MICHIGAN DEPARTMENT OF TRANSPORTATION

NONMOTORIZED DATA COLLECTION AND MONITORING

Program Guide and Implementation Plan

Prepared by Toole Design with
University of North Carolina, Highway Safety Research Center

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ACKNOWLEDGEMENTS

Michigan Department of Transportation

Josh DeBruyn, AICP, Pedestrian and Bicycle Coordinator/Specialist, Co-Project Manager

Edward Potter, Transportation Planner, Co-Project Manager

Debra Alfonso, Intermodal Policy Division Manager

Chris Hundt, Supervisor - Travel Information and Electronic Services Unit

Kyle Kirchmeier, Transportation Planner

Charles Jarvis, Graphic Designer

Consultant Team

Tom Huber, Toole Design

Joe Fish, Toole Design

Frank Proulx, Ph.D., Toole Design

Krista Nordback, Ph.D., University of North Carolina, Highway Safety Research Center

INTRODUCTION

Why count bicyclists and pedestrians?

In recent years, cities and states throughout the United States and internationally have increased the amount of data they collect on their transportation system, with particularly large growth in nonmotorized data collection systems. This growth can be attributed to a combination of factors, including the development of automated data collection technologies, greater data management and processing capabilities, a broad interest in data-driven policymaking, greater interest in bicycling and walking generally, and the increased awareness by the Federal Highway Administration (FHWA) of the importance of nonmotorized counting, with an explicit inclusion and coverage of nonmotorized traffic volume data collection in the 2013 edition of the FHWA Traffic Monitoring Guide (TMG) and subsequent revisions.[1]

Nonmotorized traffic data can fulfill a range of needs for transportation planners and engineers. As confirmed through a series of surveys and discussions with Michigan transportation planners and engineers, these include:

- Tracking levels of walking and bicycling over time,
- Conducting before and after counts of bicycle and pedestrian projects,
- Controlling for exposure in traffic safety studies,
- Understanding determinants of nonmotorized travel,
- Informing investments and prioritizing infrastructure projects,
- Prioritizing infrastructure projects,
- Optimizing signal timing for all modes,
- Informing studies of economic and health impacts of nonmotorized travel, and
- Calibrating travel demand models.

"Measure what matters"

For years, bicyclists and pedestrians were rarely counted as part of traffic. Decisions were made regarding investments and accommodations with little regard to this type of traffic. Safety studies reached conclusions without the benefit of crash rates for bicycling and walking, as count data to determine levels of exposure was lacking.

Fortunately, the importance of walking and bicycling as part of the multimodal transportation system has become more widely recognized concurrent with increasing availability of nonmotorized count technologies and data management tools. Although counting nonmotorized traffic is different than counting motor vehicles, many of the same protocols and techniques can be used and sometimes the same count locations can be shared. All of this results in a comprehensive and systematic means of counting all transportation system users.

[1] Federal Highway Administration 2016 Traffic Monitoring Guide. ***www.fhwa.dot.gov/policyinformation/tmguide***

Project purpose and process

The Michigan Department of Transportation (MDOT) initiated this project to develop the Nonmotorized Monitoring Program in early 2017. The purpose of the project is to establish a strategic, coordinated, and efficient approach to collecting and analyzing nonmotorized volume data in Michigan. The outputs of the program will enhance MDOT's ability to plan for and implement projects that improve conditions for people who walk or bicycle. Additionally, providing nonmotorized volume data will begin to address the data gap between motorized and nonmotorized modes of transportation in Michigan and may eventually support development of walking and bicycling performance measures.

Local agencies across Michigan will benefit from the guidance developed through this project and by having access to a centralized database where they can store and analyze their data. The data produced through the program will also help FHWA achieve its goals related to data collection and nonmotorized transportation.

The key steps in the program development process included:

» Reviewing statewide motorized and nonmotorized traffic monitoring and data management practices,

» Conducting stakeholder outreach,

» Developing program goals and the program technical structure,

» Collecting nonmotorized volume data,

» Developing a consolidated data file,

» Establishing a factor group framework, and

» Identifying actions for MDOT to implement.

Primer on Nonmotorized Traffic Monitoring Programs

Nonmotorized traffic monitoring programs are typically comprised of three components: a permanent count program, a short-duration count program, and an as-needed count program. Permanent/continuous counters are installed at fixed locations and continuously monitor bicycle or pedestrian traffic, with the primary goal of understanding the time-related activity patterns. Short-duration counts, on the other hand, are conducted for limited durations, typically between two hours and two weeks, and are then moved systematically between locations to increase the spatial coverage of the monitoring program. Short-duration counts can either be collected manually or using automated counters. Finally, as-needed counts are performed when requested by stakeholders to observe patterns associated with projects, high-crash locations, or other locations as desired.

To aid understanding of the underlying travel patterns, count sites are categorized into factor groups based on having similar distributions of traffic across time. While bicycle and pedestrian factor grouping is still an active area of research, patterns are typically presumed to be associated with surrounding land uses, climatic region, and facility types. The permanent counters are used to calculate adjustment factors to correct short-duration counts for hour-of-day, day-of-week, and seasonal variations. The factoring process enables annual average daily bicycle traffic (AADBT) and annual average daily pedestrian traffic (AADPT) to be estimated based on a short-duration count.

National trends

Various national efforts have developed useful guidance for institutionalizing nonmotorized traffic monitoring programs, methods to conduct counts, and approaches to analyzing the resulting data. While practices for monitoring motorized traffic are very well established, nonmotorized traffic has some important distinctions that require special consideration in developing a counting program:

» Pedestrians and bicyclists are more difficult to monitor than motor vehicles because they do not follow constrained paths, may occlude one another from the sensors, and are more difficult to reliably detect.

» Nonmotorized traffic variability is more complicated than motorized traffic, and these patterns are not thoroughly understood. For example, it is well established that bicycle trips are less likely during precipitation, but the extent to which this varies by geography, trip purpose, day of week, and time of day is less well-studied. Practically, this means that factoring methods might need to be different from established practices for motorized traffic.

» The technologies used for nonmotorized traffic are sometimes different from those used for motorized traffic, and therefore may represent an additional investment for the DOT.

Traffic Monitoring Guide (TMG)

As of the 2013 edition, chapter 4 of the TMG provides information on nonmotorized traffic monitoring. The TMG provides definitive guidance to state DOTs on how to monitor traffic on their road networks, including coverage of traffic volume, speed, and weights. The bicycle and pedestrian monitoring chapter details some of the main technologies for nonmotorized traffic, explains traffic monitoring concepts such as factor groups in the context of nonmotorized volumes, and prescribes a general process for establishing a nonmotorized traffic monitoring program.

Traffic data collected by state DOTs and their local agency partners following the standards outlined in the TMG is submitted to FHWA for inclusion in their Travel Monitoring Analysis System (TMAS). The 2016 TMG (Sections 7.9 and 7.10) specifies a database schema for including bicycle and pedestrian counts in TMAS, which now accommodates and is accepting submissions of nonmotorized traffic counts. In support of this effort, FHWA released a supplemental guidebook on how to comply with the specified TMAS data format.[2] While FHWA mandates that motorized traffic volume measurements be taken on a regular basis, there is not currently a similar mandate for nonmotorized traffic monitoring.

National Cooperative Highways Research Program (NCHRP) 797

NCHRP 797: Guidebook on Pedestrian and Bicycle Volume Data Collection provides additional guidance beyond the TMG on methods and technologies to collect volume data.[3] The research project resulting in this guidebook included a large-scale field test of various data collection technologies, the results of which are included in the guidebook. The guidebook also includes chapters on applications of count data, data collection planning and implementation, how to adjust count data to achieve accurate volume estimates, and a toolbox of sensor technologies. Examples from practice are highlighted throughout the guidebook to inspire those developing new programs.

A follow-up study to NCHRP 797 was recently completed and released as NCHRP Web-Only Document 229.[4] This study involved additional technology tests and a revision of all the analysis from the first study to correct errors and improve the approach.

[2] Laustsen, K., S. Mah, C. Semler, K. Nordback, L. Sandt, C. Sundstrom, J. Raw, and S. Jessberger. 2016. Coding Nonmotorized Station Location Information in the 2016 Traffic Monitoring Guide Format. ***https://trid.trb.org/view.aspx?id=1445973***

[3] Ryus, P., E. Ferguson, K. Laustsen, R. Schneider, F. Proulx, T. Hull, L. Miranda-Moreno. 2014. Guidebook on Pedestrian and Bicycle Volume Data Collection. ***www.trb.org/Main/Blurbs/171973.aspx***

[4] Ryus, P., A. Butsick, F. Proulx, R. Schneider, T. Hull. 2016. NCHRP Web-Only Document 229: Methods and Technologies for Pedestrian and Bicycle Volume Data Collection, Phase 2. ***www.nap.edu/download/24732#***

FHWA Exploring Pedestrian Counting Procedures

FHWA recently released a guidebook specifically focused on best practices in pedestrian counting. The guidebook was developed based on literature, interviews, and an interactive webinar with expert practitioners. Their high-level recommendations, many of which are also transferable to bicycle counts, include:

1) Expanding the use of multi-day/multi-week counts to reduce estimation error rates, and rotate counts around the network;
2) Validating equipment at installation and regularly thereafter;
3) Tailoring quality checks appropriate for low-volume versus high-volume locations;
4) Computing bias compensation factors (e.g., occlusion adjustment factors) to account for limitations related to equipment and locations; and
5) Conducting both short-duration and continuous counts to fully consider temporal and spatial aspects of pedestrian traffic patterns.

FHWA Bicycle/Pedestrian Count Technology Pilot Project

In this FHWA project, 10 metropolitan planning organizations (MPOs) were given seed funding to develop bicycle and pedestrian counting programs and technical assistance to support their programs via a series of webinars and support on an e-mail listserv. Each of the webinars were recorded and are available on the Pedestrian and Bicycle Information Center website.

A final report was also published detailing the MPOs' experiences with collecting count data. One major lesson learned for most agencies was that procurement of counters can take longer than expected, and that counters must be installed carefully to ensure accurate data. The final report includes callout boxes with other lessons learned, many of which are relevant for DOTs.

Other statewide programs

Many state DOTs have begun to expand nonmotorized counting programs and are supporting count efforts among MPOs and communities. These have generally followed a similar model, where local initiatives preceded the development of the statewide count program.[7] Along with this, off-street path monitoring has been a common starting point for many states, as in Michigan. Examples of states with nonmotorized monitoring programs in varying stages of development include Colorado, Delaware, Ohio, Oregon, Minnesota, North Carolina, Vermont, Utah, Tennessee, Washington, and Wisconsin. Lessons learned from these states' experiences informed the development of Michigan's program.

[5] Nordback, K., S. Kothuri, T. Petritsch, P. McLeod, E. Rose, and H. Twaddell. 2016. Exploring Pedestrian Counting Procedures. ***www.fhwa.dot.gov/policyinformation/travel_monitoring/pubs/hpl16026***

[6] Pedestrian and Bicycle Information Center. Counts Pilot Program. ***www.pedbikeinfo.org/planning/tools_counts_pilot_program.cfm***

[7] Lindsey, G., K. Nordback, and M. Figliozzi. 2014. Institutionalizing Bicycle and Pedestrian Monitoring Programs in Three States. Transportation Research Record: Journal of the Transportation Research Board 2443, pp. 134-142.

REPORT CONTENTS

The remainder of this report includes the following chapters:

» State of Nonmotorized Monitoring in Michigan
» Michigan Nonmotorized Monitoring Program
» Implementation Plan
» Appendix

- Data Collection Protocols
- Michigan Nonmotorized Monitoring Factor Group Framework
- Supplement to MS2 User Guide
- Recommended MS2 NMDS Feature Upgrades
- Recommended MS2 NMDS User Privileges

"Local volunteers can literally move mountains but time is a scarce resource. Automated nonmotorized count would assist in bridging this gap and yielding benefits to the group and public."

– Survey respondent

STATE OF NONMOTORIZED MONITORING IN MICHIGAN

Needs and desires for nonmotorized volume data

The interest in nonmotorized volume data in Michigan is evident from the data collection efforts currently underway and from plans that explicitly support improved data collection. For example, the Michigan Pedestrian and Bicycle Safety Action Plan 2013-2016 "encourages data collection on new and existing bicycle and pedestrian facilities." Similarly, the Bicycle and Pedestrian Travel Plan for Southeast Michigan recommends that the Southeast Michigan Council of Governments (SEMCOG) "encourage the routine collection of bicycle and pedestrian count data in bicycle and pedestrian supportive areas and along major trails." A statewide nonmotorized monitoring program will provide support for these and other statewide and regional project recommendations.

To develop a greater understanding of the highest priority nonmotorized data needs in Michigan, the project team conducted an online survey of stakeholders across Michigan. The survey was distributed by e-mail and was completed by 25 respondents representing local, regional, and state agencies, and nonprofit organizations. Some additional respondents partially completed the survey. The responses discussed in this section are limited to complete responses.

Nine survey respondents indicated their organization currently counts either bicyclists and pedestrians (32 percent) or bicyclists only (4 percent) (Figure 1).

Among agencies that do not currently count pedestrians and bicyclists, lack of staff time was the most common reason, followed by lack of understand about counting technologies or methods (Figure 2).

