Research Report: SPR-1738

UTILIZING VIDEO ANALYTICS WITH CONNECTED VEHICLE FOR IMPROVED SAFETY

MDOT

Kimley»Horn
of Michigan, Inc.

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16. Abstract Focus of this research was to assess the current capabilities of video analytics within the market and to validate the potential value for implementing the systems in Michigan. Multiple video analytic vendors partnered to demonstrate the technology in predefined use cases at a specific location in southeast Detroit. The data results implied the technology could provide safety benefits, however, limitations with the pilot deployment made it challenging to verify the full capabilities with respect to safety applications. Future research is recommended with a focus on mitigating the challenges and risks experiences during the initial pilot project.		

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Utilizing Video Analytics with Connected Vehicles for Improved Safety – Research Report

Final Report

Prepared by:
Kimley-Horn of Michigan

January 2024

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Executive Summary

The state of Michigan ranks 10th in largest overall population in the United States with the Michigan Department of Transportation (MDOT) oversees roughly 10,000 miles of state highways.

In addition to MDOT's Vision of providing a safe, future-driven, and connected transportation system, they also strive to research and provide new ways to operate efficiently by creating a transportation system that is safe, integrated, and resilient. One key component of this vision is to be *proactive* versus reactive responses to incidents or events as they occur. To accomplish this, MDOT sought to research video analytic systems – what is the feasibility of the technology, what is available, and what the capabilities are – to then establish specifications for future projects.

Current Gaps

- Availability of existing infrastructure with lack of updated technology and systems to provide real-time data to reduce human error by identifying and communicating current risk conditions.
- Infrequent and incomplete data collection leading up to an event.
- Lack of real-time crash notifications impedes MDOT's ability to identify and introduce comprehensive mitigation strategies to reduce incident frequency and severity.
- Underutilized dynamic message signs (DMS)

Core Objectives and Research Confirmation

The research scope included a pilot deployment focused on assessing the viability and applicability of video analytics to identify potential crash and safety scenarios and provide a means for pushing warnings through CV technologies.

Initially, the research team focused on assessing the applicability of the technology within four focus areas.

1. **Traffic Conditions—Ability of the data to understand crashes and near misses.**
2. **Incident Management—Connectivity for first responders to have better situational awareness.**
3. **Traffic Operations—Incorporation of technology within operational improvements.**
4. **Awareness—Data-driven alerts to motorists and non-motorized users.**

Objective 1	Objective 2	Objective 3	Objective 4
Effectiveness of identifying risky conditions within an intersection.	Ability to use data for TMC Operations.	Ability to effectively warn users of at-risk conditions.	Benefits of integrating video analytics technology with CV.
Confirmed	**Confirmed**	**Unconfirmed**	**Unconfirmed**

Research Methodology

Research Methodology

Market Assessment

Determine the level of maturity of currently available technology and the capabilities of vendors to deliver this technology.

Use Case Development

Identify how individual components and the system should function overall while simultaneously delineating the roles of those involved in each scenario.

Corridor Evaluation

Define a methodology for evaluating potential locations to deploy the video analytics system.

Demonstration

Pilot the technology in a closed environment to confirm the applicability of the technology to meeting the project's needs.

Research Results

Although there are existing vendors in the market that have *readily available* video analytics technology, there is *still room for growth*.

The data from this research showed that the proposed system *could* provide additional safety and mobility information. However, additional research utilizing additional considerations could prove advantageous. Guidance on future, more temporary deployments, is provided in the Implementation Toolbox.

Introduction

Background

According to the National Highway Traffic Safety Administration (NHTSA), 94% of serious crashes are due to human error and can be attributed to human distraction (e.g., distracted driving, drowsy driving) or human decisions (e.g., impaired driving, speeding). As technology evolves, MDOT is interested in leveraging emerging technologies that support improved safety and mobility by more efficiently identifying risks and alerting others that could be compromised by those risks.

MDOT's Vision

To provide people with a safe, future-driven, interconnected multimodal transportation network that ensures equitable options.

In support of MDOT's Vision, this research project provides the means to assess emerging technologies and their current availability in the market. Some of these emerging technologies include the use of video analytics and connected vehicles (CV). The integration of these technologies into all transportation modes is expected to reduce the number of risks associated with human error tasks during driving. Reducing or eliminating the human errors that impact vehicle performance provides the potential to reduce fatalities and serious injuries of road users and proactively mitigate hazardous situations.

Video analytics technology provides the means to monitor traffic performance and identify specific types of events as they occur. Video analytics provide solutions that observe traffic movements and determine crashes or near misses between vehicles, bicycles, pedestrians, and other vulnerable road users. MDOT is interested in the reliability of the event detection and the potential actions that can occur once the system identifies a specific event.

MDOT has determined a benefit to coordinating efforts that integrates both video analytics technology and CV capabilities. Access to more enhanced situational awareness from CVs coupled with video analysis of the road users' actions would support better accuracy in the data collected. Real-time notifications of crash-like conditions generated from the comprehensive data would introduce mitigation strategies that lessen the likelihood and/or severity of incidents. Agencies can share this real-time data through CV technologies, the posting of messages to dynamic message signs (DMS), and other traveler information tools. Once the technology collects data, the system could analyze trends and feed decisions around intersection improvements, signal timing modifications, or other enhancements focused on mitigating the trend of risks identified.

Project Purpose

MDOT decided to research this theory through a pilot deployment of video analytics technology. The research defined an approach to evaluate the ability of emerging technologies to address the risks of MDOT's road users within specific use cases. The research scope included a pilot deployment focused on assessing the *viability* and *applicability* of video analytics to identify potential crash and safety scenarios and provide a means for pushing warnings through CV technologies.

Initially, the research team focused on assessing the applicability of the technology within four focus areas.

1. Traffic Conditions—Ability of the data to understand crashes and near misses.
2. Incident Management—Connectivity for first responders to have better situational awareness.
3. Traffic Operations—Incorporation of technology within operational improvements.
4. Awareness—Data-driven alerts to motorists and non-motorized users.

As the research team understood more about the capabilities of the technology and how an agency could administer a pilot, the focus areas were refined into the following four objectives. These include perspectives from the data collected, value to the traffic management center (TMC), and ability to deliver messages to other users.

Objective 1: Effectiveness of Identifying Risky Conditions Within an Intersection

Objective 2: Ability to Use the Data for TMC Operations

Objective 3: Ability to Effectively Warn Users of At-Risk Conditions

Objective 4: Benefits of Integrating Video Analytics Technology with CV

Based on the assessment relative to these objectives, the research team will provide guidance on the viability of these technologies as a strategy to positively impact safety and mobility. The results of the research will support the derivation of technology specifications based on functionality that is consistently available in the market. Additionally, the research findings will support the development of an implementation plan that MDOT can reference for implementing the technology at the most appropriate locations based on localized need and the anticipated benefit.

Research Project

Methodology

The research methodology included a multi-step process shown in **Figure 1.**

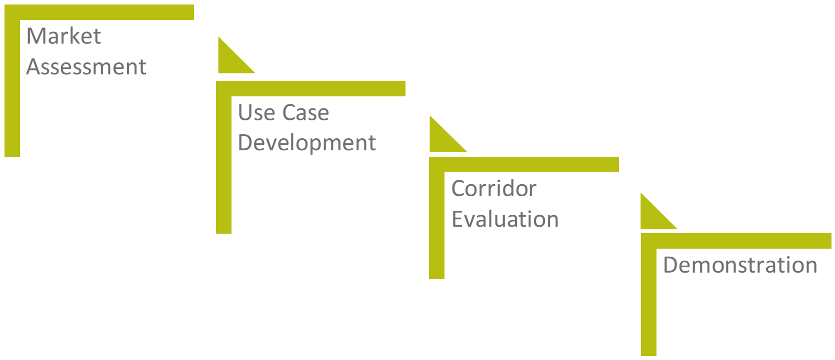

Figure 1. Multi-Step Research Process

Each step provided an additional level of detail and framework for the subsequent step. The initial step included a *market assessment* of the industry with the intent to ascertain the level of maturity of the technology currently available in the market. Additionally, it focused on understanding the number of vendors capable of successfully delivering this technology. The research team collected information from discussions with agencies familiar with the technology, surveys, publicly accessible web searches, and responses from the industry to a publicly advertised Request for Information (RFI). The research focused on the available functionality relative to intersection and midblock interactions between motorized vehicles, pedestrians, bicyclists, and other non-motorized users. **Appendix A Market Assessment** includes additional details.

The *use case development* occurred somewhat parallel to the market assessment while also integrating knowledge obtained from the market assessment. The use cases defined the operational intentions that MDOT was anticipating from the proposed scenarios. The use cases allowed the research team and the vendors to better understand how the individual components and overall system should function while simultaneously delineating the roles of users involved in each scenario. **Appendix B Use Cases** provides a complete summary of all uses cases defined for the project.

The *corridor evaluation* defined a methodology for evaluating potential locations to deploy the video analytics system. The corridor evaluation process defined key areas of consideration based on the available technology, the characteristics of a corridor or intersection, and the defined use cases. **Appendix C Corridor Evaluation Report** includes the details of the corridor evaluation methodology**.**

The *demonstration* of the technology was the final step in the research process and included an advertisement of a Request for Proposal (RFP), referred to as Technology Demonstration Opportunity. With the coordination of responding vendors, MDOT was able to assess the capabilities and viability of the technology and its applicability toward Michigan's wants and needs defined in the **Appendix D Analytic Report.**

Each step of the research provided an additional level of granularity as compared to its predecessor. This report highlights the details documented throughout the research effort and how the knowledge obtained can provide input to guide the implementation of this technology in Michigan.

Requirements

Table 1 provides a summary of the requirements developed in support of the demonstration RFP. The research team derived requirements from information gathered through the market assessment, use cases, and objectives of the overall project.

Table 1. Project Requirements

No.	Requirement	Objectives
1	The system shall capture vehicle near miss events.	1, 2
2	The system shall detect pedestrians in the road—either at the crosswalk or midblock.	1, 2, 3
3	The system shall detect hard braking instances.	2
4	The system shall detect potential crash conflicts.	1, 3
5	The system shall detect red light running vehicles.	1, 3
6	The system shall utilize connected technology to provide alerts to users.	3, 4
7	The system shall utilize real-time video stream for data analytics.	1, 2, 3
8	The system shall connect to traffic signal controllers for data analytics.	3, 4
9	The system shall be capable of providing data outputs via multiple methods.	1
10	The system shall be capable of providing data outputs within a short duration (less than 2 weeks).	1

Technology

The technology uses two different approaches for the analytics solution: video and lidar. Both approaches ingest the surveillance data that is then processed through algorithms and machine learning techniques to compare against define thresholds and triggers for "acceptable" conditions. Video surveillance relies on light to detect, see, or track objects whereas lidar surveillance uses pulses of ultraviolet light to detect objects in its surroundings. Both systems measure the time required for the reflected light to return to a receiver which is converted into the corresponding range of data.

Evaluation

Figure 2 provides a listing of the initial strategy for the demonstration. It assumed that those involved could integrate vendor-provided field equipment with existing cameras to collect and analyze the data.

6 Month Deployment

- At least 3 vendors install their equipment (e.g., edge box) at 1 location
- 1-2 *existing* cameras
- Dashboard to view *real time data analytics* (per use cases)
- Provide *real time* alerts based on the analytics

Figure 2. Initial Methods Identified for the Demonstration

Based on challenges related to integrating with existing field equipment, the research team revised the method as shown in **Figure 3**. MDOT installed infrastructure, including one camera, on a portable trailer. Only one of the vendors installed edge equipment in the field; the remaining vendors conducted their analysis on recorded video and provided their results to the research team.

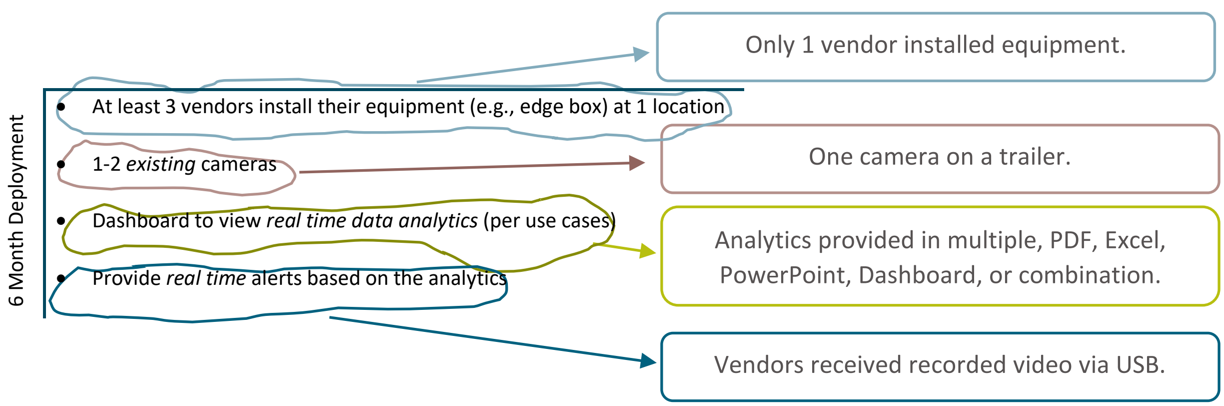

Figure 3. Final Method Performed during the Demonstration

The portable trailer had one quad view cameras positioned 35 feet above the ground to record video over one week. MDOT positioned the trailer on the south side of the intersection of M-3 (Gratiot) and Beaubien Street, with the following viewshed per Google Earth, **Figure 4**.

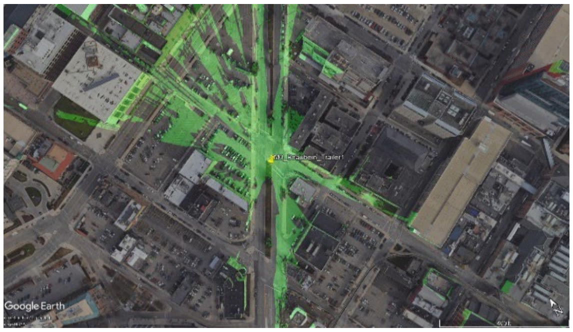

Figure 4. The Viewshed from the Demonstration Location of M3/Beaubien

The research team assessed how effectively the system could identify an event as defined in each of the use cases. The analysis identified the following data points for each vendor:

- How many times was an event identified (if at all)?
- How many times was an event identified accurately?
- How many times was an event missed?

The research team focused the evaluation on the effectiveness of the whole system. The research focused on evaluating the performance of the intended benefits identified at the outset of the project, including:

- Effectiveness of identifying intersections with a high crash potential.
- Ability to use the data for TMC operations.
- Ability to mitigate crashes by effectively warning drivers and pedestrians of likely conflicts.
- Benefits of continued implementation of video analytics technology with CV.

Table 2 includes the key evaluation areas the project team used in evaluating the system regarding the intended performance.

Table 2. Key Evaluation Areas

Key Evaluation Areas
Does the system provide additional safety and mobility information?
Can the system be implemented at an individual intersection, or does it require a corridor connection?
Can the system utilize one camera?
Can the system integrate with existing infrastructure?
What are the required costs for operations and maintenance of the system?
What are the necessary requirements for implementing across the state?

Key Findings

Each portion of the project brought about unique findings. It was essential to understand the potential capabilities of different technologies–whether they were readily accessible or required future development prior to laying out a plan for the demonstration and advertising the RFP. **Table 3** includes the key findings the research team integrated into the evaluation phase of the project.

Table 3. Key Findings and Potential Impacts

Step	Finding	Potential Impact
Market Assessment	Recognized 14 different vendors.	Technology is established and robust.
Use Cases Development	Developed 16 different scenarios based on the intent of how this technology could be used.	Technology demonstrates the opportunity to provide a benefit within multiple scenarios.
Corridor Evaluation	Identified four key areas of consideration when deploying the system.	Technology aligns with the goal of improving safety issues along arterials.
Demonstration	Six vendors partnered with MDOT for the demonstration.	The vendors are very willing to partner with DOTs to understand the needs and goals in support of the safety and mobility aspects of the technology.

The project team used the demonstration and previous research to confirm whether the project met the evaluation criteria. **Table 4** provides a summary noting that the technology demonstrated the ability to meet four of the six evaluation areas. The remaining two evaluation areas are part of the data provided in the Implementation Plan.

Table 4. Ability to Meet Evaluation Areas

Evaluation Areas	Met
Does the system provide additional safety and mobility information?	✓
Can the system be implemented at an individual intersection, or does it require a corridor connection?	✓
Can the system utilize one camera?	✓
Can the system integrate with existing infrastructure?	✓
What are the required costs for operations and maintenance of the system?	Implementation Toolbox
What are the necessary requirements for implementing across the state?	Implementation Toolbox

Appendix E Implementation Toolbox provides a summary of the requirements for implementing the technology within the state. This information also includes the estimated costs for implementing a system along a corridor/location for one year.

Another component of the evaluation included how well the vendor solutions could accomplish the scenarios defined within the 16 use cases. The evaluation was based on both the results from the Market Assessment and the information recognized through the demonstration. **Table 5** notes the research team's observation of the technology capabilities as met, likely, or inconclusive based on the data available.

(M) Met	available information supports that the use case *can* be provided
(L) Likely	available information supports that the use case *could* be provided
(I) Inconclusive	available information is insufficient to determine if the use case could be provided

Table 5. Meeting the Use Cases

Use Cases	Level of Priority	Overall Market Readiness	Met, Likely, Inconclusive
Pedestrian Use Cases			
Left Turn and Pedestrian Near Miss	Have to Have	High	M
Right Turn and Pedestrian Near Miss	Have to Have	High	M
Connected Users–Pedestrian in Crosswalk	Have to Have	Medium	I
Pedestrian Not Using Crosswalk	Have to Have	High	M
Pedestrian in the Road	Have to Have	High	M
Midblock Crossing Near Miss	Have to Have	Medium	L
Connected Users–Stopped Transit Vehicle Alert	Nice to Have	Low	I
Vehicle Use Cases			
Vehicle and Vehicle Near Miss	**Have to Have**	High	M
Crash Detection	Have to Have	High	I
Connected Users–Left Turn Assist	Have to Have	Low	I
Red Light Running	Have to Have	Medium	I
Hard Braking	Nice to Have	Medium	I
Bicyclist Use Cases			
Connected Users–Bicyclist Proximity Alert	Nice to Have	Low	I
Connected Users–Left Turn and Bicycle	Nice to Have	Low	I
Left Turn and Bicycle Near Miss	Have to Have	Medium	I
Right Turn and Bicyclist Near Miss	Have to Have	Medium	I

The research team narrowed the number of use cases for vendors to demonstrate within the RFP to nine. Of the nine use cases, vendors clearly demonstrated six use cases based on the configuration of the test site and the technology each vendor used. Refer to **Appendix D Analytic Report** for further detail on the findings of the demonstration.

One of the most notable findings is the fact that the Crash Detection use case proved to be highly available from the market assessment research conducted before the demonstration, but no crashes occurred during the demonstration period which led to an inconclusive research result.

At the conclusion of the pilot, the research team collected feedback from each vendor on the overall demonstration process. **Table 6** includes the combined feedback.

Table 6: Overview of Feedback from the Demonstration Vendors

Topic	Vendor Feedback
Camera	• Recommend coordination with each vendor regarding camera specifications (their preferred camera models). • The quad view camera was not ideal. • Multiple cameras installed and focused on specific components of the intersection configuration would provide better viewing angles and a more comprehensive coverage of all potential conflicts. • Lower resolution and a slower frame rate are better for data storage.
Video	• Access to live video streams supports better system training, calibration, and detection accuracy.
Data	• Define the post encroachment time (PET), time to collision (TTC), and detection zones during the requirements development. • Leverage existing infrastructure like red light running cameras. • Access to existing data (e.g., traffic signal timing) to increase the usefulness and predictive measures. • Video would need to be supplemented with some level of lidar, radar, or infrared technology to address certain use cases.

Summary of Research

The following summaries capture how well video analytics technology can achieve the following objectives.

Objective 1: Effectiveness of Identifying Risky Conditions Within an Intersection

Objective Confirmed. All systems tested during the demonstration captured data collected that represented multiple near miss events. The systems did not all capture the same events or the same number of near miss events, but the research team attributed this variation to the systems setting a different value for the post encroachment time (PET). Use cases included vehicle-to-vehicle and pedestrian-to-vehicle near misses, but not all vendors categorized the type of events within their data.

Objective 2: Ability to Use the Data for TMC Operations

Objective Confirmed. The systems tested during the demonstration collected data that would provide value to TMC operations in support of multiple traffic management activities. Agencies could use the data collected to assess the performance of existing traffic signal configurations at the intersection to determine potential revisions to optimize the performance. The data could support traveler information relative to real-time traffic conditions, including the use of changeable message signs (CMS) to alert users about impacts on the corridor. These notifications could minimize near misses and crashes at risky or high--volume intersections.

Objective 3: Ability to Effectively Warn Users of At-Risk Conditions

Objective Unconfirmed. Because the demonstration had to shift from the use of real-time video access to recorded video, the project was unable to verify the ability of the system to issue real-time warnings to approaching users. The technology involved in the pilot deployment did not provide the functionality to evaluate the ability of the vendor solutions to issue warning messages. Therefore, the industry review for this objective is inconclusive.

Objective 4: Benefits of Integrating Video Analytics Technology with CV

Objective Unconfirmed. Based on the complexity of additional infrastructure required to verify the connected vehicle component of the project, the research team decided to remove this component of the evaluation from the demonstration.

Recommendations

The research project provided an opportunity to assess the viability of integrating video analytics and CV technology to impact the safety and mobility of arterial traffic. Using a small-scale deployment of infrastructure at the M-3 (Gratiot) and Beaubien intersection, the research team was able to provide data for vendors to analyze. The vendors provided their analysis to the research team for review and to summarize findings.

The overall goal of the project was to assess whether the currently available technology can provide capabilities defined within the use cases and positively impact safety and mobility. Although there are existing vendors in the market that have *readily available* video analytics technology, there is *still room for growth*. Limitations with the pilot deployment prevented the research project from assessing all the defined use cases. Vendors were able to demonstrate their applications were effective and *specific to traffic* (e.g., traffic counts, vehicle classifications), but the research team was unable to verify the full capabilities specific to *safety applications*.

Based on the results of the research, here are some recommended next steps.

1. **Conduct additional research.** Below is a list of additional considerations to integrate with the next phase of research to evaluate the unconfirmed objectives.
    a. Provide a longer test period–*conduct the demonstration for a longer period of time (at least one month) to better identify trends or patterns in the data.*
    b. Red light running use case assessment–*integrate the video analytics equipment with the intersection signal controller to better assess the red-light running use case.*
    c. CV use case assessment–*partner with a vendor or third-party provider to assess the capabilities of integrating with CV data.*
    d. Assess using real-time video–*coordinate for communications to support live-streaming of video to the vendor systems that use a central analysis architecture.*

   e. Impacts of weather–*confirm if adverse weather (e.g., snow, high winds, rain) impacts the accuracy of the technology.*
   f. Data integration–*assess the ability of data integration from multiple technologies (e.g., video, LIDAR, radar) to supplement data collection and improve accuracy.*
2. **Use the Implementation Toolbox.** Reference **Appendix E Implementation Toolbox** to guide the implementation of video analytics solution.
   a. Define goals and objectives to measure progress and performance.
   b. Schedule milestone to track project completion.
   c. Allocate resources to plan for necessary resources.
   d. Designate team responsibilities to hold the project team accountable.
   e. Identify metrics of success to measure progress and performance.
   f. Define how to adapt to account for risk.
   g. Evaluate success to assess project completion.

Appendix A Market Assessment

MARKET ASSESSMENT

UTILIZING VIDEO ANALYTICS WITH CONNECTED VEHICLE FOR IMPROVED SAFETY

FINAL REPORT

MDOT

Kimley»Horn
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Version Control

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1.0	Mike Ruelle, Sarah Butler / Jeffery Dale	5/28/2021	Initial Draft Submittal
1.1	Sarah Butler / Jeffery Dale	1/6/2022	Final Submittal; Incorporates Data Collected from RFI

OVERVIEW

Michigan DOT's (MDOT) focus within this research project is to identify and vet emerging technologies that can help save lives through better analysis and proactive responses. MDOT recognizes the ability of operations to leverage technology to improve safety by decreasing or eliminating fatalities and serious injuries due to crashes. This is further supported by an ability to identify near-misses so MDOT can determine and implement mitigation strategies that address issues that may cause unsafe conditions – thereby implementing strategies before the crashes occur. The ultimate objectives of the research findings include:

1. Reduce the frequency and severity of intersection conflicts by using the data to understand crashes and near misses and make necessary improvements.
2. Reduce the frequency and severity of intersection and mid-block conflicts through traffic control and operational improvements.
3. Reduce crashes and fatalities by disseminating intersection and mid-block conflict alerts to motorists and non-motorized users.

As represented in the objectives, this research effort is primarily focused on arterial performance, but will capture additional capabilities the identified solutions offer beyond those applications. The research will focus on the solutions' functions relative to intersection and midblock interactions between motorized vehicles, pedestrians, bicyclists, and other non-motorized users. The research also focuses on the technology's ability to interface with connected vehicle (CV) communications to receive data and push notifications for unsafe conditions. Lastly, the research will capture the technologies' ability to adjust the signal performance in support of providing a safer experience for the users.

PROJECT NEEDS

MDOT is focused on identifying video analytics applications that can work in coordination with CV technology to proactively identify safety concerns and implement mitigation strategies in response to those concerns. The initial research effort and resulting pilot deployments will allow MDOT to evaluate the technology's ability to capture crash and near miss data in support of immediate safety responses such as notifications to other road users or possible signal timing adjustments that provide additional safety to those users. Additionally, the data analysis should allow for trend analysis in support of safety improvements for the monitored sections.

The findings of the pilot project are intended to support MDOT's decision regarding full deployments of the technology at viable locations. The results of the pilot project will include the development of guidance for evaluating other locations and implementing the technology based on localized and specific needs.

METHODOLOGY

The market assessment was conducted in two distinct steps, preliminary research, and secondary research, as shown in **Figure 1**. A survey of agencies conducting similar pilot projects or deployments of video analytics solutions was conducted. The survey focused on lessons learned from the experiences of the identified agencies. Those agencies were identified based on the understanding of their projects' alignment with MDOT's overall objectives.

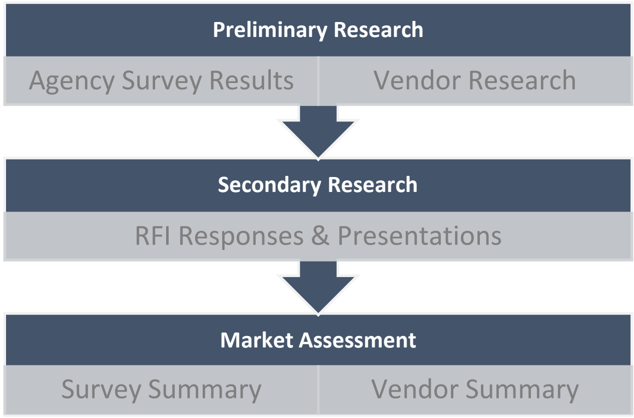


Figure 1: Methodology Flow Chart

Simultaneously, preliminary research was conducted on vendors that are currently providing video analytics technology. The research focused on a cursory review of readily available information from the vendors' web sites, documentation from current project deployments, and other existing research efforts that were attainable for review by the research team.

For the secondary research conducted, a Request for Information (RFI) document was advertised for vendor response. The RFI responses were used to select vendors for presentations with the research team to gather additional details about the vendors' solutions and capabilities. Information collected from these presentations was combined with the previous vendor research to provide a more comprehensive assessment of what is currently available within the video analytics market.

SURVEY OF VIDEO ANALYTICS PROJECTS

Over the past decade, MDOT has conducted two separate market assessments focused on video analytics, one in May 2013 and one in June 2019. Both efforts included a public agency survey and were designed to better understand the different video analytics solutions available in the marketplace, identify specific use cases for the deployment of the technology, and collect feedback on the project results and the overall success of the video analytics solution. The research team reviewed the approach and the findings from these previous assessments which were predominantly focused on freeway environments and use cases focused on automated detection of incidents (crashes, stalled vehicles, debris on roadway, etc.).

This market assessment is focused on arterial environments and the ability to monitor motorized vehicles and non-motorized vehicles including pedestrians, bikes, and micro-mobility options. The research team developed a survey that includes questions designed to obtain information from specific agencies that have implemented or are currently evaluating different video analytics solutions.

LIST OF AGENCIES

The project team assembled a list of potential agencies for participation in the project survey. Agencies were identified by conducting a nationwide scan of completed, ongoing, or planned projects that include the deployment of a video analytics solution. Only one agency (Georgia DOT) from the 2019 survey that received this market assessment survey. The 2013 survey was only distributed internally with Michigan DOT stakeholders and was not provided to any outside agencies. The list of candidate agencies was refined through preliminary discussions with public agency staff involved in the projects, vendors providing video analytics solutions, and collaboration with industry partners that are involved in some of the projects.

The nationwide scan included agencies that are deploying different applications of video analytics solutions including, both freeway and arterial environments. The scan also focused on identifying projects that are assessing the performance of non-motorized vehicles within those environments.

Agencies that had deployed the technology in a freeway environment or solutions that were focused on motorized vehicles were not excluded from the assessment as these agencies and projects are likely to still provide value to the research. In total, eleven agencies, shown in **Figure 2,** were identified for participation in the survey. Additional context as to why each agency or project was included for participation in the survey is presented after the figure.

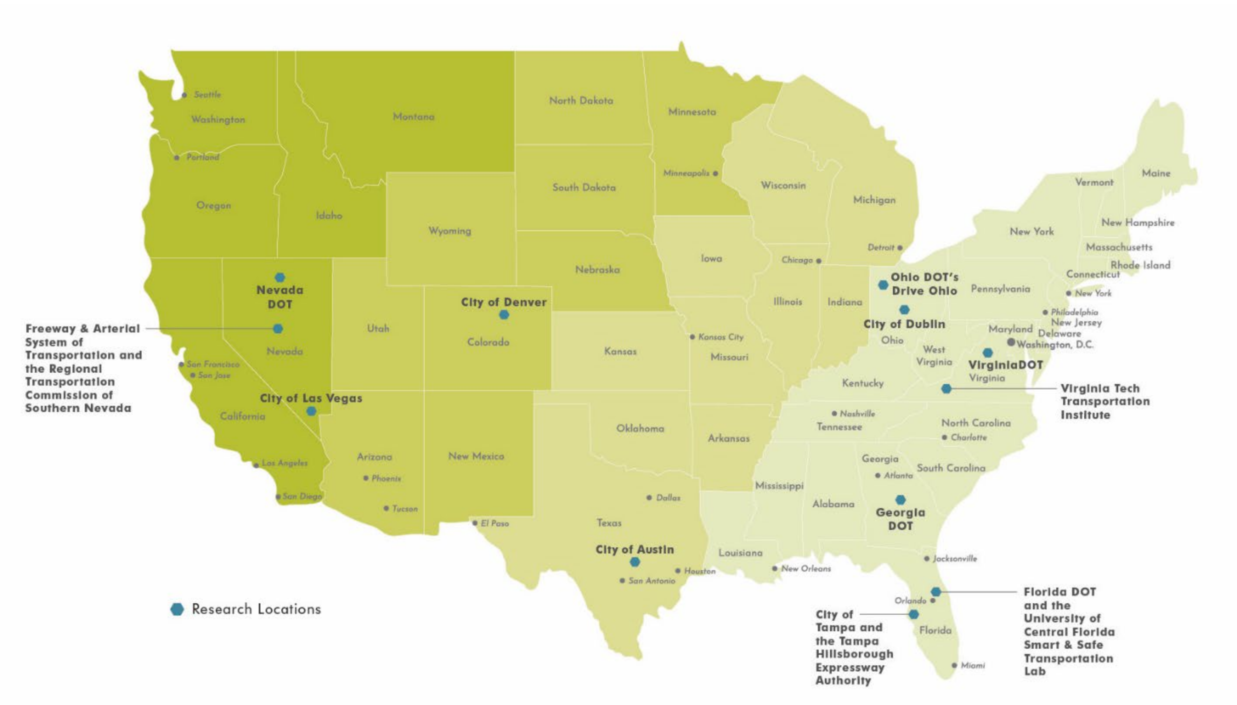


Figure 2. Identified Agencies for Surveys

City of Austin, TX

The City of Austin is currently investigating and in the initial stages of a potential deployment of the ETALYC video analytics solution at half a dozen intersections to help ***monitor and identify 'near misses' and 'close calls' involving pedestrians and bicyclists***. The project is in its early stages and no hardware or software has been deployed.

