classes with the greatest number of WIM sites are Interstate – Rural and Principal Arterial – Rural. All other highway classes have less than six WIM systems deployed on them.

Table 1. Distribution of WIM and ATR systems on the highway network by group class.

Functional Class	WIM	ATR	Combined
Interstate – Rural	14	6	20
Interstate – Urban	1	3	4
Principal Arterial - Rural	17	16	33
Principal Arterial - Urban	0	5	5
Minor Arterial - Rural	5	6	11
Minor Arterial - Urban	0	3	3
Major Collector - Rural	1	7	8
Collector - Urban	0	2	2
Minor Collector - Rural	0	0	0
Recreational*	0	12	12
TOTAL	38	60	98

* ATR stations in the recreational grouping are distributed over the following functional classifications: rural principal arterials (6 ATRs), rural minor arterials (5 ATRs) and rural major collectors (1 ATR).

As may be obvious, in assessing the adequacy of WIM/ATR coverage by highway functional class, important factors may be overlooked if only the number of data collection sites per functional classification is considered. Absent the performance of detailed statistical analyses as described in the TMG, other relatively simple metrics that could be of interest in such an assessment include geographic extent and volume of traffic carried on each functional highway class. As might be expected, current deployments of permanent WIM and ATR sites reflect both of these parameters, with highway classes that consist of more miles of roadway and that carry greater volumes of traffic correspondingly having more data collection sites (both WIM and ATR sites).

Considering, for example, geographic extent, one possible metric reflecting this parameter is data collection site density, simply calculated as centerline miles of roadway divided by number of data collection sites by highway class. This metric is reported in Table 2 by highway functional classification (mileage was taken from the HPMS (FHWA, undated)).

Table 2. Density of WIM and ATR sites (miles of highway/site) by highway class.

Functional Class	Centerline Mileage	Density (miles/site)		
		WIM	ATR	Combined
Interstate - Rural	1,129	81	188	56
Interstate - Urban	63	63	21	16
Principal Arterial – Rural	2,623	154	119	67
Principal Arterial – Urban	191	-	38	38
Minor Arterial – Rural	2,979	596	271	186
Minor Arterial – Urban	245	-	82	82
Major Collector – Rural	7,047	7,047	881	783
Collector – Urban	330	-	165	165
Minor Collector – Rural	8,817	-	-	-

- indicates no permanent, continuous data collection is done on this class of highways

Referring to Table 1 and Table 2, while the greatest number of combined data collection sites (WIM and ATR) is on the Principal Arterial – Rural system (numbering 39, including ATRs in the recreational grouping), and one of the fewest number of combined data collection sites is on the Interstate – Urban system (numbering just 4), considered from a miles/data collection site perspective, representation is stronger on the Interstate – Urban system (16 miles/site) compared to the Principal Arterial - Rural system (67 miles per site). The mileage that must be accounted for by each data collection site increases as functional classification decreases, as might be expected. Often the lower functional classifications carry less traffic, and they correspondingly have fewer data collection sites deployed on them. No continuous data collection is done on Rural Minor Collectors, although this classification comprises 8,800 centerline highway miles. WIM coverage also becomes particularly sparse in moving down through the functional classifications, notably with no WIM systems located on Minor Rural Collectors. Once again, traffic on these classes is lighter than on most other highway classifications.

While the metric discussed above – average miles of highway per continuous data collection site - provides a measure of the physical dispersion of WIM and ATR sites, it does not offer insight on their distribution by volume of traffic being monitored. Thus, a second metric of interest is the average vehicle-miles-of-travel (VMT) covered by WIM and ATR sites by highway classification, which is reported in Table 3. Once again, the data employed to calculate this metric came from the HPMS and is the estimated annual VMT in 2011.

Table 3. Density of WIM and ATR sites (millions of VMT/site) by highway class.

Functional Class	VMT (millions)	Density (millions of VMT/site)		
		WIM	ATR	Combined
Interstate – Rural	2449	175	408	122
Interstate – Urban	361	361	120	90
Principal Arterial - Rural	2284	134	104	59
Principal Arterial - Urban	985	-	197	197
Minor Arterial - Rural	1191	238	108	74
Minor Arterial - Urban	553	-	184	184
Major Collector - Rural	1134	1134	142	126
Collector - Urban	332	-	166	166
Minor Collector - Rural	438	-	-	-

- indicates no permanent, continuous data collection is done on this class of highways

Referring to Table 3, as might be expected, average VMT per data site by highway class is more closely grouped than average highway mileage per data site (reported in Table 2). Relative to combined data collection (WIM and ATR), the highest VMT per data site (197 million VMT per site) is for Principal Arterial – Urban. The lowest VMT per data site (59 million VMT per site) is for Principal Arterial Rural. As observed previously, no data is continuously collected at permanent WIM or ATR sites on the Minor Collector – Rural System (estimated traffic of 438 million VMT).

WIM sites provide varying levels of average coverage by VMT depending on the specific route classification being considered. Urban Interstate VMT is covered entirely by one WIM site, resulting in a relatively high level of VMT per site (361 million VMT), notably compared to

Interstate – Rural that has many sites (numbering 20) and an average of 175 million VMT per WIM site. Remaining WIM sites are located on rural Principal and Minor Arterials, and Major Collectors; no WIM systems are deployed on the Minor Collector - Rural system. The highest VMT per site is for Major Collector - Rural, with single site monitoring an estimated 1,134 million VMT.