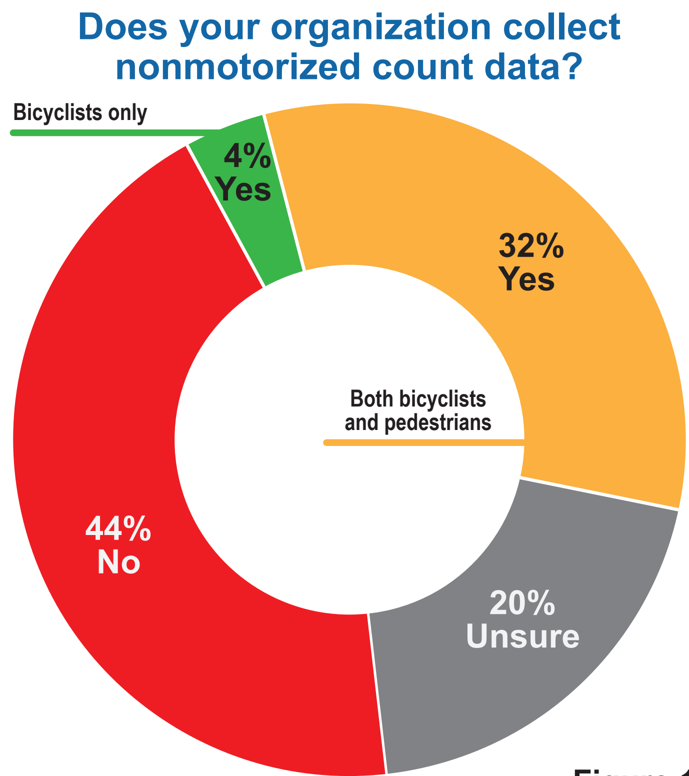


Figure 1

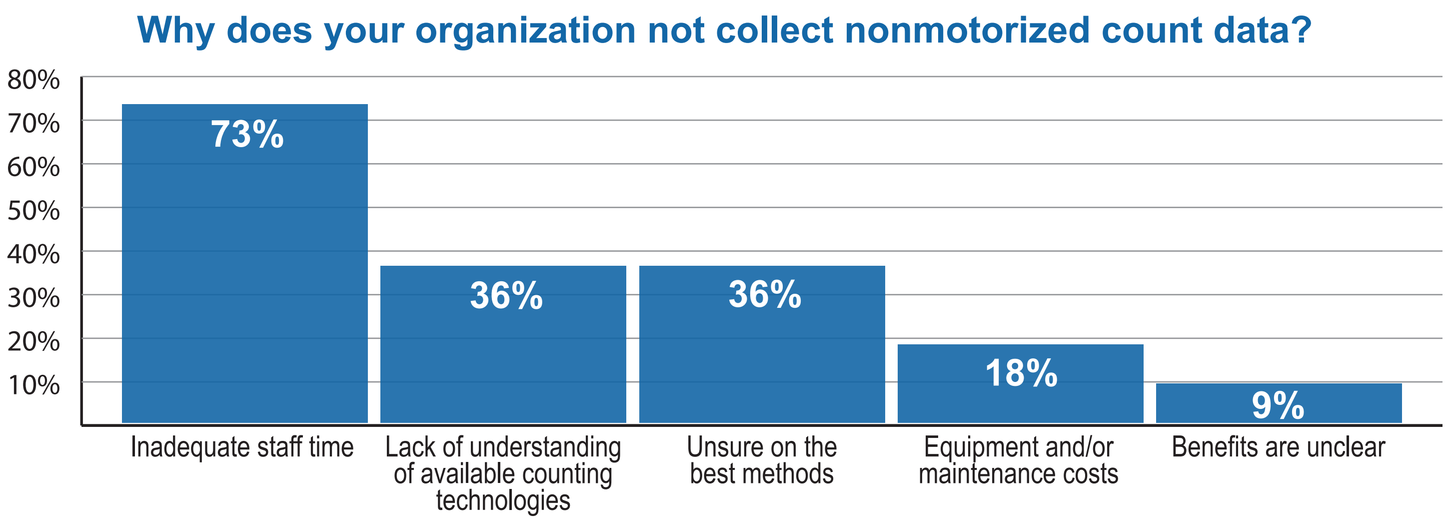


Figure 2

Note: respondents could select more than one answer, so responses don't sum to 100 percent.

Information obtained through the survey indicates many current or potential uses for nonmotorized volume data (Figure 3). Almost all respondents indicated count data would be useful to demonstrate facility use, and the majority also indicated it would be useful for funding requests, monitoring trends, comparing use before and after implementation of facilities, and conducting safety analysis. Other potential uses such as travel demand modeling and economic impacts analysis were noted in write-in responses.

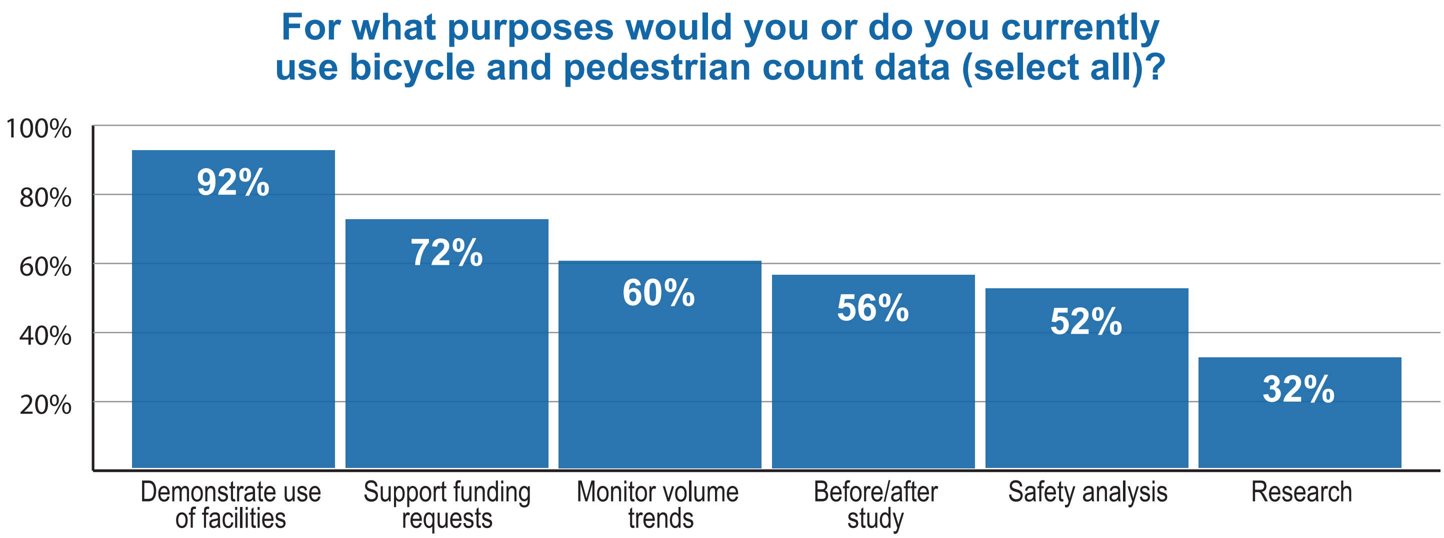


Figure 3

Note: respondents could select more than one answer, so responses don't sum to 100 percent.

When asked what assistance would be needed to begin counting or improve upon current count efforts, respondents indicated a roughly equal need for training, access to a data repository, loaner equipment, and support for analysis. Specific to the role that MDOT should play in nonmotorized counting, collecting and sharing count data were the most common responses, though respondents indicated support for MDOT playing a role in several aspects of nonmotorized monitoring (Figure 4).

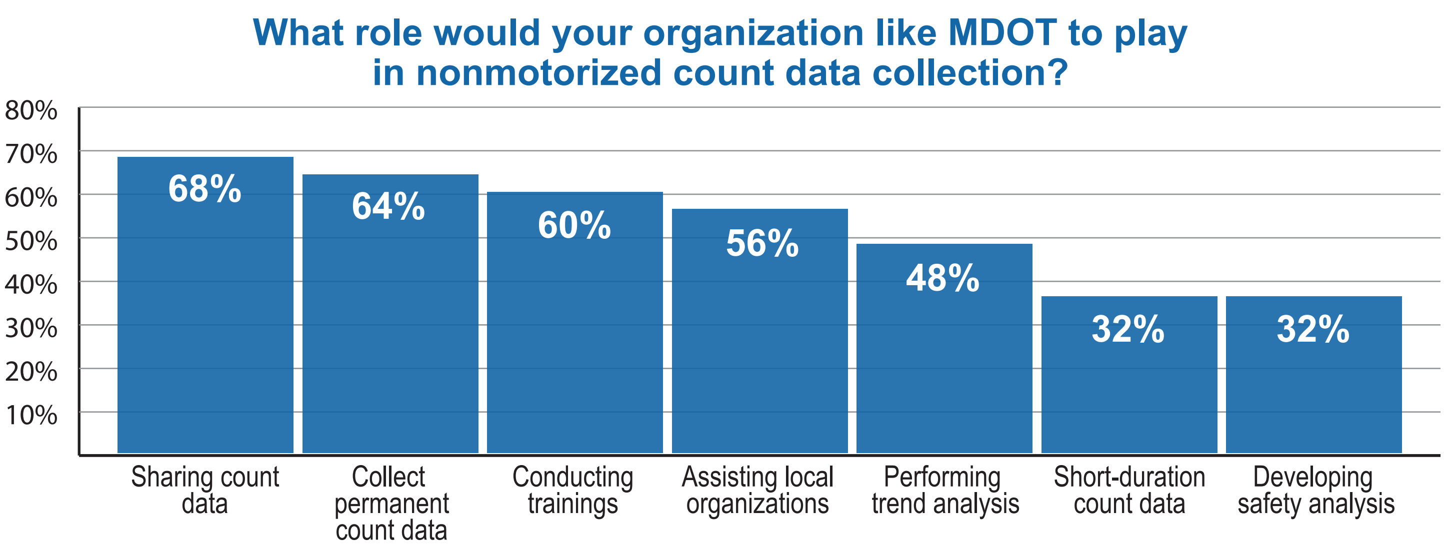


Figure 4

Note: respondents could select more than one answer, so responses don't sum to 100 percent.

> *"This would be of great value to us and trail groups for a number of projects, and it is encouraging to know MDOT is considering it. Funding, training, process standardization, and access to equipment are vital for us to be able to do this."*
>
> *– Survey respondent*

Previous data collection efforts

While MDOT has conducted some nonmotorized counts to date, several local agencies and other groups throughout Michigan are collecting bicycle and pedestrian counts on a routine basis. Based on the responses received in the survey discussed above, stakeholders were contacted and asked to provide their nonmotorized count data so that it could be included in a centralized statewide database. Agencies that submitted count data to MDOT are listed in Table 1.

Data collected by agency

Agency	Data collection equipment in use	Number of count stations
City of Lansing	TRAFx Infrared	Short-duration: 4
Detroit Greenways Coalition	Eco-Counter Multi (infrared and loops) and Tubes	Permanent: 3 Short-duration: 4
Genesee County Metropolitan Planning Commission	Eco-Counter Pyro (infrared)	Short-duration: 17
Iron Ore Heritage Recreation Authority	TRAFx Infrared	Permanent: 3
Michigan Department of Natural Resources	Eco-Counter Pyro (infrared)	Permanent: 2
Michigan Department of Transportation	Eco-Counter Tubes; Diamond	Short-duration: 21
Southeast Michigan Council of Governments	Miovision cameras	Short-duration: 30
Traverse Area Recreation and Transportation Trails	TRAFx Infrared	Permanent: 9
Washtenaw Area Transportation Study	Eco-Counter Multi (infrared and loops) and Pyro (infrared)	Permanent: 3 Short-duration: 17

Table 1

Note: Traverse City indicated that they have collected count data in their survey response but the data was unable to be obtained.

Location Characteristics

Collectively, the count stations listed in Table 1 span 83 locations, representing various facility types and contexts, data collection technologies, modes of traffic, and count durations. The count location details are discussed in greater detail in the next sections.

Permanent Counters

There are 20 permanent bicycle and pedestrian counters installed across Michigan (Figure 5). Seven of these counters are in the lower part of the state, characterized by hot summers (climate zone Dfa). The remaining 13 are in the northern part of the state (climate zone Dfb), where summers are mild and winter is colder. Among the latter group, three permanent counters have been established in the Upper Peninsula while the remainder are in the Traverse City area.

Permanent and short-duration count stations and Michigan climate zones

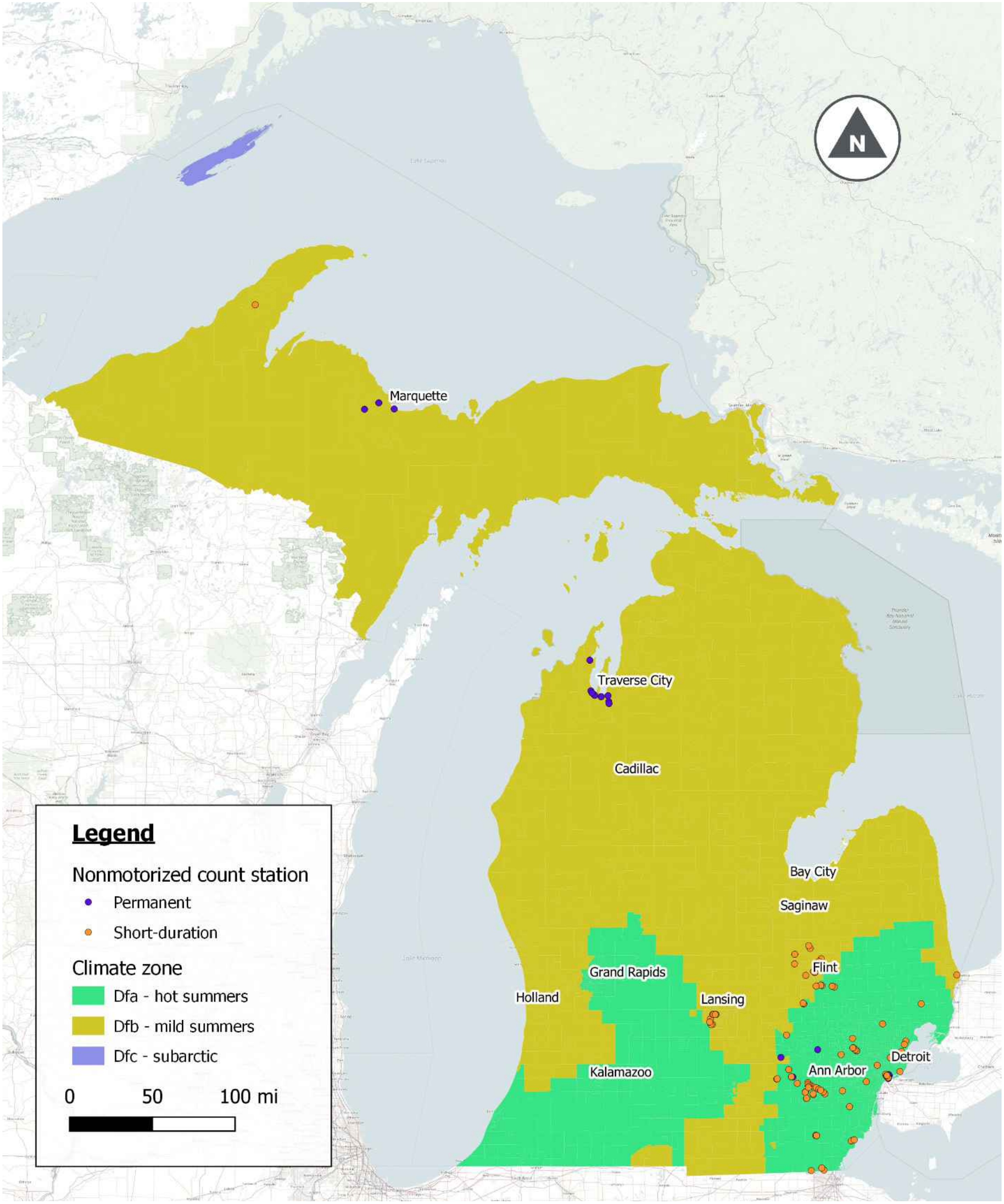


Figure 5

Permanent counters have generally been installed in less-populated census tracts compared to the statewide distribution (Figure 6). More than half of the permanent counters are in census tracts within the lower 25th percentile for population density. Similarly, few permanent counters have been installed in very high-density tracts.

