DEPARTMENT OF TRANSPORTATION

Use of Material Delivery Management System (MDMS) for Asphalt Paving Applications

Rebecca Embacher, Principal Investigator
Minnesota Department of Transportation
Office of Materials and Road Research

MARCH 2021

Research Project
Final Report 2021-10

To request this document in an alternative format, such as braille or large print, call 651-366-4718 or 1-800-657-3774 (Greater Minnesota) or email your request to ADArequest.dot@state.mn.us. Please request at least one week in advance.

Technical Report Documentation Page

1. Report No. MN 2021-10	2.	3. Recipients Accession No.
4. Title and Subtitle Use of Material Delivery Management System (MDMS) for Asphalt Paving Applications		5. Report Date March 2021 6.
7. Author(s) Rebecca Embacher		8. Performing Organization Report No.
9. Performing Organization Name and Address Minnesota Department of Transportation Office of Materials and Road Research 1400 Gervais Avenue Maplewood, MN 55109		10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. Lab2019014
12. Sponsoring Organization Name and Address Minnesota Department of Transportation Office of Research & Innovation 395 John Ireland Boulevard, MS 330 St. Paul, Minnesota 55155-1899		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code
15. Supplementary Notes https://mndot.gov/research/reports/2021/202110.pdf		

16. Abstract (Limit: 250 words)

Each year, the Minnesota Department of Transportation (MnDOT) is affected by the large volume of data produced each day on highway construction projects. Significant time and resources are spent toward proper documentation, organization, mining, and review and use of this information. Intelligent construction technologies (ICT) are continuously being developed by the industry to assist agencies with simplifying and improving these processes along with other heavy construction activities. Efforts toward electronic construction are one of the many ICT initiatives that are moving forward for use nationally and internationally – electronic ticketing being one of them. The Material Delivery Management System (MDMS), formerly called the E-Ticketing system, was piloted on approximately 40 projects. This report summarizes the lessons learned, future recommendations, and the American Association of State Highway and Transportation Officials (AASHTO) provisional practice created as a result of these efforts. Additionally, this report details the workflow that was created to guide a user through pre-construction activities, the source process, delivery of material, data export, and end-of-day activities such as reconciling of quantities and labor compliance reviews as related to the MDMS. Future enhancements are recommended to establish a standardized platform for the viewing of MDMS by the agency (Veta MDMS) and for standardization of data for import into AASHTOWare Project, using Representational State Transfer Application Programming Interface (REST API) and JavaScript Notation (JSON), along with enhancements to the Veta software.

17. Document Analysis/Descriptors Construction projects, Building information models, Project delivery, Automatic data collection systems, Fleet management		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 142	22. Price

USE OF MATERIAL DELIVERY MANAGEMENT SYSTEM (MDMS) FOR ASPHALT PAVING APPLICATIONS

FINAL REPORT

Prepared by:

Rebecca A. Embacher
Minnesota Department of Transportation

March 2021

Published by:

Minnesota Department of Transportation
Office of Research & Innovation
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

ACKNOWLEDGMENTS

The Minnesota Department of Transportation (MnDOT) would like to express appreciation to the MnDOT's Research Services for funding the work to pilot the use of the Material Delivery Management System. Additionally, MnDOT would like to extend a sincere thank you to the contractors and district offices that were willing to pilot the technology and participate in debriefing meetings. A special thank you is extended to the Material Delivery Management System (MDMS) vendors that provided technical support to these pilot projects and also participated in debriefing meetings after completion of the given construction contracts. A sincere thank you is also extended to the vendors and other state agencies that participated in the MDMS Expert Task Group meetings and for those that assisted in review of the American Association of State Highway and Transportation Officials (AASHTO) provisional practice. Lastly, a special thank you is extended to the following individuals for assistance in development of the Application Programming Interface (API) and JavaScript Notation (JSON) language for use with centralized suppliers and contractor-owned sources: Bruce Jacobson (Granite Construction Inc.), Gautham Subramanian (Construction Digital & Technology/Caterpillar Inc.), Dann Rawls (Construction Digital & Technology/Caterpillar Inc.), Dan Miller (Tiller Corporation), Gene Schaff (Tiller Corporation), Chris Benson (Tiller Corporation), and Joel Hartleib (Tiller Corporation).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

America Association of State Highway and Transportation Officials (AASHTO)

AASHTOWare Project (AWP)

Application Programing Interface (API)

Dielectric Profile Method (DPM)

Independent Truck Operator (ITO)

Intelligent Compaction (IC)

Intelligent Construction Technology (ICT)

JavaScript Object Notation (JSON)

Material Delivery Management (MDM)

Material Delivery Management System (MDMS)

Managed Truck Operator (MTO)

Minnesota Department of Transportation (MnDOT)

Paver Mounted Thermal Profile (PMTP)

Representational State Transfer (REST)

EXECUTIVE SUMMARY

Each year, the Minnesota Department of Transportation (MnDOT) is impacted by the large volume of data produced each day on highway construction projects. Significant time and resources are spent toward proper documentation, organization, mining, and review and use of this information. Intelligent construction technologies (ICT) are continuously being developed by industry to assist agencies with simplifying and improving these processes along with other heavy construction activities. Efforts toward electronic construction are one of the many ICT initiatives that are moving forward for use nationally and internationally – electronic ticketing being one of them.

An electronic ticket (E-Ticket) is the exportable, **digitalized** source data (i.e., digitalization of the computer-generated paper weight ticket [bill of lading] generated by source loadout software). The agency project and source identification, material code, loading and weight information are considered source data. Please note that "digitalized" is considered to be data that are provided in a database format, and therefore, pdf or photo images are not considered E-Tickets.

E-Tickets are desired to assist with increasing the ease of reconciling quantities through E-Construction initiatives. In Minnesota, it is estimated that 3 million tons of asphalt mix are used each year. On average, about 15 tons of asphalt mixture are delivered per truck (i.e., paper ticket), which would generate 200,000 tickets per year! Assuming approximately 170 working days per year, this would result in 1,176 paper tickets generated per workday! MnDOT is currently paying the inspector to collect and file tickets, review and audit tickets, manually enter ticket quantities into spreadsheets, search for missing tickets, reconcile quantities and report quantities for pay estimates. E-Tickets are now available to simplify and automate these tasks.

It is anticipated that the use of E-Tickets will allow the following benefits to be realized: increased safety as the collection of paper tickets often requires the inspector to be near live traffic and heavy construction equipment, which significantly increases the risk of injury and death; increased accuracy of tabulations as the use of E-Tickets will prevent the encountering of lost or damaged paper tickets, increase accuracy in tabulations of quantities since source data will now be digitalized and not require manual data entry, and provide ease in development of summary reports (e.g., daily, monthly, contract, project, funding, material code, etc.); digitalized documentation for contract archives as paper tickets are often unable to be scanned for archiving purposes due to use of thermal paper, damaged tickets, etc.

MnDOT's objective for this project was to capture an electronic, digital version of the computer-generated paper weight ticket (that would be made available through cloud storage and/or computing) on two to three **<u>asphalt paving</u>** contracts during the 2018-20 construction season. E-Ticketing was put on 10 projects during the 2018-19 and on an additional 30 projects in 2020 due to COVID-19 to assist with social distancing and minimizing the handling of paper tickets. The digitalized E-Tickets were used to assist field personnel during delivery of the material and the paper tickets were collected as a bundle either at the end of the day or weekly for use in reconciling quantities on these projects.

Prior to the start of the pilot projects requiring digitalization of E-Tickets (source data), the technology was solely referred to as "E-Ticketing." However, after MnDOT's preliminary pilot of projects, it was determined that additional data is needed to support the E-Ticket to adequately reconcile daily quantities. This information is recorded by both the engineer and contractor during daily construction activities, such as split load quantities and associated pay items, rejected loads, partial load quantities, etc. Again, this information is not generated as part of the E-Ticket but rather later in the field during the truck exchange (dump). It was also realized that reconciling quantities can be extremely complex on contracts with multiple projects and/or funding categories, and therefore, fleet data would also be needed for those agencies that elect to automate this process. Fleet data is data generated such as dumping details, geofence names, date and time stamps, and durations. This data can be used to assist with automatic reconciling of quantities with respect to contract, project and funding categories, which requires an extensive amount of time and resources when tracking via field notes.

After further discussions with contractors and individuals working with AASHTOWare Project (AWP) and within the labor compliance and civil rights groups, it was also determined that the E-Ticket and fleet data would also greatly assist and support their efforts during the auditing process. Only a few additional fleet management and hauler data fields would be needed to complement the already existing data being captured to reconcile quantities and for generation of flow rates.

Consequently, it was deemed necessary to move away from solely using the term "E-Ticketing" and establish a naming convention that would encompass the various types of data needed to assist with reconciling quantities, develop flow rates, and support general audits and labor compliance and civil rights activities. Through discussions with vendors and contractors, it was decided to call this technology the Material Delivery Management System (MDMS). Therefore, the MDMS was defined as a system that manages source, fleet, hauler, agency and contractor data associated with delivery of material to a contract.

The following summarizes the conclusions and recommendations realized from the pilot projects, debriefing meetings with contractors and MnDOT construction staff and with meetings with MDMS vendors.

- It was deemed necessary to move away from solely using the term "E-Ticketing" and establish a naming convention that would encompass the various types of data needed to assist with reconciling quantities, develop flow rates, and support general audits and labor compliance and civil rights activities. Through discussions with vendors and contractors, it was decided to call this technology the Material Delivery Management System (MDMS). Therefore, the MDMS was defined as a system that manages source, fleet, hauler, agency and contractor data associated with delivery of material to a contract.
- As a result of the pilot projects, industry, national department of transportation (DOT) needs, and to better support mitigation of the spread of COVID-19, it was deemed necessary to establish an American Association of State Highway and Transportation Officials (AASHTO) standard for the MDMS. Consequently, MnDOT volunteered to be the steward for development

of the AASHTO provisional practice for the MDMS. This provisional was written for asphalt applications; however, in the future, additional material types will be included.

- The MDMS can effectively be used to digitalize source data (i.e., generate an E-Ticket); however, hauler, fleet, agency and contractor data should be included in these systems to support other construction and administrative needs and to increase buy-in from contractors.
- Annual MDMS costs appear to be affected by the size of the project (quantities), and therefore, a pay item for a unit of “tons” was created for asphalt applications. In the future, another pay item will be created for ready-mix using a unit of “cubic yards.”
- There are desired features and data fields that are not available from the majority of vendors, and consequently, MnDOT has issued a single lump sum payment of $5,000 for contracts where the MDMS collects, stores and exports all of the data fields per the requirements of the provision. “When available” was included in the special provision language to allow MDMS to still be used when the given features and data fields that were not available at the time of these pilot projects cannot be provided. The monetary adjustment will be removed from the special provision sometime after the material delivery management (MDM) systems can complete the needed enhancements.
- As a result of the findings of the debriefing meeting, MnDOT created a workflow to guide a user through pre-construction activities, the source process, delivery of material, data export, and end-of-day activities such as reconciling of quantities and labor compliance reviews as related to the MDMS.
- Some contractors are still running DOS-based source loadout software platforms that most MDM systems are unable to communicate with for transmittal of source data. Consequently, these sources will require upgrading to GEN OS (or the processing capacity must be increased) to work properly with most MDM systems. This can be costly, and contractors will need time to make these needed upgrades.
- Some yearly, loadout software maintenance updates can affect transmittal of source data to the contractor’s MDMS, where source data transferred with no issues prior to the update but later encountered problems after the maintenance update.
- Vendors have noted that it can be difficult and require extensive time and resources to get some loadout software platforms to communicate with the contractor’s MDMS – resulting in each source often being treated and set up separately for a given contractor.
- Internet connectivity (or satellite connectivity for those entities that elect to use satellites for data transfer) was often overlooked for portable sources.
- Unique truck identifications were not always used in the loadout software at each source. Distinct identifications are needed to allow for correct association of the material being hauled with respect to the serial number of the breadcrumb recording device, generation of accurate flow rates, truck summary reports, accurate material association with dumped locations, etc.
- Some Managed Truck Operators (MTO) may use the same truck identification for multiple trucks. Therefore, it is important that the contractor distinctly identifies these trucks to allow for correct association of the material being hauled with respect to the tracking device, generation

of accurate flow rates, truck summary reports, accurate material association with dumped locations, etc.

- Automatically recording a description for the dump locations is necessary to assist with reconciling quantities for agencies that are automatically capturing truck exchange (dump) information. The inspectors typically record this information during truck exchanges on the paper tickets or within a diary. Consequently, the creation of geofences around geographic and funding category regions is necessary to automatically digitally record a description of the dump location.
- Dump information (i.e., date and time stamp, and dump latitude and longitude) was not always successfully recorded and will require time and experience by the contractor to learn how to successfully set up the needed information per contract, paving crew and equipment. Automatic triggering of the dump requires optimization, by the contractor, of settings such as duration of time spent within the mobile geofence and the radius of the mobile geofence. For example, crews that have slow versus quick truck exchanges will need to be set up with different time durations within the geofence to ensure capturing of the dump. Additionally, equipment also affects these settings. For instance, as to whether material transfer devices, end dumps or pick up machines are being used will affect both the time within the geofence and geofence radius being used.
- The use of circular geofences can make it difficult to correctly track truck exchanges when paving in echelon, or when secondary pavers are in proximity. Rectangular geofences may help mitigate these issues, should they become available.
- During debriefing meetings with the contractors, they elaborated on the difficulty of accurately capturing hauler information and to do so within a reasonable time frame. Additionally, the contractors did not want the responsibility of populating this information into the MDMS for Independent Truck Operator's (ITO's) and MTOs, and therefore, it was determined that this should be the hauler's responsibility. In addition to the use of fleet data for reconciling quantities, fleet data provides the needed details for improved workmanship, flow rates, identification of inefficiencies, labor compliance audits, and general contract closeouts and audits. Obtaining missing trucking reports is often the number one reason for delay in closing out contracts. Additionally, disabled business enterprise (DBE), or small business closeouts, can also delay contract finals and hold up a contractor's bond. These time stamps assist with documentation of prevailing wage hours, along with independently verifying that loads indeed made it to the contract limits and were dumped. Additionally, questionable time stamps can assist with investigating (and or verifying) whether entire loads (or partial loads) were delivered to other contracts or locations.
- During the debriefing meetings with Minnesota contractors, the following items were also noted with respect to the need for collection of time stamps and durations (fleet data), and hauler data: (1) the contractors recommended that the MDMS includes the collection of data required for labor compliance activities and believe that this is where the greatest "buy-in" for the technology lies (i.e., not in the digitalization of computer-generated paper weight tickets, but in the ability to support documentation for labor compliance activities); (2) trucking is one of the

contractor's top expenses (typically the second top expense); (3) completion of prevailing wage reports are complex and require a significant amount of time and resources to complete correctly; (4) collection of fleet data would assist with prevailing wage compliance; (5) many haulers often have a limited amount of time to complete prevailing wage documentation, and consequently, this documentation is often not completed in a timely manner; (6) it is the contractor's responsibility to ensure that prevailing wage reports are completed correctly, ensure that the truck hauler is paid correctly and to take appropriate actions to ensure compliance with the contract; (7) connecting hauler information to the source data (E-Ticket) assists with monitoring and documentation of the craft/classification/trade, while labor compliance audits can take months or years to complete, making it difficult to gather needed documentation; (8) the fleet data would aid with determining whether additional documentation and reporting is needed for compliance with the Federal Davis Bacon Law; and (9) the fleet data would also aid in civil rights activities.

- During material delivery there may be instances where the agency and/or contractor needs to record the following information into the MDMS for use in reconciling quantities: split loads 1, 2, 3 weight, split loads 1, 2, 3 pay item, split loads 1, 2, 3 location note, wasted material weight, load acceptance and rejection, partial rejected load weight, dump station number, field notes, inspector/identification, date and time stamp (of agency/contractor data entry). Currently, this information is often recorded on the paper weight tickets, or within diaries.
- Additional data fields, beyond that of the source data, are needed to adequately reconcile quantities. The following source, fleet, agency, and contractor data fields are required to correctly reconcile quantities: (1) Source Data: contract identification, agency project identification, material code, ticket number, load number, voided ticket, loading data and time, net weight; (2) Fleet Data: overweight weight, dump equipment identification, dump geofence name; (3) Agency/Contractor Data: split load 1, 2, 3 weight, split load 1, 2, 3 pay item, split load 1, 2, 3 location notes, wasted material weight, load acceptance and rejection, partial rejected load weight, notes.
- Source, fleet, and hauler data fields are used to support labor compliance and civil rights audit review activities. The following data fields are needed: (1) Source Data: contractor identification, agency project identification, source identification, material code, ticket number, truck identification, trailer identification, voided ticket, loading date and time; (2) Fleet Data: source geofence name, contract geofence name, dump geofence name, truck enters source geofence date and time, truck exits source geofence date and time, time at source, source to contract transit time, truck enters contract geofence date and time, truck exits contract geofence date and time, time at contract, contract to source transit time, dump date and time; (3) Hauler Data: hauler company name, broker name, DOT number, truck identification, driver name.
- Contractors who distributed the asset trackers for the duration of the contract to MTOs and ITOs found this method to work effectively and would most likely use this distribution process again in the future. Those contractors who collected and distributed the asset trackers daily found this process to be cumbersome and time consuming due to the difficulty in dealing with

trucks that do not always come back to the source at the end of the day and the tracking, re-assignment, and constant redistribution of the trackers.

- It is recommended that a sixth data type (as-built data) is added to the contractor's MDMS. As-built data would include measurements collected by the paver to assist with calculation of yield rates, analysis of intelligent compaction and paver mounted thermal profile data (i.e., development of location filters) and more. The as-built data would include data fields such as paving width, depth at left edge, depth at right edge, distance paved and paver speed.
- During the early stages of deployment of the MDMS, it is recommended that a pay item be included to compensate for the annual costs associated with the technology (e.g., data entry of project information, set up of appropriate MDMS components, system set up to transmit source data into the contractor's MDMS, Internet connectivity at permanent and portable sources, set up of geofences, system monitoring, assigning and distribution of truck asset trackers, monitoring of yields rates recorded by the contractor's MDMS, remote server storage, cloud-based software accessibility and data package plans). In the future, the pay item should be revaluated to determine whether the MDMS method should be considered incidental or continue to be supported via a pay item.
- It is recommended that vendors allow for use of Representational State Transfer Application Programing Interface (REST API) and JavaScript (JSON) request body with contractor-owned permanent and portable sources to allow an easier process of transmittal of source data regardless of the loadout software used, or whether any updates were made to the software. The use of REST APIs and JSON not only assists contractor-owned sources (for those who elect to use this more streamlined data transfer process) but also centralized suppliers. Centralized suppliers are suppliers that provide material to multiple contractors. It is not effective for these suppliers to purchase multiple MDM systems to supply source data to the varying systems.
- The contractor's MDMS should allow for the ability to perch devices, as needed, when sources are in low-lying areas to increase data signal strength.
- It is recommended that static data (i.e., data that remains the same in each ticket) is directly entered into the contractor's MDMS in lieu of pushing this data with each ticket. This would help minimize the volume of data being pushed with each ticket. Therefore, it is recommended that the contractor's MDMS allows the contractor to enter the following source identification information directly into the contractor's MDMS: source identification, source name, portable plant (yes/no), source address and source phone number.
- The source and contract geofences are recommended to be set up by the contractor. The source geofence is a static virtual perimeter around boundary of source (e.g., boundary around a plant), while the contract geofence is a static virtual perimeter around the limits of the work to be completed in the contract (e.g., boundary of jobsite).
- As part of pre-construction activities, it is recommended that the agency create the project and category geofences. A project geofence is a static virtual perimeter around a subsection of the contract with specialized geographic designations (e.g., control section numbers), while the category geofence is a static virtual perimeter around a subsection of a project with different funding sources.

- It is recommended that the contractor set up a mobile dump geofence around the boundaries of equipment that material is being delivered to (such as the paver, pickup machine, or material transfer device, etc.) for those agencies that desire automated recording of the material being delivered.
- Training is extremely important as there is not currently a standardized platform for agencies to view the contractor's MDMS data; therefore, training is recommended as part of the preconstruction activities.
- It is recommended that the overweight permit number and maximum gross weight are included in the hauler data requirements as this information is used, along with the net weight on the E-Ticket for calculation of overweight quantities. Some agencies are unable to pay for these quantities and must subtract these weights when reconciling quantities.
- It is recommended that a hauler user interface is created within the contractor's MDMS and an agency and contractor user interface is created in the Veta MDMS.
- It is recommended that each agency randomly reviews the source and hauler data to ensure no issues are present with the contractor's MDMS and that source data stored within the contractor's MDMS is accurate for use in yield checks and reconciling of quantities. This independent field verification information is also used to verify that the final MDMS data set reflects those values originally reviewed in the field.
- All MDMS vendors can export data using conventional file downloads in dbase ASCII, CSV, XLSX, or text format. However, in the future, it is recommended that enhancements are made to allow for transfer of data using APIs and JSON from the contractor's MDMS to the Veta MDMS.
- It is recommended that enhancements are made to AASHTOWare Project (AWP) to allow for import of source, fleet, hauler, agency, and contractor data into AWP "Construction and Materials" and "Estimating" modules for use in reconciling daily quantities and for use with future estimated quantities, respectively. Additionally, this data should be imported into the materials testing and acceptance system to ensure acceptance testing is completed at the required frequency. Fleet and hauler data should be imported into the AWP "Civil Rights and Labor" module for agencies that elect to capture fleet and hauler data.
- It is recommended that Veta is converted from a desktop platform to a web-based application to allow for use as a standardized solution for the agency's MDMS. Additionally, conversion of Veta to a web-based application would also assist with the field use and automated analyses of other ICT (e.g., IC, PMTP, DPS, AMG-Milling, etc.).
- It is recommended that MDMS data sets that contain the latitude and longitude for the dump location (e.g., time stamp of loading, placement time, mix designation and asphalt/air temperature data) are overlaid over intelligent construction data such as intelligent compaction, paver mounted thermal profiling and dielectric profile data within Veta. This information could then be used to assist with identification of workmanship issues, remove and replace limits, development of field heat loss curves, verification of dielectric profile calibration equations, and for use in future long-term pavement issues should these arise.
- A few entities have stated that they would prefer that data fields associated with labor compliance are not included in the contractor's MDMS. However, this information significantly

assists both the contractor and agency. Additionally, it only requires a few extra fields beyond those already needed for reconciling quantities and generation of flow rates, and therefore, is recommended for inclusion with the MDMS and agency requirements.

- It is recommended that language for system failures is included in the requirements. System failure occurs when the MDMS does not collect and/or store data per the requirements of specification or when data cellular coverage is limited. It is recommended that during system failures, the source data will revert to other means, which is approved by the engineer, for sharing source data during system failures. For example, this could be going back to paper-generated weight tickets, or maybe in areas with limited to no data cellular coverage, quick response (QR) codes could be used, etc.
- Discussions were also held regarding the use of smart devices for the tracking of trucks. While this is a viable solution, care should be taken as to whether "personal" devices are used versus designated devices used solely for the purpose of collecting MDMS data. Depending on any future litigation, personal devices used to capture MDMS data may be collected during the discovery process. Consequently, personal devices for the collection of agency data are not recommended.

CHAPTER 1: BACKGROUND

Each year, the Minnesota Department of Transportation (MnDOT) is impacted by the large volume of data produced each day on highway construction projects. Significant time and resources are spent toward proper documentation, organization, mining, and review and use of this information. Intelligent construction technologies (ICT) are continuously being developed by industry to assist agencies with simplifying and improving these processes along with other heavy construction activities. Efforts toward electronic construction are one of the many ICT initiatives that are moving forward for use nationally and internationally – electronic ticketing being one of them.

1.1 WHAT IS AN E-TICKET?

An electronic ticket (E-Ticket) is the exportable, **digitalized** source data (i.e., digitalization of the computer-generated paper weight ticket [bill of lading] generated by source loadout software). The agency project and source identification, material code, loading and weight information are considered source data. Please note that "digitalized" is considered to be data that is provided in a database format, and therefore, pdf or photo images are not considered E-Tickets.

1.2 BENEFITS

E-Tickets are desired to assist with increasing the ease of reconciling quantities through E-Construction initiatives. In Minnesota, an estimated 3 million tons of asphalt mix are used each year. On average about 15 tons of asphalt mixture are delivered per truck (i.e., paper ticket), which would generate 200,000 tickets per year! Assuming approximately 170 working days per year, this would result in 1,176 paper tickets generated per workday! MnDOT is currently paying the inspector to collect and file tickets, review and audit tickets, manually enter ticket quantities into spreadsheets, search for missing tickets, reconcile quantities and report quantities for pay estimates. E-Tickets are now available to simplify and automate these tasks.

It is anticipated that the use of E-Tickets will allow the following benefits to be realized:

1. Increased Safety
   Collection of paper tickets often requires the inspector to be near live traffic and heavy construction equipment, which significantly increases the risk of injury and death. Safety is part of MnDOT's core values. "Safety as a core value means we reflect our commitment to everyone's well-being both in our work and on our transportation system. We strive Towards Zero Death in traffic safety and strive to attain zero fatalities and prevent injuries at work. It is a high standard, but when we hold Safety as a core value, it pushes us to revisit, assess, re-engineer, train and hold one another accountable. Our success at living this core value depends on the wellbeing of our employees and the citizens we serve."

2. Increased Accuracy of Tabulations
   The use of E-Tickets will:

- Prevent the encountering of lost or damaged paper tickets
- Increase accuracy in tabulations of quantities since source data will now be digitalized and not require manual data entry
- Provide ease in development of summary reports (e.g., daily, monthly, contract, project, funding, material code, etc.)

3. Digitalized Documentation for Contract Archives
   Paper tickets are often unable to be scanned for archiving purposes due to the use of thermal paper, damaged tickets, etc. E-Tickets will assist with archiving source data in the contract files and increase the ease of future audits.

1.3 PROJECT OBJECTIVE

MnDOT's objective for this project was to capture an electronic, digital version of the computer-generated paper weight ticket (that would be made available through cloud storage and/or computing) on two to three **asphalt paving** contracts during the 2018-20 construction season. The engineer would continue to use the computer-generated paper weight tickets for generation of density lots and calculation of pay quantities on these pilot projects. However, the contractor would be required to submit the E-Ticket to the engineer on a weekly basis for use in validation of this system with respect to the computer-generated paper weight tickets.

In addition to the E-Ticket, MnDOT required that the following fleet data to be collected with each E-Ticket: truck enters and exits source and contract date and time, dump date and time, and dump latitude and longitude.

The following projects were selected as the pilot projects:

Construction Year (2018)

- SP3804-60 TH13
- SP4710-27 TH22
- SP4710-27 TH55

Construction Year (2019-20)

- SP6917-143 TH53 (2019 only)
- SP6920-53 TH53 (2019 only)
- SP1985-148 TH494
- SAP085-609-019 CSAH 9
- SAP085-609-019 CSAH 12
- SAP085-609-019 CSAH 15
- SAP085-609-019 CSAH 17

As a result of COVID-19, more than 30 projects used the E-Ticketing technology during the 2020 construction season to assist with social distancing and to minimize the handling of the paper tickets. The digitalized E-Tickets were used to assist field personnel during delivery of the material, and the paper tickets were collected as a bundle either at the end of the day or weekly. The paper tickets were still used for reconciling quantities on these projects as was done on the other pilot projects listed above. The lessons learned from these projects will also be included in this report.

CHAPTER 2: MATERIAL DELIVERY MANAGEMENT SYSTEM PILOT PROJECTS

2.1 MATERIAL DELIVERY MANAGEMENT SYSTEM (MDMS)

Prior to the start of the pilot projects requiring digitalization of E-Tickets (source data), the technology was solely referred to as “E-Ticketing”. However, after MnDOT’s preliminary pilot of projects, it was determined that additional data is needed to support the E-Ticket for adequate reconciling of daily quantities. This information is recorded by both the Engineer and Contractor during daily construction activities, such as split load quantities and associated pay items, rejected loads, partial load quantities, etc. Again, this information is not generated as part of the E-Ticket, but rather later in the field during the truck exchange (dump). In was also realized that reconciling quantities can be extremely complex on contracts with multiple projects and/or funding categories, and therefore, fleet data would also be needed for those agencies that elect to automate this process. Fleet data is data generated such as dumping details, geofence names, date and time stamps, and durations. This data can be used to assist with automatic reconciling of quantities with respect to contract, project and funding categories which requires an extensive amount of time and resources when tracking via field notes.

After further discussions with Contractors and individuals working with AASHTOWare Project (AWP) and within the Labor Compliance and Civil Rights groups, it was also determined that the E-Ticket and fleet data would also greatly assist and support their efforts during the auditing process. Only a few additional fleet management and Hauler data fields would be needed to compliment the already existing data being captured to reconcile quantities and for generation of flow rates.

Consequently, it was deemed necessary to move away from solely using the term “E-Ticketing” and establishing a naming convention that would encompass the various types of data needed to assist with reconciling quantities, develop flow rates, and to support general audits and labor compliance and civil rights activities. Through discussions with vendors and Contractors, it was decided to call this technology the “Material Delivery Management System (MDMS)”. Therefore, the MDMS is defined as a system that manages source, fleet, Hauler, Agency and Contractor data associated with delivery of material to a contract. Figure 2.1 illustrates the schematic of the data associated with the MDMS. Please note that discussions have commenced regarding adding a sixth data type (as-built data) to the MDMS. As-built data would include measurements collected by the paver to assist with calculation of yield rates, analysis of intelligent compaction and paver mounted thermal profile data (i.e., development of location filters) and more. The as-built data would include data fields such as: paving width, depth at left edge, depth at right edge, distance paved and paver speed. Further discussions are still needed, and therefore, As-Built Data will not be discussed in this report.

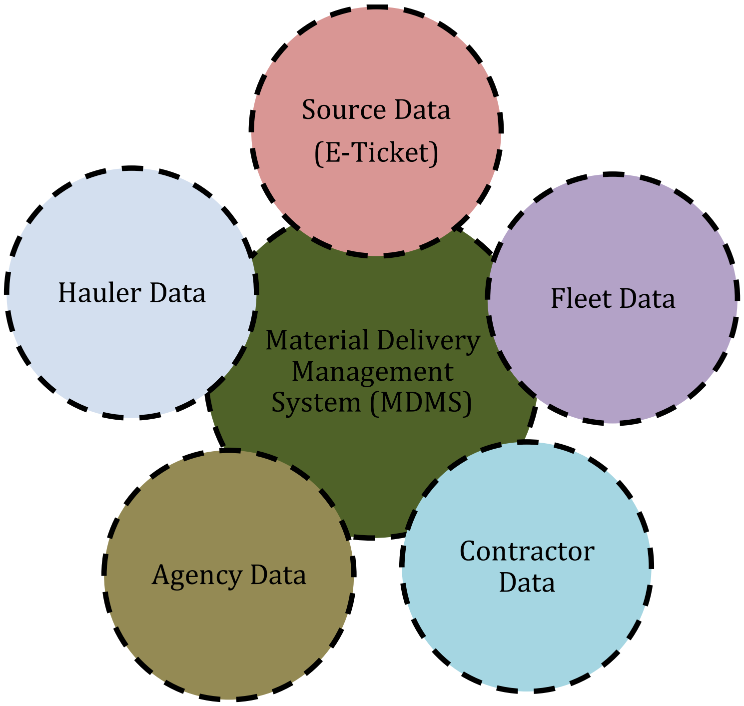


Figure 2.1 Schematic of MDMS data.

As a result of the lessons learned from the 40 MDMS projects to date, the following subsections outline the use of the MDMS from development of needed standards – to pre-construction and construction activities – to the reconciling of quantities.

2.2 MDMS STANDARDS

2.2.1 AASHTO "Standard Practice for Material Delivery Management System"

As a result of the pilot projects, industry, national DOT needs, and to better support mitigation of the spread of COVI-19, it was deemed necessary to establish an AASHTO standard for the MDMS. Consequently, MnDOT volunteered to be the steward for development of the AASHTO provisional practice for the "Material Delivery Management system", with the goal of submitting the provisional for balloting in 2021 and publication in April of 2022. This provisional was first written for asphalt applications, however, in the future additional material types will be included in this provisional. See "CHAPTER 3: General Roadmap" for the schedule of tasks related to the development of this provisional practice.

See Appendix A for the current draft of the MDMS AASHTO provisional practice.

2.2.2 MnDOT's MDMS Special Provision

In addition to development of the AASHTO provisional practice, MnDOT has also been developing and refining MnDOT's special provision used both directly in contracts and through change orders. Appendix B, presents the latest version of MnDOT's MDMS special provision. In addition to the development of this special provision, MnDOT has also worked with the letting's office for creation of a pay item for use with the MDMS on contracts. While working with the Contractors, it was realized that there are both one-time start-up costs associated with the technology, along with annual costs. The pay item is intended to assist with payment of the annual costs such as: data entry of project information, set up of appropriate MDMS components, system set up to transmit source data into the MDMS, internet connectivity at permanent and portable sources, set up of geofences, system monitoring, assigning and distribution of truck asset trackers, monitoring of yields rates recorded by MDMS, remote server storage, cloud-based software accessibility, and data package plans. It was also found that the costs appear to be affected by the size of the project (quantities), and therefore, a pay item for a unit of "tons" was created. In the future, another pay item will be created for ready-mix using a unit of "cubic yards". At this time, it is uncertain as to whether the MDMS will be considered as incidental in the future, and consequently, those discussions will occur 5 to 10 years from now after the progression of the technology and better understanding of the annual costs.

In addition to establishment of a pay item, a monetary adjustment was also added to the special provision. After pilot of the technology, it was found that there were desired features and data fields that were not available by the majority of vendors, and consequently, a single lump sum payment of $5,000 would be issued for contracts where the MDMS collects, stores and exports all of the data fields per the requirements of the provision. These additional features and data fields are currently listed as "when available" within the provision. It is believed that inclusion of this monetary adjustment will assist MnDOT as follows:

1. Provide transparency to both the Contractors and vendors as to what features MnDOT currently requires, but also for those features that will be required in the future. This information helps the Contractors better determine which system to purchase. As some vendors may elect to never provide some of the future data and features required by MnDOT. This is a large investment to be made by the Contractors, where knowing this information in advance, will better mitigate the need of purchasing a different system in the future.
2. Providing a detailed listing of future requirements, allows the vendors to incorporating these enhancements into their systems, should they elect to provide systems to Minnesota Contractors.

