M2D2

GUIDEBOOK

MULTI MODAL DEVELOPMENT & DELIVERY GUIDEBOOK

MICHIGAN DEPARTMENT OF TRANSPORTATION

2019

Plan prepared for:

Plan funded by:

Plan prepared by:

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01 INTRODUCTION

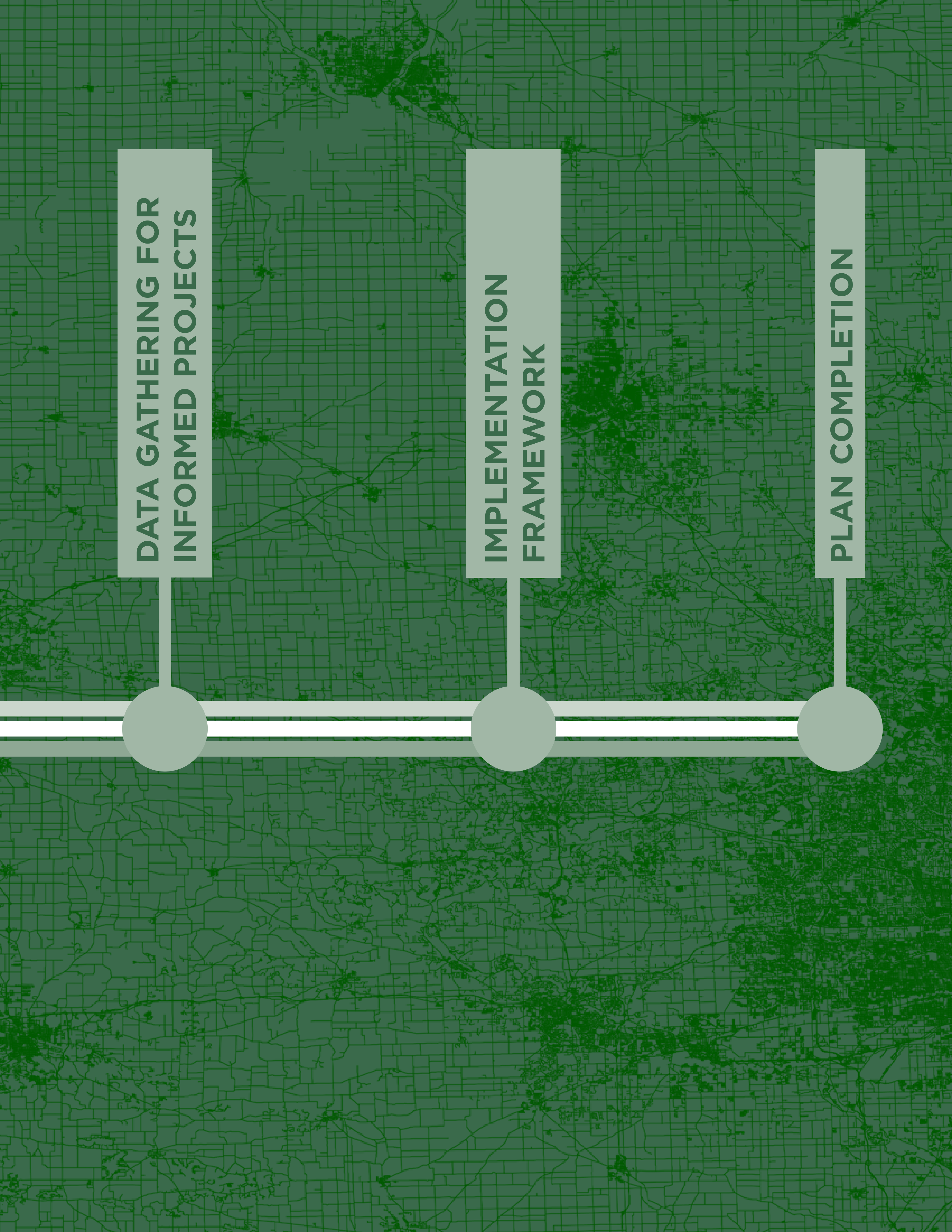
MDOT's Multi-Modal Development and Delivery (M2D2) initiative is a process developed to encourage collaboration between different departments at the Michigan Department of Transportation and with local governments that are planning for non-motorized, transit, and future mobility improvements on state owned roads within their jurisdiction. The M2D2 Guidebook is designed to provide information on existing and future transportation modes, identify new and upcoming data collection opportunities, and develop a framework for planning, designing, and constructing context sensitive transportation solutions in the State of Michigan.

BENCHMARKING

OVERVIEW

MULTI MODAL DEVELOPMENT & DELIVERY

M2D2 GUIDEBOOK


DATA GATHERING FOR INFORMED PROJECTS
IMPLEMENTATION FRAMEWORK
PLAN COMPLETION

Introduction

Overview

The Michigan Department of Transportation's (MDOT) mission is "providing the highest quality of integrated transportation services for economic benefit and improved quality of life" for residents across the State. As the transportation system evolves and the needs of communities change, MDOT is now looking to plan, design, construct, and maintain State roadways for all modes of travel, in order to meet this mission.

MDOT was awarded State Transportation Innovation Council (STIC) Incentive funds for the development of an M2D2 Guidebook to support implementation of the Multi-Modal Development and Delivery (M2D2) process. The M2D2 Guidebook will help provide MDOT with analysis tools and resources to effectively consider performance management approaches for planning, designing, and building transportation projects that promote modal choice, connectivity, revitalize communities, and improve public health and safety. The M2D2 Guidebook will also help serve as a resource to local communities, non-profits, and other State agencies to ensure planned transportation projects meet MDOT's goals for multi-modal travel.

MDOT will use the recommendations from this guidebook to better tie the State's project scoping to local and regional planning processes by setting design standards for all agencies to consider. The M2D2 Guidebook brings attention to multi-modal transportation options through regional and national best practices that support and enhance collaboration on local and regional transportation plans for all uses of the public right of way.

Multi Modal Development & Delivery

Multi Modal Development and Delivery (M2D2) is a project to support Michigan's economic recovery by improving MDOT's institutional capacity to plan, construct, operate, and maintain Michigan's transportation system for Complete Streets and multiple modes. In 2013, MDOT, in partnership with Smart Growth America, began to explore the needs and expectations for the transportation modes utilizing State roadways and identify ways MDOT can balance those needs and modes collectively.

This led to the M2D2 Work Plan in January of 2015, which set in place a process for MDOT to modify and augment practices, standards, and guidance to align with the purpose of the initiative within the organization. The M2D2 Guidebook is a continuation of those efforts and is meant to be a collaboration tool for MDOT Staff, communities throughout Michigan, non profits, and other state agencies that are working to implement multi-modal opportunities throughout the State.

M2D2 Process

M2D2 Guidebook

The goal of this document is to provide a guidebook and examples of best practices to be used for planning and designing smart transportation networks that support sustainable and livable communities. The plan identifies multi-modal design options, transportation analysis tools, best practice case studies, and resources to support the implementation of the M2D2 initiative. It will also inform access to and sharing of geospatial data associated with existing and proposed land use and environmental information.

Work performed in this document consisted of:

- Preparation of an M2D2 process framework to be integrated with current MDOT project development processes
- Guidance for local communities, non-profits, and other State agencies to use to collaborate with MDOT on future transportation projects.
- Identification of best practices related Complete Streets, Transit, and Autonomous Vehicle Readiness.
- Identification of relevant, available geospatial datasets (land use, socio-economic, environmental, and natural resource data).
- Identification of future technologies and data sources that may assist MDOT in planning and constructing safer, more efficient roadways.
- Description of principles for MDOT to follow for creating multi-modal roadways.
- Prioritization of design elements for urban, suburban, rural, and corridor settings.

INTRODUCTION

How to use this Plan

The M2D2 Guidebook is one element of MDOT's M2D2 initiative, which is looking to proactively plan and implement multi-modal infrastructure along Michigan's roadways. The Guidebook is intended to be an educational resource and tool for MDOT Staff, local communities, non-profits, and other state agencies to use when considering infrastructure updates to the state owned transportation system.

This Guidebook should be used as a starting point for reference and should be built upon as transportation evolves and as MDOT implements multi-modal projects across the State. Although not every element of the Guidebook is applicable to all communities, extensive effort was made to ensure the document considered all potential contexts in Michigan, including urban, suburban, and rural areas.

Michigan Department of Transportation (MDOT)

MDOT staff and leadership should familiarize themselves with the content of this Guidebook early in the project planning and development process. The Guidebook is meant to inform staff of relevant considerations for multi-modal connections including the variety of possible modes on a roadway, existing and future considerations with each mode, current and future data sources to help make informed decisions, and how M2D2 fits within the project development process.

Non-Profits

Like state agencies, non-profits within Michigan also impact or are impacted by transportation decisions within the state. Non-profits that focus on issues of equity, health, mobility, and environment, among other areas, should use this Guidebook to inform there own plans and policies and to explore shared opportunities with MDOT to further there mission and the purpose of M2D2.

State Agencies

Many state agencies within Michigan impact or are impacted by transportation decisions within the State. While MDOT prepares to implement multi-modal connections throughout the State, other state agencies should use this Guidebook to stay informed about existing and future infrastructure and technology around multi-modal connections. State agencies should also use this document to explore opportunities for shared interests including ongoing or planned projects and additional data sources.

Michigan Communities

Throughout Michigan, counties, cities, townships, villages, and unincorporated areas have State of Michigan roadways that interlink with local roadways, as well as transit and active transportation connections. As infrastructure improvements are made, this Guidebook should serve as a toolkit for local leaders to plan and implement multi-modal projects on both State and local roadways within their communities. It should also help leadership educate and identify how changing transportation systems will impact their communities in the mid-and-long-term.

Incorporating the M2D2 Guidebook in the MDOT Project Development Proecess

MDOT	M2D2
Standard MDOT project selection process for identification and selection of multi-modal projects.	Consult the corresponding M2D2 Guidebook chapters for each step of the MDOT project process to ensure M2D2 recommendations are carried through to new MDOT projects.

PHASE I

KICKOFF LAUNCH
(IDENTIFY CANDIDATE PROJECTS)

CONSULT THIS CHAPTER

02 - BENCHMARKING

PHASE II

EXISTING CONDITIONS & DATA GATHERING

03 - DATA GATHERING FOR INFORMED PROJECTS

PHASE III

ALTERNATIVE DEVELOPMENT

04 - IMPLEMENTATION FRAMEWORK

PHASE IV

PREFERRED SCENARIO DEVELOPMENT
(5 YR PROGRAM ANNOUNCED)

PLAN COMPLETION

INTRODUCTION

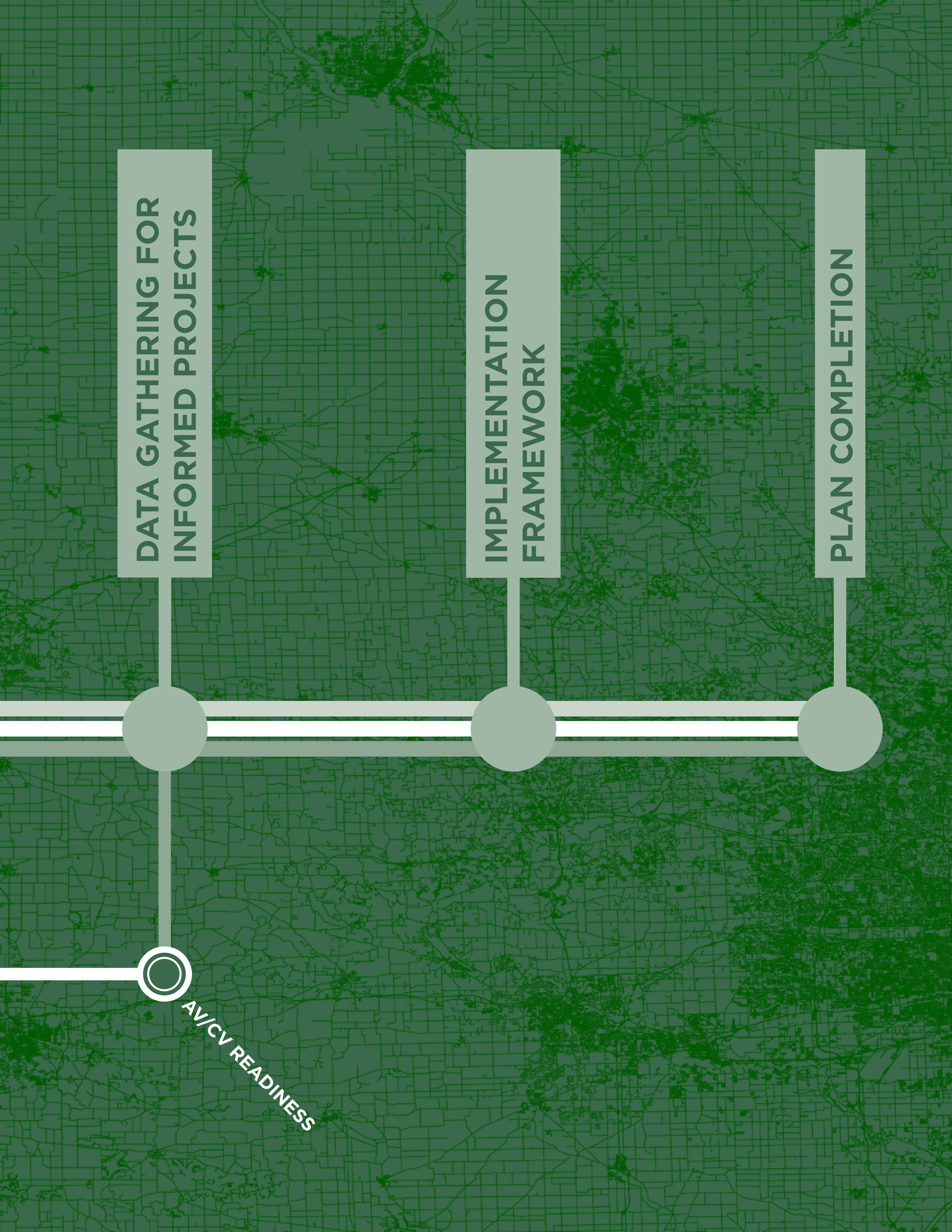
02

BENCHMARKING

The purpose of the Benchmarking section of the M2D2 Guidebook is to identify the existing Complete Streets, Transit, and AV/CV Readiness best practices and case studies that MDOT and other agencies can use when planning and designing projects on state roadways. Agency staff should use this compilation of best practices to ensure upcoming projects meet the multi-modal goals of M2D2 as best as possible. Additionally, MDOT can compare their final products to the benchmarks to see how well they meet the design aspects associated with each. Not all will be applicable to every roadway in the State, but consideration was taken to include examples from urban, suburban, rural, and connecting corridors that apply to most municipalities in Michigan.

COMPLETE STREETS

TRANSIT


DATA GATHERING FOR INFORMED PROJECTS
IMPLEMENTATION FRAMEWORK
PLAN COMPLETION
AV/CV READINESS

Complete Streets

OVERVIEW

Complete Streets are roadways planned, designed, and constructed to provide appropriate access to all users in a safe and efficient manner. A transportation network comprised of Complete Streets can be easily navigated by travelers of all ages and abilities and across all mobility modes, including motorists and trucks, transit, rail, bicyclists, and pedestrians. The application of Complete Streets is dependent on the context of the community including the community's needs and function of the roadway.

Implementing policies and improvements which support these mobility options can be costly, time intensive, and ineffective if done without proper evaluation and analysis. By establishing guidelines to review future roadway projects through a lens of Complete Streets, improvements which support the safety and accessible mobility for all can be efficiently integrated into MDOT projects.

MICHIGAN COMPLETE STREETS

In 2010, two laws in Michigan were passed for Complete Streets: Public Acts 134 and 135. These laws are intended to further the development of Complete Streets and create communication between agencies and departments working on transportation projects across the State. Specifically, the laws required MDOT to adopt a Complete Streets policy which provides guidance for roadway projects that promotes Complete Streets. The law also created a Complete Streets Advisory Council that was charged with providing education and advice to agencies regarding the development and implementation of Complete Streets. The Council fulfilled their charge and was dissolved in 2016.

The laws specify that roadway commissions, local governments, and MDOT must communicate with each other about planning or implementing Complete Streets on a particular roadway project. Local governments may pass a Complete Streets Policy, however, they are not required.

MDOT also recently released the *Guidance for Trunkline Main Streets* to coordinate efforts and responsibilities between local agencies and MDOT. As many Complete Streets projects will be implemented on trunklines, this document can be used in conjunction with the M2D2 guidelines.

In This Section:

- **Applicable Complete Streets Programs:** Complete Streets programs from across the U.S. that include key features relevant to Michigan.
- **Implementing Complete Streets:** Flow chart summarizing the relevant Complete Streets programs in relation to MDOT implementation.

Incorporating the M2D2 Guidebook in the MDOT Project Development Proecess

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PHASE I

CONSULT THIS CHAPTER

MDOT	M2D2
KICKOFF LAUNCH (IDENTIFY CANDIDATE PROJECTS)	**02 - BENCHMARKING**

PHASE II

MDOT	M2D2
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PHASE IV

MDOT	M2D2
PREFERRED SCENARIO DEVELOPMENT (5 YR PROGRAM ANNOUNCED)	**PLAN COMPLETION**

COMPLETE STREETS BENCHMARKING

This section includes best practice examples from state, regional, and local organizations on applying Complete Streets improvements to the roadway network. Each document contains different elements that may be helpful in guiding MDOT's evaluation of complete street implementation and identifying context sensitive solutions for each roadway. Table 2-1 summarizes the referenced Complete Streets documents by identifying which useful elements, such as graphics or data, each plan or manual contains. The table may serve as a guide in reviewing the program overviews provided in this section.

The Complete Streets guidance summaries act as sources by which MDOT may pull relevant examples and best practices to be applied appropriately to Michigan roadways. The document overview lists a key feature which the reader may choose to focus on when reviewing the manual or document. An overview of all document features is also provided, including a brief application to MDOT.

The flow chart below summarizes the reports highlighted throughout this section, including the key ideas, respective approaches, and accompanying documents to find further information.

Define the Street Context

1. Classification of streets on state network based on different land uses. *(Florida DOT, NCDOT)*

Clearly Communicate Design Needs for Different Streets and Users

1. Illustrative diagrams and sections begin to clearly communicate the different design needs based on different locations throughout the network. *(NACTO, Grand Rapids Vital Streets)*
2. Summary tables for each "complete street" component are an alternative approach to organizing recommendations. *(Knoxville RTPO).*
3. Advocacy organizations' research provides an informed understanding of the needs of specific users of Complete Streets. *(e.g. People for Bikes with bike advocacy).*

Develop a Decision Matrix to Prioritize Investments

1. An overview evaluation matrix can help organize recommend Complete Streets components based on surrounding land use context. *(VTrans)*
2. A more nuanced evaluation matrix accounts for other elements important to the implementation process, including construction phasing and necessary public engagement. *(City of New Haven).*
3. Weighted priority matrices account for proximity to different land uses, along with anticipated stress level of the proposed facility. *(Nashville MPO, People for Bikes).*

TABLE 2-1: NOTEWORTHY COMPLETE STREETS DOCUMENTS

Noteworthy Complete Streets Documents

PLAN / MANUAL TITLE	IDENTIFIES STREET HIERARCHY & CONTEXT	PROVIDES DIMENSIONAL GUIDELINES	CONTAINS CLEAR, ILLUSTRATIVE GRAPHICS, VISUALS	PROVIDES DECISION / IMPLEMENTATION MATRIX OR CHECKLIST	REFERENCES TECHNICAL INFORMATION OR DATA NEEDED	INCLUDES CASE STUDIES	INCLUDES MULTI DEPARTMENT PROJECT REVIEW PROCESS
Florida Department of Transportation Context Classification for Complete Streets	●		●		●	●	
North Carolina Department of Transportation Complete Streets Planning and Design Guidelines	●	●	●		●	●	
Knoxville Regional Transportation Planning Organization Complete Streets Design Guidelines		●	●		●		
Vermont Agency of Transportation Complete Streets Guidance	●			●	●		●
City of New Haven, Connecticut Complete Streets Design Manual	●	●	●	●			●
Nashville Area Metropolitan Planning Organization 2035 Regional Transportation Plan Project Evaluation Criteria				●			
Grand Rapids Vital Streets Plan and Design Guide	●	●	●	●	●		●
National Association of City Transportation Officials (NACTO) Urban Street Design Guide		●	●		●	●	
People for Bikes - Bicycle Network Analysis Database	●		●		●		

FLORIDA DOT

Context Classification for Complete Streets

To implement Complete Streets in Florida, the state used an approach which first assigns a roadway segment to a detailed classification. This classification is based on building and zoning specifications such as land use, setbacks, and building height, among other features.