City of Denver, CO

The City of Denver is in the initial stages of deploying infrared cameras/sensors at 17 intersections with heavy pedestrian traffic to ***identify the presence of pedestrians in the crosswalk and extend walk times*** until the pedestrian can safely exit the crosswalk.

City of Dublin, OH

The City of Dublin has partnered with Denso to deploy smart infrastructure along a busy arterial corridor with heavy pedestrian traffic that includes several signalized intersections, a school zone, roundabout, and an unsignalized crossing. The project includes deployment of an edge-based video analytics software to provide traffic and safety insights that include the ***ability to generate personal safety***

messages (PSMs) for vulnerable road users (VRUs), identify and report near-miss events, identify instances of mid-block pedestrian crossings as well as counts for vehicles, pedestrians, and bicyclists.

City of Las Vegas

In 2016, the City of Las Vegas deployed Motionloft, a video and software-based solution within the City's Innovation District in downtown Las Vegas. While deployed, the Motionloft solution used multiple video feeds to ***detect, count, and analyze pedestrian, bicyclist, and vehicle movements to improve pedestrian safety***. After the survey was conducted, the project team confirmed that the City has highlighted an alternate video analytics deployment. This decision was driven by Motionloft no longer supporting existing deployments or providing video analytics solutions.

City of Tampa and the Tampa Hillsborough Expressway Authority (THEA)

The City of Tampa and THEA began a multi-phase connected vehicle pilot project in 2015 to help improve mobility and safety of pedestrians, transit, and vehicles in downtown Tampa. The pedestrian safety portion of the project included the use of LIDAR and FLIR cameras to ***detect pedestrians in a mid-block crossing and alert approaching motorists to their presence***.

Nevada Department of Transportation (NDOT), Freeway & Arterial System of Transportation (FAST), and the Regional Transportation Commission (RTC) of Southern Nevada

NDOT, FAST, and the RTC of Southern Nevada have collaborated on several projects that include the use of video analytics. One such project includes the integration of video from 42 intersections on Flamingo Road in Las Vegas to ***detect and report near-miss events between vulnerable road users (pedestrians and bicyclists) and vehicles***. A second project utilizes Nexar's CityStream platform and connected vehicle network to ingest data from multiple data sources and sensors, including video from vehicle dashcams, to ***identify and analyze construction zones in real-time***.

Georgia Department of Transportation (GDOT)

GDOT deployed an automated incident detection pilot project along a segment of I-475 located near northwest Macon that involved integrating video from over 150 existing closed-circuit television (CCTV) cameras into TrafficVision's video analytics solution to ***identify incidents or atypical conditions (crashes, debris, stranded motorists, pedestrians)*** along the project corridor.

Drive Ohio (Ohio Department of Transportation)

Drive Ohio is supported by the Ohio Department of Transportation along with multiple public agencies and private sector partners. This effort has deployed Bosch thermal cameras with built-in analytics as part of several different connected vehicle projects. The infrared cameras ***detect both motorized and non-motorized vehicles*** and, using hardware and software provided by MH Corbin, the solution ***generates alerts to road users*** to improve safety and mobility. The projects include deployment of the technology on I-670 and US 33 to ***identify congestion, incidents, stopped vehicles, vehicle queues, and wrong way drivers*** as well as at an arterial intersection to ***detect pedestrians and bicyclists and alert nearby motorists to their presence***.

Virginia Department of Transportation (VDOT)

Multiple VDOT districts have been using the video analytics solution from Miovision to provide ***pedestrian and bicyclist counts and performance metrics at signalized intersections***.

Florida Department of Transportation (FDOT) and the University of Central Florida (UCF)

The FDOT, in partnership with MetroPlan Orlando, the University of Central Florida, the City of Orlando, and Orange County were awarded an Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant for the Connecting the East Orlando Communities project. The project includes a PedSafe program designed to improve pedestrian safety at intersections by using video analytics to ***identify pedestrians in the crosswalk, alerting approaching motorists, and extending pedestrian walk times*** to allow the pedestrians to safely cross.

Virginia Tech Transportation Institute (VTTI)

VTTI has completed several pedestrian and bicyclist safety projects that incorporate the use of video analytics. These projects included an analysis of video from existing CCTV cameras at an intersection to ***estimate pedestrian and bicyclist injury exposure***, a project analyzing multiple video feeds both internal and external to the vehicle to ***analyze Level 2 automated driving features***, a project that analyzed CCTV video upstream of and in a construction work zone to ***provide alerts to construction workers***, and a project to demonstrate how an intelligent traffic management center (ITMC) can use safety surrogate measures (SSMs) to ***identify near crash situations at signalized intersections*** that can then be applied in proactive risk calculations.

SURVEY

Questions for the survey were developed to obtain focused feedback from each agency regarding the video analytics solution the agency has deployed or is looking to deploy. Survey questions include the actual technology deployed, the data collected, any documentation developed, and the overall success of the project and video analytics solution. The overall length of the survey was limited to 30 questions to limit the amount of time required to complete the survey and to foster increased participation. To further streamline the agency's time commitment and the research team's data consolidation, each question includes prepopulated multiple-choice options. In addition to the multiple-choice responses, many of the questions include an "other" response with free form text so the respondent can provide the provide additional information. The first four questions of the survey requested contact information from the survey respondent to allow the research team to follow-up for additional information. The contents of the survey are summarized below, and the complete survey is provided in **Appendix A**.

Summary of Survey Questions:

- Agency Name and Contact Information *(Questions 1 – 4)*
- Solution Need, Procurement, and Vendor Selection *(Questions 5 – 10)*
- Solution Hardware and Software Requirements (*Question 11 – 12)*
- Solution and Vendor Performance (Questions 13 – 14, 18, and 22 – 23)
- Data Collection, Reports, and Performance Metrics *(Questions 15 – 17, 19, 21, and 25)*
- Project Challenges and Lessons Learned *(Question (26 – 30)*

SURVEY SUMMARY

This section summarizes the seven survey responses received out of the eleven sent out. The responses identified the video analytics solution deployed by each agency and allows correlation to the market assessment research that was conducted in parallel to the surveys. The summary includes information about the solution procurement, any identified integration requirements, the performance of the solution and vendor, and, where available, the overall project results as experienced by the agency. **Appendix B** includes a complete list of the responses from each agency.

Video Analytics Solutions Deployed

This section summarizes the solution identified for each of the agency deployments. **Table 1** includes a summary with each agency name, the video analytics solution deployed (or planned for deployment in the future), the type of location for the solution, the current deployment status at the time of the survey, and the data collected. Agencies that responded to the survey were in varying stages of project deployment including planning stages, deployment and integration, or project complete. **Figure 3** depicts the distribution of survey respondents' project status. **Table 1** summarizes the status of the video analytics solution deployments based on the survey responses received in May 2021.

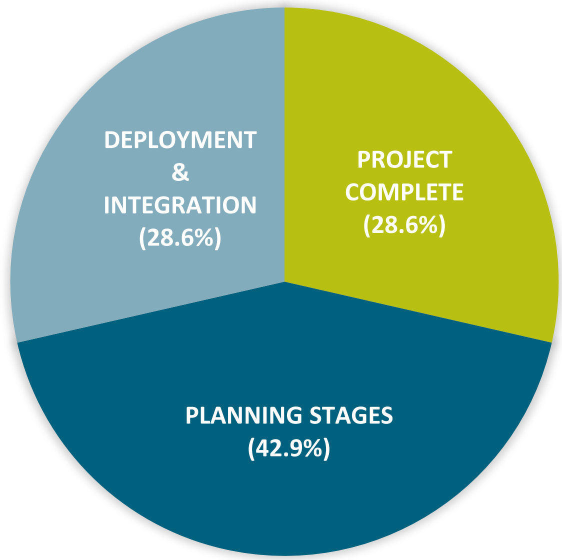


Figure 3. Solution Deployment Status

Table 1: Agency Responses for Solution Deployments

Agency	Proposed Solution	Deployment Location	Deployment Status	Data Collected
City of Austin	ETALYC Hyperflow	Six signalized intersections	Planning stages	• Crashes/incidents • Near-miss events • Anomalies
City of Las Vegas	Has not yet been identified but will either be DERQ (most likely) or expanded to include three to four different vendors	A single signalized intersection	Planning stages	• Volume and speed data • Crashes/incidents • Near-miss events • Wrong-way vehicles • Red light running • Vehicle-pedestrian conflicts • Post encroachment time*

Agency	Proposed Solution	Deployment Location	Deployment Status	Data Collected
City of Tampa / THEA	Bosch model 8000 camera with integrated analytics	A single mid-block pedestrian crossing	Project complete	• VRU location • VRU travel speed • VRU heading • VRU future path trajectory • Individual VRU vs. cluster of VRUs
Drive Ohio (Ohio DOT)	Bosch thermal camera with integrated analytics and MH Corbin Connect processor	A single signalized intersection	Deployment and integration	• Pedestrians, bicyclists, motorcycle, vehicle, and freight movements
Georgia DOT	TrafficVision	Freeway corridor northwest of Macon	Project complete	• Volume, speed, and occupancy data • Vehicle classification • Stopped vehicles • Slow speeds and congestion • Debris on road • Wrong way vehicles • Pedestrians
UCF SST Lab	Solution has not yet been selected	Arterial corridor	Planning stages	• Vehicle trajectory data • Volume and speed data • Post-encroachment time* • Time to collision
VTTI	In-house video annotation and analytics developed methods	Naturalistic driving study	Deployment and integration	• Crash rate • Incident response • Incident duration • False positive rate • System accuracy • System/device availability • Crash severity

**Post Encroachment Time (PET) represents the time difference between a vehicle leaving a particular area and a conflicting vehicle entering that same area.*

Integration Requirements

All the agencies that responded to the survey had or will have to perform some level of integration to implement their selected video analytics solution. The overall level of integration effort required is dependent on the solution being deployed and the desired outcome of the agency. Solutions that incorporate active or real time alerts and the ability to push notifications to motorists and VRUs often required a larger integration effort due to the multiple hardware and software subsystems that are required to achieve the full deployment. **Table 2** includes an overview of the integration effort of each agency's deployment and any existing hardware or software subsystems that had to be integrated as part of their project.

Table 2: Integration Requirements

Agency	Proposed Solution	Integration Requirements
City of Austin	ETALYC Hyperflow software	Integration of video feeds from up to 10 existing cameras located at six signalized intersections into Hyperflow cloud-hosted software.
City of Las Vegas	DERQ software with potential to add additional vendors	Integration of existing video feed(s) from intersection into DERQ cloud-hosted software.
City of Tampa / THEA	LiDAR sensors, Bosch thermal cameras, roadside units, and onboard units	The solution originally used LiDAR sensors but, due to suboptimum results, the project switched to Bosch thermal cameras which had to be integrated with roadside units and onboard units.
Drive Ohio (Ohio DOT)	Bosch thermal camera and MH Corbin Connect processor	Installation of Bosch thermal camera which had to be integrated with MH Corbin Connect processor, a roadside unit, and several onboard units.
Georgia DOT	TrafficVision	Integration of approximately 180 existing camera feeds into the TrafficVision cloud-hosted software. GDOT is currently looking to install the TrafficVision software on-premises.
UCF SST Lab	Solution not selected	The selected solution will require integration of CCTV video, video analytics software, roadside units, and on-board units.
VTTI	In-house video annotation and analytics software	The video analytics software was developed in-house and hosted on-premises and included integration of multiple video feeds from inside and outside the vehicle as well as information from several in-vehicle sensors and data.

Agency Defined Next Steps for Completed Pilot Projects

Many of the video analytics solutions identified by agencies that participated in the survey were in the concept development or planning stages and thus were not able to report on the results of the project or the performance of the video analytics solution. Of the agencies that responded to the survey, only Georgia DOT and the City of Tampa / THEA projects were far enough along in the project to provide feedback on the overall performance of the video analytics solution.

The City of Tampa originally deployed a system that included LiDAR sensors to detect pedestrians in a mid-block pedestrian crossing. Initial results using the LiDAR sensors resulted in an approximate 85% false positive rate which led to replacing the LiDAR sensors with Bosch thermal cameras. The Bosch cameras ***resulted in a significant improvement for identifying and tracking pedestrians*** as well as a significant reduction in false positives. The pilot project is still ongoing and conclusive results from the project are forthcoming.

The Georgia DOT deployment included the integration of approximately 180 existing CCTV camera feeds into the cloud-hosted instance of the TrafficVision solution. An analysis was completed at the end of the eight-month pilot project. It determined an average reduction in the incident detection time of six to eight minutes as compared to traditional methods (operator monitoring video feeds, receipt of CAD incident, citizen call). The positive results from the pilot project have supported ***GDOT's decision to expand the deployment to include additional video feeds beyond the initial pilot project limits***. GDOT prefers to host all applications and as they look to shift from the initial pilot to a more permanent deployment, they are looking to ***revise the cloud-hosted pilot deployment to an on-premises data center*** in alignment with their agency preferences.

Procurement Process and Cost

All the agencies that responded to the survey are ***procuring their video analytics solution as part of a pilot project that does not include a traditional competitive RFP process***. Additionally, several of the deployments were done at no cost or at a significant discount to the managing agency. In the case of the UCF SST Lab and VTTI projects, the software solution is being developed through in-house resources. Independent of the procurement process applied during the pilot project, the lessons learned will enable the agencies to better understand the technology and use the knowledge gained to follow a more traditional procurement process such as an RFP to expand the deployment of their preferred solution.

MARKET ASSESSMENT

Independent of the agency survey, the research team conducted an analysis of potential vendors within the video analytics market. The research focused on the different types of technologies available, the types of data the systems can collect, and different applications for the use of that data. A comparison of this information between the identified vendors provided the research team with a better understanding of the available technologies in the market and their capabilities to increase safety based on MDOT's objectives.

The research team focused on complete solutions when developing the list of potential vendors. This includes systems that provide video analytics processing and that can integrate with traveler information systems or traffic signals. The potential vendors did not include systems that were developed by an agency in-house or were a collection of multiple sub-systems to provide the solution. This is important to convey why some of the technologies identified in the agency surveys are not included in the market assessment for vendor analytics vendors.

REQUEST FOR INFORMATION

Based on the initial research efforts, it was determined that the video analytics market contains a large number of emerging players and existing documentation or deployments were limited. The research team drafted and publicly advertised a Request for Information (RFI) with a focus on capturing more of these potential solution providers. The full RFI document can be found in **Appendix C**. The RFI includes a program overview of the research objectives, criteria for the video analytics solutions, and an opportunity for vendors to respond to topics and questions pertaining to their specific solution. After reviewing the RFI responses, the research team scheduled presentations with select vendors, which allowed for additional data collection through a virtual presentation and question and answer session.

VIDEO ANALYTICS VENDORS

Research Findings

Table 3 provides a list of 9 vendors and information about each specific technology based on the initial market research. Each vendor includes a hyperlink to its website for additional information.

Table 3: List of Vendors

Vendor	Technology	Proposed Application	Data Collected
AMAG	Created the Safe Mobility Alert Real Time (SMART) Digital Platform which uses video analytics, AI, deep learning, and advanced econometric techniques	Monitors for increased risk along transport networks, improves traffic signal operation when crash risk is high, and offers signal timing that is optimized for Crash Risk and Delay simultaneously	• Vehicles • Crashes • Near misses • Crash risk • Volumes • Traffic violations • Speeds
Citilog	Offers a variety of intelligent cameras and video analytics that can be combined to provide real-time data to monitor and manage traffic in cities and on road infrastructure	Provides smart, video-based solutions for incident management, traffic efficiency, remote enforcement, urban traffic light optimization, illegal parking detection, and access to traffic statistics	• Vehicles • Pedestrians • Crashes • Congestion • Traffic violations
DERQ	Real-time infrastructure perception providing full situational awareness to Connected and Autonomous Vehicles (CAV), detecting and predicting dangerous conflicts with pedestrians, vehicles, or other vulnerable road users, to avoid collisions	Using connected infrastructure, DERQ has created platforms for CAVs including pedestrian interaction, situational awareness, safety insights, crash forensics, and traffic insights	• Vehicles • Pedestrians • Bicyclists • Near-misses • Crashes • Traffic violations • Counts/ classification/ turning movement counts
MicroTraffic	Provides video detection software for pedestrian safety analytics	After the technology runs a risk diagnosis using the video, safety engineers work with the diagnostic data to develop recommendations in a road safety improvement plan and can predict injury crashes with 94% accuracy	• Vehicles • Pedestrians • Bicyclists • Near-misses
Miovision	Offers TrafficLink Detection which uses deep neural networks to "see" an intersection, so it can recognize vehicles in all types of weather conditions	TrafficLink Detection provides detailed and easy to understand ATSPMs	• Vehicles • Pedestrians • Bicyclists • Crashes • Traffic Violations
NTTData	Works primarily in consulting, system development, and IT outsourcing to develop solutions to issues through technology development	In 2019, NTT Data demonstrated how AI can predict future traffic conditions and jams cased on the latest road conditions	N/A

Vendor	Technology	Proposed Application	Data Collected
TrafficSurvey	Uses a video-analytics platform for fully automated extraction of accurate traffic data using AI and machine learning methods (Pixel tracking technology)	Using a desktop tool DFS Viewer, the user can analyze the data up to milliseconds and display analysis in the video	• Vehicles • Pedestrians • Crashes • Traffic violations
TrafficVision	Provides pixel tracking technology through software that turns any traffic monitoring camera into an intelligent sensor	The daily incident and congestion management automates highway monitoring for DOTs and TMCs	• Vehicles • Pedestrians • Crashes • Volume, speed, and occupancy data • Stopped vehicles • Slow speeds and congestion Anomalies
Velodyne Lidar	An infrastructure solution generates real-time data analytics and predictions to help improve traffic and crowd flow efficiency, advanced sustainability and protect road users	The infrastructure detects collisions and near-miss incidents in real time to provide data to emergency response services for faster dispatch in both urban and rural environments	• Vehicles • Pedestrians • Bicyclists • Crashes • Anomalies

RFI and Presentation Responses

Once the research team received all responses from the RFI, vendor presentations were scheduled. **Table 4** includes a list of the vendors that responded to the RFI. From the nine (9) responses to the RFI, seven (7) submissions were identified for an invitation to present to the research team. The vendors that participated in the presentation phase are noted in the second portion of the table.

Table 4: RFI Responses and Presentations

Vendor	Proposed Solution
Responded to RFI	
Boulder AI	Virtual sensors to detect and process pedestrian data
Kevadiya Inc. (KVD)	Road-Bo KOP Management System (RBK)
Presented Solution	
Accenture	Mobi Solution
AMAG	SMART Digital Platform
Currux	SmartCity ITS Platform and Software
DERQ	Real-Time Perception and Connectivity AI Platform
IBM	Intelligent Video Analytics to recognize P.O.L.E.
IREX	Video-based cloud service and software platform
Smartek	Sighthound/BAI DNN platform

SUMMARY OF ALL VIDEO ANALYTICS VENDORS

The perceived success and applicability to MDOT's objectives were the more important areas that were reviewed during this assessment. This review will form the foundation for how potential pilot solutions are determined for MDOT. A better understanding of what is readily available in the market will help in developing the requirements and functionality for the pilot project as the research effort moves forward. The research team refined the assessment based on the Final Use Cases Memo and the information collected through all phases of the market research.

Table 5 presents a summary matrix based on the data from the market assessment. The matrix includes the following structure:

- 14 vendors identified during all phases of the market assessment
- 16 Use Cases as presented in the Final Use Cases Memo
- Level of Priority assigned to each use case
  - Have to Have
  - Nice to Have
- Summary of Overall Market Readiness Relative to Each Use Case
  - Low: up to 5 *Readily Available* or *Likely Available* solutions
  - Medium: 6 – 10 *Readily Available* or *Likely Available* solutions
  - High: more than 10 *Readily Available* or *Likely Available* solutions
- Qualitative Assessment of Vendor's Capacity to Address Each Use
  - Readily Available: available information supports that the use case *can* be provided
  - Likely Available: available information supports that the use case *could* be provided
  - Inconclusive: available information is insufficient to determine if the use case could be provided

Table 5. Market Readiness by Use Case

Use Cases	Level of Priority	Overall Market Readiness	Vendors													
			Vendors from RFI							Vendors from Research						
			ACCENTURE	AMAG	CURRUX	DERQ	IREX	IBM	SMARTEK	CITILOG	MICROTRAFFIC	MIOVISION	NTTDATA	TRAFFICSURVEY	TRAFFICVISION	VELODYNE LIDAR
Pedestrian Use Cases																
Left Turn and Pedestrian Near Miss	**Have to Have**	High	R	R	R	R	R	R	R	INC	R	L	*	L	INC	L
Right Turn and Pedestrian Near Miss	**Have to Have**	High	R	R	R	R	R	R	R	INC	R	L	*	L	INC	L
Connected Users – Pedestrian in Crosswalk	**Have to Have**	Medium	L	INC	L	R	INC	L	INC	INC	INC	L	*	INC	INC	L
Pedestrian Not Using Crosswalk	**Have to Have**	High	R	R	R	R	L	INC	R	R	L	R	*	R	L	L
Pedestrian in the Road	**Have to Have**	High	R	R	R	R	R	R	R	R	R	R	*	R	R	R
Midblock Crossing Near Miss	**Have to Have**	Medium	R	R	R	R	INC	L	R	INC	L	INC	*	L	INC	L
Connected Users – Stopped Transit Vehicle Alert	Nice to have	Low	L	INC	L	L	INC	INC	INC	INC	INC	INC	*	INC	INC	INC
Vehicle Use Cases																
Vehicle and Vehicle Near Miss	**Have to Have**	High	R	R	R	R	R	R	R	INC	R	L	*	L	INC	R
Crash Detection	**Have to Have**	High	R	R	R	R	L	R	R	R	L	R	*	R	R	R
Connected Users – Left Turn Assist	**Have to Have**	Low	INC	INC	L	L	INC	INC	INC	INC	INC	INC	*	INC	INC	INC

Use Cases	Level of Priority	Overall Market Readiness	Vendors													
			Vendors from RFI							Vendors from Research						
			ACCENTURE	AMAG	CURRUX	DERQ	IREX	IBM	SMARTEK	CITILOG	MICROTRAFFIC	MIOVISION	NTTDATA	TRAFFICSURVEY	TRAFFICVISION	VELODYNE LIDAR
Red Light Running	**Have to Have**	Medium	R	R	R	R	INC	INC	R	R	INC	R	*	R	INC	INC
Hard Braking	Nice to have	Medium	L	L	L	L	INC	INC	L	INC	INC	INC	*	L	L	INC
Bicyclist Use Case																
Connected Users – Bicyclist Proximity Alert	Nice to have	Low	L	INC	L	R	INC	INC	INC	INC	INC	INC	*	INC	INC	L
Connected Users – Left Turn and Bicycle	Nice to have	Low	L	INC	L	R	INC	INC	INC	INC	INC	INC	*	INC	INC	INC
Left Turn and Bicycle Near Miss	**Have to Have**	Medium	R	R	R	R	R	R	R	INC	R	L	*	INC	INC	L
Right Turn and Bicyclist Near Miss	**Have to Have**	Medium	R	R	R	R	R	R	R	INC	R	L	*	INC	INC	L

*Indicates that the solution would need to be developed from scratch

Readily Available	Likely Available	Inconclusive

LICENSING OR OPERATIONS COST

The research team was unable to confirm costs for most of the vendor solutions. Based on the cursory review from the identified vendors, the following cost determinations were identified and should be understood by the research team.

Considerations for Costing of Solutions

- Ongoing licensing cost to support data analytics
- Number of video streams (per intersection and total number)
- Cost comparison between cloud-based versus agency hosted solution

NEXT STEPS

This market assessment assembled the responses from the agency surveys and a summary of what is readily available in the market for video analytics solutions. The current process has established a framework that will be further refined to support the follow-on tasks of the research project, achieve a pilot project deployment, and provide MDOT with guidance for the applicability and process to potentially expand the technology into full deployments.

The matrix aligns with the Final Use Case Memo and defined Use Cases. It provides the level of priority and market readiness for each use case along with how each vendor's solution aligns with each use case. The matrix will remain an important tool to guide the identification of potential locations for the pilot project and the development of the procurement documents needed to support the project.

Appendix A – Complete Survey

Question Number	Survey Question
1	Agency Name
2	Surveyor Name
3	Surveyor Email Address
4	Surveyor Contact Number (for potential follow up)
5	What type of project was the video analytics solution deployed as a part of? Please select the answer that best fits the project. • Pilot/research project • Data collection project • Safety improvement project • Larger ITS deployment project • Traffic signal design project • Roadway construction project • Other: (open response)
6	Where was the project implemented? Please select the answer that best fits the current deployment status. • Arterial corridor • Freeway corridor • Single intersection • Other: (open response)
7	What is the current status of the video analytics solution deployment? Please select the answer that best fits the current deployment status. • Planning/concept development • Procurement • Deployment/integration • Post implementation analysis • Project complete • No longer active/removed
8	How was the video analytics solution deployed as part of the project selected? Please select the answer that best fits the project. • Problem presented by agency and vendor proposes solution • Agency issued system/device requirements and vendor proposes solution • Agency interested in deploying/analyzing a particular vendor's solution • Other: (open response)
9	What manufacturer/vendor and solution was ultimately selected to provide the video analytics deployment?

Question Number	Survey Question
10	How was the video analytics solution procurement contract structured? Please select all that apply. • One-time procurement fee • One-time deployment/integration fee • Ongoing maintenance/support fee • Ongoing license/subscription fee • No cost demonstration/pilot • Other: (open response)
11	If software was required to be deployed as part of the video analytics solution, where was the software hosted? • On-premise at the agency • In a third-party cloud environment • On hardware located in the field • On a local user's computer/workstation • Other: (open response)
12	In order to successfully integrate the video analytics solution, was any of the following infrastructure (existing or new) required? Please select all that apply. • Video CCTV camera(s) • Thermal/infrared CCTV camera(s) • Wired communications • Wireless communications • Ethernet switch(es) • Detection device (microwave, Bluetooth, etc.) • Intersection processor/CPU • Roadside equipment (RSE) or roadside unit (RSU) • Physical server(s) for deployed software • Other: (open response)
13	Throughout the course of the project, how responsive was the vendor? Please select the answer that best describes the vendor's responsiveness. • Very responsive • Somewhat responsive • Somewhat unresponsive • Very unresponsive • Not involved
14	Do/did any of the following conditions impact performance of the video analytics solution? Please select all that apply. • Night/low light • Rain • Fog • Snow/ice • Dust • None

Question Number	Survey Question
15	In addition to pedestrians, what other modes of transportation is/was the video analytics solution able to detect? Please select all that apply. • Bicyclists • Micro-mobility (I.e., scooters) • Motorcycles • Vehicles • Freight vehicles • Other: (open response)
16	What type of data is the deployed video analytics solution able to collect?
17	Does the video analytics solution incorporate artificial intelligence (AI) or machine learning? • Yes • No
18	Does the video analytics solution meet your accuracy requirements? • Yes • No
19	How long does the system keep data/reports?
20	Were any alerts or reports generated by the video analytics solution during or after the project was completed? Please select all that apply. • Realtime alert via text or email as event occurs • Realtime alert with video feed or snapshot from CCTV camera • Realtime alert or pop-up window within video analytics application • Periodic summary reports (daily, weekly, etc.) • Post project analysis/report • Other: (open response)
21	Were any performance measures developed or analyzed as part of the project to assess the video analytics solution? Please select all that apply. • System/device availability • System accuracy • False positive rate • Crash rate • Crash severity • Incident response time • Incident duration • Other: (open response)
22	Overall, how satisfied were you with the overall performance of the video analytics solution? Please select the one that best describes your satisfaction. • Very satisfied • Satisfied • Unsatisfied • Very unsatisfied • Unknown or project ongoing

Question Number	Survey Question
23	How likely are you to recommend the video analytics solution for future deployments at your agency or by another partner agency? Please select the one that best describes your likelihood. • Very likely • Likely • Unlikely • Very unlikely • Unknown or project ongoing
24	Were any documents (market assessment, survey, RFI/RFQ/RFP, etc.) developed for the video analytics solution as part of the project? • Yes • No
25	As a result of the video analytics solution deployment, did you observe any direct or indirect safety or mobility improvements?
26	During the video analytics solution deployment, were there any lessons learned or items you wish you had considered earlier in the project? • Yes • No
27	If you responded yes to question 26, please identify.
28	During or as a result of the video analytics deployment project, did you encounter any unexpected issues and/or outcomes that you would be willing to share? • Yes • No
29	If you responded yes to question 26, please identify.
30	What challenges do you expect to encounter if you were to expand/further deploy the video analytics solution to additional locations/corridors? Please select all that apply. • Technology not meeting expectations • High deployment costs • Lack of available funding • Legal or regulatory issues • Integration issues with existing infrastructure/systems • High maintenance costs • Lack of staff expertise • Other: (open response)