Distribution of permanent counters by population density, compared to all census tracts

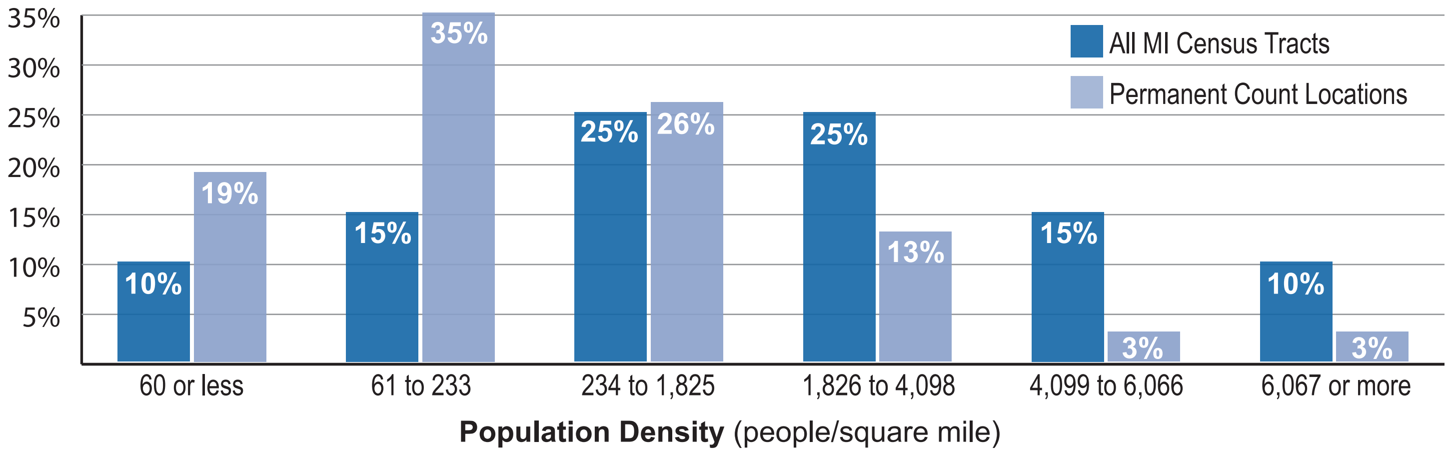


Figure 6

The permanent counters installed to date are located exclusively on shared-use paths. Infrared counters are in use at 14 of the locations, while a combination of technologies (infrared and inductive loops) are used at the remaining six (Figure 7). Bicyclist and pedestrian activity cannot be tracked separately using infrared only but locations with combination units allow for separate tracking. Of the 14 permanently installed infrared counters, 12 are TRAFx devices while the other two are Eco-Counters (PYRO). All of the six combination units are Eco-Counter MULTI devices.

Number of permanent count stations by technology and vendor

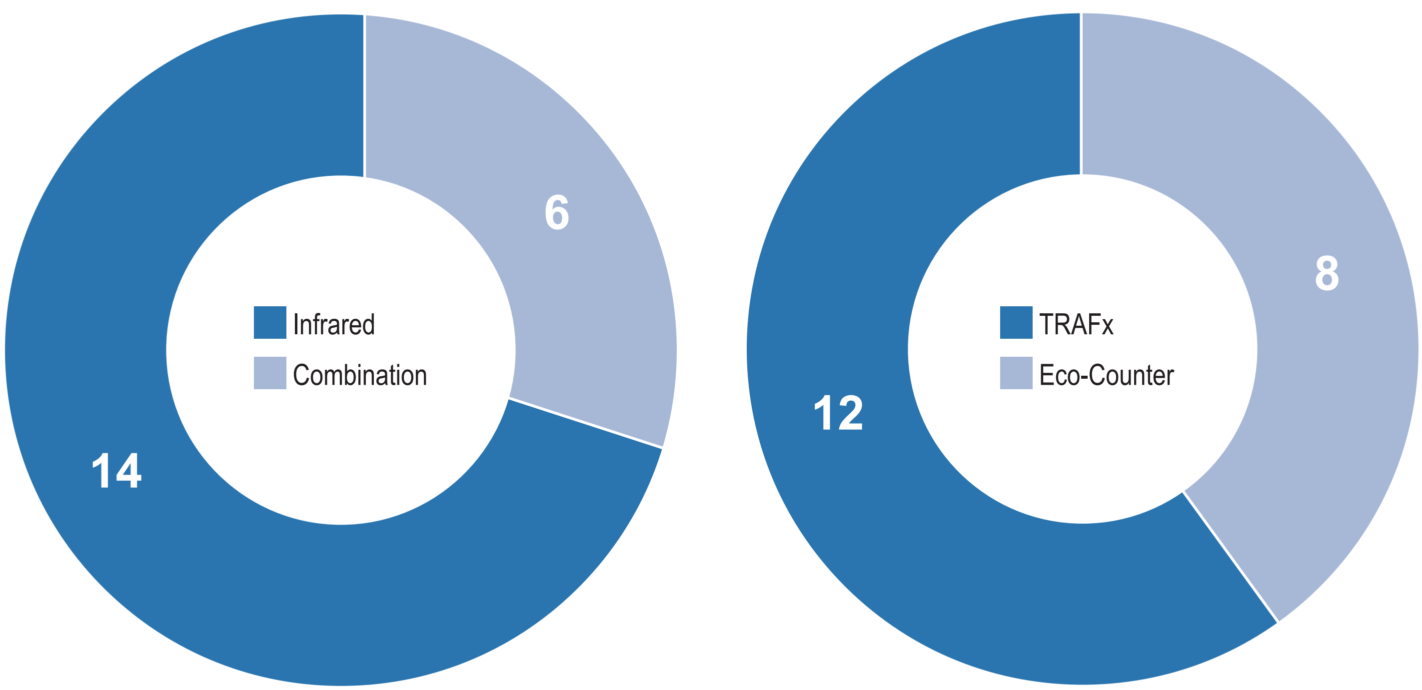


Figure 7

Short-duration counters

Public agencies and stakeholder groups have conducted short-duration automated counts at 63 locations across Michigan. These locations have somewhat different characteristics than the permanent count stations. More than half (56 percent) are located in the warmer climate zone (Dfa) that encompasses Detroit and Ann Arbor (Figure 5). Short-duration counts have not been conducted in the far northern parts of Michigan.

The distribution of short-duration count stations with respect to population density more closely matches the statewide distribution (Figure 8). In particular, census tracts with high population density are well-represented among short-duration count stations.

Distribution of short-duration counters by population density, compared to all census tracts

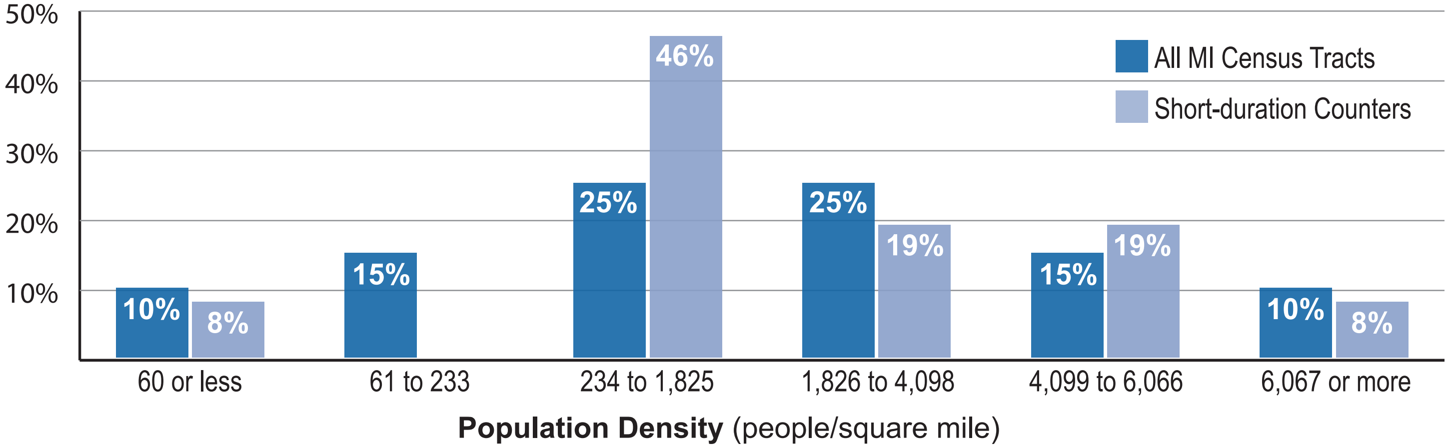


Figure 8

Short-duration counts have been conducted on a wider range of facility types than permanent count stations. While shared-use paths remain the most common facility, counts have also been conducted on bike lanes and sidewalks, and on or adjacent to roadways (Table 2). Infrared is the most commonly used technology for short-duration counts but pneumatic tubes are also common. Eco-Counter devices have been used to collect data at 39 short-duration count stations, and Diamond tubes have been used at 20 locations. TRAFx infrared counters have also been used at four locations.

Number of short-duration count stations by technology and facility type

		Facility type				Total
		Shared-use path	Sidewalk	Bike lane	Unknown	
Tech	Infrared	31	6	0	1	**38**
	Pneumatic tube	2	0	19	4	**25**
Total		**33**	**6**	**19**	**5**	**63**

Table 2

Michigan is divided into seven regions for MDOT maintenance and administrative purposes. These regions cover anywhere from three to 21 counties and are further divided into service areas administered by Transportation Service Centers (TSCs). There are generally three TSCs per region and these TSCs can cover anywhere from one to seven counties. The distribution of permanent and short-duration counters by TSC is shown in Table 3. TSCs not shown in Table 3 do not currently have any counters within their boundaries.

Number of count stations by MDOT Transportation Service Center

		Permanent count stations	Short-duration count stations				Total
		Shared-use path	Shared-use path	Sidewalk	Bike lane	Unknown	
TSC	Brighton	4	16	0	0	1	**21**
	Davison	0	11	6	0	0	**17**
	Detroit	3	1	0	0	3	**7**
	Huron	0	1	0	0	0	**1**
	Ishpeming	3	0	0	0	1	**4**
	Lansing	0	4	0	10	0	**14**
	Oakland	1	0	0	9	0	**10**
	Traverse City	9	0	0	0	0	**9**
Total		**20**	**33**	**6**	**19**	**5**	**83**

Table 3

Challenges and gaps

The number of agencies counting bicyclists and pedestrians across Michigan is encouraging. There are, however, a few concerns worth noting.

Facility coverage and geographic distribution

An important coverage gap relates to the exclusive reliance on shared-use path locations for permanent counts. Since activity patterns from permanent counters establish the basis for estimating annual volume from short-duration counts, and shared-use paths may exhibit different patterns than on-street facilities, there is a gap in on-street permanent counter coverage. The geographic distribution of permanent counters could also be improved; more counters are needed in areas with medium-to-high population density.

Technologies

Another concern with the current permanent counters in use is that most of the counters use infrared technology that cannot distinguish between bicyclists and pedestrians. Since bicyclists and pedestrians have different activity patterns, these modes should ideally be tracked separately for more accurate expansion factor development.

Data quality

Beyond the overall distribution of counters across the state, there are a few data quality concerns associated with the data obtained for the project. Most importantly, it is unclear whether and to what extent validation of permanent and short-duration count data has occurred. As a result, there may be accuracy issues with the data obtained. Going forward, validation should be incorporated into data collection for any count data submitted to MDOT, and the validation process should be documented.

Data management

General data management issues were also apparent from the data obtained. Lack of file format consistency, duplication of files across spreadsheets, and lack of metadata were common. Better documentation and management of count data files will improve the reliability of nonmotorized volume data.

MICHIGAN NONMOTORIZED MONITORING PROGRAM

While bicycle and pedestrian volume data collection occurs in most, if not all, states, few proactively plan for and manage the data collection effort. The result is that the data is often not used to its fullest potential. Through the current effort and subsequent implementation of this plan's recommendations, Michigan is establishing itself as one of a handful of states in the country to take a strategic and coordinated approach to nonmotorized monitoring. Doing so will help MDOT and its partners make better use of the data that is collected and ultimately to make more informed decisions regarding bicycling and walking investments. The count program will also help planners and engineers to better understand the relationship between crashes and levels of bicycling and walking.

Program goals

One of the key efforts of the project was to establish goals for the Michigan Nonmotorized Monitoring Program that would guide the future efforts of MDOT staff and partners. Goals were developed based on information obtained from a number of sources, including:

» Feedback from stakeholders obtained through the aforementioned survey and a webinar conducted for the project,

» Research and documentation of MDOT's current vehicle traffic monitoring programs,

» Discussions with MDOT staff and external partners, and

» A review of best practices.

The resulting goals are presented here, along with a brief description of the rationale for each. The goals also inform the Implementation Plan, which is discussed in the next chapter.

Goal 1: Define program roles and establish MDOT as the centralized resource for nonmotorized monitoring efforts in Michigan.

» Rationale: MDOT is uniquely positioned to play a leading role in nonmotorized monitoring across Michigan. The department plays a similar role for motor vehicle traffic data collection and has established relationships with the FHWA, other state agencies, regional planning organizations, local agencies, and advocacy groups. Each of these agencies would naturally look to MDOT to provide guidance on nonmotorized data collection.

Goal 2: Implement permanent counters to develop factor groups and support other planning and analysis needs.

» Rationale: Permanent counters are needed to establish the foundation of the nonmotorized monitoring program. These counters will provide the basis for annualizing short-duration counts and will serve as a benchmark for monitoring progress over time.

Goal 3: Create a statewide data collection standard for short-duration counts.

» Rationale: Current approaches to nonmotorized data collection in Michigan are highly variable in terms of duration of short-duration counts, counter location selection, and geographic representation. Standardizing the approach will enable data sharing across agencies, statewide analysis, and application of data to a variety of measures and questions.

Goal 4: Manage nonmotorized count data to support state, regional, and local planning processes.

» Rationale: Data is most useful when it is stored in a central, consistently formatted repository that facilitates access and minimizes processing requirements for end-users. Many agencies in Michigan are already collecting data on the local networks. Combining this data with MDOT data will inform the needs of both parties, and this can be accomplished most effectively by defining a standard format.