MnDOT is hoping that the items included in the special provision as "when available" are made accessible by 2024. The monetary adjustment will be removed from the special provision sometime after the MDM systems used by Minnesota Contractors can provide this information. It is undecided how long this overlap period will extend, but this will be determined at a future date.

2.3 MDMS WORKFLOW

MnDOT generated a workflow for the use of the MDMS as a result of debriefing meetings held with Contractors and vendors related to the pilot projects. Figures 2.2 through 2.6 presents the workflow which guides the user through pre-construction activities, the source process, delivery of material, data export, and the end of day activities such as reconciling of quantities and labor compliance reviews. Please note that the section references within this workflow are with respect to those contained within the AASHTO provisional practice outlined in Appendix A. Additionally, the data field numbers listed are with respect to those listed in Table 1 of Appendix A.

The following subsections provides detail for the processes of this workflow.

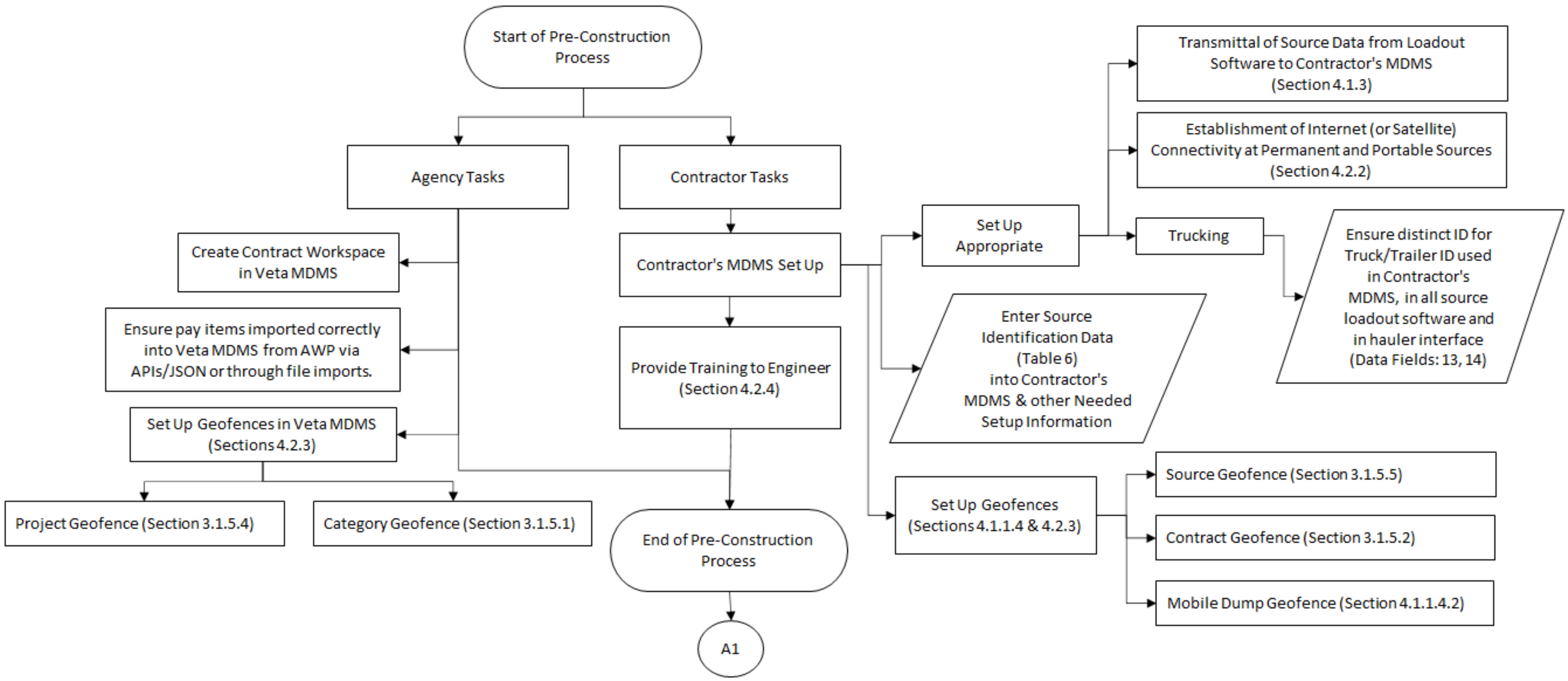


Figure 2.2 Schematic of the MDMS Workflow (Preconstruction Process).

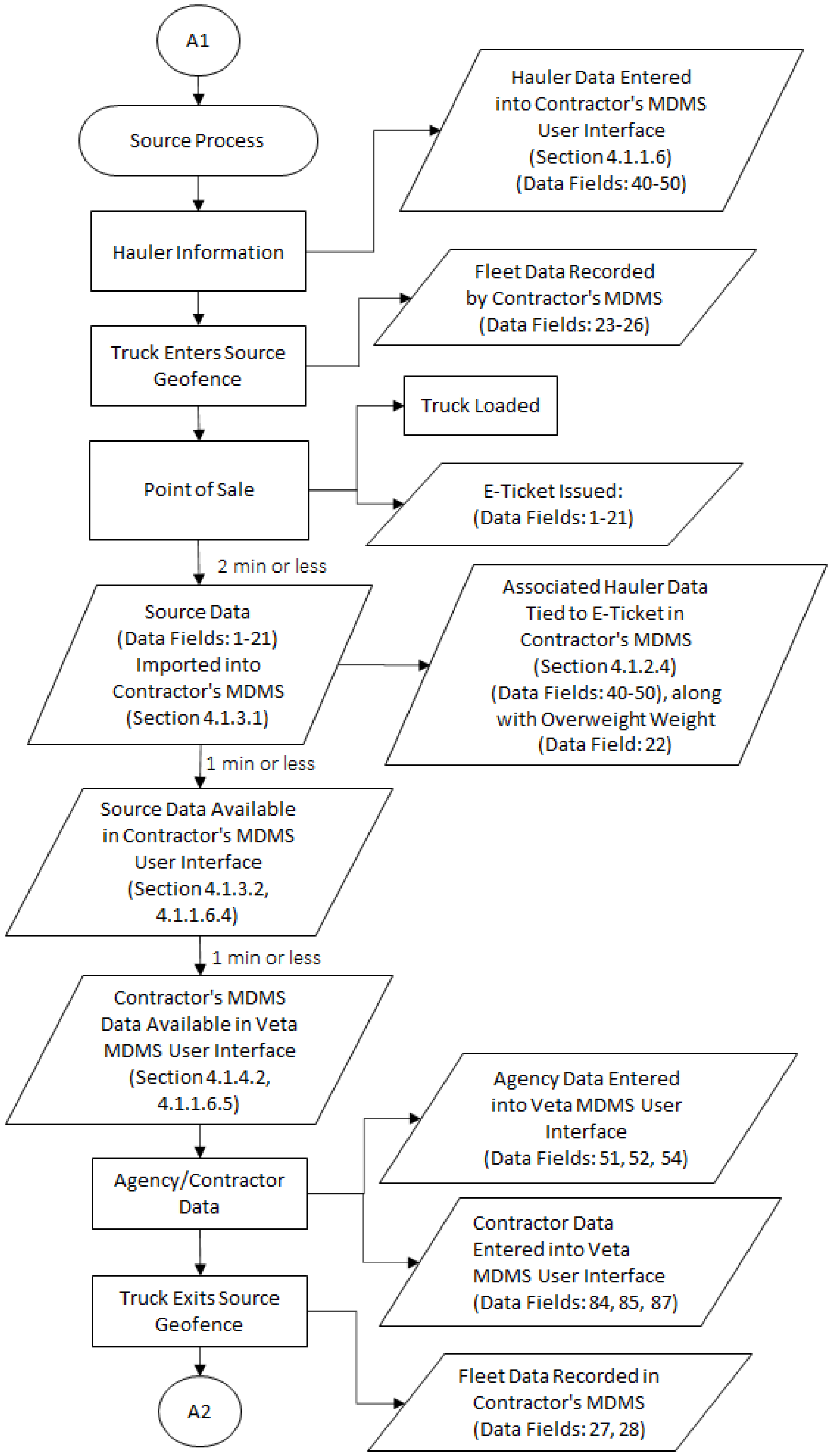


Figure 2.3 Schematic of the MDMS Workflow (Source Process).

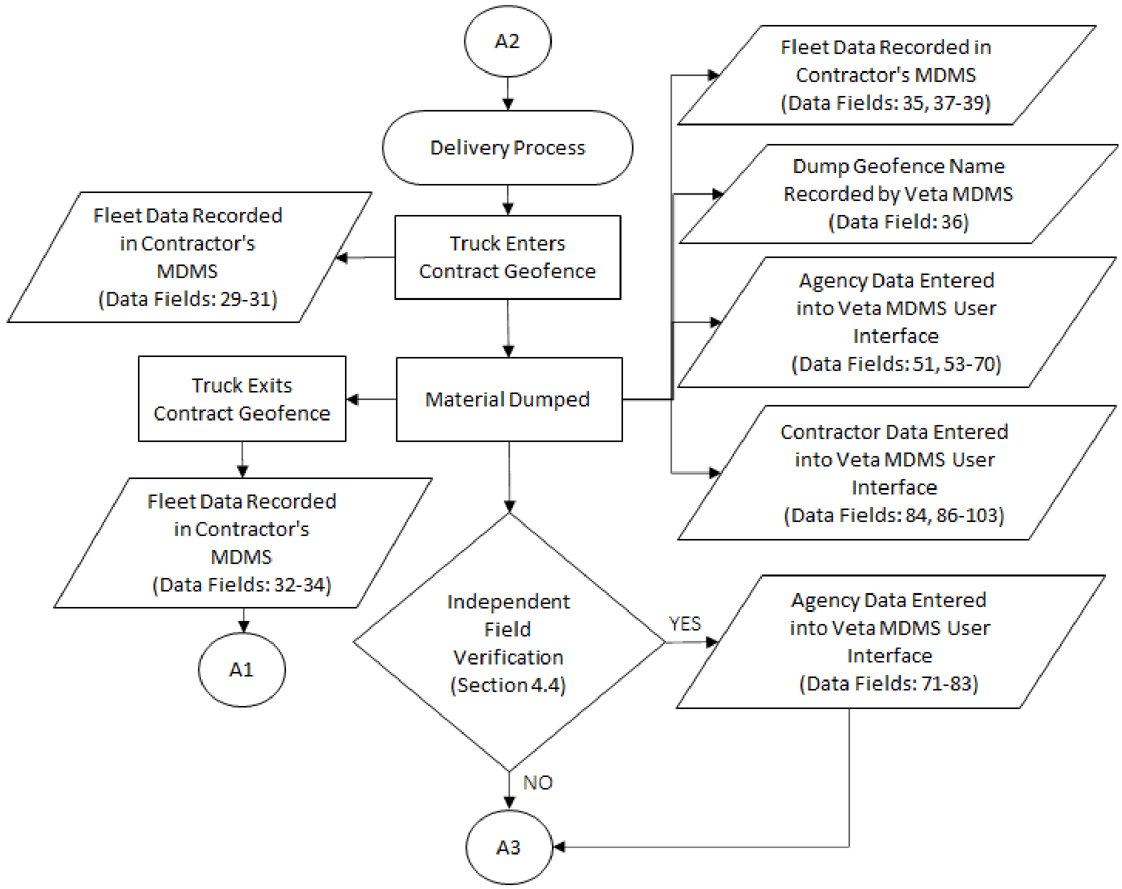


Figure 2.4 Schematic of the MDMS Workflow (Delivery Process).

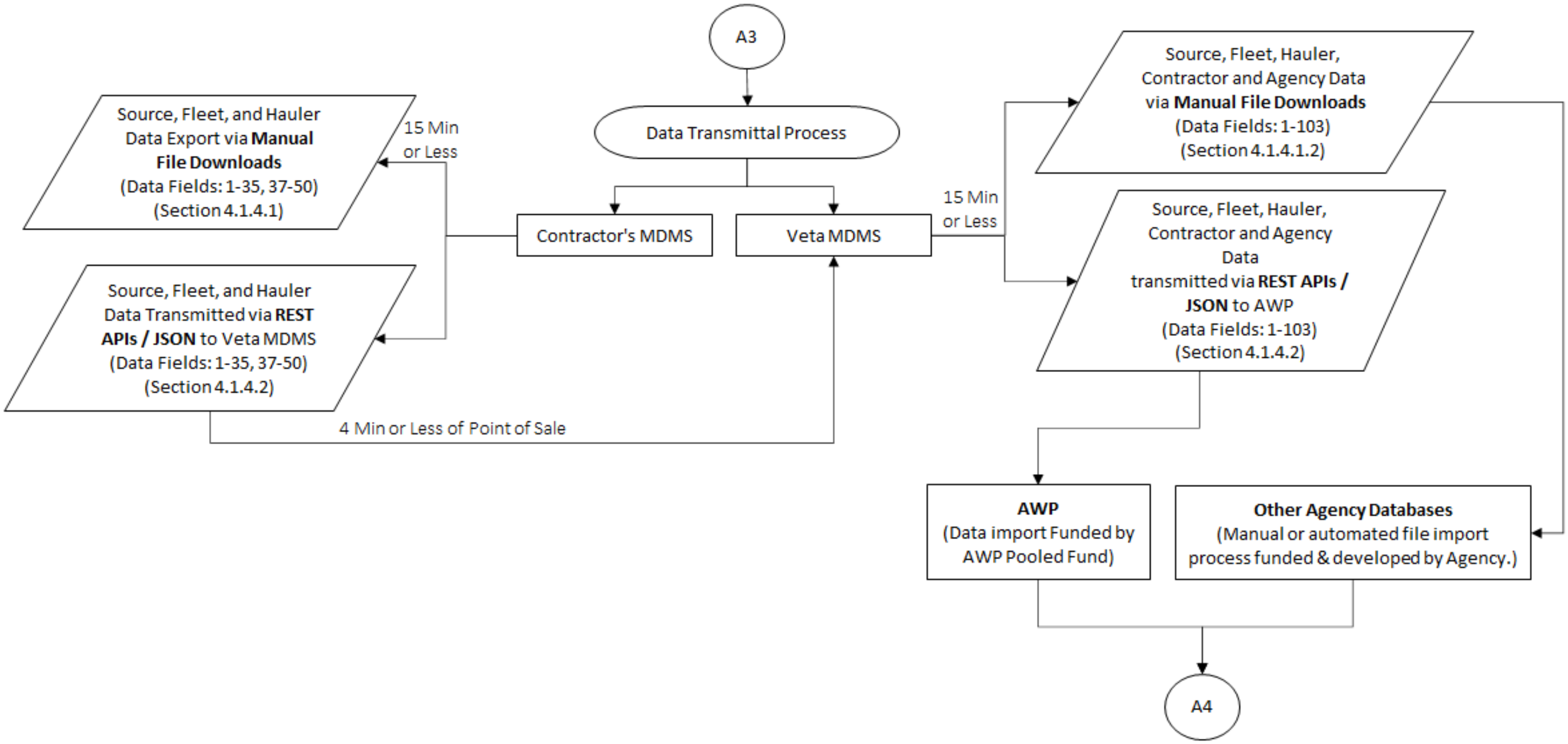


Figure 2.5 Schematic of the MDMS Workflow (Data Transmittal Process).

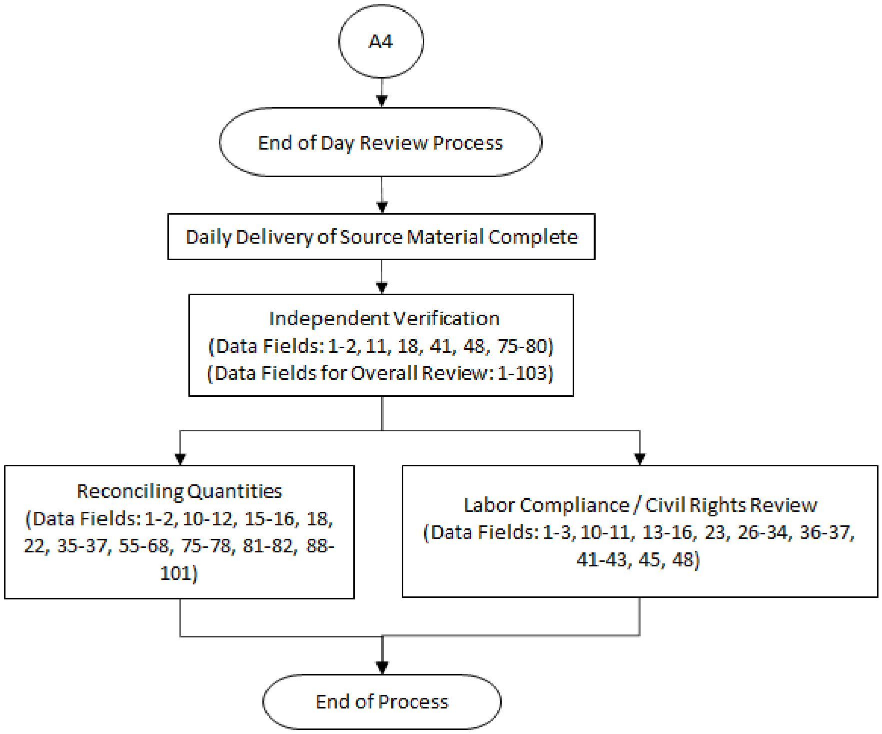


Figure 2.6 Schematic of the MDMS Workflow (End-of-Day Review).

2.3.1 Pre-Construction Process

The first step of the MDMS workflow details the steps entailed during the pre-construction process. As per Figure 2.2, this process consists of both Agency and Contractor tasks. The Agency tasks entail setting up Veta for the Contract, while the Contractor tasks require setting up the MDMS prior to the start of material delivery activities and providing the needed training to the Engineer. The following subsections discuss the elements of this process.

2.3.1.1 Agency Tasks

(See Figure 2.7 for workflow of agency tasks.)

The Agency tasks consist of creating the contract workspace in the Veta MDMS, ensuring that the pay items have been imported correctly into the Veta MDMS, and creation of geofences. Please see section 3.3 “Veta MDMS Enhancements” for additional details related to the creation of a standardized platform for use by Agencies for viewing of MDMS data.

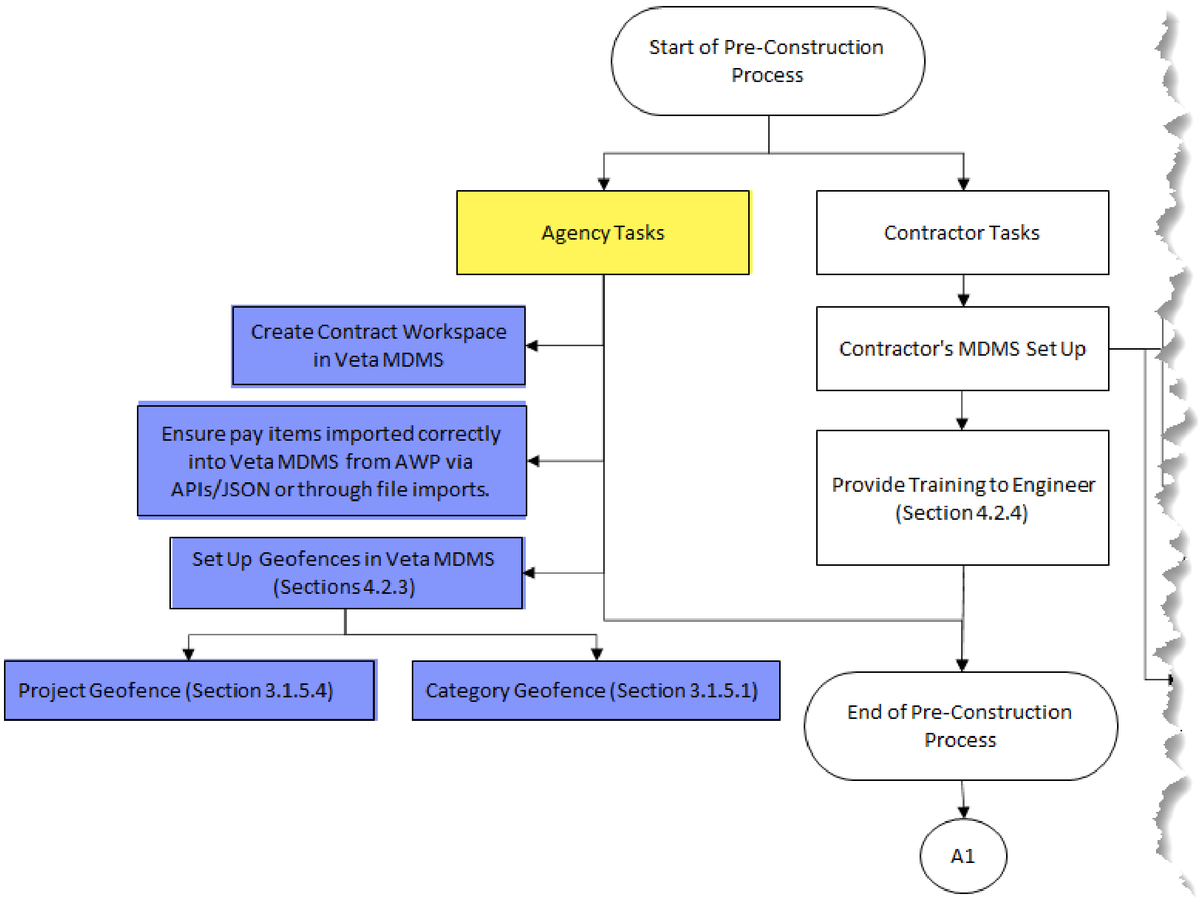


Figure 2.7 Agency Tasks (Pre-Construction Workflow Schematic).

CREATE CONTRACT WORKSPACE IN VETA MDMS

Creation of contract workspace will allow construction staff to access and view MDMS data for the given contract, create project and category geofences, and enter Agency data during construction activities.

ENSURE PAY ITEMS IMPORTED CORRECTLY INTO VETA MDMS

The pay items, associated with the material being monitored with the MDMS, will be imported into the Veta MDMS to help ensure consistent labeling of pay items associated with split load quantities. This allows users the ability to select the appropriate pay item from the Veta MDMS in lieu of manually entering this information.

SET UP PROJECT AND CATEGORY GEOFENCES IN VETA MDMS

It was determined that automatically recording a description for the dump locations is necessary to assist with reconciling quantities for agencies that are automatically capturing truck exchange (dump) information. The inspectors typically record this information during truck exchanges on the paper tickets or within a diary. Consequently, the creation of geofences around geographic and funding category regions is necessary in order to automatically, digitally record a description for the dump location. A geofence is defined as a virtual perimeter that indicates when a mobile device enters or exits a predefined area. As part of pre-construction activities, the Agency would create the following geofences (see Section 4.2.3.2 of Appendix A):

Project Geofence – static virtual perimeter around a subsection of the contract with specialized geographic designations (e.g., control section numbers).

Category Geofence - Static virtual perimeter around a subsection of a project with different funding sources.

Tables 2.1 and 2.2 present examples of contracts that have multiple projects and funding categories. Again, on these contracts, the inspectors are required to track quantities with respect to both the given project and funding category. This is used for payment purposes and in life cycle cost analyses for the given projects (control sections).

Figure 2.8 provides an example of project and category geofences. As illustrated, this contract contains three projects as depicted by the solid green (SP6901-29 TH1), blue (SP3101-37 TH1) and red (SP6931-01 TH73) lines. Additionally, project SP6931-01 TH73 contains two funding categories (reflected by the gray and yellow shaded regions). For this example, the Agency would create the following four geofences in the Veta MDMS to allow for capturing of the project and category information for each dump location:

- SP6901-29_StLouis
- SP3101-37_Itasca
- SP6931-01_StLouis_CAT001
- SP6931-01_StLouis_CAT002

Please note that these geofences are labeled with the standardized naming convention per Table 10 of Appendix A.

Table 2.1 Statement of Quantities for Contract Number 200074 with Multiple Projects and Funding Categories.

Tab.	Sheet Number	Item Number	Item	Unit	Total Estimated Quantities	SP1007-21 (A) Notes 1, 3	SP1006-29 (A) Notes 2, 3	100% City of Mayer (B) Notes 2, 4	100% City of Watertown (C) Notes 1, 5
C	19	2360.509	Type SP9.5 Wearing Course Mixture (2,C)	Ton	352	194	158	0	0
C	19	2360.509	Type SP 12.5 Wearing course Mixture (3,C)	Ton	21479	21479	6447	0	0
C	19	2360.509	Type SP 12.5 Wearing Course Mixture 4,C)	Ton	602	602	1300	0	0
…	…	…	…	…	…	…	…	…	…

Note 1: Project = Element ID = 122874 = SP1007-21 (Prime Contract)
Note 2: Project = Element ID = 122873 = SP1006-29
Note 3: Funding Category 0001 = (A) 80% STP / 20% State Funds
Note 4: Funding Category 0002 = (B) 100% City of Mayer Funds (See Agreement Number 1036535 with the City of Mayer)
Note 5: Funding Category 0003 = (C) Special Funding (See Agreement Number 1036540 with the City of Watertown)

Table 2.2 Statement of Quantities for Contract Number 200066 with Multiple Projects and Funding Categories.

Tab.	Sheet Number	Item Number	Item	Unit	Total Estimated Quantities	SP3608-48 (A) Notes 1, 4	SP3608-48 (B) Notes 1, 6	SP3606-56 (A) Notes 2, 4	SP3615-06 (A) Notes 3, 4	100% City of International Falls (F) Notes 1, 5
G, O	22-23, 45-49	2360.509	Type SP9.5 Wearing Course Mixture (3,C)	Ton	19279	15464	0	1160	928	1727
…	…	…	…	…	…	…	…		…	…

Note 1: Project = Element ID = 84613 = SP3608-48 (Prime Contract)
Note 2: Project = Element ID = 83665 = SP3606-56
Note 3: Project = Element ID = 135009 = SP3615-06
Note 4: Funding Category 0001 = (A) 80% NHPP Federal / 20% State Funds
Note 5: Funding Category 0002 = (F) 100% City of International Falls
Note 6: Funding Category 0003 = (B) 40% NHPP Federal, 10% State Funds, 50% City of International Falls Fund

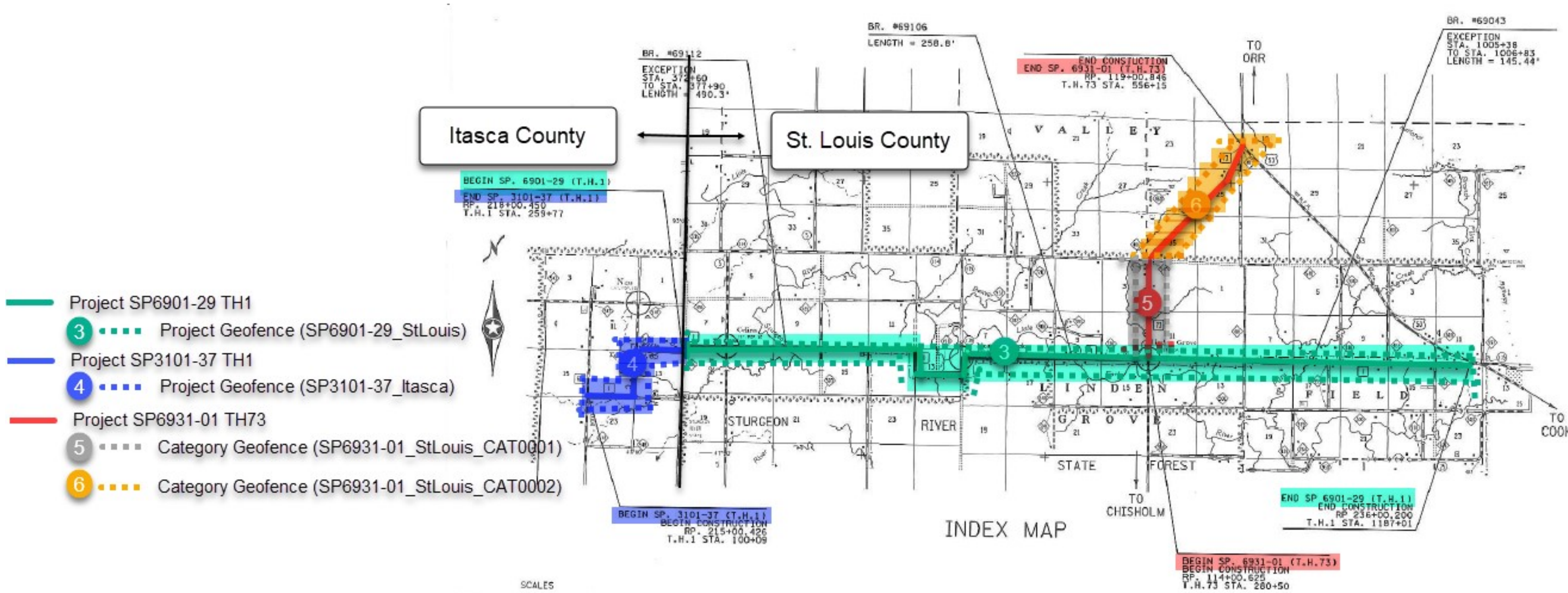


Figure 2.8 Example of Project and Category Geofences

2.3.1.2 Contractor Tasks

SET UP APPROPRIATE COMPONENTS

The first step of the Contractor's tasks in the pre-construction process is to set up appropriate components of the MDMS (see Figure 2.9). The following components require setup prior to construction activities: set up of the source loadout software for transmittal of source data to the Contractor's MDMS, establishment of internet (or satellite) connectivity at permanent and portable sources, and trucking identifications and tracking.

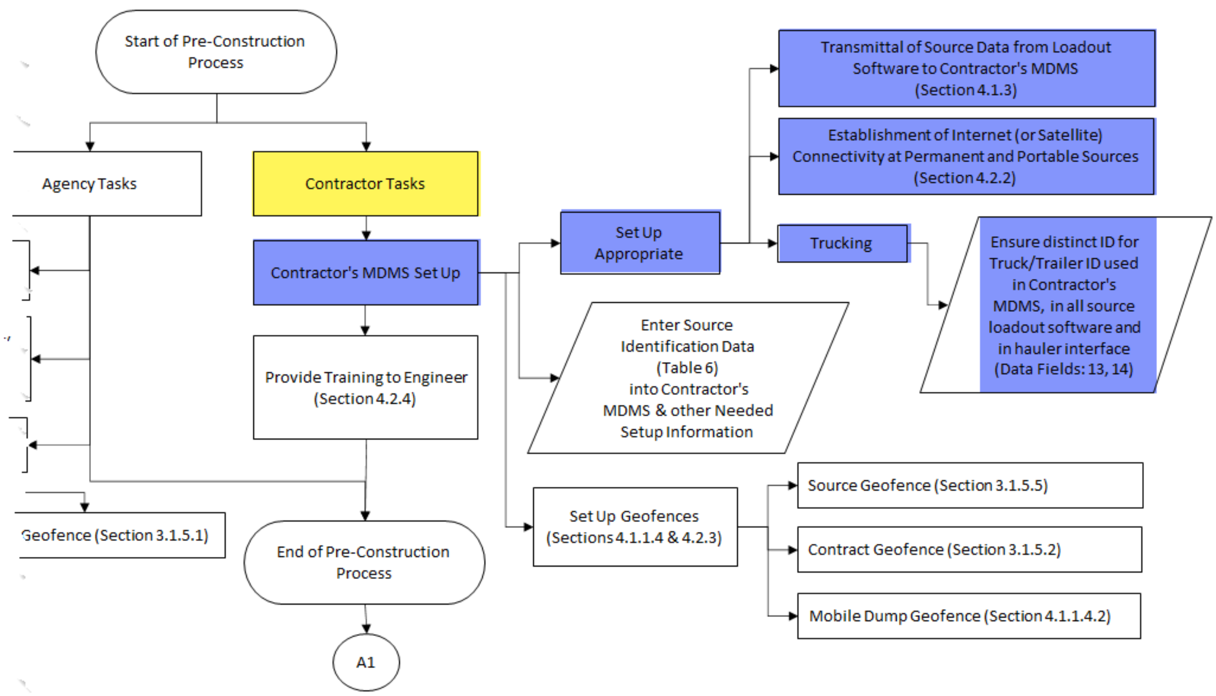


Figure 2.9 MDMS Set up – Set up Appropriate Components (Pre-Construction Workflow Schematic).

TRANSMITTAL OF SOURCE DATA FROM LOADOUT SOFTWARE TO CONTRACTOR'S MDMS

During the pilot projects, it was found that some Contractors are still running DOS-based source loadout software platforms that most MDM systems are unable to communicate with for transmittal of source data. Consequently, these sources will require upgrading to GEN OS (or the processing capacity must be increased) to work properly with most MDM systems. This can be costly, and Contractor's will need time to make these needed upgrades.

It was also found that some yearly, loadout software maintenance updates can also affect transmittal of source data to the Contractor's MDMS, where source data transferred with no issues prior to the update, but later encountered problems after the maintenance update.

Vendors have also noted that it can be difficult, and require extensive time and resources, to get some loadout software platforms to communicate with the Contractor's MDMS – resulting in each source often being treated and set up separately for a given contractor.

Consequently, language to allow for use of REST APIs and JSON request body was added to the special provision to allow an easier process for transmittal of source data regardless of the loadout software used, or whether any updates were made to the software. See section 4.1.3 of Appendix A.

The use of REST APIs and JSON not only assists Contractor owned sources (for those that elect to use this more streamlined data transfer process), but also for centralized suppliers. Centralized suppliers are suppliers that provide material to multiple contractors. It is not effective for these suppliers to purchase multiple MDM systems in order to supply source data to the varying systems. Therefore, this language was also included to allow for a standardize means of transferring source data from centralized suppliers to any MDMS. This language can also be found in section 4.1.3 of Appendix A.

ESTABLISHMENT OF INTERNET (OR SATELLITE) CONNECTIVITY

Internet connectivity (or satellite connectivity for those entities that elect to use satellites for data transfer) was often overlooked for portable sources. Source data will require transfer from the loadout software from both permanent and portable sources for transmittal to the Contractor's MDMS. Consequently, internet/satellite connectivity was added to the standard as part of the pre-construction activities. See section 4.2.2 of Appendix A.