In considering specifically WIM data collection to support vehicle weight related tasks (e.g., pavement design), average commercial vehicle VMT per WIM site might be a metric of greater interest than total VMT. Notably, passenger cars and light trucks, while constituting the majority of vehicles operating on the highway, only nominally contribute to load related design demands on a pavement structure. Load related design demands are almost solely due to commercial vehicle operations. Thus, future consideration should be given to generating a table similar to Table 3 in terms of WIM sites and commercial vehicle VMT.

Finally, relative to ensuring that traffic data collection efforts are providing adequate system coverage, other factors that should be considered include geographic region and local economic activity. In a geographic context, it is possible that while the total number of data collection sites deployed on a particular highway class statewide appears adequate (i.e., relative to number of sites, and roadway mileage and VMT per site), some regions of the state may have only a few or no WIM/ATR sites. If this is the case, some regions of the state are underrepresented in the overall network of WIM/ATR sites. Notably, if economic conditions change significantly in a particular region (e.g. rapid increase in oil exploration and production), additional data collection sites may be merited in that region.

Data Collection to Support Specific Activities

Several MDT activities very directly use traffic data in their execution, including pavement design, speed and weight limit enforcement, border security, etc. As introduced immediately above, one important use of WIM/ATR data is in pavement design. This is particularly true of WIM data, due to the significant impact of heavier vehicles on pavement deterioration. As would be expected, significant resources are required to repair and replace pavements, and WIM/ATR sites provide an effective system for monitoring commercial vehicle traffic and weights. This information is then employed when designing pavements for anticipated traffic volumes and vehicle weights on new and reconstruction projects.

Speed data from WIM/ATR sites is also used in reviewing and setting speed limits on different roads, as well as serving as an input in the design process for horizontal curves and other geometric features.

In addition to these uses, WIM/ATR data are used by specific agencies in various parts of their operations. Such data is used by Homeland Security to track goods movements across the U.S.-Canadian border. Motor Carrier Services uses WIM/ATR data to track goods movements throughout the state in order to better identify locations where weight enforcement should be done. Finally, other entities, such as the Montana Highway Patrol also use count and speed data from WIM/ATR sites to identify locations and corridors for increased or targeted enforcement, as well as in the analysis of crash trends.

Collectively, the uses of data in these activities should receive consideration when evaluating and ranking different potential sites.

Opportunistic and Situational Factors

Aside from the uses and users of data collected by WIM/ATR sites, other factors can play a role in identifying and selecting new sites to be deployed. Such factors are related to unique opportunities or specific conditions that favor (or disfavor) WIM/ATR installation at a particular location. Regardless of how these factors are categorized, they are aspects unique to a particular site that should be taken into account during the prioritization process. The following paragraphs discuss such factors in more detail.

One opportunistic factor that can exist is scheduled construction in the near future on a route or in an area for which improved data collection is desired. Such sites present an opportunity to deploy WIM/ATR systems coincident with other planned work (e.g., a widening or reconstruction project), which can minimize disruption of traffic and reduce some costs (e.g., construction mobilization, traffic control, and any paving costs). Consequently, an acceptable but less than ideal site may increase in priority for WIM/ATR deployment, depending on scheduled construction projects in the near future in the target area.

Situational factors that could impact WIM/ATR deployment generally are associated with existing site conditions pertinent to WIM/ATR performance. Somewhat more critical for WIM systems, pavement at deployment sites should be in good condition (smooth and free of distress) and strong enough to support the sensors, and the road alignment should be straight and flat. Traffic at proposed sites should be free flowing at a reasonable speed with minimal passing activity.

Additionally, WIM/ATR sites require power and communications infrastructure to run equipment and transmit data to centralized databases. In light of this, power and communications both represent situational factors that must be considered in evaluating prospective sites. In less populated areas of the state, providing power and communications at a remote location could represent a significant cost.

MDT WIM/ATR Site Selection Process

MDT's current approach to prioritizing WIM/ATR deployments considers all of the factors introduced above, although it is relatively subjective in nature. Potential sites are discussed and numerically ranked based on professional judgment at a meeting each year of Traffic Data Collection and Analysis (TDCA) Section staff and traffic data users. Using a checklist approach, each proposed site is evaluated based on whether they support:

traffic factoring,

collection of vehicle weight data,

data requirements for pavement design,

vehicle speed related data uses,

data needs of Motor Carrier Services, and

data needs of Home Land Security.

When any of these items will be supported by a proposed site, it is checked off in MDT's "WIM and ATR Installation/Prioritization Plan" spreadsheet, which is also used to track general comments about each site (MDT 2015). Comments are made about physical conditions at particular sites that are conducive or counter to system installation (e.g., pavement too thin), as well as about particular reasons for site installation (e.g., need to monitor oil field impacts). Based on this information and its discussion, a numerical ranking is assigned by consensus to each site to reflect its priority independently as a WIM or ATR site; with a further ranking of the two types of systems combined. These rankings and their justifications are recorded in the spreadsheet.

While this approach produces a prioritized list of WIM/ATR deployments, it is subjective in nature, and does not necessarily follow a replicable framework that consistently considers each factor using the same degree of relative importance in a manner that can be repeated from site to site and facilitate objective comparisons and rankings among them. There is a need for a more quantitative and objective prioritization process. From a quantitative perspective, such a process could use a set of weights to establish and consistently apply the relative importance of each criterion in the decision-making process. From an objective perspective, the approach would employ, as possible, a standardized method to establish the value of a particular feature or capability of a site. The use of a standardized framework will result in a prioritization process that reduces the subjectivity of the current approach and allows for a better comparison between sites.