Goal 5: Identify standard metrics and analysis approaches.

» Rationale: Identifying and clearly defining standard metrics will ensure consistency across studies and regions and increase analytical efficiency by reducing time spent on selecting processes. Standardized metrics will reduce the burden on MDOT staff and partners associated with analyzing count data. This reduced burden, and the eventual automation of processes, will help to ensure that data gets turned into useful information rather than simply being collected and not used. Standard analyses should be seen as a starting point for deeper analysis when desired.

Goal 6: Supplement count data with related datasets.

» Rationale: Although the focus of the MDOT nonmotorized monitoring program should be on directly observed traffic volumes, this data can only be collected at a sample of sites. Incorporating additional data with greater spatial coverage can greatly increase the understanding of bicycling and walking patterns throughout the state. Pedestrian and bicycle counts can be supplemented with crowdsourced data from smartphone applications, bikeshare usage information, or signal controller data. Additionally, travel surveys can provide detailed information regarding individual trip choices and can be used to estimate pedestrian or bicycle miles traveled. While these datasets are not a replacement for high-quality count data, they can be useful in combination for a more thorough understanding of patterns.

Introduction to the MS2 Nonmotorized Database System

Prior to the initiation of the current project, MDOT selected MS2's Nonmotorized Database System (NMDS) to serve as a statewide repository for nonmotorized volume data. MS2's motor vehicle traffic data platforms are used by MDOT for vehicle traffic data storage, making the use of MS2 for nonmotorized data a logical choice.

The key capabilities of the NMDS for MDOT's ongoing nonmotorized data management and analysis needs include:

» Creating stations and assigning station identifiers,

» Importing data in common vendor formats in use throughout Michigan (TRAFx, Eco-Counter, Miovision pathways),

» Applying quality control tests during data import,

» Mapping count locations,

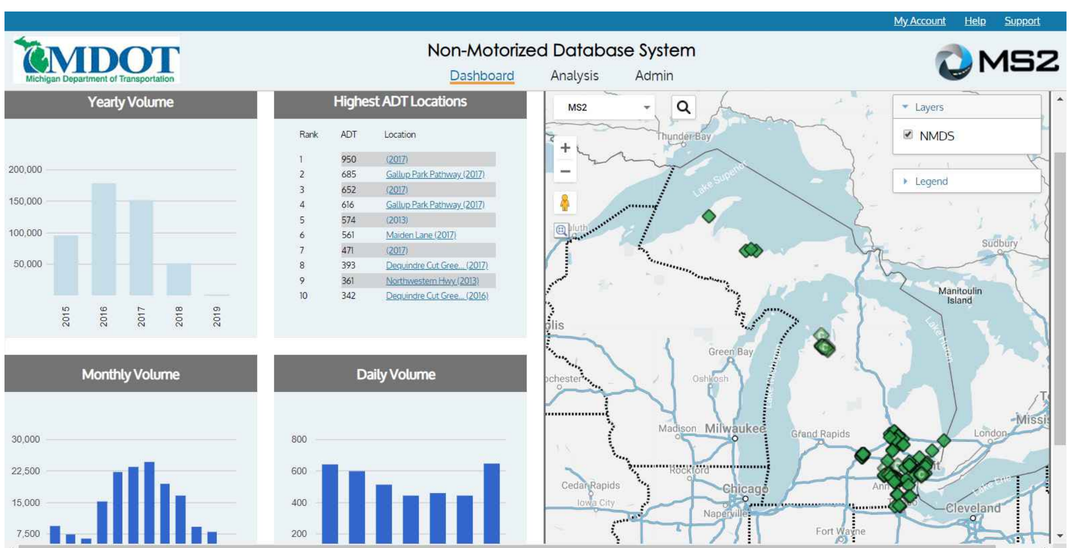
» Creating and applying factor groups,

» Exporting data, and

» Providing access privileges to users from different agencies, with varying permissions through a web interface.

Through the current project, the MDOT NMDS was populated with the data provided to the project team. Additionally, protocols were established for how station identifiers will be created in the future and how different agencies will interact with the software. More detail related to the NMDS is provided in the Implementation Plan and Appendix C.

MDOT's Nonmotorized Database System



Roles and responsibilities

Development of a robust statewide nonmotorized volume data collection program will require MDOT to work in partnership with local agencies, regional agencies, and external stakeholders. There is ample opportunity in the nonmotorized traffic monitoring program for collaboration with local agencies; in fact, such collaboration is needed to advance the program. For example, permanent count data both on and off the state roadway system can be used to construct adjustment factors, and short-duration counts from anywhere on the road network could be used to develop or calibrate travel demand or volume-prediction models.

MDOT roles

Findings from the survey discussed above help shape MDOT's role in the nonmotorized monitoring program. The survey found that several agencies are already collecting nonmotorized count data in Michigan. Among these, the overall program strategy, technologies in use, and types of counts conducted vary substantially. This limits MDOT's ability to efficiently integrate count data across the state. Greater consistency in approaches would improve the transferability of the data collected.

Another finding from the survey is that some agencies lack basic information about counting technologies and methods. While inadequate staff time was found to be the greatest deterrent to counting, information gaps can be addressed by MDOT through training and technical assistance. Additionally, MDOT's role as the steward of nonmotorized count data could help local agencies by reducing the amount of staff time required to process and analyze collected data.

When asked what role survey respondents would like MDOT to play in nonmotorized count data collection, they expressed a strong desire for MDOT to collect permanent count data, with a lesser desire for MDOT to collect short-duration count data. In practice, permanent count data collection would be most effectively accomplished as a collaborative effort, where some data is collected by local agencies and MDOT collects additional data at permanent locations to support the development of factor groups across the state. This would allow for greater representation of facility types than if MDOT were to be solely or primarily in charge of data collection. Data sharing also emerged as a high priority request.

Based on the overall program goals and input from survey respondents, the following roles for MDOT are recommended:

» Provide guidance regarding overall count strategy, technologies, and types of counts,

» Provide training and technical assistance to local agencies interested in conducting counts,

» Collect permanent count data to supplement data collected by local agencies and to inform the development of factor groups, and

» Serve as the steward for nonmotorized count data. This includes development of recommended data formats, management of data collected by local agencies that meets format requirements, development of factor groups, and basic analysis, reporting, and data sharing functions.

Roles of other agencies

The success of the nonmotorized monitoring program hinges on the participation of other agencies, including other state agencies (the Michigan departments of Natural Resources and Technology, Management and Budget, in particular), regional and local agencies, and nonprofit organizations. The primary way for these agencies and organizations to contribute to the program is through permanent and short-duration count data collection. This could entail working with MDOT to select appropriate locations, installing and maintaining the counters, downloading data, performing quality checks on the data, and submitting data to MDOT through MS2. The greatest benefit to the statewide program will be realized if data collected by local agencies follows MDOT protocols (especially quality control) and is collected in a consistent manner.

Another opportunity for other agencies to contribute to the program is through expanded analysis. While it is recommended that MDOT provide a basic level of analysis for statewide data, such as calculating extrapolation factors annually for the permanent counters, it is unlikely that MDOT will have the staff resources to conduct extensive analyses on a routine basis. Some MPOs, local agencies, or researchers may be able to dedicate a greater amount of time to analysis of count data within their respective jurisdictions.

The count data collection and management process is shown in Figure 9, with an emphasis on the roles and responsibilities of MDOT and external agencies.

Roles and responsibilities of MDOT and external agencies

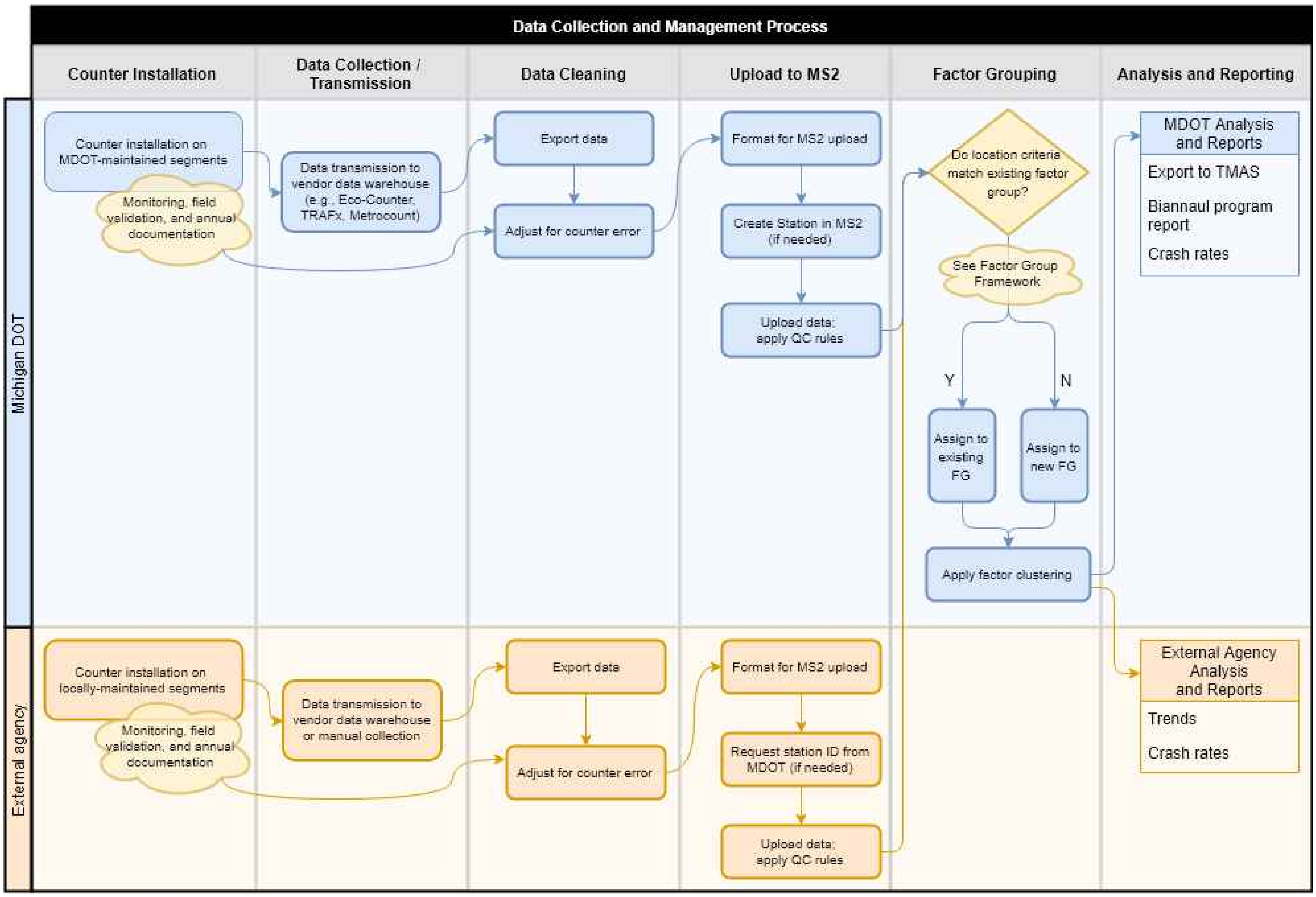


Figure 9

IMPLEMENTATION PLAN

The implementation plan presented in this chapter outlines the specific actions to be undertaken over the next several years to fully establish and grow the nonmotorized monitoring program. The actions are organized according to the relevant program goals that they support and they are focused on the steps MDOT will take, though the importance of local agency participation is acknowledged. Since Fiscal Year (FY) 2019 will be halfway complete by the time this report is finalized, and MDOT staff will need time to integrate these actions into their respective work programs, actions are listed as beginning in 2020. However, some actions may begin in 2019, as time allows.

Goal 1: Define program roles and establish MDOT as the centralized resource for nonmotorized monitoring efforts in Michigan.

	Action	Lead Agency/ Department	Timeline
1-1	Allocate MDOT staff (0.25 FTE) to manage MS2 NMDS and other nonmotorized monitoring program data.	MDOT Travel Information Unit (TIU)	2020
1-2	Establish MDOT staff as contact person for local agencies (0.1 FTE).	MDOT Asset Management and Policy Division (AMPD)	2020
1-3	Develop nonmotorized monitoring training for local agency partners; conduct training once per year via webinar.	MDOT TIU	2020 and annually
1-4	Convene nonmotorized monitoring stakeholders, such as data providers and data users.	MDOT AMPD, MDOT TIU	2021 and annually
1-5	Develop a report that summarizes nonmotorized monitoring program progress on a biannual basis, such as annually or every two years.	MDOT TIU, MDOT AMPD	2022 and every two years after

Action 1-1: MS2 Nonmotorized Database System Management

A staff member within MDOT's Travel Information Unit (TIU) will be responsible for managing the MS2 NMDS. In this role, he or she will ensure that station data entered into MS2 follows appropriate conventions, that data is uploaded following the proper procedures and with valid attributes, and that factor groups are created on an annual basis. The specific guidance and processes for completing these steps are documented in Appendix C and in the MS2 NMDS user guide. MDOT TIU staff will also serve as the liaison to local agencies and MPOs that collect nonmotorized volume data, and will manage access to MS2, including implementing appropriate permissions for external partners, as outlined in Appendix E. Finally, he or she will assist with data extraction as needed.

Action 1-2: Local program contact

While staff from MDOT's TIU will be responsible for managing the technical aspects of the program, MDOT Asset Management and Policy Division (AMPD) staff have strong relationships and ongoing coordination with bicycle and pedestrian planners across the state. In many cases, these individuals will be the primary data collectors at the local and regional levels. MDOT AMPD staff will serve as an initial point of contact for the program, assist with location selection for new counter installations, and assist with counter deployment where applicable (such as on state routes).

Action 1-3: Training

Training is essential to ensure that data entered into the statewide nonmotorized count database is reliable and useful. Annual training, conducted via webinar, will help staff who are new to nonmotorized counting learn the basic considerations and protocols for data collection in Michigan. The training should address the following elements:

- Overview of MDOT's program
- Nonmotorized monitoring basics
  - Data collection technologies, including overcoming installation challenges
  - Factoring
- Continuous counter installation
  - Quality control/field validation
- Short-duration counter installation
  - Minimum duration
  - Quality control/field validation
- Data management
- MS2[8]
  - Uploading data
  - Working with data and exporting
  - Report generation

Action 1-4: Nonmotorized monitoring information exchange

In addition to the recommended training, MDOT should convene nonmotorized monitoring stakeholders on an annual basis, preferably in person. This would allow local data providers to share their experiences and findings, learn from each other, discuss data uses, and identify common challenges. To achieve greater participation, it may be best to leverage a previously planned event, such as the Michigan Transportation Planning Association conference or regional pedestrian and bike committee coordination meetings.