The classification informs planners and engineers of the type of users along different segments of roadway. Once assigned to a classification, relevant design and development principles for all modes of transportation may be applied to that segment. For example, in the C6-Urban Core Context Classification, there will be a higher number of pedestrians, bicyclists, and transit users than in a C2-Rural Context Classification. Therefore, reduced speeds, signal spacing, and lane widths are appropriate design strategies. A clear definition of the street hierarchy lays the foundation for implementing Complete Streets recommendations.

Key Feature: Street Hierarchy

Document Features:

- **Document Name:** Florida Department of Transportation Context Classification for Complete Streets
- **Completed:** 2017
- **Key Features:** Street classification transect and matrix, list of relevant data by mode of transportation
- **Application to MDOT:** As MDOT further develops the Complete Streets implementation policy, defining the street context will be important for laying the foundation for a context appropriate plan.

FIGURE 2-1: DEVELOPMENT TRANSECT

Clear graphics, such as the transect highlighted above, are helpful to illustrate the variety of roadway context throughout MDOT's network and its implications on use.
(FDOT Context Classification for Complete Streets, Pages 2-3)

NORTH CAROLINA DOT

Complete Streets Planning and Design Guidelines

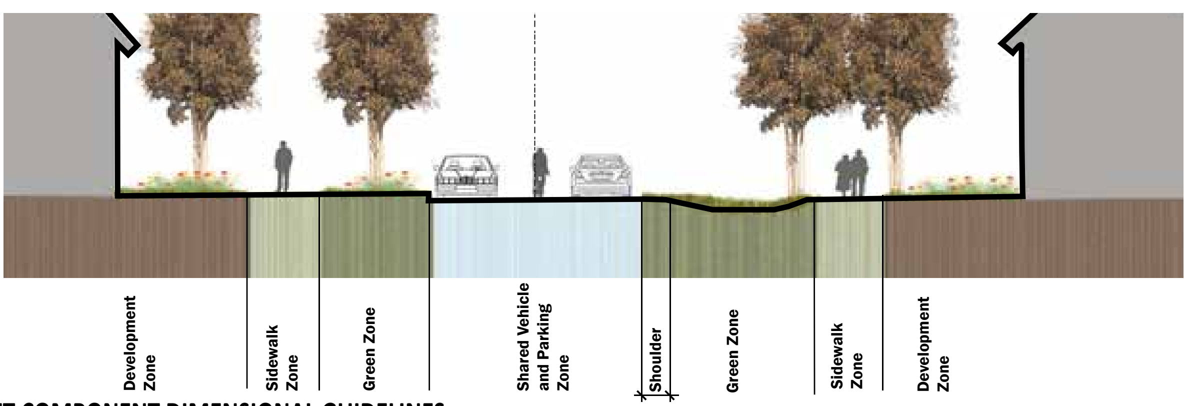
North Carolina took a comprehensive approach to implementing Complete Streets in the state. Similar to Florida's recommendations, and many other policies, planning and design guidelines place an emphasis on adjacent land use as an appropriate way to understand street context. One helpful tool (see Figure 2-2) are the illustrative street cross-sections outlining recommended street dimensions for each type of street on NCDOT's network. These clear diagrams can assist those well-versed in urban design as well as other interested parties begin to understand how Complete Streets can begin to be implemented.

Key Feature:
Detailed Street Classification and Diagrams

Document Features:

- **Document Name:** North Carolina Complete Streets Planning and Design Guidelines
- **Completed:** 2012
- **Key Features:** Complete Streets policy context, design guidelines per street type, quality graphics
- **Application to MDOT:** Clear, illustrative diagrams and cross-sections are helpful methods to communicate Complete Streets design to interested parties.

FIGURE 2-2: STREET CLASSIFICATION CROSS SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

	Minimum Travelway F.O.C. to F.O.C. *(feet)*	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Parking Zone *(feet)*	Lane Width *(feet)*	Shoulder *(feet)*
Local / Subdivision (Traditional Neighborhood Guidelines - Lane)	18'	5' - 6'	4' - 8'	very low demand	9' with no parking	4' - 6'
Local / Subdivision (Low Parking Demand)	24'	5' - 6'	4' - 8'	low demand	10' with low demand parking	4' - 6'

Street classification guidelines are provided in a table and illustrative cross section format. Additionally, the final chapter details the process for implementing the guidelines through maintenance and operations projects. (NCDOT Complete Streets Planning and Design Guidelines, Page 91)

KNOXVILLE RTPO

Complete Streets Guidelines

The Knoxville Regional Transportation Planning Organization (RTPO) developed qualitative and quantitative metrics to focus their Complete Streets guidelines. Specifically, Chapter 4 organizes guidelines around each element of a complete street (road diet, sidewalks, parking lanes, etc.).

For each component of a complete street, like on-street parking, the guidelines outline the types of parking (parallel on-street parking, angled on-street parking). Then, the guidelines suggest appropriate dimensions and the appropriate street context for each element. These tables (see Figure 2-3) are another way to begin to organize the implementation of Complete Streets policies and could be combined with the illustrative graphics from the Florida DOT and North Carolina DOT examples.

Key Feature: Design Guidelines for Streetscape Elements

Document Features:

- **Document Name:** Knoxville's RTPO's Complete Streets Design Guidelines
- **Completed:** 2009
- **Key Features:** Guideline tables, policy context, general tools for implementation.
- **Application to MDOT:** Organizing guidelines based on specific Complete Streets elements, rather than street context, is an alternative approach to implementation.

FIGURE 2-3: ROADWAY GUIDANCE FROM PLAN

Table 4.1 Road Diet Guidelines

Approach	Guideline
Four-lane to three-lane conversion	Should be considered for all four-lane streets. Must be based on analysis of traffic data. Case study research has found that replacing two travel lanes with a center turn lane can improve safety and reduce vehicular delay.
Lane reductions	Should be considered when traffic volumes warrant or all other reasonable options for reclaiming ROW have been exhausted. Must be based on analysis of traffic data. Lane reductions may be facilitated by a traffic shift to parallel streets.
Lane width reduction	See next section

Table 4.4 Sidewalk Guidelines

Width	Size	Guideline
Minimum Width	6 feet (separated)	With a minimum 3-foot planting strip between the sidewalk and curb (see section on fixed objects and horizontal clearances).
	8 feet (attached)	Minimum width to accommodate fixed objects at edge of curb.
Preferred Width in Highly Walkable Areas	10-12 feet	Could be greater based on context and available space (high pedestrian traffic, etc.).

Table 4.5 Parking Lane Width Guidelines

Type	Size	Guideline
Parallel Parking	7 feet (minimum) 8 feet (preferred)	Appropriate on streets with operating speeds of 35 mph or less.
Angle Parking (45 degree)	17 feet, 8 inches in depth (perpendicular to curb)	Appropriate on low-volume, low-speed commercial "main streets"

The Knoxville Regional Transportation Planning Organization begins to identify a number of design characteristics to help guide Complete Streets investments. Guidance for road diets, sidewalk improvements and preferred parking strategies are among the recommendations laid out in the Plan.

VERMONT VTRANS

Complete Streets Guidance

The different approaches to guidelines in the last few case studies are an important foundation to developing a decision matrix, whereby policymakers can determine where and how to make Complete Streets investments. To implement Complete Streets in Vermont, the Vermont Agency of Transportation (VTrans) developed a high-level, one-page evaluation matrix that summarizes appropriate Complete Streets investments. These investments are based on land use context and roadway type. A matrix like this would be helpful in summarizing MDOT's design recommendations and framing up a weighted, prioritization decision matrix (see Figure 2-4).

Key Feature: Decision Matrix

Document Features:

» **Document Name:** Vermont Agency of Transportation Complete Streets Guidance

» **Completed:** 2012

» **Key Features:** Evaluation matrix for certain Complete Streets treatments, planning and design checklists for project implementation.

» **Application to MDOT:** A summary evaluation matrix can help frame a weighted priority decision table.

FIGURE 2-4: COMPLETE STREETS EVALUATION MATRIX

COMPLETE STREETS EVALUATION MATRIX

The treatments shown in this matrix are most likely to be considered in full depth construction projects that serve to reconstruct or construct new infrastructure. These projects often contain changes to the horizontal and vertical alignments, extensive earthworks, and adjacent resources and landowners. Examples of this work include; bridge replacement, roadway reconstruction, and intersection reconstruction. On other projects with a more limited scope, designers are expected to consider treatments to the extent feasible within

Land Use Context/Roadway Functional Class	Shoulder	Median	Bike Lane*	Sidewalk / Shared Use Path	Transit	
Limited Access	Shoulders for all limited access roadways should be paved and delineated using appropriate pavement markings. The shoulders should be widened to comply with the State of VT Design Standards as well as the guidance found in HSDEI 11-004.	Medians are common on limited access roadways. Improvements to medians may include; curb work, signage, and landscaping.	Not applicable, bike lanes are not installed on limited access roadways.	Sidewalks and shared use paths are typically not installed on limited access roadways. Associated ramps may intersect with state or local roads. Work at these locations may include; sidewalk repair, curb repair, installation of appropriate sidewalk ramps, and installation of a crosswalk and detectable warning surfaces. Pedestrian paths may cross limited access roadways as an overpass or underpass. These facilities should be upgraded to comply with the American with Disabilities Act (ADA). Proper drainage and facility cross slope must be installed/constructed to prevent ponding water and the potential for freezing. These facilities must be adequately protected from errant vehicles, as well as debris and snow removal. The limited access roadway in these locations must also be protected from debris and snow removal from the pedestrian facility.	While transit providers may use limited access roads as part of their routes, transit stops would not be permitted on a limited access roadway.	Most limited ac… interchanges tha… roadway. Wher… intersecting roa… consider use by… may be problem… higher vehicle s…
Rural Arterials & Collectors	Shoulders for all rural arterials and collectors should be paved and delineated using appropriate pavement markings. The shoulders should be widened to comply with the State of VT Design Standards as well as the guidance found in HSDEI 11-004. Additional widening of shoulders should be considered in locations identified as primary corridors for bicyclists as well as those locations where the Town or Regional Plan indicate a future use. The roadway horizontal alignment, vertical alignment, and superelevation should meet the requirements of the AASHTO "A Policy on Geometric Design of Highways and Streets." All drainage structure grates located within the shoulder shall be "bicycle-safe."	Medians are not generally provided on rural stretches of roadway.	Not applicable, bike lanes are not installed on rural arterials & collectors.	Truly rural roads typically do not include sidewalks as there is unlikely to be significant pedestrian demand to justify their installation. If there are clear origins and destinations within project limits or a defined Town/Regional Plan and a shared use path is sought by the community to connect those origins and destinations, designers should consider the inclusion of the shared use path in the project.	It is possible that public transit routes travel over rural roadways. A transit stop on a rural road would most likely consist solely of a sign, with no changes to the roadway typical section.	Rural roadway i… adequate sight d… road has a bicyc… design should c… with the roadwa… signalized and t… appropriate ped…
Transitional Zone	Shoulders for transitional zone arterials and collectors should be paved and delineated using appropriate pavement markings. The shoulders should be widened to comply with the State of VT Design Standards as well as the guidance found in HSDEI 11-004. Additional …	Medians should be considered for certain situations on arterials …	Designers may consider the use of a bike lane on a transitional zone roadway as the zone approaches a more urban/village …	Generally, sidewalks would not be found in transitional zones, except where the speed limit is lower and on the outskirts of more densely developed urban/village centers. If there are clear origins and destinations within project limits or a defined …	It is possible that public transit routes travel over roadways in …	Transitional roa… ensure that adeq… If the side road …

(VTrans Complete Streets Guidance, Page 12)

CITY OF NEW HAVEN, CT

Complete Streets Design Manual

The City of New Haven, Connecticut passed its Complete Streets Design Manual in 2010. It's a comprehensive and graphic-rich document that covers engineering considerations, design guidelines, and funding strategies, among other elements that may be useful to review.

Among the many features applicable to MDOT's work is the detailed decision matrix included in the appendix. The matrix is categorized by "Complete Streets users," including pedestrians, automobiles, and transit users. For each complete street component that a user might use (e.g. bumpouts), the matrix outlines when this might be implemented in the construction process as well as public engagement that may be necessary, and appropriate roads where it may be installed. A similar tool could be helpful to MDOT as it starts to organize implementation of Complete Streets.

Key Feature: Decision Matrix

Document Highlights:

- **Document Name:** City of New Haven Complete Streets Design Manual
- **Completed:** 2010
- **Key Features:** Quality graphics, comprehensive approach, decision matrix
- **Application to MDOT:** Outlines Complete Streets elements, the type of construction needed to install each element, identifies local stakeholders, and identifies spaces where they can be used. A more focused version of New Haven's decision matrix may be useful for MDOT's implementation plan.

FIGURE 2-5: COMPLETE STREETS DECISION MATRIX

COMPLETE STREETS DECISION MATRIX

	Calming	Streets					Sidewalks		
ROAD ACTIVITY	No Road Work Planned	Preservation	Resurfacing	Mill and Pave	Road Reconstruction	New Road	Sidewalk Repair	Sidewalk Reconstruction	New Sidewalk
Service Life (years)	0	4	7	15	20	20	5	15	15
Lead Time (months)	0	3	6	9	18	36	3	6	24
Enhancement									
Pedestrian									
Sidewalk widening	Y	N	N	N	Y	Y	N	Y	Y
Handicapped ramps	Y	N	N	N	Y	Y	Y	Y	Y
Street furniture	Y	N	N	N	Y	Y	N	Y	Y
Crosswalks									
Surface treatment	Y	N	N	N	Y	Y	N	Y	Y
Tree belt enhancements	Y	N	N	N	Y	Y	N	Y	Y
Motor									
Pavement Markings	N	Y	Y	Y	Y	Y	N	Y	Y
Surface treatment	Y	Y	Y	Y	Y	Y	N	N	N
Speed Humps	Y	N	Y	Y	Y	Y	N	N	N
Islands	Y	N	N	N	Y	Y	N	N	N

	INVOLVEMENT GUIDELINES							CLASSIFICATION GUIDLEINES				
ROAD ACTIVITY	Neighborhood Interest	Community Support	Adjacent Neighbor Consent	Education	City Interest	Speed/Volume Study	Engineering Justification	Principal Arterial >10,000 vpd	Minor Arterial 5,000-10,000 vpd	Collector 1,000-5,000 vpd	Local 500-1,000 vpd	Low-Volume Local <500 vpd
Pedestrian												
Sidewalk widening	Y	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y
Handicapped ramps	N	N	N	N	N	N	N	Y	Y	Y	Y	Y
Street furniture	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y
Crosswalks	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Surface treatment	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y
Tree belt enhancements	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y
Motor												
Pavement Markings	N	N	N	Y	Y	Y	N	Y	Y	Y	Y	Y
Surface treatment	N	N	N	Y	N	N	N	Y	Y	Y	Y	Y
Speed Humps	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N
Islands	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N

To complement the descriptive text and graphics throughout the manual, a decision matrix is included in the appendix. (New Haven Complete Streets Design Manual, Page 20)

NASHVILLE MPO

Project Evaluation Criteria

One of the last decision matrices helpful for MDOT is a weighted prioritization matrix. The Nashville area Metropolitan Planning Organization (MPO) created a point system for project evaluation criteria to compliment its 2035 Regional Transportation Plan. The scoring checklist aligns with policy goals in the Plan and important factors in the region identified by the Executive Board. At the time of its publication, the Nashville MPO and TDOT did not have a Complete Streets policy, but encouraged multi-modal facilities and accommodations throughout the Plan and the evaluation checklist.

Key Feature: Decision Matrix

Document Highlights:

» **Document Name:** Nashville Area Metropolitan Planning Organization 2035 Regional Transportation Plan Project Evaluation Criteria

» **Completed:** 2010

» **Key Features:** Weighted point system for project evaluation.

» **Application to MDOT:** Though not specifically linked to Complete Streets, the MPO's scoring checklist may serve as an example in weighting project goals and characteristics in a streamlined manner.

FIGURE 2-6: PROJECT EVALUATION CRITERIA

Nashville Area Metropolitan Planning Organization

2035 Regional Transportation Plan | Project Evaluation Criteria

Endorsed by MPO Executive Board on March 17, 2010

EVALUATION CRITERIA	SCORE
TOTAL POSSIBLE POINTS	**100**
SYSTEM PRESERVATION & ENHANCEMENT	**15**
Project Improves Existing Route	+
Project Upgrades Route to Context Sensitive/ Prescribed Design Standards	+
Project Addresses Major Maintenance (e.g., bridge repair, etc.)	+
Project Integrates ITS Technology	+
Project Has Sustainable Operations/ Ongoing Maintenance Support	+
QUALITY GROWTH, SUSTAINABLE DEVELOPMENT, & ECONOMIC PROSPERITY	**15**
Project Supports Quality Growth Principles	
Project Improves Accessibility and/or Connectivity to Existing Development	+
Project Located in Preferred Growth Area	+
Project Supports Infill/ Redevelopment	+
Project Incorporates Streetscaping/ Enhancements	+
Project Located Near Mixed-Use, High Density Areas	+
Project is Consistent with Desired Urban Design/ Form-Based Codes	+
Project Corrects Poor Storm water Flow/ Drainage	+
Project Improves Utility Location	+

(Nashville Area Metropolitan Planning Organization 2035 Regional Transportation Plan Project Evaluation Criteria, Page 1)

CITY OF GRAND RAPIDS

Vital Streets Plan

The City of Grand Rapids' Vital Streets Plan lays out modal priorities for all of the roadways within the City of Grand Rapids and helps determine where dedicated Vital Streets funding will be directed. The intention of the Vital Streets Plan is to promote consistency and provide a framework to use best practices in project-based decision-making. Grand Rapids aspires to ensure that Vital Streets projects serve the City's overall vision and deliver a complete and viable network that sustains the City over time.

The Vital Streets Plan contains a number of components that help determine how limited transportation dollars will be spent in the City. The plan establishes a street typology that unites street design with local land use, it defines an integrated, multi-modal network for all users, and provides best practice guidance for street design solutions for each street type. A clear methodology for decision making is included in the plan and a structure for performance measurement was developed to evaluate the outcomes of each investment.

The Vital Streets Plan is specifically intended for street design professionals to use during project design and development. However, it is also a guidebook for taxpayers to better understand where their tax dollars are being spent.

Key Feature: Street Hierarchy and Context

Document Highlights:

- **Document Name:** City of Grand Rapids Vital Streets Plan and Design Guidelines
- **Completed:** 2016
- **Key Features:** Quality graphics, comprehensive street classification, comprehensive approach
- **Application to MDOT:** Outlines complete streets elements based on a street hierarchy, outlines specific design elements, provides a methodology for classifying streets based on travel mode and land use. MDOT could classify trunklines passing through downtown areas in a similar fashion, prioritizing specific modal choices.

Illustrative layouts of each street type are presented in the Vital Streets Plan, along with specific characteristics that should be included within each. (Vital Streets Plan, Page 27)

NACTO

Urban Streets Design Guide

The National Association of City Transportation Officials (NACTO) Urban Streets Design Guide offers a wealth of information about designing streets for all users. A blueprint for designing 21st century streets, the Guide summarizes the toolbox and the tactics cities can use to make streets safer, more livable, and more economically vibrant. The Guide outlines both a clear vision for complete streets and a basic framework for how to implement the pieces.

The Urban Streets Design Guide consists of typical street typologies found in most urban areas, suburban cities, and small towns, examples of street design elements that could be added to a street, and interim design strategies to test ideas before spending a huge amount of money. The Guide also includes information on intersections, including specific design elements and design controls (such as speed, vehicles, and time of day).

Local agencies and MDOT can use the NACTO Guide to identify designs that would work within the local context and create streets that all users can feel safe and comfortable on.

Key Feature:
Design Guidelines for All Street Types

Document Highlights:

- **Document Name:** NACTO Urban Streets Design Guide
- **Completed:** 2013
- **Key Features:** Quality graphics, comprehensive examples, easy to understand
- **Application to MDOT:** Presents potential street designs that could be applied to any type of roadway in Michigan, from local streets to busy transit corridors. Design options for many different scenarios are given, along with interim design strategies that can be employed to test a design before committing.