Please note, that it is was also found that the MDMS should allow for the ability to perch devices, as needed, when sources are in low lying areas to increase data signal strength.

DISTINCT TRUCK AND TRAILER IDENTIFICATIONS

Unique truck and trailer identifications were found to be inconsistent on some pilot projects. Unique truck identifications were not always used in the loadout software at each source. For example, a truck may be labeled as "16tr" at one source and "16TR" at another source. It should be noted that trucks might end up at multiple sources in any given day, and therefore, it is critical to ensure that the loadout software (from the various sources) is using the same naming convention for each truck/trailer. Distinct identifications are needed to allow for correct association of the material being hauled with respect to the serial number of the breadcrumb recording device, generation of accurate flow rates, truck summary reports, accurate material association with dumped locations, etc. (Please note, that it takes about one minute to load a truck, and consequently, there is not enough time to fix this problem during the loading operation.)

In addition to contractor owned truck/trailer identifications, it was also noted that some MTO trucks may use the same truck identification for multiple trucks. Therefore, it is important that the Contractor distinctly identifies these trucks as well for the above reasons.

ENTER SOURCE IDENTIFICATION DATA

Another component of the MDMS set up is to enter source identification data (per Table 6 of Appendix A) into the MDMS and also the other needed setup information as designated by the vendor (see Figure 2.10). During the pilot projects, the source identification data was pushed as part of the source data (i.e., included with the ticket number, weight information, material codes, etc.) to the MDMS. However, after discussions with MDMS vendors, it was recommended that static data (i.e., data that remains the same in each ticket) is directly entered into the Contractor's MDMS in lieu of pushing this data with each ticket. This would help minimize the volume of data being pushed with each ticket. Consequently, Table 6 and section 4.1.2.2.2 of Appendix A was added to allow the Contractor to enter the following source identification information directly into the Contractor's MDMS: source identification, source name, portable plant (yes/no), source address, and source phone number.

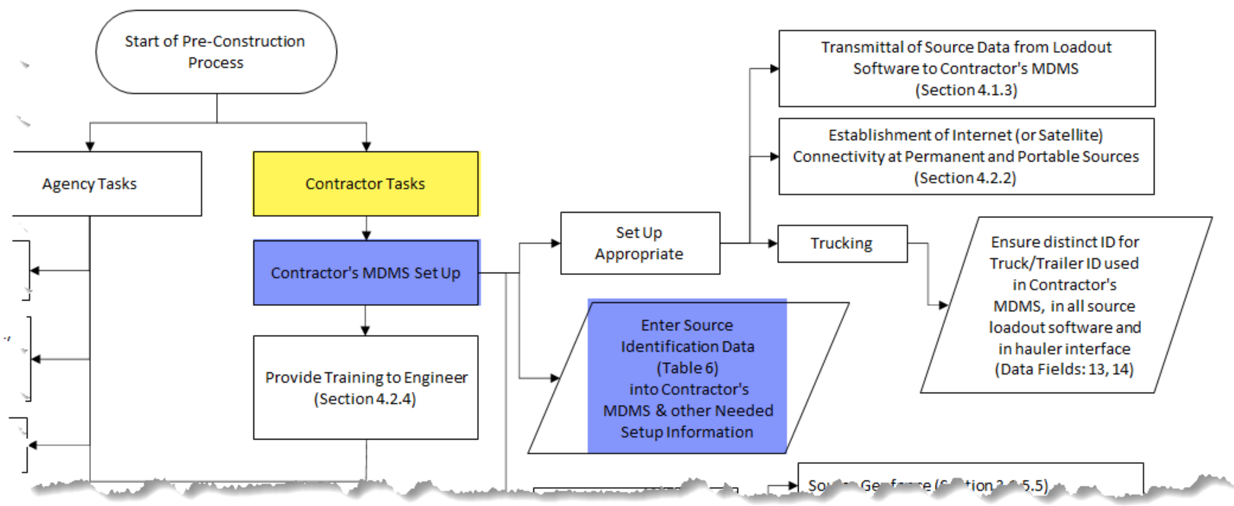


Figure 2.10 MDMS Set up – Enter Source Identification Data (Pre-Construction Workflow Schematic).

SET UP GEOFENCES

The establishment of geofences is another activity that requires completion during the pre-construction process (See Figure 2.11). As previously discussed, a geofence is defined as a virtual perimeter that indicates when a mobile device enters or exits a predefined area. The following subsections discuss the geofences which are recommended for creation with the Contractor's MDMS (i.e., Source, Contract, and Mobile Dump geofence).

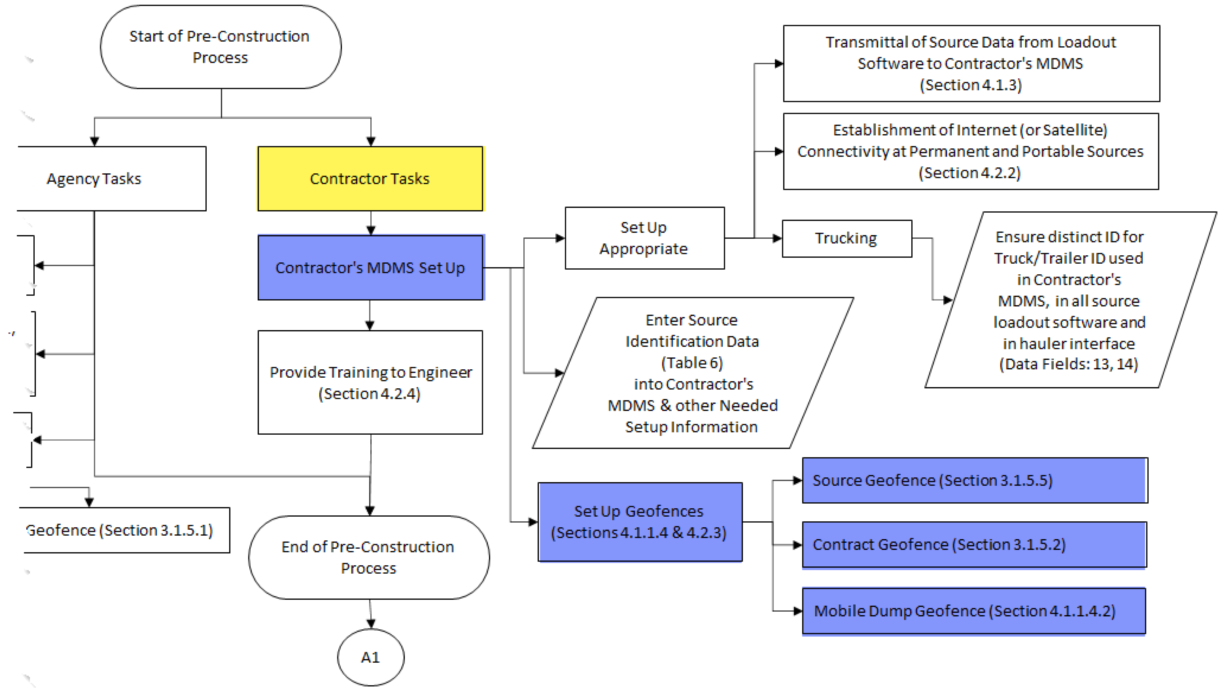


Figure 2.11 MDMS Setup – Setup Geofences (Pre-Construction Workflow Schematic).

SOURCE AND CONTRACT GEOFENCES

The source and contract geofences are recommended to be set up by the Contractor (see Section 4.2.3.1 of Appendix A). These geofences are defined as follows:

> **Source Geofence** – static virtual perimeter around boundary of source (e.g., boundary around a plant).
>
> **Contract Geofence** – static virtual perimeter around the limits of the work to be completed in the contract (e.g., boundary of jobsite).

Figure 2.12 provides an example of the source and contract geofence. The static geofences are drawn around the contract and source using colored dashed lines. Please note that the boundaries are not drawn correctly to perspective but were exaggerated in boundary sizes to assist with visualization. As illustrated, the contract geofence is drawn with purple dashed lines, while the source geofence is presented with black, alternating short and long dashed lines. These geofences are labeled with the standardized naming convention per Table 10 of Appendix A. For example, the contract and source geofence names are labeled “CN200078” and “BP001_StLouis”, respectively. It should also be noted that most Contractor’s would split the contract geofence boundary into smaller sections to support contract staging and more accurate quantification of flow rates. As per Table 10 of Appendix A, an additional acronym would be added to these geofence names to distinguish these subcontract regions (e.g., CN200078_W, CN200078_E).

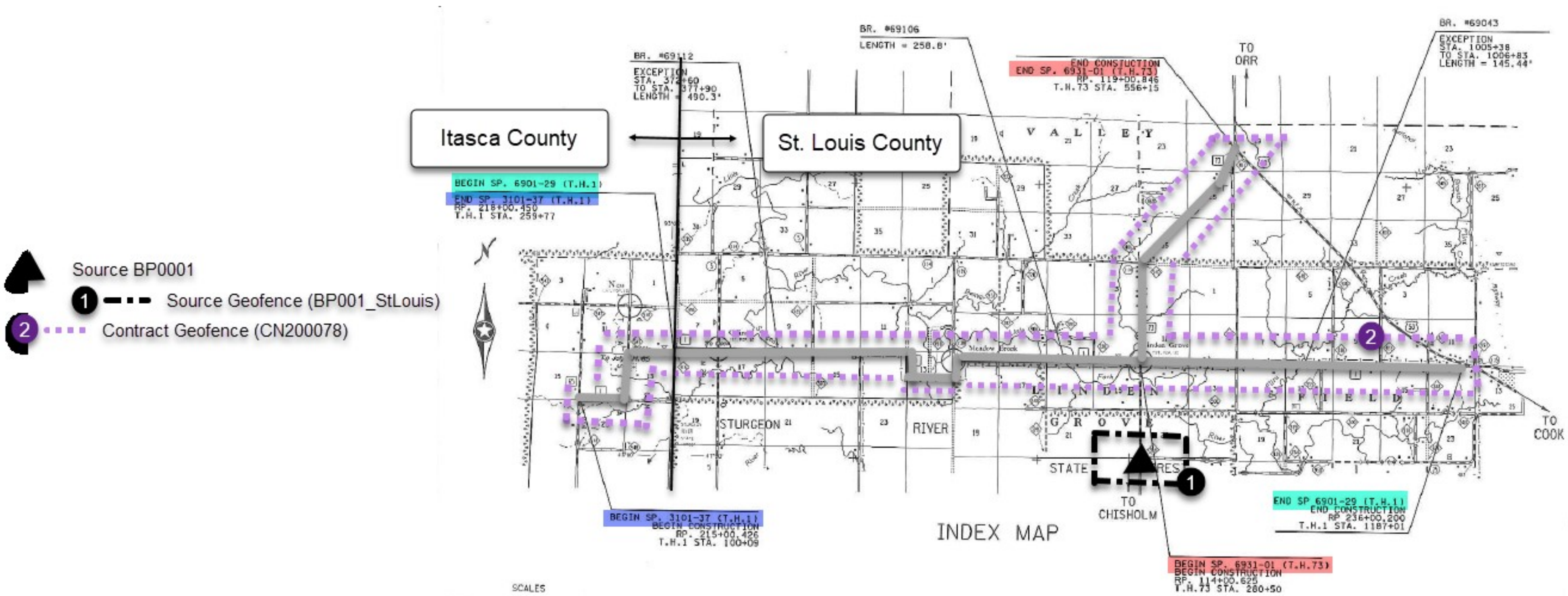


Figure 2.12 Example of Source and Contract Geofences.

Knowing the time stamps of when a truck enters and exits the source, resulting durations (time at source, time at contract, source to contract transit time, contract to source transit time), and loading and dump (delivery of material) times are used for generation of flow rates to assist the Contractor with identification of inefficiencies and optimization of paving operations. The following are a few examples of possible inefficiencies that can be identified using this information:

- Which trucks are taking too long to deliver material?
- Which trucks are not using designated haul routes?
- Why are given trucks parked?
- Which haul routes are most optimal at given times of the day?
- How many trucks are needed for the day?

Some examples of optimization of the paving operation are:

- Identification of inefficiencies (as described above).
- Controlling the rate that mix is coming out of the plant to ensure that the paver does not run out of mix, or that too many trucks are parked waiting to provide mix to the paver.
- Matching paver speeds to delivery of material (the screed operator can use the MDMS to know the estimated time of arrival of the next truck and modify paving speeds accordingly in hopes of preventing paver stops).

In 2018, MnDOT fully deployed the use of the paver mounted thermal profiling system (AASHTO PP-80) and provides monetary adjustments in the form of incentives and disincentives based on the thermal uniformity of the surface temperatures of the mat immediately behind the trailing edge of the screed. Use of flow rates, will assist the Contractor with improving thermal uniformity behind the paver and increasing pavement smoothness, thereby allowing improvements to long-term pavement performance, compaction efforts, density, ride, permeability and more. Figure 2.13 illustrates the cooler temperatures resulting from a paver stop, along with the MDMS also indicating the occurrence of a paver stop through the recording of estimated time of arrival of the next truck, along with the number of trucks waiting to deliver material. As illustrated, the first paver stop occurred at 11:56AM, with no trucks waiting to dump mix and the next truck arriving in 1 minute. The second paver stop occurred shortly thereafter at 12:05PM. However, for this instance four trucks arrived at the paver and were waiting to dump mix (truck ID: 26dm, 27dm, 4w and 30). The estimated time of arrive for the next truck after the placement of this material was not for another 9 minutes.

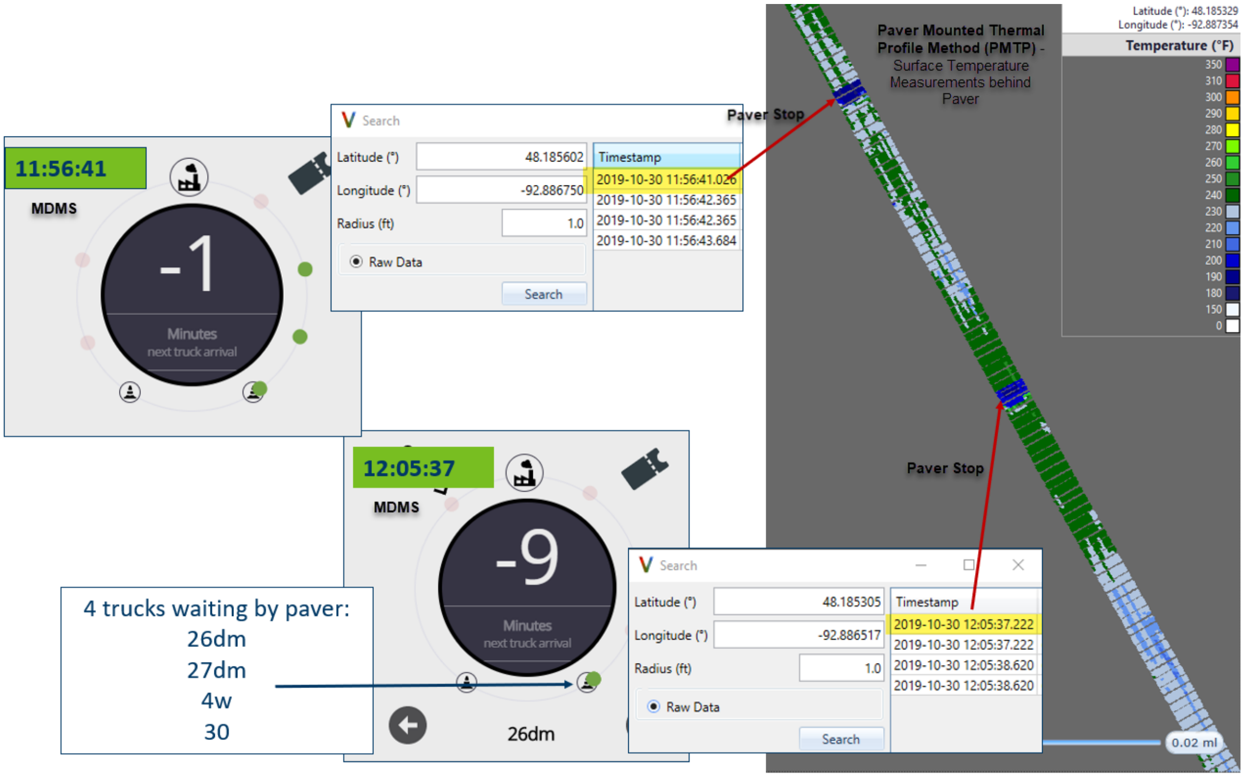


Figure 2.13 Example of paver stops captured with MDMS and Paver Thermal Profile Method.

In the addition to the use of this information for improved workmanship, flow rates and identification of inefficiencies, the time stamps and durations are also used to assist with labor compliance audits and general contract closeouts and audits. Obtaining missing trucking reports is often the number one reason for delay in closing out contracts. Additionally, disabled business enterprise (DBE), or small business closeouts, can also delay contract finals and hold up a Contractor's bond. These time stamps assist with documentation of prevailing wage hours, along with independently verifying that loads indeed made it to the contract limits and were dumped. Additionally, questionable time stamps can assist with investigating (and or verifying) whether entire loads (or partial loads) were delivered to other contracts or locations.

During the debriefing meetings with Minnesota Contractors, the following items were also noted with respect to the need for collection of time stamps and durations:

- The Contractors recommended that the MDMS includes the collection of data required for labor compliance activities and believes that this is where the greatest "buy-in" for the technology lies (i.e., not in the digitalization of computer-generated paper weight tickets, but in the ability to support documentation for labor compliance activities).
- Trucking is one of the Contractor's top expenses (typically the second top expense).
- Completion of prevailing wage reports are complex and require a significant amount of time and resources to complete correctly. Collection of fleet data would assist with prevailing wage compliance.

- Many Haulers often have a limited amount of time to complete prevailing wage documentation, and consequently, this documentation is often not completed in a timely manner.
- It is the Contractor's responsibility to ensure that prevailing wage reports are completed correctly, ensure that the truck Hauler is paid correctly and to take appropriate actions to ensure compliance with the contract. The following lists examples of some of the Contractor requirements contained within the Contract that the MDMS could assist with providing supporting documentation:
    - **Overtime**
        - A Contractor shall not permit or require a worker to work in excess of 40 hours per week unless the worker is compensated at a rate not less than 1-1/2 times the basic hours rate as determined by the United States Secretary of Labor (Required Contract Provisions Federal-Aid Construction Contractors Form-1273, Section IV, Subpart 7).
        - A Contractor shall not permit or require a worker to work longer than the prevailing hours of labor unless the worker is paid for all hours in excess of the prevailing hours at a rate of at least 1-1/2 times the hourly basic hourly rate of pay. (Minnesota Statute 177.44, Subdivision 1)
        - The prevailing hours of labor is defined as not more than 8 hours per day or more than 40 hours per week. (Minnesota Statute 177.42, Subdivision 4).
    - **Subcontracting Part of Contract** (MN/DOT Standard Specifications for Construction, Section 1801)
        - The prime Contractor's organization shall perform work amounting to not less than 40 percent of the total original contract cost. However, contracts with Disadvantaged Business Enterprise (DBE) or Targeted Group Business (TGB) established goals, or both, the Contractor's organization shall perform work amounting to not less than 30 percent of the total original contract cost.
    - **Trucking / Off-Site Facilities**
        - The prime Contract is responsible to ensure that its workers and those of all subcontractors are compensated in accordance with the federal wage decision incorporated into and found elsewhere in this contract for the following work duties:
            - The processing or manufacturing of material, including the hauling of material to and from an immediately adjacent, dedicated off-site facility. (29 CFR Part 5.2[I][2])
            - The hauling of any or all stockpiled or excavated materials on the project work site to other locations on the same project. (29 CFR Part 5.2[J](1)
        - The prime contractor is responsible to ensure that its workers and those of all subcontractors, are compensated in accordance with the state wage determination incorporated into and found elsewhere in this contract for the following work duties:

            - The processing or manufacturing of material, including the hauling of material to and from a prime Contractor's material operation that is not a separate commercial establishment. (ALJ Findings of Fact, Conclusions of Law, and Recommendation, Conclusions [7], Case #12-3000-11993-2)
            - The processing or manufacturing of material, including the hauling of material to and from an off-site material operation that is not considered a commercial establishment. (Minnesota Rules 5200.1106, Subpart 3B[2])
            - The hauling of any or all stockpiled or excavated materials on the project work site to other locations on the same project even if the truck leaves the work site at some point. (Minnesota Rules 5200.1106, Subpart 3B[1])
            - The delivery of materials from a non-commercial establishment to the project and the return haul. (Minnesota Rules 5200.1106, Subpart 3B[2])
            - The delivery of materials from another construction project site to the public works project and the return haul, either empty or loaded. Construction projects are not considered commercial establishments. (Minnesota Rules 5200.1106, Subpart 3B[3])
            - The hauling required to remove any materials from the project to a location off the project site and the return haul, either empty or loaded from other than a commercial establishment. (Minnesota Rules 5200.1106, Subpart 3B[4])
            - The delivery of mineral aggregate materials from a commercial establishment, which is deposited "substantially in place" and the return haul, either empty or loaded.
- **Non-Compliance and Enforcement**
    - The prime contractor shall be liable for any unpaid wages to its workers or those of any subcontractor, ITO, MTO and/or Truck Broker. (MN/DOT Standard Specifications for Construction, Section 1801)
    - If it is determined that a contractor has violated federal and/or state prevailing wage laws, or any portion of this contract, the department may implement, after written notice, one or more of the following sanctions:
        - Withhold or cause to be withheld from the prime contractor under this contract, or any other federally funded contract with the same prime contractor, as much of the accrued payments or advances as may be considered necessary to pay workers employed by the prime contractor or any subcontractor the full amount of wages required by this contract. (Required Contract Provisions Federal-Aid Construction Contracts Form-1273, Section IV, Subpart 6)

        - Withhold or cause to be withheld from the prime contractor such amounts in considerations or assessments against the prime contractor, whether arising from this contract or other contract with the department. (MN/DOT Standard Specifications for Construction, Section 1906)
        - The department may reject a bid from a prime contractor that has demonstrated continued or persistent noncompliance with the prevailing wage law on previous or current contracts with the department. (Minnesota Statute 161.32, Subdivision 1[d])
        - The department may take the prosecution of the work out of the hands of the prime contractor, place the contractor in default and terminate this contract for failure to demonstrate compliance with these provisions. (MN/DOT Standard Specifications for Construction, Section 1808)
    - **Any contractor who violates the state prevailing wage law is guilty of a misdemeanor and may be fined not more than $300 or imprisoned not more than 90 days or both. Each day that the violation continues is a separate offense.** (Minnesota Statute 177.44, Subdivision 6)
    - **All required documents and certification reports are legal documents; willful falsification of the documents may result in civil action and/or criminal prosecution** (Minnesota Statutes 16B, 161.315, Subdivision 2, 177.43,Subdivision 5 177.44, Subdivision 6, 609.63) and may be grounds for debarment proceedings (Minnesota Statute 161.315).
- Connecting Hauler information to the source data (E-Ticket) assists with monitoring and documentation of the Craft / Classification / Trade.
- Labor compliance audits can take months or years to complete, making it difficult to gather needed documentation.
- The fleet data would aid with determining whether additional documentation and reporting is needed for compliance with the Federal Davis Bacon Law.
- The Fleet data would also aid in Civil Rights Activities.

MOBILE DUMP GEOFENCE

As determined by the pilot projects, it is recommended that the Contractor sets up a mobile dump geofence around the boundaries of equipment that material is being delivered to such as the paver, pickup machine, or material transfer device, etc. for those agencies that desire automated recording of the material being delivered. Consequently, the following language was added to the AASHTO provisional practice (see section 4.1.1.4.2 of Appendix A):

[The Contractor's MDMS will allow the] establishment of a mobile geofence around dump location (e.g., paver, material transfer device, pickup machine) for recording of dump time, location and dump

geofence name. Hardware allows for user defined creation of geofence and an automated method to correctly indicate dump locations within 60 m [200 feet].

Table X2.1 of Appendix A was created to detail the dump geofence name to be recorded as determined by the number of projects and categories contained within the contract. The following subsection provides an example of dump geofence names as generated via the truck dump location and static project and category geofences.

Again as previously discussed, recording of the dump time and location will assist with generation of flow rates, identifications of inefficiencies, improvements to workmanship, reconciling quantities with respect to project and funding categories, and to assist with prevailing wage documentation (as the dump location is used to determine the prevailing wage rate to be used on a project). Additionally, recording of the latitude and longitude for the dump location can be used for the following:

- Referencing failing materials for remove and replace limits, or for use in evaluation of long-term pavement performance.
- Tracking mix design (material code) changes for use with the dielectric profile method (i.e., [PP-98] verification of calibration curves), troubleshooting density issues and long-term pavement performance.
- Import of Contractor's MDMS data into Veta MDMS for: (1) correlation with the dielectric profile method (PP-98), continuous thermal profile of asphalt mixture construction (PP-80) and Intelligent Compaction Technology for Embankments and Asphalt Pavement Applications (PP-81); (2) generation of heat loss curves using temperatures from source, Contractor and Agency data, PP-80, and PP-81.

Upon review of the Contractor's MDMS data generated by the pilot projects, it was noted that dump information (i.e., date and time stamp, and dump latitude and longitude) were not always successfully recorded and will require time and experience by the Contractor to learn how to successfully set up the needed information per Contract, paving crew and equipment. Please note that this data is automatically being recorded using mobile geofences. Again, a geofence is defined as a virtual perimeter that indicates when a mobile device enters or exits a predefined area. Consequently, automatic triggering of the dump requires optimization, by the Contractor, of settings such as duration of time spent within the geofence and the radius of the geofence. For example, crews that have slow versus quick truck exchanges will need to be set up with different time durations within the geofence to ensure capturing of the dump. Additionally, equipment also affects these settings. For instance, as to whether material transfer devices, end dumps or pick up machines are being used will affect both the time within the geofence and geofence radius being used.

It was also found that the use of circular geofences can make it difficult to correctly track truck exchanges when paving in echelon, or when secondary pavers are in proximity. Rectangular geofences may help mitigate these issues, should they become available.

EXAMPLE OF DUMP GEOFENCE NAMES

As previously discussed, a standardized naming convention for source, contract, project and category geofences was established to allow automation for the reconciling of quantities in AWP and other Agency database systems (see Section 4.2.3.3 and Tables 1 and 10 of Appendix A). Again, this helps ensure that a unique naming convention is used throughout the contract that allows for correct summing of quantities with respect to projects, funding categories, and material codes. Consequently, the name of the dump geofence where the material was dumped within, records the associated standardized naming convention for the given project or category geofence.

Figure 2.14 presents the previous example of a contract with more than one project and funding category. Again, as illustrated, this contract contains one source as depicted by the black triangle and three projects as depicted by the solid green (SP6901-29 TH1), blue (SP3101-37 TH1) and red (SP6931-01 TH73) lines. Additionally, project SP6931-01 TH73 contains two funding categories (reflected by the gray and yellow dashed geofence lines and shaded regions).

As previously discussed, the static geofences are drawn around the contract, source, project and categories using colored dashed lines. Again, please note that the boundaries are not drawn correctly to perspective but were exaggerated in boundary sizes to assist with visualization.

Table 2.3 provides an example of time stamps, transit times and geofence names recorded for the delivery of material to each of the project and category regions illustrated in Figure 2.14. The example dump locations are illustrated in Figure 2.14 using the number embedded within a circle. For example, the dump geofence name, when material is delivered at location 3 is reflective of the project geofence name “SP6901-29_StLouis”, since this location does not include multiple funding categories (see Table 1 and 10 of Appendix A for required dump geofence name and the standardized naming convention, respectively). Location 4 also does not include multiple funding categories but is within a different county and project identification than that of location 3. Therefore, the dump geofence name for this location is “SP3101-37_Itasca”. Locations 5 and 6 are within one project (SP6931-01 TH73) but contain multiple funding categories. Consequently, the dump geofence name for locations 5 and 6 also contain the funding category and are recorded as “SP6931-01_Stlouis_CAT0001” and “SP6931-01_Stlouis_CAT0002”, respectively.

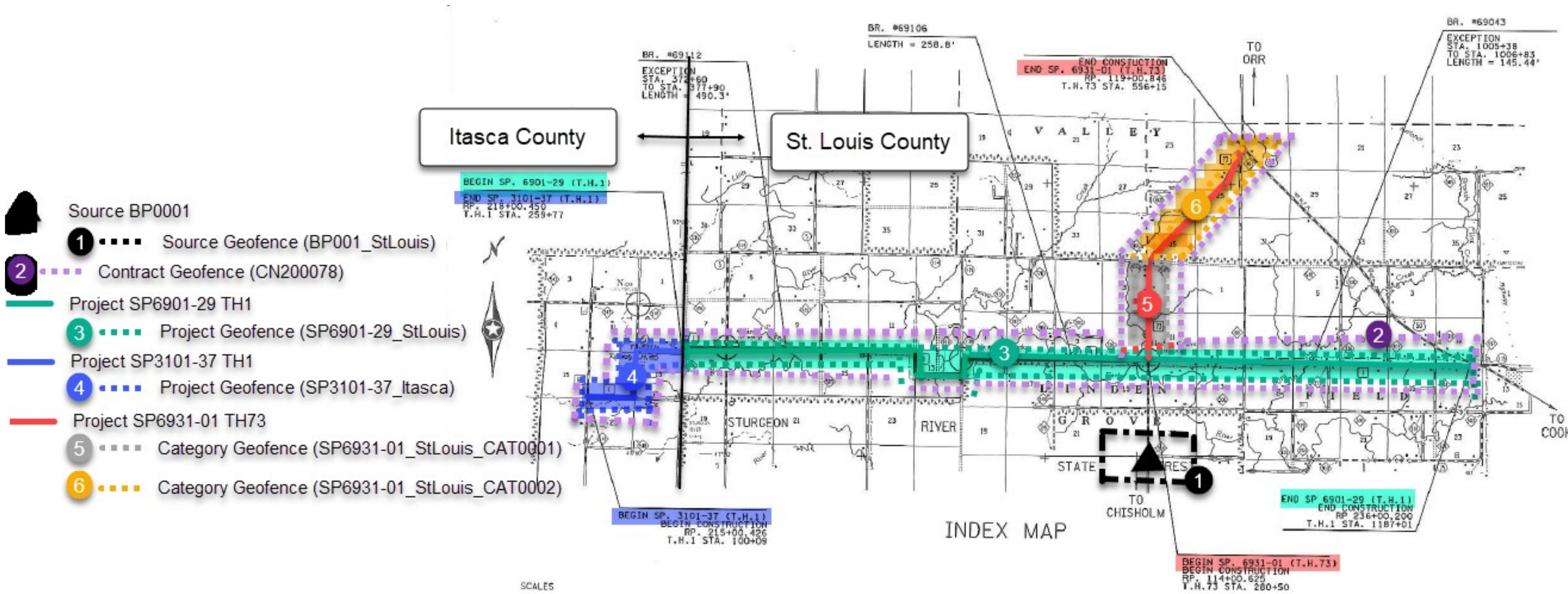


Figure 2.14 Example of source, contract, project and category geofences.

Table 2.3 Example data field values for contract shown in Figure 2.14

Dump	3	4	5	6
TicketNum	101	102	103	104
SourceGeoName	BP001_StLouis	BP001_StLouis	BP001_StLouis	BP001_StLouis
TruckEntersSourceGeoDateTime	2020-04-05T10:00-02:00	2020-04-05T10:40-02:00	2020-04-05T11:30-02:00	2020-04-05T12:05-02:00
LoadDateTime	2020-04-05T10:05-02:00	2020-04-05T10:45-02:00	2020-04-05T11:35-02:00	2020-04-05T12:10-02:00
TruckExitsSourceGeoDateTime	2020-04-05T10:10-02:00	2020-04-05T10:50-02:00	2020-04-05T11:40-02:00	2020-04-05T12:15-02:00
TimeAtSource	00:10:00	00:10:00	00:10:00	00:10:00
SourceToContractTime	00:05:00	00:05:00	00:10:00	00:10:00
ContractGeoName	CN200078	CN200078	CN200078	CN200078
TruckEntersContractGeoDateTime	2020-04-05T10:15-02:00	2020-04-05T10:55-02:00	2020-04-05T11:50-02:00	2020-04-05T12:25-02:00
TruckExitsContractGeoDateTime	2020-04-05T10:35-02:00	2020-04-05T11:25-02:00	2020-04-05T12:00-02:00	2020-04-05T12:35-02:00
TimeAtContract	00:20:00	00:30:00	00:10:00	00:10:00
ContractToSourceTime	00:05:00	00:05:00	00:05:00	(Blank - truck did not return back to plant)
PaverGeoName	Mainline_23456	Mainline_23456	Mainline_23456	Mainline_23456
DumpGeoName	SP6901-29_StLouis	SP3101-37_Itasca	SP6931-01_StLouis_CAT0001	SP6931-01_StLouis_CAT0002
DumpDateTime	2020-04-05T10:25-02:00	2020-04-05T11:10-02:00	2020-04-05T11:55-02:00	2020-04-05T12:30-02:00

2.3.1.3 Provide Training to Engineer

The second step of the pre-construction process is to provide training to the Engineer (see Figure 2.15 and Section 4.2.4 of Appendix A). Training is extremely important as there is not currently a standardized platform for agencies to view MDMS data. Consequently, the Engineer will encounter various MDMS platforms being used on any given contract and will need the appropriate training. A minimum of the following should be included in the training:

- Contractor's MDMS web- and/or application-based platforms and user interface.
- Creation of geofence boundaries and naming conventions.
- Geofence boundaries and naming conventions.
- Data fields included in Contractor's MDMS data collection and export.

- Real-time viewing of the following:
  - number of tracks at source, in transit from source to contract, at contract (and/or dump) and in transit from contract to source
  - Tabular summary of ticket status
  - Source and Hauler data
- Playback of breadcrumb trails.
- Example export of Contractor's MDMS data.

In the future, enhancements will be made to the Veta MDMS to allow this platform to be used as the standardized platform for viewing MDMS data. See Section 3.3 "Veta MDMS" for additional details.