Appendix B – Survey Results

#1	Agency Name	City of Las Vegas Public Works Transportation Engineering Division	DriveOhio - OhioDOT	GDOT	Tampa Hillsborough Expressway Authority	City of Austin	University of Central Florida Smart and Safe Transportation (UCF SST) Lab	Virginia Tech Transportation Institute
#2	Surveyor Name	Sean Robinson	Nick Hegemier	Emily Dwyer	Steve Novosad	Brian Craig	Dr. Mohamed Abdel-Aty	Michelle Chaka
#3	Email from the Surveyor	Sean	nick.hegemier@drive.ohio.gov	edwyer@dot.ga.gov	snovosad@hntb.com	brian.craig@austintexas.gov	M.Aty@ucf.edu	mchaka@vtti.vt.edu
#4	Contact Number from the Surveyor (for potential follow up)	702-229-2199	7402728462	404-858-2774	2105572621	5129744061	(407) 823-4535	734-678-7474
#5	What type of project was the video analytics solution deployed as a part of? Please select the answer that best fits the project.	Has not currently been implemented but would be looking at Pilot/research, Data Collection Project, Safety Improvement Project	Pilot/research project	Pilot/research project	Pilot/research project	Pilot/research project	Data collection project	Data collection project
#6	Where was the project implemented? Please select the answer that best fits the current deployment status.	Has not been implemented but would be looking at Single Intersection for first deployment	Single intersection	Freeway corridor	mid block crosswalk	We've have a couple of projects underway	Arterial corridor	naturalistic driving study
#7	What is the current status of the video analytics solution deployment? Please select the answer that best fits the current deployment status.	Planning/concept development	Deployment/integration	Post implementation analysis	Project complete	Planning/concept development	Planning/concept development	Deployment/integration
#8	How was the video analytics solution deployed as part of the project selected? Please select the answer that best fits the project.	Has not currently been implemented but would be most likely trying to address a problem presented by agency and vendor proposed solution	Co-development with Vendor and Agency	Problem presented by agency and vendor proposes solution	Problem presented by agency and vendor proposes solution	All of the above	Agency interested in deploying/analyzing a particular vendor's solution	needed to address research questions
#9	What manufacturer/vendor and solution was ultimately selected to provide the video analytics deployment?	Has not currently been implemented but right now most likely DERQ. However, possible that we may implement 3-4 different vendors in a pilot type study so we can determine which solution may work best for us.	Bosch Video Analytic Cameras w/ MH Corbin Connect ITS device	TrafficVision	a.Manufacturer: Bosch b.Solution: Model 8000	Verizon, Etalyc, Parsons	N/A	In-house video annotation and analytics developed methods
#10	How was the video analytics solution procurement contract structured? Please select all that apply.	Has not currently been implemented but believe it would first be a no cost demonstration/pilot;	One-time deployment/integration fee;	Ongoing license/subscription fee;	One-time deployment/integration fee;Ongoing maintenance/support fee;	No cost demonstration/pilot;One-time procurement fee;	No cost demonstration/pilot;	Cost to develop in-house solution and on-going maintenance ;Ongoing maintenance/support fee;
#11	If software was required to be deployed as part of the video analytics solution, where was the software hosted?	Unsure as have not started;	On hardware located in the field;	Originally it was cloud hosted, but we are currently looking into on-prem solutions to satisfy our IT preference.;In a third-party cloud environment;On-premise at the agency;	Analytics for object location and motion hosted on the edge within the camera.Analytics for standardized data translation and distribution hosted on the edge within Roadside Unit;	In a third-party cloud environment;	In a third-party cloud environment;On hardware located in the field;On a local user's computer/workstation;	On-premise at the agency;
#12	In order to successfully integrate the video analytics solution, was any of the following infrastructure (existing or new) required? Please select all that apply.	Have not used but we are looking at the checked options;Video CCTV camera(s);Wired communications;Wireless communications;Ethernet switch(es);Detection device (microwave, Bluetooth, etc.);Intersection processor/CPU;Roadside equipment (RSE) or roadside unit (RSU);	Thermal/infrared CCTV camera(s);Wired communications;Wireless communications;Ethernet switch(es);Intersection processor/CPU;Roadside equipment (RSE) or roadside unit (RSU);	No camera purchases was required, but we found that we had more reliable feedback on fixed cameras. Our initial deployment included PTZ cameras and we learned that the cameras were too often moved/improperly positioned for ideal results. We did procure servers to ensure we have proper capacity.;	Video CCTV camera(s);Wireless communications;Roadside equipment (RSE) or roadside unit (RSU);	Video CCTV camera(s);	Video CCTV camera(s);Wired communications;Wireless communications;Ethernet switch(es);Detection device (microwave, Bluetooth, etc.);Intersection processor/CPU;Roadside equipment (RSE) or roadside unit (RSU);Physical server(s) for deployed software;	leveraged resources already available;
#13	Throughout the course of the project, how responsive was the vendor? Please select the answer that best describes the vendor's responsiveness.	Not involved	Very responsive	Very responsive	Very responsive	Very responsive	Not involved	Not involved
#14	Do/did any of the following conditions impact performance of the video analytics solution? Please select all that apply.	Night/low light;	Night/low light;Rain;Fog;Snow/ice;Dust;	None;	None;	None;	Night/low light;Rain;Fog;	Night/low light;Rain;Fog;Snow/ice;Dust;
#15	In addition to pedestrians, what other modes of transportation is/was the video analytics solution able to detect? Please select all that apply.	Has not currently been implemented but would be looking at all or as many modes as possible;	Bicyclists;Motorcycles;Vehicles;Freight vehicles;	Freight vehicles;Vehicles;Motorcycles;Micro-mobility (I.e., scooters);Bicyclists;Does not classify bicycles vs scooters vs peds, but can detect.;	n/a;	Bicyclists;	Bicyclists;Motorcycles;Vehicles;Freight vehicles;Micro-mobility (I.e., scooters);	Bicyclists;Micro-mobility (I.e., scooters);Motorcycles;Vehicles;Freight vehicles;
#16	What type of data is the deployed video analytics solution able to collect?	Red light running, video recording of incident, wrong way, near miss, post encroachment time, vehicle paths versus pedestrian paths, speed and volume by lane	Pedestrian activity, vehicle movements into and away from the intersection	Traffic and incident data (speed, volume occupancy, classification, stopped vehicle, congestion, slowed speeds, wrong way driving, unsafe pedestrians)	a.Location of Vulnerable Road Users (VRU), such as pedestrians and cyclists b.VRU location includes latitude, longitude, and elevation c.VRU location accuracy d.VRU travel speed e.VRU heading (direction) f.VRU size classification g.VRU future path trajectory h.Individual VRUs i.Clusters of VRUs j.All VRU video analytics data is updated, timestamped, and logged 10 times per second	Near collision situations	Trajectory,Traffic Statistics (e.g., speed, volume),Safety Indicators (e.g., PET, TTC)	For the majority of research project, time-series data for position and movement
#17	Does the video analytics solution incorporate artificial intelligence (AI) or machine learning?	No	No	Yes	No	No	Yes	Yes
#18	Does the video analytics solution meet your accuracy requirements?	No	Yes	Yes	Yes	Yes	Yes	Yes
#19	How long does the system keep data/reports?	Does not apply	There are two solutions; One is Bosch's that will store the data in the cloud based on the agencies needs and another MH Corbin solution for storing minimal data on the device and/or longer data in the cloud.	This is user configurable, but video retention is in line with GDOT's retention policy. Metadata (speed/volume/occupancy/etc.) is perpetually stored.	a.All VRU data is stored in non-volatile memory within the RSU until uploaded by the central, within the RSU memory capacity. b.Uploaded data is archived by the central indefinitely	?	24/7	It depends on the project and information

#1	Agency Name	City of Las Vegas Public Works Transportation Engineering Division	DriveOhio - OhioDOT	GDOT	Tampa Hillsborough Expressway Authority	City of Austin	University of Central Florida Smart and Safe Transportation (UCF SST) Lab	Virginia Tech Transportation Institute
#20	Were any alerts or reports generated by the video analytics solution during or after the project was completed? Please select all that apply.	Does not apply;	Ghost PSMs were generated and broadcast to CVs in the area. ;	Realtime alert with video feed or snapshot from CCTV camera;Realtime alert or pop-up window within video analytics application ;	real time in vehicle alerts;	Post project analysis / report;	Realtime alert with video feed or snapshot from CCTV camera;Periodic summary reports (daily, weekly, etc.);Post project analysis / report;Realtime alert via text or email as event occurs;Realtime alert or pop-up window within video analytics application ;	Varies by project;
#21	Were any performance measures developed or analyzed as part of the project to assess the video analytics solution? Please select all that apply.	does not apply;	Visual Verification;	System accuracy;False positive rate;Incident response time;	System/ device availability;System accuracy;False positive rate;	Ongoing;	System/ device availability;System accuracy;False positive rate;Crash rate;Crash severity;Incident response time;Incident duration;	Crash rate;Incident response time;Incident duration;False positive rate;System accuracy;System/ device availability;Crash severity;
#22	Overall, how satisfied were you with the overall performance of the video analytics solution? Please select the one that best describes your satisfaction.	Unknown or project ongoing	Satisfied	Very satisfied	Very satisfied	Unknown or project ongoing	Satisfied	Satisfied
#23	How likely are you to recommend the video analytics solution for future deployments at your agency or by another partner agency? Please select the one that best describes your likelihood.	Unknown or project ongoing	Likely	Very likely	Likely	Unknown or project ongoing	Likely	Likely
#24	Were any documents (market assessment,	No	No	No	No	No	No	No
#25	As a result of the video analytics solution deployment, did you observe any direct or indirect safety or mobility improvements?	Has not occurred but would be intent of using	Assessment to occur in future as additional phases and development is implemented	The biggest takeaway for GDOT was the increase in detection of incidents. The ability to more quickly detect incidents results in less congestion on the interstate and a reduced likelihood of secondary incidents. Also more quickly detecting incidents results in quicker response that can be life saving.	The initially deployed LiDAR-based Pedestrian Collision Warning system faced several deployment challenges resulting in reliability issues and failure to meet the required deployment specifications. The system integrator replaced the system with a thermal sensor to accurately detect and track pedestrians. After testing, the new system became operational on August 5, 2020. During the operational time of the LiDAR sensors, the PCW application triggered 27 warnings that consisted of 85 percent FPs due to the sensors' inability to correctly identify pedestrians and triggering warnings at large distances between the HV and pedestrian. The large distance was due to the loosened operational parameters of the system at the time. The change of sensors from LiDAR to thermal camera shows an overall improvement in pedestrian identification and tracking. During testing scenarios, the system was able to correctly identify pedestrians on the sidewalk and not trigger warnings, and it was able to correctly identify pedestrians on the crosswalk and trigger warnings as intended. The test data cannot be used as an overall reliability of the system as several scenarios were purposefully testing the operation of the new sensors. Due to the COVID-19 pandemic that began in March 2020 and its impact on the participants' travel in the area, no PCW warning data have been recorded from participant vehicles at the time of this report. The new system became officially operational on August 5, 2020. Further data collection in subsequent months can provide information as to the effectiveness of the PCW application.	Project is ongoing. No results yet	improve vulnerable road user safety, weather detection	The video analytics solution is for improving transportation safety. However, the implementation may differ from MDOT's implementation.
#26	During the video analytics solution deployment, were there any lessons learned or items you wish you had considered earlier in the project?	No	No	Yes	Yes	Yes	No	Yes
#27	If yes, please identify:			Performed blind evaluation by not informing operators of the system running. One specialist operator was chosen to operate this system in the background. This allowed us to identify that the software was detecting ~7 minutes faster than other detection methods (called in or visually identified via camera).	As stated in question 25, the initial solution of LIDAR proved to be inconsistent and not supportable.	Project is ongoing and no lessons learned		There are vendor solutions that we are also considering instead of our in-house solution for some applications.
#28	During or as a result of the video analytics deployment project, did you encounter any unexpected issues and/ or outcomes that you would be willing to share?	No	No	Yes	Yes	No	No	No
#29	If yes, please identify:			There was a large component of involving GDOT's legal team to discuss video retention. This was a significant impact to the project schedule.	Initial deployment of LIDAR was unsuccessful due to lack of support by LIDAR vendor			
#30	What challenges do you expect to encounter if you were to expand/ further deploy the video analytics solution to additional locations / corridors? Please select all that apply.	does not apply;	High deployment costs;Lack of available funding;Lack of staff expertise ;question 14 did not have a none response. None of those things affected the performance;	We experienced a pretty smooth roll out. ;	High deployment costs;Lack of available funding;	Integration issues with existing infrastructure/ systems;	Lack of available funding;High maintenance costs;	Assuming roadway infrastructure implementation: Not knowing what the driver is doing and technologies available/ enabled on vehicle.;

Appendix C – Request for Information

STATE OF MICHIGAN
Department of Transportation

210000000011
MDOT - Utilizing Video Analytics with Connected Vehicles
For Improved Safety

This Request for Information (RFI) seeks to obtain market information about readily available video analytic technologies to increase safety conditions for motorized and non-motorized users in arterial environments. The information gathered is intended to assist the State of Michigan to better understand (a) readily available technologies in the market, (b) effective operating models, and (c) potential pilot deployment.

Anticipated Timeline

Issue Date		8/30/2021
Deadline to Submit Questions	3:00 p.m. EST	9/17/2021
Anticipated Date State will Post Answers to Questions		9/24/2021
Deadline to Submit Response	3:00 p.m. EST	10/4/2021

The information in this document is subject to change. Check www.michigan.gov/SIGMAVSS for the current information.

STATE OF MICHIGAN

REQUEST FOR INFORMATION INSTRUCTIONS

1. **CONTACT INFORMATION FOR THE STATE.** The sole point of contact concerning this Request for Information (RFI) is:

   Christopher Martin
   517-643-2833
   martinc20@michigan.gov

2. **QUESTIONS.** Questions concerning the RFI must be emailed to martinc20@michigan.gov no later than the time and date specified on the cover page of this document. Answers to questions will be posted on www.michigan.gov/SIGMAVSS.

   Questions should be submitted using the following format:

Q #	Document and Section	Page# / Requirement#	Question

3. Please provide an informational response on www.michigan.gov/SIGMAVSS no later than the date and time located on the cover page of this document. All documents should be created using tools that are compatible with Microsoft Office standard desktop tools, without need for conversion. System prompts for pricing attachments and information can be disregarded.

   Questions on how to submit information or how to navigate in the SIGMA system can be answered by calling (517) 284-0540 or (888) 734-9749.

4. **ORAL PRESENTATION.** The State reserves the right to invite some vendors for oral presentations.

5. **GENERAL RESPONSE CONDITIONS.** The State will not be liable for any costs incurred in preparation of vendor's response, delivery of the response, and any follow-up discussions with the State. This RFI is not an offer to enter into a contract.

6. **FREEDOM OF INFORMATION ACT.** All portions of a response are subject to disclosure as required under the Michigan's Freedom of Information Act, 1976 Public Act 422.

7. **RIGHTS TO INFORMATION CONTAINED IN RESPONSES.** All informational responses will be considered the property of the State.

STATE OF MICHIGAN

Request For Information
Utilizing Video Analytics with Connected Vehicles for Improved Safety

The purpose for this Request for Information (RFI) includes, but is not limited to, collecting market information to better understand best practices about video analytics applications that can work in coordination with connected vehicle (CV) technology to proactively identify safety concerns and implement mitigation strategies in response to those concerns. The information gathered may be used to assist the State in developing a strategy that integrates video analytics into safety and mobility solutions. Additionally, the information collected may be used as part of an Request for Proposal (RFP) or Competitive Proof of Concept (CPC) development.

1. Program Overview

The Michigan Department of Transportation's (MDOT) focus with this initiative is to identify and vet emerging technologies that can help save lives through better analysis and proactive responses, primarily, but not exclusively, in arterial environments. The objectives of the research findings include:

- Reduce the frequency and severity of intersection conflicts by using the data to understand crashes and near misses and determine any necessary improvements
- Reduce the frequency and severity of intersection and mid-block conflicts through traffic control and operational improvements
- Reduce crashes and fatalities by disseminating intersection and mid-block conflict alerts to motorists and non-motorized users

2. Criteria

MDOT is interested to learn about video analytics solutions that are capable of the following functions:

- Must be able to collect or utilize existing video feed data for analysis
- Must be able to process the collected data to determine near misses, vehicles, pedestrians and bicycles, crashes/incidents, and traffic violations
- Must be able to produce real time alerts when specific conditions are identified
- Must be able to push notifications to motorists and non-motorized users
- Should provide functionality that includes potential actions such as CV coordination, signal control, crosswalk control, crash investigation, remote video access, agency alerts, Waze integration, and MiDrive integration

STATE OF MICHIGAN

Request for Information
Utilizing Video Analytics with Connected Vehicles for Improved Safety

RESPONSE PREPARATION

Please respond to the following topics and questions in a “Question and Answer” format, providing thorough information for each, when possible.

1. Name, Company Name, and Contact Information

2. Provide a description of your available video analytics solution to improve safety in arterial environments for motorized and non-motorized users.

   a. Describe how the video analytics solution addresses the need of increased safety by decreasing or eliminating fatalities or serious injuries due to crashes.

   b. Describe previous deployments and how they relate/support the video analytics solution.

   c. Describe your video analytics solution’s ability to capture data including near miss, vehicles, pedestrians and bicyclists, crashes and incidents, and traffic violations.

   d. Describe any alerts or reports that are generated by the video analytics solution.

   e. Describe whether and how the video analytics solution incorporates CV communications.

   f. Provide other information about the video analytics solution that is of benefit to the Department of the State.

3. Describe any partnerships or collaboration efforts needed to employ the video analytics solution.

4. For budgeting purposes, please provide any information available regarding typical pricing structure.

5. Please provide any additional pertinent information.

6. If an RFP or CPC is issued for provision of this solution, is it likely that your company will bid on it?

EXHIBIT A: FORM-001 SUBMITTER INFORMATION

Project: ____

Name of Submitter: ____

Street Address: ____

City: ___________________________ **State:** _________________

Zip: ______________________

Contract Person: ____

Telephone No.: __________________________ **E-Mail:** __________________________

☐ The Submitter, by checking this box, certifies the truth and correctness of the contents included in their RFI response.

Please indicate if Submitter is interested and willing to provide MDOT and its stakeholders a software demonstration as part of the RFI process: ☐ Yes ☐ No

______________________________________ ________________
(Name) (Date)

____
(Title)

____
(Signature)

Appendix B Use Cases

USE CASES MEMO

UTILIZING VIDEO ANALYTICS WITH CONNECTED VEHICLE FOR IMPROVED SAFETY

FINAL REPORT

MDOT

Kimley»Horn
of Michigan, Inc.

January 2022

OR2021 0250

CONTENTS

List of Figures

Version Control

Version	Author/QC	Date	Changes
1.0	Danielle Curri, Stacie Phillips / Jeffery Dale	9/10/2021	Initial Draft Submittal
2.0	Danielle Curri, Stacie Phillips / Jeffery Dale	1/6/2021	Final Draft Submittal

INTRODUCTION

MDOT is focused on identifying video analytics applications that can work in coordination with connected vehicle (CV) technology to proactively identify safety concerns and implement mitigation strategies in response to those concerns. The initial research effort and resulting pilot deployments will allow MDOT to evaluate the technologies' ability to capture crash, near miss, and other relevant data in support of immediate safety responses. Additionally, the data analysis should allow for trend analysis in support of safety improvements for the monitored locations. The ultimate objectives of the research findings include:

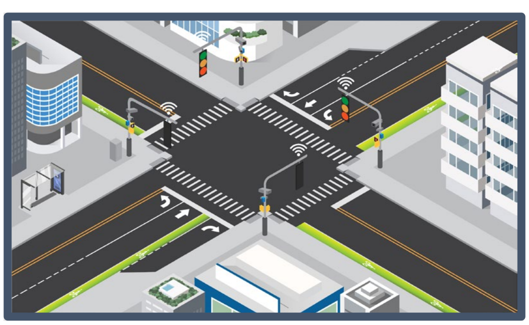
1. Reduce the frequency and severity of intersection crashes by using the data to understand crashes and near misses and make necessary improvements.
2. Reduce the frequency and severity of intersection and midblock crashes through traffic control and operational improvements.
3. Reduce crashes and fatalities by disseminating intersection and midblock conflict alerts to motorists and non-motorized users.

The findings of the pilot project are intended to support MDOT's decision for full deployments of the technology. The pilot project will allow MDOT to assess both the technical and operational feasibility of video analytics systems. The results of the pilot project will guide the development of strategies that can be used to evaluate other locations and implement the technology based on specific needs, life cycle costs, and the proven benefit experienced from the pilot deployments.

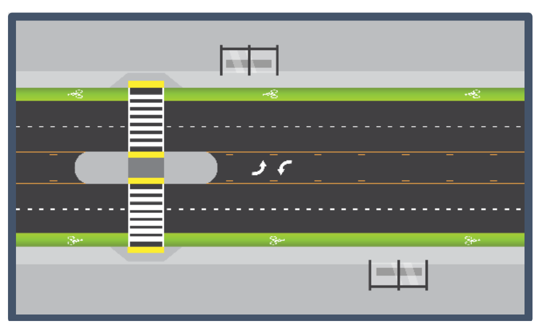
This memo is focused on establishing Use Cases that qualify the project objectives and gain consensus from the project team and stakeholders involved. The Use Cases present the operational intentions of the proposed system under different circumstances. They allow for a better understanding of the roles of different users in various scenarios. These Use Cases were developed in conjunction with the Market Assessment and revised based upon feedback from the Research Advisory Panel (RAP).

SETTINGS

The Use Cases are focused on arterial roads; however, the technology used could also be applied to other roadway settings. There are two base settings for the Use Cases presented in **Figure 1**: an arterial intersection and a midblock setting.



Intersection



Midblock

Figure 1. Use Case Settings

CHARACTERS

The characters represent the individual users of the system. In the Use Cases, the users are represented by a series of icons shown in **Figure 2**. The users of the system represent a variety of transportation modes commonly found on arterials and the entities that interact with the system. The users include both motorized and non-motorized roadway users. Vehicles include passenger cars, transit vehicles, commercial vehicles, and motorized bikes. Connected vehicles include users with connected technology on personal vehicles, connected applications on personal devices or autonomous vehicles with connected technology.

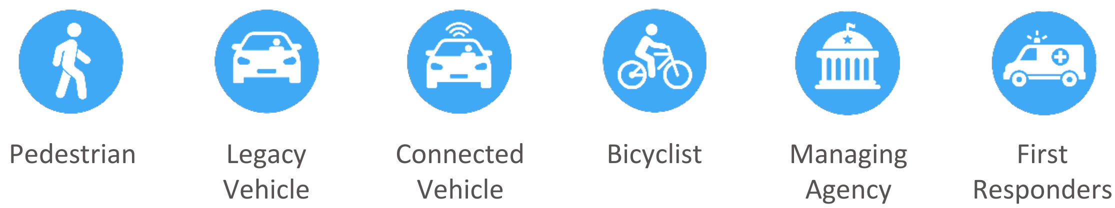


Figure 2. Use Case Characters

POTENTIAL APPLICATIONS

The technology being assessed can provide a wide range of functionality. The potential applications are defined to capture these focus areas of the video analytics system. Each of the potential applications is denoted with an icon so they can be easily referenced within each of the Use Cases.

Event Detection	Video analytics functionality that recognizes events such as a pedestrian crossing the road, a vehicle in the road, a crash, or a near miss between any two road users. In addition, the system can store data* to be used for analysis. ** Examples of the data collected by the system could include direction and speed of travel, path identification, deceleration, lane deviation, wrong way driving, and signal phasing.*
Trajectory Identification	The video analytics capability to identify the trajectory and movements of system users in real time—for example, a vehicle turning left or a pedestrian crossing the road.
User Alert	The video analytics system functionality to push an alert to connected users. Users would receive the notifications using their own devices such as smartphones, connected vehicles, and autonomous vehicles with connected technology. These alerts are based on safety concerns associated with identified risks in the vicinity of the user for the purpose of preventing a crash.
Agency Notification	The video analytics system ability to notify the managing agency of an event or aggregation of events based on thresholds established by the stakeholders and the roles of the agency.
Video Capture	The video analytics functionality to capture videos of events* that can be accessed by the managing agency or shared with agency partners. The capture could be a live feed or a brief recording following the identification of an event. ** The video analytics system would be constantly capturing video and temporarily storing short clips. When an event is detected, it would tag the clip that was captured just before, during, and after the event to be used for emergency response and safety reviews.*
Trend Analysis	The video analytics system capability to analyze the stored data in alignment with defined performance measures to assist the agency in making data-driven decisions that can improve safety or mobility.

PEDESTRIAN USE CASES

Use Case #1: Left Turn and Pedestrian Near Miss

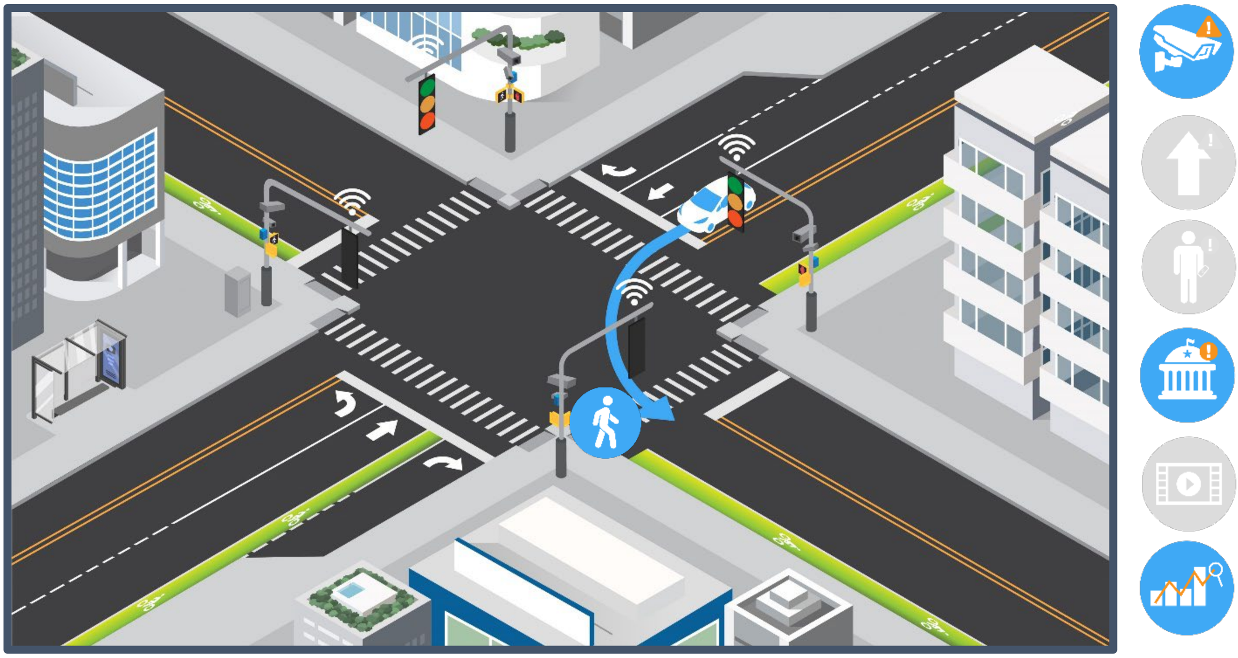


Figure 3. Left Turn and Pedestrian Near Miss Use Case

Scenario

1. A vehicle (connected or legacy) performs a permissive left turn while a pedestrian is entering the crosswalk. The video analytics system detects both events.
2. The pedestrian in the crosswalk experiences a near miss with the turning vehicle.
3. The video analytics system detects the near miss and stores the collected data.
4. The video analytics system aggregates the data and reports trends to the managing agency.
5. As trends of multiple near misses are identified, the agency references the data and reports to assess the intersection performance and generate recommendations.

Potential Outcomes

This Use Case presents a scenario where the managing agency could use an aggregation of near misses to identify safety issues at the intersection. If the video analytics system identifies a trend of vehicle and pedestrian near misses, the managing agency could recommend a series of countermeasures. Examples of these countermeasures include implementing Leading Pedestrian Intervals (LPI), implementing exclusive pedestrian phasing, or inhibiting permissive left turn phasing while there is a pedestrian in the crosswalk. Using the video analytics system, the managing agency could then study if the measures lead to a decrease in near misses. This Use Case could be applied at both signalized and unsignalized intersections.

Use Case #2: Right Turn and Pedestrian Near Miss

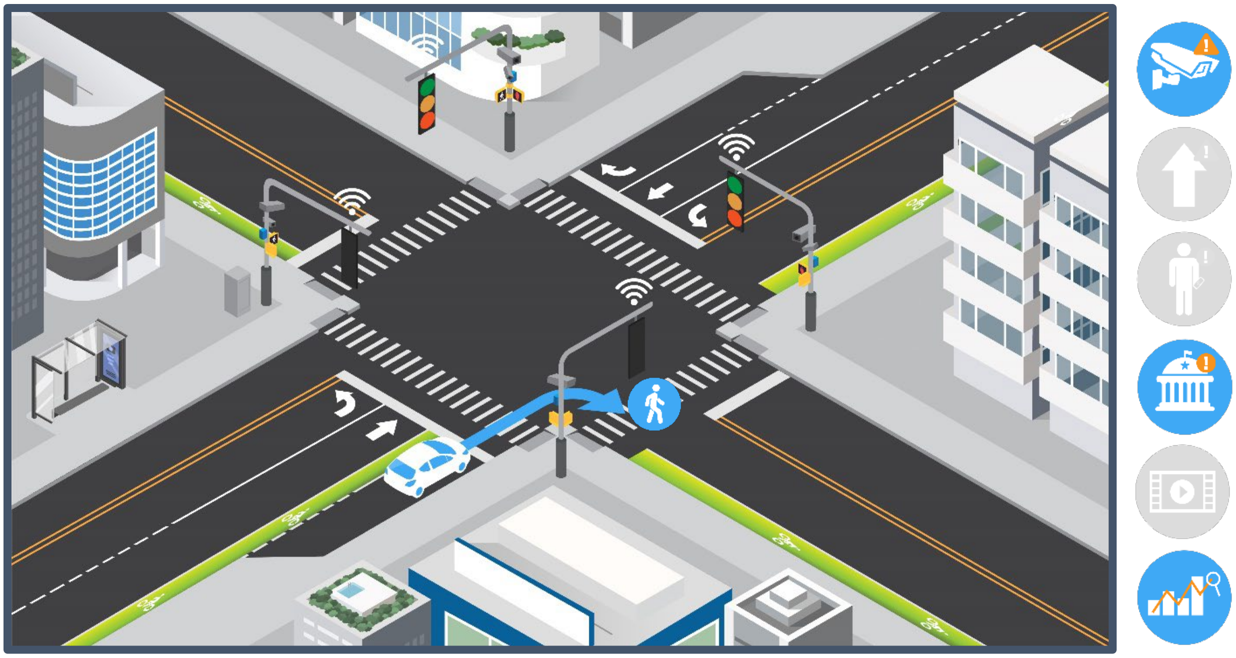


Figure 4. Right Turn and Pedestrian Near Miss Use Case

Scenario

1. A vehicle (connected or legacy) is turning right while a pedestrian is entering the crosswalk. The video analytics system detects both events.
2. The pedestrian in the crosswalk has a near miss with the turning vehicle.
3. The video analytics system detects the near miss and stores the collected data.
4. The video analytics system aggregates the data and reports trends to the managing agency.
5. As trends of multiple near misses are identified, the managing agency references the data and reports to assess the intersection performance and generate recommendations.

Potential Outcomes

This Use Case is separated out from left turn near misses due to the different nuances of right turns. If the video analytics system identifies a trend of vehicle and pedestrian near misses, the managing agency could recommend a series of countermeasures. Examples of these countermeasures include implementing Leading Pedestrian Intervals (LPI), implementing exclusive pedestrian phasing, disallowing right turns on red, or inhibiting right turn phasing while there is a pedestrian in the crosswalk. Using the video analytics system, the managing agency could then study if the measures lead to a decrease in near misses. This Use Case could be applied at both signalized and unsignalized intersections.

Use Case #3: Connected Users - Pedestrian in Crosswalk

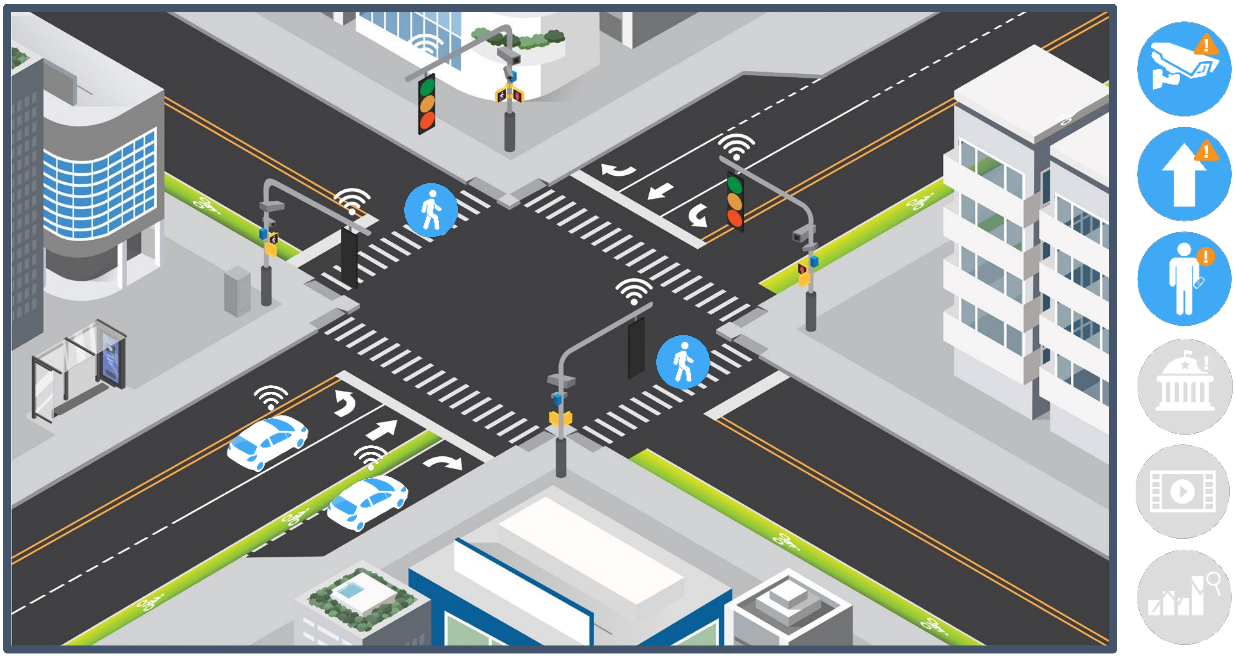


Figure 5. Pedestrian in Crosswalk Use Case

Scenario

1. A connected user in a vehicle is approaching the intersection.
2. The video analytics system detects both the pedestrian in the crosswalk and the vehicle approaching the intersection.
3. The video analytics system identifies the trajectory of the vehicle and the pedestrian and recognizes the potential conflict.
4. The video analytics system pushes an alert that there is a pedestrian in the crosswalk.
5. Connected users utilize the alert to make real-time decisions.

Potential Outcomes

This Use Case highlights the ability of the video analytics system to work with connected technology. By pushing the alert, the video analytics system allows users to receive information on their personal devices. This could include a connected vehicle or a connected smartphone application. An example of the alert could include, "Caution – Pedestrian in Crosswalk". Driver failure to yield to pedestrians in the crosswalk is a danger to pedestrians crossing the road. Drivers making permissive turning movements often do not yield to pedestrians or have difficulty seeing them while turning. By pushing real time alerts, connected users can make real-time decisions. For example, a driver could yield to a pedestrian they did not see in the crosswalk while making a turning movement. Additionally, the alert could warn drivers of pedestrians crossing counter to the pedestrian signal in front of them. This Use Case could be applied at both signalized and unsignalized intersections.

Use Case #4: Pedestrian Not Using Crosswalk

Figure 6. Pedestrian Not Using Crosswalk Use Case

Scenario

1. A pedestrian enters the road at a location with a crosswalk but does not use the crosswalk.
2. The video analytics system detects the pedestrian outside of the crosswalk.
3. The video analytics system aggregates the data and reports trends to the managing agency.
4. As trends are identified, the managing agency references the data and reports to assess the intersection performance and generate recommendations.