PROPOSED PRIORITIZATION/RANKING SCHEME

In light of the different factors discussed in the previous section of this report, a prioritization/ranking scheme that facilitates a systematic evaluation of potential WIM/ATR sites was developed. The simplest form of multi-criteria decision analysis (MCDA) is a weighted sum model (WSM), in which each identified criterion is assigned a weight (reflective of its importance), and alternatives are evaluated by summing the product of how well an alternative meets the criteria times its weight. As identified above, the major criteria recommended for use in this case and the associated sub-parameters are:

1) improves the quality/comprehensiveness of the traffic data collected by increasing:
   a) the number of data collection sites within a traffic factor group (traffic factor groups currently are generally aligned with highway functional classifications),
   b) the geographic distribution of sites within a traffic factor group,
   c) the VMT coverage within a traffic factor group, and
   d) the coverage of recognized route/region of increased vehicle activity.
2) supports the direct use of traffic data in the activities of:
   a) commercial vehicle weight limit and safety enforcement,
   b) pavement design,
   c) safety analyses using speed data, and
   d) Homeland Security.
3) offers opportunistic/situational advantages factors specific to the proposed site such as:
   a) the site is already scheduled for other construction activity,
   b) has geometric and pavement conditions conducive to collecting good data, and
   c) has power and communications available.

Considerations in formulating a WSM include that the criteria used are comprehensive and independent, which were taken into account in selecting the criteria listed above. A WSM illustrating the use of these criteria with user assigned weighting factors and assessments of the degree to which each criterion is met by a potential site is presented in Table 4. All values used in the table are arbitrary, with the intent of illustrating execution of the prioritization methodology. While the weights used may accurately reflect agency priorities and objectives, they should be reviewed and adjusted as necessary by TDCA staff working together with other traffic data users. As structured in Table 4, the same WSM can be applied to both potential WIM and ATR sites. WIM versus ATR priority is embedded in the evaluation process through the vehicle weight related criteria of pavement design and weight enforcement. That being said, separate but generally similar models could be set up for independent prioritization of WIM and ATR sites, as is commented on further below.

Table 4. Proposed WIM/ATR Site Prioritization Scheme

Site Information					Summary of Scores				Prioritization Criteria and Weights															
									Quality/comprehensiveness of data					Support of specific user activities					Opportunistic/situational factors				Other extenuating circumstance	
Name	Dept Route	Dept RP	Func Class	WIM or ATR	WIM and ATR sites (w/ wgt)	WIM and ATR sites (w/o wgt)	WIM sites only (w/wgt)	ATR sites only (w/o wgt)	general coverage within groups	geographic coverage within groups	volumetric coverage within groups	route with increased activity	sub total	weight enforce	pave design	speed related safety and other activities	HS[a]	sub total	scheduled for other construct activities	alignment, pavement conditions, etc.	power and comm	sub total	score	explanation
									10	10	10	15	45	20	10	5	5	40	5	5	5	15	-	-
Sweetgrass	I-15	392	RI	WIM	84	92	84		0	56	61	50	19	50	100	100	100	30	100	100	100	15	20	replacement of exisitng site
Manhattan	I-90	287	RI	WIM	62	74	62		0	56	61	0	12	0	100	100	50	18	0	-50	100	3	30	analyze long term travel impacts
Judith Gap	N-63	20	RPA	WIM	45	21	45		0	0	0	50	8	100	100	50	50	35	0	-50	100	3		
Eureka	N-5	184	RPA	WIM	38	11	38		0	0	0	50	8	100	100	50	50	35	0	-100	0	-5		
E Culbertson	N-1	648	RPA	WIM	58	39	58		0	0	0	100	15	100	100	50	100	38	100	0	0	5		
S of Bridger	N-4	10	RPA	WIM	48	25	48		0	0	0	100	15	100	100	50	50	35	0	-50	0	-3		
Scobey	P-32	65	RMA	WIM	24	34	24		0	100	36	50	21	0	0	0	100	5	0	-50	0	-3		
Miles City	P-18	14	RMA	WIM	59	55	59		0	100	36	100	29	50	100	0	0	20	0	100	100	10		
Turner	S-241	43	RMC	WIM	44	55	44		100	100	63	50	34	0	50	0	100	10	0	0	0	0		
Stanford	N-57	35	RPA	ATR	28	32		32	0	0	0	100	15	0	50	50	50	10	0	50	0	3		
Forsyth	P-14	265	RMA	ATR	36	44		44	0	100	36	50	21	0	50	50	50	10	0	100	0	5		
N. of Terry	S-253	25	RMC	ATR	41	52		52	100	100	63	50	34	0	50	0	50	7.5	0	0	0	0		
Checkerboard	P-14	73	RMA	ATR	49	62		62	0	100	36	100	29	0	50	50	50	10	100	100	0	10		
Maxville	P-19	55	RMA	ATR	35	43		43	0	100	36	0	14	0	50	50	25	8.8	100	100	50	13		

-shaded cells are user entries -unshaded cells are WSM results

-darker shaded cells are weighting factors

[a] Homeland Security

In evaluating each individual site, participants in this process assign scores representing the degree to which a particular site meets various criteria and situational factors. The following paragraphs discuss the overall approach to assigning relative weights to the various criteria and subsequently assessing the degree to which proposed sites meet these criteria.

Note that final decisions on WIM/ATR deployment are not expected to be made simply based on the output from a WSM. Rather, results of the WSM are expected to a) promote more thorough and consistent discussion of various key factors that affect such decisions, and b) provide a relatively objective and quantitative input to be considered in what otherwise could be a subjective decision making process.