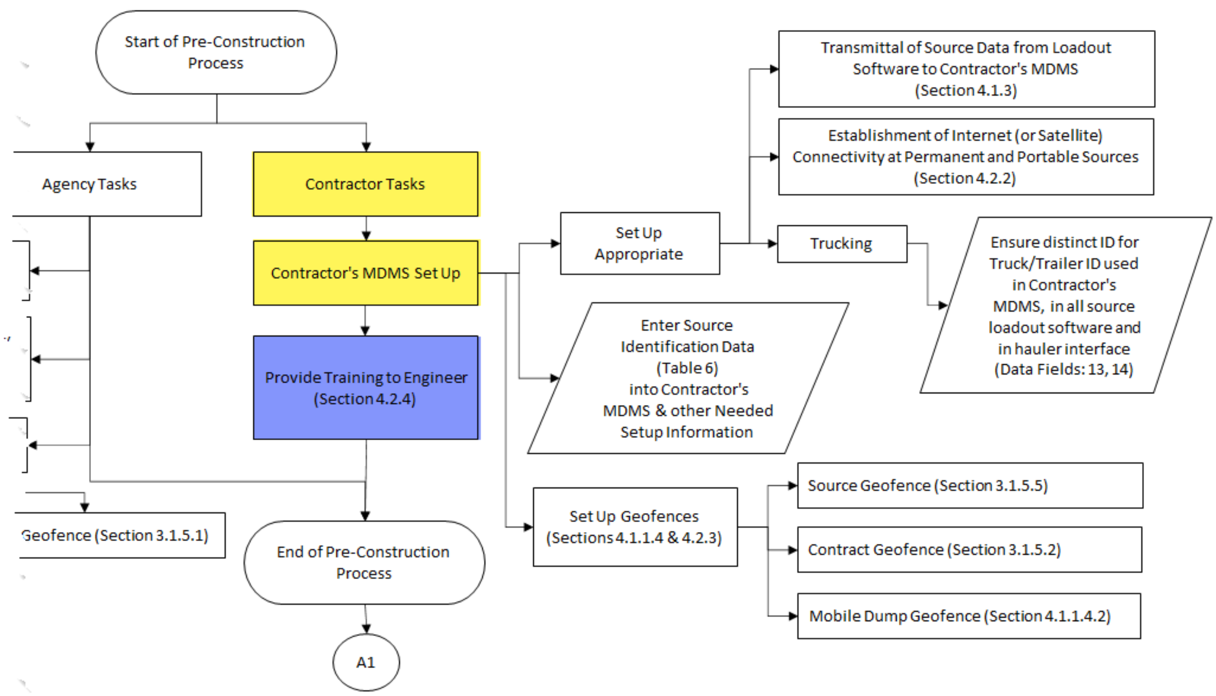


Figure 2.15 Provide Training to Engineer (Pre-Construction Workflow Schematic).

2.3.2 Source Process

The second step of the MDMS workflow details the steps entailed during the process at the source. As illustrated in Figure 2.3, this process consists of the following key elements: data entry of Hauler information, truck entering the source geofence, point of sale, transmittal of source data to Contractor's MDMS, transmittal of source data to Contractor's MDMS user interface, data entry of Agency and contractor data in Veta MDMS user interface, and the truck exiting the source geofence. The following subsections provide details related to the elements of this process.

2.3.2.1 Hauler Information (Data Fields 40-50)

As previously discussed in Section 2.3.1.2 inclusion of Hauler data (see Figure 2.16) will assist Contractors and the Agencies with monitoring and documentation of prevailing wage (Labor Compliance) and Civil Rights activities, along with the ability of capturing overweight quantities. During debriefing meetings with the Contractors, they elaborated on the difficulty of accurately capturing this information and to do so within a reasonable time frame. Additionally, the Contractors did not want the responsibility of populating this information into the MDMS for ITOs and MTOs, and therefore, it was determined that this should be the Haulers responsibility. Consequently, a Hauler user interface requirement was added to the AASHTO provisional practice (see Sections 4.1.1.6.1, 4.1.2.2.1, and 4.1.2.3 of Appendix A) to allow for manual entry of Hauler data and to ensure that modifications to this data can only be made by the Hauler. (Please note that the Hauler for the given truck identification may be the Contractor, ITO, or MTO.) Additionally, it was desired that this data is automatically tied to each E-Ticket. Therefore, the following requirement was also added (section 4.1.2.4 of Appendix A):

> *Hauler data entered, into Contractor's MDMS user interface, is auto-populated into the associated data block fields of the MDMS (per Table 1), by tying (at a minimum) contract job number, truck identification and shift start and end times to the Load Date and Time.*

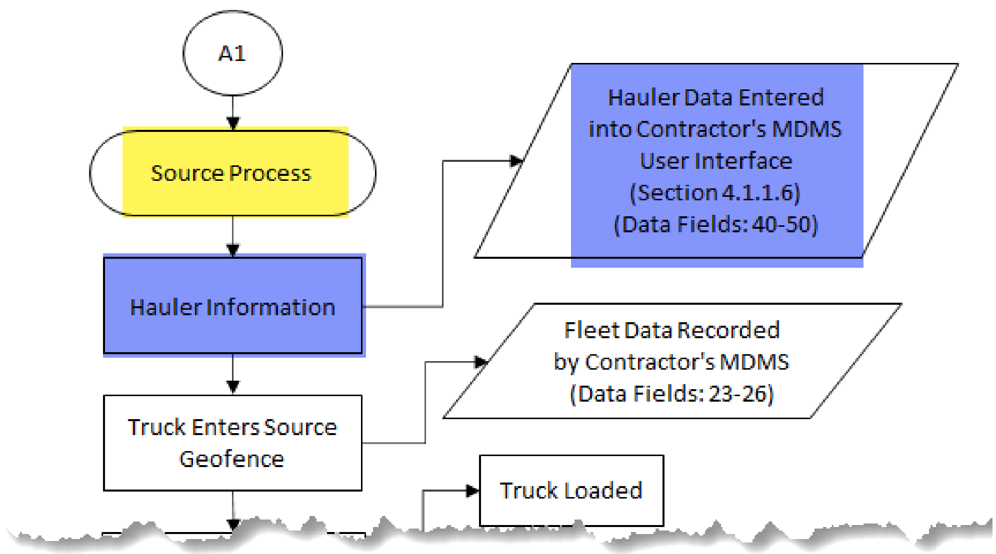


Figure 2.16 Hauler Information (Source Process Workflow Schematic).

The following fields are considered as Hauler Data in the Contractor's MDMS (see Table 1 of Appendix A for additional details related to these data fields):

Contractor Job Number

Hauler Company Name

Broker Name

DOT Number

Hauler Truck Identification

Truck Driver Classification

Overweight Permit Number

Maximum Gross Weight

Driver Name

Shift Start Date and Time

Shift End Data and Time

Please note that Truck Driver Classification is the description of the truck classification as defined by the Federal Wage System (e.g., tractor trailer driver; four or more axle unit, straight body truck; three axle units; or two axle units).

The overweight permit number and maximum gross weight are included in the Hauler data requirements as this information is used, along with the net weight on the E-Ticket for calculation of overweight quantities. Some agencies are unable to pay for these quantities and must subtract these weights when reconciling quantities.

2.3.2.2 Truck Enters Source Geofence (Data Fields 23 through 26)

(See Figure 2.17 for location of this step within workflow for the source process.)

The "source geofence name", "source latitude", "source longitude", and "truck enters source date and time stamp" are recorded (data fields 23 through 26 of Table 1 of Appendix A) when the truck enters the source geofence. Again, this data assists with generation of flow rates, prevailing wage documentation, and general material delivery audits. The source latitude and longitude are used by some states as part of data analytic tracking of where sources are located with respect to activity.

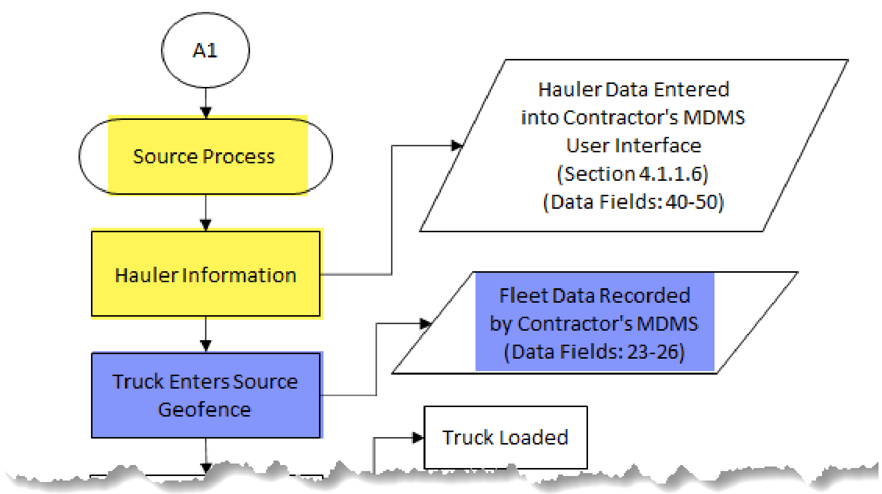


Figure 2.17 Truck Enters Source Geofence (Source Process Workflow Schematic).

2.3.2.3 Point of Sale (Data Fields 1-21)

The point of sale is initiated when the truck is loaded with the material and an E-Ticket is issued (see Figure 2.18). As previously discussed, an E-Ticket is the digitalized source data. The following lists the data fields that are considered as source data within the MDMS system (see Table 1 of Appendix A for additional details related to these data fields):

Contract Identification

Agency Project Identification

Source Identification

Scale Identification

Silo Identification

Source Operator Name

Source Operator Certification Number

Source Notes

Mix Design Identification

Material Code

Ticket Number

Load Number

Truck Identification

Trailer Identification

Voided Ticket

Loading Date and Time

Gross Weight

Truck Tare Weight

Daily Running Total by Mix Designation Weight

Contract Total by Mix Designation Weight

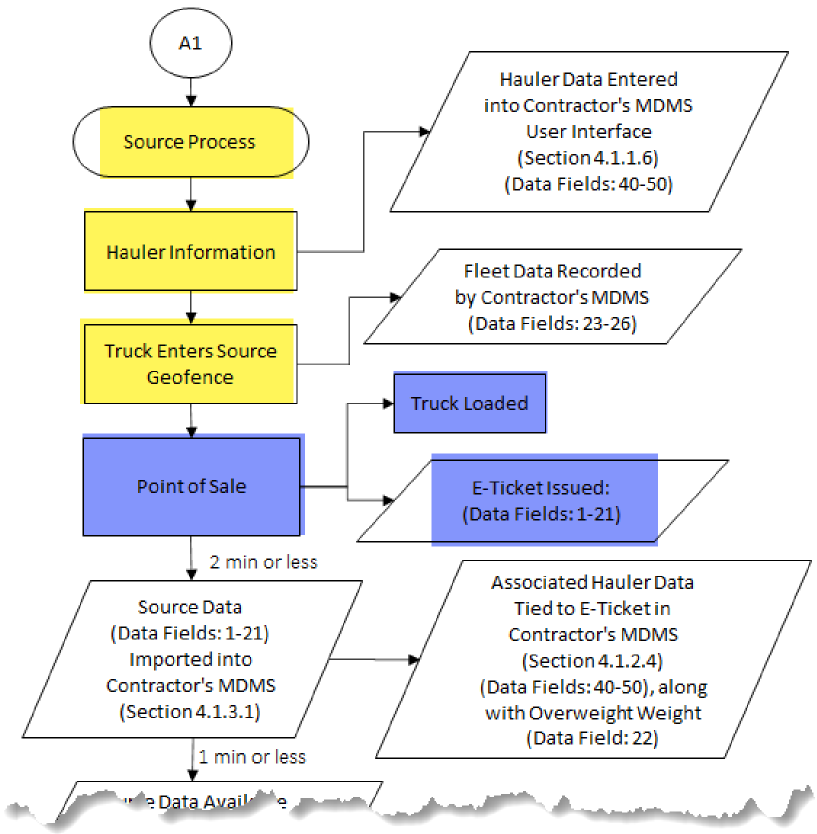


Figure 2.18 Point of Sale (Source Process Workflow Schematic).

Additional fields may be added to this list in the future as more agencies utilize the MDMS, however, these appear to be the standard fields used for asphalt materials based on the latest national meetings that MnDOT had put together with industry and other agencies.

Please note the following:

- Contract identification is the contract number in AWP.
- Scale and Silo Identification are recorded by centralized suppliers that provide material to a given contract from multiple scales and silos during any given day.
- The term source is used to reflect “Plants” for asphalt applications. This is a generic term that allows for future use with other material types (e.g., aggregate quarries, ready-mix plants, etc.). Additionally, this is the standard term used in AWP.
- Some state statutes require the recording of the weigh master’s name and certification number; and consequently, source operator name and certification number were included as part of the source data.
- Some states require additional notes to be included on the paper tickets. For instance, Caltrans requires a cancer warning included on all paper tickets, while other entities include notes for the first and last loads, etc. Consequently, “Source Notes” was added to the source data to allow for inclusion of specialized notes.

- AWP uses “Mix Design Identification” and “Material Code” to track mix design report numbers and mix designations, respectively, and therefore, these terms are used as the standard field name in the AASHTO provisional practice.
- Truck tare weights are not required at sources where a load cell is used on hoppers beneath a surge or storage bin.
- Daily running total by mix designation weight and contract total by mix designation weight can be computed by some loadout software, but not others. Consequently, the AASHTO provisional practice includes a note that this field is provided by either the loadout software or Contractor’s MDMS.

2.3.2.4 Source Data Imported into Contractor’s MDMS (Data Fields 1-21, 22, 40-50)

After generation of the E-Ticket, the source data is imported into the Contractor’s MDMS. As previously discussed in the subsection 2.3.1.2 “Transmittal of Source Data from Loadout Software to Contractor’s MDMS”, language was included in the AASHTO provisional practice to require the source data (data fields 1-21) to import into the Contractor’s MDMS in two minutes or less of the point of sale (see section 4.1.3.1 of Appendix A). Additionally, per section 4.1.2.4 of Appendix A, associated Hauler data (data fields 40-50) must be automatically tied to the E-Ticket (see Figure 2.19). During this step, the overweight weight (data field 22) should also be calculated and included in the Contractor’s MDMS. The overweight weight is the weight of material exceeding the maximum allowable gross weight as calculated using the Net Weight (data field 18) and Maximum Gross Weight (data field 47).

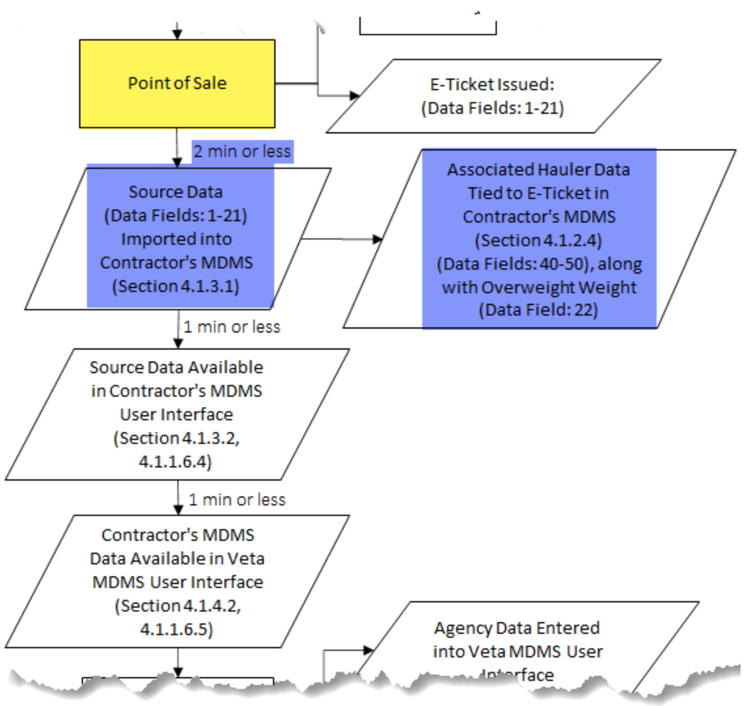


Figure 2.19 Source Data Imported into Contractor’s MDMS and Hauler Data Tied to E-Ticket (Source Process Workflow Schematic).

2.3.2.5 Source Data Available for Viewing in Contractor's MDMS User Interface

As previously discussed, in the subsection 2.3.1.2 "Transmittal of Source Data from Loadout Software to Contractor's MDMS", language was also included in the AASHTO provisional practice to require the source data (data fields 1-21) and Hauler data, to be viewable in the user interface in 3 minutes or less of the point of sale using a web-or application-based interface (see Figure 2.20). The interface should provide viewing of the following information when adequate data cellular coverage is available (see section 4.1.3.2 and 4.1.1.6.4 of Appendix A):

- Number of trucks at source, in transit from source to contract, at contract (and/or dump) and in transit from contract to source.
- Tabular summary of ticket status (e.g., ticket number, loaded, in transit, dumped).
- Source data per Tables 1 and 6 of Appendix A.
- Hauler data per Table 1 of Appendix A.

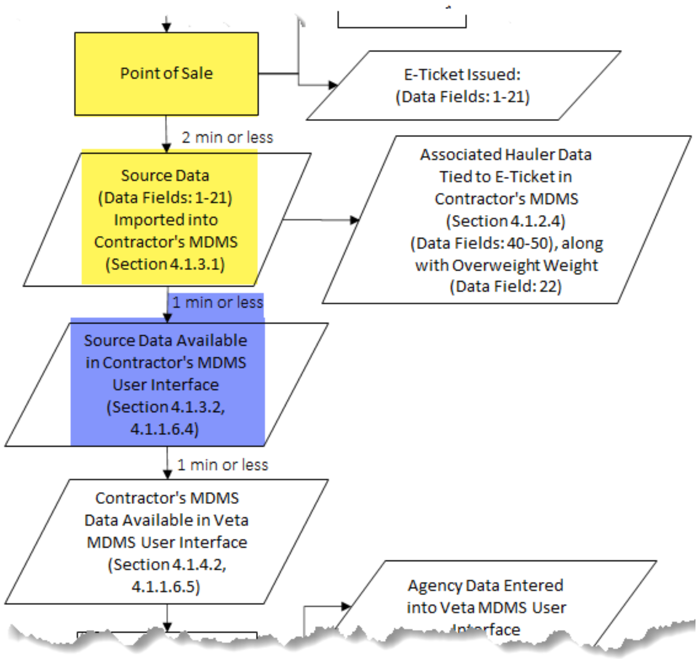


Figure 2.20 Source Data Available for Viewing in Contractor's MDMS User Interface (Source Process Workflow Schematic).

2.3.2.6 Contractor's MDMS Data Available in Veta MDMS User Interface

As previously discussed in the subsection 2.3.1.1 "2.3.1.2 ", Veta MDMS will be the standardized MDMS platform for the Agency in the future. Consequently, language was included in the AASHTO provisional practice to require the source, fleet and Hauler data to be transmitted from the Contractor's MDMS to the Veta MDMS in 4 minutes or less of the point of sale (see Figure 2.21, and sections 4.1.4.2 and 4.1.1.6.5 of Appendix A).

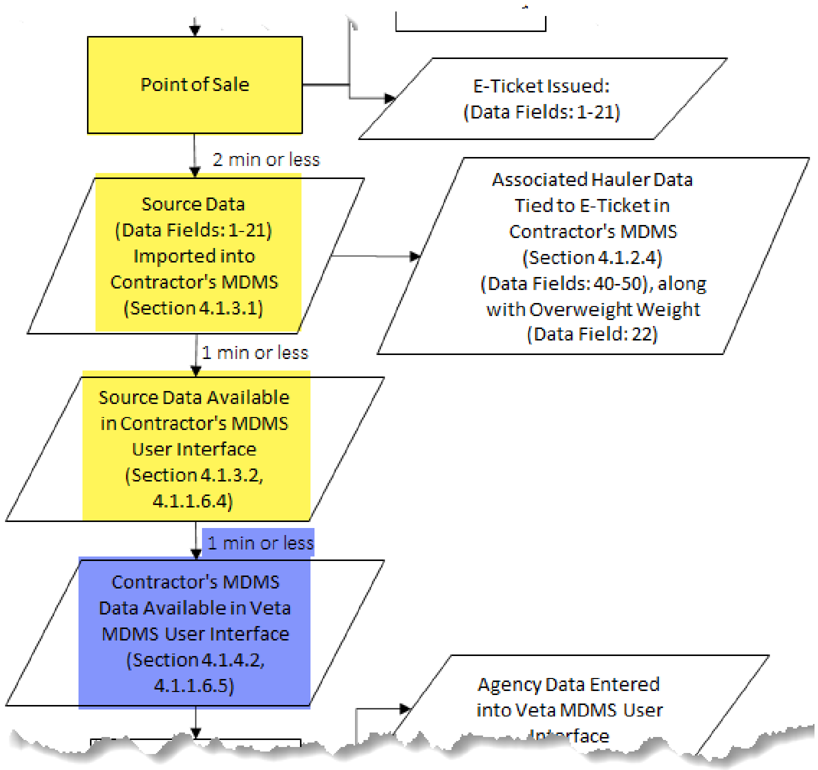


Figure 2.21 Contractor's MDMS Data Available in Veta MDMS User Interface (Source Process Workflow Schematic).

2.3.2.7 Agency and Contractor Data (Data Fields 51-52, 54, 84-85, 87)

(See Figure 2.22 for location of this step within workflow for the source process.)

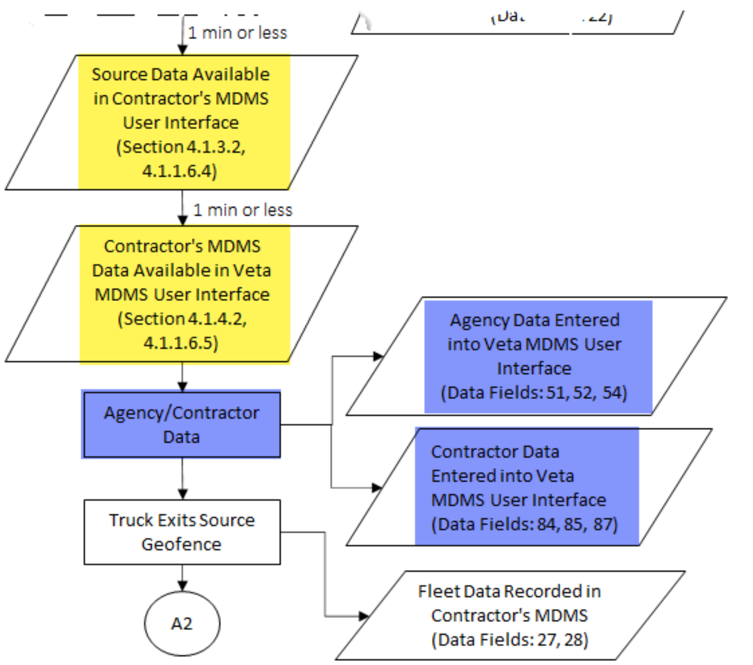


Figure 2.22 Agency and Contractor Data (Source Process Workflow Schematic).

Both the Agency and Contractor has information that they record either on the paper tickets and/or in their diaries while at the source. Material samples and temperatures are sometimes collected at the source for asphalt materials. It is beneficial to tie this information directly to the E-Ticket. Additionally, there is other information that is later recorded during delivery of the material (see section 2.3.3.2 “Material Dumped (Data Fields 35-39, 51, 53-70, 84, 86-103)”). Consequently, in addition to requiring a Hauler user interface in the Contractor’s MDMS as detailed in section 2.3.2.1 language was also included for the Veta MDMS to provide a user interface for both the Contractor and Agency (see Note 3 of Appendix A). The sample identification, material temperature at the source, and air temperature would be entered into the Veta MDMS user interface in the future when this feature becomes available.

2.3.2.8 Truck Exits Source Geofence (Data Fields 27, 28)

(See Figure 2.23 for location of this step within workflow for the source process.)

The truck has now been loaded and is exiting the source geofence for delivery of material to the contract (jobsite). As the truck exits the source geofence, the truck “exits the source date and time stamp” is recorded and the Contractor’s MDMS calculates and stores the “time at source” (data fields 27 and 28 of Table 1 of Appendix A). Again, this data assists with generation of flow rates, prevailing wage documentation, and general material delivery audits.

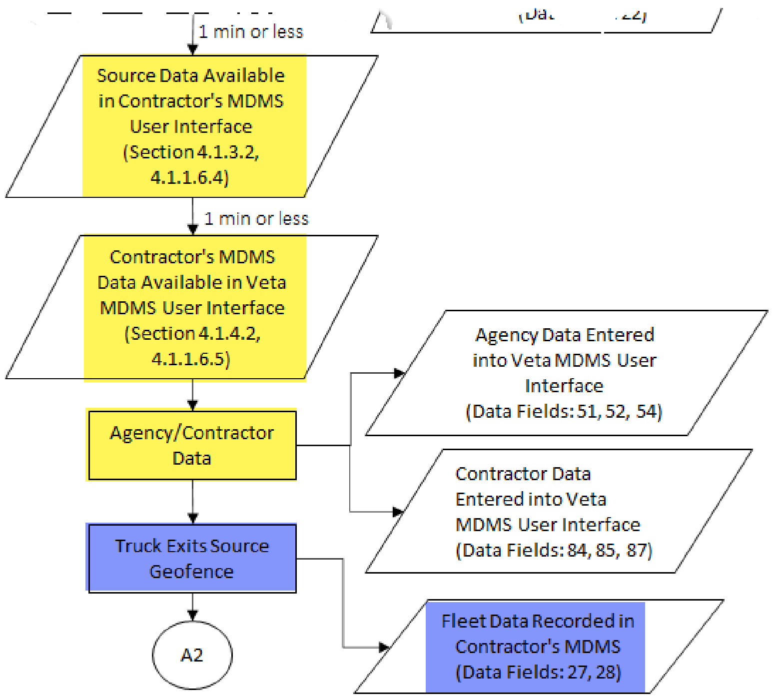


Figure 2.23 Truck Exits Source Geofence (Source Process Workflow Schematic).

2.3.3 Delivery of Material

The third step of the MDMS workflow details the steps entailed during the delivery of material. As illustrated in Figure 2.4, this process consists of the following key elements: truck entering the contract geofence, material dumped, independent field verification, and the truck exiting the contract geofence. The following subsections provides details related to the elements of this process.

2.3.3.1 Truck Entering Contract Geofence (Data Fields 29-31)

(See Figure 2.24 for location of this step within workflow for the delivery of material process.)

After loading the material into the truck at the source, the truck then leaves the source and travels to the jobsite. As the truck enters the contract geofence (i.e., jobsite limits) the “contract geofence name” and truck “enters contract date and time stamp” are recorded, along with calculation of the “source to contract transit time” (data fields 29 through 31 of Table 1 of Appendix A). Again, this data assists with generation of flow rates, prevailing wage documentation, and general material delivery audits.

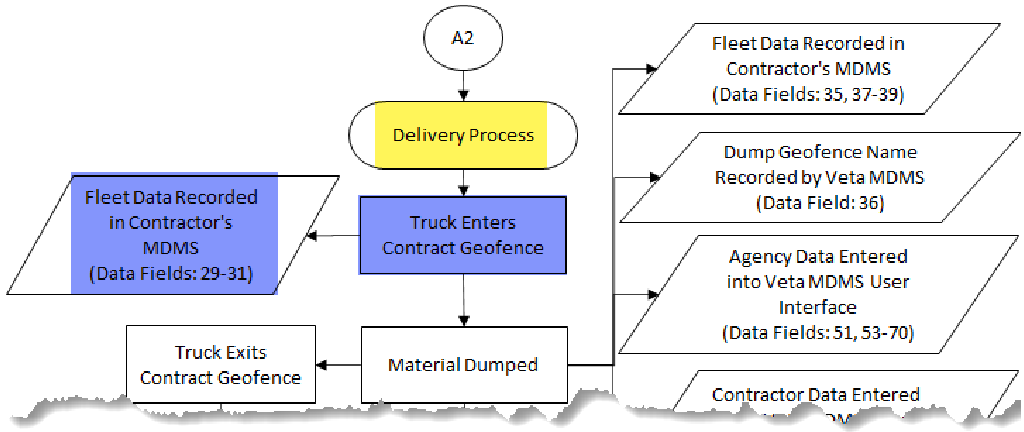


Figure 2.24 Truck Enters Contract Geofence (Delivery Process Workflow Schematic).

2.3.3.2 Material Dumped (Data Fields 35-39, 51, 53-70, 84, 86-103)

(See Figure 2.25 for location of this step within workflow for the source process.)

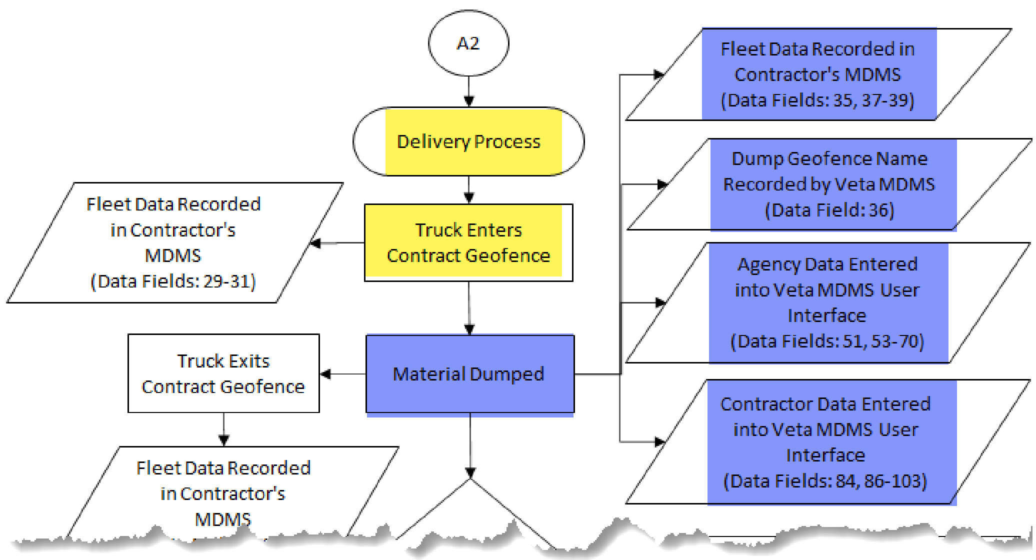


Figure 2.25 Material Dumped (Delivery Process Workflow Schematic).

As previously discussed in section 2.3.1.2 2.3.1.1 "Mobile Dump Geofence", the mobile geofence established around the dump location (e.g., paver, material transfer device, pickup machine), along with the latitude and longitude of the dump location, is used to assist with capturing the dump time and dump geofence name (fleet data fields 35-39 of Table 1 of Appendix A). Additionally, during material delivery, there may be instances where the Agency and/or Contractor also record the following information (see Agency data fields 51, 53-70 and Contractor data fields 84 and 86-103 of Table 1 of Appendix A):

Sample Identification

Material Temperature at Field

Air Temperature

Split Loads 1, 2, 3 Weight

Split Loads 1, 2, 3 Pay Item

Split Loads 1, 2, 3 Location Note

Wasted Material Weight

Load Acceptance and Rejection

Partial Rejected Load Weight

Dump Station Number

Field Notes

Inspector Identification

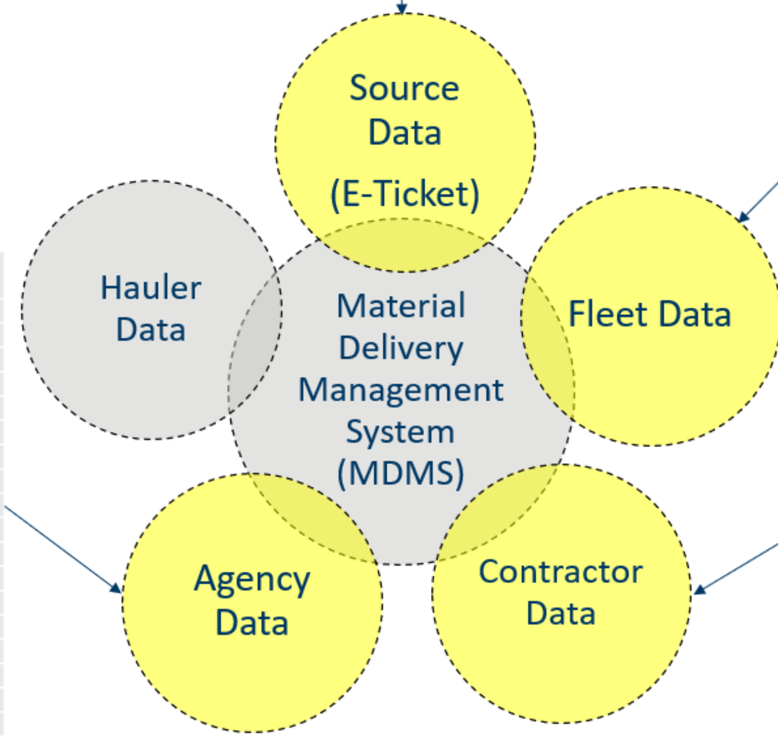
Date and Time Stamp (of Agency/Contractor data entry)

Please note that split loads are loads that are split during delivery for use at more than one location, such as for patching, entrances, etc. For example, material might be split for use in patching work located in front of the paver and the remaining material is provided to the paver for mainline paving. Typically, patching mix is paid for using a different pay item and unit price, than that of mainline paving, as it requires hand placement. The average bid price per ton of mainline paving in Minnesota is about $70 per ton, while that for patching is $120 per ton. Consequently, it is extremely important to correctly track these quantities for later use in payments. Another example where split loads may occur, is when there is extra mix available from the mainline paving. Instead of wasting this mix, it is used for paving of shoulders. Shoulders often use a different pay item as they use material codes (mix designations) for a lower level of traffic, etc. The Agency will still want to use the shouldering pay item for this material, even though it was mainline mix, as it was the Contractor that elected to use this more expensive mix for shouldering. Therefore, it is important that this information is recorded appropriately for use in reconciling quantities.

As illustrated in Figure 2.26, during delivery of the material, fleet, Agency and Contractor data is collected, recorded and associated to the source data (E-Ticket). Again, these fields are all necessary for the reconciling of quantities. Consequently, in addition to the E-Ticket (source data) an Agency should ensure that MDMS requirements also include the appropriate fleet, Agency and Contractor data fields.