The Urban Street Design Guide provides potential improvements to a busy major intersection that will help improve safety and movement for all modes of travel. (NACTO)

PEOPLE FOR BIKES

The previous case studies evaluate how state, regional, and local governments evaluate and implement Complete Streets policies. Non-profit and advocacy organizations, like People for Bikes, also have developed an informed perspective on promoting the effective design of Complete Streets.

People for Bikes, a nationwide bike advocacy organization, has spearheaded a large amount of research that provides a snapshot of who rides bikes in America and at what age. The U.S. Bicycling Participation Study, commissioned in 2016, provides a snapshot as to who bikes in America and can help MDOT understand the nuances of effective street design to accommodate specific populations.

People for Bikes developed the Bike Network Analysis database which centers around "bicycle level of traffic stress", or simply stress, to determine how comfortable people are using a bike for transportation on a given specific street. Low Stress streets are where most people would feel comfortable riding, while only experienced cyclists will use high stress streets. Stress levels are calculated using population, nearby core services, motor vehicle speed, bicycle facility type, number of travel lanes, and on street parking.

People for Bikes studies the demographics of bicycle riders in America. Since different types of users have different needs, this can help people plan for appropriate bicycle facilities on the roadway.

Key Feature: Bicycle User Research and Bike Network Analysis Scoring Matrix*

Document Highlights:

- **Document Name:** U.S. Bicycling Participation Study
- **Completed:** 2016
- **Key Features:** Robust research study on what works to get people riding bikes more frequently.
- **Scoring Matrix*:** The scoring matrix developed for the Bike Network Analysis (BNA) measures how well bike facilities connect people to places based on proximity to existing services (education, employment, opportunity, etc.) and the planned stress level of the facility. (*Abbreviated version is shown on the following page).
- **Application to MDOT:** Understanding how and why people choose to bicycle can help MDOT develop more context specific solutions to reach target users (children, an aging population, etc.). MDOT can use the aggregated BNA database to understand where high stress roads exist and coordinate facility improvements.

TABLE 2-2: BIKE NETWORK ANALYSIS EVALUATION MATRIX (ABBREVIATED)

SCORING CATEGORY	WEIGHT (OVERALL)	MEASURE	SUBCATEGORY WEIGHT	SCORING PROCESS
PEOPLE	15	POPULATION	N/A	*Max 100 Calculate ratio of low stress: high stress streets per census block. Points given as follows: - Up to 3% = 10 points - Up to 20% = 40 points - Up to 50% = 80 points - 100% = 100 points*
OPPORTUNITY	20	EMPLOYMENT	35	*Max 100 Calculate ratio of low stress: high stress streets per census block. Points given as follows: - Up to 3% = 10 points - Up to 20% = 40 points - Up to 50% = 80 points - 100% = 100 points*
		K-12 EDUCATION	35	*Max 100 Points given cumulatively as follows: - First low stress destination = 30 points - Second low stress destination = 20 points - Third low stress destination = 20 points (Access to all low stress destinations = 100 points) After three low stress destinations, points are prorated based on ratio of low stress: high stress access*
		TECHNICAL/ VOCATIONAL SCHOOL	10	*Max 100 Points given cumulatively as follows: - First low stress destination = 70 points (Access to all low stress destinations = 100 points) After one low stress destination, points are prorated based on ratio of low stress: high stress access*
		HIGHER EDUCATION	20	*Max 100 Points given cumulatively as follows: - First low stress destination = 70 points (Access to all low stress destinations = 100 points) After one low stress destination, points are prorated based on ratio of low stress: high stress access*

This table is an abbreviated version of the People for Bikes evaluation and scoring criteria. Additional scoring categories included in their overall evaluation include recreation, retail and transit.

Transit

OVERVIEW

Throughout Michigan, cities and municipalities contain streets that share space with transit routes. These streets can vary immensely in the types of vehicles used, the existing roadway design, transit amenities, and surrounding land use depending on the city and the amount of ridership in a corridor. Road agencies can help ensure transit riders are comfortable and arrive at their destination on time by considering how transit fits into the right-of-way early into the design process.

Regardless of a corridor's transit ridership or vehicle type, there are certain design elements that can be applied to every street that carries transit vehicles. Woodward Avenue in Detroit and West Washington Avenue in Jackson are two very different streets with drastically different amounts of transit service and vehicle types. However, both can benefit from roadway designs that focus on people and pedestrians, improve safety and accessibility, and consider the long term plans for the street.

General Transit Principles

People First Design

All transit trips start and end with a walking or bicycling trip, regardless of the type of transit system. This is why all streets with transit routes should be designed with pedestrians in mind. Streets with transit should be walkable, comfortable for pedestrians, and have access to public spaces.

Sidewalks should be ubiquitous and wide enough to support the pedestrian demands of the street. Land use planning should complement the walkability and bikeability of a transit street. Designing streets that are more human scaled can make using transit more appealing by making riders feel comfortable while traveling to and from transit stops.

Long Term Planning

Cities should consider previous planning and studies in the corridor and how future growth, funding, needs or other changes could affect the space needs of the corridor. Low cost, short term projects may increase the functionality of the existing transit now, while reserving the space for transit improvements in the future. New ideas can be tested quickly using

Designing streets around pedestrians, like in Downtown Grand Rapids, can make riding transit easier, safer, and more convenient.

paint and other temporary materials to determine if a greater investment is warranted.

Safety and Accessibility

Safe conditions at all transit stops should be made a priority regardless of the system or amount of ridership. This includes having ample lighting at stops and stations, proper space for riders to wait, safe vehicle travel speeds on the roadway, and proper pedestrian infrastructure. Additionally, universal design standards should be applied at stops and stations to allow all transit users to easily access the stop. This includes ADA accessible ramps, tactile strips in correct locations, audible cues, and color based wayfinding. Employing these design solutions makes riding transit easier for everyone.

High Capacity Transit

High capacity transit corridors in Michigan are typically served by traditional bus transit systems, but more are implementing bus rapid transit (BRT) and rail systems as well. In the future, Michigan cities may see additional BRT or rail systems implemented on current high capacity corridors. Regardless of the mode using the high capacity transit corridors in Michigan, there are design and infrastructure guidelines that can be considered to make transit faster, more reliable, more comfortable, and more visible to the public.

When planning for incorporating transit on a roadway, there is a need for long-term thinking and adaptability. Previous plans and studies for the corridor should be considered to better understand how future growth, funding, local needs or other changes could affect the needs of the corridor. Planners should consider low cost, short term projects that may increase the functionality of the existing transit now, while reserving the space for more substantial improvements in the future.

The Denver Region has implemented low cost dedicated bus lanes using paint and signage that preserve space for transit until a larger investment can be made.

Safe, well lit, and accessible transit stops are very important to encouraging riders to use transit.

The Silver Line BRT in Grand Rapids is the state's first bus rapid transit system

Right of Way Design

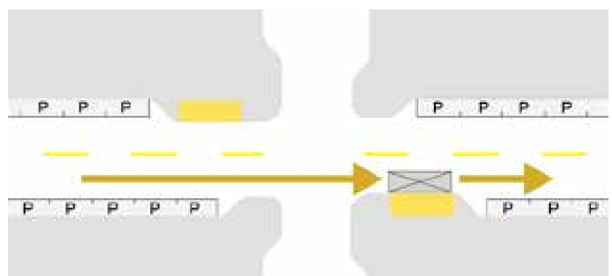
As transit typically runs in an existing roadway, design options that allow for the efficient operations of transit vehicles should be considered for both the travel lanes and the sidewalk areas.

- **Prioritization** - Allowing transit to bypass vehicle traffic can improve operations and make riding more convenient. Priority improvements can range from a full dedicated transit way to smaller, strategically located areas to bypass backups, like queue jumps and shared transit/ right turn lanes. Adding improvements like this can improve transit operations, while showing the public that transit exists and is a valued amenity.
- **Stations and Stops** – Reserve enough space on sidewalks for shelters and stop expansions at appropriate locations. Depending on the plans of corridor, consider how ROW will be affected in the short term and how much ROW is needed for stations if future BRT/LRT is planned.
- **Stop Locations** – In most cases “far side, in lane stops” are preferred from an operations and efficiency standpoint. Design of sidewalks, bicycle facilities, and parking should be considered to allow for these types of stops. In some cases, near side stops can be co-located with far side stops where transfers occur to make transfers quicker and easier.

Dedicated transit lanes are demarcated by a change in pavement treatment.

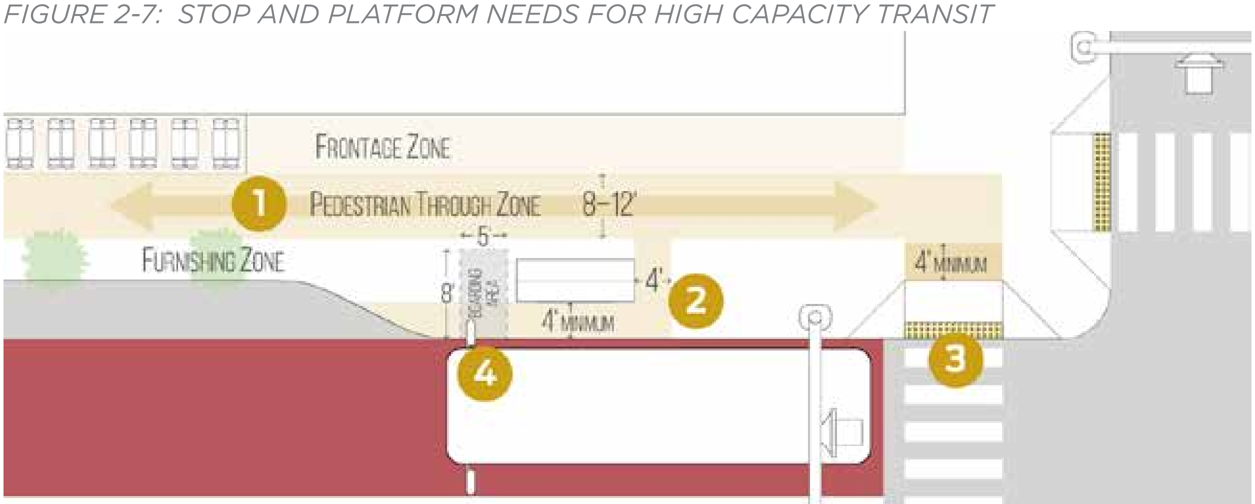
Stop Position	40’ Bus	60’ Bus	2x40’ Bus	2x60’ Bus
Near-Side	35	55	80	115
Far-Side	45	65	90	130
Mid-Block	35	55	80	115

Platforms and boarding areas can be a variety of lengths and can be considered depending on the number of passengers boarding at a stop and budget.



“Far Side, In Lane” stops are the most efficient for transit operations

FIGURE 2-7: STOP AND PLATFORM NEEDS FOR HIGH CAPACITY TRANSIT



1. Pedestrian Zone; 2. Waiting Area; 3. Crossing Zone; 4. Boarding Area

- **Platform needs** – Depending on the number of transit vehicles, type of vehicles, frequency in a corridor, and stop location, different platform lengths will be required. These will need to be taken into account as streets are designed.
- **Bus Pads** - Concrete bus pads should be poured to reduce the distortion of pavement at stops and reduce the need for future repairs. Pads can be colored concrete or painted to inform motorists to avoid parking in front of stops.
- **Stop Infrastructure** – Dedicated curb space should be allocated for transit stops in high capacity corridors so that riders do not have to step into the street to board the bus. This can take the form of a bus bulb or a pull-out stop and allows for vehicles to pull up to the curb. This is especially important for riders who are disabled and during the winter when snow build up can impede boarding.

Stop infrastructure upgrades like a concrete pad and demarcated curb improve the longevity of the stop and create a dedicated space for transit.

A stop bump out keeps boarders out of the roadway, improving safety.

Infrastructure Enhancements

In addition to specific considerations for roadway improvements to high capacity transit, there are a number of smaller infrastructure and technology improvements that can increase efficiency and access within the system.

- **Transit Signal Priority & Signal Timing** – Incorporating signal priority technology helps reduce delays at red lights both by keeping lights green for longer and changing the red phase to green sooner. Transit Signal Priority (TSP) can be implemented at select congested intersections or throughout an entire corridor. Signal timing throughout a corridor can be updated to account for the average speed of a transit vehicle to reduce delays.
- **Space for Last Mile Connections** – At heavily used stops consider how the immediate surrounding area could be allocated for various last mile connections, including long term bicycle parking, bike share stations, ride hailing zones, electric scooter parking, and other emerging technology.

Co-locating transit stops and shared bicycle facilities increase access and mobility options for users of both.

Traditional Transit

Transit systems located in smaller cities or lower ridership corridor will not warrant the investment in infrastructure and amenities that high capacity transit corridors require. There are, however, design considerations that should be taken into account on roadways located in smaller communities with transit service. Cities such as Jackson, Saginaw, Flint, and others that have public transit systems, can consider improvements that raise the profile of transit service and provide dedicated space for riders.

Right of Way Design

Similar to high capacity transit, there are a number of right of way improvements that should be incorporated into traditional transit. Some of these considerations include:

- **Transit Stops** – The roadway design should consider the surrounding roadway context to ensure riders can board vehicles safely. The solutions needed in a downtown setting are different than those on a major arterial street in a busy commercial area. Also consider how stop locations can be altered to improve operations by evaluating far side vs near side intersection placement and transfer opportunities.
- **Walkability** – Since all transit trips start and end with a walking or biking trip, streets that carry transit vehicles need to be safe and accessible for pedestrians and cyclist. Sidewalks should be connected to the surrounding street network for maximum accessibility. All bike lanes should connect to a larger network in the region.
- **Bus Bulbs & Pull-Outs** – Implementing bus bulbs or bus pull-out areas reduces bus movements and makes it easier for vehicles to pull up to the curb. Bus bulbs can speed up service by keeping the vehicle in the travel lane.
- **Transit Visibility** – Dedicate space on busy travel corridors in the system for transit to become more visible. Shelters, bicycle parking, signage, wayfinding, and painted bus pads can be added for a relatively low cost but can increase transit's presence in areas where it can be overlooked.

A stop bump-out improves safety by allowing passengers to wait and board from the sidewalk and not withing the roadway.

A crosswalk located adjacent to a bus stop creates easier access for those utilizing transit.

With a bus shelter and wayfinding signage in place, passerby can easily recognize a stop along their journey.

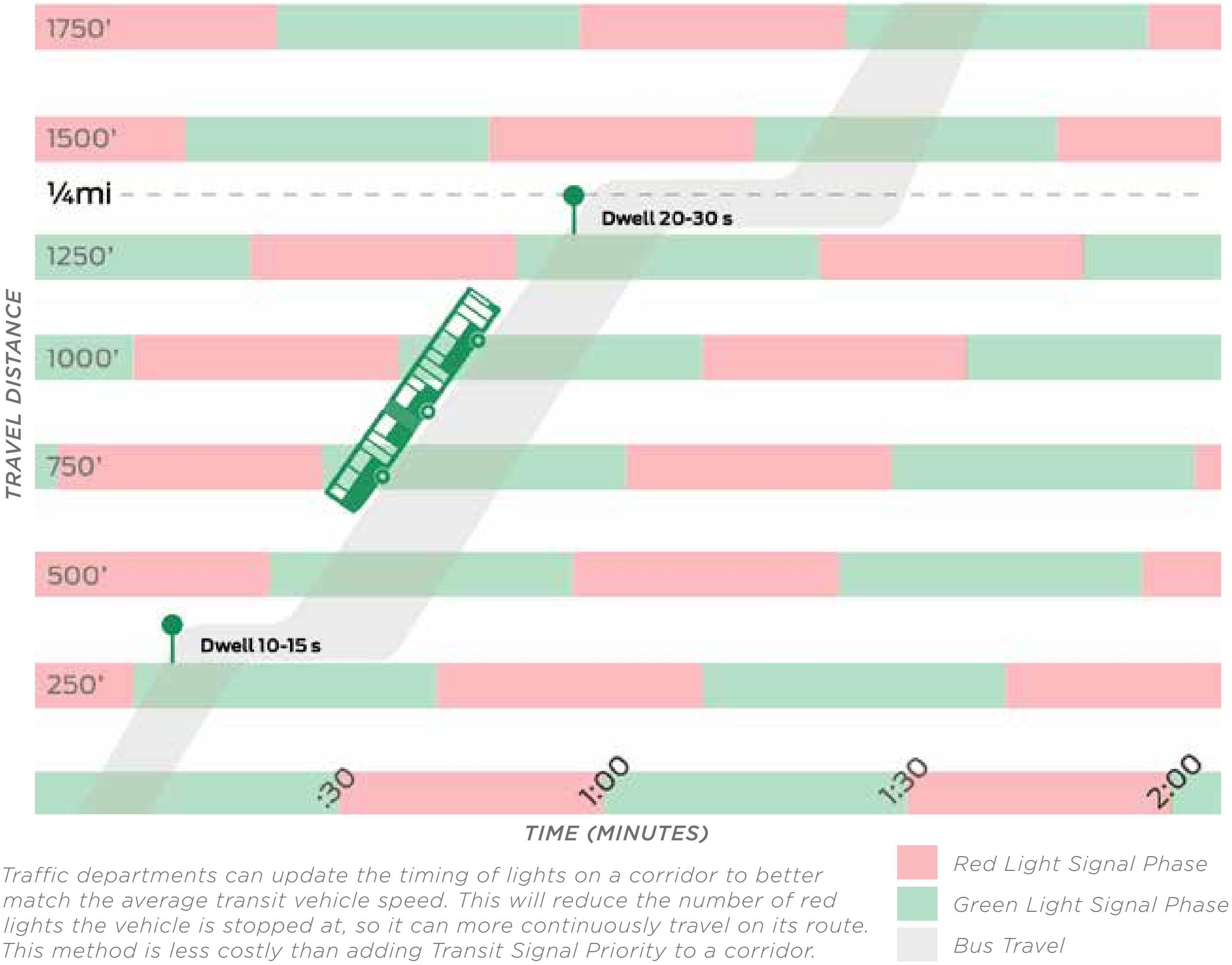
Infrastructure Enhancements

In addition to specific considerations for roadway improvements to high capacity transit, there are a number of smaller infrastructure and technology improvements that can increase efficiency and access within the system.

- **Signal Timing** - Matching signal timing with the average transit vehicle speed in corridors with on-time performance issues can help reduce stoppage at red lights.
- **Transit Mall or Dedicated Lane** - In areas where many buses converge at a transit center, a dedicated transit mall or lane can reduce delays and increase vehicle waiting space for less cost than an expanded transit center.

Champaign, IL has a small transit only street near the University of Illinois that serves as a transit hub for university students and bus layover area.

FIGURE 2-8: SIGNAL TIMING MATCHED WITH AVERAGE BUS SPEED



Traffic departments can update the timing of lights on a corridor to better match the average transit vehicle speed. This will reduce the number of red lights the vehicle is stopped at, so it can more continuously travel on its route. This method is less costly than adding Transit Signal Priority to a corridor.

Hyperloop

One of the most talked about developments in transportation over the past few years has been the Hyperloop. The Hyperloop idea has been pushed into the mainstream by Tesla and SpaceX founder Elon Musk, and its feasibility is now being studied by numerous government agencies around the country. The Hyperloop would use a vacuumed sealed tube to transport passengers and goods at a speed of over 750 mph. A Hyperloop between Detroit and Grand Rapids would complete the journey in under 15 minutes.

Hyperloop will require right-of-way similar to that of a railroad in order to be constructed and agencies and municipalities can help plan for and identify potential travel corridors. There is no definitive proof that Hyperloops will succeed as a commercially viable form of transportation, so agencies should keep other forms of transportation in mind for both the short term (until Hyperloop can be implemented) and the long term (if Hyperloop is built).

- **Plan for Multiple Modes**

As the Hyperloop is still relatively untested and has yet to be constructed, agencies planning for Hyperloop need to consider that the technology will not be ready for many years. However, planning for other modes using the right-of-way in the interim can make the investment more viable. Consider traditional higher speed rail (125 mph) or high speed rail (200 mph) to encourage ridership in the corridor and preserve the right-of-way for future technology like Hyperloop.

Right-of-way needs similar to that of existing passenger rail will be needed for Hyperloop implementation. Hyperloop tubes could be constructed on top of traditional rails.

- **Route Design**

Follow the formula laid out by railroads in the past and route Hyperloop infrastructure through city centers. Select station locations that are walkable and well connected to existing transportation networks.