Criterion Weights

The first step in the proposed prioritization process is the assignment of relative weights to the identified criteria. In the specific structure suggested herein, the relative weights should sum to 100, as shown in Table 4. The values of these weights are very important, as they represent a binding assessment of the relative importance of the various factors and motivations that affect site prioritization. These relative weights have to be agreed upon among the individuals/agencies included in the evaluation process. Participants in this process include the TDCA Section staff and stakeholder groups that employ WIM/ATR data for pavement design, weight enforcement, planning, etc.

The weights suggested by each group are likely to differ based on the competing priorities of the entities they represent. If achieving consensus on values for the relative weights is difficult, average relative weights could be calculated for each criterion across the values suggested by the various stakeholder groups. These average values represent the collective opinion of these groups, assuming that input from each group carries the same weight. The average relative weights could then be further discussed as necessary. Values of the relative weights should be revisited in each ranking round or as often as deemed necessary to reflect changing needs and priorities of MDT and its constituents.

Reviewing the weights as they are assigned in Table 4, for example, shows that improving the quality/comprehensiveness of the data being collected is more important (collective weight of 45) relative to deploying a WIM or ATR system to take advantage of situational factors at a specific location (weight of 15). Viewed from a slightly different perspective, if two potential sites equally support improvements in the quality/comprehensiveness of the data being collected, the site that also has situational advantages will realize an increased score consistent with the advantage it offers (for the indicated example weights, the score could increase by a maximum of 15 points out of a possible total score of 100 points).

Assessment of Degree Criteria are Met

Another critical step in the ranking scheme is to assess for each proposed site the degree to which the site satisfies each criterion. This assessment is made on a scale of 0 to 100, with zero corresponding to a criterion unsupported by a given site and 100 corresponding to a criterion fully supported by a given site. Participants in this process are expected to only offer input on those criteria on which they have some knowledge and expertise. Motor Carrier Services, for example, may primarily and potentially only offer input on the degree to which proposed sites are important in their weight enforcement efforts. The TDCA Section may primarily determine the degree to which various sites would be expected to improve overall data quality and level of system coverage. Certainly, it is anticipated that the various participants in the process could generate different assessments of the degree to which a particular criterion is met by a given site, reflecting their individual professional experience and perspective. In such situations, the WSM could be executed with these different assessments and the results compared, and/or the assessments could be discussed and consensus reached on a value to be input for that criterion prior to executing the WSM. One such value might be the average score calculated from the individual stakeholder assessments.

For many of the criteria, and at the discretion of the participants in the process, numerical "scales" and/or guidelines could be developed to promote consistency in applying the criteria across potential sites, as described below for each category of criteria.

1) Improves the quality/comprehensiveness of the traffic data collected

Increase in number of data collection sites within a traffic factor group (currently corresponding to highway functional class)

The most comprehensive technique to assess the need and impact of increasing the number of data collection sites on a functional highway class (which as previously mentioned closely map to MDT's current traffic factor groups) is to use the statistical analysis procedure presented in the TMG for this purpose, coupled with a target reliability level. That being said, and as previously mentioned, at recommended data reliability levels (10 percent precision with 95 percent confidence), a minimum of six data collection sites (WIM plus ATR combined) typically are needed in a traffic factor group, with due allowance for sites that are temporarily offline. Thus, pursing a simpler but less precise approach, a scale could be used, for example, that assigned values of 0 to 100 for this criterion as follows:

No data collection sites on system	100
Sixteen or more data collection sites (counting WIM plus ATR on system)	0
For other cases, linearly interpolate between these two values	

This scale was simply established so that a "neutral" score of 50 would be assigned to a proposed site on a system with eight monitoring sites, which corresponds to the TMG "rule-of-thumb" that approximately six sites are required to realize an acceptable level of reliability, with contingencies (in this case, two additional sites) for sites being offline for maintenance and repair. To put this scale in perspective, the current disposition of data collection sites by system was presented in Table 1, with values ranging from 0 to 39 sites (combined WIM plus ATR sites) across the various functional classes, and an average of approximately 10 sites per system.

Improvement in centerline miles per data collection site by system

A strategic objective of traffic data collection programs typically is to increase data collection on elements of the system that have geographically sparse coverage. The previously introduced parameter of centerline miles of highway per data collection site calculated by system (reported earlier in Table 2) reflects the degree of current coverage in this regard (albeit assuming the sites are at least to some degree dispersed rather than clustered on the routes comprising the system). A scale for this metric could be, for example:

Average centerline mileage per site for system of greater than	100 mi	100
(or, no data collection sites are presently on the system)		
Average centerline mileage per site for system of less than	10 mi	0
For other cases, linearly interpolate between these values		

To a large extent, this scale was derived based on a subjective assessment of the general nature of traffic operations on the state highway network. Notably, traffic often is relatively constant on highway segments between one or more major intersections, with a range in major intersection spacing on the order of magnitude of just a few miles to 100 miles. Large values of average centerline miles per data collection site can imply that sites are too widely spaced to capture variations in traffic characteristics on different highway segments. This scale results in a score of approximately 50 for a proposed site on a system with an average mileage per site of 50 miles. Again, to provide some perspective on this scale, average centerline mileage per site ranges from 38 to 783 miles across the various functional classes (see Table 2), with an average value of 174 miles.