Potential Outcomes

The Pedestrian Not Using Crosswalk Use Case helps identify areas where pedestrians are choosing to cross roadways outside of existing crosswalks. The purpose of this Use Case is to help identify potential safety issues and potential infrastructure gaps that motivate pedestrians to not use the crosswalk. For example, poor maintenance of curb ramps could be causing pedestrians to divert from using the crosswalk or pedestrians could be choosing paths to specific destinations that are more direct than the existing crosswalk. This Use Case could be applied at both signalized and unsignalized intersections.

Use Case #5: Pedestrian in the Road

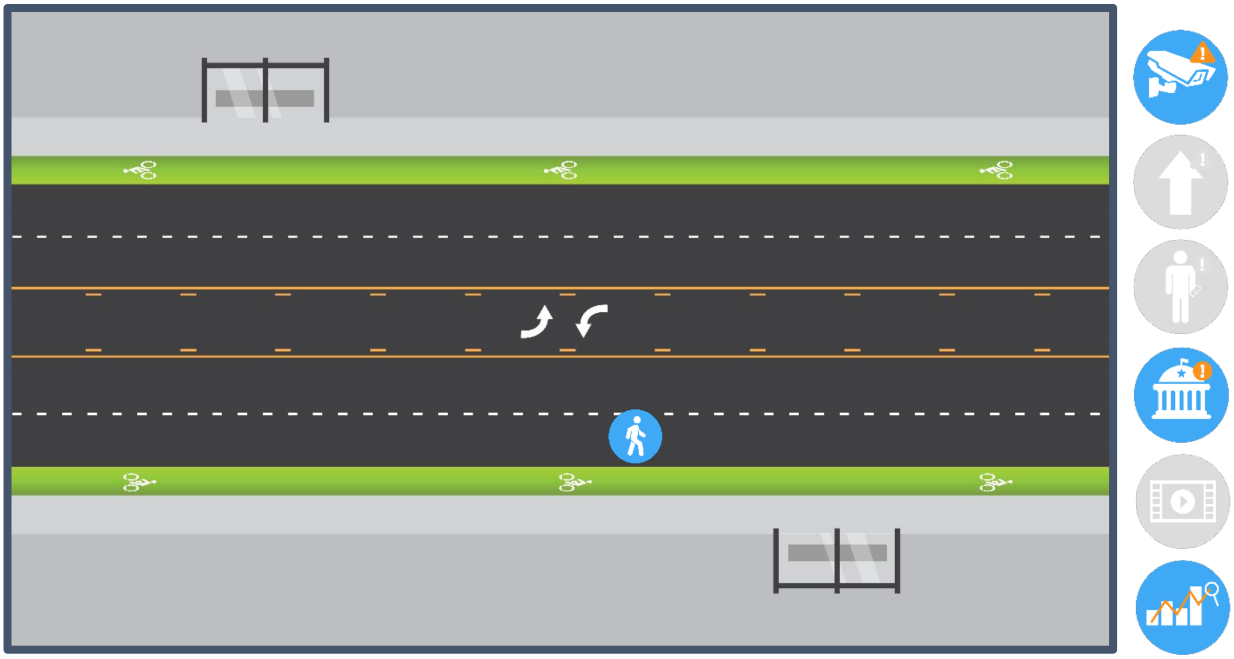


Figure 7. Pedestrian in the Road Use Case

Scenario

1. A pedestrian enters the road at a location without a crosswalk.
2. The video analytics system detects the pedestrian.
3. The video analytics system aggregates the data and reports trends to the managing agency.
4. As trends are identified, the managing agency references the data and reports to assess pedestrian needs performance and generate recommendations.

Potential Outcomes

The Pedestrian in the Road Use Case demonstrates the ability of the video analytics system to assist with identifying pedestrian infrastructure needs beyond intersections. At midblock crossings, this Use Case applies to pedestrians crossing the road and pedestrians entering the road alongside live traffic. By identifying these areas, the managing agency can use trend analysis to identify risks and prioritize investments in additional pedestrian infrastructure. For example, if the video analytics system recognizes a trend of pedestrians walking alongside traffic, the managing agency could further assess the need for additional sidewalks. If the video analytics system recognizes a pattern of pedestrians crossing the road, the managing agency could identify the need for an additional crosswalk. The distance covered by the video analytics system within the midblock will depend on the vendor and intent at each location.

This Use Case is also an example of where a portable video analytics system could be used. If an agency is receiving reports of a needed crosswalk, the managing agency could use the portable system to capture real time pedestrian pathways. Once the location has been evaluated and a decision made, the portable system could then be transferred to a different location. The portability of the system would provide agencies with versatility in addressing needs at multiple locations.

Use Case #6: Midblock Crossing Near Miss

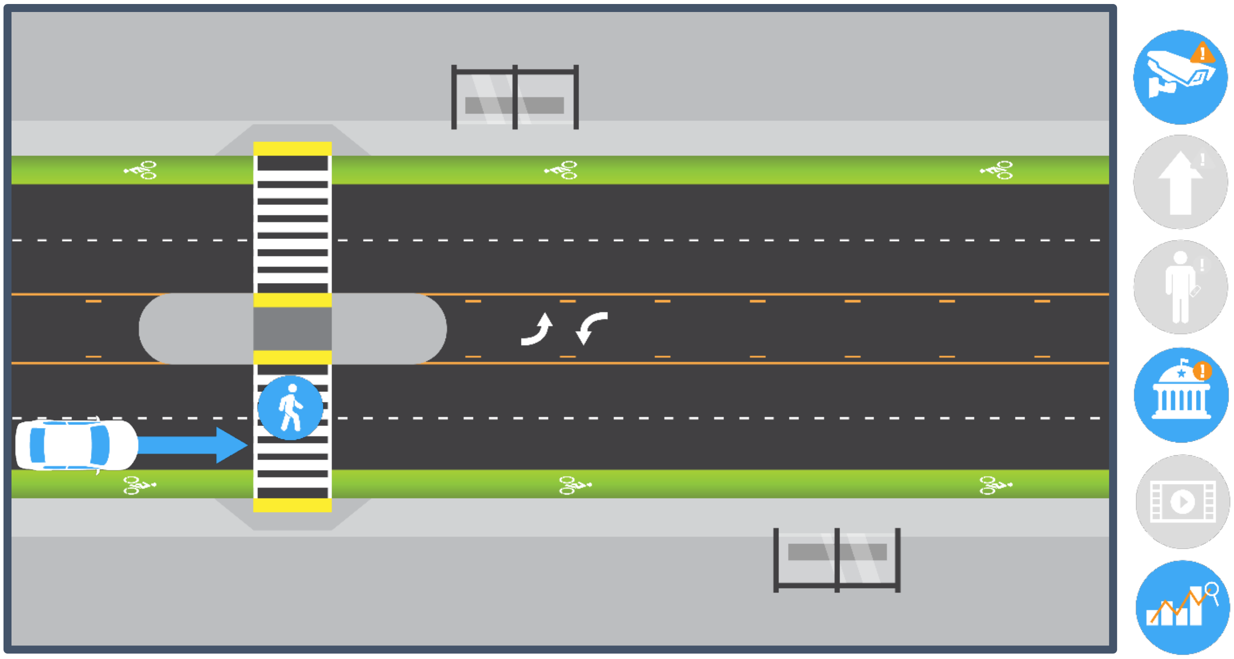


Figure 8. Midblock Crossing Near Miss Use Case

Scenario

1. A pedestrian enters the road.
2. The video analytics system detects the pedestrian and the vehicle.
3. The pedestrian in the crosswalk has a near miss with the approaching vehicle.
4. The video analytics system detects the near miss and stores the collected data.
5. The video analytics system aggregates the data and reports trends to the managing agency.
6. As trends of multiple near misses are identified, the managing agency references the data and reports to assess pedestrian needs and generate recommendations.

Potential Outcomes

This Use Case shows the ability of the video analytics system to assist with pedestrian crossings beyond intersections. If the video analytics system recognizes a pattern of near misses at midblock crossings, the managing agency can consider a series of recommendations including high visibility crosswalks, signage, and Pedestrian Hybrid Beacons (PHBs).

This Use Case is also a scenario where a portable video analytics system could be used. If an agency is receiving complaints of unsafe conditions where vehicles are not yielding to pedestrians, the managing agency could use a portable video analytics system to evaluate the performance in the vicinity of the crosswalk. Based on the trends reported by the video analytics system, the agency could make data driven recommendations for treatments.

Use Case #7: Connected Users – Stopped Transit Vehicle Alert

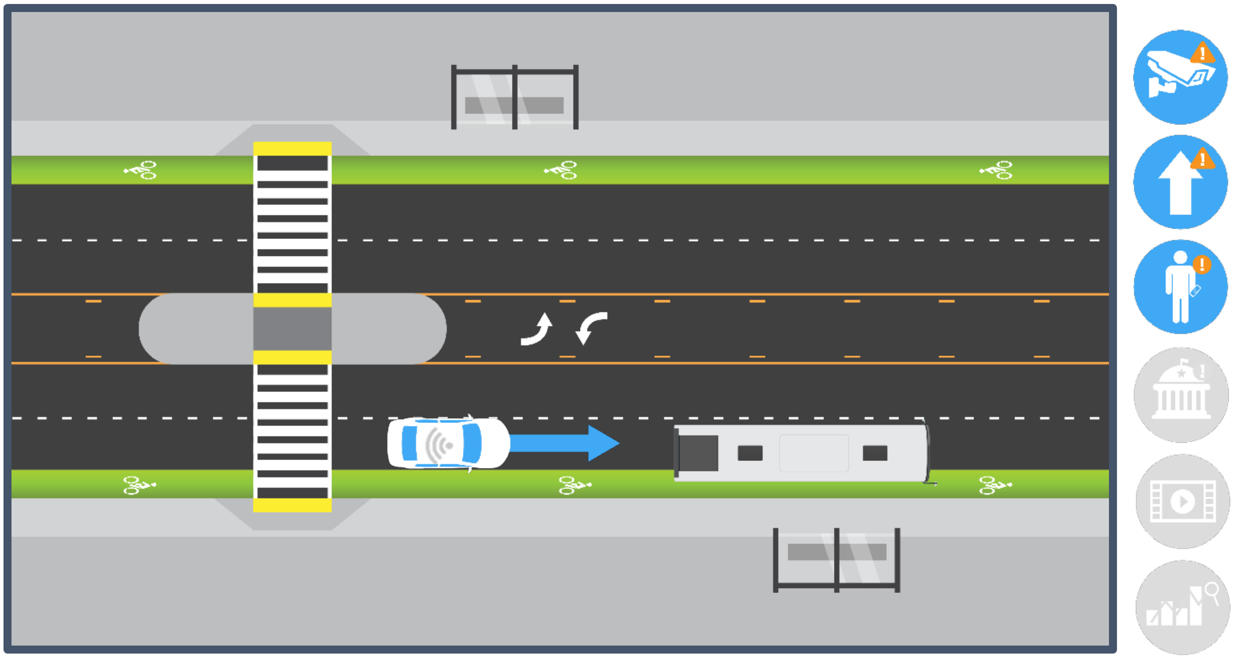


Figure 9. Stopped Transit Vehicle Use Case

Scenario

1. A connected user in a vehicle approaches a stopped transit vehicle. Pedestrians enter and exit the transit vehicle.
2. The video analytics system detects the connected vehicle, the stopped transit vehicle, and pedestrians.
3. The video analytics system identifies the trajectories of the vehicle, transit vehicle, and pedestrians.
4. The system pushes an alert to the connected users of the potential conflicts.
5. Connected users use the alert to make real-time decisions.

Potential Outcomes

This Use Case shows the ability of the video analytics system to assist with transit stops. Transit vehicles frequently stop blocking lanes. Depending on the roadway, drivers can have a difficult time viewing the transit vehicle blocking the roadway. Additionally, as passengers enter or exit the vehicle pedestrians can be obscured by the transit vehicle making it hard for drivers to see them. By pushing real time alerts, the video analytics system can assist connected users to make real-time decisions and drivers could become aware of transit vehicles and potential pedestrian conflicts. An example of the alert could include, "Warning – Stopped Transit Vehicle Ahead".

VEHICLE USE CASES

Use Case #8: Vehicle and Vehicle Near Miss


Figure 10. Left Turn and Vehicle Near Miss Example

Scenario

1. A vehicle is continuing straight through the intersection while another vehicle makes a permissive left turn.
2. A near miss occurs between the two vehicles.
3. The video analytics system detects the near miss and stores the collected data.
4. The video analytics system aggregates the data and reports trends to the managing agency.
5. As trends of multiple near misses are identified, the managing agency references the data and reports to assess the intersection performance and generate recommendations.

Near Miss Alternatives

The scenario details the Vehicle and Vehicle Near Miss Use Case with a left turn and vehicle near miss. However, the Use Case extends to other variations of near misses between vehicles. Potential types of near misses include angle, right turn, left turn, sideswipe, rear end, head on, right turn, and backing up. Additionally, this Use Case could be applied at both signalized and unsignalized intersections.

Potential Outcomes

The video analytics system collects data to assist the managing agency in making recommendations based on the frequency of near misses. This data captures nuances related to the variation of potential near misses. For example, if the system identifies a trend of left turn near misses, the managing agency could implement countermeasures such as evaluating sight distance to determine if permissive left turns are appropriate in that location, flashing yellow arrows, or protected only phasing. Utilizing the video analytics system, the managing agency could then study if the measures lead to a decrease in near misses.

Use Case #9: Crash Detection

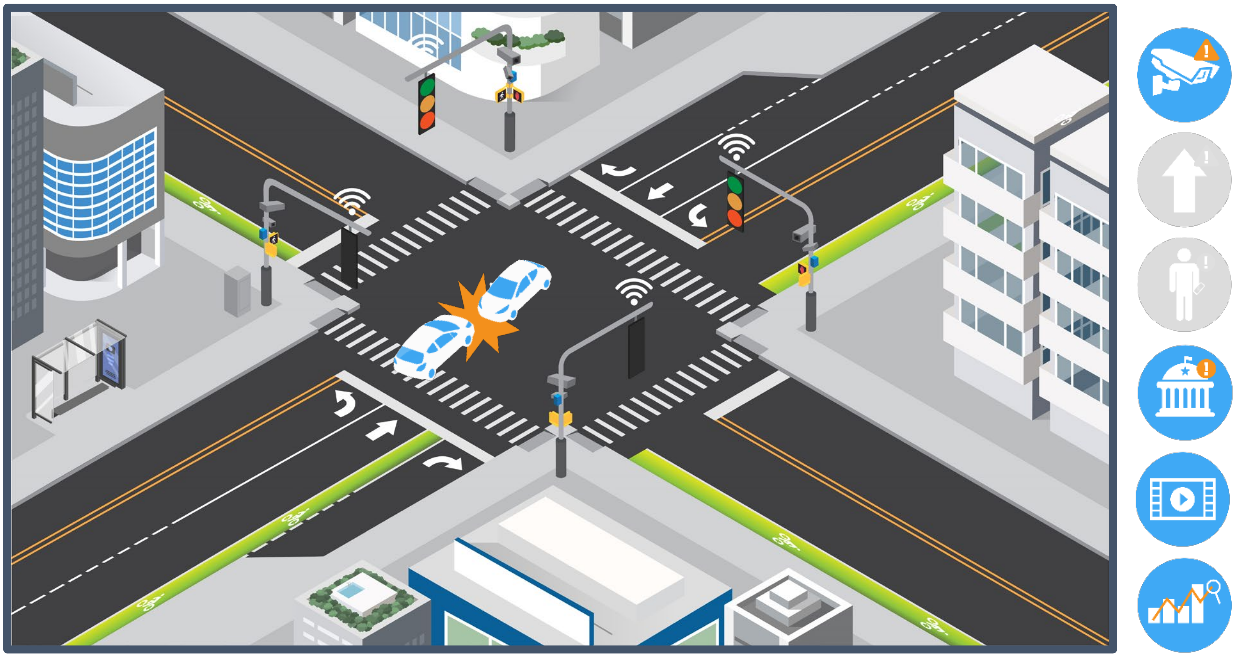


Figure 11. Crash Detection Use Case

Base Scenario

1. A crash occurs at the intersection.
2. The video analytics system identifies the crash and stores data.
3. The video analytics system stores a short clip of the video of the crash for a defined duration before and after the crash and continues to record a live feed of the scene.
4. The video analytics system notifies the managing agency of the crash. The system provides the managing agency with the collected data for a defined duration before, during, and after the crash. The system also provides the managing agency with any preliminary crash analysis.
5. The managing agency provides any relevant data to first responders so that they can better respond to the crash.
6. First responders are given access to the short clip of the crash and a live feed to a video stream of the intersection.
7. The managing agency uses the feed to determine their response and notifies other users as needed.
8. The video analytics system aggregates the data and reports trends to the managing agency.
9. As trends of crashes are identified, the managing agency references the data and reports to assess the intersection performance and generate recommendations.

Video Use Guidelines

For the utilization of video captured by the video analytics system, MDOT Traffic Cameras – Access and Video/Image Sharing Policy (10212) will be referenced. Per the policy, MDOT may share CCTV views with other agencies/entities to achieve common transportation objectives in improving planning, traffic management, and traveler information. Cooperative understandings for sharing must be formed with a signed document. The policy states that video/images shall not be recorded unless it meets an exception where a review of the video/images would contribute to improving safety and/or future traffic operations procedures or system planning and performance. For recordings captured by the video analytics system, MDOT's record retention schedule will be referenced. As requirements are developed, the Access and Video/Image Sharing Policy and record retention schedule will continue to be referenced and evaluated.

Crash Alternatives

The video analytics system will detect all crash types between all intersection users at both signalized and unsignalized intersections. The video analytics system will process a preliminary analysis on the crash cause to assist the managing agency in responding to the incident and in generating recommendations. For example, the video analytics system could identify if any intersection users had deviated from a travel lane, were operating at excessive speed, or had demonstrated hard braking leading up to the crash. The video analytics system could also identify the entities involved in the crash and the crash severity. Example types of crashes include angle, left turn, sideswipe, rear end, head on, right turn, backing up, pedestrian, and bicyclist. Below, the base scenario is expanded to give an example of the nuances of the response given a specific crash scenario.

Specific Crash Scenario

In the graphic below, a specific crash scenario narrative is presented showing the responses by involved characters when a crash occurs. It is shown how the video analytics system assists the managing agency and first responders react to the crash in a more effective manner.

A vehicle executing a permissive left turn crashes into a vehicle proceedi through the intersection. The crash results in an injury and blocks a leg of the intersection.

The video analytics system identifies that a crash has occurred and stores data from the incident. Examples of data include type of crash, speed, and signal phasing.

The video analytics system stores a short clip of the crash for a duration before and after the incident and records a live video feed

The agency confirms the crash and reviews the data presented including the short clip of the crash and live feed. The video analytics system assists the agency in determining impacts of the incident and which users need to be alerted. The agency determines it is a severe incident that will cause significant delays.

The agency notifies first responders of the incident and shares data about the scene.

First responders use the short clip of the incident and live feed to determine which personnel and equipment should respond to the scene. Using the information shared from the agency and live feed, the first responders are prepared to treat an injury and respond to the lane closures in the intersection. The short clip of the incident allows responders to spend less time conducting the crash investigation, which improves first responder safety and allows them to focus on managing the incident.

The agency continues to monitor the video and determines there will be significant delays to the system. The agency alerts nearby transit drivers to reroute to avoid the intersection.

The video analytics system compiles data from the incident, past incidents, and nea misses. The agency reviews the data and adds additional data as needed. The video analytics system reports trends to the agency.

The agency uses the data and reports to evaluate the intersection. Using the data, they determine there is a trend of left turn crashes at the intersection. The agency recommends countermeasures such as flashing yellow arrows, protected movements, and sight distance improvements to help improve safety at the intersection.

Potential Outcomes

As shown in the expanded crash scenario, the video analytics system supports the crash response, scene management, and data analysis of various crash scenarios. The video analytics system provides the managing agency and first responders with real time data that allows them to manage the scene actively and effectively. After the crash has been cleared, the trend analysis helps the managing agency determine recommendations through a series of countermeasures. The data driven decisions on countermeasures can be nuanced based on the type of crashes, frequency of the crashes, and the users involved in the crash.

Use Case #10: Connected Users - Left Turn Assist

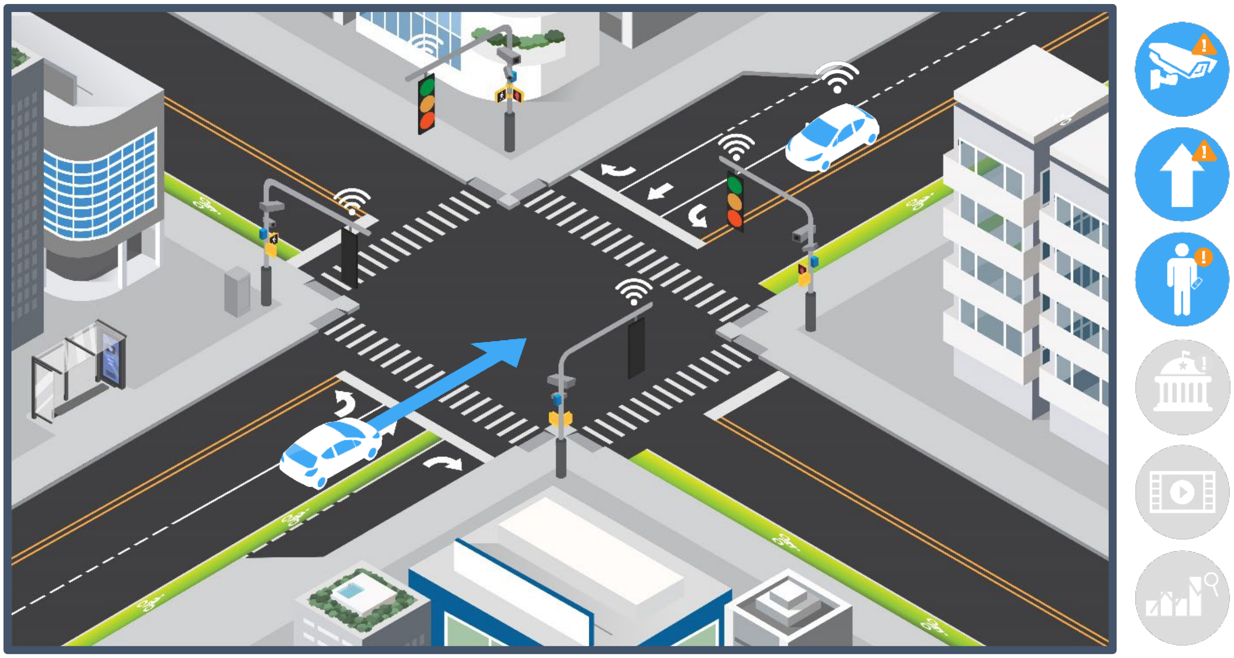


Figure 12. Left Turn Assist Use Case

Scenario

1. A connected user in a vehicle approaches a permissive left turn.
2. The video analytics system detects the connected vehicle and another vehicle (connected or legacy) continuing straight through the intersection.
3. The video analytics system identifies the trajectories of the two vehicles and the potential conflict.
4. The system pushes an alert to the connected users of the potential conflict.
5. Connected users use the alert to make real-time decisions.

Potential Outcomes

The Left Turn Assist Use Case showcases the ability of the video analytics system to work with connected technology. Drivers making permissive left turns are often challenged to accurately determine the speeds and distances of oncoming vehicles. By pushing real time alerts, connected users can make real-time decisions and vehicles could become aware of a risk from another vehicle and yield appropriately. An example of the alert could include, “Yield – Oncoming Vehicle”. This Use Case could be applied at both signalized and unsignalized intersections.

Use Case #11: Connected Users - Red Light Running

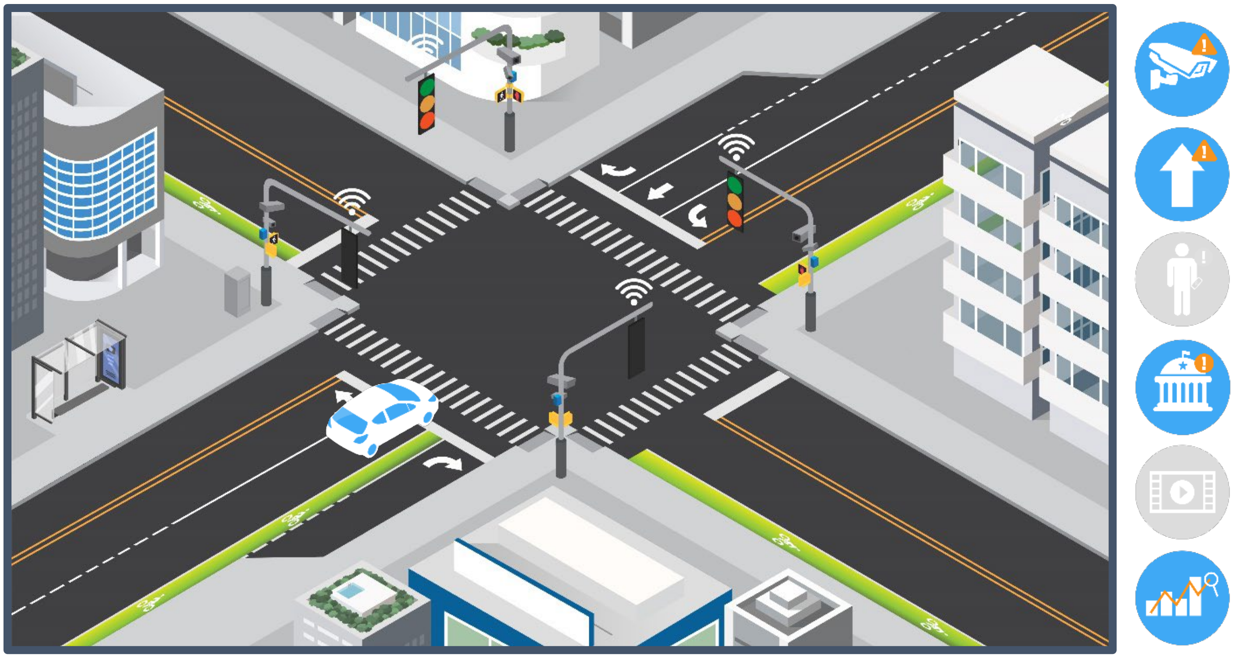


Figure 13. Red Light Running Use Case

Scenario

1. A vehicle (connected or legacy) is running a red light.
2. The video analytics system detects the incident and stores the collected data. The system identifies the trajectories of the vehicle running the red light and other vehicles in proximity.
3. The system pushes an alert to connected users of the potential conflict.
4. The video analytics system aggregates the data and reports trends to the managing agency.
5. As trends of red light running are identified, the managing agency references the data and reports to assess the intersection performance and generate recommendations.

Potential Outcomes

This Use Case is focused on potential safety risks at a signalized intersection and is not intended for law enforcement purposes. Red light running can be an indicator of multiple transportation system issues such as non-compliance, congestion, poor gaps for turning movements, and poor signal timing. Looking at aggregated data and red light running trends may reveal to the managing agency warning signs of other safety issues. The Red Light Running Use Case also showcases the ability of the video analytics system to work with connected technology. By pushing real time alerts, connected users can make real-time decisions and vehicles could become aware of a risk from another vehicle and react appropriately. An example of the alert could include, “Warning - Vehicle Running Red Light”.

This Use Case could also be an example where a portable video analytics system could be used. The managing agency could use the portable system to determine the number and frequency of red light running incidents in a variety of locations. This could guide the need for further video analytics deployment or other mitigating steps such as signal retiming or an examination of clearance intervals.

Use Case #12: Hard Braking

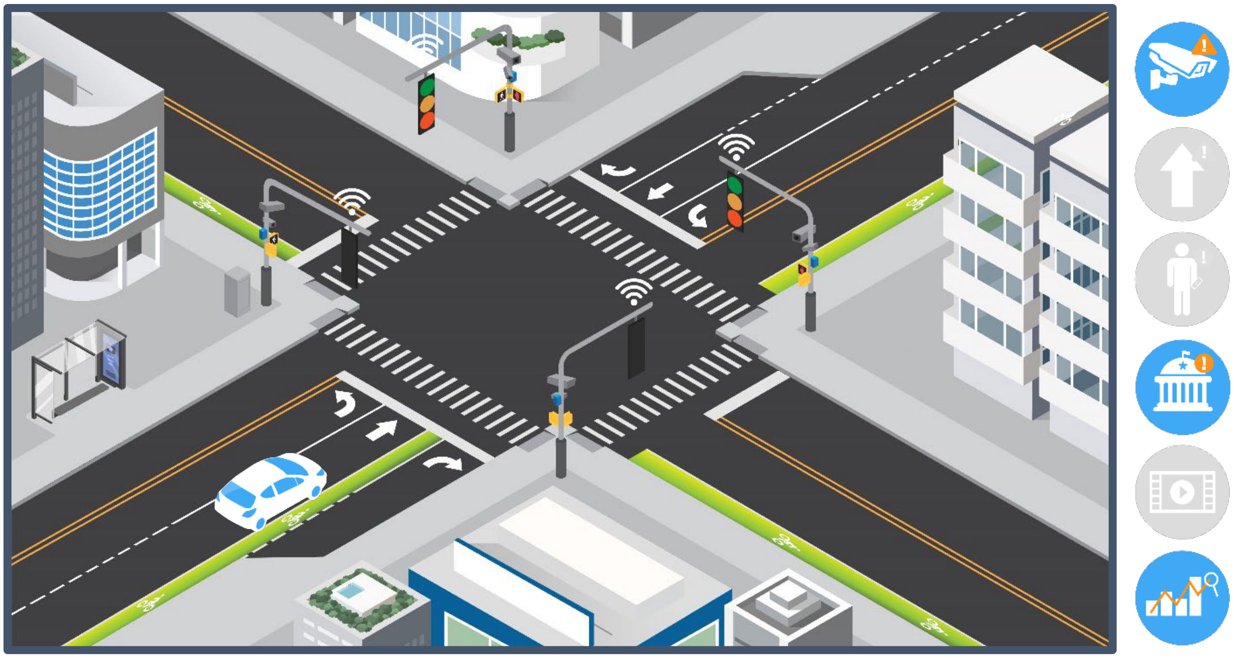


Figure 14. Hard Braking Use Case

Scenario

1. A vehicle (connected or legacy) brakes harshly in dilemma zone.
2. The video analytics system detects the incident and stores the collected data.
3. The video analytics system aggregates the data and reports trends to the managing agency.
4. As trends of hard braking are identified, the managing agency references the data and reports to assess the intersection performance and generate recommendations.

Potential Outcomes

This Use Case is focused on potential safety risks at a signalized intersection and is not intended for enforcement purposes. Hard braking can be an indicator of multiple transportation system issues such as congestion, broken detectors, poor gaps for turning movements, poor visibility of traffic signal heads, and poor signal timing. By looking at aggregated data and trends of hard braking, the managing agency can obtain advance warning signs of other safety issues.

This Use Case could also be an example where a portable video analytics system could be used. The managing agency could use the portable system to determine the number and frequency of hard braking incidents in a variety of locations. This could guide the need for further video analytics deployment or other mitigating steps.

BICYCLIST USE CASES

Use Case #13: Connected Users - Bicyclist Proximity Alert

Figure 15. Bicyclist Proximity Alert Use Case

Scenario

1. A connected user in a vehicle approaches an intersection with the intention to turn right while a bicyclist is in the proximity of the vehicle.
2. The video analytics system detects the vehicle and the bicyclist approaching the vehicle.
3. The video analytics system pushes an alert to connected users that there is a bicyclist approaching.
4. Connected users utilize the alert to make real-time decisions.

Potential Outcomes

One of the goals of this Use Case is to help prevent right hook crashes. Right hook crashes occur when a vehicle turns right in front of a bicyclist as shown in **Figure 16**. This commonly happens when a vehicle is merging into a right turn lane or turning right and the bicyclist traveling next to the vehicle is intending to continue straight through the intersection. Right hook crashes are extremely dangerous for bicyclists.