- **Consider the Costs**

As Hyperloop's technology is new, constructing the system will likely require a large investment in infrastructure and maintenance. This may passed on to the local government or to passengers.

Hyperloop vehicles would travel in a vacuum-sealed tube at around 750 mph, yet remain virtually untested. ROW can be preserved for other uses while the technology is developed further.

CASE STUDY: SILVER LINE BUS RAPID TRANSIT

Grand Rapids, Michigan

The Silver Line Bus Rapid Transit line was the first BRT implemented in the State of Michigan. Although it does not travel on an MDOT owned roadway, the principles of design can be applied to other projects throughout the State.

The Silver Line travels between Downtown Grand Rapids and 60th St SE on Division Avenue, which is one of the region's highest transit ridership corridors. The Silver Line incorporates most of the design philosophies detailed in this section that helps Division Avenue become a much more functional multi-modal street.

Semi Dedicated Lanes that give buses priority during the peak hours are marked using paint and signage. Upon implementation, fully dedicated lanes were not politically feasible, so The Rapid used paint and signage to keep that space "claimed" until a greater investment could be made for priority lanes. Transit signal priority was installed at each intersection in the corridor which helps the Silver Line achieve a faster end to end travel time than the standard Route 1 - Division bus.

Each Silver Line station is designed to be well lit and accessible, with level boarding and distinctive styling. Concrete bus pads were poured at each station and extra space was left for bicycle parking. Additionally, dedicated curb space, with level boarding platforms, were installed to make passenger boarding as easy as possible.

CASE STUDY: MAIN STREET ON HIGHWAY 101

Yachts, OR

Yacahts, Oregon is a rural community along the Pacific Coast. The town's main street is Highway 101, which is also the terminus for the Tillamook - Yachats bus route. Visitors arrive in Yachats twice a day via transit and are dropped off on busy Highway 101. To improve rider safety, increase the visibility of transit, and improve walkability for passengers, the City of Yachats worked to improve the pedestrian experience along Highway 101. The goal of this project was to calm traffic and create a "main street feel" that improves walkability and lays out better multi-modal connections.

The City added a bus shelter and dedicated bus parking area, multiple crosswalks, and continuous bike lanes within the Downtown area. Additionally, the parking areas were reconfigured to eliminate diagonal and head-in parking, while also adding more parking areas on side streets and adding buffer areas between sidewalks and vehicle areas. Reconfiguring the parking helps reduce the potential for vehicle to pedestrian conflicts.

Yachats, OR is a rural community that improved the transit experience by redesigning the public right of way.

Autonomous and Connected Vehicle Readiness

OVERVIEW

Autonomous vehicle (AV) and connected vehicle (CV) technology is expected to greatly change transportation in cities. This technology, including vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and infrastructure-to-vehicle (I2V), has the ability to improve access and mobility for a variety of users, but it must be planned and implemented appropriately. Therefore, leaders and policy makers must have an understanding of what this technology is, what is can do, and how it can best be implemented within our roadways to improve not only mobility but equity, environment, and economy.

MDOT AV/CV

PlanetM is a statewide initiative to develop and deploy emerging mobility technologies. At the state level, PlanetM is a partnership between the Michigan Economic Development Corporation and MDOT although other organizations, communities, educational institutions, research and development, and government agencies are part of the initiative. The goal of PlanetM is to connect new and growing companies, startups, and investors in future transportation technology to the resources Michigan has to offer within the industry.

Related to this effort, MDOT has set the vision for Michigan's smart corridor, a connected vehicle environment encompassing a large segment of southeast Michigan, centered along the freeway and surrounding arterial network in the metropolitan Detroit area. This public-private partnership shows MDOT's readiness and willingness to implement AV/CV technology to improve safety and mobility on state roadways.

In This Section:

» **Future Impacts:** Impacts of AV/CV technology including on the roadway network.

» **Future of Freight:** Impacts of AV/CV technology on urban and rural freght.

» **Case Studies:** Example case studies for AV/CV technology including in San Francisco, Wyoming, Columbus, and Detroit.

FUTURE IMPACTS

Generally, there are three elements that AV/CV technology will impact in relation to the roadway: land use, site design, and the roadway network. Although we cannot be certain how quickly and extensively AV/CV technology will be adopted, many major automakers have made plans to have self driving vehicles on highways and in urban areas over the next 5 to 10 years. The technology is expected to be relatively affordable for most of the population, especially with car-sharing services (Emerj, 2018). Therefore, there is potential for wide-spread adoption in the next 15 to 20 years (The Tribune, 2018), although it will depend on the people and specifics of each community.

Land Use

Autonomous vehicles, in conjunction with automation in general, will have a significant impact on land use. The decisions made now surrounding the implementation of AV/CV technology can help determine how it will impact the built environment. Autonomous vehicles could reduce the number of vehicles per household along with the demand for on-site parking at a home or destination. This can allow higher density development for residential and commercial uses.

At the same time, there are changes within the retail market that are further disrupting the current land use mix. The Harvard Business Review, among other sources, indicate significant growth in retail moving forward will come from eating out and “experiences,” as opposed to purchasing goods from isolated brick-and-mortar stores. The rise in online shopping is expected to continue and will increase the need for delivery logistics nationwide.

Automated vehicles, coupled with these two retail trends, will require land use plans to contemplate a wider mix of potential uses in one location. This is likely to include a mix of residential options in areas that may have previously been exclusively commercial. In relation to an increase in on-demand delivery of goods, opportunities for small-scale warehousing might become more prevalent.

If implemented correctly, autonomous and connected vehicle technology can improve the mobility and safety of our roadways, reducing infrastructure costs long-term (Fortegra).

Site Design

With a decrease in parking requirements and an increase in needed space for pick-up/drop-off locations, autonomous vehicles are also expected to impact site design, or the siting of buildings, parking, access, and other elements of new development. As this change occurs over time, utilizing traditional design principles in current developments will help ensure sites can be adapted to future uses. This includes creating internal site roadway grids and placing buildings along rights-of-way, thereby reducing focus on large-scale parking areas. An emphasis on creating quality places will be the impetus to attract the office, commercial and residential development desired.

Roadway Network

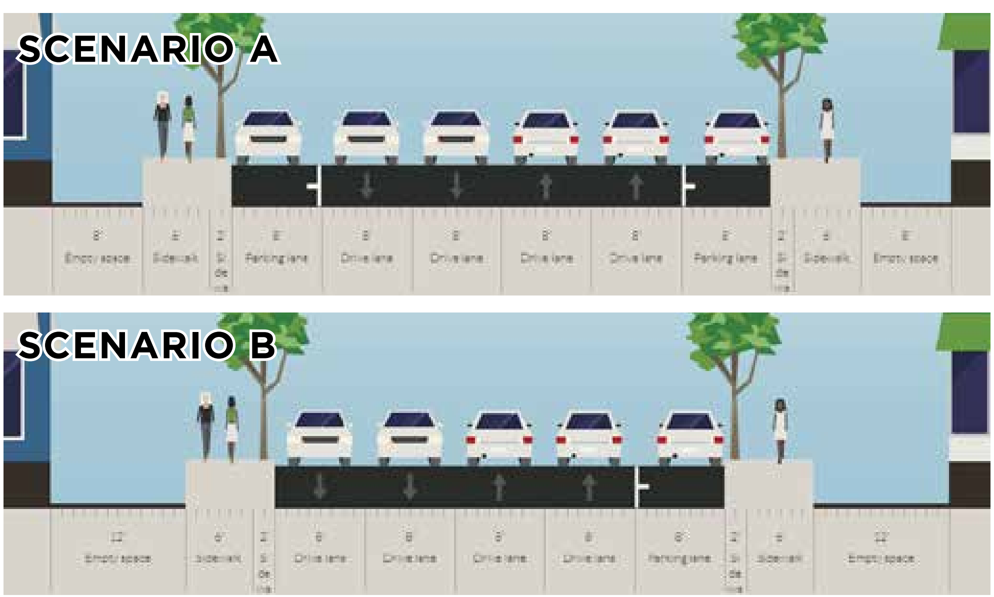
Perhaps most relevant to M2D2, the roadway network will also be impacted by autonomous vehicles. Increased safety and more efficient use of the roadway network is expected. This means more vehicles will use less roadway space, increasing capacity.

At the same time, additional congestion could be seen along certain roadways. Autonomous car sharing services would not require parking at a final destination. Instead, as vehicles wait for the next trip, they may continue to drive along roadways, even if no passenger is in the vehicle. Additionally, while autonomous vehicles will help increase the capacity of the existing roadways, there is still an inherent density issue with single occupancy vehicles regardless of their size and how close they can follow one another. More efficient travel modes, like trains and buses, will still be needed for people to easily access the most densely populated areas of the State. Therefore, a flexible approach to implementing autonomous vehicles will be needed over the coming decades as old rules and shifting behaviors will require adaptations to the new reality. In general, adoption of autonomous vehicles will effect three key aspects of the right-of-way.

- **Road Lanes**. Autonomous vehicles may require less lane width in the roadway. This is because vehicles may be smaller and autonomous technology, including vehicle platooning, may allow vehicles to drive closer together without compromising comfort or safety. Reduced lanes will still be traversable by conventional drivers, but they may need to drive at reduced speeds.
- **Parking.** Depending on the service model that is adopted for autonomous vehicles, there may be less demand for parking on roadways. This may free up space for other roadway activities.
- **Curb Access Management.** With a change in preference for different mobility options, access to the curb could be increasingly important for many users. This includes: increased pick-up and drop-off for ride-share companies; changing demand for on-street parking; increased deliveries; and new/increased modes of non-motorized transportation.

FIGURE 2-9: AV/CV ROADWAY SECTIONS

*AV/CV technology may allow a reduction of travel lane width. In **Scenario A**, a reduction of travel lanes to 8 feet (from 9 feet) opens up additional space in the public realm which could be used for outdoor cafes, pedestrians, bicyclists, etc., while still being accessible to AV/CV's and human controlled vehicles at slower speeds.*



*For **Scenario B**, in addition to 8 foot travel lanes, a reduction of on-street parking, an expected outcome of autonomous vehicles, creates even more available space in the public realm.*

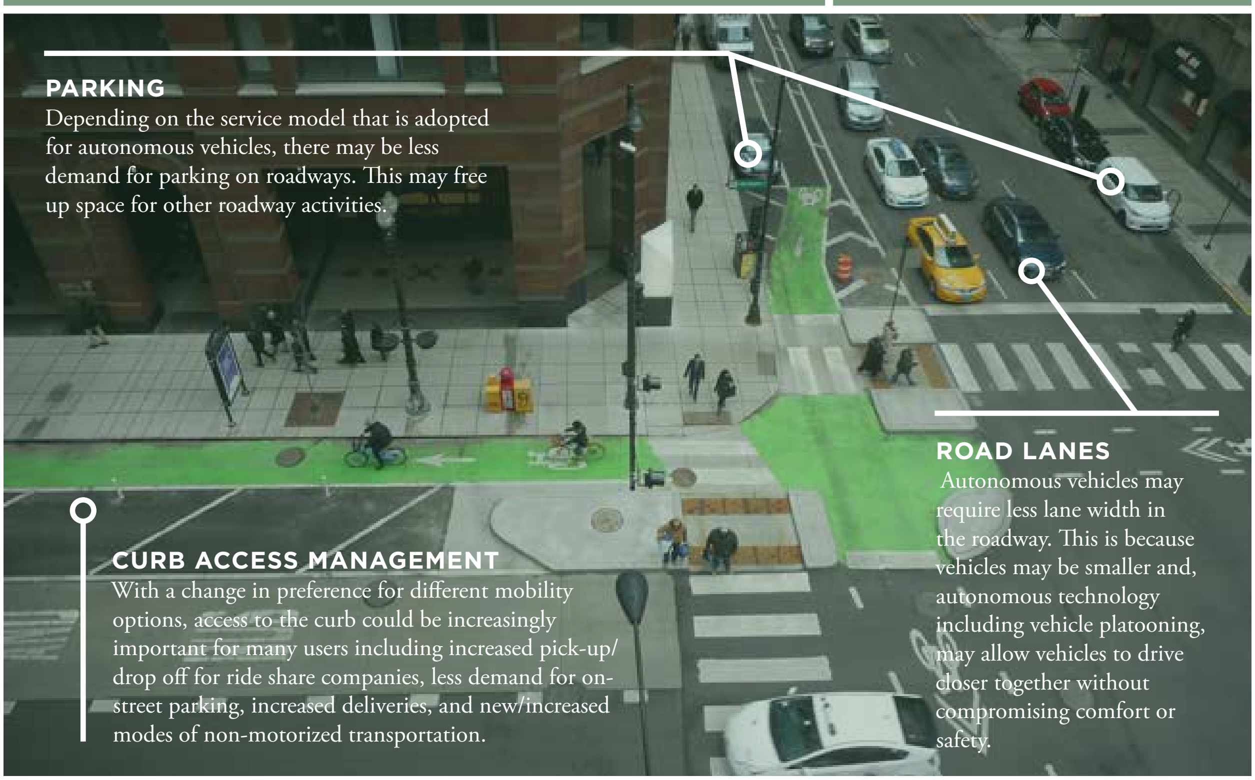
AV/CV Future Impacts Summary

A change to AV/CV technology will have rippling effects throughout the urban fabric but they generally fall into three categories: Land Use, Site Design, and Roadway Network.

AV/CV may reduce the need for car ownership and on-site parking which would change current land use patterns.

A decrease in parking requirements and increase in need for pick-up/drop-off locations may impact the siting of buildings, parking, and access.

Perhaps most relevant to MDOT, roadways may be used more efficiently which will impact roadway design, parking requirements, and curb access management.



PARKING
Depending on the service model that is adopted for autonomous vehicles, there may be less demand for parking on roadways. This may free up space for other roadway activities.

ROAD LANES
Autonomous vehicles may require less lane width in the roadway. This is because vehicles may be smaller and, autonomous technology including vehicle platooning, may allow vehicles to drive closer together without compromising comfort or safety.

CURB ACCESS MANAGEMENT
With a change in preference for different mobility options, access to the curb could be increasingly important for many users including increased pick-up/drop off for ride share companies, less demand for on-street parking, increased deliveries, and new/increased modes of non-motorized transportation.

Future of freight

It is no surprise that in the past decade, freight and delivery movement have become vital links in our economy and spending habits. This trend is likely here to stay, as businesses, residents, and others continue to rely on deliveries for many of their everyday needs. The nature of freight will likely change in the near future as well with the advent of autonomous trucking, V2V communications, and truck platooning making long haul shipping more efficient. Delivery logistics will also change as urban areas become more dense, streets are updated to fit all travel modes, and deliveries become more common.

The expected impacts and changes needed for urban and more densely populated areas will vary greatly compared to those on interstates, highways, and in rural areas.

Autonomous freight trucks, such as this concept from Mercedes Benz, will allow for a more efficient movement of goods.

Rural Freight Impacts

- **Autonomous Trucking**

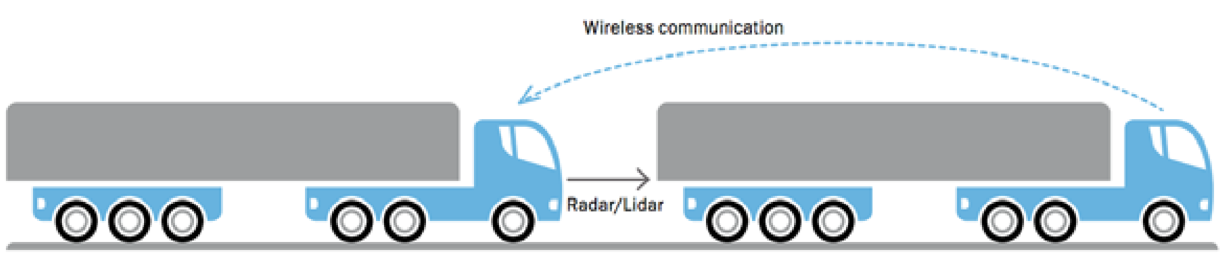
A major disruptor in the trucking industry will be the implementation of autonomous freight vehicles for long distance deliveries. These vehicles will travel primarily on limited access highways to logistics centers outside of urban areas.

- **Truck Platooning**

Truck platooning will involve connected and autonomous trucks traveling in a convoy with a close distance between each other. Truck platooning can increase safety, lower total fuel consumption, reduce CO2 emissions, and improve traffic flows.

- **Connected Vehicles and Infrastructure**

In areas of the State that are not served by Interstates or grade separated highways, connected infrastructure can help keep freight trucks moving efficiently. Implementing connected infrastructure and connected trucking vehicles can keep traffic signals green to allow for truck platoons to continue without stopping and reroute vehicles based on roadway conditions.



Truck platooning allows connected, autonomous, and semi-autonomous trucks to travel very close together in order to improve efficiency, safety, and traffic flow.

Urban Freight Impacts

- **Smaller Vehicles**

As urban streets continue to evolve to right-size the space needed for each travel mode, there will be less overall space for large delivery vehicles. A larger fleet of smaller, more agile delivery vehicles may be introduced to more easily navigate busy city streets. These vehicles may range from small delivery vans to electric bicycles fitted with cargo carrying boxes.

- **Loading Zones**

Loading, and unloading, zones will need to be factored into roadway designs, especially in dense residential and commercial areas that lack adequate parking. Loading zones can be used as a flex space that delivery vehicles, emergency vehicles, and ride hailing vehicles can all use throughout the day.

- **Emerging Technology**

Considerations can be made for the delivery technology of the future, which will likely involve some type of small autonomous vehicle. These may be aerial or ground based and will need some way to access the final delivery location. As this technology is implemented, dedicated space on the sidewalk, at the curb, or within bicycle/mobility lanes may need to be allocated in order all users to travel efficiently.

DHL (above) and UPS (below) are two global shipping companies adjusting their vehicle needs based on the changing space availability in dense cities.

Autonomous delivery vehicles, such as this concept, will become a more common sight as the technology is refined. Dedicated space on sidewalks, outside of the walkway, could be made available for these vehicles to wait while the customer comes to retrieve the delivery.

CASE STUDY: SAN FRANCISCO CURB STUDY

San Francisco, CA

FIGURE 2-10: STRATEGIES FOR IMPROVING CURBSIDE ACCESS

With the increasing adoption of ridesharing services through Transportation Network Companies (i.e. Uber, Lyft, etc.) across the U.S., the safety and efficiency of curbside access for vehicles is increasingly important. This has led to more cities creating curbside "flex" space so they can be more intentional with who can access the curb and when.

A 2018 study, by Fehr and Peers, was conducted to better understand curbside activity, and how unique management tools, such as creating flex space, can improve access for all curbside activities (rideshare, taxi, transit, parking, etc.). The study looked at several locations with moderate to high passenger loading activity with a mix of roadway and land use characteristics. It was found that no locations had adequate curb space to accommodate the passenger loading demand, which created congestion within the travel way. Three basic strategies were identified to improve curb productivity: relocation, conversion, and flexibility. Depending on a specific roadway location and curbside access problem, each of these solutions should be considered along with other considerations including safety, policy, land use, infrastructure, and community values, among others.

FIGURE 2-11: COMMON ISSUES WITH CURBSIDE ACCESS

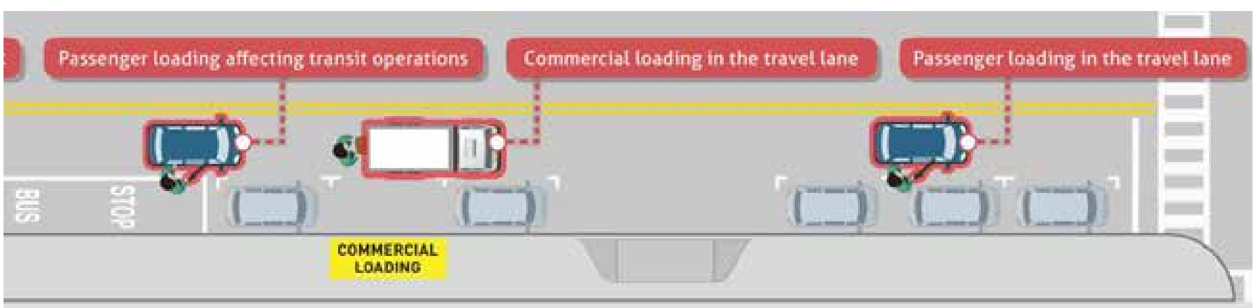


FIGURE 2-12: FLEXIBLE SOLUTION FOR CURBSIDE ACCESS

Depending on the roadway condition and need and priorities for the local community, a flexible solution to curb access management can allow many different users access at different times of the day. This helps ensure that the space is available when it is needed most (Fehr & Peers).