Improvement in VMT per data collection site by system

Another strategic objective of the traffic data collection program generally is to increase data collection on elements of the system that currently have relatively sparse data representation based on volume of traffic carried. The previously introduced parameter of VMT per data collection site, calculated by system, reflects the degree of this coverage (reported above in Table 3). Based on a qualitative review of current values for this metric, the following type of scale with scores ranging from 0 to 100 could be used:

Average VMT per site (WIM plus ATR sites) for system greater than 200 million (or, no data collection sites presently on the system)	100
Average VMT per site is less than 50 million	0
For other cases, linearly interpolate between these values	

This scale was simply derived based on current practice, by approximately bracketing the existing range of VMT per site across the various highway classes (see Table 3).

Provide better coverage of a route/region of increased vehicle activity

Professional judgment will have to be used in assessing the degree to which a proposed site meets the criterion of supporting data collection along a route or in a region of expected (or realized) increased vehicle activity. That being said, one possible approach for assessing the degree to which this priority will be met by a proposed site would be to assign a score relative to an extreme scenario generally familiar to the transportation community. Energy development in the Bakken, for example, is expected to have a significant impact on highway transportation in that region. It is difficult to foresee other events that would have more impact on traffic than the situation in the Bakken. Thus, proposed sites in the area impacted by the Bakken would be assigned a value of 100 for this criterion, with this criterion being scaled accordingly (using professional judgment) in other areas experiencing some form of distinct socio/economic event that has traffic impacts. This factor conceivably could be negative, if for whatever reason vehicle activity in a region is expected to decrease into the foreseeable future.

2) Supports direct use of data in various selected MDT activities

Commercial vehicle weight limit and safety enforcement

The degree to which a proposed site supports vehicle weight enforcement will have to be determined based on professional judgment. Generally, the type of site in such cases will be a WIM site. Factors to be considered for any given location include the expected degree of overweight vehicle operations, use of the route as a major corridor to transport equipment/commodities, the nature of equipment/commodities involved, etc. As for all the criteria, an important aspect in determining appropriate scores is relative consistency in their determination. For example, a location on a "heavily" travelled route with an expected high incidence of overweight vehicle operation, might be assigned a score of 100. Correspondingly, a site on a relatively "lightly" travelled route with an expected low incidence of overweight vehicle operation would be given a somewhat lower score, of say 30. Other situations would then be scored based on these benchmark values.

Pavement design

Pavement design is dependent on both vehicle weight and volume data. A fairly gross scale for this criteria could be a score of 50 for ATR sites, as only traffic volume/configuration data is collected, and a score of 100 for WIM sites, as both traffic volume/configuration and weight data is collected.

3) Offers opportunistic/situational advantages

Opportunistic advantages

Significant cost benefits are realized when WIM and ATR systems can be opportunistically installed coincident with a roadway construction/reconstruction project. This criterion is generally binary in nature, i.e., if coincident construction is planned at the proposed site, the input value is 100; if not, the input value is zero.

Situational advantages

As introduced above, favorable circumstances at data traffic collection sites include good pavement conditions (strong and free from distress); straight and flat roadway geometry; and free flowing traffic moving at a reasonable speed with minimal passing activity. The basis for one ranking scheme would be to assign a site a value of 100, if all of these conditions are well met, linearly transitioning to a value of zero, if none of these conditions are met. Further, if physical conditions at a site do not support deployment (i.e., the pavement is too thin), a negative score could be assigned to this criteria. Additionally, WIM/ATR sites require power and communications infrastructure to run equipment and transmit data to centralized databases. Similarly, one ranking scheme would be to assign a site a value of 100 if both power and communications are readily available, with a score of 50 assigned if only one these services is readily available.

4) Other extenuating circumstances

The intent of the WSM approach proposed herein is to include all the major factors involved in, and appropriately represent their effect on, the prioritization of future WIM and ATR deployments. Occasionally, however, some relatively unique feature of a proposed site that is obviously critical in the decision making process could fall outside the criteria listed above. While this factor could be introduced into the decision making process during subsequent discussion and formulation of final recommendations for the future, it can also be introduced by providing within the WSM the opportunity to adjust the total score for a site based on this factor. Thus, the WSM described in Table 4 includes an entry labeled "Other extenuating circumstance." The numerical value entered here simply is added to the weighted sum generated for the standard criteria. This entry could be positive or negative. An explanation of this input should/must be offered and readily accessible for review by participants in the prioritization process.

Prioritization of WIM Versus ATR Sites

The ranking scheme developed herein provides an objective comparison among sites regardless of the type of data collection, i.e., WIM or ATR. That being said, two WSM scores are calculated for each proposed site, one with and one without consideration of the weight related benefits sites may offer. The score calculated without weight related benefits is further re-normalized to produce a highest possible score of 100 points. This score effectively evaluates all proposed sites as ATR sites.