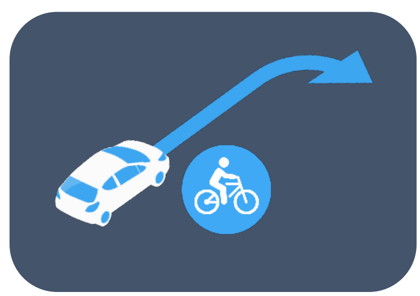


Figure 16. Right Hook Crash

Another goal of this Use Case is to alert connected vehicles of approaching bicyclists. While some connected vehicles may be able to detect nearby bicyclists, the video analytics system provides a more advanced notice of the approaching bicyclists. The video analytics system pushes the alert to all connected users that are able to receive the alert. Therefore, users in connected vehicles or using a connected application both would be alerted to nearby bicyclists. An example of this alert could include, "Warning – Approaching Bicyclist". This Use Case could be applied at both signalized and unsignalized intersections.

Use Case #14: Connected Users - Left Turn and Bicycle

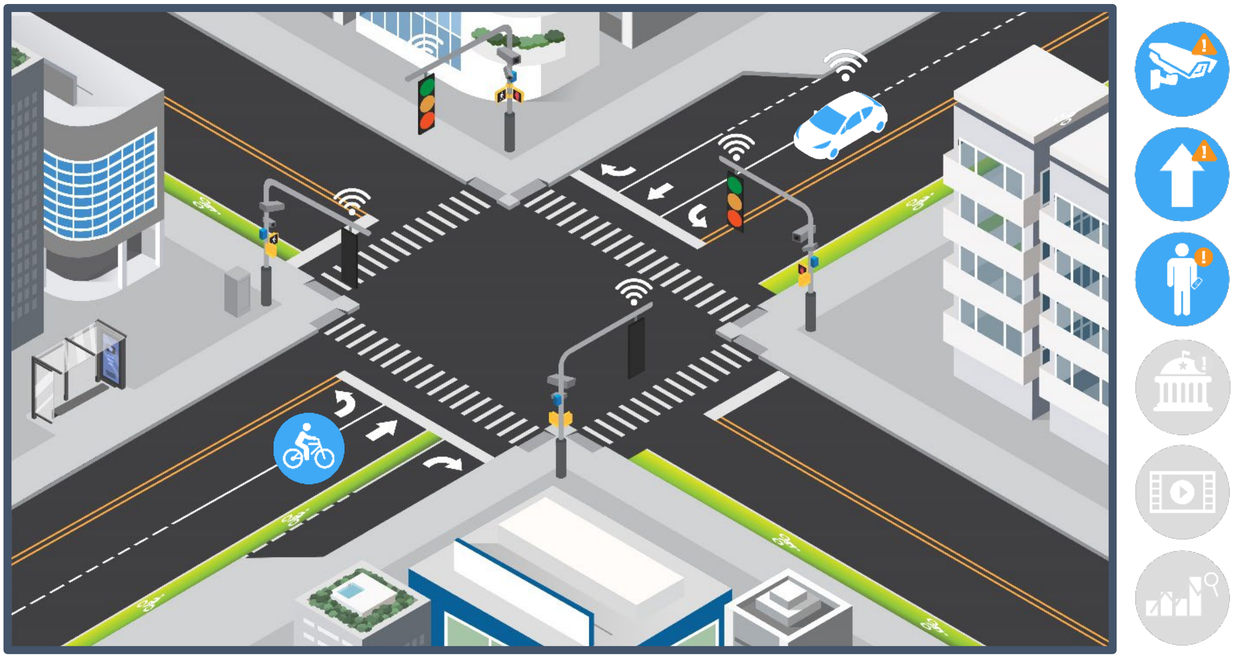


Figure 17. Left Turn and Bicycle Use Case

Scenario

1. A connected user in a vehicle approaches an intersection with the intention to turn left. A bicyclist is proceeding through the intersection on the opposing approach.
2. The video analytics system detects the vehicle turning left and the bicyclist traveling in the path of the turning vehicle.
3. The video analytics system pushes the alert that there is a bicyclist present.
4. Connected users utilize the alert to make real-time decisions.

Potential Outcomes

This Use Case showcases the ability of the video analytics system to work with connected technology. Drivers often struggle with determining the speeds of bicyclists when trying to find a gap in oncoming traffic to make a permissive left turn. Drivers also fail to notice bicyclists they encounter while performing a left turn movement. Additionally, turning vehicles are often focused on identifying gaps in approaching vehicles and may fail to notice a bicyclist on the same approach. By pushing real time alerts, connected users can make real-time decisions such as being alerted of a bicyclist they did not see. The driver could then safely yield to the bicyclist. An example of the alert could include, "Yield – Oncoming Bicyclist". This Use Case could be applied at both signalized and unsignalized intersections.

Use Case #15: Left Turn and Bicycle Near Miss

Figure 18. Left Turn and Bicycle Near Miss Use Case

Scenario

1. A vehicle (connected or legacy) is conducting a permissive left turn while a bicyclist is continuing straight through the intersection. The video analytics system detects both events.
2. The bicyclist has a near miss with the turning vehicle.
3. The video analytics system detects the near miss and stores the collected data.
4. The video analytics system aggregates the data and reports trends to the managing agency.
5. As trends of near misses are identified, the managing agency references the data and reports to assess the intersection performance and generate recommendations.

Potential Outcomes

If the video analytics system identifies a trend of near misses between vehicles and bicyclists, the managing agency can determine a series of safety countermeasures. Examples of these countermeasures include evaluating sight distance to determine if permissive left turns are appropriate in that location, providing exclusive bike phasing, or inhibiting permissive left turn movements when bicyclists are present. Using the video analytics system, the managing agency could then study if the measures lead to a decrease in near misses. This Use Case could be applied at both signalized and unsignalized intersections.

Use Case #16: Right Turn and Bicyclist Near Miss

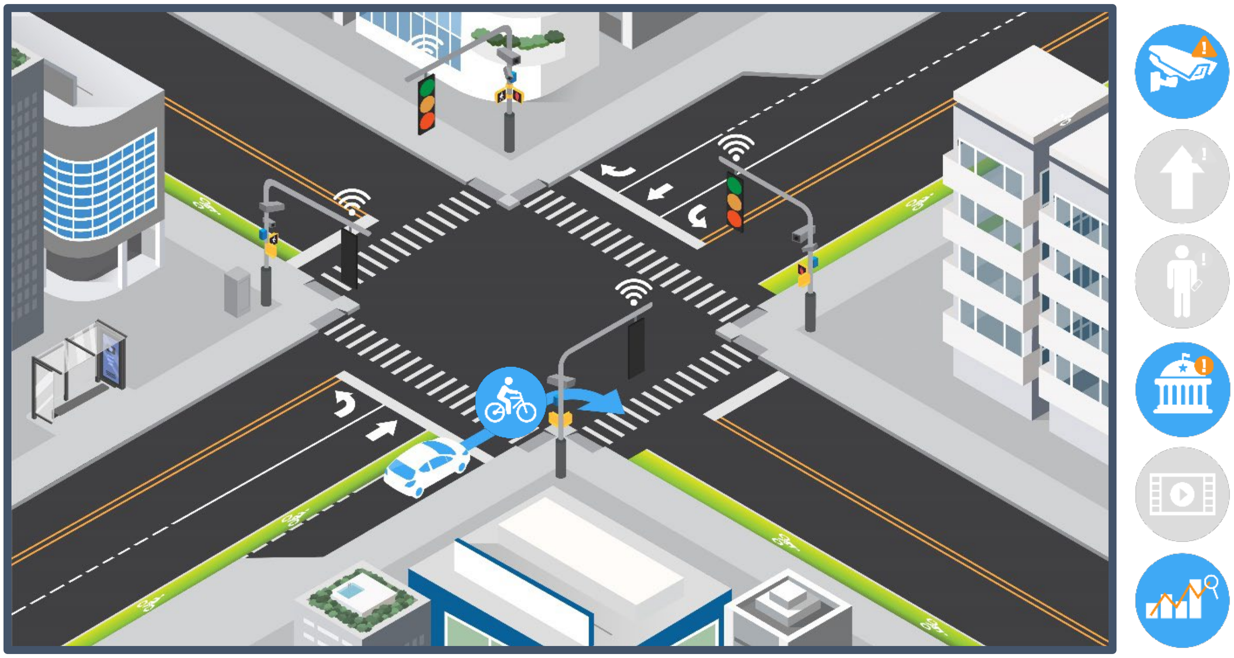


Figure 19. Right Turn and Bicyclist Near Miss Use Case

Scenario

1. A vehicle (connected or legacy) is turning right while a bicyclist is continuing straight or turning right in the intersection. The video analytics system detects both events.
2. The bicyclist has a near miss with the turning vehicle.
3. The video analytics system detects the near miss and stores the collected data.
4. The video analytics system aggregates the data and reports trends to the managing agency.
5. As trends of near misses are identified, the managing agency references the data and reports to assess the intersection performance and generate recommendations.

Potential Outcomes

This Use Case is separated out from left turn near misses due to the different nuances of right turns. Right turning vehicles are dangerous for bicyclists due to the risk of right hook crashes. If the video analytics system identifies a trend of near misses between vehicles and bicyclists, the managing agency can determine a series of safety countermeasures. Examples of these countermeasures include adding bike lanes, installing dedicated merging areas in bicycle lanes, and implementing exclusive bicycle phases. Utilizing the video analytics system, the managing agency could then study if the measures lead to a decrease in near misses. This Use Case could be applied at both signalized and unsignalized intersections.

CONCLUSION

This Use Case Memo presents the operational intentions of the proposed video analytics system in various scenarios. The Use Cases were broken into three user focus areas: pedestrians, vehicles, and bicyclists. They demonstrate the different scenarios along arterials where video analytics could help improve safety at intersections and midblock locations. The Use Cases range from presenting connected users with real-time data, providing the managing agency with data aggregations for trend analysis of safety warning signs, and providing the managing agency with data to analyze crashes.

The Use Cases Memo, in conjunction with the Market Assessment Report, will guide the development of the evaluation criteria for identifying and locating corridors and for assessing the applicability of the technology for MDOT’s use. The results of both reports will be used to derive the functional requirements as part of the request for proposal (RFP) development. The RFP will be used for the procurement of pilot deployments at locations that align with the scenarios defined in the Use Cases to ensure they support MDOT’s overall objectives.

Appendix C Corridor Evaluation Report

Corridor Evaluation

UTILIZING VIDEO ANALYTICS WITH CONNECTED VEHICLE FOR IMPROVED SAFETY

FINAL REPORT

MDOT

Kimley»Horn
of Michigan, Inc.

March 2023

OR2021 0250

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INTRODUCTION

MDOT is focused on identifying video analytics applications that can work in coordination with connected vehicle (CV) technology to proactively identify safety concerns and implement mitigation strategies in response to those concerns. The initial research effort and resulting pilot deployments will allow MDOT to evaluate the technologies' ability to capture crash, near miss, and other relevant data in support of immediate safety responses. Additionally, the data analysis should allow for trend analysis in support of safety improvements for the monitored locations. The ultimate objectives of the research findings include:

1. Reduce the frequency and severity of intersection crashes by using the data to understand crashes and near misses and make necessary improvements.
2. Reduce the frequency and severity of intersection and midblock crashes through traffic control and operational improvements.
3. Reduce crashes and fatalities by disseminating intersection and midblock conflict alerts to motorists and non-motorized users.

The findings of the pilot project are intended to support MDOT's decision regarding deployments of the technology. The pilot project will allow MDOT to assess both the technical and operational feasibility of video analytics systems. The results of the pilot project will guide the development of strategies that can be used to evaluate other locations and implement the technology based on specific needs, life cycle costs, and the proven benefit experienced from the pilot deployments.

This memo is focused on establishing an evaluation process for identifying corridors for implementation of the video analytics technology. A general philosophy is outlined for considering corridors for implementation. For the pilot study, the evaluation process is detailed for the selection of pilot locations. Additionally, the memo establishes considerations for identifying corridors for future deployments. The Corridor Evaluation Process was developed based on the Use Cases and revised based upon feedback from the Research Advisory Panel (RAP).

PHILOSOPHY

To begin evaluating corridors for the video analytics system, a philosophy was developed. Based upon the Use Cases, four key areas were identified for consideration when deploying the video analytics system. The four areas are safety issues, connected users, multimodal, and ease of implementation. Three of the key areas were established based on the project goals and use cases. The relationship between the key areas and use cases is shown in **Table 1**.

Table 1: Use Cases Relationship with Key Areas

USE CASES	KEY AREA		
	Safety Issues	Connected Users	Multimodal
Left Turn and Pedestrian Near Miss	●		●
Right Turn and Pedestrian Near Miss	●		●
Connected Users - Pedestrian in Crosswalk	●	●	●
Pedestrian Not Using Crosswalk	●		●
Pedestrian in the Road	●		●
Midblock Crossing Near Miss	●		●
Connected Users – Stopped Transit Vehicle Alert	●	●	●
Vehicle and Vehicle Near Miss	●		
Crash Detection	●		●
Connected Users - Left Turn Assist	●	●	
Connected Users - Red Light Running	●	●	
Hard Braking	●		
Connected Users - Bicyclist Proximity Alert	●	●	●
Connected Users - Left Turn and Bicycle	●	●	●
Left Turn and Bicycle Near Miss	●		●
Right Turn and Bicyclist Near Miss	●		●

The key areas of safety issues, connected users, and multimodal align with the project goal of improving safety issues along arterials and align with the Use Cases. The fourth key area is ease of implementation. Each of the key areas is detailed further below.

Multimodal

The multimodal key area was added with the recognition that vulnerable users are overrepresented in severe and fatal crashes, and additional effort is needed to identify and understand conflicts and crashes involving these users. Examples of users at an individual intersection include drivers, pedestrians, bicyclists, and transit users. The video analytics system can provide monitoring of the interactions between each of these users. Additionally, the system can report near misses and patterns of conflicts between vehicles and vulnerable users for proactive improvements to infrastructure.

Safety Issues

The safety issue key area recognizes that existing safety issues are prevalent on the corridor whether that is identified through crashes, reports from users or agency officials, or high safety risk (reference MDOT Pedestrian and Bicyclist Safety Risk Assessment Tool). The video analytics system can help identify these issues to allow for proactive response.

Connected Users

The connected users' key area recognizes the presence of connected users on the corridor. The video analytics system can push alerts to connected users to make them aware of potential crashes and other users.

Ease of Implementation

The ease of implementation key area recognizes the logistic and physical constraints that could hinder deployments such as outdated equipment at the intersection, construction, or geometric constraints.

Selection

The ideal corridor for deployment of the video analytics system would contain overlaps between the four key areas as demonstrated by the center of the Venn Diagram in **Figure 1**. While it is unlikely that a singular corridor will meet all the criteria, the goal for the evaluation is to identify corridors with overlap between as many key areas as possible. Based on this philosophy, metrics were developed to evaluate the pilot study locations and guidance was developed for the selection of future sites.

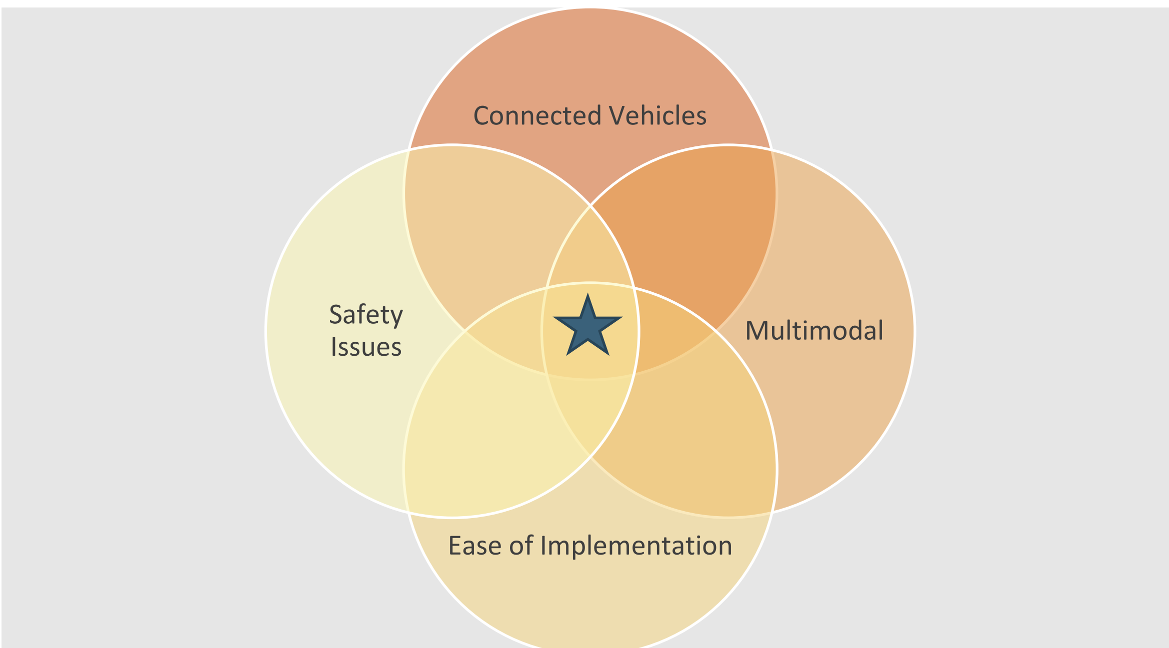


Figure 1: Corridor Evaluation Key Area Philosophy

PILOT LOCATION EVALUATION

Locations

For the pilot location evaluation, the RAP board was asked to provide locations that they felt would best meet the philosophy requirements. Many of the locations reflect areas where MDOT has received complaints or have high crash histories. The full list of provided locations is included in **Appendix A**.

Process

The process for the Pilot Location Evaluation was formulated based on the developed philosophy and key areas. For the Pilot Location Evaluation, the ability for a given location to have potential for testing a use case was also added as a key area for study. One of the goals of the pilots is to test as many use cases as possible. Therefore, the number of use cases was added as an additional key area as shown in **Figure 2**. Through discussions with MDOT, it was decided that the pilot would not test Connected Vehicle Technology at this time. That key area was not evaluated.

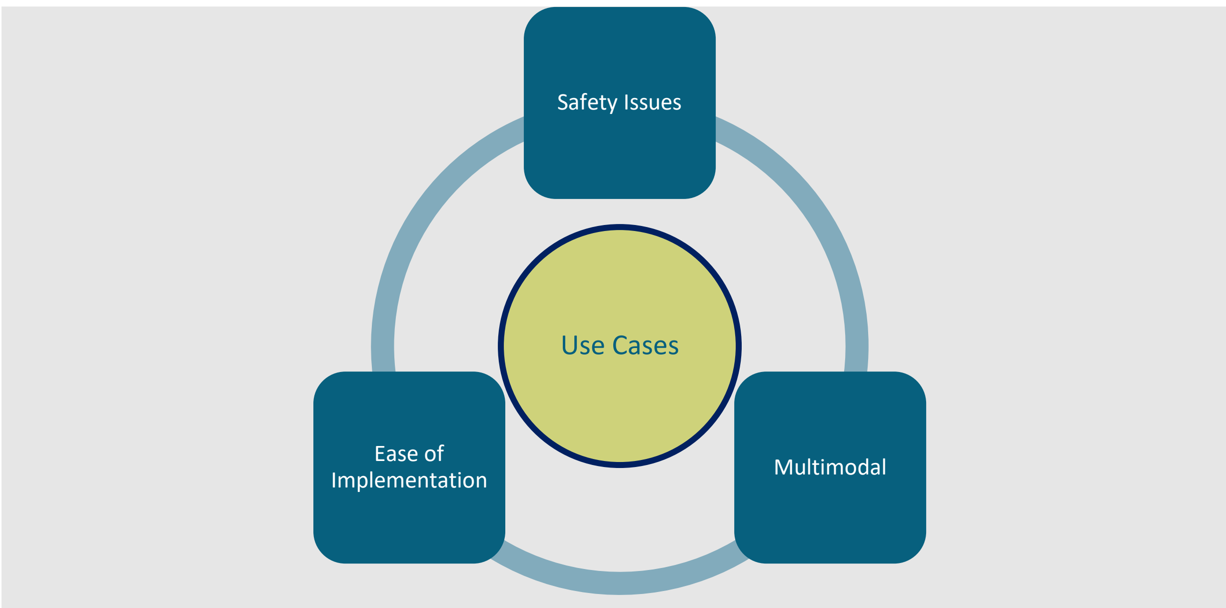


Figure 2: Pilot Location Evaluation Key Areas

For the Pilot Location Evaluation, metrics were developed based on the philosphy and available data. First, each intersection was evaluated based on ***Ease of Implementation*** to ensure that it is physically possible to place the equipment at the intersection, and that no construction was planned for the corridor in the near future. The Ease of Implementation process is a series of binary criteria based on having adequate camera view, consistency through the project, and room for the trailer. If the criteria is met, the evaluation is continued. Otherwise, the evaluation is stopped because it is not possible to deploy the technology. This process is shown in **Figure 3**.

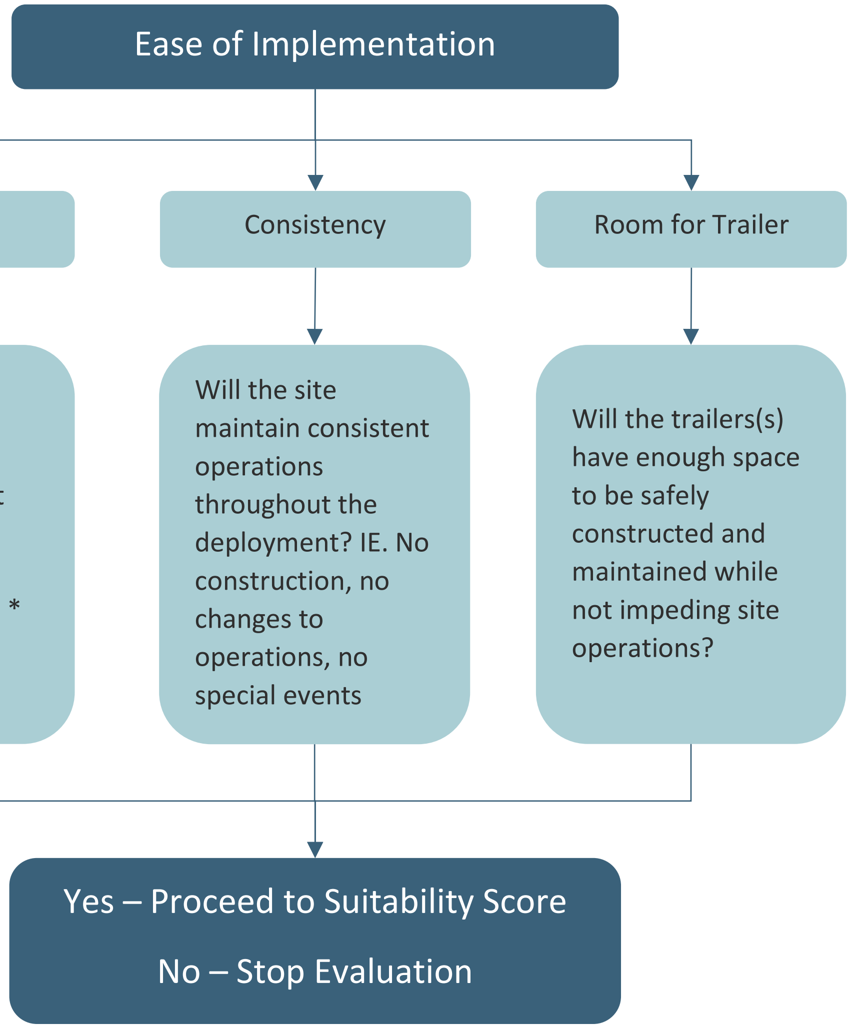


Figure 3: Ease of Implementation Process

*Observations based on Google Street view. Before deployment, an in-person site visit should be performed to verify that a proper view angle can be obtained.

Next, a series of metrics are calculated to quantify the key areas based on the philosophy. The evaluation criteria calculated are a ***Suitability Score***, ***Safety Prioritization***, and ***Use Cases***.

The first calculation is the ***Suitability Score.*** The Suitability Score is made up of two pieces, the ***Multimodal Evaluation*** and ***Safety Issue Evaluation***. The goal of the Suitability Score is to check that the intersection has multimodal users and there are noted safety issues at the intersection. The Multimodal Evaluation Process is shown in **Figure 4.**

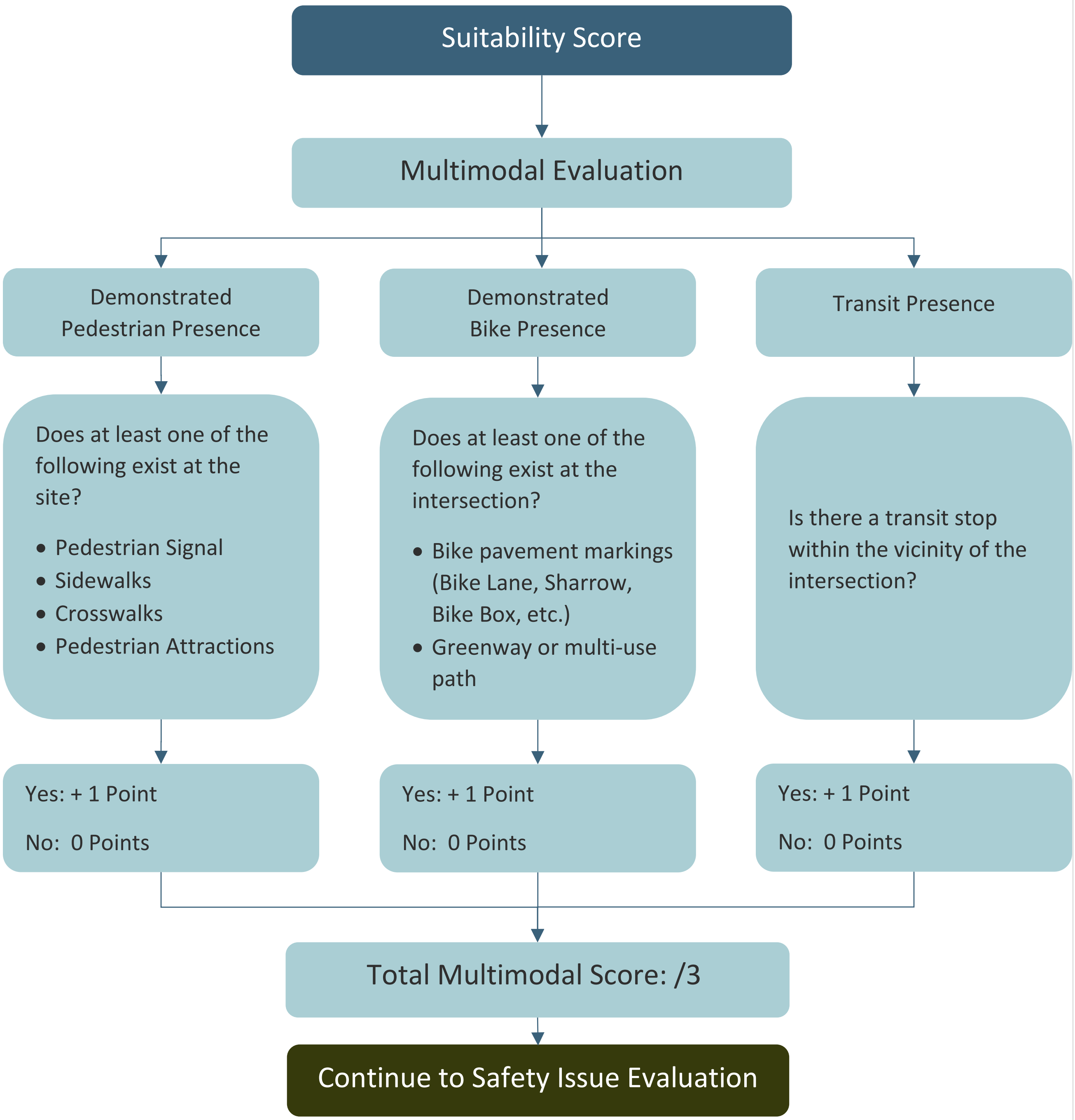


Figure 4: Multimodal Evaluation Process

The Safety Issue Evaluation is then performed to evaluate the likelihood of safety issues by considering bicycle crash data, pedestrian crash data, pedestrian risk, bicycle risk, agency reports, and fatal crash data. The Safety Issues Evaluation is shown in **Figure 5.**

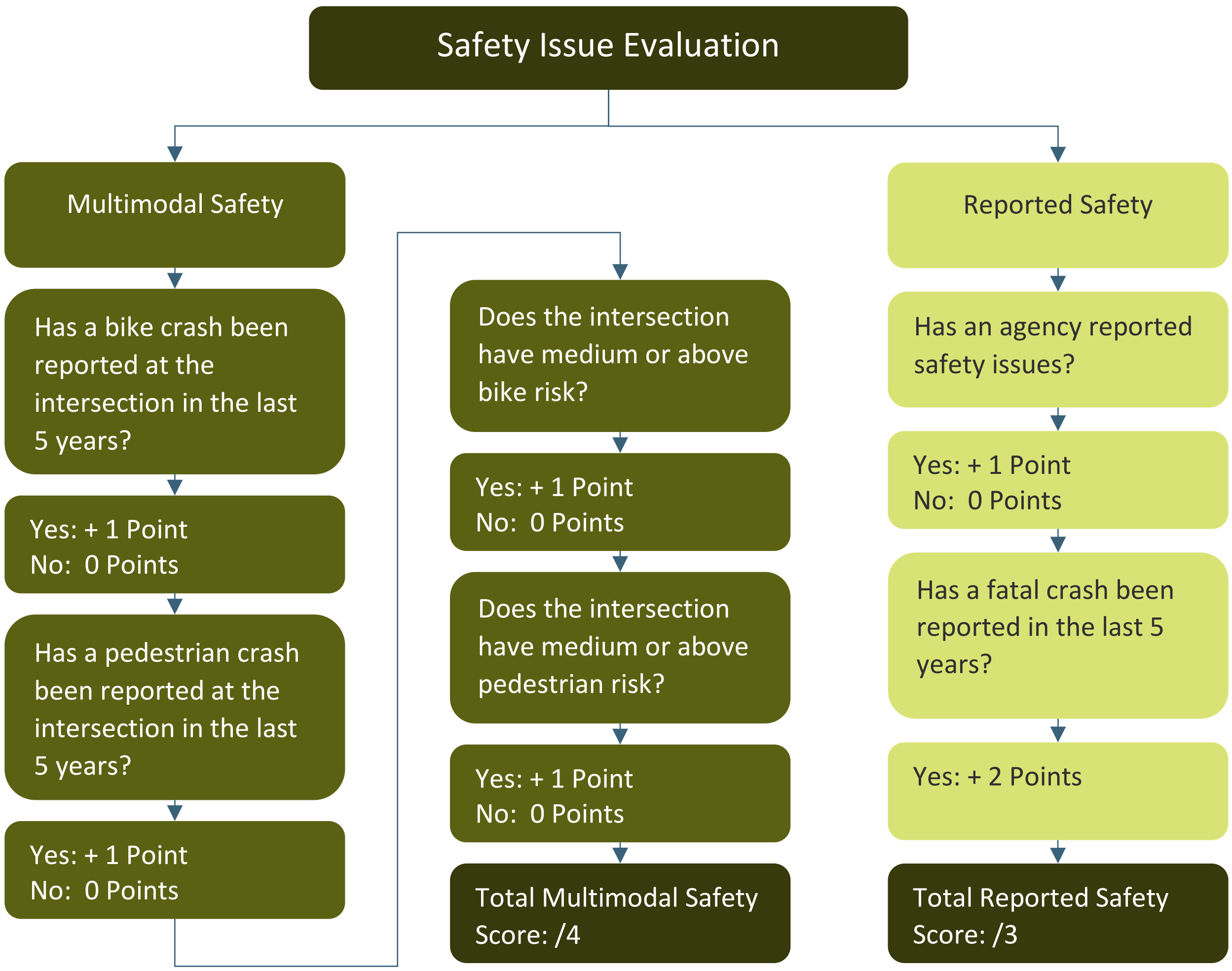


Figure 5: Safety Issue Evaluation Process

Finally, the Suitability Score is calculated using the Multimodal Score and Safety Issues Evaluation as shown in **Figure 6**.

Suitability Score = Multimodal Score + Safety Issue Evaluation

Figure 6. Suitability Score Equation

Next, the ***Safety Prioritization*** is performed to provide safety metrics to compare the intersections. The data utilized for these analyses was pulled utilizing the *Michigan Traffic Crash Facts Data Query Tool* for a five-year period. These metrics are calculated in addition to the Safety Issue Evaluation which ensures pedestrian, bicycle, and vehicular crashes are considered. The formulas used to perform the Safety Prioritization are shown in **Figure 7**.