CASE STUDY: WYOMING CONNECTED CORRIDOR

Wyoming, Interstate 80

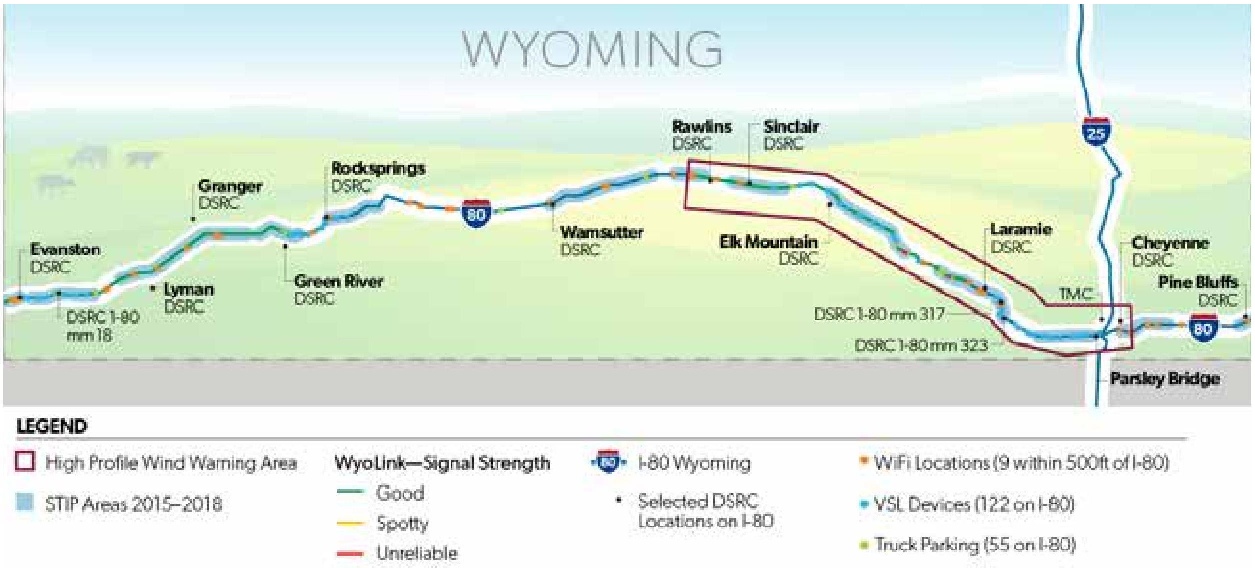
The U.S. DOT is preparing for the changes that connected vehicles will bring to the roadway. To better understand these technologies, the U.S. DOT has created pilot programs, one of which, is in Wyoming along Interstate 80 (I-80).

Interstate 80 is an east-west corridor that stretches 402 miles along Wyoming's southern border. This heavily traveled corridor accommodates passenger and freight travel. Trucks can make up to 70% of the roadway volume during peak periods. This stretch of highway also experiences dangerous weather conditions including snow blowing, fog, and high winds.

The Wyoming DOT is installing V2V, V2I, and I2V technology along I-80 to improve monitoring and reporting of road conditions to vehicles. This includes 75 roadside units that receive and broadcast messages, 400 instrumented fleet vehicles, that are equipped with devices to receive messages and collect weather data, and a "511" information application and website to update travelers with roadway information. This allows a range of services to be provided including forward collision warning, localized weather impact warnings, ability to emit distress notifications, communication of work zone warnings, and I2V situational awareness (weather alerts, speed restrictions, etc.). In fall of 2018, the connected vehicle system is being tested for a minimum of 18 months. The system will be monitored and measured to improve the implementation of future connected vehicle systems.

Throughout the year, I-80 experiences extreme weather conditions that create safety hazards.

FIGURE 2-13: I-80 CONNECTED VEHICLE IMPROVEMENTS



Vehicle technology along the corridor supports a range of services, including roadside alerts, parking notifications, and dynamic travel guidance (US DOT).

CASE STUDY: 33 SMART MOBILITY CORRIDOR

Northwest Columbus, Ohio

The 33 Smart Mobility Corridor is a 35-mile highway northwest of Columbus that connects two cities, Dublin and Marysville, to Honda's North America Plant. This corridor is a part of Ohio's Smart Mobility Guidebook, that aims to research and implement future vehicle technologies in Ohio and across the U.S.. Several organizations are involved in this effort, including, Ohio DOT and many universities and other public organizations.

The 33 Corridor is a heavily traveled highway and is home to several engineering and automotive companies. Like many highways within the region, there are issues with traffic safety and congestion along the roadway. At the same time, there is also a lack of fiber technology available to local businesses, which inhibits business expansion and retention.

The 33 Smart Mobility Corridor will be improved through interchange upgrades and widening, along with the installation of fibers and sensors. These fibers and sensors will allow for implementation of AV/CV technology which will improve safety and alleviate traffic congestion on the roadway.

The corridor will also act as a testing bed for the state's Smart Mobility Guidebook, providing needed information about dedicated short range communications (DSRC) and other technologies, including truck platooning.

Fiber will also be installed along the corridor for local businesses to access. Broadband is a growing need for companies to stay competitive within the global market. This access to fiber as well as a smart corridor, creates an economic development tool, creating a roadway that improves economy and mobility within the region.

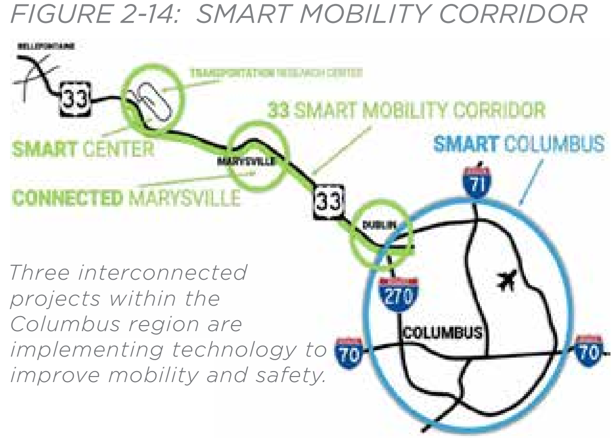
CASE STUDY: CONNECTED MARYSVILLE

Marysville, Ohio

Situated within Ohio's Smart Mobility corridor and home to many automotive companies, Marysville, Ohio, a city of about 22,000, is incorporating AV/CV technology throughout the city. Marysville aspires to be the first "fully connected" city in the world.

Marysville, with help from the Ohio DOT and other partners, is upgrading the city's traffic signals with Dedicated Short Range Communication (DSRC). This will allow for signal phasing and timing data and other safety messages to be delivered to vehicles equipped with related technology. To test the technology in a more rural environment DSRCs will also be installed in other areas of the City to allow for road testing in different environments. It is expected that approximately 10% (1,200 vehicles) will be equipped within the City, creating a more saturated environment to test these technologies than if the same number of vehicles were released in a larger city.

FIGURE 2-14: SMART MOBILITY CORRIDOR



Three interconnected projects within the Columbus region are implementing technology to improve mobility and safety.

CASE STUDY: LARNED STREET

Detroit, Michigan

In June of 2018, the City of Detroit unveiled the "World's Smartest Intersections," which is comprised of five intersections along a two mile stretch of Larned Street in Downtown Detroit. This corridor, and related intersections, were selected to help address roadway safety issues and help reduce traffic related injuries and fatalities. The smart intersections use real-time video analysis and networked traffic signals to respond to changing traffic conditions. Video is analyzed on the spot to determine different types of road users and the signals respond to how the users are moving.

The system is able to determine different road users and respond accordingly to their behavior. For example, traffic lights can be extended to accommodate cyclists or pedestrians to allow them to clear the intersection before the light changes. The cameras can detect jaywalkers and alert drivers using the Waze traffic smartphone app and connected vehicles to their presence. Signal priority can also be given to specific vehicles like emergency, transit, and freight to improve response times, on-time performance, and operations. Because the intersections are being monitored at all times, data collected by the system can be analyzed and used to improve safety outcomes for all users.

Along Larned Street, five intersections have been upgraded to respond to real time roadway condition.

Since the smart intersection technology has been implemented, the corridor has seen an over 30% reduction in travel time. The smart traffic technology hardware is being deployed on over 40% of the intersections in Detroit and can help reduce travel time and delays in other areas of the city as well. Even though this technology is relatively new, the City of Detroit is hoping it will help improve traffic congestion for vehicles, travel time for transit and freight, and safety for all road users.

FIGURE 2-15: SMART INTERSECTION

Smart intersections along Larned Street make the roadway safer by using real-time video analysis and networked traffic signals to respond to changing traffic conditions.

Key Findings

The following are key findings from Chapter 02: Benchmarking. This summary has been categorized by context area (Urban, Suburban, Small Town, and Rural Roadways and Corridors) to help with application of the document based on the project context.

Urban roadways generally occur in dense urban environments with a diverse mix of land uses. Area populations generally exceed 100,000 residents.

URBAN ENVIRONMENTS

- **Complete Streets** will likely end up being complex areas, but should still fit the local context and account for all potential roadway users. Along many roadways, dedicated facilities for automobiles, trucks, transit, bicyclists, and pedestrians may be appropriate.
- **Transit**, including traditional or high capacity, likely already exists in urban areas and may be planned for expansion. Roadway projects should increase access, safety, and comfort of transit users and include planned or potential transit improvements.
- **AV/CV Technology** may reduce the need for parking and the width of travel lanes, creating additional space within the public right-of-way for other amenities or modes of travel. In dense, congested, urban areas, curb access management may be required to balance the needs of various users.
- As **Freight** adapts to new technologies, urban areas may expect to see larger fleets of smaller vehicles, the need for additional loading zones, and the use of emerging technologies to create efficiencies.

Roadways that occur in lower-density environments, usually surrounded by auto-oriented commercial and residential uses. Area populations generally are between 20,000-100,000 residents.

SUBURBAN ENVIRONMENTS

- **Complete Street** designs should take into account the community's needs and surrounding context including planning for all potential users of the roadway. Along the busiest roadways, dedicated facilities for automobiles, trucks, bicyclists, and pedestrians may be appropriate.
- **Transit**, including high capacity and traditional, may exist or be planned along major thoroughfares. Roadway projects should increase access and safety of transit users and include planned pedestrian and bicycle connections.
- **AV/CV Technology** may increase roadway safety and travel efficiency in suburban areas. The need for large parking areas will be reduced in both commercial and residential areas, creating additional space on both public and private property.
- **Freight** delivery may evolve into larger fleets of smaller vehicles and may utilize emerging technologies. Loading zones may be less of a concern as ample space may already exist.

SMALL TOWN ENVIRONMENTS

Small town roadways generally occur in low density areas with distinct land uses. Small town populations generally are less than 20,000.

- **Complete Streets** in small towns will look different than in urban or suburban areas, and will likely be less complex. Understanding the community's needs, surrounding context, and accounting for all potential roadway users will create context sensitive solutions.
- **Transit** is less common in rural areas. However, on-demand transit or limited access regional transit may be present now or in the future.
- Small towns are typically compact and walkable or bikeable. Roadway projects should include improvements to the pedestrian and bicycle networks.
- **AV/CV Technology** has the ability to increase safety in rural towns. However, residents may be able to commute longer distances due to increased ease of travel, which may pose sustainability concerns.
- **Freight** in rural areas may utilize **AV/CV Technology** for autonomous trucking and truck platooning. This will increase the safety and efficiency of the movement of goods and people.

RURAL ROADWAYS & CORRIDORS

Rural roadways and corridors are the state and U.S. highways that connect cities, suburbs, and towns. These roadway networks are largely rural and tend to accommodate freight traffic.

- Along Rural Roadways and Corridors, **Complete Streets** may focus on automobile, truck, and transit traffic. However, depending on local context and needs, other users such as bicyclists and pedestrians may need to be considered.
- Regional intercity **transit**, including dedicated busways and high speed rail (and potentially Hyperloop), may necessitate access to the right-of-way. Roadway projects should account for planned improvements to the pedestrian, bicycle, and transit networks.
- **AV/CV Technology** may greatly improve safety and efficiency along Rural Roadways and Corridors. Roadway projects should consider implementing these technologies or creating space for them to be implemented in the future.
- **Freight** may utilize **AV/CV technology** for autonomous trucking and truck platooning. This will increase the safety and efficiency of the movement of goods and people.

INTRODUCTION

BENCHMARKING

DATA GATHERING FOR INFORMED PROJECTS

As roadway projects are planned, it is important to consider the role data plays in the implementation of projects. This section of the M2D2 Guidebook lays out the existing and future data sources that should be consulted while planning and designing multi-modal projects. As our technology continues to improve and reliance on data becomes heavier, many of the future data sources identified will become important to understanding where and why people travel around Michigan and how MDOT can accommodate that travel more efficiently.

IMPLEMENTATION FRAMEWORK

PLAN COMPLETION

03

CURRENT DATA

EMERGING DATA & TRENDS

Current Data Sources

OVERVIEW

Across the country, DOT agencies are working to advance multi-modal investments on a variety of roadway projects. Since many of these roadway projects are currently being planned and designed, MDOT and other agencies will need to use the existing available data to the best of their ability to ensure the project is designed and implemented to best meet the project goals.

Existing available data is getting more accurate and more consistent with every passing year, and in the right hands, can be a powerful tool to understand the transportation needs of an area. One of the essential components of implementing M2D2 is the ability to use current and reliable land use, transportation, and roadway data in order to guide multi-modal investments to meet the needs of the people using the corridor. This section provides an overview of the various data sources necessary to direct these investments.

Most new transportation modes that are implemented are heavily reliant on technology and data to work, which presents opportunities for MDOT and other agencies looking to gain insight on how roadways are utilized. Going forward, MDOT can work with these new mobility providers to capture very specific travel data, leading to a better understanding of the travel demands along a roadway. In turn, these data can guide infrastructure investments to ensure streets function as seamlessly as possible.

In This Section:

» **Existing Data:** Land Use and Roadway Data

» **Data Sources Overview:** MDOT, National Agencies, Other State Agencies, Regional Agencies, Local Agencies

Incorporating the M2D2 Guidebook in the MDOT Project Development Proecess

MDOT	M2D2
Standard MDOT project selection process for identification and selection of multi-modal projects.	Consult the corresponding M2D2 Guidebook chapters for each step of the MDOT project process to ensure M2D2 recommendations are carried through to new MDOT projects.

	CONSULT THIS CHAPTER
PHASE I KICKOFF LAUNCH (IDENTIFY CANDIDATE PROJECTS)	02 - BENCHMARKING
PHASE II EXISTING CONDITIONS & DATA GATHERING	03 - DATA GATHERING FOR INFORMED PROJECTS
PHASE III ALTERNATIVE DEVELOPMENT	04 - IMPLEMENTATION FRAMEWORK
PHASE IV PREFERRED SCENARIO DEVELOPMENT (5 YR PROGRAM ANNOUNCED)	PLAN COMPLETION

EXISTING DATA

As MDOT develops its M2D2 implementation strategy, there are two categories of existing data that will be important for effective implementation: Land Use Data and Transportation Data.

The following tables identify many of the relevant sources that should be considered when implementing projects. To assist with this effort, general data sources have been identified for the necessary categories outlined in the previous table and organized by source: MDOT, National Agency, State Agency, Local Agency. Qualitative information about each of the relevant data sources is shown on the pages following the tables.

Target User: When MDOT, or a local jurisdiction, is examining a potential project, such as a multi-use trail, specific data may need to be considered for effective implementation. These may include both understanding surrounding land uses and existing transportation data. These data types and sources are categorized in this table.

DATA CATEGORIES

Category: Land Use Data

SUBCATEGORIES:

- Employment, Schools, and Other Services
- Core Services/Social/Recreational
- Environmental

Category: Transportation Data

SUBCATEGORIES:

- Roadway Information
- User/Ridership Information
- Non-motorized Infrastructure
- Connectivity

DATA SOURCES

Source: MDOT

- GIS Open Data Portal
- Lane Mile Inventory

Source: National Agency

- U.S. Census Bureau
- U.S. Fish & Wildlife
- U.S. Federal Emergency Management Agency

Source: State Agency

- Department of Technology, Management, and Budget
- Center for Shared Solutions
- Michigan Trails and Greenway Alliance
- State Historic Preservation Office

Source: Regional Agency

- Regional Planning Organizations
- Transit Agencies

Source: Local Agency

- Local Municipalities
- Bike Share Companies

TABLE 3-1: LAND USE DATA

Land Use Data	MDOT	NATIONAL AGENCY	OTHER STATE AGENCIES	REGIONAL AGENCY	LOCAL AGENCY
Employment, Schools, and Other Services					
Employment			●		●
K-12 Schools			●		●
Residential Density					
Technical and Higher Education			●		●
Industrial Parks				●	●
Existing Zoning and Proposed Future Land Use				●	●
Population Growth Centers			●	●	●
State Parks and Other Recreational Areas			●		
Traffic Stress					
Core Services/Social/Recreational					
Doctor Offices/Clinics					●
Hospitals			●	●	●
Pharmacies					●
Supermarkets					●
Social Services			●		●
Regional Shopping				●	●
Local Parks					●
Community Centers					●
Environmental					
Critical Dunes			●		
Wetlands			●		●
Historic Districts			●		
Threatened & Endangered			●		
4f/6f			●		
ESA			●		

TABLE 3-2: TRANSPORTATION DATA

Roadway Data	MDOT LANE MILE INVENTORY	NATIONAL AGENCY	OTHER STATE AGENCIES	REGIONAL AGENCY	LOCAL AGENCY
Roadway Information					
Average daily traffic (ADT)	●				
R/W Width	●				
Lane Configurations & Widths	●				
Geometrics	●				
Crash Data	●			●	●
NHS Truck Route	●				
National Freight Network	●				
Non-Motorized and Transit					
Bicycle (on and off road network) Infrastructure	●			●	●
Bicycle Ridership				●	●
Bike Share Stations					●
Sidewalks	●				●
Transit Ridership		●		●	●
Transit Infrastructure			●	●	●
Connectivity & Planning					
Non-Motorized Proposed Facilities				●	●
US Bike Routes	●				
Freight Corridor	●		●		
Transit Corridor	●		●		

MDOT

MDOT has numerous data types and categories already aggregated for use by the organization and the general public. When possible, data from MDOT should be primarily utilized over other sources because of its ease of access within the organization.

GIS Open Data Portal

Data Categories: School districts and buildings, hydrography, wetlands, critical dunes, ADT, MDOT Carpool Lots.

» **Description:** MDOT has its own data portal that houses spreadsheet, shapefile, and KMZ files that are open for public use. This portal includes data across many state departments and interest areas.

» **Data Type:** Shapefile, spreadsheet, KMZ, webmap

» **Data Quality:** Data age, frequency with which it is updated, and accuracy may vary based on each data set. Metadata for each data set should be reviewed before use.

» **Application:** This data portal should be a primary source of information because it is aggregated in once place and is the state's current central data hub.

» **Source:** gis-mdot.opendata.arcgis.com

Lane Mile Inventory

Data Categories: Lane configuration, speed, presence of bike lanes, sidewalk, on-street parking, etc.

» **Description:** The Lane Mile Inventory is a GPS assisted survey data collection of the number of lanes, road type, speed limit, bike lanes, etc. on Michigan state highways.

» **Data Type:** Webmap, shapefile

» **Data Quality:** The data set is updated yearly with the entire system updated on a 5-year cycle. The inventory is complete of all State of Michigan trunkline roadways. The database has information for when each attribute was last updated.

» **Application:** This database should be a primary source for gathering roadway information.

» **Source:** gis-mdot.opendata.arcgis.com/datasets/mdot-lane-mile-inventory-lmi

NATIONAL AGENCIES

Many federal departments and agencies have national datasets for their area of interest. Some of this data may also be available on state and local sources.