Reference Field No.	Long Description
11	Ticket Number

Reference Field No.	Long Description
35	Dump Equipment Identification
36	Dump Geofence Name
37	Dump Date and Time
38	Dump Latitude
39	Dump Longitude



Reference Field No.	Long Description
51	Agency Sample Identification
53	Agency Matl Temperature at Field
54	Agency Air Temperature
55	Agency Split Load 1 Weight
56	Agency Split Load 1 Pay Item
57	Agency Split Load 1 Location Note
58	Agency Split Load 2 Weight
59	Agency Split Load 2 Pay Item
60	Agency Split Load 2 Location Note
61	Agency Split Load 3 Weight
62	Agency Split Load 3 Pay Item
63	Agency Split Load 3 Location Note
64	Agency Wasted Material Weight
65	Agency Load Acceptance and Rejection
66	Agency Partial Rejected Load Weight
67	Agency Dump Station Number
68	Agency Field Notes
69	Agency Inspector Identification
70	Agency date and time

Reference Field No.	Long Description
84	Contractor Sample Identification
86	Contractor Material Temperature at Field
87	Contractor Air Temperature
88	Contractor Split Load 1 Weight
89	Contractor Split Load 1 Pay Item
90	Contractor Split Load 1 Location Note
91	Contractor Split Load 2 Weight
92	Contractor Split Load 2 Pay Item
93	Contractor Split Load 2 Location Note
94	Contractor Split Load 3 Weight
95	Contractor Split Load 3 Pay Item
96	Contractor Split Load 3 Location Note
97	Contractor Wasted Material Weight
98	Contractor Load Acceptance and Rejection
99	Contractor Partial Rejected Load Weight
100	Contractor Dump Station Number
101	Contractor Field Notes
102	Agency Staff Identification
103	Contractor date and time

Figure 2.26 Schematic of MDMS data types collected during material delivery (dump).

2.3.3.3 Independent Field Verification (Data Fields 71-83)

(See Figure 2.27 for location of this step within workflow for the delivery of material process.)

Language was added to the AASHTO provisional practice to provide a reminder for Agencies to randomly verify source and Hauler data in the field to assist with mitigation of fraud within the Contractor's MDMS (see Section 4.4 of Appendix A). It is recommended that each Agency randomly reviews the source and Hauler data to ensure no issues are present with the Contractor's MDMS and that source data stored within the Contractor's MDMS is accurate for use in yield checks and reconciling of quantities. This field verification information is also used to verify that the final data exported from the Contractor's MDMS reflects those values originally reviewed in the field.

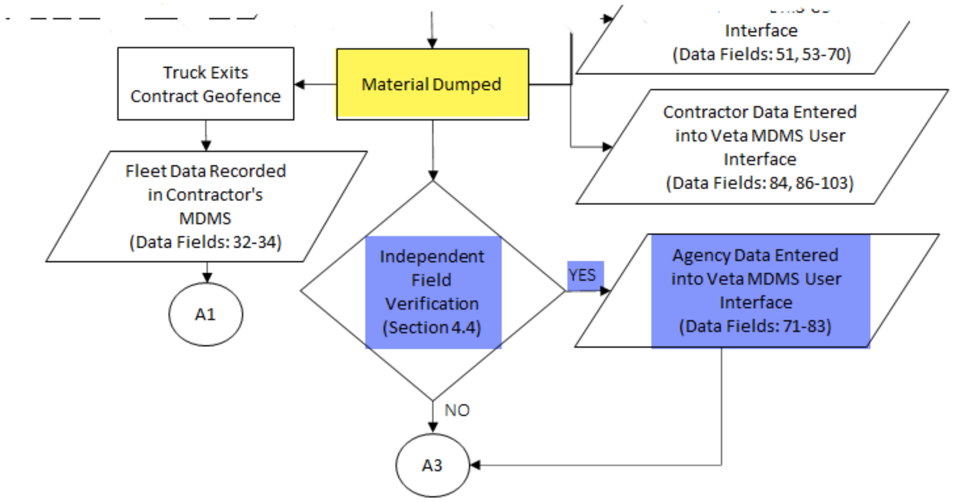


Figure 2.27 Independent Field Verification (Delivery Process Workflow Schematic).

The following independent field verification language was added to the MnDOT special provision and was also added as a note in the AASHTO provisional practice (see Figure 2.28 for image of MnDOT's independent verification workflow):

> *Engineer will complete independent field verification within delivery of first 10 loads of material and 1,000-ton lots thereafter. Use Engineer approved random number generator to determine independent field verification tonnage for each lot. The Engineer's independent field verification will consist of the following:*
>
> *(1) Review of source data contained within MDMS to verify that all required fields, per Table 2016-1 (MDMS), are available and accurate.*
>
> *(2) Compare Engineer's estimated net weight of material delivered by truck to net weight contained in MDMS. Record Engineer's estimated net weight and net weight*

provided in MDMS for later use in verification of net weight included in the final MDMS data export used for reconciling quantities.

(3) If source data is invalid, the Engineer will report the system failure to the Contractor. The Contractor will provide the Engineer with a resolution to the issues and acceptable time frame for completing the resolution prior to resuming the next day's paving operation. The Engineer will complete independent field verification within delivery of the first 10 loads of material and 1,000-tons lots thereafter, upon resolution of the system failure.

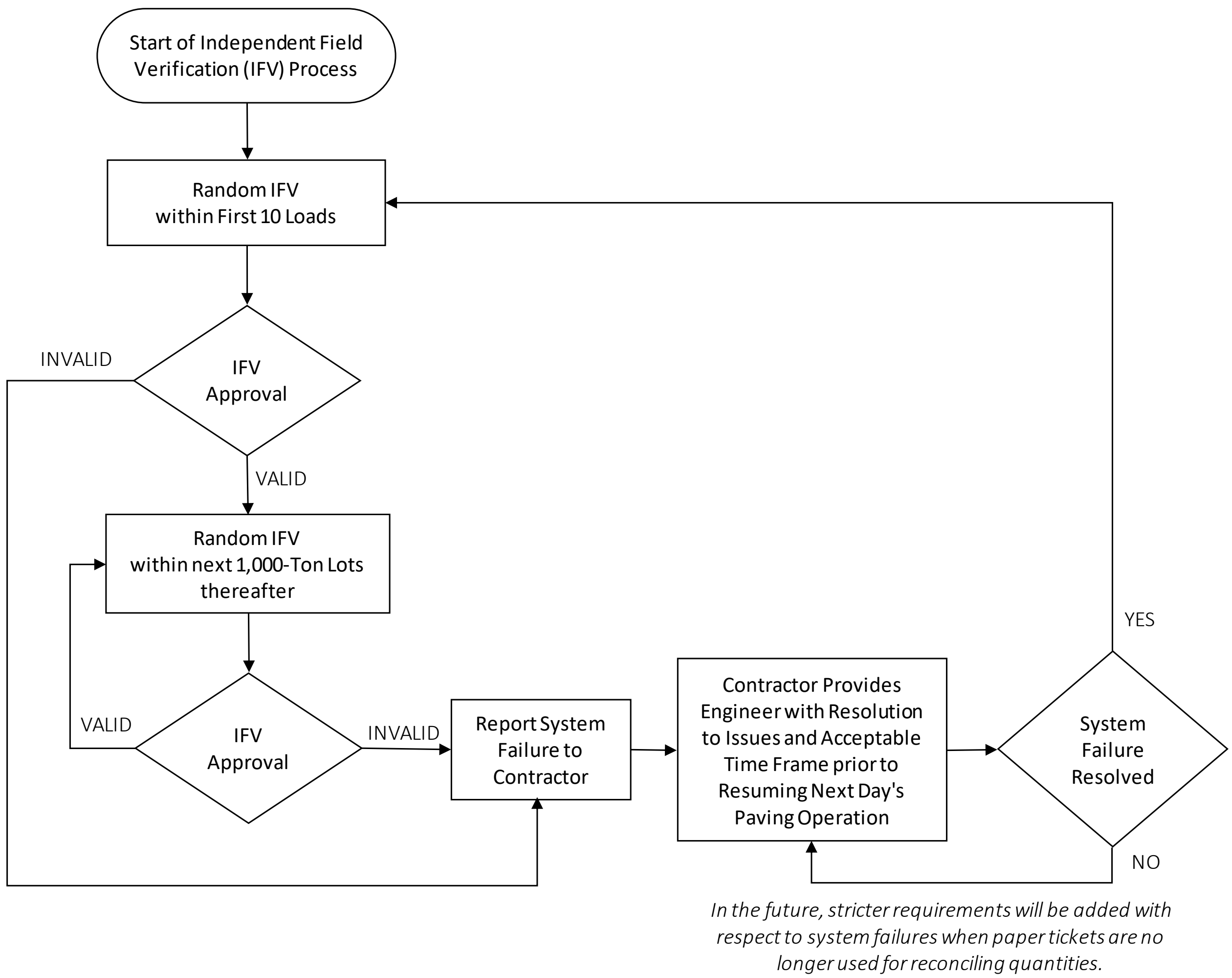


Figure 2.28 MnDOT's Independent Field Verification Workflow.

As noted in Figure 2.28, stricter requirements will be added with respect to system failures when paper tickets are no longer used for reconciling quantities. System failure is defined as when the MDMS does not collect and/or store data per the requirements of this provision and/or when data cellular coverage is limited. Currently, MnDOT requires that each truck driver carries a computer-generated weight ticket that is collected by the Engineer. The Engineer will use the computer-generated weight ticket for generation of density lots and calculation of pay quantities per the requirements of MnDOT 2360. MnDOT intends to continue to use the computer-generated weight tickets until both MnDOT and the Contractor have fully verified the stability of the MDMS and that the needed Agency and Contractor data fields are tied to the source data (E-Ticket) for the reconciling and independent verification of quantities. As previously discussed, Agency and Contractor data fields 51-103 are not available for most systems.

The following data fields (data fields 71-83 of Table 1 in Appendix A) are recorded as part of the independent field verification process:

Date and Time

Latitude

Longitude

Station

Estimated Net Weight

Independent Scale Weight

Independent Scale Certification

Net Weight on E-Ticket

Driver Name

Hauler Company Name

Approval

Notes

Inspector Identification

The latitude and longitude will only be recorded if the Engineer has the location service for the device turned on for collection of this type of information.

2.3.3.4 Truck Exiting Contract Geofence (Data Fields 32-34)

(See Figure 2.29 for location of this step within workflow for the delivery of material process.)

After delivery of the material, the truck will either continue back to the source or go to a new location. As the truck exits the contract geofence (i.e., jobsite limits), the truck "exits contract geofence date and time" and the "time at contract" will be recorded. Should the truck return to the source, the "contract to source transit time" (data field 34) will also be recorded. (See data fields 32 through 34 of Table 1 of Appendix A). Again, this data assists with generation of flow rates, prevailing wage documentation, and general material delivery audits.

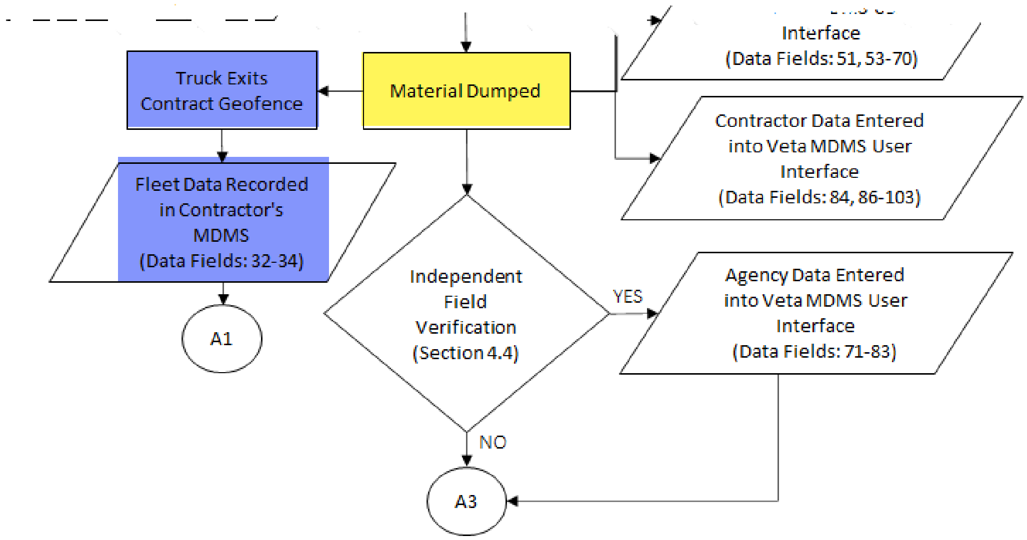


Figure 2.29 Truck Exiting Contract Geofence (Delivery Process Workflow Schematic).

2.3.4 Data Transmittal

The fourth step of the MDMS workflow details the steps entailed during the transmittal of MDMS data. As illustrated in Figure 2.5, this process consists of transmittal of data using conventional methods (i.e., file downloads) and using API and JSON coding. The following subsections provide details related to the elements of this process.

2.3.4.1 Contractor's MDMS (Data Fields 1-35, 37-50)

(See Figure 2.30 for location of this step within workflow for the data export process.)

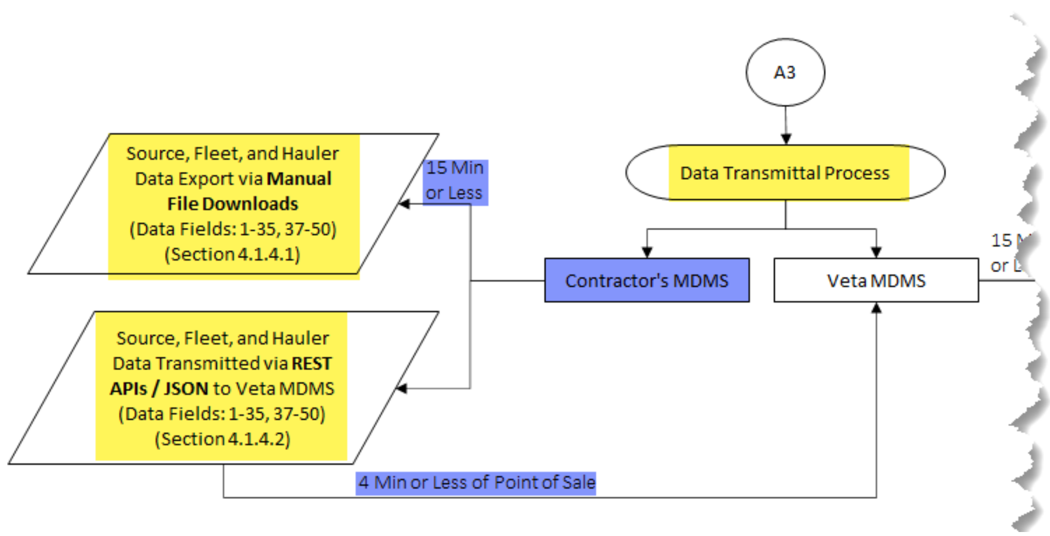


Figure 2.30 Contractor's MDMS (Data Transmittal Process Workflow Schematic).

All MDMS vendors can export data using conventional file downloads in dbase ASCII, CSV, XLSX, or text format. This is not the preferred method of transfer of data but is currently being used by most Agencies until enhancements are made to allow for transfer of data using APIs and JSON. Consequently, the Contractor and Engineer can export data fields 1-35 and 37-50 in a dbase ASCII, CSV, XLSX, or text format from the Contractor's MDMS in 15-minute intervals or less (see Section 4.1.4.1 of Appendix A).

As previously discussed, and per Notes 16-18 of Appendix A, further enhancements are needed to allow for transmittal of the Contractor's MDMS data into the Veta MDMS using REST APIs and JSON. However, language was included in the AASHTO provisional to allow for this transmittal process. Per section 4.1.4.2 of Appendix A, the MDMS vendors will provide source, fleet, and Hauler data (data fields 1-35 and 37-50) to Veta MDMS in 4 minutes or less of point of sale. Additionally, the Veta MDMS will allow import of more than one ticket (batch queuing of tickets), and associated MDMS data, per JSON message.

2.3.4.2 Veta MDMS (Data Fields 1-103)

(See Figure 2.31 for location of this step within workflow for the data export process.)

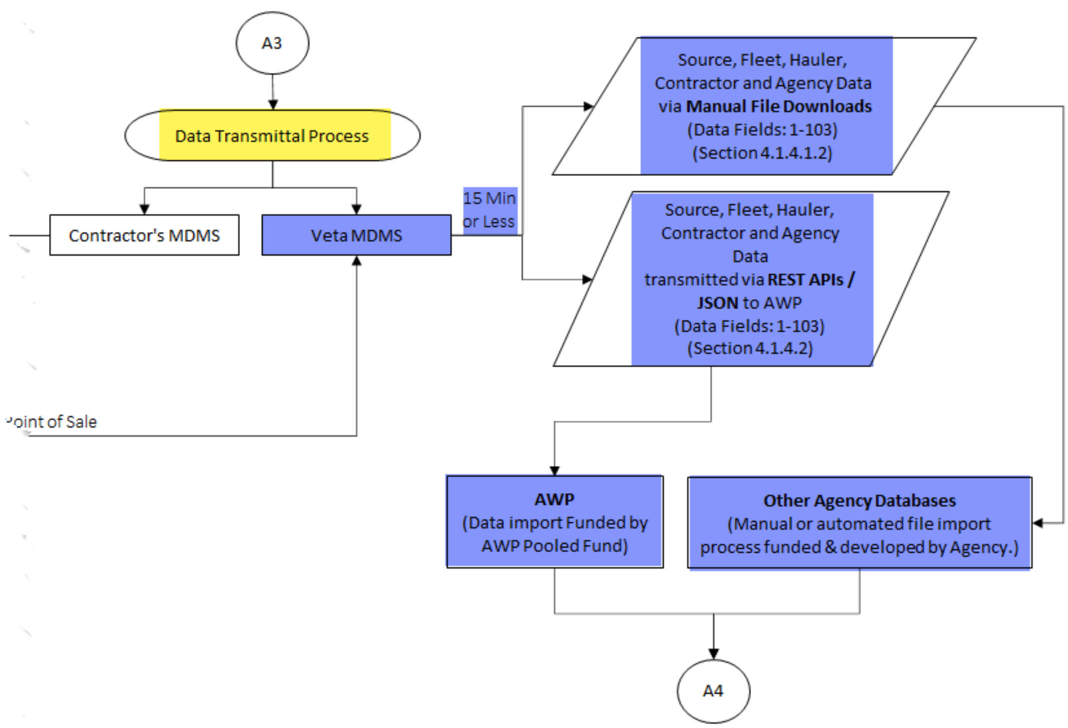


Figure 2.31 Veta MDMS (Data Transmittal Process Workflow Schematic).

As with the Contractor's MDMS, the Veta MDMS is also required to provide manual file downloads. After the source, fleet and Hauler data is imported into the Veta MDMS, this data is joined with the associated dump geofence name (data field 36) and Agency and Contractor data (data fields 51-103). This combined data set is then required to be available for download within 15-minute intervals or less by the user in a dbase ASCII, CSV, XLSX, or text format. Again, this feature is not currently available, but the needed enhancements will be made in the future as funding becomes available. Please note that these file downloads would be used by Agencies that are not using AWP, such that these entities can upload this data into the agencies' own database.

In addition to manual file downloads, the Veta MDMS is also required to transmit the MDMS data (data fields 1-103) via REST APIs and JSON to AWP (see section 4.1.4.2 of Appendix A). This feature is also not currently available and will require enhancements both to the Veta MDMS and AWP.

It is recommended that source, fleet, Hauler, Agency and Contractor data is importable into AWP "Construction and Materials" and "Estimating" modules for use in reconciling daily quantities and for use with future estimated quantities, respectively. Additionally, this data will be imported into the materials testing and acceptance system to ensure acceptance testing is completed at the required frequency. Fleet and Hauler data will be imported into the AWP "Civil Rights and Labor" module for Agencies that elect to capture fleet and Hauler data.

2.3.5 End-of-Day Review

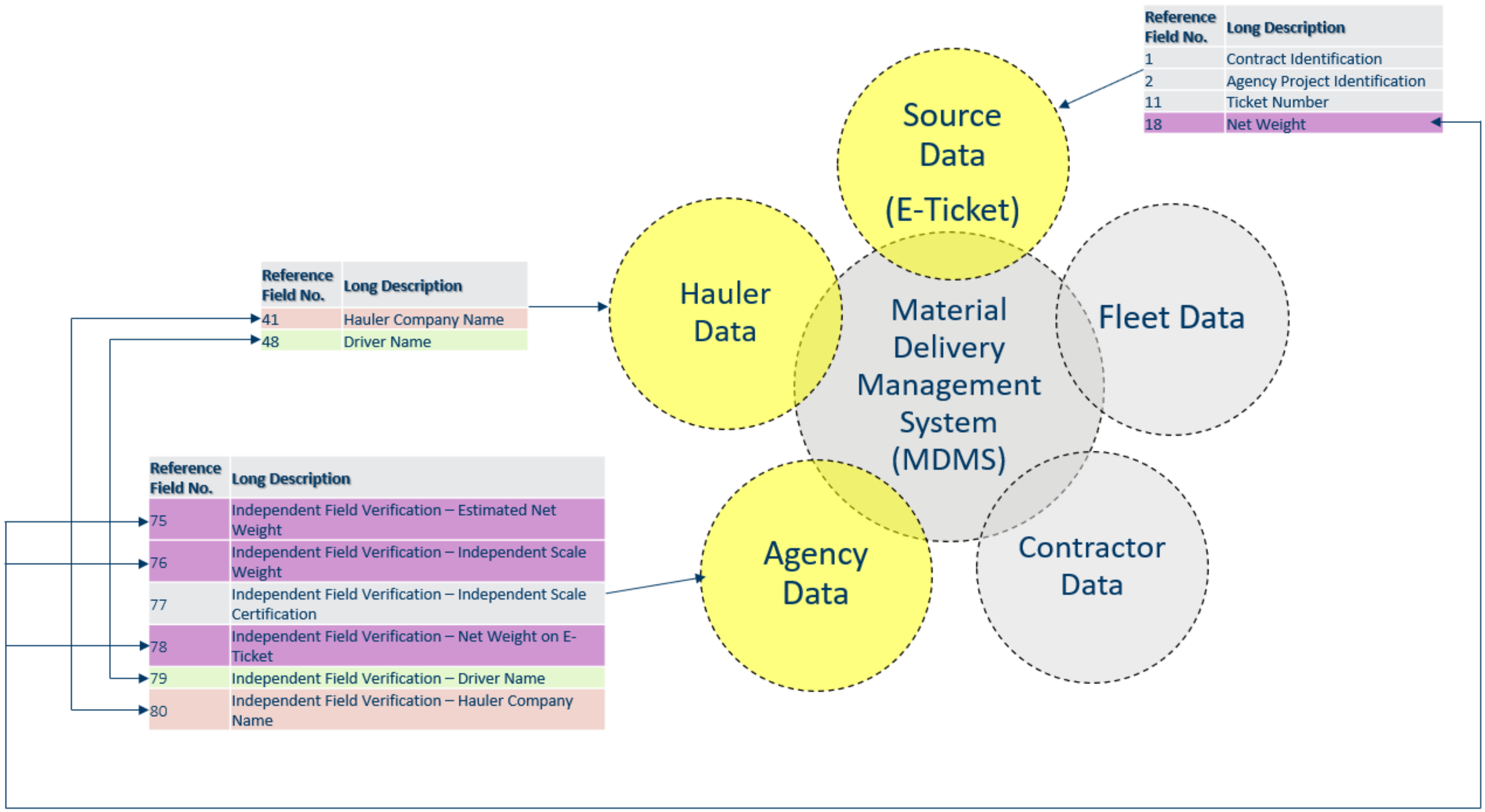
The fifth, and final, step of the MDMS workflow details the steps at the end of the day. As illustrated in Figure 2.5, this process consists of reviewing the independent field verification values with those contained within the final MDMS data export, reconciling weight quantities, and Labor Compliance and Civil Rights Review. The following subsections provide details related to the elements of this process.

2.3.5.1 Independent Verification

In addition to the review of the source and Hauler data during the independent verification process in the field (see Section 2.3.3.3 , it is also recommended that independent verification is again completed at the end of each day against the final MDMS dataset. This process includes a minimum of the following (see Figure 2.32):

- Comparison of "Independent Field Verification – Net Weight on E-Ticket" (Data Field 78) to the "Net Weight" (Source Data Field 18) contained within the E-Ticket to ensure that no modifications to the source data have occurred since field review. If values do not match, the "Independent Field Verification – Estimated Net Weight on E-Ticket" (Data Field 75), or "Independent Field Verification - Independent Scale Weight" (Data Field 76), could also be compared to the "Net Weight" (Source Data Field 18) to assist with troubleshooting.
- Comparison of "Independent Field Verification – Hauler Company Name" (Data Field 80) to "Hauler Company Name" (Hauler Data Field 41).
- Comparison of "Independent Field Verification – Driver Name" (Data Field 79) to "Driver Name" (Hauler Data Field 48).

Additionally, it is recommended that a general review of all MDMS data (data fields 1-101) is completed to ensure no missing, corrupt, or odd data values are present.



Reference Field No.	Long Description
1	Contract Identification
2	Agency Project Identification
11	Ticket Number
18	Net Weight

Reference Field No.	Long Description
41	Hauler Company Name
48	Driver Name

Reference Field No.	Long Description
75	Independent Field Verification – Estimated Net Weight
76	Independent Field Verification – Independent Scale Weight
77	Independent Field Verification – Independent Scale Certification
78	Independent Field Verification – Net Weight on E-Ticket
79	Independent Field Verification – Driver Name
80	Independent Field Verification – Hauler Company Name

Figure 2.32 Comparison of Independent Field Verification Values with Final MDMS Dataset.

2.3.5.2 Reconciling Quantities

Source, fleet, Agency and Contractor data fields are required in order to correctly reconcile quantities. Figure 2.33 illustrates both the data types and fields required to reconcile quantities. As illustrated, the following data fields are used for reconciling quantities:

Source Data

- *Contract Identification (Data Field 1)* – Allows connection of source, fleet, Agency and Contractor data to the correct contract.
- *Agency Project Identification (Data Field 2)* – Allows connection of source, fleet, Agency and Contractor data to Agency prime project identification.
- *Material Code (Data Field 10)* – Used for reconciling of quantities by mix designation (pay item). The material code is tied to the pay item in the Agency database.
- *Ticket Number (Data Field 11)* – Used to ensure that a given ticket number is not duplicated in the database, or as to whether a ticket is potentially missing (i.e., a number is missing in the sequence that is not considered a voided ticket).
- *Load Number (Data Field 12)* – Assists with determination as to whether any tickets are missing.
- *Voided Ticket (Data Field 15)* – Net weight quantities for voided tickets are not included in the quantities. Additionally, this information is used to assist with determination as to whether there are any missing tickets.
- *Loading Data and Time (Data Field 16)* – Used to allow for reconciling of quantities per material delivery date for use in pay estimates / vouchers.
- *Net Weight (Data Field 18)* – Weight of material, for given material code, used in tabulation of quantities for pay estimates/vouchers.

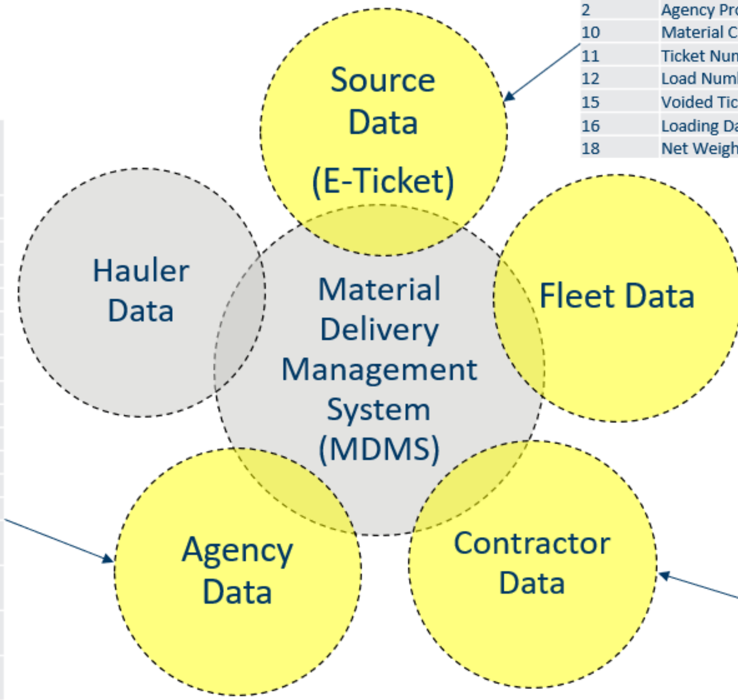
Fleet Data

- *Overweight Weight (Data Field 22)* – Some Agencies cannot include overweight quantities as part of the net weight. Consequently, these quantities are removed from the net weight, for the given ticket / material code for those instances.
- *Dump Equipment Identification (Data Field 35)* – Available to allow for manual (and possible automated) connection of a given ticket to the correct pay item, should the material be used differently. For simpler construction staging, this information could potentially be used to automatically re-define a pay item associated with a given load, should the same equipment be used throughout the operation on a given date and/or contract duration.
- *Dump Geofence Name (Data Field 36)* – The dump geofence name is used to allow for tabulation of quantities per a given project and funding category.
- *Dump Date and Time (Data Field 37)* – Used to query the data for varying time periods used for pay vouchers.

Agency / Contractor Data

- *Split Load 1, 2, 3 Weight (Data Fields 55, 58, 61, 88, 91, 94)* – Allows the net weight, for the given ticket, to be split with respect to what the material was being used for during the construction operation (i.e., pay item).
- *Split Load 1, 2, 3 Pay Item (Data Fields 56, 59, 62, 89, 92, 95)* – Allows the net weight, for the given ticket, to be split and tied to the correct pay item.
- *Split Load 1, 2, 3 Location Notes (Data Fields 57, 60, 63, 90, 93, 96)* – (When populated) is used to verify that the split material was tied to the correct pay item.
- *Wasted Material Weight (Data Fields 64, 97)* – The quantity is not paid for by the Agency, and therefore, is subtracted from the net weight.
- *Load Acceptance and Rejection (Data Fields 65, 98)* – The quantities associated with rejected loads are not paid for by the Agency, and therefore, subtracted from the net weight. By default, the entire net weight for the given ticket would be subtracted, unless a weight was included in the "Partial Rejected Load Weight" field.
- *Partial Rejected Load Weight (Data Fields 66, 99)* – Instances occur, where only a partial load is rejected. For these instances, the partial rejected load weight would be subtracted from the net weight when reconciling quantities.
- *Notes (Data Fields 68, 101)* – Special notes may require manual adjustments to the net weight and/ or pay item when reconciling quantities.

Reference Field No.	Long Description
1	Contract Identification
2	Agency Project Identification
10	Material Code
11	Ticket Number
12	Load Number
15	Voided Ticket
16	Loading Date and Time
18	Net Weight



MDMS Data	Reference Field No.	Long Description
Fleet	22	Overweight Weight
Fleet	35	Dump Equipment Identification
Fleet	36	Dump Geofence Name
Fleet	37	Dump Date and Time

Reference Field No.	Long Description
88	Contractor Split Load 1 Weight
89	Contractor Split Load 1 Pay Item
90	Contractor Split Load 1 Location Note
91	Contractor Split Load 2 Weight
92	Contractor Split Load 2 Pay Item
93	Contractor Split Load 2 Location Note
94	Contractor Split Load 3 Weight
95	Contractor Split Load 3 Pay Item
96	Contractor Split Load 3 Location Note
97	Contractor Wasted Material Weight
98	Contractor Load Acceptance and Rejection
99	Contractor Partial Rejected Load Weight
100	Contractor Dump Station Number
101	Contractor Field Notes

Reference Field No.	Long Description
55	Agency Split Load 1 Weight
56	Agency Split Load 1 Pay Item
57	Agency Split Load 1 Location Note
58	Agency Split Load 2 Weight
59	Agency Split Load 2 Pay Item
60	Agency Split Load 2 Location Note
61	Agency Split Load 3 Weight
62	Agency Split Load 3 Pay Item
63	Agency Split Load 3 Location Note
64	Agency Wasted Material Weight
65	Agency Load Acceptance and Rejection
66	Agency Partial Rejected Load Weight
67	Agency Dump Station Number
68	Agency Field Notes
75	Independent Field Verification – Estimated Net Weight
76	Independent Field Verification – Independent Scale Weight
77	Independent Field Verification – Independent Scale Certification
78	Independent Field Verification – Net Weight on E-Ticket
81	Independent Field Verification – Approval
82	Independent Field Verification – Notes

Figure 2.33 Schematic of MDMS Data Types and Fields Required for Reconciling Quantities.

2.3.5.3 Labor Compliance / Civil Rights Review

Source, fleet, and Hauler data fields are used to support labor compliance and civil rights audit review activities (see Figure 2.34). As illustrated, the following data fields are used with these efforts:

Source Data (E-Ticket)

- *Contractor Identification (Data Field 1)* - Allows connection of source, fleet, and Hauler data to the correct contract.
- *Agency Project Identification (Data Field 2)* - Allows connection of source, fleet, and Hauler data to the prime project identification.
- *Source Identification (Data Field 3)* – The location of the source impacts prevailing wage rates and hours.
- *Material Code (Data Field 10)* – Used to verify the labor code/craft/trade used for prevailing wage rates.
- *Ticket Number (Data Field 11)* – Ties activity to material being delivered.
- *Truck Identification (Data Field 13)* – Allows generation of summary information per truck (driver).
- *Trailer Identification (Data Field 14)* – Allows generation of summary information per truck (driver).
- *Voided Ticket (Data Field 15)* – Material was not delivered to project, and therefore, no hours should be tabulated and used for the given ticket.
- *Loading Date and Time (Data Field 16)* – Used for tabulation of transit times and verification that material was indeed loaded for delivery.