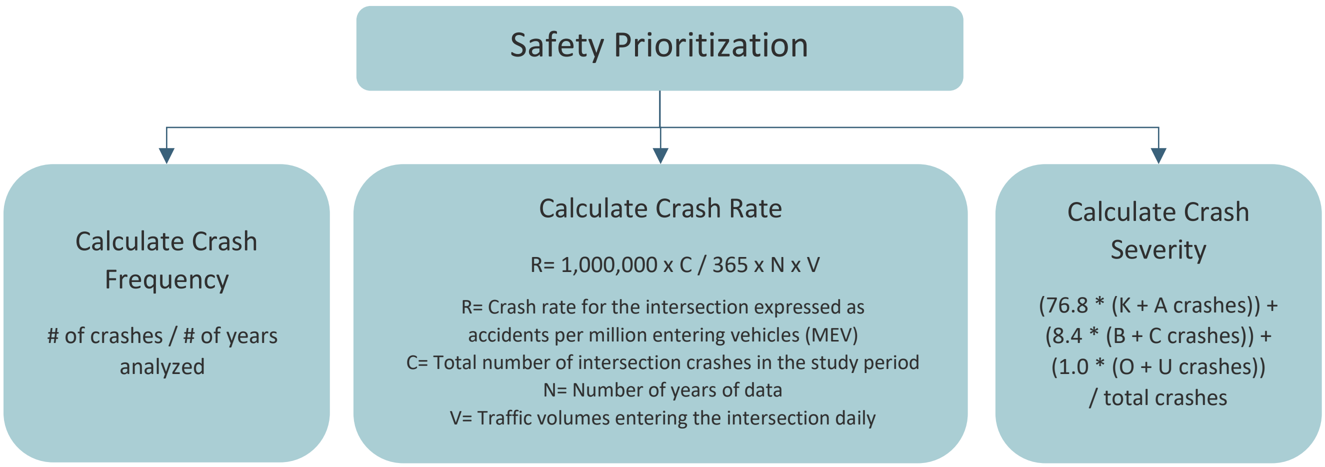


Figure 7: Safety Prioritization Equations

One of the goals of the pilot is to test as many ***Use Cases*** as possible for the video analytics system. Therefore, a checklist was created to identify which Use Cases could be studied at each intersection. This is shown in **Table 2**.

Table 2. Use Case Checklist

Use Cases	Applicable?
Pedestrian Use Cases	
Use Case #1: Left Turn and Pedestrian Near Miss	
Use Case #2: Right Turn and Pedestrian Near Miss	
Use Case #3: Connected Users - Pedestrian in Crosswalk	
Use Case #4: Pedestrian Not Using Crosswalk	
Use Case #5: Pedestrian in the Road	
Use Case #6: Midblock Crossing Near Miss	
Use Case #7: Connected Users – Stopped Transit Vehicle Alert	
Vehicle Use Cases	
Use Case #8: Vehicle and Vehicle Near Miss	
Use Case #9: Crash Detection	
Use Case #10: Connected Users - Left Turn Assist	
Use Case #11: Connected Users - Red Light Running	
Use Case #12: Hard Braking	
Bicyclist Use Cases	
Use Case #13: Connected Users - Bicyclist Proximity Alert	
Use Case #14: Connected Users - Left Turn and Bicycle	
Use Case #15: Left Turn and Bicycle Near Miss	
Use Case #16: Right Turn and Bicyclist Near Miss	
Total	

Southeast Detriot Example

For this pilot, the focus is on the Detroit Area. As the requirements for the pilot deployment were developed, it became apparent that the initial deployment would need to be based in the Detroit Area. Given that MDOT is supplying some of the equipment and vendors will be testing at the same locations, proximity to the MDOT personnel and a facility to maintain the equipment was necessary. The locations from the RAP board were filtered to only include the locations within the Detroit area. When corridors were provided, prefiltering was performed to identify the intersections with the most prevalent safety issues. Additionally, it was determined that the Use Cases involving connected vehicles would not be tested at this time. The following four locations were studied using the process outlined above.

- M-3 (Gratiot) at M-1 (Woodward)
- 9 Mile at M-1
- M-3 at Beaubien Blvd.
- M-3 at Brush St.

The detailed results of the corridor evaluation and proposed layouts of the trailers are included in **Appendix B**– Pilot Study Intersection Sheets. The calculated scores and metrics are summarized in **Table 3**.

Table 3. Summarized Scores and Metrics

Location	Suitability Score	Number of Use Cases	Crash Frequency	Crash Rate	Crash Severity
M-3 (Gratiot) at M-1 (Woodward)	6	7	4	0.41	1.37
9 Mile at M-1	7	6	16.4	0.73	6.89
M-3 at Beaubien Blvd.	5	7	5	0.45	11.21
M-3 at Brush St.	6	7	3.2	0.22	2.85

From the summary table, each of the intersections was ranked for each of the summarized scores and metrics. A rank of 1 reflects the highest score or metrics i.e., the most suitable intersection or worst safety metrics. The ranks were then summed to calculate a total prioritization score. The rankings are shown in **Table 4**.

Table 4. Pilot Location Rankings

Location	Suitability Score Rank	Use Cases Rank	Crash Frequency Rank	Crash Rate Rank	Crash Severity Rank	Total Prioritization Score
M-3 (Gratiot) at M-1 (Woodward)	2	1	3	3	4	13
9 Mile at M-1	1	4	1	1	2	9
M-3 at Beaubien Blvd.	4	1	2	2	1	10
M-3 at Brush St.	2	1	4	4	3	14

At the time of this memo, a site visit is still needed at each of the intersections to confirm the Ease of Implementation criteria. Given the size of the trailers and large footprint of some of the intersections, a site visit must be performed to determine that the cameras will be able to be deployed. The rankings of the intersections from the evaluation process and key attributes are shown below in **Table 5**. The detailed results of the corridor evaluation and proposed layouts of the trailers are included in **Appendix B**– Pilot Study Intersection Sheets.

Table 5. Southeast Detroit Corridor Rankings

Rank	Intersection	Key Attributes
1	9 Mile at M-1	• Highest crash frequency by 11.4 crashes per year. • Highest crash rate • Second highest crash severity • Demonstrated pedestrian and bicyclist safety issues • Will not test the Left Turn and Pedestrian Near Miss Use Case
2	M-3 at Beaubien Blvd.	• Highest crash severity, 63 % higher than other sites. • Second highest crash frequency • Second highest crash rate • Less likelihood of bicyclists. Demonstrated pedestrian safety issues.
3	M-3 (Gratiot) at M-1 (Woodward)	• Lowest crash severity • Third crash rate and crash frequency • Demonstrated pedestrian safety issues • MDOT has received several reports of safety issues at the intersection
4	M-3 at Brush St.	• Lowest crash rate and crash frequency • Third crash severity • Demonstrated pedestrian and bicyclist safety issues.

FUTURE SITE SELECTION GUIDANCE

Utilizing the experience of selecting the corridor for the pilot study, guidance was developed to assist with future site selection for video analytics systems. The philosophy as discussed previously and shown in **Figure 1** should be utilized to guide site selection.

The metrics used to evaluate the key areas will depend on available data in the region. For the pilot study evaluation, several data sources were utilized as shown in **Table 6**. Overall, Michigan had very detailed data available for the Detroit Region. Other locations may have to adapt the philosophy depending on available sources.

Table 6. Pilot Study Data Sources

Source	Data Utilized
Google Maps	• Aerial imagery for geometric observations • Transit stop identification
MDOT Pedestrian and Bicyclist Safety Risk Assessment Tool	• Pedestrian and bicyclist risk
MDOT Project Management Team	• Feedback on reported safety issues and corridors
Michigan Traffic Crash Facts	• Detailed Crash data
NearMap	• Aerial imagery for geometric observations
RAP Board	• Initial corridor list
SEMCOG Traffic Volume Map	• Annual Average Daily Traffic (AADT) data utilized for Safety Prioritization

The pilot study focused on identifying locations for the installation of the video analytics system on portable trailers. Future implementations should consider both portable and permanent solutions depending on the goals of the deployments. Permanent systems are preferable for long term monitoring of intersections with historic safety issues. Permanent systems also allow for real time data sharing with roadway users, first responders, traffic incident management, and DOT personnel. Additionally, permanent systems can be connected to traffic signal controllers to collect more data. The benefits and challenges of the permanent systems are further described in **Figure 8.**

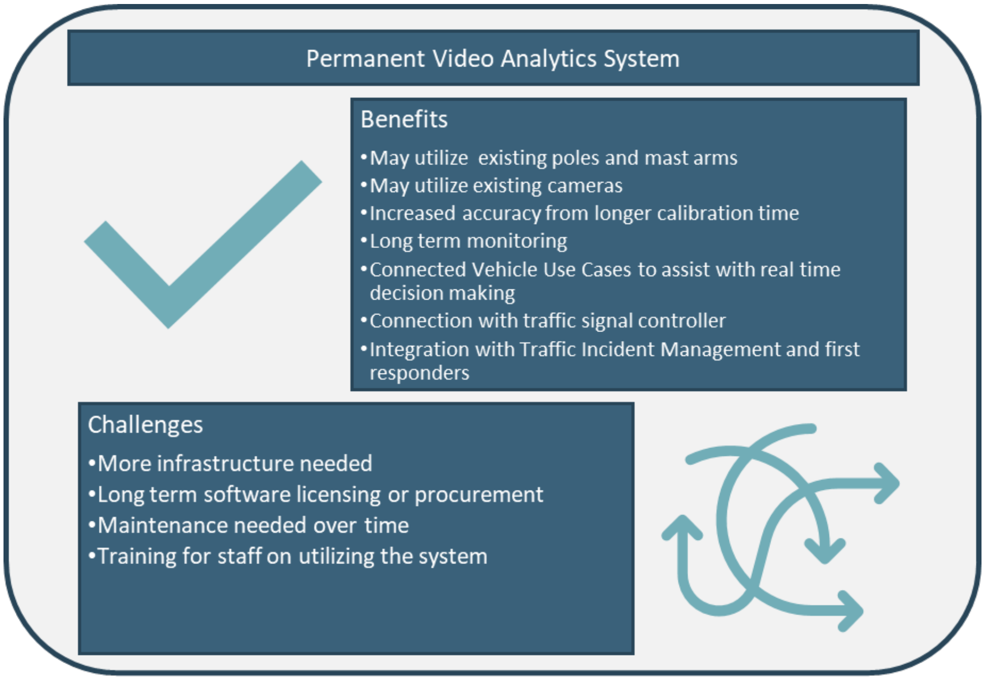


Figure 8. Permanent Video Analytics System Benefits and Challenges

Portable systems are preferable for short term monitoring of increasing safety issues at an intersection. For example, if an agency is receiving reports of increased safety issues at an intersection, the portable system can be deployed to study the intersection. The portable system allows for the technology to be moved around to study multiple intersections without having to connect to the infrastructure at the intersection. The benefits and challenges of the portable system are described in **Figure 9**.

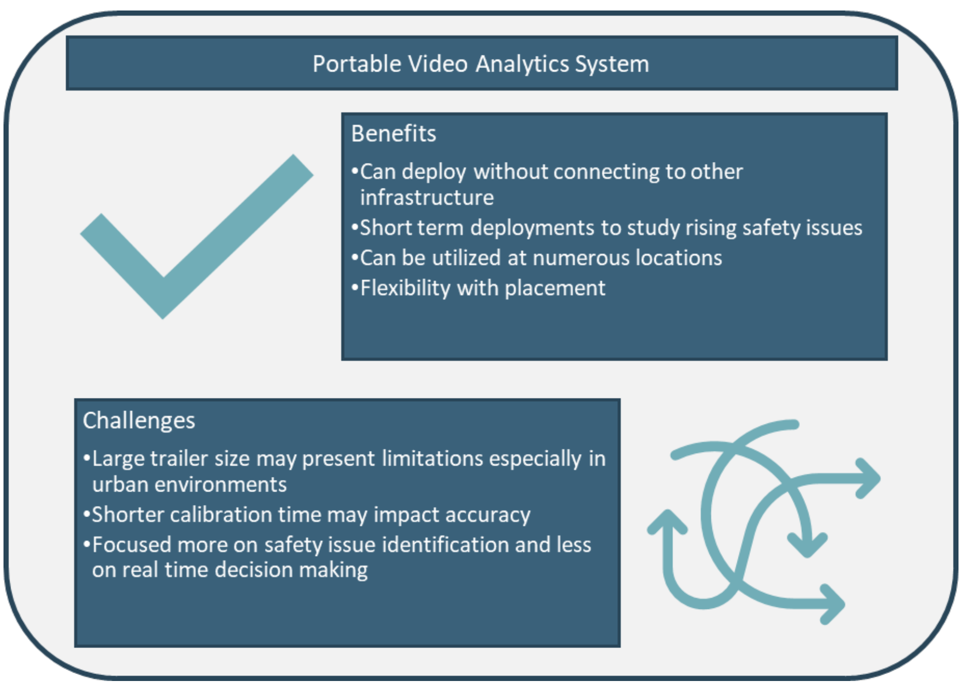


Figure 9. Portable Video Analytics System Benefits and Challenges

CONCLUSION

This Corridor Evaluation Memo presents the methods utilized to evaluate potential locations to deploy the video analytics system. A philosophy was presented to represent the key areas that need to be considered before selecting a location. Then the methodology used to evaluate four corridors in Southeast Detroit and results were presented. Lastly, guidance for future evaluations of sites was provided.

Following this memo, site visits will be performed at each of the four intersections to confirm the Ease of Implementation criteria are met. Conversations will be held with the Project Management Team to ultimately select the locations for pilot deployment supported by the results of the corridor evaluation.

APPENDICIES

Appendix A – Locations for Consideration from the RAP board

Location	*City*	*County*	*Type (Intersection or Corridor)*	*Evaluated*
M-3 Gratiot Corridor at M-1 Woodward	Detroit	Wayne	Intersection	X
M-3	Detroit	Wayne	Corridor	X
M-43 at W. Main	Kalamazoo	Kalamazoo	Intersection	
I-75 Business Route	Sault Ste. Marie	Chippewa	Corridor	
Lincoln at Ludington	Escanaba	Delta	Intersection	
US 2 at M-35	Gladstone	Delta	Intersection	
Downtown St Ignace	St. Ignace	Mackinac	Corridor	
9 Mile at M-1	Ferndale	Oakland	Intersection	X
US-31	Grand Haven	Ottowa	Corridor	
M-89	Ostego	Allegan	Corridor	
US-31BR	Muskegon	Muskegon	Corridor	
M-37/East Beltline	Grand Rapids	Kent	Corridor	
M-89 at Farmers St.	Ostego	Allegan	Intersection	
US-31BR at Norton Ave.	North Shores	Muskegon	Intersection	
US-31 at Jackson St.	Grand Haven	Ottowa	Intersection	
M-11 to Lake Eastbrook	Grand Rapids	Kent	Intersection	

Two additional locations were evaluated where existing video analytics technology is currently deployed under a different MDOT project. The information from this evaluation will be used for comparison during the final assessment report. Those locations are listed below, and their evaluation sheets are in **Appendix B**– Pilot Study Intersection Sheets.

- M-53 at GM Tech Center Rd.
- E. Jefferson at Randolph St.

Appendix B– Pilot Study Intersection Sheets

INTERSECTION: M3(GRATIOT) AT M 1 (WOODWARD)

CITY: DETROIT		
COUNTY: WAYNE		
Ease of Implementation		Suitability Score
Need to Confirm		6/10
Safety Prioritization		
Crash Frequency	*Crash Rate*	*Crash Severity*
4 per year	.41 per MEV	1.37
Site Overview		
Potential for trailer to impede pedestrian sidewalks in Urban Core Area. Confirm trailer placement and camera view of the intersection.		

Use Cases	
Pedestrian Use Cases	
Left Turn and Pedestrian Near Miss	Y
Right Turn and Pedestrian Near Miss	Y
Connected Users - Pedestrian in Crosswalk	N/A
Pedestrian Not Using Crosswalk	Y
Pedestrian in the Road	N
Midblock Crossing Near Miss	N
Connected Users – Stopped Transit Vehicle Alert	N/A
Vehicle Use Cases	
Vehicle and Vehicle Near Miss	Y
Crash Detection	Y
Connected Users - Left Turn Assist	N/A
Red Light Running	Y
Hard Braking	Y
Bicyclist Use Cases	
Connected Users - Bicyclist Proximity Alert	N/A
Connected Users - Left Turn and Bicycle	N/A
Left Turn and Bicycle Near Miss	N
Right Turn and Bicyclist Near Miss	N
Total:	7

INTERSECTION: 9 MILE AT M 1

CITY: FERNDALE	
COUNTY: OAKLAND	
Ease of Implementation	Suitability Score
Need to Confirm	7/10

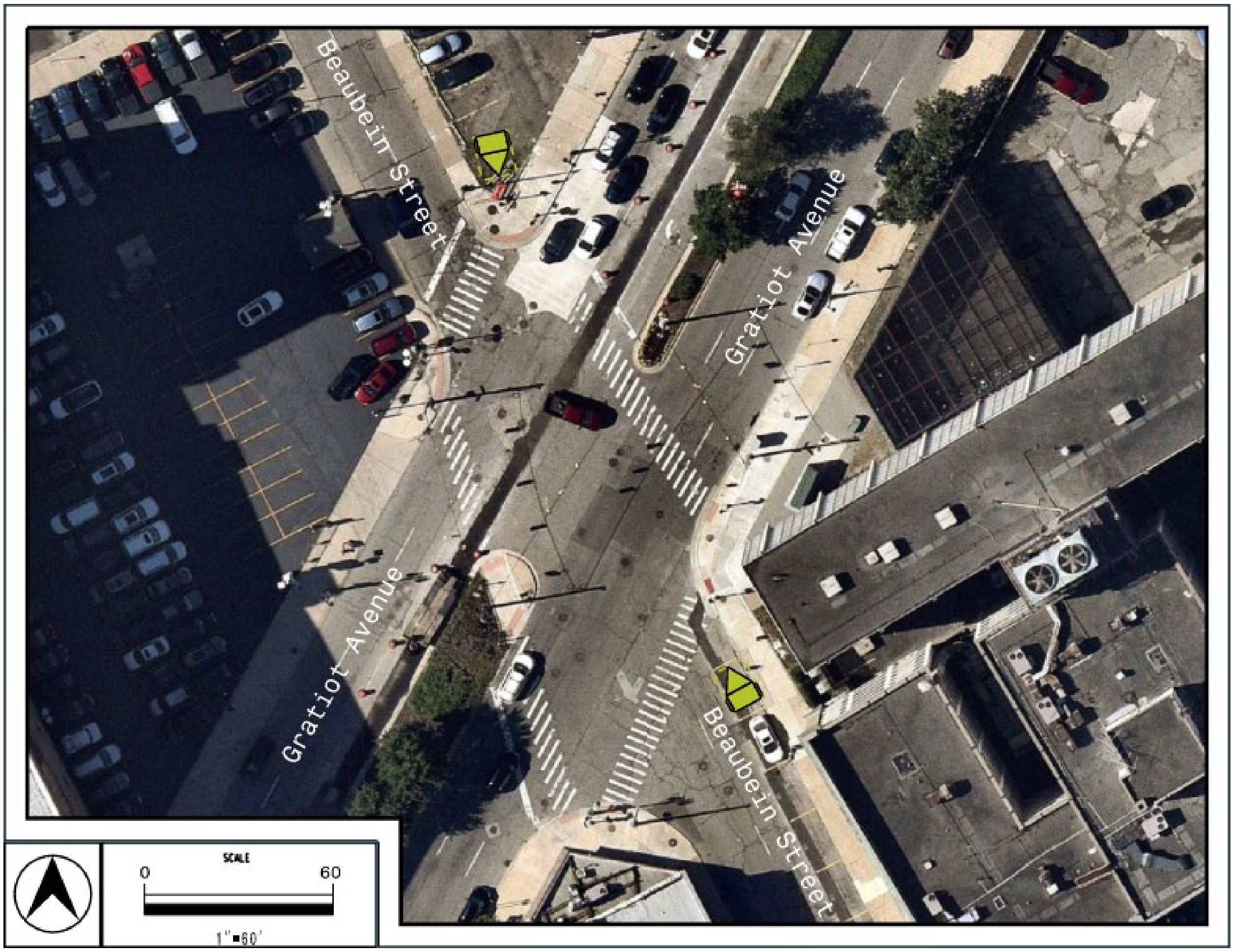
Safety Prioritization		
Crash Frequency	*Crash Rate*	*Crash Severity*
16.4 per year	.73 per MEV	6.89

Site Overview

- Identify and confirm trailer locations.
- Confirm camera angle and capabilities given the large intersection footprint.

Use Cases	
Pedestrian Use Cases	
Left Turn and Pedestrian Near Miss	N
Right Turn and Pedestrian Near Miss	Y
Connected Users - Pedestrian in Crosswalk	N/A
Pedestrian Not Using Crosswalk	Y
Pedestrian in the Road	N
Midblock Crossing Near Miss	N
Connected Users – Stopped Transit Vehicle Alert	N/A
Vehicle Use Cases	
Vehicle and Vehicle Near Miss	Y
Crash Detection	Y
Connected Users - Left Turn Assist	N/A
Red Light Running	Y
Hard Braking	Y
Bicyclist Use Cases	
Connected Users - Bicyclist Proximity Alert	N/A
Connected Users - Left Turn and Bicycle	N/A
Left Turn and Bicycle Near Miss	N
Right Turn and Bicyclist Near Miss	N
Total:	6

c



Intersection: M 3 at Beaubien Blvd.

City: Detroit		
County: Wayne		
Ease of Implementation	Suitability Score	
Need to Confirm	5/10	
Safety Prioritization		
Crash Frequency	*Crash Rate*	*Crash Severity*
5 per year	.45 per MEV	11.21

Site Overview

- Identify and confirm trailer locations.
- Confirm camera angle and capabilities given the large intersection footprint.

Use Cases	
Pedestrian Use Cases	
Left Turn and Pedestrian Near Miss	Y
Right Turn and Pedestrian Near Miss	Y
Connected Users - Pedestrian in Crosswalk	N/A
Pedestrian Not Using Crosswalk	Y
Pedestrian in the Road	N
Midblock Crossing Near Miss	N
Connected Users – Stopped Transit Vehicle Alert	N/A
Vehicle Use Cases	
Vehicle and Vehicle Near Miss	Y
Crash Detection	Y
Connected Users - Left Turn Assist	N/A
Red Light Running	Y
Hard Braking	Y
Bicyclist Use Cases	
Connected Users - Bicyclist Proximity Alert	N/A
Connected Users - Left Turn and Bicycle	N/A
Left Turn and Bicycle Near Miss	N
Right Turn and Bicyclist Near Miss	N
Total:	7

INTERSECTION: M 3 AT BRUSH ST.

CITY: DETROIT

COUNTY: WAYNE

Ease of Implementation	Suitability Score
Confirm with MDOT	6/10

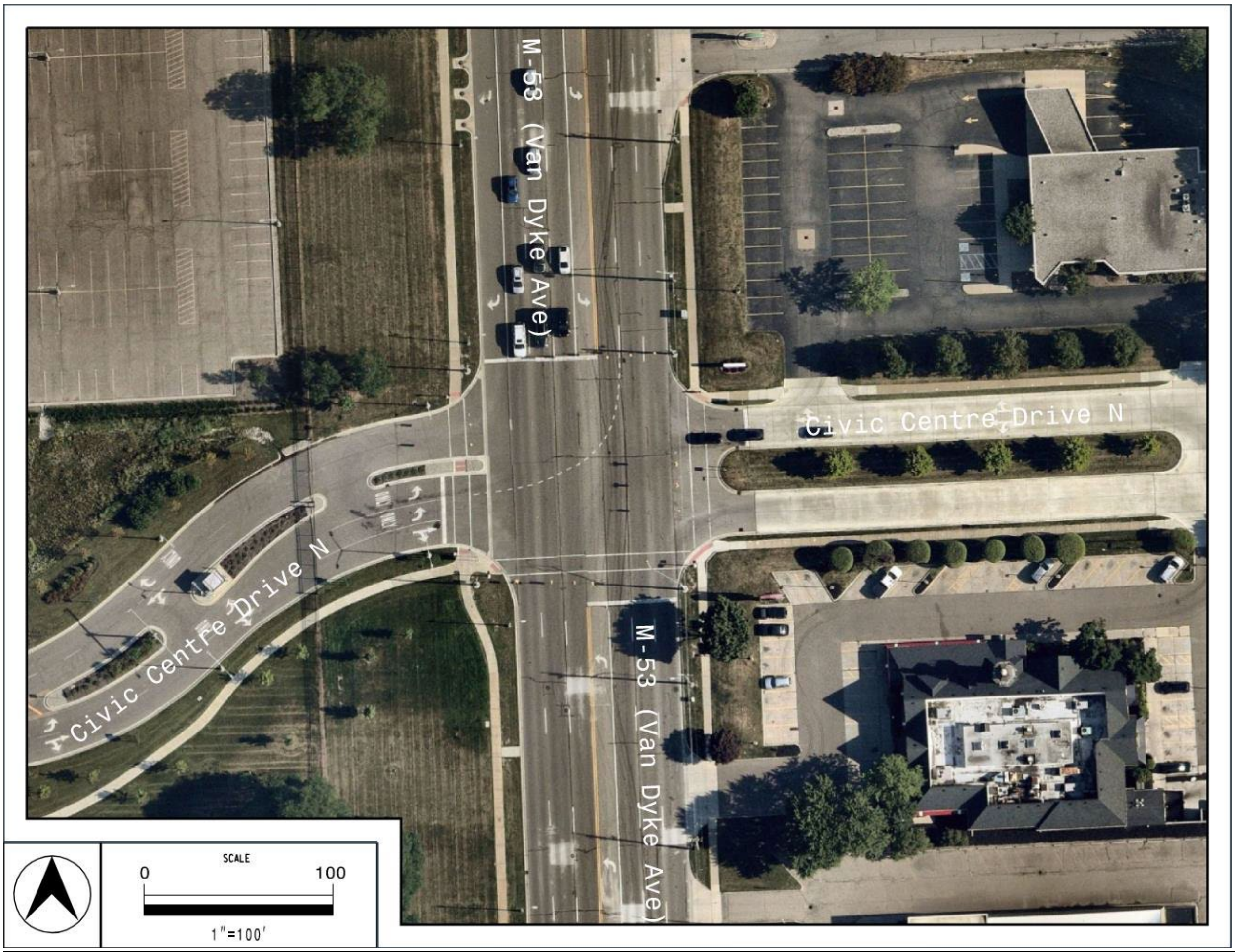
Safety Prioritization		
Crash Frequency	*Crash Rate*	*Crash Severity*
3.2 per year	.22 per MEV	2.85

Site Overview

- Identify and confirm trailer locations.
- Confirm camera angle and capabilities given the large intersection footprint

Use Cases	
Pedestrian Use Cases	
Left Turn and Pedestrian Near Miss	Y
Right Turn and Pedestrian Near Miss	Y
Connected Users - Pedestrian in Crosswalk	N/A
Pedestrian Not Using Crosswalk	Y
Pedestrian in the Road	N
Midblock Crossing Near Miss	N
Connected Users – Stopped Transit Vehicle Alert	N/A
Vehicle Use Cases	
Vehicle and Vehicle Near Miss	Y
Crash Detection	Y
Connected Users - Left Turn Assist	N/A
Red Light Running	Y
Hard Braking	Y
Bicyclist Use Cases	
Connected Users - Bicyclist Proximity Alert	N/A
Connected Users - Left Turn and Bicycle	N/A
Left Turn and Bicycle Near Miss	N
Right Turn and Bicyclist Near Miss	N
Total:	7

e



Intersection: M 53 at GM Tech Center Rd.

City: Detroit		
County: Wayne		
Ease of Implementation	Suitability Score	
Confirm with MDOT	2/10	
Safety Prioritization		
Crash Frequency	*Crash Rate*	*Crash Severity*
.8 per year	.02 per MEV	1
Site Overview		

Use Cases	
Pedestrian Use Cases	
Left Turn and Pedestrian Near Miss	Y
Right Turn and Pedestrian Near Miss	Y
Connected Users - Pedestrian in Crosswalk	N/A
Pedestrian Not Using Crosswalk	N
Pedestrian in the Road	N
Midblock Crossing Near Miss	N
Connected Users – Stopped Transit Vehicle Alert	N/A
Vehicle Use Cases	
Vehicle and Vehicle Near Miss	Y
Crash Detection	Y
Connected Users - Left Turn Assist	N/A
Red Light Running	Y
Hard Braking	Y
Bicyclist Use Cases	
Connected Users - Bicyclist Proximity Alert	N/A
Connected Users - Left Turn and Bicycle	N/A
Left Turn and Bicycle Near Miss	Y
Right Turn and Bicyclist Near Miss	Y
Total:	8

Intersection: E. Jefferson at Randolph St.

City: Detroit

County: Wayne

Ease of Implementation	Suitability Score	
Confirm with MDOT	5/10	
Safety Prioritization		
Crash Frequency	*Crash Rate*	*Crash Severity*
12 per year	.45 per MEV	3

Site Overview

- MDOT to confirm existing camera location

Use Cases	
Pedestrian Use Cases	
Left Turn and Pedestrian Near Miss	Y
Right Turn and Pedestrian Near Miss	Y
Connected Users - Pedestrian in Crosswalk	N/A
Pedestrian Not Using Crosswalk	Y
Pedestrian in the Road	Y
Midblock Crossing Near Miss	N
Connected Users – Stopped Transit Vehicle Alert	N/A
Vehicle Use Cases	
Vehicle and Vehicle Near Miss	Y
Crash Detection	Y
Connected Users - Left Turn Assist	N/A
Red Light Running	Y
Hard Braking	Y
Bicyclist Use Cases	
Connected Users - Bicyclist Proximity Alert	N/A
Connected Users - Left Turn and Bicycle	N/A
Left Turn and Bicycle Near Miss	Y
Right Turn and Bicyclist Near Miss	Y
Total:	10

Appendix D Analytic Report

ANALYTIC REPORT

UTILIZING VIDEO ANALYTICS WITH CONNECTED VEHICLE FOR IMPROVED SAFETY

DECEMBER 2023

OR2021-0250

MDOT

Kimley»Horn
of Michigan, Inc.

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Version Control

Version	Author/QC	Date	Changes
1.0	Sarah Butler/ Amanda Good/ Jeff Dale	11/15/2023	
1.1	KH	12/21/2023	Revised text per initial comments.

Introduction

The Michigan Department of Transportation's (MDOT) conducted a pilot demonstration to test video analytic technologies. MDOT was not looking to select any one vendor at the end of the demonstration, but rather confirm the technology can work to meet their needs of identification of near misses to support a proactive response. The demonstration was to do two things:

1. Assess the capabilities within the market; (and)
2. Validate the possible value for implementing the systems in Michigan.

The ultimate goal of this pilot demonstration was to identify the feasibility of the technology, what is available, and what are the capabilities, and then write specifications for MDOT to use in future projects. The demonstration identified three key performance indicators (KPIs) to support the validation of the technology and used the data provided from each vendor to assess. The KPIs used to assess the technologies' ability included the following.

- How many times was an event identified (at all)?
- How many times was an event identified accurately?
- How many times was an event missed?

This assessment report provides a summary of the findings from pilot demonstration. These findings are intended to support MDOT's decision regarding future deployments of the technology and provide guidance on the designation of viable locations for implementing the technology based on specific needs. The report includes the following sections:

- Introduction – brief overview of the demonstration
- Technology Demonstration Opportunity – defines the process MDOT took to set up the demonstration
- Findings – summarizes the results of the data evaluation and considerations MDOT could incorporate as they look to support future deployments
- Summary and Recommendations – provides a summary of the demonstration and recommendations for MDOT regarding the video analytic technology

Project Description

This demonstration is one step from MDOT's research project, *identify and vet emerging technologies that can help save lives through better analysis and proactive responses*. MDOT recognizes the ability of operations to leverage technology to improve safety by decreasing or eliminating fatalities and serious injuries due to crashes. This is further supported by an ability to identify near-misses so MDOT can determine and implement mitigation strategies that address issues that may cause unsafe conditions – thereby implementing strategies before the crashes occur. The research focuses on the solutions' functions relative to intersection and midblock interactions between motorized vehicles, pedestrians, bicyclists, and other non-motorized users.

The research project deliverables completed to date that supported this demonstration include:

- Market Assessment Memo – preliminary research on vendors currently providing video analytic technology through outreach, surveys, online searches, and a request for information (RFI).

- Use Case Memo – presented the operational intentions of the proposed system under difference circumstances to allow for a better understanding of the roles of different users in various scenarios.
- Corridor Evaluation Memo – established considerations for identifying corridors for the pilot and future deployments.