U.S. Census Bureau

Data Categories: Population, employment

- **Description:** The Census and American Community Survey (ACS) have information on population, education, housing, jobs, etc. Unlike the decennial Census, the American Community Survey (ACS) is an ongoing survey.
- **Data Type:** Spreadsheet
- **Data Quality:** The American Community Survey is based on 5-year, 3-year or 1-year estimates, with 5-year estimates being the most precise and 1-year being the most current.
- **Application:** Both the Census and ACS provide population data for a specific area. The ACS should be utilized when current population and employment data is needed.
- **Source:** factfinder.census.gov

U.S. Census Bureau

Data Categories: Geographic boundaries, political boundaries, natural features, transportation features

- **Description:** The Topically Integrated Geographic Encoding and Reference (TIGER) data is geographic based data for the United States.
- **Data Type:** Shapefile, database, geodatabase, KML
- **Data Quality:** TIGER data is updated annually, or on an as-needed basis.
- **Application:** TIGER data can be used to provide boundary files for demographic analysis or when up-to-date roadway or other transportation data is needed.
- **Source:** census.gov/geo/maps-data/data/tiger.html

National Highway Freight Network

Data Categories: National Freight Network

- **Description:** The National Highway Freight Network is a designated roadway system where federal funds are directed to improve performance.
- **Data Type:** Static map, shapefile
- **Data Quality:** State maps and tables show designated highways. There is also a nationwide shapefile.
- **Source:** ops.fhwa.dot.gov/freight/infrastructure/nfn/index.htm

NATIONAL AGENCIES (CONTINUED)

National Transit Database (NTD)

Data Categories: Systemwide Transit Ridership

- **Description:** The National Transit Database is collection of transit profiles from all transit agencies in the country. Agencies submit total ridership, spending, revenue, and more each year.
- **Data Type:** Spreadsheet
- **Data Quality:** Updated annually, with a year delay in some cases.
- **Source:** transit.dot.gov/ntd

U.S. Fish and Wildlife

Data Categories: Threatened/endangered species, wetlands, protected lands, coastal resources

- **Description:** Threatened and endangered species are plants and animals that have become rare or may become rare in the future and are therefore protected under certain laws and regulations.
- **Data Type:** Shapefile, spreadsheet, KMZ
- **Data Quality:** U.S. Fish & Wildlife has information on this data by county in Michigan.
- **Application:** When considering roadway network expansion, intrusion into habitats of threatened and endangered species and sensitive or protected lands should be avoided.
- **Source:** fws.gov/midwest/endangered/lists/cty_indx.html

Federal Emergency Management Agency (FEMA)

Data Categories: Flood hazard

- **Description:** FEMA manages the National Flood Hazard Layer which provides information on current effective flood hazard data.
- **Data Type:** Shapefile, static map, webmap
- **Data Quality:** Maps are updated based on an effective date and include historic mapping data.
- **Application:** When considering new transportation infrastructure, flood zones should be considered and avoided, if possible.
- **Source:** msc.fema.gov/portal/advanceSearch

STATE AGENCIES

Similar to MDOT, state agencies may create their own datasets or aggregate data from other sources. When data cannot be located through MDOT, a state agency should be explored for data.

Department of Technology, Management, and Budget (DTMB)

Data Categories: Employment, population

» **Description:** DTMB has aggregated statewide labor market data that includes employment, occupation, population, and projection data, among others.

» **Data Type:** Spreadsheet

» **Application:** This employment and population density data can be used to identify employment and population centers or at risk populations.

» **Source:** milmi.org/datasearch

Michigan Trails & Greenway Alliance (MTGA)

Data Categories: Multi-use trails (existing and planned)

» **Description:** MTGA is a statewide nonprofit that assists communities in expanding trails and works on statewide trail plans.

» **Data Type:** Static maps

» **Data Quality:** Unknown

» **Application:** Complete streets can help link existing and proposed trails to extend the network for cyclists, increasing safety and access.

» **Source:** michigantrails.org

State Historic Preservation Office (SHPO)

Data Categories: Historic districts

» **Data Type:** Cards, reports, photos, etc.

» **Data Quality:** The statewide survey program has been active since 1970. Users should verify the accuracy and last updated date of data with SHPO.

» **Application:** Many state roadways pass through historic downtowns and districts. The presence of these districts may have an impact on potential facilities, alignment, and aesthetic of the roadway. SHPO also has streetscape guidelines for historic districts.

» **Source:** michigan.gov/mshda/0,4641,7-141-54317---,00.html

REGIONAL AGENCY

There are 13 Metropolitan Planning Organizations (MPOs) and 79 public transit providers in Michigan. Available data can vary greatly by region.

Regional Planning Organizations

Data Categories: Land Use Data, (e.g. commercial, retail, office, and public space).

» **Description:** Regional planning organizations often have land use data that has been aggregated from surrounding municipalities.

» **Data Type:** Shapefile, static maps, spreadsheet

» **Data Quality:** Due to the continually changing nature of land use, land use data may be out of date or incorrect. The metadata file associated with the data should be reviewed for the data age.

» **Application:** Land Use data can help reveal where important destinations are located such as schools, parks, business centers, groceries, and hospitals. These locations need to be accessed safely, and from a variety of transportation methods.

» **Source:** Various regional organizations.

Regional Planning Organizations

Data Categories: Traffic crash data, high frequency crash locations, ADT

» **Description:** Many regional planning organizations have traffic related data including traffic counts and crash data.

» **Data Type:** Webmaps, shapefile, spreadsheet

» **Data Quality:** Traffic data is frequently updated by regional planning organizations. Verifying the collection date of the data and examining historical trends will improve decision making.

» **Application:** Traffic crash data can indicate where roadways are unsafe and specifics about crashes including type of vehicles involved, whether there were bicyclists or pedestrians involved, and how severe the crash was.

» **Source:** Various regional organizations.

LOCAL AGENCY

Locally based data can come from cities, townships, counties, or local organizations. Data quality and availability can vary greatly by municipality.

Local Municipalities

Data Categories: Existing land uses and building type

» **Description:** Individual municipalities have planning and zoning documents that include maps and graphics with land use related data.

» **Data Type:** Shapefile, static maps

» **Data Quality:** Due to the continually changing nature of land use, land use data may be out of date or incorrect. Before use, land use data should be critically examined for accuracy. The metadata file associated with the data should be reviewed for the data age.

» **Application:** Land Use data can help reveal where important destinations are located such as schools, parks, business centers, groceries, and hospitals. These locations need to be accessed safely, and from a variety of transportation methods.

» **Source:** Various local municipalities

Bike Share Programs

Data Categories: Bike share locations

» **Description:** Many large cities and universities have bike share programs in-place or are being developed. Information about bike share locations can be found on a local basis through the city website or bike share provider

» **Data Type:** Webmap, website

» **Data Quality:** Locations should be accurate because consumers depend on accuracy. However, mapping of bike share locations is dependent on local organizations.

» **Application:** Locating bike share locations near facilities for bicycles can improve safety and access for cyclists.

» **Source:** Various local cities and/or bike share organizations (Detroit, Grand Rapids, Ann Arbor, etc.)

LOCAL AGENCY (CONTINUED)

Transit Agencies

Data Categories: Transit systems, including stops, routes, and ridership

- **Description:** Many transit providers are locally or regionally based and can provide information on routes, stops, ridership, and upcoming system plans.
- **Data Type:** Shapefile, webmaps, static maps, spreadsheet, planning documents
- **Data Quality:** Quality and availability of data may vary greatly by area depending on the investment that has been made in data collection infrastructure. Transit lines and stops should be aggregated in GIS for areas where this information is available.
- **Application:** Transit system data can help determine where adjustments or new capital investments should be made to increase the efficiency of the system. MDOT and other agencies can use this data to coordinate new bus stops, curb infrastructure, and other improvements with roadway projects.
- **Source:** Existing local transit agencies or regional planning organizations.

Emerging Data and Trends

OVERVIEW

Future transportation systems will require increased connectivity among vehicles, people, and infrastructure to increase efficiency to the entire transportation network. The data that is used and generated from implementation of these new modes may be applied to planning and design efforts to improve future transportation networks. For example, origin-destination data collected by ride-hailing companies like Uber and Lyft can be used by MDOT and agency planners to better understand how people who do not want to drive are traveling in an area.

Additionally, new ways of collecting data are being developed now that will help the collection and analysis of more accurate bicycle, pedestrian, and transit ridership data. For example, MDOT and University of Michigan recently created a bicycle and pedestrian risk assessment model to help determine the areas where safety improvements are needed the most. The tool can help agencies and staff pinpoint the most dangerous areas for non-motorized users.

New technology and data collection methods will help agencies ensure that new infrastructure is being implemented in the areas that will benefit the most people. While some of these data sources are already available, there will be many additional sources available in the future and the efficient aggregation and management of these future data sources is still being planned.

In This Section:

- **Overview of Emerging Trends:** Intelligent Transportation Systems and Smart Cities
- **Overview of Emerging Data:** New Data Collection Technology for Bikes, Pedestrians, and Transit Users
- **SMART Columbus:** Program Overview
- **Emerging Roadway Technologies:** Considerations for MDOT
- **Emerging Mobility Options:** Considerations for MDOT

Bicycle and Pedestrian Counting Technology

Data has become an essential part of decision-making and will only continue to become an even more important factor. More than ever, data is being used to help agencies prioritize limited funding for investments in infrastructure. New investments in bicycle and pedestrian infrastructure will need to "prove" their value by showing the existing number of cyclists or pedestrians using a roadway.

Traditionally, MDOT and other agencies have relied on volunteers performing manual counts of bicyclists and pedestrians during set weeks. Much planning prior to the count days is needed to ensure the counts are captured accurately. However, data can be hard to collect in this way and can be subject to adverse weather or other extenuating circumstances that may artificially increase or decrease the total count.

MDOT, local agencies, and others should explore collecting bicycle and pedestrian travel utilizing new advances in technology that capture data with the same accuracy as vehicle counts. The following new and emerging technologies can be used to gather accurate counts and travel data of non-motorized roadway users:

- **Infrared Sensors** - Permanent or temporary hardware installed that counts travelers passing through and breaking an infrared beam at a specific speed.

Infrared counters can be connected to a digital display to show the total number of rides in an area.

- **Pneumatic Tubes** - Used for counting vehicles as well, pneumatic tubes can be re-calibrated to detect bicyclists crossing them.
- **Inductive Loops** - Similar to those at stop lights to trigger a traffic signal, inductive loops can be calibrated to detect bicyclists crossing.

Pneumatic tube counters are inexpensive to set up and maintain, but are not permanently installed.

- **Piezoelectric** - Sensors or mats placed on the ground that use pressure count pedestrians and cyclists as they pass over them, but cannot distinguish between the two.

Piezoelectric counters are permanently installed, best for counting bikes and pedestrians on shared use paths.

- **Radar -** Sensors embedded in the concrete that use radar waves to count passing bicyclists and can differentiate between vehicles and bikes.
- **Video Imaging** - Cameras use computer vision software to count bicyclists and pedestrians within the field of view, but can be inaccurate at times due to weather or available light.
- **Mobile Tech** - Apps, GPS tracking, and anonymous data collection can be used as a low cost solution to count bikes and pedestrians but may be less accurate than physical counters.

Transit Data Collection

Understanding how many and where transit riders board and alight buses and trains has been hard to quantify until now. Advances in technology now allow transit planners and operations managers to better understand how, where, and when people are riding transit. This data is incredibly valuable and allows transit agencies to adjust schedules and routes to provide a more convenient service for customers to maximize ridership. The following technology can be used to generate accurate rider data from any transit system:

- **Automatic Vehicle Location (AVL)**- Onboard GPS sensors that tracks the location of transit vehicles and displays real-time location of each vehicle on a map using specialized software. Agencies can use timing data to identify on-time performance issues.
- **Automatic Passenger Counting (APC)** - System to count and record passenger boarding and deboarding at each stop. Works in conjunction with AVL to assign GPS coordinates to each stop, allowing agencies to see where the busiest stops are located.
- **Mobile/Smart Ticketing** - Transit fare available for purchase using a dedicated smarphone app or smart card. Agencies that use a "tap on, tap off" system can use the data to develop an anonymized database to understand where riders board and deboard.

The Rapid in Grand Rapids recently launched a smart card and mobile app based fare system.

Intelligent Transportation Systems

According to the U.S DOT, Intelligent Transportation Systems (ITS) help improve transportation safety and mobility and reduce environmental impacts through the integration of advanced communications based information and electronic technologies within transportation infrastructure and vehicles. The connected environment these technologies create helps disseminate information about the roadway which allows users to make informed decisions about the many potential modes of travel. ITS technologies come in many formats and serve a range of purposes. While some of these technologies have been in-use for decades, others are still under development. Examples of ITS elements and their practical application are provided in the following sections.

Using ITS Data

Intelligent Transportation System components, including sensors, mobile devices, and connected vehicles, can generate unprecedented amounts of transportation related data on all users. To help manage and operate future systems, this data will need to be collected, organized, shared, and analyzed with various users in an enterprise system.

The city of San Diego uses its streetlights as smart infrastructure to collect data on mobility, air quality, safety, and other measures.

The U.S. DOT has outlined several benefits of enterprise data resulting from ITS:

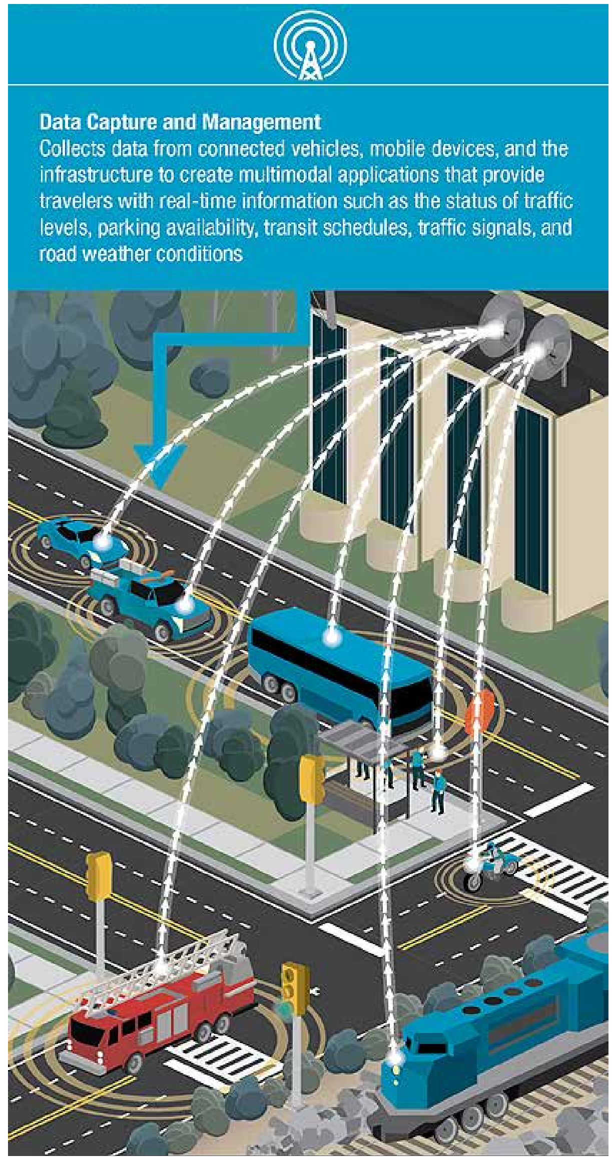
- Monitoring performance and creating more efficient responses
- Stimulating innovation in additional applications and research
- Creating additional revenue opportunities
- Protecting public privacy in relation to data
- Efficiently managing and sharing data

Smart Cities

A smart city is an urban area that utilizes data collection and communication of information to manage assets and resources efficiently. This includes data collected from citizens, devices, and assets that is processed and analyzed to monitor and manage a number of community systems and services including traffic and transportation systems. Smart Cities is as an initiative to help strengthen the information available to decisions makers so they can create the safest, most efficient systems for users.

Smart Cities Challenge

In December 2015, US DOT launched the Smart City Challenge, that prompted cities, nationwide, to share their ideas for how to create an integrated, first-of-its-kind smart transportation system that would use data, applications, and technology to help people and goods move faster, cheaper, and more efficiently (US DOT). This challenge helped cities identify issues related to urban mobility and solutions rooted in existing or future ITS technologies. This work, completed by cities across the U.S., could help inform solutions to problems that places across Michigan are facing in relation to roadway safety and comfort.



Communication among many users and devices will create efficiencies in the transportation system (US DOT).

Existing elements of the roadway network, such as street lights, traffic cameras, or signage can be integrated into a “smart” network.

SMART COLUMBUS

Columbus, Ohio

Columbus, Ohio was the winner of the U.S. DOT's Smart Cities Challenge and was awarded $50 million in funding to implement a more diversified and agile transportation system using data and a connected network. Smart Columbus, the Smart Cities initiative, is a partnership between local businesses, governments, research groups, and other organizations to reimagine mobility within the City.

Smart Columbus has a number of focus areas that aim to solve issues within the City related to equity, the economy, and the environment. These include:

Enabling Technologies

- Creating a connected vehicle environment which will enhance safety and mobility throughout the city's transportation system, especially as it relates to high-crash intersections and corridors.

Enhanced Human Services

- Implementing a multi-modal trip planning app with a common payment system in order to make multi-modal travel options more easily accessible. This application will include not only routes, schedules, and dispatching capabilities, but it will also facilitate payment for multiple transportation systems.
- Increase mobility assistance for people with cognitive disabilities that will allow for trip pre-planning and various mobility option reservations, including bike share and car share.
- Improve prenatal trip assistance. Columbus has a high rate of infant mortality, especially in low-income neighborhoods. Improving mobility for these populations with transit, car share services, and on-demand transportation services will improve health outcomes.
- Integrate parking information from multiple providers for event parking information and reservations.

Emerging Technologies

- Implement connected electric autonomous vehicles to better connect transit riders to opportunities in job centers like Easton Shopping Center
- Incorporate truck platooning on select roadways to ensure the efficient and safe movement of logistics-related vehicles

The Smart Columbus Guidebook aims to utilize emerging tools like AV/CV shuttles to address issues of public health, safety, and economic insecurity.

> As part of Smart Columbus, the City is aggregating data from numerous sources. Unlike many other public organization aggregated data systems, this data includes both public and private sources and it can be inputted into applications that leverage the data and operating system so organizations can make better decisions regarding mobility and services.

OVERVIEW OF EMERGING TECHNOLOGIES

The seven finalists for the Smart Cities Challenge identified a variety of projects that would be funded with their grants. Table 3-3 on the following page summarizes many of the projects proposed by the seven finalists that may be applicable to MDOT in the future. While each emerging tool may have multiple potential outputs and applications, the primary focus for the purpose of this plan is that of data and its future use for MDOT.

The emerging technologies identified in this chapter do not represent an exhaustive list and present only a summary of potential new and evolving data sources for the state of Michigan. Communication and coordination surrounding data collection between MDOT, municipalities, regional planning organizations, and other mobility and infrastructure entities will help ensure that emerging tools are being leveraged at all levels of government efficiently and effectively.