Fleet Data

The location of the source, contract and dump location may impact prevailing wage rates and hours. Per section 2.3.1.2 “Example of Dump Geofence Names”,2.3.1.1 the standardized geofence naming conventions include the county name to assist with Federal and/or State Prevailing wage rates. Consequently, the following geofence names are recorded:

- *Source Geofence Name (Data Field 23)*
- *Contract Geofence Name (Data Field 28)*
- *Dump Geofence Name (Data Field 34)*

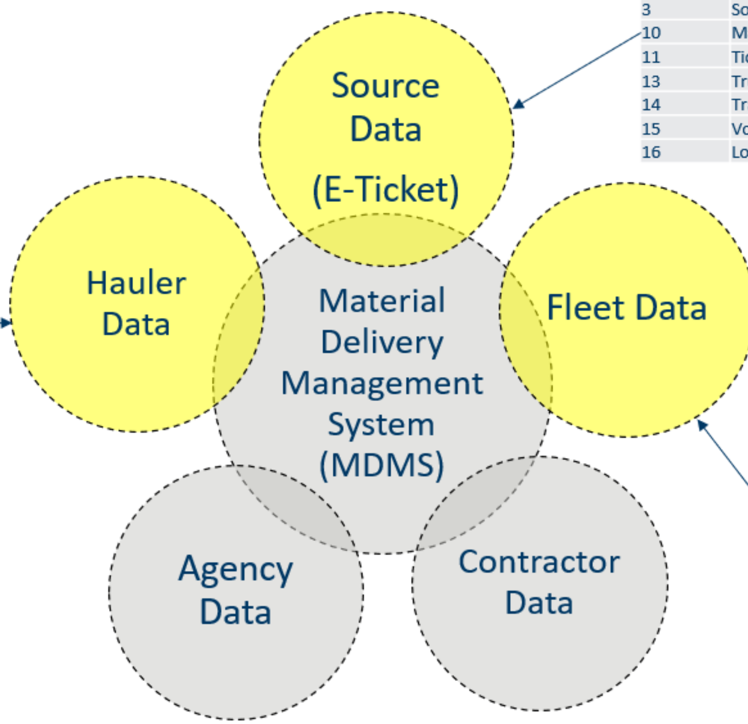
The following fleet data fields are used for tabulation of transit times (prevailing wage hours), payrolls, DBE and/or small business hours, determination as to whether additional documentation and reporting is required for adherence to the Federal Davis Bacon Law, etc.:

- *Truck Enters Source Geofence Date and Time (Data Field 24)*
- *Truck Exits Source Geofence Date and Time (Data Field 25)*
- *Time at Source (Data Field 26)*
- *Source to Contract Transit Time (Data Field 27)*

- *Truck Enters Contract Geofence Date and Time (Data Field 29)*
- *Truck Exits Contract Geofence Date and Time (Data Field 30)*
- *Time at Contract (Data Field 31)*
- *Contract to Source Transit Time (Data Field 32)*
- *Dump Date and Time (Data Field 35) – This field is also used to confirm that the material was indeed delivered to the contract by the given driver.*

Hauler Data

- *Hauler Company Name (Data Field 39)* – Assists with verification of driver's names.
- *Broker Name (Data Field 40)* – It can be difficult to identify the broker name for the given driver. This field reduces time and resources spent determining MTO information.
- *DOT Number (Data Field 41)* – Used for verification of valid DOT numbers. All Haulers need a DOT number regardless of whether an ITO or MTO. Surprisingly, there are many drivers that should not be hauling as their DOT number has been revoked.
- *Truck Identification (Data Field 43)* – Ties the material being delivered to the E-Ticket, driver and Hauler information.
- *Driver Name (Data Field 46)* – It has been identified that changing driver names is a real problem, as companies change out the real driver's names to avoid prevailing wage laws.



Reference Field No.	Long Description
1	Contract Identification
2	Agency Project Identification
3	Source Identification
10	Material Code
11	Ticket Number
13	Truck Identification
14	Trailer Identification
15	Voided Ticket
16	Loading Date and Time

Reference Field No.	Long Description
41	Hauler Company Name
42	Broker Name
43	DOT Number
45	Truck Driver Classification
48	Driver Name

Reference Field No.	Long Description
23	Source Geofence Name
26	Truck Enters Source Geofence Date and Time
27	Truck Exits Source Geofence Date and Time
28	Time at Source
29	Source to Contract Transit Time
30	Contract Geofence Name
31	Truck Enters Contract Geofence Date and Time
32	Truck Exits Contract Geofence Date and Time
33	Time At Contract
34	Contract to Source Transit Time
36	Dump Geofence Name
37	Dump Date and Time

Figure 2.34 Schematic of MDMS Data Types and Fields used with Labor Compliance / Civil Rights Activities.

A few entities have stated that they would prefer that data fields associated with labor compliance are not included in the MDMS. However, as previously discussed in section 2.3.1.2 2.3.1.1 "Source and Contract Geofences", this information significantly assists both the Contractor and Agency. Additionally, it only requires a few extra fields beyond those already needed for reconciling quantities and generation of flow rates. Table 2.4 lists the data fields used for labor compliance with respect to those data fields that are also used for reconciling quantities and/or generation of flow rates. As illustrated, all labor compliance/civil rights data fields, with the exception of Hauler data, are also used for either reconciling quantities and/or generation of flow rates. Consequently, it recommended to support as many administration functions for the Agency and Contractors, as possible through these automated methods.

Table 2.4 Labor Compliance/Civil Rights also used for Reconciling Quantities and Flow Rates

MDMS Data	Reference Field No.	Long Description	Labor Compliance and Civil Rights Activities	Reconciling Quantities	Flow Rates
Source	1	Contract Identification	Yes	Yes	Yes
Source	2	Agency Project Identification	Yes	Yes	Yes
Source	3	Source Identification	Yes	No	Yes
Source	10	Material Code	Yes	Yes	Yes
Source	11	Ticket Number	Yes	Yes	No
Source	13	Truck Identification	Yes	No	Yes
Source	14	Trailer Identification	Yes	No	Yes
Source	15	Voided Ticket	Yes	Yes	Yes
Source	16	Loading Date and Time	Yes	Yes	Yes
Fleet	23	Source Geofence Name	Yes	No	No
Fleet	24	Truck Enters Source Geofence Date and Time	Yes	No	Yes
Fleet	25	Truck Exits Source Geofence Date and Time	Yes	No	Yes
Fleet	26	Time at Source	Yes	No	Yes
Fleet	27	Source to Contract Transit Time	Yes	No	Yes
Fleet	28	Contract Geofence Name	Yes	No	No
Fleet	29	Truck Enters Contract Geofence Date and Time	Yes	No	Yes
Fleet	30	Truck Exits Contract Geofence Date and Time	Yes	No	Yes
Fleet	31	Time At Contract	Yes	No	Yes
Fleet	32	Contract to Source Transit Time	Yes	No	Yes
Fleet	34	Dump Geofence Name	Yes	Yes	No
Fleet	35	Dump Date and Time	Yes	Yes	Yes
Hauler	39	Hauler Company Name	Yes	No	No
Hauler	40	Broker Name	Yes	No	No
Hauler	41	DOT Number	Yes	No	No
Hauler	43	Truck Driver Classification	Yes	No	No
Hauler	46	Driver Name	Yes	No	No

2.3.6 Veta MDMS

As previously discussed, a standardized platform for the Agency view of MDMS data is recommended. Currently, it is recommended that Veta is enhanced to be this platform (see Section 3.3 for additional details). Figure 2.35 presents the workflow process with respect to the Veta MDMS. It contains the workflow elements contained in the preconstruction, construction and data transmittal workflows that are associated with the Veta MDMS. The individual process elements presented within this workflow were previously discussed (see Sections 2.3.1 to 2.3.5), and therefore, will not be discussed again within this subsection.

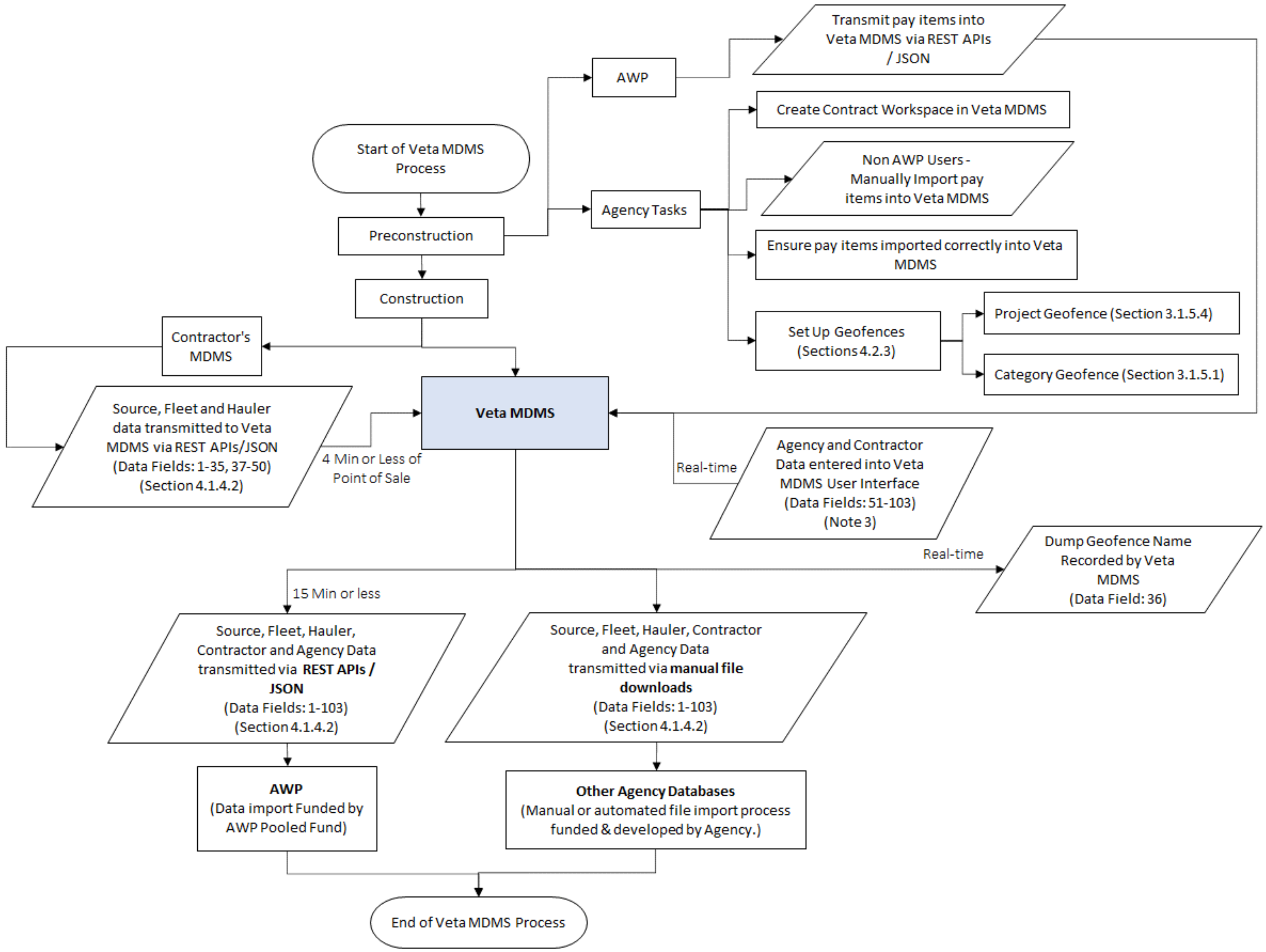


Figure 2.35 Veta MDMS Process Workflow.

2.4 SYSTEM FAILURE

As with the intelligent compaction (AASHTO PP-81) and the paver mounted thermal profile method (AASHTO PP-80), it is important to include language for system failures. System failure occurs when the MDMS does not collect and/or store data per the requirements of specification or when data cellular coverage is limited. The Contractor should notify Engineer when system failure occurs and immediately after resolution of issues. During system failures, the source data will revert to other means, which is approved by the Engineer, for sharing source data during system failures. For example, this could be going back to paper-generated weight tickets, or maybe in areas with limited to no data cellular coverage, quick response (QR) codes are used, etc. See section 4.3 of Appendix A for system failure language.

2.5 TRUCK LOCATIONS

In order to record the needed fleet data time stamps, the pilot projects required a portable, or hardwired, GNSS system to track truck locations (see section 4.1.1.3 of Appendix A).

Overall, the pilot projects were successfully able to track trucks, however, it was found that not all truck drivers were ensuring that their devices were charged prior to hauling the subsequent day. Additionally, some vendors require 12-volt accessory ports to charge the device while in route, however, many newer vehicles no longer have this port, requiring other charging setups to be used. The Contractor's recommend that the devices send them alerts when the battery life drops below a given level to assist with mitigation of lost data.

Another element encountered, were instances where a given Contractor did not instrument all trucks delivering material to the job site. For example, each day, there were a different combination of trucks being used (e.g., live bottom dumps on one day and then belly dumps, etc.) depending upon the various operations that were occurring (e.g., mainline paving, shouldering, ramps, intersections, etc.). It is extremely difficult to re-assign and distribute the asset tracking devices after the first load goes out for the day. Consequently, deployment efforts will need to take this into consideration, as it will take time and resources to get the needed amount of fleet instrumented with tracking devices to ensure that every truck possibly used on a contract is instrumented appropriately. This is a big expense and again, some trucks will need the technology at all times, and this could vary throughout the day.

The distribution of asset tracking devices to independent truck operators (ITO), and/or managed truck operators (MTO) varied by Contractor. Some contractors had an agreement where the ITO / MTO held on to the asset trackers until completion of the contract, while others collected and distributed them daily. The Contractors that distributed the asset trackers for the duration of the contract found this method to work effectively and would most likely do this distribution process again in the future. Those Contractors that collected and distributed the asset trackers daily found this process to be cumbersome and time consuming due to the difficulty in dealing with the trucks that do not always come back to the source at the end of the day and the tracking, re-assignment, and constant re-distribution of the trackers.

Discussions were also held regarding the use of smart devices for the tracking of trucks. While this is a viable solution, care should be taken as to whether “personal” devices are used versus designated devices used solely for the purpose of collecting MDMS data. Depending upon any future litigation, personal devices used to capture MDMS data may be collected during the discovery process. Consequently, personal devices for the collection of Agency data is not recommended.

CHAPTER 3: GENERAL ROADMAP

As previously discussed, in addition to development of a MnDOT standard, MnDOT is also the steward of the AASHTO provisional practice, see Appendices B and A, respectively. Consequently, the following outlines the roadmap for both MnDOT and the AASHTO provisional practice.

3.1 AASHTO PROVISIONAL PRACTICE PUBLICATION

As illustrated in Table 2.1, the draft AASHTO provisional practice will be submitted to subcommittee 5c "Quality Assurance and Environmental" March of 2021 for balloting in August of 2021. Assuming the balloting process approves the provisional practice, it would then be published in April of 2022. Consequently, MnDOT's goal is to have the MDMS fully deployed on asphalt projects by 2025. This would provide vendors the time to complete the needed enhancements outlined in the published MDMS provisional practice in April 2022 (see

Table 3.2 for vendor schedule), along with completion of the needed enhancements within the Veta MDMS. Regardless of the full deployment schedule, MnDOT plans to continue using the technology on projects requested by MnDOT construction staff and/or Contractors. However, automated reconciling of quantities using MDMS data cannot be utilized until the needed Agency and Contractor fields are added to the MDMS data sets.

During 2021, MnDOT plans to work with vendors and other state Agencies, on the modifications needed to add both ready mix and aggregate to the MDMS provisional practice. The goal would be to get this draft submitted for balloting in August 2022 and publication in 2023. Other material types may be added to the provisional practice in the subsequent years, however, which materials to incorporate next have not yet been discussed.

Table 3.1 MDMS Roadmap – AASHTO Provisional Practice.

Material Type	Date	Description
Asphalt	March 2021	MnDOT will submit the MDMS provisional practice to AASHTO Subcommittee 5c Quality Assurance and Environmental.
Asphalt	August 2021	AASHTO Subcommittee 5c will complete the balloting process on the MDMS provisional practice.
Asphalt	April 2022	Assuming approval of the MDMS provisional practice through the balloting process, the provision will be assigned a standard number (e.g., PP-XX-21) and published.
Ready Mix and Aggregate	May 2021 through February 2022	Ready Mix and Aggregate will be added to the MDMS provisional practice
Ready Mix and Aggregate	March 2022	Submit updated provisional practice to AASHTO Subcommittee 5c.

Material Type	Date	Description
Ready Mix and Aggregate	August 2022	AASHTO Subcommittee 5c will complete the balloting process on the MDMS provisional practice which now includes asphalt, ready-mix and aggregate.
Ready Mix and Aggregate	April 2023	Assuming approval of the MDMS provisional practice through the balloting process, the provision will be published and now contain asphalt, ready-mix and aggregate.
Next Material Type To be Determined (TBD)	TBD	The expert task group will discuss which material types to add to the provisional next.

Table 3.2 MDMS Roadmap – MDMS Vendor Enhancements

Date	Description
March 2021 and Later	Begin making desired MDMS enhancements based on MDMS provisional practice.
Future	Let users (Agencies and Contractors) know when given enhancements are available for use.
Continuous / Yearly	Continue to assist with review of updates made to MDMS provisional practice. Updates needed by March of each year.

3.2 AASHTOWARE PROJECT ENHANCEMENTS

Table 3.3 outlines the schedule for AWP enhancements. As presented, the process to incorporate MDMS enhancements into AWP have not yet commenced. The first step requires that a state generates a call ticket detailing the needed AWP projects. The consultant designing AWP (i.e., Infotech) would then review the call ticket and determine whether the enhancement(s) warrant moving forward in the process for further discussions. A ticket modification request (TMR) is generated for call tickets that warrant further discussions. In September of each year, a pug conference is held to discuss outstanding TMRs. The states then vote on the highest priority TMR's in October, where the project task force then meets in January to decide which TMRs to move forward based on funding, priorities, and schedules.

Table 3.3 MDMS Roadmap – AWP Enhancements

Yearly Schedule	Description
January-August	One state needs to generate a **call ticket** that details the AWP enhancements associated with the MDMS (e.g., import of MDMS data using API/JSON, reconciling quantities, labor compliance / civil rights summaries, user interface, etc.).
January–August	Infotech creates a **ticket modification request** (TMR) if the tasks outlined in the call ticket warrants moving forward.
September	**Pug conference** is held to discuss outstanding TMRs.
October	States vote on highest priority TMR items.

Yearly Schedule	Description
January	**Project Task Force** (“Board of Directors” – which includes 9 state representatives) discusses TMR items to move forward based on available funding, priority and schedules.

3.3 VETA MDMS

There are currently more than 15 vendors providing varying solutions for the MDMS technology. As with ride quality (smoothness), intelligent compaction (IC), paver mounted thermal profiling (PMTP), a standardized platform is needed to view the MDMS data regardless of the MDMS vendors used on the contracts. There could potentially be multiple MDMS platforms that an inspector is required to navigate on a given contract depending upon which MDMS each subcontractor elects to utilize (e.g., a different MDMS for asphalt, concrete, aggregate, milling, etc.).

Additionally, an agency interface is needed (independent from the Contractor’s MDMS) to allow for data entry of split load, rejected loads, and other information. Also, MDMS data and analysis results will need to be transferred into AWP and other Agency database systems. However, this will not address the standardization of the geospatial needs that the MDMS currently provides.

The potential solution to overcome the above challenges is a public-domain, standardized web-based geospatial software system. Sponsored by the FHWA and TPF, the Veta desktop software has been a proven model for integrating and mapping data from various intelligent construction technologies (ICT) with great success since 2012. Therefore, it is recommended to develop a Veta Web that can be a standardized web platform to integrate all MDMS-related data in a standardized format.

Veta is a standardized intelligent construction data management (ICDM) software that stores, maps and analyzes geospatial data resulting from intelligent construction technology (ICT) such as intelligent compaction, thermal profiling, dielectric profile method and spot test data (e.g., density, moisture). This software can perform standardized data processing, analysis and reporting to provide project summary results from various ICT manufacturers. In particular, the software can provide statistics, histograms, correlations for these measurements, document coverage area and evaluates the uniformity of the ICT measurements as part of the project quality control operations. Veta (for IC, PMTP and the dielectric profile system [DPS]) can be downloaded from the https://www.intelligentconstruction.com/veta/ website.

Figure 3.1 provides an example of the types of maps that can be viewed within Veta. The left side of the image presents a map of the final coverage for pass counts as measured with the intelligent compaction system. Frequency, amplitude, speed, impacts per foot, and surface temperature measurements can also be displayed and analyzed for the intelligent compaction data. The right side of the image presents a map of the mat surface temperature measurements immediately behind the trailing edge of the paver screed as measured with the paver mounted thermal profile method. Speed can also be displayed and analyzed for the paver mounted thermal profile data.

Figure 3.1 Example map of intelligent compaction (left) and paver mounted thermal profiling data (right) in Veta.

Veta is currently a desktop platform, however, it was recently decided that the next round of Veta enhancements will be directed towards bringing Veta from a desktop platform to a web-based application. This work will commence as part of the initiatives of TPF-5 (466) “National Road Research Alliance – NRRA (Phase II)”. The timeline for completion will be dependent upon available funding (i.e., the number of states that are interested and able to provide funding (participate) in either the entire NRRA Phase II pooled fund, or solely to the Veta portion of the NRRA Phase II initiatives). Additional information about this pooled fund can be found at: https://www.pooledfund.org/Details/Study/693.

3.3.1 Proposed Veta MDMS Web Platform

The proposed Veta Web platform would consist of a web-based server application for ICT (e.g., IC, PMTP, DPS, MDMS, etc.) data storage and computation for analysis. Being web-based, Veta Web could be run from any mobile device, laptop/desktop computers, etc., if an internet connection is available. The conceptual architecture of Veta Web is illustrated below.

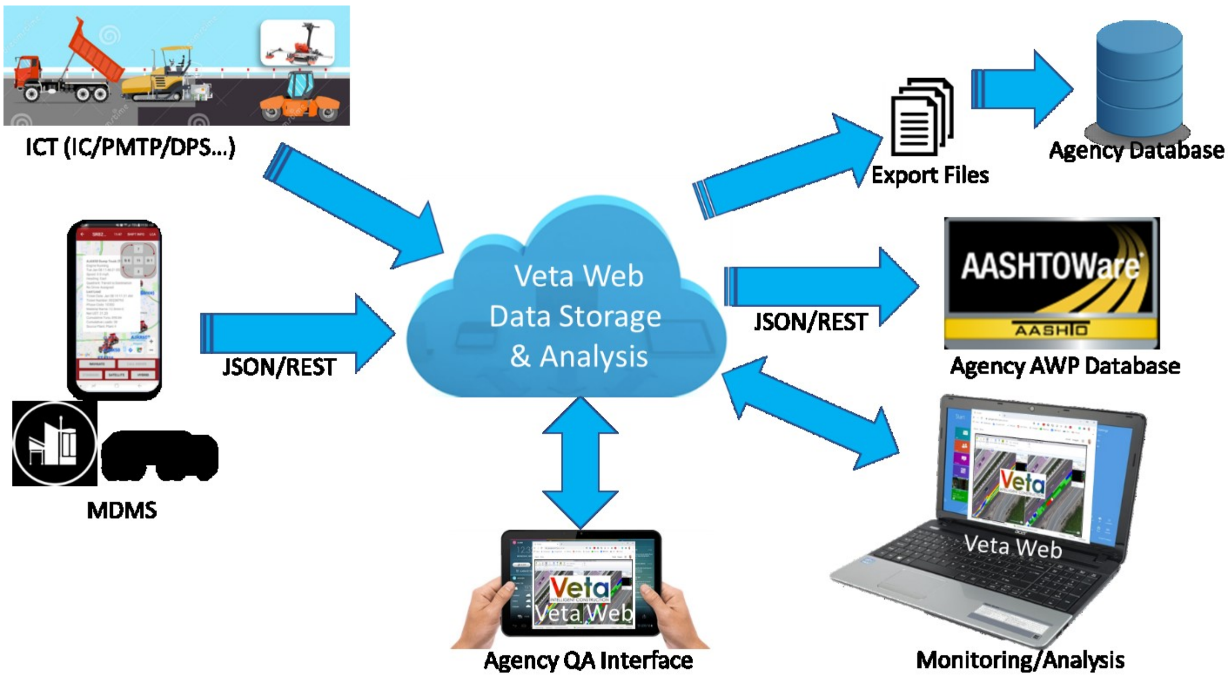


Figure 3.2 Illustration of Conceptual Architecture of Veta Web (Figure Courtesy of Transtec Group, Inc.).

- MDMS data can be pushed from transaction points and fleets to the Veta Web cloud database using a standard method (i.e., JSON and REST API).
- Agency inspectors can perform quality assurance (QA) and upload the data to the Veta Web cloud storage using the Veta Web agency interface. Also, agency inspectors can monitor the fleet information and paving progress using the same interface.
- Other intelligent construction technologies (ICT) (including IC, PMTP, Dielectric constant profiles methods – Dielectric Profile System [DPS], etc.) can also push their data to the same cloud storage.
- Agency and contractor office staff can monitor and perform mapping and analysis using the Veta Web.
- The MDMS data and analysis results can be transferred from the Veta Web cloud to agencies' AWP database using a standard file method (i.e., JSON and REST API).
- For agencies not using AWP, they can export the MDMS data and analysis results from the Veta Web cloud to local data files and upload them to the agencies' own database.

The MDMS data would be stored on the server with data security and integrity. Veta Web would be used for managing users, data-access permissions, and MDMS projects. While Veta Web would interact with the server, the time-intensive calculations would be performed on the server. This includes filtering, analyzing, reporting, and map creation similar to those in the current Veta desktop version. Specifically, the following features:

- Recreating current Veta desktop mapping GUI for the Veta Web.
- New MDMS analysis projects can be created, stored, and managed as stored in *.vetaweb files.

- MDMS data can also be downloaded by users to local computing devices on a routine basis as redundancy. In the event of data loss or corruption on the server, the user can re-upload the data, or if the data is still available from the vendor's systems, the server can re-download the data.

The anticipated benefits of using Veta Web to the implementation of MDMS include the following:

Facilitation of Data Management

- Push MDMS data in a standardized format to the cloud server from any transaction points (at the source, construction sites) and beacon devices (GPS/cellular trackers on trucks) using the single Veta Web GUI via the internet.
- Eliminate the complexities of nested geofences within the vendor's MDMS, as the Agency's static geofences needed for reconciling quantities with respect to projects and funding categories can now be created within Veta and recorded with respect to the dump location.
- Create an agency interface where agency data does not require data entry within the contractor's MDMS.
- Push MDMS data to AWP or other Agency databases through a standardized method (e.g., REST APIs, JSON).
- Export of MDMS data as an ASCII, CSV, XLSX, or text format. Agencies can then upload these files to their own database.

Near Real-Time Monitoring with Powerful Mapping Visualization

- Map the numbers of trucks at the source, transit, at the construction site, and return to the source.
- Show maps to allow the user to click on any given truck to view the associated E-Ticket.
- Overlay material dump locations on ICT data maps, including DPS, IC, and PMTP data for Agencies collecting dump latitude and longitude coordinates.
- Identify mix changes with respect to dump placement locations.
- Near Real-Time Data Analysis
- Tabularize the ticket status summary (e.g., ticket number, loaded, in transit, dumped).
- Estimate the arrival time to the dump location and wait-time of trucks before dumping.
- Calculate flow/feed rates and show them on maps.

MDMS Data Integration with ICT Data and QA Data

- Tie QA sample identifications and test results for a given load of material to the dump locations.
- Determine appropriate calibration curve (as related to mix design changes) to associate with the DPS.
- Generate as-built heat loss curves for troubleshooting workmanship issues using MDMS temperatures collected at the source and Jobsite, PMTP, and IC temperature measurements.

- Identify remove-and-replace limits using dump locations collected by the MDMS, DPS, IC, PMTP, and spot test data.

Figure 3.3 presents an example mark-up for one of the Veta Web features described above to tie each E-Ticket with stationing on the PMTP temperature map. Comparing the PMTP temperature and IC pass count maps, a QA core data location can be tied to the asphalt truck, stationing of the dump, sublot, temperature segregation, and pass count information. This information can be used to help identify causes of QA noncompliance.

Figure 3.3 Example Mark-Up of E-Ticket with Respect to IC and PMTP Data in Veta Web.

3.3.2 Additional Benefits Realized from Veta Web Platform

In addition to the benefits previously outlined with respect to Veta Web being used as the standardized MDMS, the following benefits would also be realized with respect to other ICT by converting Veta from a desktop platform to a web-based application:

Near, real-time viewing

A web-based application of Veta would allow for near, real-time viewing of the following data sets through a standardized platform:

- Intelligent Compaction (IC) Data (PP-81)
- Paver Mounted Thermal Profile (PMTP) Data (PP-80)
- Dielectric Profile System (DPS) Data (PP-98)
- MDMS Data (PP-XX)

IC, PMTP and DPS data can already be viewed and analyzed using Veta, however, it is post-processed data since Veta is currently a desktop platform. This has prevented these measurements from fully being used in the field to help mitigate workmanship issues on a real-time basis. These measurements have only been able to be used to troubleshoot the causes of workmanship issues after the fact due to the delays of post-processing data.

Remove and Replace Limits

Overlaying MDMS data (i.e., dump locations with respect to E-Ticket [source] information) on top of IC, PMTP, DPS and Ride data would provide the Engineer and Contractor extremely transparent information regarding remove and replace limits. One would know the location that material was delivered along with the associated thermal segregation information, compaction efforts, and in-place estimated density measurements. This information would help construction staff make informed decisions and have the needed data to justify decisions.

Automation of Veta Project Creation

Automation features have already been included within the desktop version of Veta, however, additional features could be added if Veta was a web-based platform. These enhancements would significantly reduce the amount of time required by the Contractor to create these projects and could potentially fully create Veta projects for more simpler contracts (e.g., 2-lane roadways). Additionally, the more data filtering that can be completed automatically will allow for more accurate real-time viewing of information during construction efforts.

Third Party System for MDMS Agency/Contractor Data

In addition to the MDMS Agency data, previously discussed in this report, there is other Agency data that is recorded in the field and used for creation of Veta projects for the IC, PMTP and DPS data. It would only make sense to have a “one-stop-shop” for data entry of all Agency data for the Engineer to mitigate the number of platforms that field personnel are required to navigate. Examples of additional data that requires input into Veta are: production start and end station limits, permanent and temporary exclusion limits, production dates, centerline offsets, DPS calibration curve equations, spot test results (e.g., core densities, temperatures, etc.), etc.

Third Party System for Viewing of MDMS Data

As was done for other ICT technologies (i.e., ride (ProVal), IC, PMTP, and DPM), a standardized platform is needed for viewing of MDMS data from the various vendors to allow for integration of MDMS data with the other ICT technologies used on the contract. Veta currently houses the IC, PMTP and DPS data sets and will import Ride data (generated from ProVal) in the future. Veta provides a mapping platform, integrated with a database in the background to allow for visualization of data, along with general statistical analyses and reporting. As discussed above, this would provide a powerful BIM system to be used during the construction operation.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

The following summarizes the conclusions and recommendations realized from the pilot projects, debriefing meetings with contractors and MnDOT construction staff, and with meetings with MDMS vendors.

4.1 CONCLUSIONS

- It was deemed necessary to move away from solely using the term “E-Ticketing” and establish a naming convention that would encompass the various types of data needed to assist with reconciling quantities, develop flow rates, and to support general audits and labor compliance and civil rights activities. Through discussions with vendors and contractors, it was decided to call this technology the Material Delivery Management System (MDMS). Therefore, the MDMS is defined as a system that manages source, fleet, hauler, agency and contractor data associated with delivery of material to a contract.
- As a result of the pilot projects, industry, national DOT needs, and to better support mitigation of the spread of COVID-19, it was deemed necessary to establish an AASHTO standard for the MDMS. Consequently, MnDOT volunteered to be the steward for development of the AASHTO provisional practice for the Material Delivery Management System. This provisional was written for asphalt applications; however, in the future, additional material types will be included.
- The MDMS can effectively be used to digitalize source data (i.e., generate an E-Ticket); however, hauler, fleet, agency and contractor data should be included in these systems to support other construction and administrative needs and to increase buy-in from contractors.
- Annual MDMS costs appear to be affected by the size of the project (quantities), and therefore, a pay item for a unit of “tons” was created for asphalt applications. In the future, another pay item will be created for ready-mix using a unit of “cubic yards.”
- There are desired features and data fields that are not available from the majority of vendors, and consequently, MnDOT has issued a single lump sum payment of $5,000 for contracts where the MDMS collects, stores and exports all of the data fields per the requirements of the provision. “When available” was included in the special provision language to allow MDMS to still be used when the given features and data fields that were not available at the time of these pilot projects cannot currently be provided. The monetary adjustment will be removed from the special provision sometime after the MDM systems can complete the needed enhancements.
- As a result of the findings of the debriefing meeting, MnDOT created a workflow to guide a user through pre-construction activities, the source process, delivery of material, data export, and end-of-day activities such as reconciling of quantities and labor compliance reviews as related to the MDMS.
- Some contractors are still running DOS-based source loadout software platforms that most MDM systems are unable to communicate with for transmittal of source data. Consequently, these sources will require upgrading to GEN OS (or the processing capacity must be increased) to work properly with most MDM systems. This can be costly, and contractors will need time to make these needed upgrades.