As a) WIM data can be used for very different purposes from ATR data, b) some funding available for data collection may be exclusively directed to WIM versus ATR systems, and c) WIM systems are significantly more expensive than ATR systems, there may be a need to separately prioritize proposed deployments by system. As previously mentioned, one of the outputs from the WSM already introduced effectively prioritizes deploying all proposed sites as ATR sites, namely WIM and ATR sites considered together, without weight criteria included in the assessment. While another output of this WSM is "WIM sites considered independently", this output evaluates the contribution of such sites to improving data quality and comprehensiveness only in the context of the volume/classification data a WIM site collects, rather than in the context of the weight data it collects. Recall that in addition to traffic factor groups, traffic weight groups are important to support agency tasks that are significantly dependent on load related vehicle characteristics, such as pavement design. Therefore, a second WSM was developed for prioritizing just WIM sites with the criteria addressing data quality/comprehensiveness being focused on WIM metrics rather than combined WIM and ATR metrics. An example of a WIM-focused WSM is presented in Table 5. Relative to appropriate criteria and scales, and following the earlier discussion of the combined WIM and ATR WSM, adjusted criterion and scales for the WIM-focused WSM could be:

Increase in number of WIM sites within a weight group (currently corresponding to highway functional class)

The TMG indicates that there should be at least two WIM sites per weight group, with a typical target of six WIM sites per weight group. A possible scale for this criterion thus could be:

No WIM sites on system	100
Six or more WIM sites on system	0
For other cases, linearly interpolate between these two values	

Following this scale, a score of 50 would be used for a proposed site on a system with three existing WIM deployments.

Improvement in centerline miles per WIM site by system

As discussed above for combined WIM and ATR sites, traffic in Montana often is relatively constant on highway segments between one or more major intersections, with a range in major intersection spacing on the order of magnitude of just a few miles to 100 miles. Based on this subjective observation, a possible scale for this criterion would be:

Average centerline mileage per site for system of greater than	100 mi	100
(or, no WIM sites are presently on the system)		
Average centerline mileage per site for system of less than	10 mi	0
For other cases, linearly interpolate between these values		

This is the same scale suggested for evaluating WIM and ATR sites together; however, for this WSM it is evaluated using average centerline miles per WIM site by system (i.e., as reported in the third column in Table 2), rather than average centerline miles per data collection system for WIM and ATR sites combined (i.e., as reported in the fifth column in Table 2).

Improvement in VMT per data collection site by system

As discussed above, the previously introduced parameter of VMT per data collection site, calculated by system, reflects the degree of data coverage by volume on each system (reported earlier in Table 3). Based on a qualitative review of current values for this metric, the following type of scale with scores ranging from 0 to 100 could be used:

Table 5. Proposed WIM Site Prioritization Scheme

Site Information					WIM Score	Prioritization Criteria and Weights														
						Quality/comprehensiveness of WIM data					Support of specific user activities					Opportunistic/situational factors				Other extenuating circumstance	
						general WIM coverage within groups	geographic WIM coverage within groups	volumetric WIM coverage within groups	route with increased weight activity	sub total	weight enforce	traffic group factors	speed related safety and other activities	HS[a]	sub total	scheduled for other construct activities	alignment, pavement conditions, etc.	power and comm	sub total	score	explanation
Name	Dept Route	Dept RP	Func Class	WIM or ATR	WIM Score	10	10	10	15	45	15	15	5	5	40	5	5	5	15	-	-
Sweetgrass	I-15	392	RI	WIM	88	0	81	87	50	24	50	43	100	100	24	100	100	100	15	25	replacement of exisitng site
Manhattan	I-90	287	RI	WIM	61	0	81	87	0	17	0	26	100	50	11	0	-50	100	2.5	30	analyze long term travel impacts
Judith Gap	N-63	20	RPA	WIM	34	0	100	67	50	24	0	17	50	50	8	0	-50	100	2.5		
Eureka	N-5	184	RPA	WIM	42	0	100	67	50	24	100	17	50	50	23	0	-100	0	-5		
E Culbertson	N-1	648	RPA	WIM	64	0	100	67	100	32	100	33	50	100	28	100	0	0	5		
S of Bridger	N-4	10	RPA	WIM	39	0	100	67	100	32	0	33	50	50	10	0	-50	0	-2.5		
Scobey	P-32	65	RMA	WIM	54	16	100	100	50	29	100	47	0	100	27	0	-50	0	-2.5		
Miles City	P-18	14	RMA	WIM	56	16	100	100	100	37	0	64	0	0	10	0	100	100	10		
Turner	S-241	43	RMC	WIM	52	84	100	100	50	36	0	75	0	100	16	0	0	0	0		

-shaded cells are user entries

-unshaded cells are WSM results

-darker shaded cells are weighting factors

[a] Homeland Security

Average VMT per WIM site for system is greater than 200 million
(or, no data collection sites presently on the system) 100
Average VMT per WIM site is less than 50 million 0
For other cases, linearly interpolate between these values

Once again, this is the same scale suggested for evaluating WIM and ATR sites together; however, for this WSM it is evaluated using average VMT per WIM site by system (i.e., reported in the third column in Table 3), rather than average VMT per data collection system for WIM and ATR sites combined (e.g., as reported in the fifth column in Table 3).

Provide better coverage of a route/region of increased heavy vehicle activity

Heavy vehicle traffic increases and decreases in response to many factors, generally connected to changes in economic activity in a particular industry and area of the state. Professional judgment will have to be used in assessing the degree to which a proposed site meets the criterion of supporting WIM data collection due to expected (or realized) increased heavy vehicle activity. Once again, areas affected by energy development in the Bakken could possibly provide a benchmark for scoring this criterion. Routes/areas feeling direct impacts of intensive well drilling activity could be scored as 100 on a zero-to-100 scale, while areas provide ancillary support for these activities are scored at 50. Increased heavy vehicle operations at other locations and for other reasons around the state would be assessed in the context of the Bakken activity.