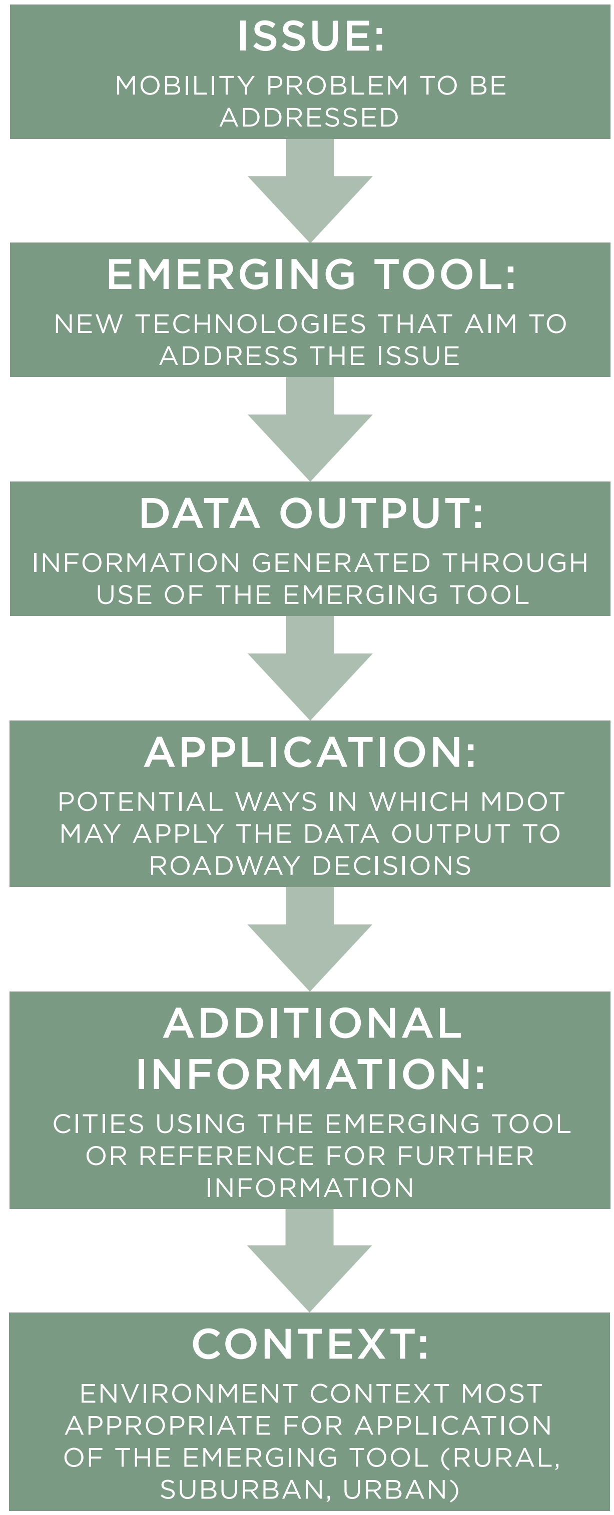


TABLE 3-3: SMART TECHNOLOGY AND ITS APPLICATION

SMART TECHNOLOGY		
ISSUE	EMERGING TOOL	DATA OUTPUT
Intersection and speed related crashes	**Artificial Intelligence (AI) exposure model** - Estimates real car volumes on all streets using exact traffic counts where they exist and predicted volumes where they don't exist	Complete citywide traffic volume data
	Video analytics traffic safety system - Detects and follows the trajectory of moving objects	Data reports identifying conditions that led to near collisions
	Connected Vehicle (CV) technology - Enables vehicles to communicate with each other using in-vehicle devices that continuously share important safety and mobility information	Communication on speed limits, upcoming curve warnings, and work zones
Traffic / Congestion	**Traffic signal coordination** - Adjusts automated system of traffic lights to behave in sync with one another	Uninterrupted traffic flow in response to demand or emergency need
	Signal priority - Automatically prioritizes signal for select users	Traffic signal adjustments based on real time needs
	V2V platooning - Feeds communication between vehicles and synchronizes behavior based on that communication	Harmonized speed, braking, and other functions
	Electronic toll collection - Automatically identifies and facilitates payment from drivers using transponders	Real time data including user demographics
	Travel information system - Uses Vehicle to Infrastructure and Vehicle to Vehicle communication to relay information about current road conditions	Updates to travelers on road conditions such as congestion and active work zones
	Variable speeds - Collects and analyzes vehicle speeds, congestion information, weather, and other road conditions	Adjusted speed limits for circumstances that would benefit from slower traffic

APPLICATION	ADDITIONAL INFORMATION	CONTEXT
Analyze the impact of roadway improvements on traffic volumes and crash rates, as well as predict the impact of an intervention on similar streets	New York City, Seattle, and New Orleans: http://www.datakind.org/projects/creating-safer-streets-through-data-science	Urban
Identity high-risk intersections and intervene with roadway improvements to prevent future crashes	City of Bellevue, Washington https://transportation.bellevuewa.gov	Urban
Use additional time and knowledge to appropriately adjust driving behavior in response to communicated conditions	U.S. Dept. of Transportation: https://www.its.dot.gov/cv_basics/cv_basics_what.htm	Urban, Suburban
Establish more efficient route for travelers	NACTO: Urban Street Design Guide https://www.nacto.org/publication/urban-street-design-guide/	Urban, Suburban
Prioritize transit, freight, or emergency vehicles to improve overall efficiency of the network	Atlanta North Avenue Smart Corridor: https://renewatlantabond.com/project/north-avenue-smart-corridor/	Urban, Suburban, Rural
Increase fuel efficiency, lower costs, and improve safety of roadways	Commercial Truck Platooning in Texas: https://static.tti.tamu.edu/tti.tamu.edu/documents/0-6836-1.pdf	Urban, Suburban, Rural
Price roads based on demand and better understand commute patterns	Ohio Turnpike: https://www.ohioturnpike.org/e-zpass/general-information	Toll roads
Make informed travel decisions and safely respond to unfavorable conditions	U.S. Dept. of Transportation: https://www.gps.gov/cgsic/meetings/2014/arnold.pdf	Urban, Suburban, Rural
Reduce stop and go traffic to make travel systems safer and more efficient	Washington State Dept. of Transportation: http://www.wsdot.wa.gov/opertations/ITS	Urban, Suburban, Rural

TABLE 3-3: SMART TECHNOLOGY AND ITS APPLICATION

SMART TECHNOLOGY		
ISSUE	EMERGING TOOL	DATA OUTPUT
First mile, Last mile	**Last mile mobility (AV/EV shuttles, on-demand bicycles, and scooters) -** Ride hailing, ride-sharing, autonomous and electric modal options	Real time data on multi-modal transportation and its relation to transit
Lack of available parking (or parking information)	**Smart parking sensors -** Provides users with information about available parking within garages, lots, streets, etc.	Real time parking data including when spots are occupied and vacated
	Demand-responsive parking pricing - Makes live adjustments to meter pricing according to demand	Parking prices and availability information which better matches demand
Comfort & Accessibility for all users	**Bicycle and pedestrian detectors -** Detects, communicates, and/or signals that bicyclists and pedestrians are at a traffic light, crosswalk, etc.	Information about pedestrian and cyclist route patterns
	Accessibility routing - Provides applications with turn by turn navigation and information on route accessibility conditions	Data on accessibility or comfort needs along specific routes
Inefficient lighting	**Motion sensor lighting -** Activates lighting structure after detecting motion	Data on when and where lights are activated

APPLICATION	ADDITIONAL INFORMATION	CONTEXT
Align streetscape improvements with multi-modal usage and enhance transit patterns	See case studies in following section (Page 66-67)	Urban, Suburban
Reduce the number of parking spaces where they are underutilized and increase multi-modal opportunities or shared parking where there is high demand	San Francisco (SF Park): http://sfpark.org/about-the-project/	Urban, Suburban
Make parking easier to find to alleviate traffic	San Francisco (SF Park): http://sfpark.org/about-the-project/	Urban
Adjust roadway design to accommodate high volume areas of pedestrian and bicyclist movement	Pedestrian and Bicycle Information Center: http://www.pedbikeinfo.org/planning/facilities_crossings_bikedetect.cfm	Urban, Suburban, Rural
Adjust routes to meet ADA, senior, and other mobility needs	University of Washington Taskar Center for Accessible Technology	Urban, Suburban
Implement pedestrian improvements in highly activated areas during peak times	City of San Diego: https://www.sandiego.gov/environmental-services/energy/programs_projects/smart-city	Urban, Suburban, Rural

EMERGING MOBILITY OPTIONS

Emerging mobility options, including bike-share, car-share, shared rides, and scooters, are changing the transportation landscape of communities across the country. As people have begun to utilize these services, private companies are collecting large volumes of micro-level data about trips taken across a transportation system. Through partnerships with these companies, Michigan's communities could use this data to help guide a variety of strategic roadway investments. Emerging mobility options include:

- **Bike Share and Scooter Share** - Many cities are requiring companies to provide real-time data about device location and usage. This data can be used to identify "first mile, last mile" deficiencies within a system, along with identifying highly-traveled roads with and without multi-use lanes and dedicated multi-use paths within a municipality.
- **Car Share** – Car-share models include options where a customer picks up and returns a car to the same point (e.g. Zipcar) or provide a customer the ability to park anywhere within a defined "home area" (e.g. Car2Go). Both services provide valuable data on hot-spots for pick-up and drop-off, providing data that might guide the location of designated on-street parking spots for car-sharing services.
- **Mobile Applications** - Increasingly, many pedestrians and cyclists utilize mobile applications to track their trips, usually for fitness purposes. Companies like MapMyRun and Strava collect user data on preferred walking and running routes. This data has been and can continue to be used to plan bike routes and pedestrian routes.

CASE STUDY: E-SCOOTERS

Baltimore Maryland

E-scooters owned by companies such as Bird and Lime are new mobility options to allow people to travel around a city. Many communities have pilot agreements in place with city governments to allow cities to access and use mobility data of scooter usage. In Baltimore, the city's pilot agreements with Bird and Lime require the companies to share the following datasets with the City:

- The number of scooters in service,
- The number of rides,
- Anonymized origin and destination data in map form.
- A point map of the scooters' location one day and one night each week,
- All scooter crashes
- Requests to re-balance the fleet by customers or the Department of Transportation
- A summary of any incidents of theft or vandalism

As communities across Michigan begin to adopt these technologies, these types of agreements will help communities understand their transportation systems better. This will help with decision making such as prioritizing where to place dedicated lanes for bicycles and scooters.

Data collected through scooter-share programs can help identify gaps in the existing transportation network.

CASE STUDY: DOCKLESS BIKESHARE

South Bend, Indiana

Lime began providing a dockless bike-service in South Bend in 2017. Dockless bike systems collect a variety of data points about users' transportation habits, including GPS location data transmitted every few seconds of a ride through built-in GPS coordinates. Through an agreement with the City, Lime agreed to share data about the usage of the system through an online dashboard. The City of South Bend receives the following information:

- How many residents rented bikes over a given time period,
- How many trips individual residents take,
- How far and long users traveled.

Anonymized GPS tracking allows the company to understand all of the routes taken by riders, which helps them prioritize where roadway investments should be made. Furthermore, by understanding where trips stop and start within communities, cities can use that information to locate bike amenities such as bike parking stalls.

Bike share data on where and for how long cyclists are traveling can guide decisions on future bike lanes, paths, or parking stations.

CONCLUSION

Opportunities exist to gather more complete and accurate data on mobility than ever before. This, in turn, may be leveraged by MDOT to advance Michigan's transportation system. When applied to roadway improvements, the data gathered by smart technologies may improve the safety, efficiency, and overall well-being of a community. Emerging tools and mobility options create the opportunity to make data-informed decisions aimed at addressing key mobility issues. Expanding the use of data can also help ensure that roadway decisions are equitable and adequately serve all members of a community, regardless of travel mode or location within the city.

Key Findings

The following are key findings from Chapter 03: Data Gathering for Informed Projects. This summary has been categorized by context area (Urban, Suburban, Small Town, Rural Roadways and Corridors) to help with application of the document based on the project context.

Urban roadways generally occur in dense urban environments with a diverse mix of land uses. Area populations generally exceed 100,000 residents.

URBAN AREA

- Urban areas will likely have the most complete and easily accessible land use and roadway data from national, state, regional, and local levels.
- Urban areas will be well-suited for implementing comprehensive and complementary technology, data, and applications to help create an integrated, “smart,” transportation system in order to move people and goods more safely and efficiently.
- Smart technologies, including real-time traffic data, traffic signal coordination, and connected vehicle technology, can alleviate many of the issues urban areas are facing including congestion, crashes, parking, and accessibility.
- Shared services, such as car, bike, and scooter sharing will not only increase mobility options, but can provide additional data about mobility needs for transportation planning.

Roadways that occur in lower-density environments, usually surrounded by auto-oriented commercial and residential uses. Area populations generally are between 20,000-100,000 residents.

SUBURBAN AREA

- Suburban areas will likely have relatively complete and easily accessible land use and roadway data. Regional and local data may vary, depending on the resources of the locality.
- Many suburban areas can benefit from “smart” technologies, especially at intersections and along major corridors. Data gathered from these technologies can be used to improve roadway conditions in real-time or longterm.
- Share services, such as car, bike, and scooter sharing will not only increase mobility options, but can provide additional data about mobility needs for transportation planning. These services may be especially helpful in alleviating “first mile, last mile” concerns.

RURAL AREA

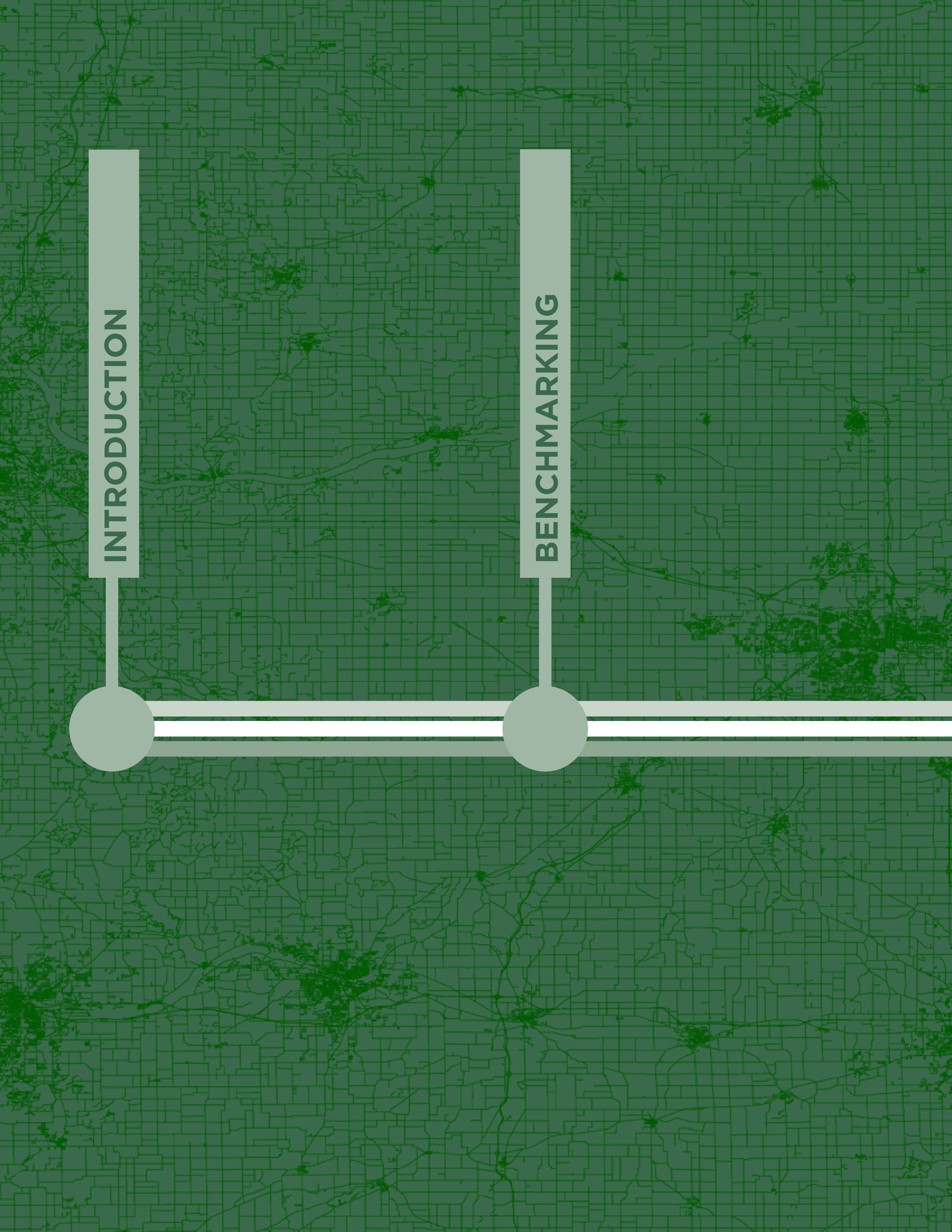
Small town roadways generally occur in low density areas with distinct land uses. Small town populations generally are less than 20,000.

- Rural areas may have less complete and accessible land use and roadway data, especially on the regional and local level. Availability of data may depend on the resources in that particular area.
- In relation to “smart” technologies, rural areas may be less connected compared to urban and suburban areas. However, some technologies aimed at reducing crashes, traffic congestion, and parking deficiencies, may be appropriate in small downtowns. Vehicle platooning and travel information systems may be more appropriate on rural roadways used for major travel.
- Depending on how autonomous vehicle technology is implemented, autonomous vehicle car sharing may increase mobility from those traveling from rural areas to larger cities. Data generated from these trips can be used in future planning efforts.

RURAL ROADWAYS & CORRIDORS

Rural roadways and corridors are the state and U.S. highways that connect cities, suburbs, and towns. These roadway networks are largely rural and tend to accommodate freight traffic.

- Rural roadways and corridors will likely have complete and accessible roadway data. However, land use data may depend on regional and local entities.
- These roadways and corridors may require aggregating data from a greater range of municipalities and organizations, depending on the extents of a project.
- “Smart” technologies are already being implemented along major thoroughfares throughout the U.S. Autonomous and connected vehicles allow for vehicle platooning, travel information systems, and variable speeds, among other technologies.


INTRODUCTION
BENCHMARKING

DATA GATHERING FOR INFORMED PROJECTS

IMPLEMENTATION FRAMEWORK

The Implementation Framework section of the M2D2 Guidebook is designed to help MDOT and other agencies determine which projects should be considered to meet the specific benchmarked goals of the roadway. The Implementation Framework is broken down into recommendations, which are general guidelines that should be considered for projects within each land use context, and specific design guidelines, which are project ideas that are rated based on their relevance to each land use context. The framework should help staff identify which improvements will have the greatest impact to Complete Streets, Transit, or AV/CV Readiness based on the project location.

PLAN COMPLETION

04

RECOMMENDATIONS

TOOLS AND ELEMENTS

04 IMPLEMENTATION FRAMEWORK

Implementation Framework

OVERVIEW

The M2D2 guidebook should be used as a tool for transportation professionals and those interested in multi-modal mobility across the State of Michigan when planning and designing transportation improvements along State roadways. To assist with implementation, this Guidebook lists potential design elements associated with future roadway improvements that should be considered for urban, suburban, rural, and connecting corridors, and the importance of each for each street context. Additionally, the design practices that should be avoided are summarized for each street context.

A full table of potential tools and design elements that should be used to improve multi-modal travel conditions has been compiled and organized by context area. A relevance rating was created for each mobility tool based on the importance of each to the four context areas. For example, bike lanes have a much higher relevance on urban streets than connecting corridors. The recommendations and mobility tool table can help those working on a particular project identify priorities that should be considered based on the surrounding land use conditions.

Newark, Ohio, a city of approximately 50,000 residents, improved pedestrian comfort and accessibility in the downtown by enhancing the streetscape and installing roundabouts, on this heavily traveled state roadway.

Incorporating the M2D2 Guidebook in the MDOT Project Development Proecess

MDOT	M2D2
Standard MDOT project selection process for identification and selection of multi-modal projects.	Consult the corresponding M2D2 Guidebook chapters for each step of the MDOT project process to ensure M2D2 recommendations are carried through to new MDOT projects.

PHASE I

CONSULT THIS CHAPTER

KICKOFF LAUNCH (IDENTIFY CANDIDATE PROJECTS)	02 - BENCHMARKING

PHASE II

EXISTING CONDITIONS & DATA GATHERING	03 - DATA GATHERING FOR INFORMED PROJECTS

PHASE III

ALTERNATIVE DEVELOPMENT	04 - IMPLEMENTATION FRAMEWORK

PHASE IV

PREFERRED SCENARIO DEVELOPMENT (5 YR PROGRAM ANNOUNCED)	PLAN COMPLETION

RECOMMENDATIONS

As MDOT considers making multi-modal investments along its roadways, the following recommendations should be taken into consideration based on the project context. These recommendations have been developed from the research, case studies, and findings throughout this Plan and the relevant plan section is referenced within the recommendation.

Urban roadways generally occur in dense urban environments with a diverse mix of land uses. Area populations generally exceed 100,000 residents.

URBAN ENVIRONMENTS

FUTURE ROADWAY IMPROVEMENTS **MUST CONSIDER:**

- Consider adjacent and nearby land uses and how that may encourage or require access for different users (*Complete Streets*).
- Understand current and anticipated changes in mobility technologies and how they may influence curb access management along dense urban roadways with a variety of users. This includes the increased prevalence of ride share services (e.g. Uber, Lyft), the increased popularity of non-motorized transportation options (bicycles, electric scooters), and changes in urban freight and delivery (*Emerging Data and Trends, AV/CV Readiness*).
- Prioritize pedestrian and bicycle access, safety, mobility and comfort within heavily-traveled transit corridors to increase the use and demand of transit (*Transit*).

FUTURE ROADWAY IMPROVEMENTS **SHOULD CONSIDER:**

- Create or re-enforce connections to existing or planned transit, pedestrian, and bicycle facilities (*Complete Streets*).
- Consider adapting roadway networks to meet the needs of autonomous vehicles. These include reduced lane widths required for autonomous vehicles, along with potentially reduced demand for on-street parking as autonomous systems shift to shared users (*AV/CV Readiness*).
- Consider long-term transit planning efforts when developing a project so a current project can support and not hinder future efforts (*Transit*).
- Utilize emerging data sources, such as those from bike sharing and scooter sharing, to improve planning and design of projects (*Emerging Data and Trends*).