Utilizing information from the three memos, noted above, defined the structure for the demonstration, formally noted as Technology Demonstration Opportunity. The intent for the demonstration was to identify vendors willing to deploy infrastructure at a specific location to test their technology's capability against established use cases. The RFP/Demonstration was open to all potential vendors.

Technology Demonstration Opportunity

The demonstration process took various steps and pivots before finalizing both the infrastructure, location, timeframe, and data. The following section presents the steps and decisions made through the process.

Temporary or Permanent

The initial intent for the demonstration was to utilize existing infrastructure at a specified location. This option would include permitting vendors to install their analytic equipment on an existing pole, connect to a controller for signal phasing and timing (SPaT) information, and access camera video feeds already in place.

> Existing Infrastructure Due to security concerns from Michigan's Department of Technology, Management, and Budget's (DTMB) and the added complexity, MDOT abandoned this option.

MCity, located on the University of Michigan's campus, was another consideration. MCity is a testing ground for "…testing the performance and safety of connected and automated vehicles and technologies under controlled and realistic conditions." The idea for this option was for vendors to install their systems on a section of the facility, and then have a test vehicle and people simulate a scenario(s) to then collect data. Although DOT was the testing agency, MCity still needed a funding and liability agreement to permit MDOT access for vendor testing.

> MCity Due to funding, potential liability to operate on the facility grounds, and extensive coordination efforts, MDOT abandoned this option.

The third option MDOT considered was the **Use of Portable Trailers.** Ultimately MDOT agreed to use two (temporary) portable trailers, MDOT owned. The idea behind the trailer was to install all necessary equipment, include capacity for additional equipment from the vendors, and provide access to the cameras on the trailers. The equipment would not be connected to MDOT's network, therefore minimal security concerns.

Equipment Procurement

MDOT proceeded to procure the necessary equipment to install on the trailers. This included:

- AXIS 5m pre-terminated cables
- Q6100E cameras
- TQ6812E kit, cover compatible with the cameras

- RJ45 cable kits (5700-371)

The trailers used solar power. The panel specifications were SLP270-24 (High Efficiency Multicrystalline PV Module).

Although MDOT procured the equipment prior to the advertisement of the RFP, the availability and lead time of the equipment pushed the actual demonstration timeframe by several weeks.

Request for Proposal

The RFP, advertised in November 2022, comprised information including the goal of the pilot project, equipment provided by MDOT, and equipment needed by the vendors. The RFP clearly stated that the selection did not include any procurement of equipment, and instead, the department was *requesting partnerships with the responding vendors*. The vendors needed to be willing to install their equipment on the trailers at their own costs. Six vendors submitted applications to demonstrate: five vendors using video and one vendor using Lidar technology.

In addition to the long lead times for equipment procurement, MDOT made the decision to hold off on the demonstration until the spring. This would avoid driving behaviors impacted by weather and other potential impacts. As such, MDOT held six vendor project team meetings mid- to early spring to discuss logistics, schedule, and questions/answers from the vendors. ***Table 1*** includes the list of vendors who participated in the demonstration and when the project team initially met with each vendor team.

Table 1: Participating Vendors in the RFP

Vendor	Meeting Date
Accenture	4/21/2023
Currux	4/14/2023
IBM	4/20/2023
Smartek	4/14/2023
Transoft Solutions	4/13/2023
Velodyne (Lidar)	4/11/2023

Configuration

The demonstration consisted of various configuration parameters. These parameters are detailed below.

Location: Prior to outfitting the portable trailers, MDOT selected the location for the demonstration based on the Corridor Evaluation parameters noted in the *Corridor Evaluation Memo*. The demonstration location was M-3/Gratiot Ave at Beaubien Blvd. in downtown Detroit.

Refer to ***Figure 1***, the green circle denoting the demonstration intersection. The trailer was placed in the northern median to have minimal impacts to pedestrians using the crosswalk.

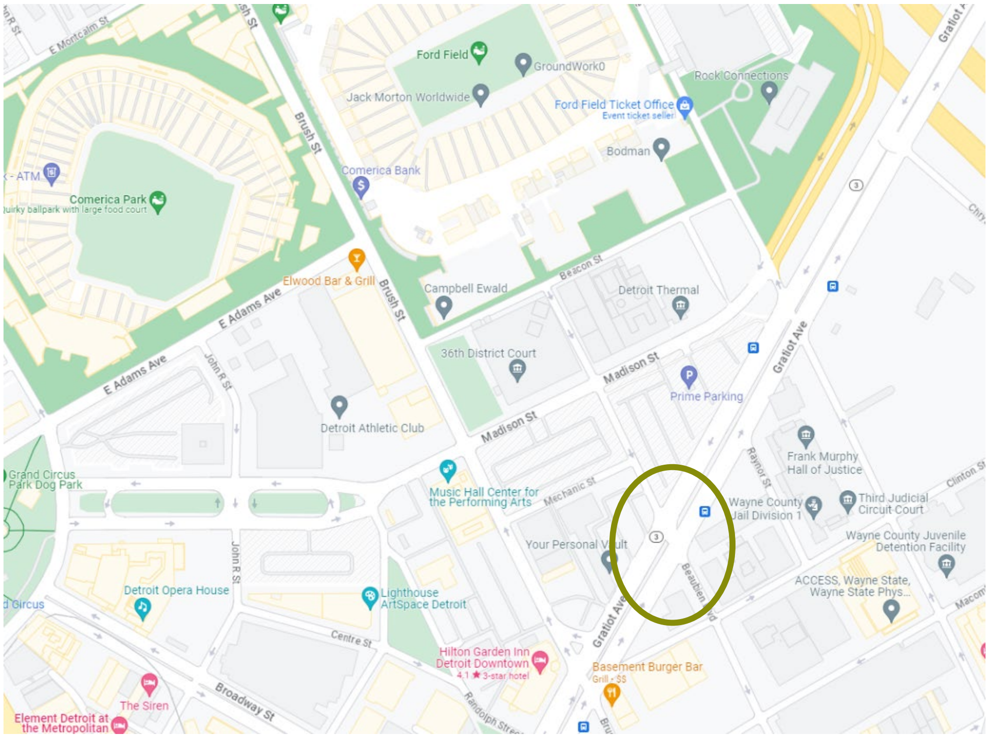

Figure 1. Map of the Demonstration Location

Figure 2. Trailer at M-3/Gratiot Ave and Beaubien Blvd.

Refer to ***Figure 2*** for a close-up of the trailer placement at the intersection. Vendors received viewsheds of the camera views to confirm approximately what the cameras would be able to view at this intersection, see ***Figure 3***. Minimal comments were received regarding concerns of the camera views.

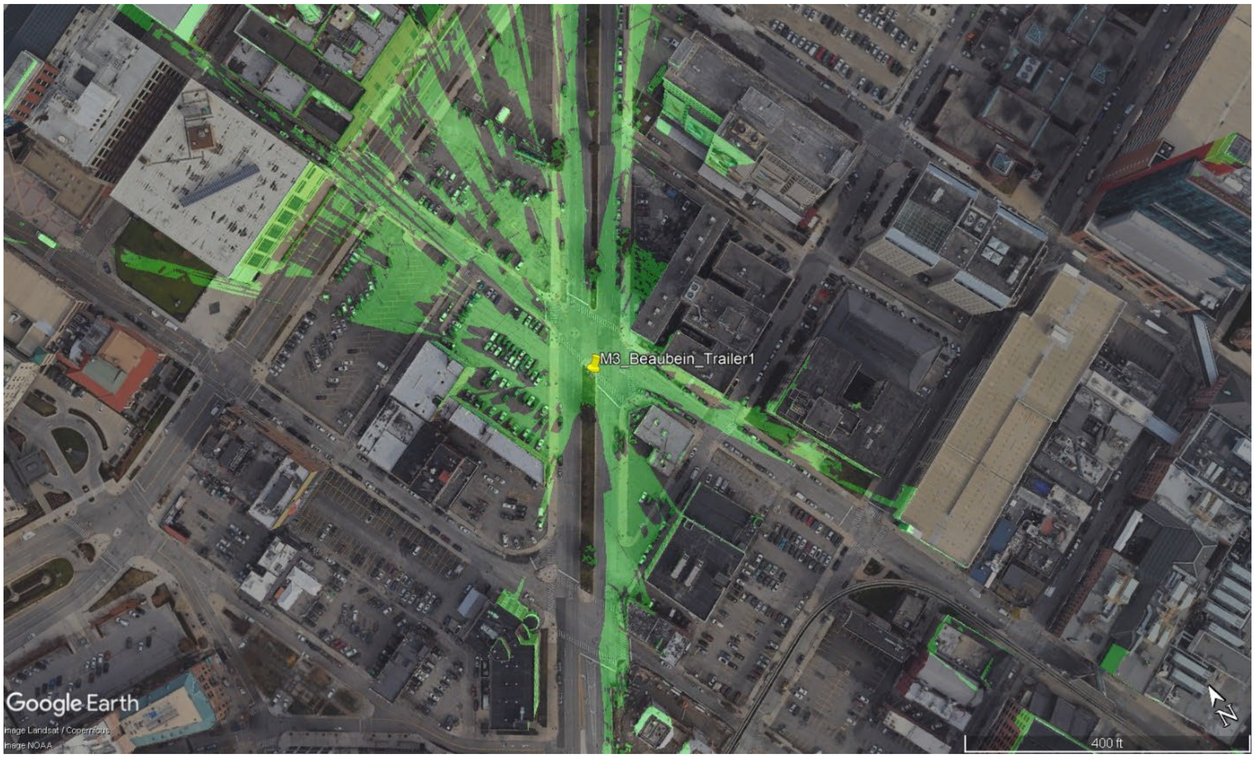

Figure 3. Viewshed at M-3/Gratiot Ave and Beaubien Blvd.

Equipment Set Up: The trailers included additional equipment, two quad-sensor cameras (one stream with four videos in a grid) with the specifications of 25 frames per second @ H-265 and a camera resolution for the single feed of 1920 x 1080 and quad feed of 2560 x 1920.

Figure 4 shows the camera grid view. Cellular modems and SD cards provided video streaming and storage.

During site analysis, the project team decided to purchase a lock to secure the trailer to its location.

Data Collection Parameters: Vendors were to analyze video for events that occurred during the following times:

- 6am-9am (AM peak)
- 12pm-2pm (mid-day)
- 6pm-9pm (PM peak)

Figure 4. Video Grid from the Cameras on the Trailers

Based on feedback from one of the vendors, an optional time was given to all vendors: 12am-3am (overnight). Due to logistical issues and bandwidth capacity with the cell modems, the project team decided to record the intersection video and provide each vendor with a hard drive for video analysis.

The vendors were expected to match events to use cases accepted for the demonstration. ***Table 2*** highlights the nine use cases identified for demonstration. Unfortunately, not all the use cases could be demonstrated due to the use and location of the portable trailer, per vendor feedback.

Table 2. Use Cases Tested During Demonstration

Use Cases	Tested During Demonstration
Pedestrian Use Cases	
Use Case #1: Left Turn and Pedestrian Near Miss	X
Use Case #2: Right Turn and Pedestrian Near Miss	X
Use Case #3: Connected Users – Pedestrian in Crosswalk	
Use Case #4: Pedestrian Not Using Crosswalk	X
Use Case #5: Pedestrian in the Road	X
Use Case #6: Midblock Crossing Near Miss	
Use Case #7: Connected Users – Stopped Transit Vehicle Alert	
Vehicle Use Cases	
Use Case #8: Vehicle and Vehicle Near Miss	X
Use Case #9: Crash Detection	X
Use Case #10: Connected Users – Left Turn Assist	
Use Case #11: Connected Users – Red Light Running	
Use Case #12: Hard Braking	X
Bicyclist Use Cases	
Use Case #13: Connected Users – Bicyclist Proximity Alert	
Use Case #14: Connected Users – Left Turn and Bicycle	
Use Case #15: Left Turn and Bicycle Near Miss	X
Use Case #16: Right Turn and Bicycle Near Miss	X

As noted earlier, the data provided from the vendors were evaluated based on the KPIs as they related to the use cases:

A. How many times was an event identified (at all)?
B. How many times was an event identified accurately?
C. How many times was an event missed?

Findings

Vendor findings were used to evaluate industry-wide technology capabilities, using defined use cases, with the goal of creating future MDOT project specifications. The project team worked to assess the technology capabilities based on each vendor provided data and independently confirmed results.

Technology Assessments

The project team did not specify any specific format for the results and each vendor provided results in different formats, as specified in ***Table 3***.

Table 3: Format of Vendor Results

Vendor	Type of Data Received			
	Dashboard	PDF/PPT Report	Spreadsheet/ Raw Data	GIF Files
Accenture	X	X		
Currux			X	X
IBM		X		
Smartek		X	X	
Transoft Solutions	X			
Velodyne	X	X		

Figure 5 quantifies use case results across the vendors. As trailers were not connected to the traffic signal cabinet, signal phase and timing (SPaT) was not incorporated. Most vendors were unable to quantify incidents for red light running. Connected vehicle use cases are bookmarked for future validation and were not included in this demonstration.

Some key points to note for **Figure 5** include:

- Smartek did not distinguish between different movements for the pedestrian and bicycle near miss use cases. Their data is quantified in Left Turn and Pedestrian Near Miss, Vehicle and Vehicle Near Miss, and Left Turn and Bicycle Near Miss.
- Velodyne only provided counts for pedestrian trajectories, however, they did break out the other near miss use cases. As a result, the pedestrian results were combined for both use cases.

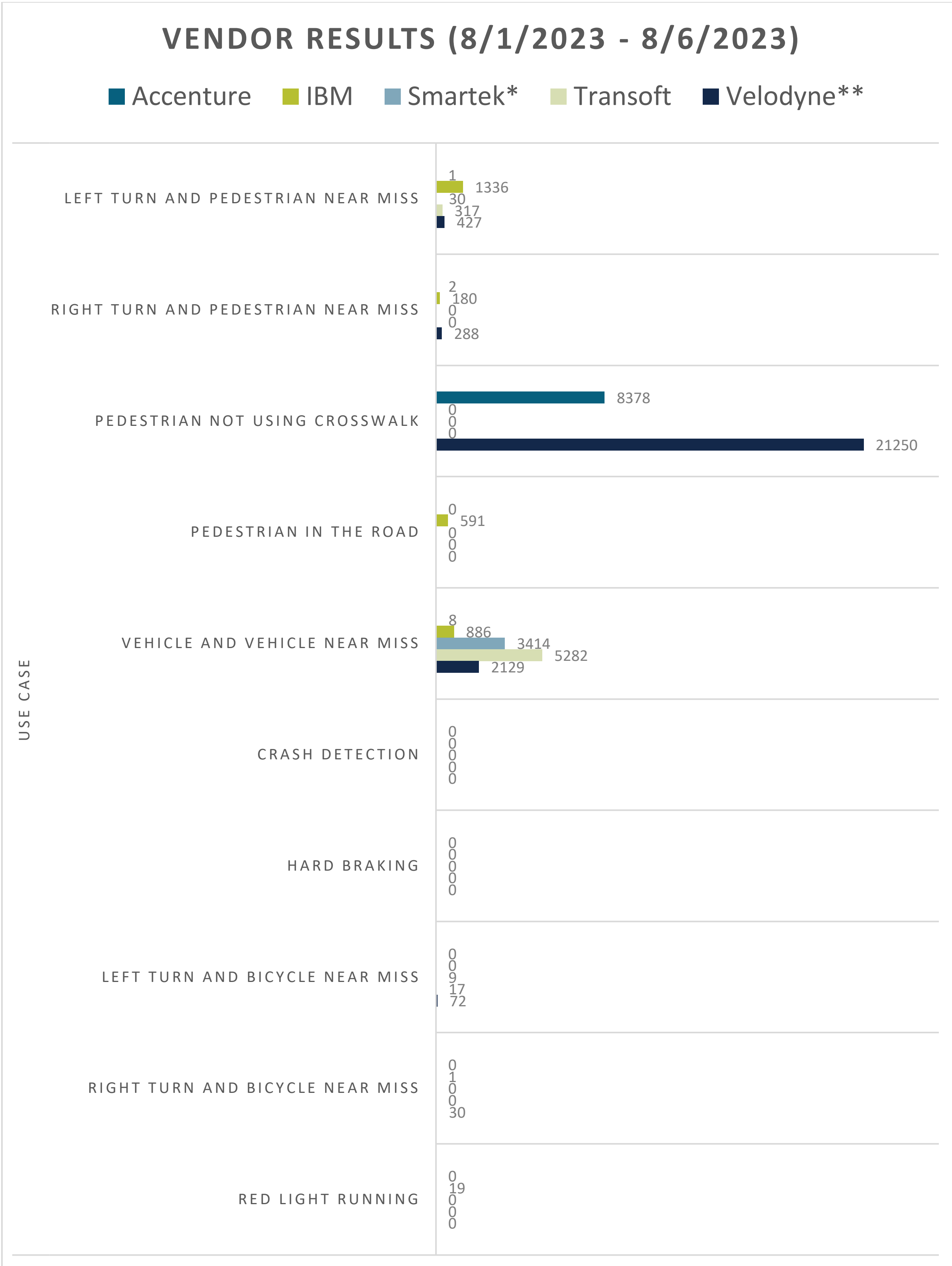

Figure 5: Vendor Results for 8/1 – 8/6

After meeting to discuss the findings from each vendor, the project team concluded that the variability in vendor results could be attributed to different use case definitions or guidelines. For example, near-miss incident variability could be attributed to discrepancies in the post encroachment time (PET) used by each vendor when defining the use case. The Federal Highway Administration (FHWA) defines post encroachment time as the time difference between the arrival of the leading and following vehicle at the location. This definition can be applied to any road user including pedestrians and bicyclists, as seen in the use cases of this demonstration.

Additionally, defined zones were created by each vendor to collect movement data for pedestrians. Because of the variability in zone creation between vendors, there were large differences in the results for pedestrians that did not use the crosswalk.

The Derq dashboard was not included as a late addition to the demonstration for the following reasons:

- The data was in a different location than the demonstration, therefore the location had different patterns
- Derq was not required to provide data that aligned to the analysis use cases

For a closer look and validation of the data, a specific data set was analyzed. On August 5, 2023, from 6 pm – 9 pm, there was a World Wrestling Entertainment (WWE) event that provided a pilot timeframe. ***Figure 6*** include the results. For Velodyne, the pedestrian results were combined for both use cases.

Validation Process: The project team reviewed the video feed to gather baseline data for vendor data validation. This is denoted as *Validation* in the figure legend. ***Table 4*** include points of consideration the project team took to validate the data.

Table 4. Baseline Validation Process

Use Cases	Validation Process
Vehicle-Pedestrian Near Miss	Vehicles and pedestrians were considered to have a near miss if the estimated PET was less than or equal to 3 seconds. If a vehicle was stopped on the crosswalk and forced pedestrians to walk around it, it was not counted. Counts were made based on the number of vehicles and not the number of pedestrians. For example, if a vehicle had a near miss with a group of 5 pedestrians, it was only counted once. However, if 2 vehicles had a near miss with the same group of pedestrians, both vehicles were counted.
Pedestrian Not Using Crosswalk	Pedestrians were only eligible to be counted if they were within the stop bars of the intersection. For travel lanes with no stop bar, the position was estimated based on the depth of the adjacent stop bar. Pedestrians were considered to not be using the crosswalk when the entirety of their body was outside the crosswalk area for a majority of the movement. For crosswalks with an island separated movement, violation on either side was counted but pedestrians were not double counted if they violated both sides. If a vehicle was stopped in the crosswalk that forced pedestrians outside of the crosswalk, it was not counted unless the pedestrian remained outside of the crosswalk after passing. *It should be noted that the construction zone on the northeast corner of the intersection caused nearly all of the crossing pedestrians to be counted for not using the crosswalk.*
Pedestrian in Road	Pedestrians were considered "in the road" if they were outside of the stop bars of the intersection and not on the sidewalk or in the immediate vicinity of it. Parallel parkers who had to exit the car into the street were counted. If a pedestrian crossed both sides of a median separated street, it was counted as 2.

Use Cases	Validation Process
Vehicle-Vehicle Near Miss	Vehicles were considered to have a "near miss" if they had an estimated PET of 3 seconds or less. Vehicles traveling in the same direction were only counted as a near miss if the following vehicle was forced to alter its path due to the front vehicle stopping or slowing down in or near the travel lane. Converging near misses (U, left, or right turns into moving traffic) were counted. On occasion, a near miss was counted if a vehicle passed another in the adjacent travel lane at very close proximity and high speed. Potential rear end conflicts were not included since the following time for nearly every vehicle was <3 seconds.
Bicycle Near Miss	Vehicles and bicycles were considered to have a near miss if the estimated PET was less than or equal to 3 seconds. Both scooters and bicycles were counted separately and combined to achieve the total count (7 scooters + 4 bicycles = 11 total). Unlike pedestrians, all bicycles and scooters were counted individually. For example, if one vehicle had a near miss with 2 scooters, this resulted in a count of 2.

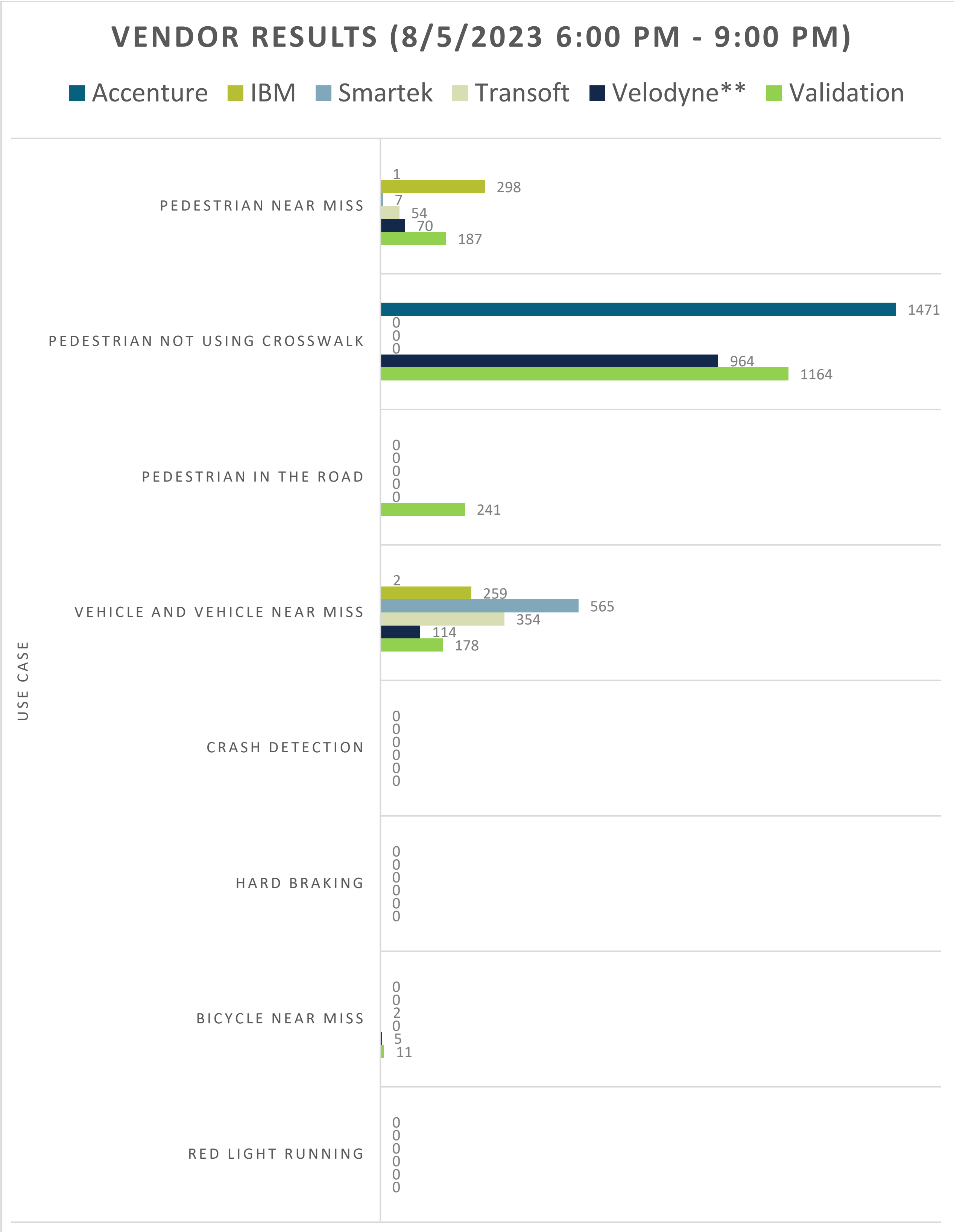

Figure 6: Vendor Results for 8/5

Technology Conclusion

Of the nine use cases demonstrated by the vendors, six use cases are possible with currently available technology.

Table 5 presents a data evaluation matrix, which is structured as follows:

- Evaluations are based on use cases tested during the demonstration.
- Qualitative assessment of the Vendor's capability of addressing the demonstrated use cases
    - Can Do – clearly demonstrated capability
    - Likely – data supports likeliness of vendor to demonstrate capability
    - Inconclusive – data does not prove or disprove vendor capability (i.e., more data is needed)

Table 5. Vendor Capability per Use Case

Use Cases	Vendors					
	Accenture	**Currux**	**IBM**	**Smartek**	**Transoft**	**Velodyne**
Pedestrian Use Cases						
Use Case #1 & #2: Pedestrian Near Miss	**Likely** *predefined PET and TTC needed*	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓
Use Case #4: Pedestrian Not Using Crosswalk	**Can Do** ✓	**Likely** *Predefined conflict zones needed*	**Likely** *Predefined conflict zones needed*	**Likely** *Predefined conflict zones needed*	**Likely** *Predefined conflict zones needed*	**Can Do** ✓
Use Case #5: Pedestrian in the Road	**Likely** *Predefined conflict zones needed*	**Likely** *Predefined conflict zones needed*	**Can Do** ✓	**Likely** *Predefined conflict zones needed*	**Likely** *predefined conflict zones needed*	**Likely** *Predefined conflict zones needed*
Vehicle Use Cases						
Use Case #8: Vehicle and Vehicle Near Miss	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓
Use Case #9: Crash Detection	**Inconclusive** *Larger sample data set needed*	**Inconclusive** *Larger sample data set needed*	**Inconclusive** *Larger sample data set needed*	**Inconclusive** *Larger sample data set needed*	**Inconclusive** *Larger sample data set needed*	**Inconclusive** *Larger sample data set needed*
Use Case #12: Hard Braking	**Inconclusive** *Better camera view & signal connection needed*	**Inconclusive** *Better camera view & signal connection needed*	**Inconclusive** *Better camera view & signal connection needed*	**Inconclusive** *Better camera view & signal connection needed*	**Inconclusive** *Better camera view & signal connection needed*	**Inconclusive** *Better camera view & signal connection needed*
Bicyclist Use Cases						
Use Case #15 & #16: Bicycle Near Miss	**Inconclusive** *Larger sample data set needed*	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓	**Can Do** ✓

TTC – Time to Collision

Technology Observations

The project team encountered multiple, unanticipated challenges during the demonstration, including long equipment lead time, cellular service limitations, solar power loss due to cloudy conditions, and corrupted digital files. These challenges did not impact demonstration goal. High-level performance observations are listed below:

- **Varying Analytic Metrics** – Providing specific guidance for each metric, including post encroachment time and defined zones for each use case would provide consistency among the data results. This could limit the "false positives" that some vendors had and make results more uniform.
- **Ocular Occlusions** – Identifying vendor camera guidelines related to camera location and positioning at the project onset would have been helpful.

Summary and Recommendations

The demonstration goal is to confirm currently available, video analytic technology capabilities. Based on vendor provided data, near miss incident detection technology is available from multiple vendors. Deployment purpose, use cases, camera type and installation, and required data output structure need to be clearly defined prior to the start of the project.

Many of these vendors consider their products a traffic analysis tool, rather than an incident management tool. There is consistency with vehicle, pedestrian, and bicycle classifications and counting, but the vendor products should be updated to accommodate incident management use cases.

Recommendations

The following recommendations could help improve similar demonstrations:

- Occlusion – Inquire with vendor about portable and permanent camera system placement and position guidelines.
- Standard PET – Standardize PET vendor requirements, during the processing video phase, to obtain consistent results.
- Additional Coordination – Ensure all groups are included on communications when unanticipated schedule changes to minimize disruption between this project and potential impacts (e.g., construction).
- Data Processing – Require vendors to provide a data visualization dashboard, configured to show the use cases to support ease of comparison.

Since not all use cases were tested during this demonstration, the project team also recommends another phase where connected vehicle technology and/or signal timing information could be used to provide real time alerts.

Appendix – Timeline of the Demonstration

The table below highlights the main actions taken throughout the demonstration process, noting specifically issues and any major decisions made along the way.

Date/Time	Actions, Issues, and Decisions Made
October 2021	Request for Information (RFI) vendors provided presentation/demonstrations of their platform. This information helped to identify initial requirements and goals for potential Request for Proposal (RFP).
January 2022	Discussions with DTMB were leaning towards not approving a deployment per an RFP. The team then considered alternatives; *DECISION: extend the RFI; post for demonstration, receive applications, comparative analysis. Continue investigating other options such as MCity.*
February 2022	Portable trailers discussion began – researching the options, requirements, funding, etc.
April 2022	Discussion with IB regarding portable trailer set up – included infrastructure, potential locations, and inclusion of RSUs at this location. *DECISION: develop a cost estimate for a portable trailer to use for final decision.*
May 2022	Meeting with MCity (5/31/2022) to discuss option for using MCity as part of this project.
July 2022	MDOT received the portable trailer cost estimate. *DECISION: move forward with the portable trailer option.*
September / October 2022	Gathering of camera information to include on the trailers; also figuring out how to pay for the hardware for the trailers. Develop schedule for the deployment and requirements; *DECISION: advertise in the winter; deploy in spring; name the opportunity Technology Demonstration Opportunity.*
October 2022	Identify the deployment location. Four locations identified. • M-3 Gratiot Corridor at M-1 Woodard (Detroit, Wayne County) • 9 Mile at M-1 (Ferndale, Oakland County) • M-3 at Beaubien Blvd (Detroit, Wayne County) • M-3 at Brush St (Detroit, Wayne County)
November 2022	MDOT advertised the Technology for Demonstration package (aka RFP) on MDOT's RFP site and sent to potential vendors (11/7/2022). The team also developed a Narrative for this Opportunity; Proposals due December 9, 2022. Procurement started for trailer equipment.
December 2022 / January 2023	5 proposals received; camera lead time increased from 6 weeks to 6 months. Discussion about power for the trailers – keeping solar or retrofit to diesel. *DECISION: keep trailers with solar power.*
February 2023	Cameras came in early. Re-reviewing the equipment needs: 1 vs 2 cameras per trailer. Schedule meetings with the applicant vendors to review the RFP and provide Q&A time. *DECISION: use 1 camera per trailer.*
Early March 2023	Confirm if this research project is too similar to the FDOT research project; still working with procurement for final equipment needs. *DECISION: Continue with this project as there is enough of a difference between projects.*
Late March 2023	Scheduling prep meetings with vendors; answering questions from the vendors in preparation of meetings; confirmed location; confirming final equipment received.
Early April 2023	Held vendor meetings to discuss the deployment (timeframe/days/times, location, camera placement, power, data/dashboard, and KPIs). Discussion regarding video stream and equipment revisions based on the video sharing system and processing needs on each trailer.
Late April 2023	Velodyne provided equipment for installation on one of the trailers.
Early May 2023	Both trailers outfitted with all equipment.
May 22-26, 2023	Performance testing conducted and found a stream performance issue; *DECISION: use 1 trailer; combine all equipment onto this 1 trailer (5/29/2023-6/2/2023).*
June 5-9, 2023	Issue with the modem and camera; Trailers outfitted with additional equipment

Date/Time	Actions, Issues, and Decisions Made
June 12-16, 2023	Trailers redeployed and performance test conducted. Cell provider issues (cannot communicate over the internet with new IPs). Velodyne asked for an additional analytic time. *DECISION: develop new game plan. Add a fourth time window for analytic assessment (12a-3a).*
June 19-27, 2023	*DECISION: extend the start date. DECISION: provide half participants one camera stream, the other half another camera stream (June 22).* Issue: unable to find a plan to provide 1.8TB of data for 6 continuous streams for a week; *DECISION: acquire two 1TBSD cards and record directly onto these cards and provide recorded video to vendors – no RTSP stream link and extend the start date (6/26).* SD cards arrived 6/28; install 6/29
June 28-30, 2023	Trailers redeployed; camera views provided to vendors for their preference (6/28)
July 3-7, 2023	Additional performance testing conducted. Failure with camera #2. *DECISION: after some troubleshooting, swapped SD cards, use camera #2 as its perspective is the only one available, all vendors will receive recording from this camera.*
July 9-15, 2023	Week of recording video (all day recording) – and a link will be provided to vendors to access the video.
July 17, 2023	Trailer picked up. Process and retrieval of recordings underway.
July 21, 2023	After much troubleshooting, the team found the following issue. Issue: only found 30 minutes of recorded video; Axis camera lost power over the weekend due to low solar trailer battery voltage; Axis database was corrupted, and active recordings lost. *DECISION: set up a low-powered HPU with 1 TB external HDD mounted inside the solar trailer enclosure; power up one of the cameras to enable daily recording with the quad view stream and activate the Velodyne system; each AM/PM log into the HPU, access the Axis camera web GUI and export the past/current day's recording to the external HDD. On the last day, perform another HPU local backup. Process and copy the video files to 1 TB external drives for shipping to designated locations.*
July 26-31, 2023	Trailers redeployed to the location. Recordings began. Issue: recordings are failing. (7/28). *DECISION: Converted the HPU external 1TB HDD to a mapped network drive; the camera sends the 24-hour recording to that drive via network storage option. Will provide 7 days of recording. (7/31)*
August 6, 2023	Batteries low due to several overcast days; generator brought to re-power the cameras (and to charge the batteries). Camera went down at 5:06pm August 6th. *DECISION: stop the recordings at the time the camera went down on 8/6; recorded video intact from July 31 (12:55p) to August 6 (5:07p) and provide this video to the vendors.*
August 14, 2023	External drives shipped to all vendors. Drives are due back 30 days after receipt.
Week of September 11	Vendor's analytic due to MDOT for comparative review.