Two additional changes were made to the WIM-focused WSM. Improvements in the quality and comprehensiveness of the weight data collected directly supports pavement design. Thus, this criterion was removed as a separate input from the category “Support of specific user activities”. Additionally, WIM sites do collect traffic volume/classification data which is used for among other things, traffic group factoring. Thus, in prioritizing potential WIM sites, the degree to which they contribute to improving the quality and comprehensiveness of volume/classification data should be considered. The corresponding factor included in the WIM-focused WSM is the subtotal from the WIM and ATR WSM for the category “Quality/comprehensiveness of data,” with an adjusted weighting factor (from 45 to 15 percent) to reduce its influence on the model results, consistent with the focus of this WSM being on weight data rather than volume/classification data.

Use of the WSM Output

The WSM processes developed herein are intended to help identify top priority WIM and ATR sites for further consideration and selection based on program objectives as embodied in the criteria and weighting system used in the WSM. While the outcomes appear numerically crisp, the process is sufficiently subjective that users should be careful not to place too much emphasis on the exact numerical scores that are generated. The list of prioritized sites that is produced can serve as a starting point for further discussions between stakeholders that will lead to final selections. It is important to note that while some situational/opportunistic factors may have implications on deployment cost, the capital investment required to build a proposed site (i.e. its total cost) is not currently directly used in the prioritization scheme. Conceivably, this could be accounted for after the initial rankings have been developed by considering the cost of the top sites generated by the ranking process before making final site selections.

Note that the proposed criteria, weights and "scales" suggested above for the WSM also provide one starting point to generally identify data collection sites that merit consideration by MDT. Any element of the highway system, for example, with a high score for criteria related to data quality/comprehensiveness is a candidate for deployment of a new data collection site. Other criteria similarly may suggest general elements of the transportation network on which improved data collection is merited.

Sample Results from Ranking Scheme

In addition to generally describing the WSM structure that could be used in prioritizing WIM and ATR site deployment, Table 4 and **Error! Reference source not found.** also include sample assessments of various potential WIM and ATR sites on the state highway network. These sample assessments were drawn from the MDT WIM and ATR Installation/Prioritization Plan spreadsheet that includes a) all the sites considered for the 2014 construction season, b) various entries on their characteristics, and c) their rankings. The spreadsheet includes approximately 80 sites, consisting of 30 WIM sites and 50 ATR sites. For demonstration purposes, 14 sites were used, 9 WIM sites and 5 ATR sites. These sites were qualitatively selected to cover the more common highway classifications and to include some diversity in site characteristics. More WIM sites were selected than ATR sites for demonstration purposes, as this underlying project is focused more on WIM systems than ATR systems. The degree each site met the various prioritization criteria was evaluated using the information available in the spreadsheet and professional judgement.

As previously mentioned, the WIM and ATR Installation/Prioritization Plan spreadsheet contains information on each of the criteria proposed in the WSM. However, and as previously mentioned, the relative importance of each criterion (i.e., its weighting factor) is not apparent in the current MDT prioritization scheme as embodied in this spreadsheet. Thus, the weights used in the WSM were generated by the researchers and need to be reviewed and modified as appropriate by MDT. Additionally, the degree to which each criterion is met by each proposed site is generally treated in binary fashion in the spreadsheet. That is, each criterion is either checked-off or not, with no indication of the relative degree to which the criterion is met by a particular site. Thus, to more fully demonstrate the proposed WSM, some refinement had to be introduced in the degree by which various sites met various criteria.

For the data quality/comprehensiveness criteria in the WSM, refinement of the degree to which a particular site met these criteria was readily accomplished using the example scales introduced earlier. For other criteria, refinement was introduced simply using broad rationale based on their nature. For example, several sites are reported in the spreadsheet as contributing to data needs of Homeland Security. For purposes of this demonstration, and with only the broadest justification, sites located at or near the border were scored 100 for this criterion, while sites distant from the border were scored 50. Many WIM and ATR sites reportedly supported pavement design needs. Once again, the degree to which these needs were supported by each site was not presented in any detail. The decision was made to score WIM sites at 100, as they provide both weight and volume data which are used in pavement design, while ATR sites were scored at 50, as they provide only volume/classification data. Similar, simple rationale were used across the remaining criteria

The results of these sample prioritization calculations for the WIM and ATR WSM and the WIM-focused WSM are included in Table 4 and **Error! Reference source not found.**, respectively. An immediate observation in reviewing these results is that both prioritization schemes generate a considerable range in final site scores, with these scores moderately well distributed within these ranges. Considering prioritization of WIM and ATR sites together (Table 4), scores across the 14 sites considered ranged from 28 to 84 out of 100. Scores ranged from 28 to 62 (Table 4) and 34 to 88 (**Error! Reference source not found.**) out of 100 for the five ATR and nine WIM sites, respectively, when considered independently. As previously mentioned, while the numerical results of these models appear exact, due to the subjectivity in arriving at some of the numerical inputs, the results are only approximate. In light of this uncertainty, if all the results were in a narrow range, or clustered tightly around certain values, the usefulness of their precise numerical order would be diminished, as modest changes in the subjective inputs could change this order. More widely spaced scores increases the likelihood that substantive differences in site priorities do exist, rather than these differences simply being introduced by inherent variability in assessing the input parameters.