- Some yearly, loadout software maintenance updates can affect transmittal of source data to the contractor's MDMS, where source data transferred with no issues prior to the update but later encountered problems after the maintenance update.
- Vendors have noted that it can be difficult and require extensive time and resources to get some loadout software platforms to communicate with the contractor's MDMS – resulting in each source often being treated and set up separately for a given contractor.
- Internet connectivity (or satellite connectivity for those entities that elect to use satellites for data transfer) was often overlooked for portable sources.
- Unique truck identifications were not always used in the loadout software at each source. Distinct identifications are needed to allow for correct association of the material being hauled with respect to the serial number of the breadcrumb recording device, generation of accurate flow rates, truck summary reports, accurate material association with dumped locations, etc.
- Some MTO trucks may use the same truck identification for multiple trucks. Therefore, it is important that the contractor distinctly identify these trucks to allow for correct association of the material being hauled with respect to the asset tracking device, generation of accurate flow rates, truck summary reports, accurate material association with dumped locations, etc.
- Automatically recording a description for the dump locations is necessary to assist with reconciling quantities for agencies that are automatically capturing truck exchange (dump) information. The inspectors typically record this information during truck exchanges on the paper tickets or within a diary. Consequently, the creation of geofences around geographic and funding category regions is necessary to automatically digitally record a description of the dump location.
- Dump information (i.e., date and time stamp, and dump latitude and longitude) was not always successfully recorded and will require time and experience by the contractor to learn how to successfully set up the needed information per contract, paving crew and equipment. Automatic triggering of the dump requires optimization, by the contractor, of settings such as duration of time spent within the mobile geofence and the radius of the mobile geofence. For example, crews that have slow versus quick truck exchanges will need to be set up with different time durations within the geofence to ensure capturing of the dump. Additionally, equipment also affects these settings. For instance, as to whether material transfer devices, end dumps or pick up machines are being used will affect both the time within the geofence and geofence radius being used.
- The use of circular geofences can make it difficult to correctly track truck exchanges when paving in echelon, or when secondary pavers are in proximity. Rectangular geofences may help mitigate these issues, should they become available.
- During debriefing meetings with the contractors, they elaborated on the difficulty of accurately capturing hauler information and to do so within a reasonable time frame. Additionally, the contractors did not want the responsibility of populating this information into the MDMS for ITOs and MTOs, and therefore, it was determined that this should be the hauler's responsibility. In addition to the use of fleet data for reconciling quantities, fleet data provides the needed details for improved workmanship, flow rates, identification of inefficiencies, labor compliance

audits, and general contract closeouts and audits. Obtaining missing trucking reports is often the number one reason for delay in closing out contracts. Additionally, disabled business enterprise (DBE), or small business closeouts, can also delay contract finals and hold up a contractor's bond. These time stamps assist with documentation of prevailing wage hours, along with independently verifying that loads indeed made it to the contract limits and were dumped. Additionally, questionable time stamps can assist with investigating (and or verifying) whether entire loads (or partial loads) were delivered to other contracts or locations.

- During the debriefing meetings with Minnesota contractors, the following items were also noted with respect to the need for collection of time stamps and durations (fleet data), and hauler data: (1) the contractors recommended that the MDMS includes the collection of data required for labor compliance activities and believes that this is where the greatest "buy-in" for the technology lies (i.e., not in the digitalization of computer-generated paper weight tickets, but in the ability to support documentation for labor compliance activities); (2) trucking is one of the contractor's top expenses (typically the second top expense); (3) completion of prevailing wage reports are complex and require a significant amount of time and resources to complete correctly; (4) collection of fleet data would assist with prevailing wage compliance; (5) many haulers often have a limited amount of time to complete prevailing wage documentation, and consequently, this documentation is often not completed in a timely manner; (6) it is the contractor's responsibility to ensure that prevailing wage reports are completed correctly, ensure that the truck hauler is paid correctly and to take appropriate actions to ensure compliance with the contract; (7) connecting hauler information to the source data (E-Ticket) assists with monitoring and documentation of the craft/classification/trade, while labor compliance audits can take months or years to complete, making it difficult to gather needed documentation; (8) the fleet data would aid with determining whether additional documentation and reporting is needed for compliance with the Federal Davis Bacon Law; and (9) the fleet data would also aid in civil rights activities.
- During material delivery there may be instances where the agency and/or contractor needs to record the following information into the MDMS for use in reconciling quantities: split loads 1, 2, 3 weight, split loads 1, 2, 3 pay item, split loads 1, 2, 3 location note, wasted material weight, load acceptance and rejection, partial rejected load weight, dump station number, field notes, inspector/contractor identification, date and time stamp (of agency/contractor data entry). Currently, this information is often recorded on the paper weight tickets, or within diaries.
- Additional data fields, beyond that of the source data, are needed to adequately reconcile quantities. The following source, fleet, agency, and contractor data fields are required to correctly reconcile quantities: (1) Source Data: contract identification, agency project identification, material code, ticket number, load number, voided ticket, loading data and time, net weight; (2) Fleet Data: overweight weight, dump equipment identification, dump geofence name; (3) Agency/Contractor Data: split load 1, 2, 3 weight, split load 1, 2, 3 pay item, split load 1, 2, 3 location notes, wasted material weight, load acceptance and rejection, partial rejected load weight, notes.

- Source, fleet, and hauler data fields are used to support labor compliance and civil rights audit review activities. The following data fields are needed: (1) Source Data: contractor identification, agency project identification, source identification, material code, ticket number, truck identification, trailer identification, voided ticket, loading date and time; (2) Fleet Data: source geofence name, contract geofence came, dump geofence name, truck enters source geofence date and time, truck exits source geofence date and time, time at source, source to contract transit time, truck enters contract geofence date and time, truck exits contract geofence date and time, time at contract, contract to source transit time, dump date and time; (3) Hauler Data: hauler company name, broker name, DOT number, truck identification, driver name.
- Contractors who distributed the asset trackers for the duration of the contract to MTOs and ITOs found this method to work effectively and would most likely use this distribution process again in the future. Those contractors who collected and distributed the asset trackers daily found this process to be cumbersome and time consuming due to the difficulty in dealing with the trucks that do not always come back to the source at the end of the day and the tracking, reassignment, and constant redistribution of the trackers.

4.2 RECOMMENDATIONS:

- It is recommended that a sixth data type (as-built data) is added to the contractor's MDMS. As-built data would include measurements collected by the paver to assist with calculation of yield rates, analysis of intelligent compaction and paver mounted thermal profile data (i.e., development of location filters) and more. The as-built data would include data fields such as paving width, depth at left edge, depth at right edge, distance paved and paver speed.
- During the early stages of deployment of the MDMS, it is recommended that a pay item be included to compensate for the annual costs associated with the technology (e.g., data entry of project information, set up of appropriate MDMS components, system set up to transmit source data into the contractor's MDMS, Internet connectivity at permanent and portable sources, set up of geofences, system monitoring, assigning and distribution of truck asset trackers, monitoring of yields rates recorded by contractor's MDMS, remote server storage, cloud-based software accessibility and data package plans). In the future, the pay item should be revaluated to determine whether the MDMS method should be considered incidental or continue to be supported via a pay item.
- It is recommended that vendors allow for use of REST APIs and JSON request body with contractor-owned permanent and portable sources to allow an easier process for transmittal of source data regardless of the loadout software used, or whether any updates were made to the software. The use of REST APIs and JSON not only assists contractor-owned sources (for those who elect to use this more streamlined data transfer process) but also centralized suppliers. Centralized suppliers are suppliers that provide material to multiple contractors. It is not effective for these suppliers to purchase multiple MDM systems to supply source data to the varying systems.
- The contractor's MDMS should allow for the ability to perch devices, as needed, when sources are in low-lying areas to increase data signal strength.

- It is recommended that static data (i.e., data that remains the same in each ticket) is directly entered into the contractor's MDMS in lieu of pushing this data with each ticket. This would help minimize the volume of data being pushed with each ticket. Therefore, it is recommended that the contractor's MDMS allows the contractor to enter the following source identification information directly into the contractor's MDMS: source identification, source name, portable plant (yes/no), source address and source phone number.
- The source and contract geofences are recommended to be set up by the contractor. The source geofence is a static virtual perimeter around boundary of source (e.g., boundary around a plant), while the contract geofence is a static virtual perimeter around the limits of the work to be completed in the contract (e.g., boundary of jobsite).
- As part of pre-construction activities, it is recommended that the agency creates the project and category geofences. A project geofence is a static virtual perimeter around a subsection of the contract with specialized geographic designations (e.g., control section numbers), while the category geofence is a static virtual perimeter around a subsection of a project with different funding sources.
- It is recommended that the contractor sets up a mobile dump geofence around the boundaries of equipment that material is being delivered to (such as the paver, pickup machine, or material transfer device, etc.) for those agencies that desire automated recording of the material being delivered.
- Training is extremely important as there is not currently a standardized platform for agencies to view the contractor's MDMS data, and therefore, training is recommended as part of the preconstruction activities.
- It is recommended that the overweight permit number and maximum gross weight are included in the hauler data requirements as this information is used along with the net weight on the E-Ticket for calculation of overweight quantities. Some agencies are unable to pay for these quantities and must subtract these weights when reconciling quantities.
- It is recommended that a hauler user interface is created within the contractor's MDMS and an agency and contractor user interface is created in the Veta MDMS.
- It is recommended that each agency randomly reviews the source and hauler data to ensure no issues are present with the contractor's MDMS and that source data stored within the contractor's MDMS is accurate for use in yield checks and reconciling of quantities. This independent field verification information is also used to verify that the final MDMS data set reflects those values originally reviewed in the field.
- All MDMS vendors can export data using conventional file downloads in dbase ASCII, CSV, XLSX, or text format. However, in the future it is recommended that enhancements be made to allow for transfer of data using APIs and JSON from the contractor's MDMS to the Veta MDMS.
- It is recommended that enhancements are made to AWP to allow for import of source, fleet, hauler, agency, and contractor data into AWP "Construction and Materials" and "Estimating" modules for use in reconciling daily quantities and for use with future estimated quantities, respectively. Additionally, this data should be imported into the materials testing and acceptance system to ensure acceptance testing is completed at the required frequency. Fleet

and hauler data should be imported into the AWP "Civil Rights and Labor" module for agencies that elect to capture fleet and hauler data.

- It is recommended that Veta is converted from a desktop platform to a web-based application to allow for use as a standardized solution for the agency's MDMS. Additionally, conversion of Veta to a web-based application would also assist with the field use and automated analyses of other ICT (e.g., IC, PMTP, DPS, AMG-Milling, etc.).
- It is recommended that MDMS data sets that contain the latitude and longitude for the dump location (e.g., time stamp of loading, placement time, mix designation and asphalt/air temperature data) are overlaid on intelligent construction data such as intelligent compaction, paver mounted thermal profiling and dielectric profile data within Veta. This information could then be used to assist with identification of workmanship issues, removal and replacement of limits, development of field heat loss curves, verification of dielectric profile calibration equations, and for use in future long-term pavement issues should these arise.
- A few entities have stated that they would prefer that data fields associated with labor compliance are not included in the contractor's MDMS. However, this information significantly assists both the contractor and agency. Additionally, it only requires a few extra fields beyond those already needed for reconciling quantities and generation of flow rates, and therefore, is recommended for inclusion with the MDMS and agency requirements.
- It is recommended that language for system failures is included in requirements. System failure occurs when the MDMS does not collect and/or store data per the requirements of specification or when data cellular coverage is limited. It is recommended that during system failures, the source data revert to other means, which is approved by the engineer, for sharing source data during system failures. For example, this could be going back to paper-generated weight tickets, or maybe in areas with limited to no data cellular coverage, quick response (QR) codes could be used, etc.
- Discussions were also held regarding the use of smart devices for the tracking of trucks. While this is a viable solution, care should be taken as to whether "personal" devices are used versus designated devices used solely for the purpose of collecting MDMS data. Depending on any future litigation, personal devices used to capture MDMS data may be collected during the discovery process. Consequently, personal devices for the collection of agency data are not recommended.

APPENDIX A: AASHTO DESIGNATION PP-XX "STANDARD PRACTICE FOR MATERIAL DELIVERY MANAGEMENT SYSTEM"

"Standard Practice for

Material Delivery Management System"

AASHTO Designation: PP XX-XX (2022)[1]

Tech Subcommittee: 5c, Quality Assurance and Environmental

Release: Group 1 (April)

AASHTO

American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, D.C. 20004

Standard Practice for

Material Delivery Management System

AASHTO Designation: PP XX-XX (2022)[1]

Technical Subcommittee: 5c, Quality Assurance and Environmental

Release: Group 1 (April)

1. SCOPE

1.1. This Standard exists to provide, Haulers, Agencies, Contractors and Vendors, a standardized format for digitalized communication of source, fleet, Hauler, Agency and Contractor data associated with the delivery of material to a contract.

1.2. Within the format of this Standard, individual Agencies will select which data blocks are necessary for the E-Ticket and associated Material Delivery Management System (MDMS).

1.3. This Standard provides a listing of possible data blocks that an Agency may want to require.

Note 1—Please note that some features and data blocks are not currently available by given MDMS Vendors. Care must be taken as to which requirements to include within an Agency's standard. Additionally, it is beneficial to be transparent with both Vendors and Contractors as to data blocks and features that will be desired in the future, even if these items are not required in the current Agency standard.

1.4. This work shall consist of capturing source, fleet, Hauler, Agency and Contractor data associated with delivery of material to a contract, for asphalt paving applications, in a digitalized format.

Note 2—In the future, other material types will be added to this Standard, such as ready mix concrete, asphalt pavement millings, concrete, aggregate, etc.

1.5. Figure 1 illustrates a schematic of the data associated with the MDMS.

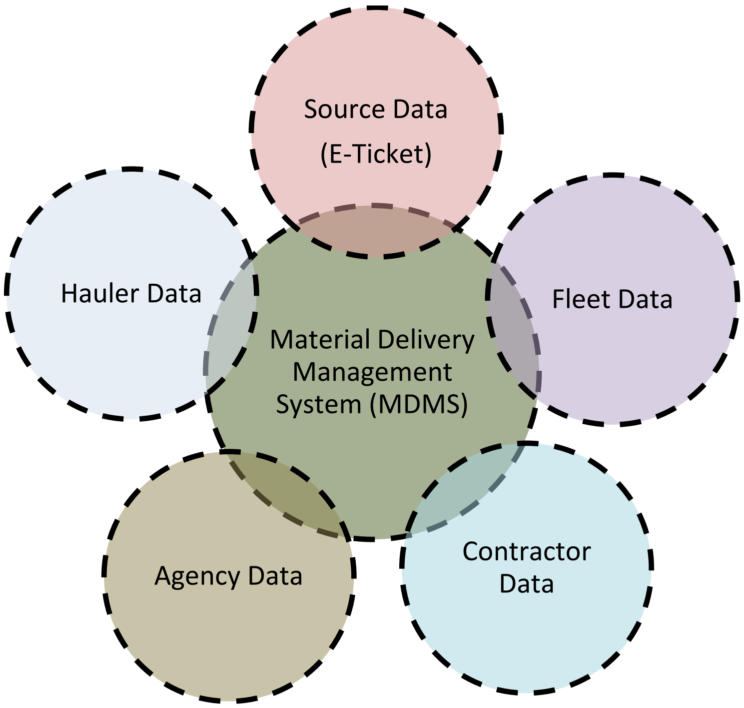


Figure 1—Schematic of MDMS data.

1.6. Figures 2 through 6 presents the workflow which guides the user through pre-construction activities, the source process, delivery of material, data export, and the end of day activities such as reconciling quantities and labor compliance reviews.

1.7. Figure 7 presents the workflow which guides the user through the steps associated with the Veta MDMS software.

Note 3—After some needed enhancements, the Veta MDMS will be used for the following: (1) Agency's standardized platform for the viewing of MDMS data; (2) User interface for data entry of Agency and Contractor data; (3) Agency creation of the project and category geofences; and (4) Recording of the Dump Geofence Name. The Agencies are working on obtaining the needed funding for these enhancements and will then execute a contract for this work. Consequently, it is not anticipated that this platform will be available until 2025 or later. Vendors may elect to include these features within the MDMS if desiring to have an intermediate solution until the Veta MDMS enhancements are completed, however, this will not be a vendor requirement in this standard.

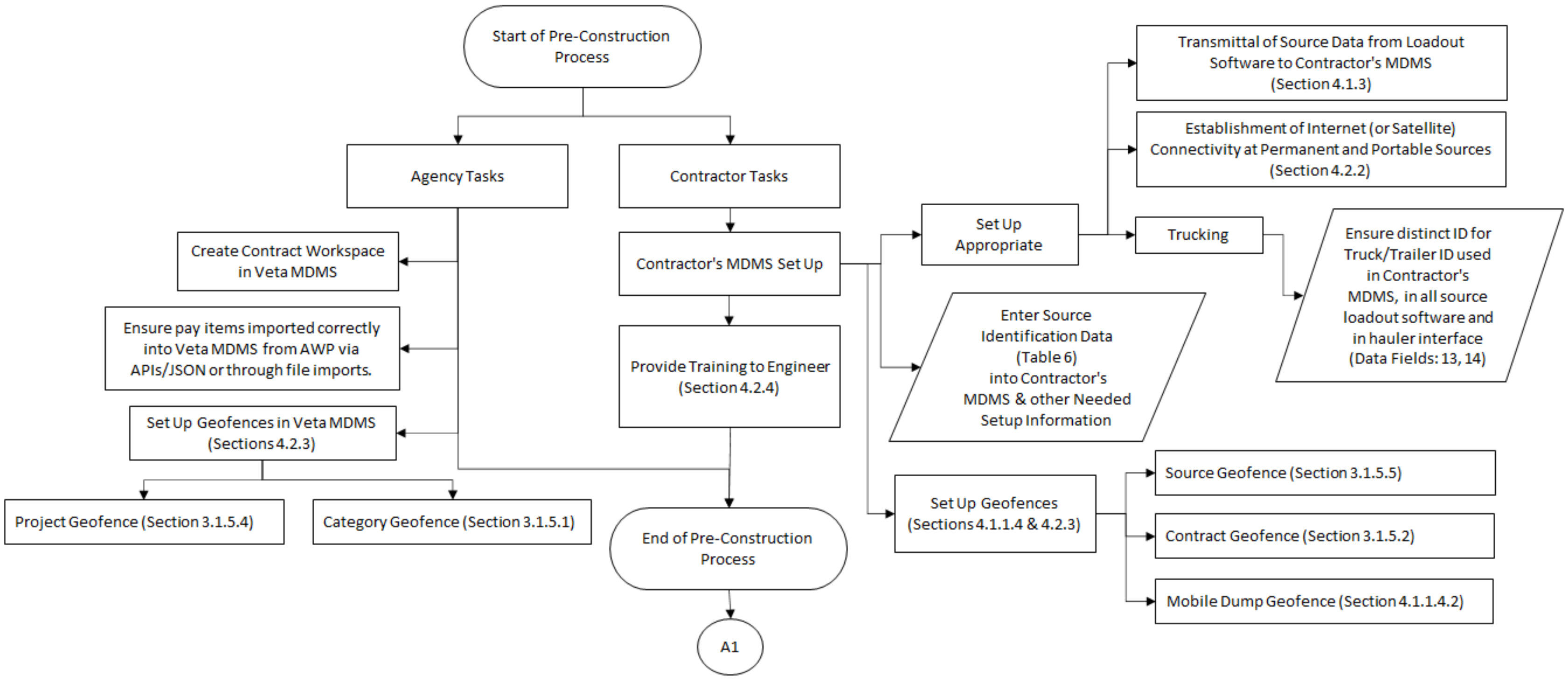


Figure 2— Schematic of MDMS Workflow (Preconstruction Process).

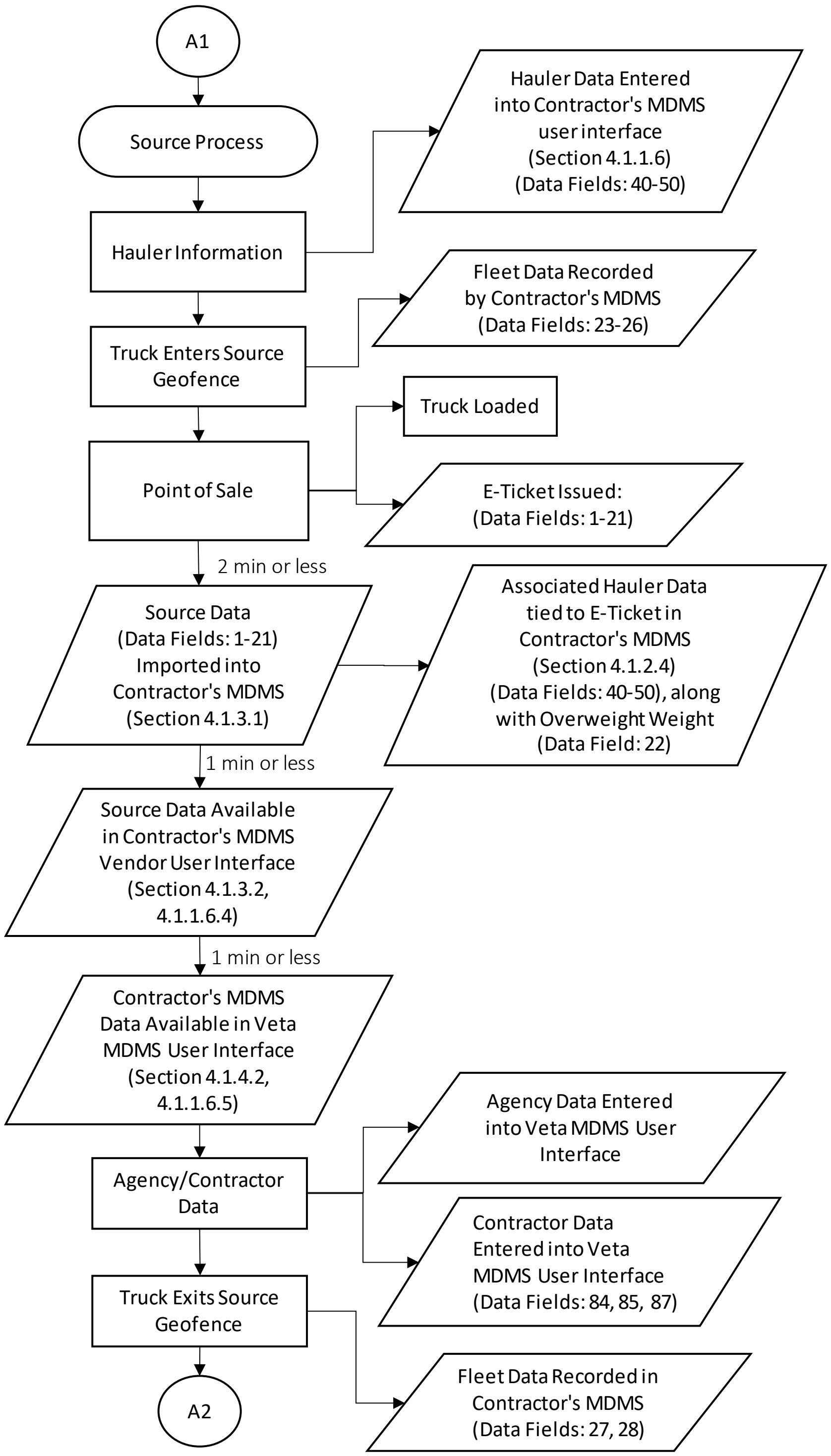


Figure 3— Schematic of MDMS Workflow (Source Process).

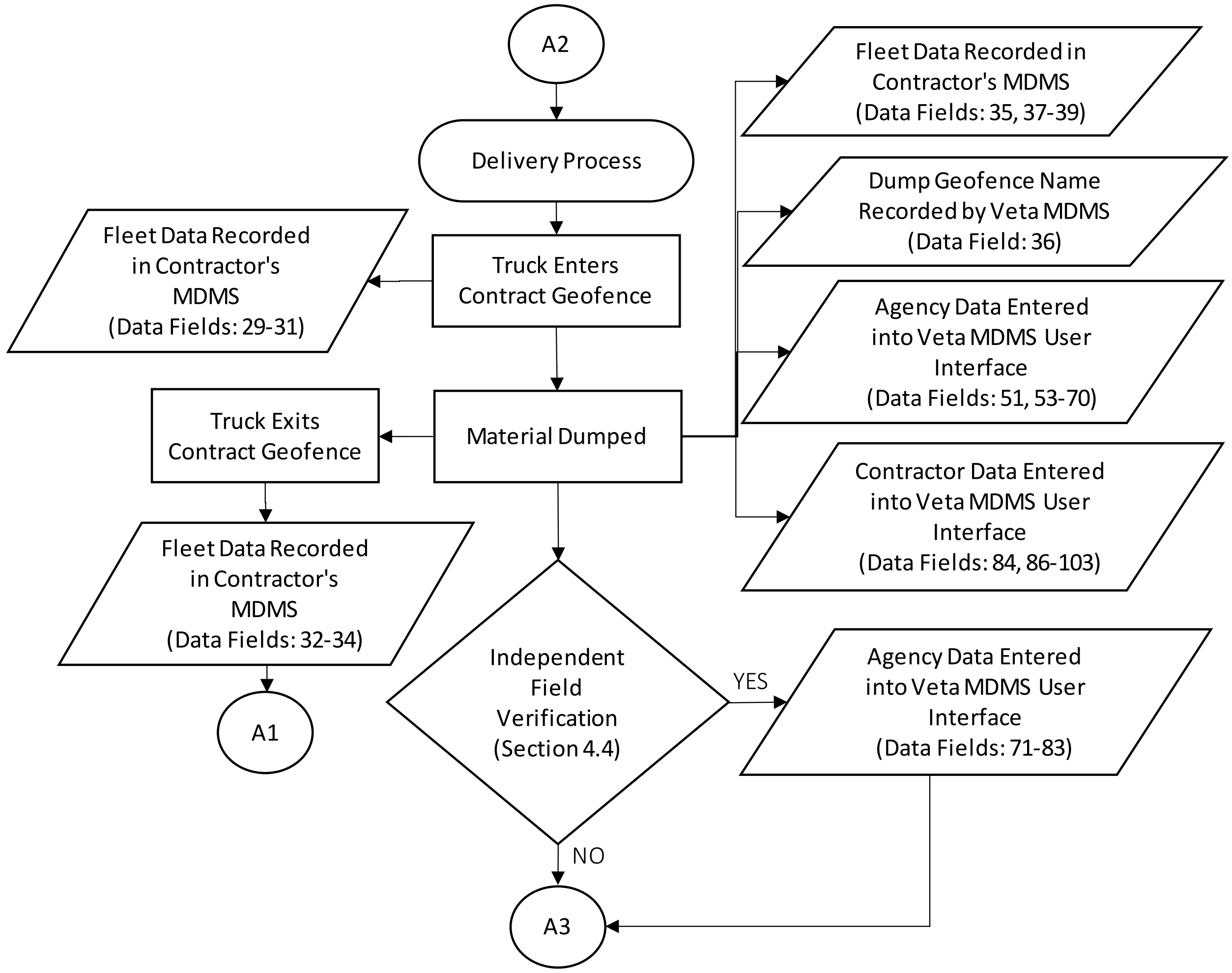


Figure 4— Schematic of MDMS Workflow (Delivery Process).

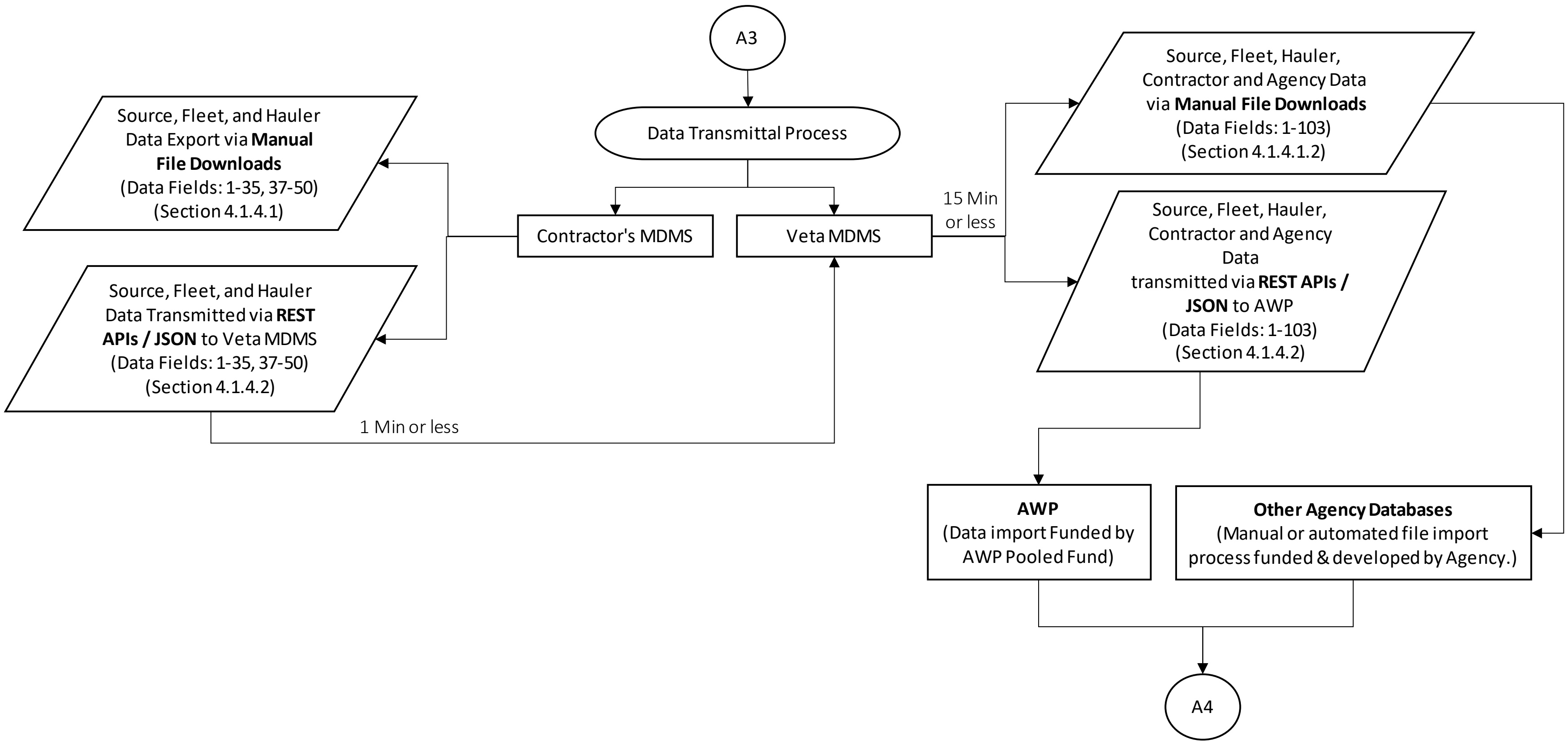


Figure 5— Schematic of MDMS Workflow (Data Transmittal Process).

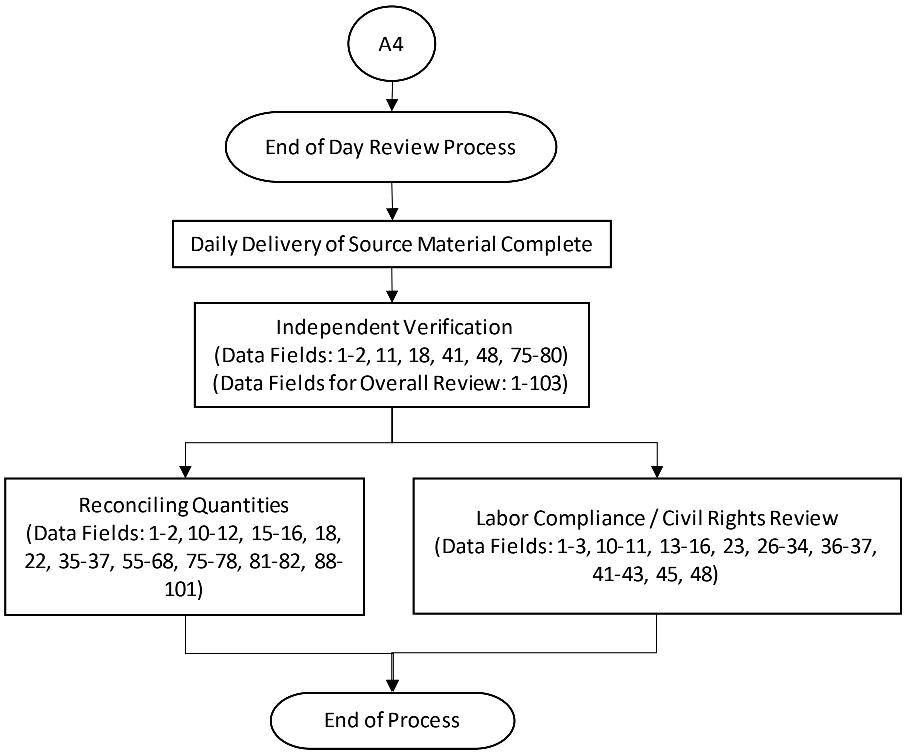


Figure 6— Schematic of MDMS Workflow (End of Day Review).

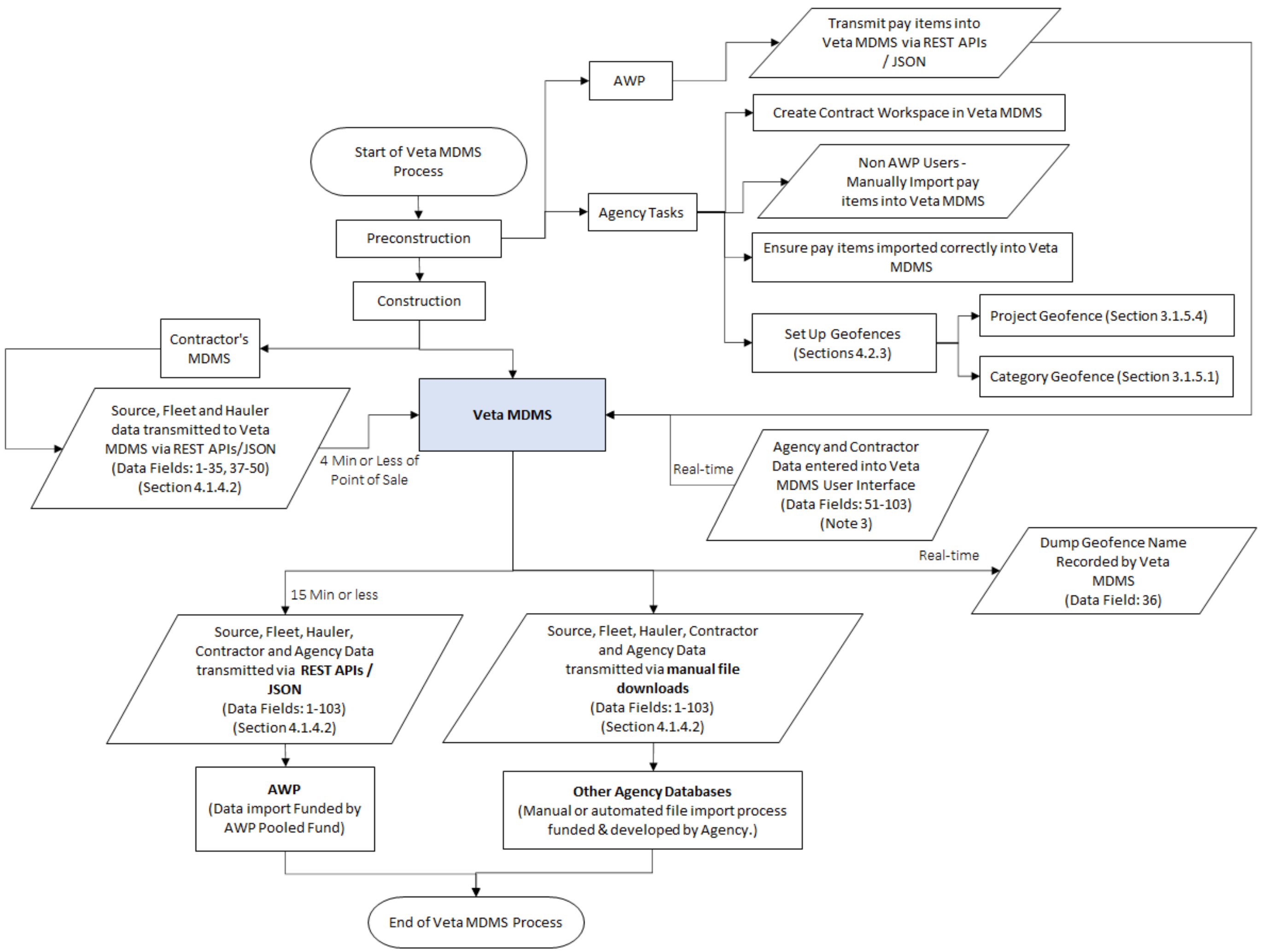


Figure 7— Schematic of Veta MDMS Workflow.