Action 1-5: Biannual report

To generate interest in and communicate the results of the statewide nonmotorized monitoring program, a biannual report should be developed by MDOT staff. The report should address the following topics:

- Program activities
  - Counter acquisition and installation
  - Trainings
  - Number of agencies uploading data to MS2
- Analysis (Note: Some of the analysis will be limited in the early years since trends will not yet be established)
  - Annual volume trends
  - Seasonal and daily patterns
  - Crash rates
  - Annual factor groups
  - Factors used for each factor group
- Policy implications of volume trends and patterns
- Innovative uses at MDOT or other agencies (if applicable)

[8] It may make sense to hold a separate training specifically for MS2 since the user base may be different than the audience for the more general training. Additionally, it may be most effective to hold the more general counting training in late winter or early spring (prior to the typical data collection period) and the MS2 training in late summer/early fall (after data are collected).

Goal 2: Implement permanent counters to develop factor groups and support other planning and analysis needs.

	Action	Lead Agency/ Department	Timeline
2-1	Purchase permanent counters annually to achieve adequate coverage of factor groups (see tables 4 through 6 for more detail).	MDOT, DNR, MPOs, local agencies	2020-2024
2-2	Install and maintain permanent counters purchased by MDOT.	MDOT, DNR, MPOs, local agencies	2020-2024; ongoing
2-3	Conduct counter validation checks at permanent count stations on an annual basis.	MDOT, DNR, MPOs, local agencies	Ongoing

Action 2-1: Purchase permanent counters

Acquisition of permanent counters is critical to the development of a comprehensive statewide count program. The level of available funding for counter purchase is currently unknown; however, three investment scenarios are presented in tables 4 through 6, assuming a combination of on-street and off-street count locations and associated technologies. For planning purposes, off-street counters are assumed to cost $6,000 each and on-street counters are assumed to cost $8,000 each (each on-street counter is assumed to require two data loggers and loop sets to cover both directions). These costs do not account for installation, which is discussed under Action 2-2. It is anticipated that the majority of new permanent counters would be purchased by MDOT; however, the Michigan Department of Natural Resources (DNR), MPOs, and local agencies may also purchase counters that fit into the statewide program.

The counter investment schedules generally seek to first achieve minimal coverage across the various location types that currently have no counters, as described in Appendix B and listed in Table 12. After minimal coverage is achieved, the goal is to enhance coverage, focusing on the highest priority location types in the state. The specific counters purchased should be selected based on consideration of the locations where they will be installed. More direction on selecting appropriate technologies is contained in Appendix A.

Roles and responsibilities of MDOT and external agencies

	Number and type of counters	Factor group	Estimated capital cost
2020	3 – Off-street combination units (infrared and loops)	Location types 1, 5, 6	$18,000
2021	3 – Off-street combination units (infrared and loops)	Location types 9, 20, 26	$18,000
2022	3 – Off-street combination units (infrared and loops)	Location types 3, 13, 25	$18,000
2023	3 – On-street bicycle facilities (inductive loops)	Location types 7, 12, 22	$24,000
2024	3 – On-street combination units (infrared and loops)	Location types 19, 21, 30	$24,000

Table 4

Permanent counter acquisition and installation schedule (medium investment scenario)

	Number and type of counters	Factor group	Estimated capital cost
2020	6 – Off-street combination units (infrared and loops)	Location types 1, 5, 6, 9, 20, 26	$36,000
2021	3 – Off-street combination units (infrared and loops) 3 – On-street bicycle facilities (inductive loops)	Location types 3, 7, 12, 13, 22, 25	$42,000
2022	3 – Off-street combination units (infrared and loops) 3 – On-street bicycle facilities (inductive loops)	Location types 19, 21, 30, 8, 11, 28	$42,000
2023	4 – Off-street combination units (infrared and loops) 3 – On-street bicycle facilities (inductive loops)	Location types 29, 16, 24, 27, 32, 15, 23	$48,000
2024	3 – Off-street combination units (infrared and loops) 3 – On-street bicycle facilities (inductive loops)	Location types 1, 2, 5, 6, 10, 26	$42,000

Table 5

Permanent counter acquisition and installation schedule (high investment scenario)

	Number and type of counters	Factor group	Estimated capital cost
2020	9 – Off-street combination units (infrared and loops)	Location types 1, 3, 5, 6, 7, 9, 12, 20, 26	$54,000
2021	6 – On-street bicycle facilities (inductive loops) 3 – Off-street combination units (infrared and loops)	Location types 8, 11, 13, 19, 21, 22, 25, 28, 30	$66,000
2022	6 – Off-street combination units (infrared and loops) 3 – On-street bicycle facilities (inductive loops)	Location types 1, 2, 15, 16, 23, 24, 27, 29, 32	$60,000
2023	6 – On-street bicycle facilities (inductive loops) 3 – Off-street combination units (infrared and loops)	Location types 4, 5, 6, 9, 10, 13, 14, 20, 26	$66,000
2024	6 – Off-street combination units (infrared and loops) 3 – On-street bicycle facilities (inductive loops)	Location types 3, 7, 8, 12, 19, 21, 22, 25, 30	$60,000

Table 6

Action 2-2: Install and maintain permanent counters

The counters purchased pursuant to Action 2-1 may be intended for installation on MDOT facilities or locally maintained facilities. For counters to be installed on MDOT facilities, the TIU should lead the installation process, working with MDOT region partners to select specific locations or support installation as appropriate. For counters to be installed on locally maintained facilities (including any purchased by MDOT through grants or other mechanisms), local agencies or MPOs should coordinate installation and be responsible for maintenance.[9]

Counter installation costs may range from $2,000 to $5,000 or more, depending on site-specific factors and selected technologies. In general, trail installations are less expensive than in-street installations. For planning purposes, $4,000 is recommended as an average installation cost. Data transmission costs of $50 per month per site should also be expected. Permanent counter maintenance includes monthly data checks, preferably automated daily or weekly monitoring, battery replacement according to manufacturer's recommendations (if applicable), and annual site visits to validate counters and check equipment for vandalism or insect or vegetation encroachment. In the early stages of implementation, more frequent site visits are likely to be needed. For staffing purposes, 12 hours per year for each site can be assumed (three visits, four hours per visit). As the program develops and more sites are added, the average per-site time requirements may be reduced to around eight hours per year.

Action 2-3: Conduct counter validation

Counters purchased with MDOT funds should follow MDOT's established data collection protocols, which are outlined in Appendix A. Most notably, permanent counters should be validated upon installation, after equipment settings change and on an annual basis thereafter. Validation should be conducted in accord with best practice exemplified by another state – the North Carolina DOT[10] and described in Appendix A. Other quality control checks will be performed as data is uploaded into MS2.

Goal 3: Create a statewide data collection standard for short-duration counts.

	Action	Lead Agency/ Department	Timeline
3-1	Establish recommended count protocols for short-duration counts to be included in MS2.	MDOT TIU	2020
3-2	Establish and implement quality control standards for short-duration counts.	MDOT TIU, local agencies	2020; ongoing
3-3	Conduct short-duration counts at representative locations.	MDOT, local agencies	Ongoing

[9] If counters are purchased by MDOT for local use, MDOT must be provided the ability to access the data. Ideally, this access will be via automated download. Additionally, MDOT must be prepared to impose the validation protocols and maintenance requirements and/or take possession of the counter if local agencies do not fulfill their obligations.

[10] ***www.pedbikeinfo.org/pdf/PBIC_Infobrief_Counting.pdf***

Action 3-1: Establish recommended protocols for short-duration counts

To develop annual estimates, it is recommended that short-duration counts cover a period of at least one week. This allows the day-of-week patterns to be identified, which are needed to confirm a short-duration count's factor group assignment. While one week is offered as a recommendation, longer short-duration counts, such as two weeks or a month, will produce more reliable estimates. Local agencies will likely continue to conduct shorter counts, which can be included in the NMDS, provided that they fall into one of the following categories:

- » Automated counts[11]
  - ▪ One week or more
  - ▪ 24-hour counts
    (7 a.m.-7 p.m. weekday plus 7 a.m.-7p.m. weekend day per site preferred)
  - ▪ 12-hour counts
    (7-9 a.m., 11 a.m.-1 p.m., 4-6 p.m. weekday plus noon to 2 p.m., 4-6 p.m. weekend day per site preferred)
- » Manual counts
  - ▪ Eight-hour counts
    (7-9 a.m., 11 a.m.-1 p.m., 4-6 p.m. weekday plus noon to 2 p.m. Saturday)
  - ▪ Four-hour counts
    (7-8 a.m., noon to 1 p.m., 5-6 p.m. weekday plus noon to 1 p.m. Saturday)

Action 3-2: Quality control for short-duration counts

The usability of data contained in MS2 depends heavily on the quality of the data collected. As discussed in Appendix A, automated counters should be calibrated with a manual count during installation to ensure accurate results. A short observation period of 15 to 30 minutes (or until 25 total counts are obtained) is sufficient unless bicycle volumes are extremely low. In that case, staff can trigger the counter by riding a bike across the path of the counter several times. However, this should not be the default method since a bicyclist riding deliberately to check a counting device doesn't represent the varying user characteristics that occur. In addition to counter calibration, photos should be taken of each installation to allow follow-up counts to be installed in the exact location and with the same counter orientation.

Action 3-3: Count at representative locations

Stratified random sampling is a recommended approach for selecting short-duration count locations. Conducting short-duration counts at sites chosen by random sampling within each location type (as identified in Appendix B) would ensure that volume estimates are available for a representative set of locations. This approach guards against the tendency to count only at sites with a high volume of nonmotorized users. Counting exclusively at such locations would result in biased estimates if used to estimate statewide volume. A downside to counting at randomly chosen locations is that some locations may have little or no nonmotorized activity and doing so could be perceived as a waste of resources. If a fully randomized approach is not possible, short-duration count sites should be selected to cover the range of location types discussed in Appendix B. The number of short-duration count stations implemented within each location type is shown in Table 11.

[11] If only one day can be counted, weekdays (Tuesday, Wednesday, or Thursday) are preferred.

Goal 4: Manage nonmotorized count data to support state, regional, and local planning processes.

	Action	Lead Agency/ Department	Timeline
4-1	Provide MS2 access to local data collection partners.	MDOT TIU; MDOT AMPD	2020
4-2	Perform key data management functions in MS2.	MDOT TIU; MDOT AMPD	Ongoing
4-3	Work with MS2 to improve data management functionality.	MDOT TIU; MDOT AMPD	Ongoing
4-4	Upload count data to TMAS.	MDOT TIU	Annually

Action 4-1: Provide MS2 privileges to local data collection partners

Leveraging and coordinating the count data collection efforts of local agencies represents a key approach to growing and improving the MDOT nonmotorized count program. Given other MDOT staff responsibilities, local agencies should be able to directly upload count data to MS2. This is consistent with the approach taken for motor vehicle count data in Michigan. Suggested privileges for local partners and MDOT are outlined in Appendix E. Use of an MDOT intern for count data upload is recommended as an alternative approach if local agencies do not consistently upload their data via MS2.

Action 4-2: Perform key data management functions in MS2

While local agencies will assist with the overall data management requirements of the program by uploading their count data, some critical data management functions should remain under MDOT's purview. Suggested data management functions for MDOT and local agencies are noted in Appendix E; they include station creation and factor group identification and processing. Additionally, MDOT would be responsible for uploading count data from its counters.

Action 4-3: Work with MS2 to improve data management and analysis functionality

Some additional or enhanced data management functionality would make the MS2 platform more useful for MDOT's long-term needs. Recommended MS2 feature upgrades are outlined in Appendix D.

Action 4-4: Upload count data to TMAS

The FHWA's Travel Monitoring Analysis System (TMAS) recently began to accept nonmotorized counts. MS2 is working on developing an export format that meets the TMAS requirements. While local agencies could, in theory, submit their nonmotorized data to TMAS, it will be easiest and most efficient for MDOT to undertake this task as the department already submits motor vehicle volume data through the system. The process for local agencies to upload their data involves several steps and has proven difficult for other local agencies.

Goal 5: Identify standard metrics and analysis approaches.

	Action	Lead Agency/ Department	Timeline
5-1	Assign new permanent counters to factor groups.	MDOT TIU; MDOT AMPD	Ongoing
5-2	Recalculate adjustment factors on an annual basis and export these factors by group for reporting to locals.	MDOT TIU	Ongoing
5-3	Assign short-duration counts to factor groups in MS2 to develop annual estimates.	MDOT TIU	Ongoing
5-4	Work with MS2 to implement additional data analysis functions.	MDOT TIU, MDOT AMPD	Ongoing

Action 5-1: Assign new permanent counters to factor groups

As new permanent counters are installed, they must be assigned to a factor group. Factor group assignment will initially be based on the features identified in Table 8. However, factor groups may change and should be refined based on observed patterns (see Appendix B for more detail).

Action 5-2: Recalculate adjustment factors on an annual basis

To develop accurate annual bicycle or pedestrian volume estimates, adjustment factors created from permanent counters should be updated each year. This is necessary due to the high degree of variability in bicycling and walking levels, especially due to weather. Adjustment factors are created in MS2 by assigning permanent counters to a group and processing the associated data using MS2's Factor Clustering function.

Action 5-3: Assign short-duration counts to factor groups in MS2 to develop annual estimates

To take advantage of the factor group functionality within MS2, short-duration counts must be assigned to a factor group. It is recommended that short-duration counts be initially assigned to a factor group based on its location type, and that the activity patterns be reviewed to ensure the day of week and hour of day patterns fit with the group. Appendix B describes location types and factor group refinement in greater detail.

Action 5-4: Work with MS2 to implement additional data analysis functions

The MS2 NMDS contains several built-in analysis and export functions. However, some additional functions are needed to assist MDOT with managing and interpreting the count data. These recommendations are described in Appendix D.

Goal 6: Supplement count data with related datasets.

	Action	Lead Agency/ Department	Timeline
6-1	Conduct a pilot project to evaluate the use of crowdsourced data.	MDOT TIU; MDOT AMPD; MDOT Research	2021
6-2	Integrate counts with crash data.	MDOT Safety	2025

Action 6-1: Conduct crowdsourced data pilot project

Crowdsourced data can supplement count data, providing a more comprehensive understanding of nonmotorized volume throughout the network. Possible data sources include Strava, bikeshare usage data, signal controller data, and other datasets derived from mobile phones. A pilot project should seek to validate these data sources with count data. Validation involves comparing estimates from crowdsourced data sources to observed count data. It is likely that crowdsourced data and observed counts will more closely match in some locations compared to others. Understanding the characteristics that influence how well crowdsourced data matches observed counts would be a useful outcome of the project. This will help MDOT and other agencies develop guidance for where and how to use crowdsourced data to estimate nonmotorized volume.