To offer further perspective on the proposed prioritization schemes, the site scores the WSM and presented in Table 4 and **Error! Reference source not found.** were used to rank the relative priority of these sites (see

Table **6**). It is difficult to comment on these results, as the "correct" priorities are unknown. That being said, in some cases these results can be compared to the priorities actually assigned by MDT to these potential sites, as these priorities are included in the WIM and ATR Installation/Prioritization Plan spreadsheet. Such a comparison, for example, is provided by columns (d) and (f), and columns (e) and (g) in

Table **6**, respectively, for ATR and WIM sites ranked independently (comparison of the rankings for the WIM and ATR sites considered together was not possible based on the information available in the MDT spreadsheet). Recall that the MDT spreadsheet considered approximately 80 total sites, consisting of 30 WIM sites and 50 ATR sites, while this demonstration considers only 14 of these sites, consisting of 9 WIM sites and 6 ATR sites. Thus, for the purposes of this comparison, the MDT priorities were renumbered for these subsets of WIM and ATR sites, based on each site's relative rank within the larger population of sites considered.

Referring to Table 6, i.e., comparing the entries in columns (d) and (f) and columns (e) and (g), it is apparent that the sample rankings determined using the proposed WSM prioritization approach and those determined by MDT are not closely correlated. The correlation coefficients in both cases are approximately 0.3. This outcome is not unexpected, as several assumptions were made by the researchers in refining input information to execute the WSM (i.e., the relative importance of the various criteria was assumed, as well as the specific degree to which each site met these criteria). When the WSM approach is put into practice, the criteria weights and subsequent scores for each site will be better determined by MDT personnel integrally involved in traffic data collection and its use. The inherent subjectivity in the process used by MDT to arrive at their rankings could also have contributed to some variability in their outcomes, and corresponding absence of strong correlation between the MDT and WSM generated priorities.

Table 6. Prioritization of Sample Results

Site Information					Relative Priorities - WSM Models -					Relative Priorities - MDT -	
					WIM and ATR considered together				WIM site focused criteria		
Name	Dept Route	Dept RP	Func Class	WIM or ATR	(a) WIM and ATR sites (w/ wgt)	(b) WIM and ATR sites (w/o wgt)	(c) WIM sites only	(d) ATR sites only	(e) only using WIM criteria	(f) MDT ATR sites only	(g) MDT WIM sites only
Sweetgrass	I-15	392	RI	WIM	1	1	1		1		1
Manhattan	I-90	287	RI	WIM	2	2	2		3		3
Judith Gap	N-63	20	RPA	WIM	7	13	6		9		4
Eureka	N-5	184	RPA	WIM	10	14	8		7		6
E Culbertson	N-1	648	RPA	WIM	4	9	4		2		7
S of Bridger	N-4	10	RPA	WIM	6	12	5		8		5
Scobey	P-32	65	RMA	WIM	14	10	9		5		8
Miles City	P-18	14	RMA	WIM	3	5	3		4		2
Turner	S-241	43	RMC	WIM	8	4	7		6		9
Stanford	N-57	35	RPA	ATR	13	11		5		4	
Forsyth	P-14	265	RMA	ATR	11	7		3		3	
N. of Terry	S-253	25	RMC	ATR	9	6		2		5	
Checkerboard	P-14	73	RMA	ATR	5	3		1		1	
Maxville	P-19	55	RMA	ATR	12	8		4		2	

CONCLUSIONS

The prioritization of WIM and ATR sites is an important aspect of any traffic data collection program. Due to resource constraints, agencies typically are unable to deploy and maintain all the sites necessary to ideally support data user needs. Thus, a process is necessary that systematically and uniformly assesses the relative importance of each site based on agency priorities. Presently, MDT has such a process that uses a list of evaluation criteria that includes such items as traffic factor group data needs, physical pavement and roadway conditions at proposed sites, commercial vehicle weight enforcement data needs, etc. Based on stakeholder discussion of this information, the proposed sites are ranked by MDT staff using their collective professional judgment. This process does not necessarily follow a replicable framework in which each criterion is consistently applied in making prioritization decisions. To address this, an alternative process was developed herein which proposes to facilitate a systematic evaluation of potential data collection sites using a WSM approach.

The proposed WSM approach includes the same criteria used in the current MDT prioritization process. Following the WSM approach, each criterion is assigned a weight which reflects its relative importance to the agency. Subsequently during the site assessment process, numerical scores are assigned indicating the degree to which the site meets each criterion, and its total score is determined as the sum of the score for each criterion multiplied by that criterion's weighting factor. The criteria considered in the WSM were grouped into the categories of data quality/comprehensiveness, specific data user needs, and opportunistic/situational factors. Two WSM models were developed, one that considers ATR and WIM sites together in the prioritization process, and one that considers them separately.

To demonstrate WSM operation, sample weights were assigned to the various criteria and sample scales were used to evaluate the degree to which sites meet these criteria. When this approach is implemented, both these weights and scales should be reviewed and modified by MDT personnel, as necessary, based on their intimate and expert knowledge of MDT's needs. The WSM were demonstrated using information available from past MDT prioritization work, consisting of the sites being considered, their characteristics, and ultimately the priority they were assigned. To execute the WSM, several assumptions had to be made in the criteria scoring process, notably to refine the degree to which a particular site met certain criteria. In this demonstration application of the WSM, rankings produced by the WSM only moderately correlated with the actual rankings generated by MDT (correlation coefficient of 0.3), in part due to these assumptions. In practice, the user of these WSM will be MDT personnel intimately familiar with the sites and data needs of the program, and thus their assumptions will be well founded and will support the generation of accurate and useful results.

The expectation is that the results of the WSM will not be the sole input used in the decision-making process for WIM/ATR site prioritization. While factors important to this process are considered in the WSM, the problem is complicated, and the WSM may not fully represent and adequately model all the unique elements of a particular siting decision. Nonetheless, and with some adjustments by the users, the WSM will provide a quantitative input to this process based on a systematic and uniform consideration of many of the important factors involved.

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