FUTURE ROADWAY IMPROVEMENTS **SHOULD NOT:**

- Be planned, designed, and constructed without consulting all relevant departments, organizations, and interested individuals (Complete Streets).
- Greatly prioritize travel efficiency, safety, access, or mobility for one particular user over all other users (Complete Streets).

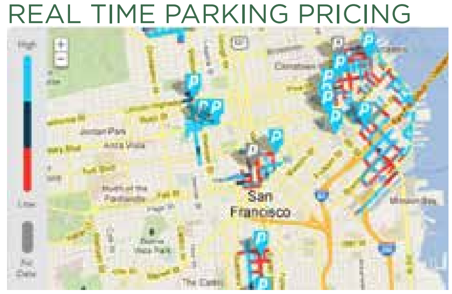
THE FOLLOWING DESIGN ELEMENTS SHOULD BE CONSIDERED TO IMPROVE MULTI-MODAL CONDITIONS ON URBAN ROADWAYS

PROTECTED BIKE LANES

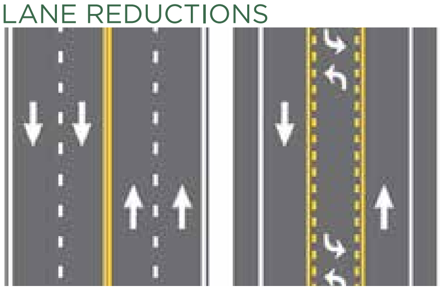
AV/EV SHUTTLES

STREETSCAPING

REAL TIME PARKING PRICING



LANE REDUCTIONS



DOCKLESS BIKES & SCOOTERS

BUS BULBS

TRANSIT SIGNAL PRIORITY & TIMING

DEDICATED BUS LANE

BIKE & PEDESTRIAN COUNTERS

Suburban roadways can vary depending on the surrounding land use, but are typically more auto oriented than Urban Environments. Area populations range from 20,000 to 100,000 residents.

SUBURBAN ENVIRONMENTS

FUTURE ROADWAY IMPROVEMENTS **MUST CONSIDER:**

» Adjacent and nearby land uses and how that may encourage or require access for different users (*Complete Streets*).

» Improved pedestrian and bicyclist safety and access within auto-oriented corridors, both to improve comfort and also to leverage multi-modal connections for future development and redevelopment along certain suburban roadway corridors (*Complete Streets*).

FUTURE ROADWAY IMPROVEMENTS **SHOULD CONSIDER:**

» Adopting roadway networks to potential changes in the transportation system including reduced lane widths necessary for cars and trucks, along with potentially reduced demand for on-street parking (*AV/CV Readiness*).

» Strengthening amenities and design around transit stops to encourage the use of public transportation (*Transit*).

» Utilizing emerging data sources, such as those from car sharing, to improve planning and design of projects (*Emerging Data and Trends*).

FUTURE ROADWAY IMPROVEMENTS **SHOULD NOT:**

» Be planned, designed, and constructed without consulting all relevant departments, organizations, and interested individuals (*Complete Streets*).

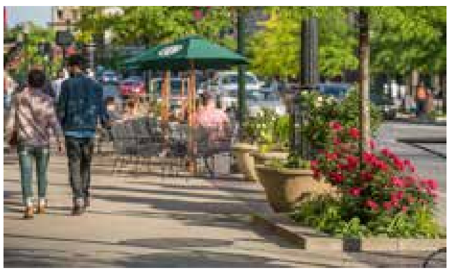
» Greatly prioritize travel efficiency, safety, access, or mobility for one particular user over all other users (*Complete Streets*).

THE FOLLOWING DESIGN ELEMENTS SHOULD BE CONSIDERED TO IMPROVE MULTI-MODAL CONDITIONS ON SUBURBAN ROADWAYS

STANDARD BIKE LANES

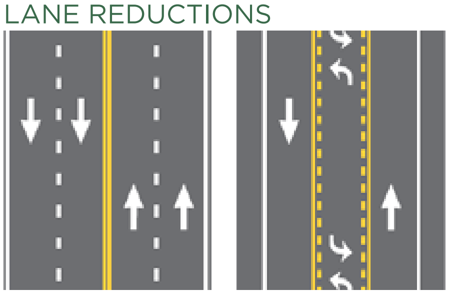
PEDESTRIAN CROSSING ISLANDS

STREETSCAPING



BIKE & PEDESTRIAN COUNTERS

LANE REDUCTIONS



DOCKLESS BIKES & SCOOTERS

BUS SHELTERS

TRANSIT SIGNAL PRIORITY OR TIMING

TRAFFIC SIGNAL COORDINATION

SMALL TOWN ENVIRONMENTS

Small town roadways generally occur in low density areas with distinct land uses. Small town populations generally are less than 20,000 residents.

FUTURE ROADWAY IMPROVEMENTS **MUST CONSIDER**:

» Balancing the safety and needs of a variety of users, including pedestrians, bicyclists, automobiles, and truck traffic *(Complete Streets)*.

» Creating or re-enforcing connections to existing or planned transit, pedestrian, and bicycle facilities (*Complete Streets)*.

FUTURE ROADWAY IMPROVEMENTS **SHOULD CONSIDER**:

» Implementing mobility options that are context sensitive, taking into account roadway conditions such as speed *(Complete Streets)*.

» Adapting roadway networks to meet the needs of autonomous vehicles. These include reduced lane widths required for autonomous vehicles, along with potentially reduced demand for on-street parking, as autonomous systems may shift to shared users *(AV/CV Readiness)*.

» Long-term transit planning efforts when developing a project so a current project can support and not hinder future efforts *(Transit)*.

» Utilizing emerging data sources, such as those from car sharing, to improve planning and design of projects *(Emerging Data and Trends)*.

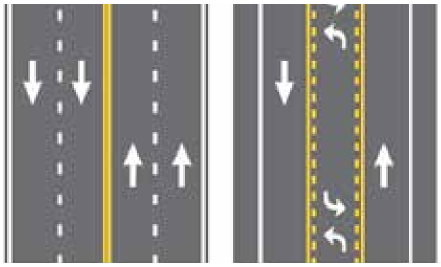
FUTURE ROADWAY IMPROVEMENTS **SHOULD NOT**:

» Be planned, designed, and constructed without consulting all relevant departments, organizations, and interested individuals *(Complete Streets)*.

» Inhibit existing, planned, or potential future transit or freight mobility options *(AV/CV Readiness)*.

THE FOLLOWING DESIGN ELEMENTS SHOULD BE CONSIDERED TO IMPROVE MULTI-MODAL CONDITIONS ON SMALL TOWN AND RURAL ROADWAYS

LANE REDUCTIONS



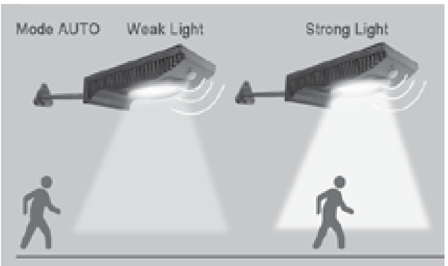
PEDESTRIAN SIGNALS

STREETSCAPING

ON-STREET PARKING

BUS SHELTERS

MOTION SENSOR LIGHTING



CONNECTED VEHICLE TECHNOLOGY

BARRIER FREE SIDEWALK RAMPS

RURAL ROADWAYS & CORRIDORS

Rural roadways and corridors are the state and U.S. highways that connect cities, suburbs, and towns. These roadway networks are largely rural and tend to accommodate freight traffic.

FUTURE ROADWAY IMPROVEMENTS **MUST CONSIDER**:

» Accommodating all roadway users, safely and efficiently *(Complete Streets)*.

» Implementing advances in roadway technology to strengthen and improve efficiency and safety, where possible. This could include autonomous and connected vehicle technology that facilitates truck platooning and real-time road condition information *(AV/CV Readiness)*.

FUTURE ROADWAY IMPROVEMENTS **SHOULD CONSIDER**:

» Adopting roadway networks to potential changes in the transportation system including reduced lane widths necessary for cars and trucks *(AV/CV Readiness)*.

» Utilizing AV/CV technology, especially on high-crash roadways, to improve safety. *(AV/CV Readiness)*.

» Utilizing emerging data sources, such as those from car sharing, to improve planning and design of projects *(Emerging Data and Trends)*.

FUTURE ROADWAY IMPROVEMENTS **SHOULD NOT**:

» Be planned, designed, and constructed without consulting all relevant departments, organizations, and interested individuals *(Complete Streets)*.

» Inhibit existing, planned, or potential future transit or freight mobility options *(Transit)*.

THE FOLLOWING DESIGN ELEMENTS SHOULD BE CONSIDERED TO IMPROVE MULTI-MODAL CONDITIONS ON CONNECTING CORRIDORS

PAVED SHOULDERS

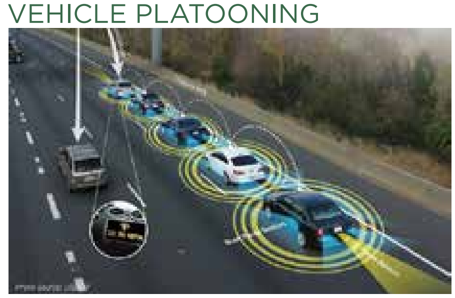
PEDESTRIAN CROSSING ISLANDS

TRANSIT SIGNAL PRIORITY

ELECTRONIC TOLL COLLECTION

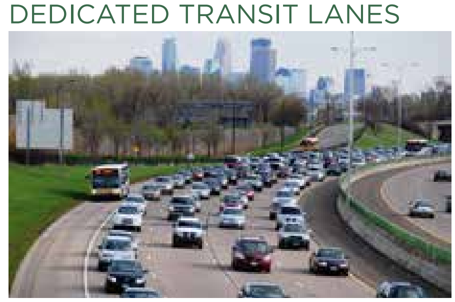
TRAFFIC SIGNAL COORDINATION

VEHICLE PLATOONING



VIDEO ANALYTICS FOR TRAFFIC SAFETY

DEDICATED TRANSIT LANES



MOBILITY TOOLS & DESIGN ELEMENTS

There are numerous tools and design techniques that MDOT and other agencies can use to advance Complete Streets, Transit, and AV/CV Technology implementation goals. Selecting the appropriate design tools, however, should be based on the land use context of the area. For example, dedicated transit lanes are much more relevant in dense, congested urban areas than they are in small towns. This section of the M2D2 Guidelines is dedicated to identifying specific Complete Streets, Transit, AV/CV Technology, and Emerging Technology capital improvements that will help improve multi-modal travel throughout the State.

Generally, the mobility tools and design elements listed in the tables on the following pages have been rated on their applicability to Urban, Suburban, Rural, and Connecting Corridor areas. However, this is only a guide. Each project or application of the tool should be considered based on the specific needs and context of that particular project. The flowchart to the right shows the steps MDOT and other agencies should take to identify the specific design elements for roadway projects.

BENCHMARK:
SELECT MODAL BENCHMARK PROJECT IS FOCUSED ON

IDENTIFY CONTEXT:
SELECT LAND USE CONTEXT OF IMPLEMENTATION AREA (RURAL, SUBURBAN, URBAN, AND CONNECTING CORRIDORS)

DESIGN:
CHOOSE DESIGN ELEMENTS TO BE INCLUDED IN NEW STREET DESIGN

ASSESS:
RATE THE IMPORTANCE OF SPECIFIC MOBILITY TOOLS TO ACHIEVING MODAL GOALS

TEST:
DETERMINE WHAT SELECTED MOBILITY TOOLS WILL FIT WITHIN THE RIGHT OF WAY

Follow this flow chart to identify specific project ideas, listed in the tables on the following pages, that can be implemented to improve multi-modal conditions along MDOT roadways.

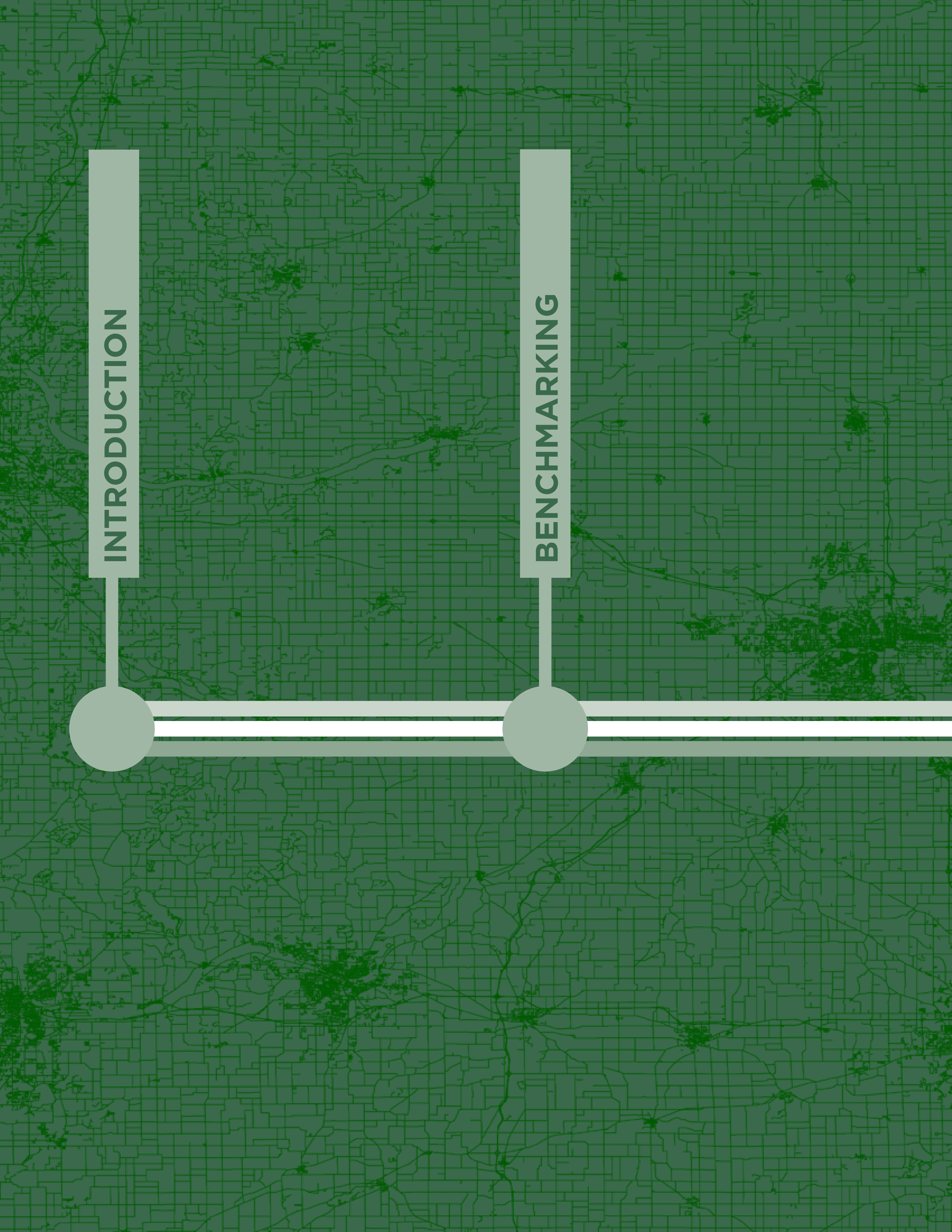
TABLE KEY

○○○ *Low Relevance* → ●●● *High Relevance*

MOBILITY TOOL/ELEMENT	URBAN	SUBURBAN	SMALL TOWN	CONNECTING CORRIDOR
COMPLETE STREETS				
Barrier-Free Ramps	●●●	●●●	●●●	●●●
Protected Bike Lanes	●●●	●●○	●○○	●○○
Standard Bike Lanes	●●●	●●●	●○○	○○○
Curb Extensions	●●○	●○○	●○○	●●○
Lane Reductions	●●●	●●●	●●●	●○○
Mid-block Crossings	●●○	●○○	●●○	○○○
On-Street Parking	●●●	●○○	●●●	○○○
Paved Shoulders	●○○	●●○	●●○	●●●
Pedestrian Islands	●●●	●●●	●○○	●●○
Shared-use Paths	●○○	●●●	●●○	●●○
Streetscaping	●●●	●●●	●●●	●○○
Pedestrian Signals	●●●	●●●	●●●	●○○

MOBILITY TOOL/ELEMENT	URBAN	SUBURBAN	SMALL TOWN	CONNECTING CORRIDOR
TRANSIT				
Future Plan Consideration	●●●	●●●	●○○	●●○
Bus Bulb	●●●	●●○	●●○	○○○
Bus Pad	●●●	●●○	●○○	●○○
Bus Shelter	●●○	●●●	●●○	●○○
Dedicated Curb Space	●●●	●○○	●○○	○○○
Dedicated Travel Lanes	●●●	●○○	●○○	●●○
Off-Board Fare Collection	●●●	●●○	●○○	●○○
Platform Length	●●●	●○○	●○○	●●○
Transit Signal Priority	●●●	●●○	●○○	●●●
Transit Signal Timing	●●●	●○○	●○○	●○○
Space for Last Mile Connections	●●●	●●●	●●○	●○○

MOBILITY TOOL/ELEMENT	URBAN	SUBURBAN	SMALL TOWN	CONNECTING CORRIDOR
AV/CV AND EMERGING TECHNOLOGY				
Accessibility Routing	●●●	●○○	●○○	○○○
AI Exposure Model	●●●	●●○	●○○	●●●
AV/EV Shuttles	●●●	●●○	●●○	●●●
Connected Vehicle Technology	●●○	●●○	●●○	●●●
Electronic Toll Collection	●●○	●○○	●○○	●●●
Motion Sensor Lighting	●●○	●●○	●●●	●●○
On-Demand Bicycles/ Scooters	●●●	●●○	●○○	○○○
Bicycle/Pedestrian Counters	●●●	●●●	●●○	●○○
Parking Demand Pricing	●●●	●○○	●○○	○○○
Signal Priority	●●●	●●○	●○○	●●○
Smart Parking Sensors	●●●	●○○	●○○	○○○
Traffic Signal Coordination	●●●	●●●	●○○	●●●
Travel Information System	●●●	●●○	●○○	●●●
Variable Speeds	●○○	●●●	●○○	●●●
Vehicle Platooning	●○○	●●○	●●○	●●●
Video Analytics Traffic Safety System	●●●	●●○	●○○	●●●


INTRODUCTION
BENCHMARKING

DATA GATHERING FOR INFORMED PROJECTS

IMPLEMENTATION FRAMEWORK

05 PLAN COMPLETION

Plan Completion

The way Michiganders travel is changing. New technology, infrastructure, and choices are making multi-modal travel much easier for residents in our cities, suburbs, and small towns. As Michigan's transportation system evolves from primarily automobile focused to one with many different available modes of travel, MDOT and local agencies should look to strategically invest in infrastructure that supports pedestrians, bicyclists, transit riders, and new mobility users to capture that demand. Providing safe, comfortable infrastructure for these users can help improve the sustainability of the transportation system, both fiscally and environmentally, increase safety outcomes for the most vulnerable users, and improve the quality of life for residents in urban, suburban, and rural areas in Michigan.

The M2D2 Guidebook is intended to be used by MDOT, local agencies, non-profits, and other state agencies as a road map for designing streets that work for all users. The solutions laid out in this Guidebook are not intended to be applied to every state road in Michigan. Rather, each roadway project should use an a-la-carte approach to identify specific multi-modal improvements that are consistent with the context of the street and the vision of the community. M2D2 will help MDOT and local agencies coordinate by offering a consistent set of solutions for streets throughout the state.

It is the goal of the M2D2 Guidebook to encourage the inclusion of multi-modal transportation infrastructure to the forefront of the design process, rather than an afterthought, following the funding and design of a roadway corridor. By considering the needs of all roadway users, the goals of the community, and future innovations in transportation, MDOT and local agencies will be able to develop a design framework focused on efficiently moving people in corridors throughout the State of Michigan.

The M2D2 Guidebook is intended to encourage the inclusion of multi-modal considerations in design so that they work for all users based on the specific context of the street, like Cass Avenue in Detroit (Source: Strategic Plan for Transportation, City of Detroit)