Action 6-2: Integrate counts with crash data

In the future, integrating MDOT's growing nonmotorized volume database with its crash data can enable significant improvements in pedestrian and bicycle crash analysis across the state. Development of pedestrian and bicycle safety performance functions is a growing area of research and interest, and volume data is a critical input into such analyses.

APPENDIX A: DATA COLLECTION PROTOCOLS

This section identifies preferred data collection protocols for the MDOT nonmotorized monitoring program. These protocols are intended to support MDOT staff and partner jurisdictions in making decisions on how to collect pedestrian and bicycle count data. Specifically, this section includes an overview of automated count technologies, including preferred technologies for common scenarios, guidance on how to select data collection sites for permanent and short-duration counts and durations and frequencies for short-duration counts, and quality assurance processes to ensure that high-quality data is collected.

Technologies

The primary guidance material for bicycle and pedestrian count technologies is NCHRP 797 and the accompanying NCHRP Web-Only Document 229 that includes revised results and additional technologies not tested in the original study[12]. Chapter 4 of the TMG also provides a strong starting point for understanding the available technologies[13]. Because these recently published documents provide a thorough understanding of the strengths and limitations of currently available technologies, this appendix only includes a brief treatment of the topic.

Using technology that can accurately differentiate pedestrians from bicyclists on shared facilities (paths and sidewalks) is recommended, as the patterns associated with each are distinct from one another. Similarly, it is best to count bicyclists in places where they are separated from motor vehicles; if this is not possible, selecting equipment that has been found to be able to accurately count bicyclists even where some motor vehicles are present is highly important. MDOT is not aware of any technology that has been found by a third party to accurately separate bicyclists from motor vehicles in areas with high motor vehicle traffic (less than 5,000 ADT). Sites where bicyclists and pedestrians are separated from motor vehicles are known to have greater accuracy. Specific sites for installation should be carefully selected based on the specifics of the technology to be used. The ability to shift the site by a block may greatly improve accuracy.

Table 7 presents preferred and alternative count technologies for various settings and for both short-duration and permanent installations.

12 Ryus, P., A. Butsick, F.R. Proulx, R.J. Schneider, and T. Hull. "NCHRP Web-Only Document 229: Methods and Technologies for Pedestrian and Bicycle Volume Data Collection- Phase 2." 2016. ***www.trb.org/Main/Blurbs/175860.aspx***

13 Federal Highway Administration. "Traffic Monitoring Guide." 2016. ***www.fhwa.dot.gov/policyinformation/tmguide***

Recommended Count Technologies by Context

Context	Short-Duration	Permanent
Bicycles in Bike Lane	Pneumatic Tubes*	Induction Loops* Piezoelectric Strips*
Bicycles in Mixed Traffic	Pneumatic Tubes	Induction Loops
Pedestrians on Sidewalk	Passive Infrared* Automated Video* Active Infrared Radar	Passive Infrared* Thermal Imaging* Active Infrared Radar
Pedestrians in Crosswalk	Manual Counts* Automated Video*	No Suitable Technologies
Pedestrians and Bicycles on Multi-Use Trail (separate counts)	Passive Infrared + Pneumatic Tubes*	Passive Infrared + Induction Loops* Passive Infrared + Piezoelectric Strips*
Pedestrians and Bicycles on Multi-Use Trail (combined count)	Passive Infrared* Active Infrared Radar	

Table 7

**Indicates preferred technology*

Brief descriptions of each of the technologies identified in Table 7 follow.

» **Manual Counts:** Data collectors manually record counts of pedestrians and/or bicyclists, either directly in the field or based on video footage. These can be used in any setting for short-duration counts but are limited to very short intervals and therefore are not recommended when alternatives are available. However, one advantage of manual counts is that they can be conducted by volunteers, if available, which can reduce agency staff burden. Additionally, manual counts allow other user information, such as the use of mobility aids, helmet usage, and wrong-way riding, to be collected.

» **Automated Video:** Video footage is taken in the field and computer algorithms are run to identify individual pedestrians or bicyclists.

» **Pneumatic Tubes:** A rubber tube or pair of tubes are nailed or taped to the road or trail surface. When the tubes are compressed, an air pulse in the tube triggers a count to be recorded. Bicycles are identified based on the sequence of pulses recorded. Note that bicycle-specific pneumatic tubes count bicyclists more accurately than general traffic tubes.

» **Induction Loops:** Wire loops are installed on or under the road or trail surface with a current running through them. When the magnetic field produced by these loops is disturbed by a vehicle, including a bicycle, a count is recorded. This technology is very similar to the induction loops used for traffic signal actuation and vehicle counts, although bicycle-specific loops are specially designed to maximize counting accuracy.

- **Piezoelectric Strips:** Piezoelectric materials produce an electric current when they are compressed. This technology involves two piezoelectric strips installed in the surface of the road or trail. Counts are recorded when the piezoelectric strips are compressed.
- **Passive Infrared:** People passing by the sensor are identified and counted based on the heat profiles that they emit.
- **Active Infrared:** An infrared beam is established across the facility between a transmitter and receiver. When the beam is broken, a count is recorded.
- **Thermal Imaging:** Infrared video footage is taken in the field and computer algorithms are run to identify individual pedestrians or bicyclists.
- **Radar:** There are two forms of radar bicycle and pedestrian counters. One type emits radar pulses in line with the direction of travel and identifies pedestrians and bicyclists based on the reflected pulses. The other emits radar laterally across the facility between a transmitter and receiver, and conducts counts when the signal is interrupted.

Location selection

Once counters are planned to be installed, they need to be sited on the network. This includes siting both permanent count stations and short-duration count stations. The specific considerations for these two types of counts are slightly different, as explained below.

Permanent counters

The primary function of permanent counters is to understand the temporal variation in nonmotorized transportation activity at a given location. This is accomplished by examining the patterns of traffic volumes for at least one year.

Selecting the number and locations for the placement of monitoring stations can be a complex task that should be based on several considerations. One of the prime objectives in locating stations is “representativeness,” the degree to which stations collectively represent the temporal patterns of Michigan’s bicycling and walking activity. To be representative, permanent monitoring locations should be located across a variety of contexts. This typically refers to urban, suburban and rural areas, but can also apply to the mix and density of uses. For instance, a downtown will have higher activity levels and different use patterns than a single-family residential neighborhood, although they are both within an urban area.

Locations with similar temporal patterns are referred to as “factor groups.” The specific patterns across Michigan aren’t known for certain prior to evaluating the data that has been collected. The “Michigan nonmotorized monitoring factor group framework” presented later in this appendix provides an initial factor group framework for bicycle and pedestrian count data.

Factor groups provide the broad framework for where to install counters from a statewide and regional perspective. At a more localized level, downtowns, university campuses, school zones, commercial areas, major regional trails and bicycle corridors, and other popular recreation facilities are good candidates for permanent count sites, particularly if the counter can be installed at a pinch point. Pinch points are places in a corridor where bicyclists and pedestrians are channeled, such as bridges over major barriers or local streets channeling into a major street.

Short-duration counts

Short-duration counts (SDCs) are focused on expanding the geographic coverage of the program. As with motor vehicle traffic monitoring, more count stations allow for greater understanding of travel patterns, additional analysis opportunities, and greater confidence in the data overall.

Research into nonmotorized monitoring programs has not determined an ideal number of short-duration stations. Resource limitations are likely to be the determining factor in how many SDCs can be undertaken.

Many communities begin monitoring bicycle and pedestrian traffic using SDCs exclusively. These counts are often collected manually in a relatively ad-hoc manner. While it is most important that the permanent count locations be strategically chosen, integrating SDCs into a strategic framework can make them more useful. SDCs should be collected following standard protocols. To achieve a representative coverage of SDC sites, count stations should not be limited to high-volume locations as this will bias traffic estimates inferred from the program.

To maximize extrapolation accuracy, SDCs should be installed for as long as possible, ideally for one to two weeks to observe the full day-of-week patterns at the count site. The following count durations and times are recommended in order of greatest to lowest preference.

- Automated counts[14]
  - One week or more
  - 24-hour counts (one weekday plus one weekend day per site preferred)
  - 12-hour counts (one weekday plus one weekend day per site preferred)
- Manual counts:
  - Eight-hour counts (7-9 a.m., 11-1 p.m., 4-6 p.m. weekday plus noon to 2 p.m. Saturday)
  - Four-hour counts (7-8 a.m., noon to 1 p.m., 5-6 p.m. weekday plus noon to 1 p.m. Saturday)

Additionally, maximum accuracy can be achieved by installing SDCs during high-volume periods, such as during the summer months. SDC sites should be recounted annually or at another interval to monitor change over time.

[14] If only one day can be counted, weekdays (Tuesday, Wednesday, or Thursday) are preferred.

Data collection quality assurance

High-quality data originates from the data collection process. When data is collected for submission to the MDOT database, the following quality assurance measures should be followed:

» When working with automated counters, make sure that all vendor specifications for installation are followed. For instance, passive infrared sensors should be installed at approximately hip-height with a solid backdrop (e.g., building face) behind them.

» Select site-level installation locations to mitigate bypass errors. This might include installing pneumatic tubes beyond the edge of the bike lane to capture bicyclists riding in the general travel lane or locating counters at pinch points such as bridges. However, vendor installation specifications should always be followed to ensure that the technology works as intended.

» Validation

- For short-duration automated count installations, at least 25 field-validated count events should be obtained.
- Permanent counters should be validated with a two-hour manual count annually, except at low-volume sites where longer video counts (24 hours or more) may be needed to validate the counter. This type of validation consists of placing video cameras on one weekday and one weekend day for at least 12 hours per day per site with the camera and counter clocks synced.[15] Bicyclist and pedestrian counts from the video and counters should be compared by hour. If accuracy is less than 80 percent, contact the manufacturer to adjust settings or change location. After changes are made, the validation must be repeated. If accuracy is 80 percent or more, use the data to compute an equipment correction factor[16] to adjust for consistent under- or overcounting (undercounting is common for properly adjusted bicycle and pedestrian counting equipment). If overcounting is due to counting motor vehicles, this data may be unusable for studying nonmotorized travel. Even slight overcounts due to counting motor vehicles as bicyclists or pedestrians can result in large errors and incorrect pattern identification at sites with high motor vehicle volume. Snowmobile and all-terrain vehicle traffic may also introduce error into count results.

» All count installations should be documented with a photo and accompanying site description.

[15] ***www.pedbikeinfo.org/pdf/PBIC_Infobrief_Counting.pdf***

[16] See NCHRP 797 Section 3.3.9 for details.

APPENDIX B: MICHIGAN NONMOTORIZED MONITORING FACTOR GROUP FRAMEWORK

Factor groups are sets of locations with similar traffic patterns. Permanent count locations are grouped together to calculate adjustment factors, which in turn are applied to short-duration count (SDC) locations that are expected to follow the same "peaking" patterns in terms of how traffic is distributed throughout the day, week, and year. Locations within a given factor group do not necessarily have similar overall volumes. In fact, two sites within a given group may have annual average daily bicycle traffic (AADBT) and annual average daily pedestrian traffic (AADPT) values that differ by orders of magnitude.

As an initial step toward identifying factor groups for Michigan, the project team developed a preliminary factor group framework. The framework includes separate approaches for urban and rural areas. The factor groups suggested by this process directly inform the recommendations contained in the Implementation Plan.

Urban factor groups

To identify preliminary factor groups for urban areas, census tracts across the state were segmented across several variables, including climatic region, population density, proximity to a university, and bicycle facility density. These variables are assumed to be associated with bicycle and pedestrian peaking patterns, and census tracts with similar combinations of these features are expected to have similar activity patterns. These variables are defined in more detail below.

- **Climatic region.** Defined based on the Koppen-Geiger classification system. All else equal, similar climatic conditions are likely to have similar seasonal peaks.
  - Dfb (cold/without dry season/warm summer): This climatic type covers a large portion of Michigan, including all of the Upper Peninsula and much of lower Michigan.
  - Dfa (cold/without dry season/hot summer): The lower part of the state falls into this category, including the Detroit, Ann Arbor, and Lansing areas.
- **Population density.** Defined based on 2010 census data. Tracts with higher population density are expected to have higher levels of pedestrian and bicycle activity and are expected to have greater rates of mid-day peaking than low-density areas.
- **Proximity to a university or college.** Universities are major attractors of bicycle and pedestrian traffic and have strong seasonal peaking patterns associated with them. Tracts within 1 mile of a university are identified as being close to a university.
- **Proximity to a large park.** Parks are another major attractor of bicycle and pedestrian traffic and have strong seasonal peaking patterns associated with them. Tracts within 1 mile of a large park are categorized as being close to a park.
- **Bicycle facility density.** Defined based on bicycle facilities, including in the Open Street Maps database. Different facilities may attract different types of travel, leading to differences in the daily and weekly patterns.

Applying this framework to census tracts within Michigan's urban areas results in 31 unique variable combinations or "location types," which serve as preliminary factor groups. It is expected that many of these will be consolidated based on observed patterns, as described in the factor group refinement section of this appendix. The project team recommends that these factor groups be used as the basis for expansion of nonmotorized volume data collection efforts in Michigan. The location types are numbered in Table 8. This numbering scheme has also been incorporated into the NMDS for location types with one or more permanent counters.

Location types by variable combination

		Population Density							
		Low to Medium				High			
Climate Zone Dfa									
Within 1 mile of a college/university?		No		Yes		No		Yes	
Within 1 mile of a large park?		No	Yes	No	Yes	No	Yes	No	Yes
Bike network density	Low to medium	1	2	3	4	5	6	7	8
	High	9	10	11	12	13	14	15	16
Climate Zone Dfb									
Within 1 mile of a college/university?		No		Yes		No		Yes	
Within 1 mile of a large park?		No	Yes	No	Yes	No	Yes	No	Yes
Bike network density	Low to medium	17	18	19	20	21	22	23	24
	High	25	26	27	28	29	30	31 [1]	32

Table 8

Note: [1] - there are no census tracts in Michigan with this combination of features.