Timeline Changes for Actual Video Analytics:

- June 4-June 10 – analytic assessment week *[trailers picked up June 12]* – original.
- June 25-July 1 – analytic assessment week *[trailer picked up July 3]* – changed 5/30/2023.
- July 9-July 15 – analytic assessment week *[trailer picked up July 17]* – changed 6/19/2023.
- July 26-August 3 – analytic assessment week *[trailer picked up August 4]* – changed 7/24/2023.
- July 31-August 6 – analytic assessment week *[trailer picked up August 8]* – changed 7/31/2023.

Appendix – Request for Proposal

Michigan Department of Transportation

Technology Demonstration Opportunity
MDOT – Utilizing Video Analytics with Connected Vehicles
For Improved Safety

<u>CONTROL SECTION(S)</u>:

<u>JOB NUMBER(S)</u>:

<u>PROJECT LOCATION</u>:
Equipment will be installed on portable trailers stored in the Detroit area and will be deployed at an intersection in Downtown Detroit.

<u>PROJECT WORK DESCRIPTION</u> *<u>(description of the project)</u>***:**

The State of Michigan is requesting letters of interest from vendors who would like to participate in a video analytics pilot project. This request will not lead to a procurement. MDOT is looking for vendors to participate through temporarily providing their video analytics solution including equipment and labor.

The pilot will consist of multiple two-week assessments. The number of assessments will be based on how many vendors participate. Each vendor will be asked for a time estimate required for installation, configuration, and removal of equipment. A detailed schedule will be coordinated with each vendor and provided at least two weeks prior to the first assessment.

MDOT has equipped two portable trailers with the following equipment to support this pilot:

- Four (4) CCTV cameras covering the intersection (two (2) per trailer), as defined in the attached specification (1 direct video stream per CCTV camera will be provided per vendor device)
- Power supply
- Equipment cabinet

Photos of the equipped trailers are included on Pages 5-11.

Vendor is expected to provide the following as part of their participation in the pilot project:

- 2 complete video analytics assemblies (1 per trailer)
- Personnel and time to install, configure, and remove equipment
- 2 weeks of archived data upon the completion of each assessment

Vendor Information Form

Please return this completed form to Michele Mueller (Muellerm2@michigan.gov)
by December 9th at 12pm

Basic Information

Vendor Name	
Vendor Address	
Primary Contact	
Email	
Phone Number	

Additional Questions

Identify the following use cases that are addressed with your solution. *See Page 4 for Use Case Descriptions.*	**Use Cases to be Tested:** ☐ Left Turn and Pedestrian Near Miss ☐ Right Turn and Pedestrian Near Miss ☐ Pedestrian Not Using Crosswalk ☐ Pedestrian in the Road ☐ Vehicle and Vehicle Near Miss ☐ Crash Detection ☐ Hard Braking ☐ Left Turn and Bicycle Near Miss ☐ Right Turn and Bicycle Near Miss ☐ Red Light Running **Potential Future Use Cases:** ☐ Connected Users – Pedestrian in Crosswalk ☐ Midblock Crossing Near Miss ☐ Connected Users – Stopped Transit Vehicle Alert ☐ Connected Users – Left Turn Assist ☐ Connected Users – Red Light Running ☐ Connected Users – Bicyclist Proximity Alert ☐ Connected Users – Left Turn and Bicycle
Document how MDOT can verify success relative to each use case noted.	
Describe how you define a 'conflict'.	
What are the actions the system completes when the use case is met (i.e. a near miss is identified)?	

Specify equipment to be provided in the vendor assembly. (Optional is a network diagram detailing equipment required as part of your solution. Note: power supply and camera feed as detailed in the spec will be provided. No remote communications are provided.)	
Describe how your data is stored, formatted, and archived.	
Describe how your data from the pilot deployment will be provided to MDOT. • **Physical Delivery (cloud based, hard drive, other?)** • **Data Management (time stamped, buckets, single data dump of information, other?)**	
Time frame needed for installation and configuration of equipment.	
Time frame needed for equipment removal.	
Recommended duration that your solution should be in place to collect adequate data and prove value to the defined use cases.	

Use Case Descriptions

Use Cases to be Tested	
Left Turn and Pedestrian Near Miss	Detection of a left turning vehicle and a pedestrian experiencing a near miss.
Right Turn and Pedestrian Near Miss	Detection of a right turning vehicle and a pedestrian experiencing a near miss.
Pedestrian Not Using Crosswalk	Detection of pedestrians not using an available crosswalk.
Pedestrian in the Road	Detection of pedestrians crossing at a location without a crosswalk.
Vehicle and Vehicle Near Miss	Detection of two or more vehicles experiencing a near miss with each other.
Crash Detection	Detection of a crash at an intersection. Storage, analysis, and collection of data before, during, and after the crash. Capability for a variety of agencies including first responders to utilize data to respond to the incident.
Hard Braking	Detection of vehicles hard braking at an intersection.
Left Turn and Bicycle Near Miss	Detection of a left turning vehicle and a bicyclist experiencing a near miss.
Right Turn and Bicycle Near Miss	Detection of a right turning vehicle and a bicyclist experiencing a near miss.
Red Light Running	Detection of red light running for vehicles.
Potential Future Use Cases	
Connected Users – Pedestrian in Crosswalk	Identification of the trajectories of a pedestrian and vehicle with the potential for a conflict. Pushing an alert to connected users to allow them to make real time decisions.
Midblock Crossing Near Miss	Detection of a vehicle and a pedestrian experiencing a near miss at a midblock crossing.
Connected Users – Stopped Transit Vehicle Alert	Identification of a stopped transit vehicle, pedestrians, and approaching vehicles. Pushing an alert to users of potential conflicts to allow users to make real time decisions.
Connected Users – Left Turn Assist	Identification of a vehicle making a permissive left turn. Alerts of potential conflicts such as oncoming traffic to allow users to make real time decisions.
Connected Users – Red Light Running	Detection of red light running for both legacy and connected vehicles. Pushing an alert to connected users to allow them to make real time decisions.
Connected Users – Bicyclist Proximity Alert	Identification of a right turning vehicle while a bicyclist is in proximity of the vehicle. Pushing an alert to connected users to allow them to make real time decisions.
Connected Users – Left Turn and Bicycle	Identification of a left turning vehicle with an oncoming bicyclist in the turning path of the vehicle. Pushing an alert to connected users to allow them to make real time decisions.


30-0515


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MICHIGAN
5-1133


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MidNite SOLAR, inc
MPPT
Industrial Switch
User Manual


TURN OFF ALL CABINET BREAKERS BEFORE
CONNECTING AC TO DC CHARGER
CAUTION
NO STEPPING


MASTERFORCE
INTEGRAL BLUE
45A BATTERY CHARGER

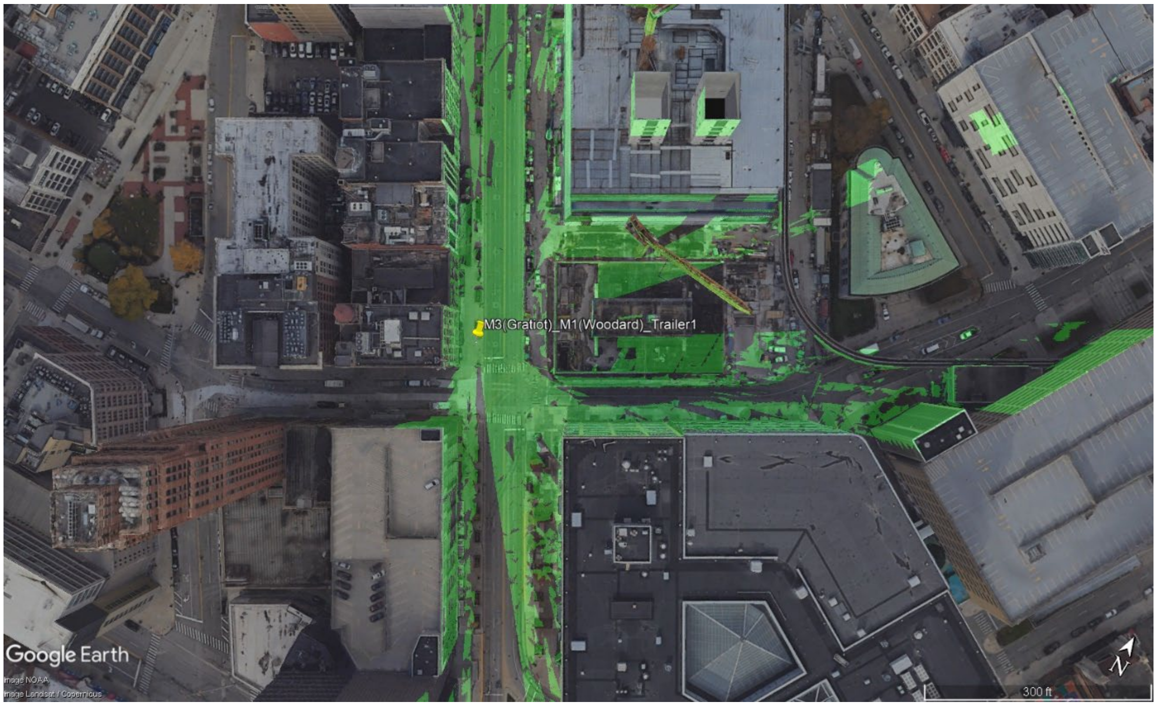

POWERMAX
POWERMAXCONVERTERS.COM

Appendix – View Sheds from Potential Intersections Evaluated

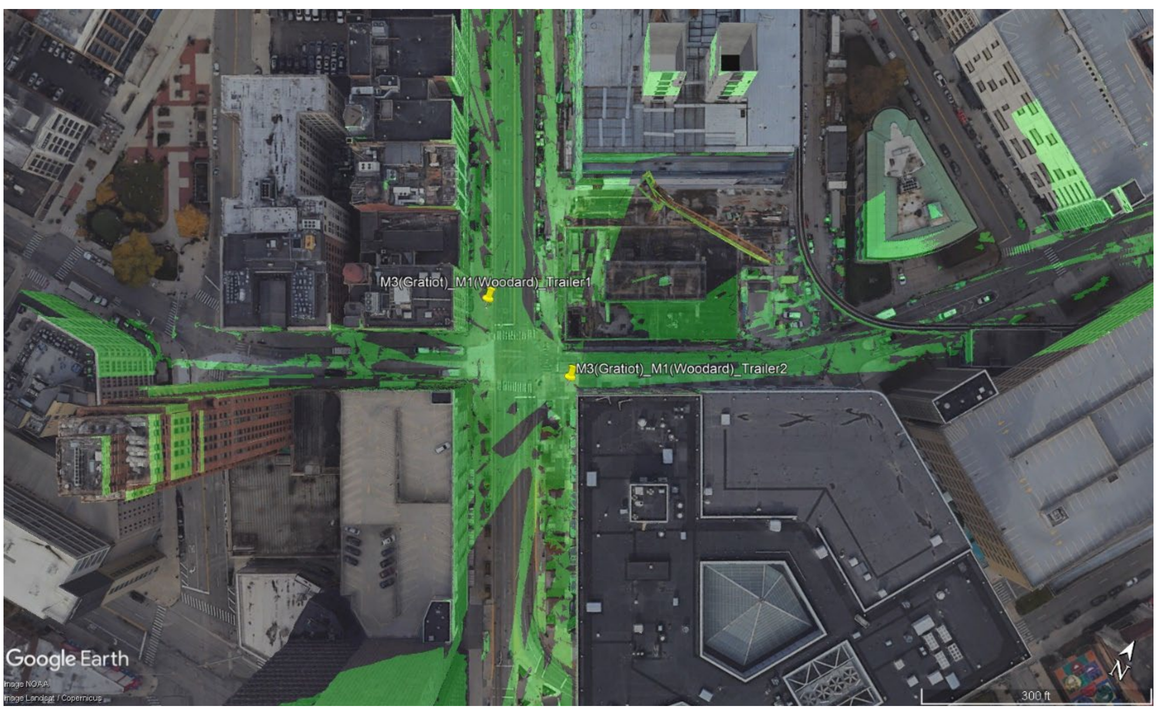
Prior to the start of the demonstration, the project team evaluated 2 camera locations each at 4 intersections in the southeast Detroit area using Google Earth Viewsheds. These camera locations assumed a camera height of 25.5’, and vendor feedback was requested to determine the final camera placement.

Viewshed at 9 Mile Rd and M-1 (Trailer 1)

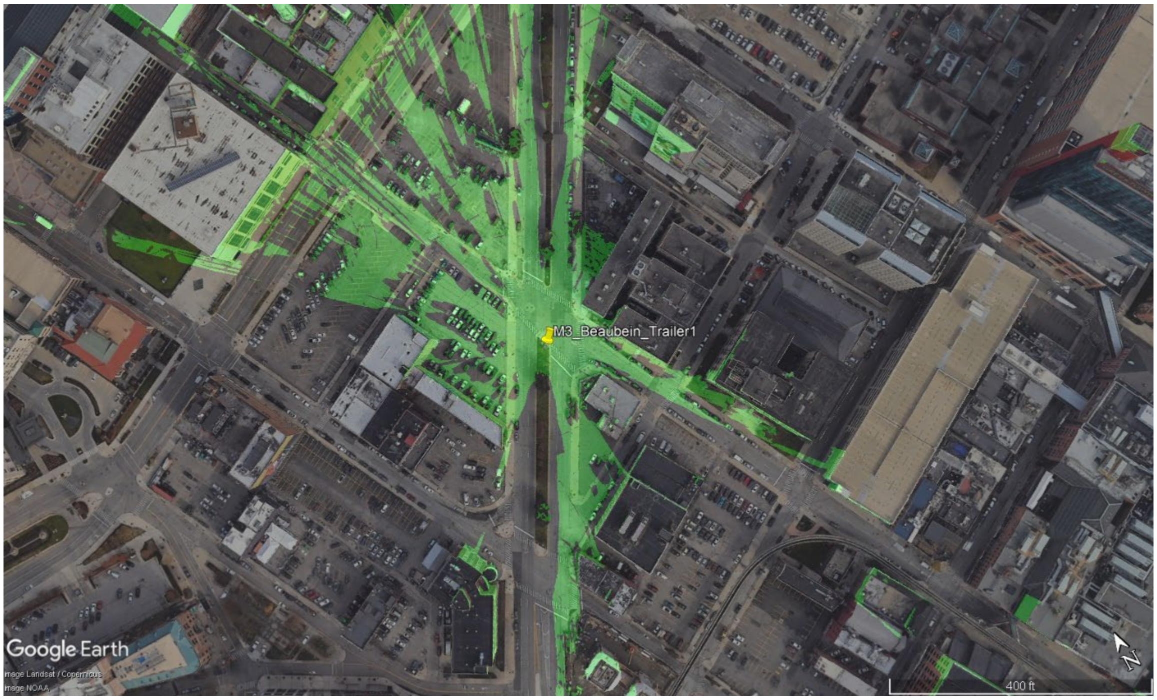
Viewshed at 9 Mile Rd and M-1 (Trailer 2)



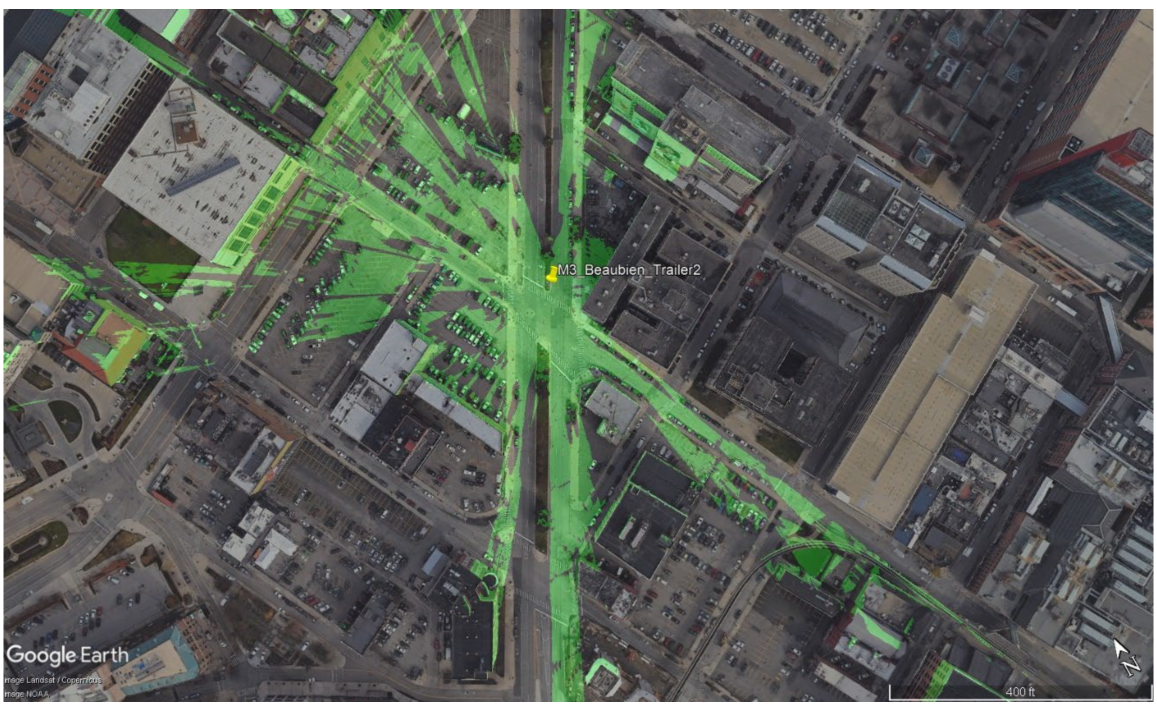
Viewshed at M-3/Gratiot Ave and M-1 (Trailer 1)



Viewshed at M-3/Gratiot Ave and M-1 (Trailer 2)



Viewshed at M-3/Gratiot Ave and Beaubien Blvd (Trailer 1)



Viewshed at M-3/Gratiot Ave Beaubien Blvd (Trailer 2)

Viewshed at M-3/Gratiot Ave and Brush St (Trailer 1)

Viewshed at M-3/Gratiot Ave and Brush St (Trailer 2)

Appendix E Implementation Toolbox

IMPLEMENTATION TOOLBOX

UTILIZING VIDEO ANALYTICS WITH CONNECTED VEHICLE FOR IMPROVED SAFETY

JANUARY 2024

OR2021-0250

MDOT

Kimley»Horn
of Michigan, Inc.

Table of Contents

Tables

Introduction

The Implementation Toolbox provides seven steps for a successful video analytics project. These steps were based on MDOT's research project. As MDOT deploys more video analytics projects, any lessons learned should be integrated into this Implementation Toolbox.

1. Define goals & objectives

To measure progress and performance

2. Schedule milestones

To track project completion

3. Allocate resources

To plan for necessary resources

4. Designate team responsibilities

To hold the team accountable

5. Define metrics of success

To measure progress and performance

6. Define how to adapt

To account for risk

7. Evaluate success

To assess project completion

1 Define Goals and Objectives

The first step in the implementation process is defining the goals and objectives for the identified location. Determine what should be accomplished when the project is complete. Establishing clear project objectives support the development of a resolute project plan. Since video analytics are an emerging technology, supplemental research and project development further improve the potential impact of the implementation. These include a current market assessment of the available technology, clear use case development, and a needs-based corridor evaluation.

When defining the project goals, identify the following:

- Anticipated outcomes of the project implementation
- Concept of the final implementation deliverables

Examples of objectives for testing video analytic technology include how well the technology can:

1. Use of data to understand crashes and near misses.
2. Incorporate technology and operational improvements.
3. Data-driven alerts to motorists and non-motorized users.

Additional examples of intended benefits to evaluate include:

- Effectiveness of identifying intersections with a high crash potential.
- Ability to use the data for TMC operations.
- Ability to mitigate crashes by effectively warming drivers and pedestrians of likely conflicts.
- Benefits of continued implementation of video analytics technology with connective vehicles.

2 Schedule Milestones

Scheduling project milestones establishes checkpoints to monitor the progress of the deployment. Project development milestones are important metrics of the project evolution but should also consider external variables such a special events or seasonal changes.

Tips to consider:

- Include wiggle room: Things do not always go as planned, even if with extensive preparation and an effective risk management plan, unanticipated challenges can arise. The inclusion of “wiggle room” or slack in the project schedule allows flexibility and increases the likelihood of the project meeting critical milestones.
- Clarify dependencies: Dependencies are tasks that rely on the initiation or completion of other tasks. Clearly identifying dependencies within the project schedule provides the project team with valuable requirements to maintaining the defined schedule.

3 Allocate Resources

Resource allocation is one of the best ways to reduce risk. Technology type projects are dependent on various resources for the success of the project including equipment and funding which is detailed below.

3.1 Equipment

The equipment needed to support a video analytics system for temporary deployment include the following:

- Trafcon or comparable portable trailer
- Camera
- Cellular modem
- Power source (solar panels)

For a permanent installation, the following equipment needed for a video analytics system include:

- Fixed pole (wood or metal)
- Camera(s)
- Cellular modem
- Power source (metered power source)

3.2 Camera Specifications

Table 1 provides the camera specifications required to support a video analytics implementation.

Table 1. Camera Specifications for Video Analytics

<table>
<tr><th></th><th>Permanent Installation</th><th>Temporary Installation</th></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>Type</td><td colspan="2">360-degree dome camera consisting of multiple fixed or PTZ sensors in a single integrated assembly</td></tr>
<tr><td>Camera Sensor (minimum)</td><td colspan="2">1/3-inch RGB CMOS</td></tr>
<tr><td>Camera Resolution (minimum)</td><td colspan="2">5 MP</td></tr>
<tr><td>Camera Features</td><td colspan="2">Automatic and Manual Day/Night (Color/Monochrome)
Automatic Color Balance
Electronic Image Stabilization (EIS)
Autofocus Lens
Overexposure Protection
Wide Dynamic Range (WDR)</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>Video Compression</td><td colspan="2">H.264
MJPEG</td></tr>
<tr><td>Video Resolution (minimum)</td><td colspan="2">1080p (1920x1080)</td></tr>
<tr><td>Video Frame Rate (minimum)</td><td colspan="2">20 fps, adjustable</td></tr>
<tr><td>Video Streaming Protocols</td><td colspan="2">RTSP/RTP/UDP
RTSP Interleaved
RTP Multicast
TCP/HTTP Tunneling</td></tr>
<tr><td>Video Features</td><td colspan="2">Text Overlay
Privacy Zones
On-Screen Messages</td></tr>
<tr><td></td><td colspan="2"></td></tr>
</table>

	Permanent Installation	Temporary Installation
Environmental Housing	Pressurized Dome NEMA 250 Enclosure Type 4X IEC 60529 IP-67	
Operating Temperature (minimum)	-29 to 165 degrees F with 95% relative humidity, condensing	
Operating Windspeed (minimum)	120 mph wind sustained for 3 seconds in any direction	
Housing Accessories	Thermostat-Controlled 24-Volt Heater	
Power	PoE++ (802.3bt Type 3)	
Power Cable	Cat5e or Cat6 ethernet, outdoor rated	
Power Source	Metered Power Source 120/240 VAC single phase	Solar Power Source with Battery Backup 110/120 VAC
Power Accessories	PoE Injector Surge Suppression Grounding System	
Mounting	Wood or Metal Pole	Trailer with Extendable Pole
Mounting Height (minimum)	30 feet	varies
Mounting Hardware	Stainless Steel Banding	
Mounting Accessories	Camera Lower Device (for heights over 40')	
Applicable Codes and Standards	NTCIP (1201, 1205, 1208, 2104, 2202, 2301) NTSC MPEG IEEE 802.3 NEMA TS2 ONVIF	

Table 2 provides the equipment specifications for Lidar technology.

Table 2. Real-Time Lidar Sensor Specifications

	Specifications
Sensor:	• 16 Channels • Measurement Range: 100m • Range Accuracy: Up to ± 3 cm (Typical)[1] • Field of View (Vertical): +15.0^o to -15.0^o (30^o) • Angular Resolution (Vertical): 2.0^o • Field of View (Horizontal): 360^o • Angular Resolution (Horizontal/Azimuth): 0.1^o - 0.4^o • Rotation Rate: 5 Hz – 20 Hz • Integrated Web Server for Easy Monitoring and Configuration
Laser:	• Laser Product Classification: Class 1 Eye-safe per IEC 60825-1:2007 & 2014 • Wavelength: 903nm
Mechanical / Electrical / Operational	• Power Consumption: 8 W (Typical)[2] • Operating Voltage: 9 V – 18 V (with Interface Box and regulated Power Supply) • Weight: ~830 g (without Cabling and Interface Box) • Dimensions: See diagram on previous page • Environmental Protection: IP67 • Operating Temperature: -10^{o}C to +60^{o}C[3] • Storage Temperature: -40^{o}C to +105^{o}C

Output:	• 3D Lidar Data Points Generated:
	  - Single Return Mode: ~300,000 points per second
	  - Dual Return Mode: ~600,000 points per second
	• 100 Mbps Ethernet Connection
	• UDP Packets Contain:
	  - Time of Flight Distance Measurement
	  - Calibrated Reflectivity Measurement
	  - Rotation Angles
	  - Synchronized Time Stamps (µs resolution)
	• GPS: $GPRMC and $GPGGA NMEA Sentences from GPS Receiver (GPS not included)

Source: Velodyne Lidar Puck Specifications (https://velodynelidar.com/wp-content/uploads/2019/12/63-9229_Rev-K_Puck-_Datasheet_Web.pdf), accessed January 17, 2024

3.3 Budget

It is essential to understand what costs would be associated with a project. Costs could include those related to equipment, software needs, and labor. Establishing a budget early in the project supports the allocation of funds to complete the project. It also provides a check and balance to the team that the project is sticking to the budget. **Table 3** includes the estimated total cost associated with deploying one trailer with the following assumptions:

1. Contract period: 12 months
2. Number of times to move trailer: 10 locations
3. Length of time to deploy trailer: 1 week
4. Participating vendors: 2 vendors
5. Cellular Plan Options: Store the video locally for after-analysis

Table 3: Estimated Equipment Costs

Item	Quantity	Overall Cost
Trailer Costs		
Trafcon or comparable trailer	1	$16,000.00
Misc. small parts	1	$1,000.00
CCTV with mounts and surge	1	$4,000.00
Cellular Modem	1	$1,000.00
Hard Drive for recording/transport	1	$200.00
Total Hardware Cost (Trailer)		**$22,200.00**
Miscellaneous Costs (for Trailer)		
Contingency/Inflation	10%	$2,220.00
Freight	8%	$1,953.60
Tax	6%	$1,582.42
Contractor Markup	15%	$4,193.40
Labor - Wiring and Buildup		$2,500.00
Total Costs for Trailer Set Up		**$34,649.42**
Cellular Plan		
External Drive (1 TB) + Shipping	2 units	$220.00
Transport / Configuration / Support		
Field Transport and Configuration	10 times	$1,650.00
Engineering Support (MDOT / Vendor)	30 hrs.	$3,900.00
Total Cost		**$40,419.42**

Two additional cellular plan options include:

- Have the video processed locally, on an edge processor from the vendor (~$2,160).
- Have the video streamed to a remote destination and provide for video access (~$2,640).

Utilizing any of these two options increases the overall estimate to $42,360 - $42,840.

Table 4 includes a cost range for the various vendor capabilities to include in potential future analytic deployments.

Table 4: Vendor Cost Estimate

Capability	Price (Using Recorded Video)	Price (Using Real Time Video)
1. Vehicle, Ped, Bike Detection Categorization	$14.50/hour for 1,000 hours	$9,833.33
2. Near Miss Analytics • Heat map of vehicle, pedestrian, and bicyclist conflict areas • Tracks of all detected objects within camera field of view with direction info • Near miss detection based on time to collision threshold • Post encroachment analysis and heat maps • Headway monitoring time by lane • Time to collision monitoring by lane	$3.60 – 3.75/hour for 1,000 hours OR $2,800 per/intersection	$2,800 – $3,749
3. Dashboard Access • Includes exporting of data in Excel or PDF	$130,000	$130,000
4. AI Integration	$224/hour OR $25,000	$224/hour OR $45,000*
5. Support and Maintenance (for 1-year timeframe)	$1,444 – $47,000	$1,444 – $47,000
6. Vendor provided hardware necessary for integration	N/A	$14,000 – $14,563
7. Connected Vehicle Integration • Real-time detection like speed, location, direction	N/A	$1,124 – $42,000
8. Real Time Notification • Detecting events like speeding and cross walk violations • Alerts sent via email or text OR integration into ATMS software	$3.75/hour for 1,000 hours	$3,749 – $38,000
9. Other *(populate as needed)*	N/A	N/A

**AI Integration price to be refined based on the specific use cases.*

4 Designate Team Responsibilities

Every action plan must include a list of responsibilities with team members assigned to each one. By assigning responsibilities, you can assess the performance of each team member and monitor progress more closely. It will be important to identify a *project manager, project team, quality assurance/quality control manager,* and *field integration team.* Table 5 provides a summary of the responsibilities for each of the identified team members.

Table 5: Project Team Responsibilities

Project Team Role	Project Team Responsibilities
Project Manager	• *Plan, Execute, and Monitor Tasks.* • *Facilitate project update meetings.* • *Provide coordination between project team and stakeholders.* • *Communicate to senior management and decision makers as appropriate.*
Project Team	• *Support project manager on the implementation of project tasks.* • *Coordinate project development with other team members and external partners.* • *Identify risks and mitigation strategies throughout the life of the project.*
Quality Assurance/Quality Control Manager	• *Ensure quality control and technical reviews are occurring through the duration of the project.* • *Ensure federal, state, and local compliance.*
Field Integration Team	• *Deploy and integrate necessary field and central equipment.* • *Implement the defined data management plan to all identified stakeholders.*

5 Identify Metrics of Success

Prior to the start of the project implementation, understand how to answer the following questions:

How do you determine success?	Develop clear evaluation metrics based on the defined project goals.
What data is used?	Document what data needs to be collected and how it will be processed in support of the defined metrics. Ensure the data directly aligns with the developed use cases.
How do we collect that data?	Identify a data management plan that defines the owner, data collection method, and how the data will be shared with the necessary project team members.

6 Risk Management

It is helpful to map out all the potential risks you may face in your project. Risks can include anything from weather and holidays to budget constraints and loss of personnel. Be flexible and proactive. Mapping out risks is more than just a preparation strategy. If you identify preventable risks during this stage of the implementation plan, you can take action to prevent those risks. This may mean adjusting your initial project goals.

7 Evaluate Success

Establish how to measure project success in different ways to identify which metrics can be used to improve the project's performance. Define how often to evaluate progress to stay on target to achieving a successful project. Success can be *meeting deadlines*, successfully *testing all defined use cases*, *validation* of the data, completing the project *under budget*, meeting project *goals and objectives*. Another important way to measure success is to collect feedback from the project team and other involved parties like vendors.

Associating each finding back to the evaluation criteria creates a clear picture of project achievements and areas for improvement.