To determine where counters should be installed, it's important to understand both the distribution of these variables and where counters have been installed to date. Table 9 shows the number of census tracts within each location type. Location types were ranked and categorized into the following groups:

- Highest representation: 91 or more tracts
- High representation: 20 to 55 tracts
- Medium representation: five to 19 tracts
- Low representation: less than five tracts

Number of census tracts by location type

		Population Density							
		Low to Medium				High			
Climate Zone Dfa									
Within 1 mile of a college/university?		No		Yes		No		Yes	
Within 1 mile of a large park?		No	Yes	No	Yes	No	Yes	No	Yes
Bike network density	Low to medium	316	581	20	55	162	222	17	10
	High	48	162	7	20	25	52	1	4
Climate Zone Dfb									
Within 1 mile of a college/university?		No		Yes		No		Yes	
Within 1 mile of a large park?		No	Yes	No	Yes	No	Yes	No	Yes
Bike network density	Low to medium	178	255	15	28	16	19	1	4
	High	23	91	2	5	5	11	0	2

Table 9

Note: darker shaded cells correspond to location types that occur with greater frequency across Michigan.

Highest representation High representation Medium representation Low representation

The current distribution of permanent counters by location type is shown in Table 10. Location types with a high number of census tracts (darker cells) and no counters indicate an important gap in coverage.

Number of permanent counters by location type

		Population Density							
		Low to Medium				High			
Climate Zone Dfa									
Within 1 mile of a college/university?		No		Yes		No		Yes	
Within 1 mile of a large park?		No	Yes	No	Yes	No	Yes	No	Yes
Bike network density	Low to medium	0	3	0	1	0	0	0	0
	High	0	2	0	0	0	1	0	0
Climate Zone Dfb									
Within 1 mile of a college/university?		No		Yes		No		Yes	
Within 1 mile of a large park?		No	Yes	No	Yes	No	Yes	No	Yes
Bike network density	Low to medium	8	5	0	0	0	0	0	0
	High	0	0	0	0	0	0	0	0

Table 10

Note: darker shaded cells correspond to location types that occur with greater frequency across Michigan. Dark cells with 0 counters indicate an important gap.

Highest representation | High representation | Medium representation | Low representation

Some of the locations where SDCs have been conducted may be logical candidates to fill gaps in the network of permanent counters. In Table 11, the number of SDCs is shown for each location type. Location types with no permanent counters, but where short-duration counts have been conducted, are highlighted. Location types with SDCs, but that are not highlighted, may still warrant consideration as permanent count locations to achieve enhanced coverage. Facility type and installation details must be considered to determine whether a short-duration count location is a good candidate for permanent installation.

Number of SDCs by location type

		Population Density							
		Low to Medium				High			
Climate Zone Dfa									
Within 1 mile of a college/university?		No		Yes		No		Yes	
Within 1 mile of a large park?		No	Yes	No	Yes	No	Yes	No	Yes
Bike network density	Low to medium	**17**	**22**	**0**	**6**	**1**	**3**	**0**	**0**
	High	**0**	**8**	**0**	**2**	**4**	**5**	**0**	**0**
Climate Zone Dfb									
Within 1 mile of a college/university?		No		Yes		No		Yes	
Within 1 mile of a large park?		No	Yes	No	Yes	No	Yes	No	Yes
Bike network density	Low to medium	**3**	**5**	**0**	**1**	**0**	**4**	**0**	**4**
	High	**3**	**4**	**1**	**0**	**0**	**1**	**0**	**2**

Table 11

Note: shaded cells indicate an opportunity for an SDC to be converted to a permanent count to fill a gap in the permanent counter network.

■ SDC location may fill high-priority gap ■ SDC location may fill lower-priority gap

Table 12 provides additional detail regarding the gaps in the permanent counter network. Location types are organized by the level of representativeness, per Table 10.

Permanent counter gaps by location type

Priority group	Location type	High population density	Within 1 mile of a college or university	Within 1 mile of a large park	Dense bike network	Number of permanent counters	Counter gap (minimal coverage)[1]	Counter gap (enhanced coverage)[2]
Highest	2			X		3	0	2
	1					0	1	5
	18			X		5	0	0
	6	X		X		0	1	5
	17					8	0	0
	5	X				0	1	5
	10			X	X	2	0	3
	26			X	X	0	1	5
High	4		X	X		1	0	3
	14	X		X	X	1	0	3
	9				X	0	1	4
	20		X	X		0	1	4
	13	X			X	0	1	4
	25				X	0	1	4
	3		X			0	1	4
	12		X	X	X	0	1	4
Medium	22	X		X		0	1	3
	7	X	X			0	1	3
	21	X				0	1	3
	19		X			0	1	3
	30	X		X	X	0	1	3
	8	X	X	X		0	1	3
	11		X		X	0	1	3
	28		X	X	X	0	1	3
Low	29	X			X	0	1	1
	16	X	X	X	X	0	1	1
	24	X	X	X		0	1	1
	27		X		X	0	1	1
	32	X	X	X	X	0	1	1
	15	X	X		X	0	1	1
	23	X	X			0	1	1

Table 12

Notes: [1] – one counter per location type is recommended for minimal coverage; [2] – the following number of counters are recommended for enhanced coverage, depending on the priority group: Highest priority – 5; High priority – 4; Medium priority – 3; Low priority – 1.

More detailed counter implementation recommendations will be provided in the Implementation Plan. Additionally, the process for working with and refining these groups is discussed later in this section.

Rural factor groups

Since bicycling and walking are less common in rural areas compared to urban areas, a simpler approach is recommended for rural factor groups. Climatic region is the only suggested variable to be used to segment census tracts in rural areas. This results in two rural factor groups corresponding to climate zones Dfb and Dfa. Interest in counting from MDOT or local partners is the primary factor that will guide installation of permanent counters in rural areas. As noted previously, there are currently no permanent counters installed outside of urbanized areas.

Factor group refinement

The preliminary urban and rural factor groups offer a starting point for classifying count sites; however, evaluating the activity patterns at individual count location sites within each group may reveal that some groups can be combined. For example, it may be determined that two sites in urban areas within and outside 1 mile of a large park, respectively, have similar peaking patterns. In this case, these two preliminary groups could be collapsed into a single group. Likewise, as the program evolves it may become apparent that there is sufficient variation in the patterns within a single factor group to warrant splitting the group into two or more groups.

As discussed in the TMG, there are three typical patterns that can be observed in nonmotorized volume data: commuter/utilitarian, recreational, and mixed. The commuter pattern is identified by higher activity during weekday morning and afternoon commute periods, higher weekday volume compared to weekends, and relatively consistent volumes throughout the year. By comparison, the recreational pattern is identified by more consistent hourly volumes, greater weekend activity, and lower volume during the winter months or other periods of inclement weather.

Peaking patterns for hour of day, day of week, and seasonal distribution can be identified by quantitative metrics or visual review. The following methods are suggested:

- Hour-of-day: Commute-to-midday ratio. The average hourly volume during weekday commute periods (7 to 9 a.m.) divided by the average midday volume (11 a.m. to 1 p.m.).
- Day-of-week: Weekday-to-weekend ratio. The average weekday volume divided by the average weekend volume. Higher values suggest a commuter pattern.
- Seasonal distribution: Warm Month Index. The average daily count for the months of April through September divided by average daily count for the months of October through March for a given year.

For each location where a permanent counter is installed, the above metrics should be calculated. As subsequent counters are installed, the results should be compared to the metrics from other locations to determine whether the new location is unique or can be incorporated into an existing factor group. There are likely to be fewer factor groups than what has been identified preliminarily as a result. Ideally, the proposed metrics would be incorporated into the NMDS to facilitate factor group consolidation.

APPENDIX C: SUPPLEMENT TO MS2 USER GUIDE

The MS2 NMDS is formally documented in the Quick Help Guide, available from MS2's website. The guide outlines how to use the basic features of the system. In this appendix, additional detail is provided to address potential challenges that may be encountered by NMDS users in Michigan.

Creating stations in MS2

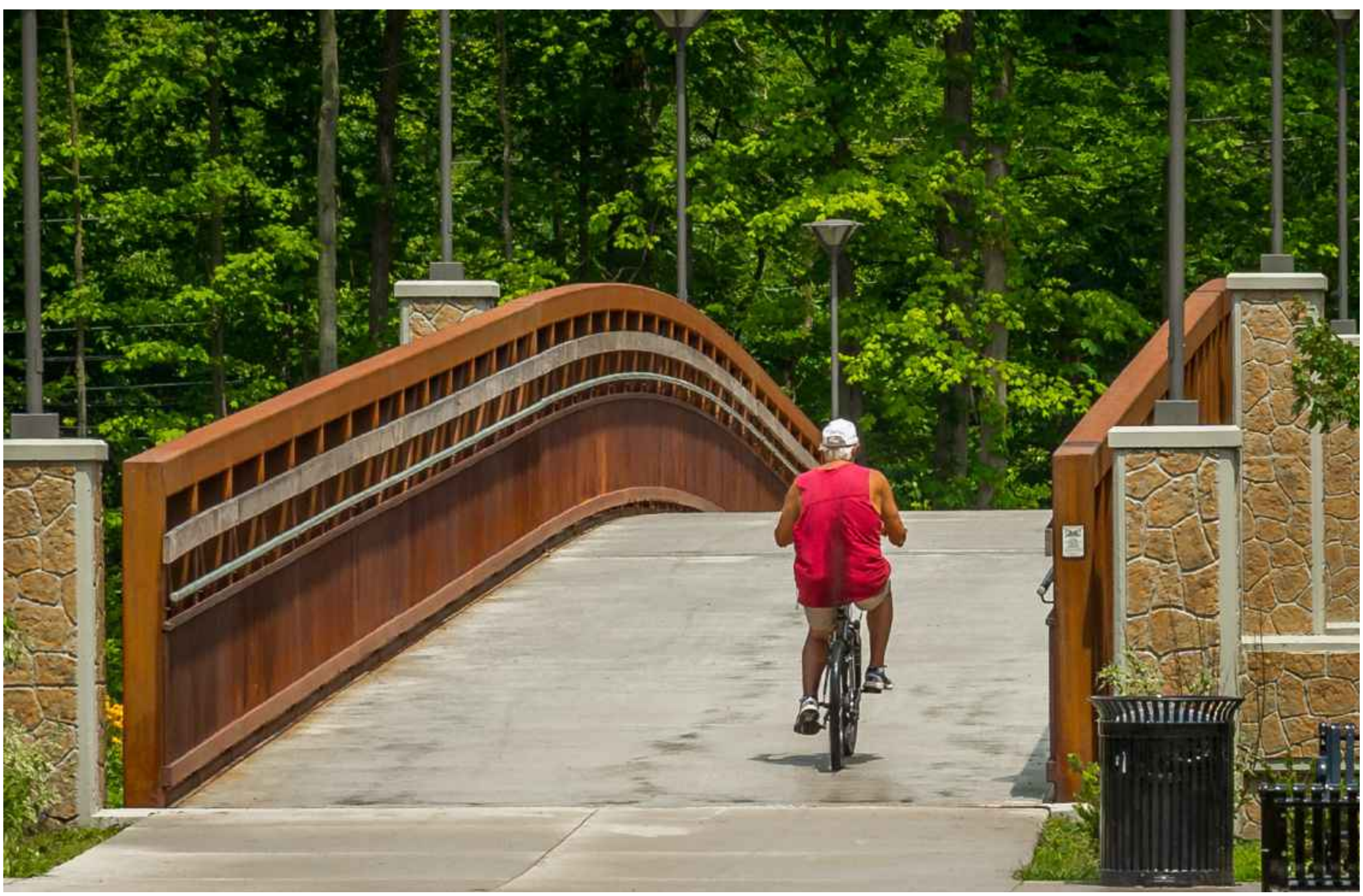
Nonmotorized monitoring data consists of two key types of data: stations and count data. Station data describe the locations where nonmotorized users are observed, whereas the actual observations are reflected in count data.

Within MS2, stations are created in the "Admin" > "Add Location" page of the NMDS. Table 13 lists the required and optional attributes to be entered for each station. While many of these attributes are straightforward, the Travel Direction and Selected Pathways attributes require careful consideration. These attributes are described in detail in the NMDS User Guide (see page 14).

Location ID format

To avoid confusion and maintain data integrity, it is important to use a consistent location identifier format for all count data uploaded into the NMDS. The following format is used for location identifiers: xx-xxxxx-N. In this format, the first two digits represent a county code, the next five are a sequential identifier, and the N distinguishes the count as a nonmotorized count. See Table 14 for a list of county codes, as used in the NMDS.

To avoid duplicate identifiers within a given county, centralized MDOT staff will need to proactively manage assignment of identifiers to count locations or work with MS2 to have identifiers autogenerated within the system. As part of the station creation process, it is also important to prevent multiple stations from being created for a single location.



MS2 NMDS station attributes

Attribute	Required	Description and typical values	Notes
Location ID	Yes	Unique location identifier; xx-xxxxx-N (see description above)	In the future, this identifier should be autogenerated
Description	No	Description of the count location	
County	Yes	County name	
Community	Yes	City or other community name	
Jurisdiction	No	Agency that owns or manages the facility	
Located On	No	Roadway or trail where the counter is located	
District/Region	No	MDOT district number	
Latitude	No	Latitude (decimal format)	
Longitude	No	Longitude (decimal format)	
TMG Station ID	No	Associated TMG station identifier (refer to TMG for more detail on acceptable format)	
Functional Class	No	Roadway functional class (major arterial, minor arterial, collector, etc., per classifications used in Michigan)	Applies to on-street facilities or side paths
Owner	Yes	Person responsible for count site	
Permanent	No	Whether the counter is a permanent installation (yes/no)	
Seasonal Factors	No	Seasonal factor group membership	Factor groups are created in the Seasonal Factors section of the NMDS
QC Group	No	Group membership defining QC rules that should be applied to the site	QC rules can only be assigned during the count upload process. QC Groups are developed in the QC Manager section of the NMDS
Urban/rural	No	Urban or rural location	Based on urbanized area designations
Travel Direction	Yes	Facility orientation; NS = north/south; EW = east/west; NESW = northeast/southwest; NWSE = northwest/southeast	Travel direction and selected pathways together determine the direction of travel for the count
Road Associated	Yes	Whether the location is associated with a roadway and intersection (yes/no)	Selected Pathways options depend on selection
Selected Pathways (subset of "Road Associated")	Yes	Type of facility on the specified offset of the location (north, south, east, west); options include bike lane, bike path, roadway, sidewalk, trail, unspecified, crosswalk	Travel direction and selected pathways together determine the direction of travel for the count
Selected Pathways (subset of "No Road Associated")	Yes	Type of facility with no offset (bike path, trail, unspecified)	Travel direction and selected pathways together determine the direction of travel for the count

Table 13

County codes for use in NMDS station identifiers

County Code	County Name
1	Alcona
2	Alger
3	Allegan
4	Alpena
5	Antrim
6	Arenac
7	Baraga
8	Barry
9	Bay
10	Benzie
11	Berrien
12	Branch
13	Calhoun
14	Cass
15	Charlevoix
16	Cheboygan
17	Chippewa
18	Clare
19	Clinton
20	Crawford
21	Delta
22	Dickinson
23	Eaton
24	Emmet
25	Genesee
26	Gladwin
27	Gogebic
28	Grand Traverse
29	Gratiot
30	Hillsdale
31	Houghton
32	Huron
33	Ingham
34	Ionia
35	Iosco
36	Iron
37	Isabella
38	Jackson
39	Kalamazoo
40	Kalkaska
41	Kent
42	Keweenaw
43	Lake
44	Lapeer
45	Leelanau
46	Lenawee
47	Livingston
48	Luce
49	Mackinac
50	Macomb
51	Manistee
52	Marquette
53	Mason
54	Mecosta
55	Menominee
56	Midland
57	Missaukee
58	Monroe
59	Montcalm
60	Montmorency
61	Muskegon
62	Newaygo
63	Oakland
64	Oceana
65	Ogemaw
66	Ontonagon
67	Osceola
68	Oscoda
69	Otsego
70	Ottawa
71	Presque Isle
72	Roscommon
73	Saginaw
74	Sanilac
75	Schoolcraft
76	Shiawassee
77	St. Clair
78	St. Joseph
79	Tuscola
80	Van Buren
81	Washtenaw
82	Wayne
83	Wexford

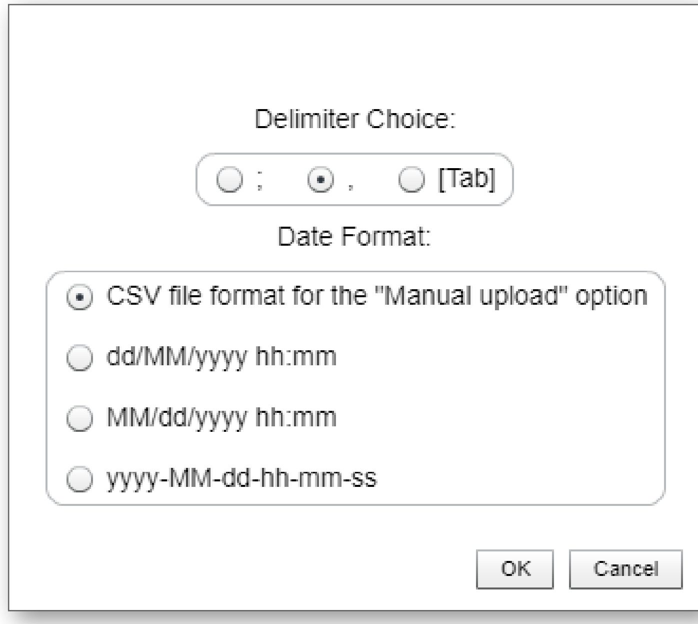
Table 14

Count data upload

Automated count data file formats vary with respect to the number of fields and naming conventions. While MS2's NMDS supports uploading count data from the most common nonmotorized count technology vendors (TRAFx, Eco-Counter, and Miovision), each provides various export options that can deviate from MS2's accepted formats. As a result, each file must be reviewed, and in some cases reformatted, to match MS2's accepted upload formats. The process for uploading Eco-Counter, TRAFx, and Miovision pathway files is described below; the currently accepted file formats are shown in tables 15 through 17. These files are uploaded to the NMDS as .csv files.

Eco-Counter format

1. Download file from Eco-Visio with total, pedestrians, and bikes by direction in 15-minute (or hourly) intervals. Use the CSV file format for the “Manual upload” option.
2. Open file in Excel.
3. Put date column in d/m/yyyy format.
4. Put time column in 13:00 format.
5. Add “Ped IN”, “Ped OUT”, “Bike IN”, and “Bike OUT” to the end of the names of the headers of the last four columns.
6. Delete lines with blank data (no counts).
7. Export to CSV.
8. Open in Notebook.
9. Make sure there are no spaces at the end of files.
10. Resave as .csv.
11. Upload to NMDS, following instructions outlined in the Quick Help Guide (see page 38).



Eco-Counter upload format

	Date	Time	[Location name]	[Location name] Ped IN	[Location name] Ped OUT	[Location name] Bike IN	[Location name] Bike OUT
Description	Date	Time, 15-minute interval	Total count	Pedestrians counted in the In direction.	Pedestrians counted in the Out direction	Bicyclists counted in the In direction	Bicyclists counted in the Out direction
Example	1/1/2013	0:15	5	0	4	1	0

Table 15

Notes: 1) IN and OUT refer to an Eco-Counter setting. The in/out designations correspond to directions of travel and are arbitrarily chosen but must be documented for accuracy of interpretation. The Eco-Counter file upload process requires the in and out directions to be specified. 2) Counts for only one mode (e.g., bicycle tube count) would not include columns for the other mode.

TRAFX format

The NMDS currently supports upload of TRAFx shuttle files but does not directly accommodate files exported from TRAFx Datanet. As a result, files exported from Datanet must be converted to the shuttle file format for upload. The schema for TRAFx shuttle files is shown in Table 16 (column names are provided for reference only and are not included in the file itself).

TRAFx upload format

	Date	Time	Count 1	Count 2
Description	Date	Time, hour interval	Total count (series 1)	Total count (series 2)
Example	16-11-10	14:00	00018	00000

Table 16

Notes: 1) MS2 also supports the TRAFx timestamped data upload format. 2) The last column could theoretically hold a count from another series but this is rarely implemented in practice.

In addition to the fields shown, the shuttle file format includes a header with a "Counter name" attribute that must be modified to include the NMDS Location ID. The header is shown at right, with the "Counter name" field circled in red.

```
D
>>>>>>~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
G4 Dock:_B4.45_C2.80_F8127
=DOCK TIME (yy-mm-dd hh:mm):18-06-15 14:32:37
Counter log start
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

System check...
*****V9.4c S/N170525 (c) 2001-2017*****
TRAFx Research Ltd. www.trafx.net
Fx:F6E0R1M3T2T_c26f26L33LN4P0A0E2_m064I2_d

Sets:N:H:001:030:E:060:000:F:Y:F:016:000:Y:000

  *Serial Number  :1705Yh
  *Counter name   :52-00111N
  *Mode           :Infrared (IR+)
  *Batt. voltage  :4.3
  *Stored records :00938

=TIME (yy-mm-dd hh:mm):18-06-15,14:33:38
=START(yy-mm-dd hh:mm):18-05-07,14:00
PERIOD (1/24/0=Timestamps) :001
DELAY     (see manual)     :030
```

Recommended steps for working with TRAFx files to be uploaded into MS2 include:

1. Refer to MS2's sample TRAFx template "Trafx_Hrly_Bin_Sample.txt."
2. Copy count data into Excel. If needed, reformat column data to match the sample exactly: yy:mm:dd, 13:30, 00005, 00000.
3. Save as .csv, open in a text editor.
4. Copy header from sample template, replacing values for "Counter Name" and "=START(yy-mm-dd hh:mm)" fields with project values.
5. Copy footer from end of sample template; no need to change anything.
6. Save as .txt file.
7. When uploading to MS2, be sure offset and pathway exactly match that of the station ID.

Note that the NMDS doesn't allow two separate TRAFx files for the same time period (one for bike and one for pedestrian). In this case, combine data for both modes.

Miovision Pathway format

The NMDS supports uploading the Miovision Pathway file format. Other Miovision formats that include pedestrians and bicyclists are supported in other MS2 modules. The Miovision Pathway file format is shown in Table 17.

Miovision Pathways upload format

	Date	Pedestrians	Bicycles
Description	Time, 15-minute intervals	Number of pedestrians observed	Number of bicycles observed
Example	1:00 PM	5	2

Table 17

In addition to the count data included in the Miovision Pathway file, the following fields are contained in the file header: Study Name, Start Date, Start Time, and Site Code. The Site Code should match the Station Identifier in the NMDS and can be manually edited if needed. Each pathway file can contain separate directional count results. The direction of travel is indicated in the row preceding the associated data and must be consistent with the direction established in the Location data.

MS2 template format

MS2 has also established a default template for uploading manual count data into the NMDS, which supports uploading up to one day of count data. This Excel template does not match the output of any known counter exports but may be appropriate for uploading manual count data aggregated at the hourly level. It includes fields for mode, location (east side, west side, etc.), and direction of travel. Count data is recorded in hourly intervals.

APPENDIX D: RECOMMENDED MS2 NMDS FEATURE UPGRADES

The following features are recommended to improve the functionality of MS2 for MDOT's use.

- Improve overall functionality to be consistent with the Traffic Count Database System with respect to upload processes, export capabilities, etc. to make the NMDS easier to learn.
- File formats
  - Add a second TRAFx file format: DataNet file format. Many local agencies in Michigan export data in DataNet format.
  - Add generic file format for continuous count data (not limited to 24-hour period).
  - Create a flexible, user-defined field matching interface for any file type.
- Quality control (QC)
  - Develop a QC rule that would flag consecutive zeros. A threshold of 168 (one week) is recommended.
  - Add QC rule to compare counts to neighboring values (e.g., count is flagged if it is a certain percentage higher or lower than the average of previous counts of same day of week).
  - Allow QC rules to be applied after data is uploaded.
- Exporting/analysis
  - Calculate the following metrics for each location (with user-definable date range) and allow users to group sites by these metrics:
    - Hour-of-day: Commute-to-midday ratio. The average hourly volume during weekday commute periods (7-9 a.m.) divided by the average midday volume (11 a.m.-1 p.m.).
    - Day-of-week: Weekend-to-weekday ratio. The average weekday volume divided by the average weekend volume. Higher values suggest a commuter pattern.
    - Seasonal distribution: Warm Month Index. The average daily count for the months of April through September divided by average daily count for the months of October through March for a given year.
  - Allow a wider range of dates for data export.
  - Add or update data export format for compliance with TMAS requirements.
  - Enable users to export reports with minimally processed data, such as by hour, reflecting any QC decisions made on the file.
- Factor groups
  - Improve stability of factor clustering module and documentation of the factor development process.
  - Separate Seasonal Factor Group by mode. It is well established in the literature that pedestrians and bicyclists can have different patterns at the same site.

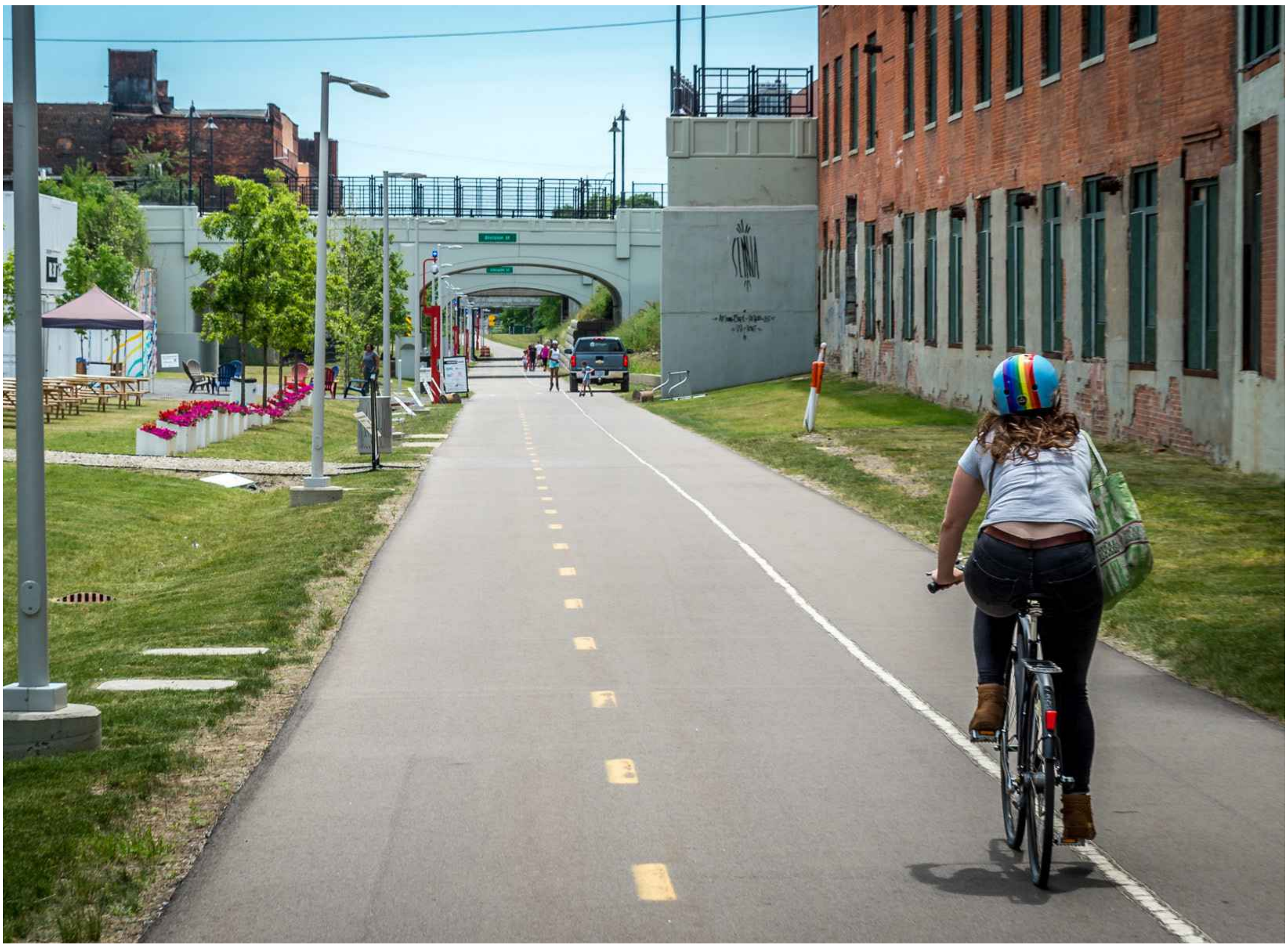
APPENDIX E: RECOMMENDED MS2 NMDS USER PRIVILEGES

The NMDS allows different users to have varying privileges within the system. Table 18 lists recommended privileges for MDOT staff and external agency staff.

Miovision Pathways upload format

MS2 Function	MDOT	External agency
Station creation (including establishing unique identifiers)	X	
Upload data	X	X
Apply QC during upload	X	X
Factor group assignment	X	
Factor group processing	X	
Exporting	X	X

Table 18



TOOLE DESIGN

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

MDOT
Michigan Department of Transportation

Providing the highest quality integrated transportation services for economic benefit and improved quality of life.