1.8. Source data is defined as data generated by the source's loadout software, such as contract, Agency project, source identification, material code, loading and weight information. **This data is considered as the E-Ticket**.

1.9. Fleet data is defined as data such as dumping details, geofence names, date and time stamps, durations and trucking information. Fleet data collected and stored in a system separate from the MDMS must contain the Ticket Number. See Appendix X1 for examples describing the use of fleet data.

1.10. Agency data is defined as data generated by the Agency, such as sampling information, split load and contract administration information (e.g., wasted material, rejected loads, field notes).

1.11. Contractor data is defined as data generated by the Contractor, such as sampling information, split load and contract administration information (e.g., wasted material, rejected loads, field notes).

Note 4—Contractor's often record the same information as the Agency to assist with mitigation of errors when reconciling quantities.

1.12. Hauler data is defined as data generated by the Hauler for the given Contract shift (e.g., shift start/end times, truck identification, driver name, broker name, DOT number, etc.). See Appendix X1 for examples describing the use of hauler data.

1.13. The Contractor shall set up source(s), trucks and dump locations with the needed MDMS components.

1.14. This specification is to be applied during the entire material delivery operation.

1.15. All tasks are the Contractor's responsibility, unless designated otherwise within this Standard.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standard*:

- PP-80, Continuous Thermal Profile of Asphalt Mixture Construction
- PP-81, Intelligent Compaction Technology for Embankments and Asphalt Pavement Applications
- PP-98, Asphalt Surface Dielectric Profiling System Using Ground Penetrating Radar

2.2. *Other Documents*:

- AASHTOWare. https://www.aashtoware.org/
- National Academies of Sciences, Engineering, and Medicine 2020. Electronic Ticketing of Materials for Construction Management. Washington, DC: The National Academies Press. https://doi.org/10.17226/25839
- "The Little Book of OAuth 2.0 RFCs". https://oauth.net/2/
- Embacher, Rebecca E. "Use of Material Delivery Management System (MDMS) for Asphalt Paving Applications". Minnesota Department of Transportation. MN/RC 2021-XX. (In publication process).

3. TERMINOLOGY

3.1. *Definitions*:

3.1.1. *AASHTOWare Project (AWP)*—Web-based software that provides a comprehensive series of software modules designed to address phases in the construction lifecycle beginning with project definition, followed by cost estimation, bidding/letting process, and construction and materials management. The software is built on a unified database that allows for easy access to data for use in decision-making, reporting, and tracking of various information (i.e. historical bid prices, civil rights and labor management, etc.).

3.1.2. *Application Programing Interface (API)*—Software interface that allows multiple platforms to connect to each other.

3.1.2.1. *Hypertext Transfer Protocol (HTTP)*—Protocol used for transmitting data over the internet.

3.1.2.2. *JavaScript Object Notation (JSON)*—JavaScript object notation in a lightweight, human-readable data-interchange format.

3.1.2.3. *OAuth 2.0*—Industry standard protocol for authorization.

3.1.2.4. *REST*—Acronym for **RE**presentational **S**tate **T**ransfer. REST is an architectural style that applies the standards in the HTTP protocol creating the capability of exposing APIs over the internet.

3.1.2.5. *RESTful*—REST requires the following 6 guiding constraints to be considered RESTful: 1) client server; 2) stateless; 3) cacheable; 4) uniform interface; 5) layered system; 6) code on demand (optional).

3.1.3. *Centralized Suppliers*—Suppliers that provide material to multiple Contractors.

3.1.4. *Material Delivery Management System (MDMS)*—System that manages source, fleet, Hauler, Agency and Contractor data associated with delivery of material to a contract.

3.1.4.1. *Agency Data*—Data generated by the Engineer, such as sampling information, split load and contract administration information (e.g., wasted material, rejected loads, field notes).

3.1.4.1.1. *Independent Field Verification*–Engineer randomly verifies source data contained within MDMS each day to ensure no issues are present with the system and that source data is accurate. Additionally, field verification information is used to verify that the final, exported MDMS data, used for reconciling quantities, reflects those originally reviewed in field.

(1) Independent Field Verification–Estimated Net Weight—Estimated quantity of material delivered to project for load being verified for instances where an independent scale is not being used for independent verification.

(2) Independent Field Verification – Notes—Details describing why an independent field verification was identified as "Invalid". For example, Truck ID contained in the source data does not match that on the truck, Net Weight contained in the source data does not match the quantity of material delivered in the field, the mix designation contained in the source data is incorrect, etc.

3.1.4.1.2. *Split Load*—Loads that are split at delivery for use at more than one location, such as for patching, entrances, etc.

3.1.4.2. *Contractor Data*—Data generated by Contractor, such as sampling information, split load and contract administration information (e.g., wasted material, rejected loads, field notes).

3.1.4.3. *Fleet Data*—Data generated such as dumping details, geofence names, date and time stamps, and durations.

3.1.4.3.1. *Breadcrumb Trail*—Latitude, longitude and associated time stamp for the truck's location recorded at pre-defined intervals.

3.1.4.3.2. *Contract to Source Time*—Duration of time spent in transit between contract and source as calculated using time stamps of when truck exits contract geofence and enters source geofence.

3.1.4.3.3. *Dump*—Delivery of source material.

3.1.4.3.4. *Overweight Weight*—Weight of material exceeding the maximum allowable gross weight.

3.1.4.3.5. *Source to Contract Time*—Duration of time spent in transit between source and contract as calculated using time stamps of when truck exits source geofence and enters contract geofence.

3.1.4.3.6. *Time at Contract*—Duration of time spent inside contract boundary as calculated using time stamps of when truck enters and exits contract geofence.

3.1.4.3.7. *Time at Source*—Duration of time spent at source as calculated using time stamps when truck enters and exits source geofence.

3.1.4.3.8. *Truck Driver Classification*—Description of truck classification as defined by the Federal Wage System. For example: Tractor Trailer Driver; Four or More Axle Unit, Straight Body Truck; Three Axle Units, or Two Axle Unit.

3.1.4.4. *Hauler Data*—Data generated by the Hauler for the given contract shift (e.g., shift start/end times, truck ID, driver name, broker name, DOT number, etc.). The Hauler for the given truck identification may be the Contractor, Independent Truck Operator (ITO), or Managed Truck Operator (MTO).

3.1.4.5. *Source Data*—Data generated by the source's loadout software, such as contract, Agency project and source identification, material code, loading and weight information. This data is considered as the E-Ticket.

3.1.4.5.1. *Contract Total by Mix Designation Weight*—Cumulative weight per mix designation and contract.

3.1.4.5.2. *Daily Running Total by Mix Designation Weight*—Cumulative daily weight per mix designation.

3.1.4.5.3. *Digitalized*—Data provided in a database format.

3.1.4.5.4. *E-Ticket*—Exportable, digitalized source data.

3.1.4.5.5. *Material Code*—Mix designation of material being delivered.

3.1.4.5.6. *Mix Design Identification*—Mix designation report number.

3.1.4.5.7. *Paper Weight Ticket*—Also called Bill of Lading. Printed copy of weight ticket created by load-out software.

3.1.4.5.8. *Source Identification*—AASHTOWare Project or State assigned source identification (e.g., plant identification, BP0001).

3.1.5. *Geofence*—virtual perimeter that indicates when a mobile device enters or exits a predefined area.

3.1.5.1. *Category Geofence*—Static virtual perimeter around a subsection of a project with different funding sources.

3.1.5.2. *Contract Geofence*—Static virtual perimeter around the limits of the work to be completed in the contract (e.g., boundary of jobsite).

3.1.5.3. *Dump Geofence Name*—Name of geofence where material was dumped within.

3.1.5.4. *Project Geofence*—Static virtual perimeter around a subsection of the contract with specialized geographic designations (e.g., control section numbers).

3.1.5.5. *Source Geofence*—Static virtual perimeter around boundary of source (e.g., boundary around plant).

3.1.6. *Veta*—Standardized intelligent construction data management (ICDM) software that stores, maps and analyzes geospatial data resulting from intelligent construction technology (ICT) such as intelligent compaction, thermal profiling, dielectric profile method and spot test data (e.g., density, moisture). This software can perform standardized data processing, analysis and reporting to provide project summary results from various ICT manufacturers. In particular, the software can provide statistics, histograms, correlations for these measurements, document coverage area and evaluates the uniformity of the ICT measurements as part of the project quality control operations. The Veta MDMS can be the Agency's standardized platform for the MDMS. (Software can be downloaded from www.intelligentconstruction.com)

4. CONSTRUCTION REQUIREMENTS

4.1. *Equipment*

4.1.1. *Contractor's MDMS* – Use system with a minimum of the following components:

4.1.1.1. Software to digitalize source data for inclusion as the E-Ticket in Contractor's MDMS.

4.1.1.2. Ability to manually accept dump.

Note 5—This requirement is used for instances where an Engineer is present and the truck exchange information is not automatically recorded per Section 4.1.1.4.2.

4.1.1.3. Portable, or hardwired, GNSS to track truck locations. The GNSS:

4.1.1.3.1. Is powered independently, and/or through use of an adapter.

4.1.1.3.2. Provides an indication of instances where there is interruption of satellite signals used to track truck locations.

4.1.1.3.3. Is associated with corresponding truck identification and ticket number.

4.1.1.3.4. Breadcrumb Trail

(a) Sends and saves breadcrumb trail at 1 minutes, or less, intervals.

Note 6—Recording breadcrumb trails is another means of verifying delivery of material, haul routes, fleet data purposes, etc.

(b) Playback features are available to display transit routes for each breadcrumb trail.

Note 7—Ensure playback features are available to both Agency and Contractor. Agencies are recommended not to download this information, but only access it via the playback feature, as needed, until closeout of projects. See Section 4.1.1.8 for duration of data availability.

4.1.1.4. *Geofences*

4.1.1.4.1. Static Geofences

Note 8—Static geofences are used to track quantities with respect to contracts, projects and categories. Additionally, these geofences are used to generate transit flow rates and for use in labor compliance and civil rights activities.

(a) Establishes static geofence around source(s) and contract(s).

Note 9—The project and category geofence will be established in the Veta MDMS by the Engineer. See Section 4.2.3.2 and Appendix X2.

(b) Records geofence name and date and time stamps associated with truck when entering and exiting the *source* and *contract* geofences.

(c) Calculates duration of time spent within the source and contract geofence, and transit times between the "source to contract" and "contract to source".

(d) Allows Contractor ability to create source and contract geofences.

(e) See Appendix X3 for example of static geofences, and associated time and date stamps and transit times.

4.1.1.4.2. Mobile Geofences

Establishes a mobile geofence around dump location (e.g., paver, material transfer device, pickup machine) for recording of dump time and location. Hardware allows for user defined creation of geofence and an automated method to correctly indicate dump locations within 60 m [200 feet].

Note 10—Recommended for instances where an Agency does not have an individual manually accepting delivery of material per Section 4.1.1.2.

4.1.1.5. Cloud storage and cloud computing to allow viewing and export of Contractor's MDMS data.

4.1.1.6. User Interfaces (Web-, or Application-Based)

4.1.1.6.1. Hauler user interface is available for entry of Hauler data per Table 1.

Note 11—The Agency and Contractor user interfaces are provided by the Veta MDMS. See Note 3.

4.1.1.6.2. Continues to store data in user interface until automatic transfer of data in areas with limited to no data cellular coverage.

4.1.1.6.3. Ability to enter Hauler data at a later date and time.

4.1.1.6.4. Engineer has *viewing* in 3 minutes or less of the point of sale (using a web- or application-based user interface) of the following information in Contractor's MDMS when adequate data cellular coverage is available:

(a) Number of trucks at source, in transit from source to contract, at contract (and/or dump) and in transit from contract to source.

(b) Tabular summary of ticket status (e.g., ticket number, loaded, in transit, dumped).

(c) Source data per Tables 1 and 6

(d) Hauler data per Table 1

4.1.1.6.5. Contractor's MDMS will transmit source, fleet and Hauler data to Veta MDMS in 4 minutes or less of point of sale.

4.1.1.7. Instrument appropriate components of MDMS on all:

4.1.1.7.1. Sources providing material to contract.

4.1.1.7.2. Dump locations (e.g., pavers, pickup machines, or material transfer devices, etc.)

4.1.1.7.3. Trucks delivering material to contract.

4.1.1.8. Provide Engineer access to cloud storage and cloud computing prior to start of delivery of material. Cloud storage data is accessible until 90 days after final acceptance of all work.

Table 1—Required Fields in MDMS for each Data Block

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Source	1	ContractID	Contract Identification	180181, R-37463	String
Source	2	ProjID	Agency Project Identification	SP1234-56, SAP047-609-012	String
Source	3	SourceID	Source Identification	BP001 (e.g., Plant Identification)	String
Source	2b	ContractorName	Contractor Name	John Doe Contracting	String
Source	4	ScaleID	Scale ID	2, A2	String
Source	5	SiloID	Silo ID	5, A3	String
Source	6	SourceOperName	Source Operator Name	John Doe (e.g., weighmaster)	String
Source	7	SourceOperCertNum	Source Operator Certification Number	1234567 (e.g., weighmaster certification number)	String
Source	8	SourceNote	Source Notes	First Load, Last Load, Warnings	String
Source	9	MixDesignID	Mix Design Identification	02-2020-184, RMX135-030, (e.g., mix design report number)	String
Source	10	MatlCode	Material Code	SPWEA340C, DMF #1932480001 (e.g., mix designation)	String
Source	11	TicketNum	Ticket Number	5126349, 101R, 539-19	String
Source	12	LoadNum	Load Number	75	Number
Source	13	TruckID	Truck Identification	51.6046, 88tb, T-1, T1	String
Source	14	TrailerID	Trailer Identification	51.6046, 88tb, T-1, T1	String
Source	15	VoidedTicket	Voided Ticket	See Table 2	String
Source	16	LoadDateTime [a]	Loading Date and Time	2007-04-05T12:30-02:00	String
Source	17	GrossWt	Gross Weight	44.33	Number
Source	18	NetWt	Net Weight	26.83	Number
Source	19	TruckTareWt [b]	Truck Tare Weight	17.50	Number
Source	20	DailyRunningTotalByMixDesignWt [c]	Daily Running Total By Mix Designation Weight	1900.64	Number
Source	21	ContractTotalByMixDesignWt [c]	Contract Total by Mix Designation Weight	2400.45	Number
Fleet	22	OverweightWt	Overweight Weight	0.33	Number
Fleet	23	SourceGeoName [d]	Source Geofence Name	See Table 10	String
Fleet	24	SourceLat	Source Latitude	45.072644	Number
Fleet	25	SourceLong	Source Longitude	-93.868772	Number
Fleet	26	TruckEntersSourceGeoDateTime [a, d]	Truck Enters Source Geofence Date and Time	2007-04-05T12:30-02:00	String

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Fleet	27	TruckExitsSourceGeoDateTime [a, d]	Truck Exits Source Geofence Date and Time	2007-04-05T12:35-02:00	String
Fleet	28	TimeAtSource [d]	Time at Source	HH:MM:SS, 00:05:00	String
Fleet	29	SourceToContractTime [d]	Source to Contract Transit Time	HH:MM:SS, 00:10:00	String
Fleet	30	ContractGeoName [d]	Contract Geofence Name	See Table 10	String
Fleet	31	TruckEntersContractGeoDateTime [a, d]	Truck Enters Contract Geofence Date and Time	2007-04-05T12:55-02:00	String
Fleet	32	TruckExitsContractGeoDateTime [a, d]	Truck Exits Contract Geofence Date and Time	2007-04-05T12:55-02:00	String
Fleet	33	TimeAtContract [d]	Time At Contract	HH:MM:SS, 00:05:00	String
Fleet	34	ContractToSourceTime [d]	Contract to Source Transit Time	HH:MM:SS, 00:10:00	String
Fleet	35	DumpEquipID [e]	Dump Equipment Identification	27XVYZLP	String
Fleet	36	DumpGeoName [d, e]	Dump Geofence Name	See Table 10 and X2.1	String
Fleet	37	DumpDateTime [a]	Dump Date and Time	2007-04-05T12:50-02:00	String
Fleet	38	DumpLat	Dump Latitude	45.072644	Number
Fleet	39	DumpLong	Dump Longitude	-93.868772	Number
Hauler	40	ContractorJobNum	Contractor Job Number	20-01	String
Hauler	41	HaulerCompName	Hauler Company Name	John Doe Contracting	String
Hauler	42	BrokerName	Broker Name	Joes	String
Hauler	43	DOTNum	DOT Number	US DOT 33136	String
Hauler	44	HaulerTruckID [f]	Hauler Truck Identification	51.6046, 88tb, T-1, T1	String
Hauler	45	TruckDriverClass	Truck Driver Classification	See Table 3	Number
Hauler	46	OverweightPermitNum	Overweight Permit Number	033I9021331	String
Hauler	47	MaxGrossWt	Maximum Gross Weight	44	Number
Hauler	48	DriverName	Driver Name	John Doe	String
Hauler	49	ShiftStartDateTime [a]	Shift Start Date and Time	2020-04-05T06:00-02:00	String
Hauler	50	ShiftEndDateTime [a]	Shift End Date and Time	2020-04-05T14:00-02:00	String
Agency	51	AgencySampleId [g]	Agency Sample Identification	583	String
Agency	52	AgencyMatlTempAtSource [g]	Agency Matl Temperature at Source	290	Number
Agency	53	AgencyMatlTempAtField [g]	Agency Matl Temperature at Field	275	Number
Agency	54	AgencyAirTemp [g]	Agency Air Temperature	90	Number
Agency	55	AgencySplitLoad1Wt	Agency Split Load 1 Weight	10.0	Number
Agency	56	AgencySplitLoad1PayItem	Agency Split Load 1 Pay Item	2260.509, 2231.507, 2105.602	String
Agency	57	AgencySplitLoad1LocNote	Agency Split Load 1 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Agency	58	AgencySplitLoad2Wt	Agency Split Load 2 Weight	3.0	Number
Agency	59	AgencySplitLoad2PayItem	Agency Split Load 2 Pay Item	2260.509, 2231.507, 2105.602	String
Agency	60	AgencySplitLoad2LocNote	Agency Split Load 2 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Agency	61	AgencySplitLoad3Wt	Agency Split Load 3 Weight	2.0	Number
Agency	62	AgencySplitLoad3PayItem	Agency Split Load 3 Pay Item	2260.509, 2231.507, 2105.602	String
Agency	63	AgencySplitLoad3LocNote	Agency Split Load 3 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Agency	64	AgencyWastedMatlWt	Agency Wasted Material Weight	13	Number
Agency	65	AgencyLoadAcceptReject [h]	Agency Load Acceptance and Rejection	See Table 4	Number

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Agency	66	AgencyPartialRejectedLoadWt	Agency Partial Rejected Load Weight	6	Number
Agency	67	AgencyDumpStationNum	Agency Dump Station Number	1200+00, 120000	String
Agency	68	AgencyFieldNote	Agency Field Notes	Load was split for patching work	String
Agency	69	AgencyInspectorId	Agency Inspector Identification	John Doe, JDJ	String
Agency	70	AgencyDateTime [a, i]	Agency date and time	2007-04-05T12:30-02:00	String
Agency	71	IndVerDateTime [a, i]	Independent Field Verification – Date and Time	2007-04-05T12:30-02:00	String
Agency	72	IndVerLat [i, j]	Independent Field Verification –Latitude	45.072644	String
Agency	73	IndVerLong [i, j]	Independent Field Verification –Longitude	-93.868772	String
Agency	74	IndVerStation	Independent Field Verification – Station	1110+00, 111000	String
Agency	75	IndVerEstNetWt	Independent Field Verification – Estimated Net Weight	15	Number
Agency	76	IndVerIndScaleWt	Independent Field Verification – Independent Scale Weight	16.25	Number
Agency	77	IndVerIndScaleCert	Independent Field Verification – Independent Scale Certification	6X23450, 123456	String
Agency	78	IndVerNetWtOnETicket	Independent Field Verification – Net Weight on E-Ticket	16.25	Number
Agency	79	IndVerDriverName	Independent Field Verification – Driver Name	John Doe	String
Agency	80	IndVerHaulerCompanyName	Independent Field Verification – Hauler Company Name	John Doe Contracting	String
Agency	81	IndVerApproval	Independent Field Verification – Approval	See Table 5	String
Agency	82	IndVerNote	Independent Field Verification – Notes	The net weight included on the E-Ticket does not match that which was delivered in the field.	String
Agency	83	IndVerInspectorID	Independent Field Verification – Inspector Identification	John Doe, JDJ	String
Contractor	84	ContractorSampleId [g]	Contractor Sample Identification	583	String
Contractor	85	ContractorMatlTempAtSource [g]	Contractor Material Temperature at Source	290	Number
Contractor	86	ContractorMatlTempAtField [g]	Contractor Material Temperature at Field	275	Number
Contractor	87	ContractorAirTemp [g]	Contractor Air Temperature	90	Number
Contractor	88	ContractorSplitLoad1Wt	Contractor Split Load 1 Weight	10.0	Number
Contractor	89	ContractorSplitLoad1PayItem	Contractor Split Load 1 Pay Item	2260.509, 2231.507, 2105.602	String
Contractor	90	ContractorSplitLoad1LocNote	Contractor Split Load 1 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Contractor	91	ContractorSplitLoad2Wt	Contractor Split Load 2 Weight	3.0	Number
Contractor	92	ContractorSplitLoad2PayItem	Contractor Split Load 2 Pay Item	2260.509, 2231.507, 2105.602	String

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Contractor	93	ContractorSplitLoad2LocNote	Contractor Split Load 2 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Contractor	94	ContractorSplitLoad3Wt	Contractor Split Load 3 Weight	2.0	Number
Contractor	95	ContractorSplitLoad3PayItem	Contractor Split Load 3 Pay Item	2260.509, 2231.507, 2105.602	String
Contractor	96	ContractorSplitLoad3LocNote	Contractor Split Load 3 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Contractor	97	ContractorWastedMatlWt	Contractor Wasted Material Weight	13	Number
Contractor	98	ContractorLoadAcceptReject [h]	Contractor Load Acceptance and Rejection	See Table 4	Number
Contractor	99	ContractorPartialRejectedLoadWt	Contractor Partial Rejected Load Weight	6	Number
Contractor	100	ContractorDumpStationNum	Contractor Dump Station Number	1200+00, 120000	String
Contractor	101	ContractorFieldNote	Contractor Field Notes	Load was split for patching work	String
Contractor	102	ContractorStaffId	Agency Staff Identification	John Doe, JDJ	String
Contractor	103	ContractorDateTime [a, i]	Contractor date and time	2007-04-05T12:30-02:00	String

Notes:

[a] Includes UTC offset.
[b] Required when a load cell is used on hoppers beneath a surge or storage bin.
[c] Data field is provided either by source or Contractor's MDMS. This information is not provided in a digitalized format by some source loadout software.
[d] Used for calculating truck transit flow rates, independent verification to assist with supporting delivery of material and for Labor Compliance audits, such as monitoring of prevailing wages, disadvantaged business enterprise (DBE) hours, State Small business Requirements, etc.
[e] Assists with reconciling pay quantities.
[f] Truck Identification must match that used with source data in E-Ticket.
[g] One or more measurements may be recorded.
[h] Used to manually accept material for instances where an Engineer is present and the truck exchange information is not automatically recorded per Section 4.1.1.2 and to also reject loads.
[i] Data is auto-generated by Contractor's MDMS.
[j] Location service on device must be turned on for collection of this information.

Table 2—Lookup Table for Voided Tickets

Source Data Description	Data Block Value
Material not loaded for delivery to project – source ticket number voided	Voided
Material loaded for delivery to project	Valid
Source ticket number generated, but does not have associated material loaded for delivery to project	Orphan

Table 3—Lookup Table for Truck Driver Classification

Format	Example Index [a]
Tractor Trailer Driver	602
Four or More Axle Unit, Straight Body Truck	604
Three Axle Units	607
Two Axle Unit	613

[a] Index reflects Labor Code used for Craft in AASHTOWare. Code will vary by Agency.

Table 4—Lookup Table for Manual Load Acceptance

Data Description	Data Block Value [a]
Load accepted for placement	Accepted
Load not accept load for placement	Rejected
Default Value	Null

[a] By default, field is set as Null.

Table 5—Lookup Table for Independent Field Verification – Approval

Description	Data Block Value
Engineer finds no issues with source and Hauler data during field review	Valid
Issues found during Engineer review of source and Hauler data contained during field review	Invalid

Table 6—Required Fields for Source Identification Data

E-Ticket Data	Field Name	Long Description	Examples	Data Type
Source	SourceID	Source Identification	BP001 (e.g., plant identification)	String
Source	SourceName	Source Name	John Asphalt, John Asphalt 3 Burnsville, John Plant 7 (e.g., long description of plant name)	String
Source	PortablePlant	Portable Plant	See Table 7 for lookup table for portable plant	String
Source	SourceAddress	Source Address	12345 Marvel Street NW, MN 56738	String
Source	SourcePhoneNum	Source Phone Number	777-777-7777	String

Table 7—Lookup Table for Portable Plant

Portable Plant Description	Data Block Value
Material is from a portable plant	Yes
Material is not from a portable plant (i.e., material is from a permanent plant)	No

4.1.2. *MDMS Data Fields*

Each data block of Contractor's MDMS will contain source, fleet, and Hauler data per Table 1 and meet the following requirements:

Note 12—Agency and Contractor data will be entered via a Veta MDMS user interface. This data is merged with source, fleet and Hauler data within the Veta MDMS. See Note 3.

4.1.2.1. Load numbers are generated in sequential order and not shared sequences with other projects.

4.1.2.2. All data fields are automatically populated, with the exception of the following:

4.1.2.2.1. Hauler can real-time manually enter Hauler data per Table 1, when adequate data cellular coverage is available, or at a later time for instances with limited to no data cellular coverage.

Note 13—The "Hauler", for the given truck identification, may be the Contractor, Independent Truck Operator (ITO), or Managed Truck Operator (MTO).

4.1.2.2.2. Ability to enter source identification data, per Table 6, into Contractor's MDMS.

4.1.2.3. Modifications or deletions to Hauler data can only be made by Hauler.

4.1.2.4. Hauler data entered, into Contractor's MDMS user interface, is auto-populated into the associated data block fields of the MDMS (per Table 1), by tying (at a minimum) contract job number, truck identification, and shift start and end times to the Load Date and Time.

4.1.2.5. Fleet data collected and stored in system separate from Contractor's MDMS must contain Ticket Number in addition to fleet data blocks listed in Table 1.

4.1.3. *Source Data to Contractor's MDMS*

4.1.3.1. Centralized suppliers and Contractor owned sources will provide source data to Contractor's MDMS in 2 minutes or less of point of sale.

4.1.3.2. Contractor's MDMS will provide source data to Contractor's MDMS user interface in 1 minute or less of receipt of data when adequate data cellular coverage is available.

4.1.3.3. *Contractor Owned Permanent / Portable Sources*

4.1.3.3.1. Contractor owned permanent and portable sources will provide source data through a solution of the Contractor's MDMS or per section 4.1.3.4.

4.1.3.4. *Centralized Suppliers and Contractor Owned Permanent / Portable Sources*

4.1.3.4.1. Centralized suppliers and Contractor owned permanent and portable sources will provide source data to Contractor's MDMS per the following method. Centralized suppliers, Contractor owned permanent and portable sources and MDMS vendors will use:

Note 14—The use of REST APIs and a JSON data interchange language mitigates the complexities that are encountered when MDMS vendors connect directly to the varying loadout software (and with loadout software updates) used by Contractor owned sources.

Note 15—DOS based systems should be updated to new GEN OS or the processing capacity must be increased to allow for the requirements of section 4.1.3.4 to be met.

(a) REST APIs (secured using the OAuth 2.0 Standard) exposed by the MDMS vendors for transmittal of source data to the MDMS vendor.

(b) JSON data interchange language as the format for data sent and received from the REST APIs.

(c) JSON request body format will contain the source data per ticket per Tables 1, 8 and 9. See Appendix X4 for example JSON.


```
{
 "messageTimestamp": 0,
 "ticketData": [
  {
   "AgencyProjNum": "string",
   "ContractID": "string",
   "SourceID": "string",
   "ScaleID": "string",
   "SiloID": "string",
   "SourceOperName": "string",
   "SourceOperCertNum": "string",
   "SourceNote": "string",
   "MixDesignID": "string",
   "MatlCode": "string",
   "TicketNum": "string",
   "LoadNum": {
    "value": 0
   },
```

```
      "TruckID": "string",
      "TrailerID": "string",
      "VoidedTicket": "string",
      "LoadDateTime": "string",
      "GrossWt": {
        "value": 0
      },
      "GrossWtUnit": {
        "value": 0
      },
      "NetWt": {
        "value": 0
      },
      "NetWtUnit": {
        "value": 0
      },
      "TruckTareWt": {
        "value": 0
      },
      "TruckTareWtUnit": {
        "value": 0
      },
      "DailyRunningTotalByMixDesignWt": {
        "value": 0
      },
      "DailyRunningTotalByMixDesignWtUnit": {
        "value": 0
      },
      "ContractTotalByMixDesignWt": {
        "value": 0
      },
      "ContractTotalByMixDesignWtUnit": {
        "value": 0
      }
    }
  }
```


Table 8—Recognized Unit Lookup Table

JSON Field	Description
LoadDateTimeUnit	YYYY-MM-DDThh:mm:ss±hh:mm
GrossWtUnit	Refer to Table 9
NetWtUnit	Refer to Table 9
TruckTareWtUnit	Refer to Table 9
DailyRunningTotalByMixDesignWtUnit	Refer to Table 9
ContractTotalByMixDesignWtUnit	Refer to Table 9

Table 9—Lookup Table for Units used for Weights

Format	Index
Metric Tons	1
US Tons	2
Kilogram	3
Pounds	4

(d) Vendor's MDMS will allow import of more than one ticket per JSON message should batch queuing occur as a result of unexpected issues by centralized supplier or Contractor owned source.

4.1.4. *Data Transmittals*

4.1.4.1. *File Downloads*

4.1.4.1.1. All Contractor's MDMS source, fleet, and Hauler data fields, per Table 1, are compiled into a single database table that is exportable by Engineer as a dbase ASCII, CSV, XLSX, or text format within 15 minutes intervals from Contractor's MDMS. Fleet data, collected in systems separate from Contractor's MDMS, may be exported as a separate table, but must include ticket number for cross referencing to source, fleet, and Hauler data.

4.1.4.1.2. All Contractor's MDMS source, fleet, Agency, Contractor, and Hauler data fields, per Table 1, are compiled into a single database table that is exportable by Engineer as a dbase ASCII, CSV, XLSX, or text format within 15 minutes intervals from the Veta MDMS.

4.1.4.2. *REST APIs and JSON*

Note 16—In the future, the source, fleet, and Hauler data will be transmitted from the Contractor's MDMS to the Veta MDMS using REST API's and JSON. This data plus the Agency data, Contractor data, and dump geofence name will then be transmitted from the Veta MDMS into AWP "Construction and Materials" and "Estimating" modules for use in reconciling daily quantities and for use with future estimated quantities, respectively. Additionally, this data will be input into the materials testing and acceptance system to ensure acceptance testing is completed at the required frequency. Fleet and Hauler data will be imported into the AWP "Civil Rights and Labor" module for Agencies that elect to capture fleet and Hauler data. See Figures 5 and 7 for workflow.

Note 17—Not all Agencies utilize AWP, but use Agency developed databases. Section 4.1.4.1.2 assists with standardization of exports of MDMS data files from the Veta MDMS to Agency owned databases.

Note 18—After future Veta MDMS enhancements, a subset of data blocks from the MDMS data set (e.g., time stamp of loading, placement time, mix designation and asphalt temperature data) that contain the latitude and longitude for the dump location will be will be overlaid over intelligent construction data such as intelligent compaction, paver mounted thermal profiling and dielectric profile data. This information will be used to assist with identification of workmanship issues, development of field heat loss curves, verification of calibration equations used with the dielectric profile method, remove and replace limits, and for use in future long-term pavement issues should these arise. See Figures 5 and 7 for workflow.

4.1.4.2.1. Veta MDMS, MDMS vendors, and AWP will use the following for transmittal of MDMS data:

(a) REST APIs (secured using the OAuth 2.0 Standard) exposed by Veta MDMS, MDMS vendors, and AWP.

(b) JSON data interchange language as the format for data sent and received from REST APIs.

(c) JSON request body format will contain MDMS data per Tables 8 and 9 and the following data fields per Table 1:

(c1) Contractor's MDMS to Veta MDMS – Data Field Numbers: source (1-21), fleet (22-35, 37-39), Hauler (40-50)

(c2) Veta MDMS to AWP – Data Field Numbers: source (1-21), fleet (22-39), Hauler (40-50), Agency (51-83), Contractor (84-103)

(d) Veta MDMS and AWP will allow import of more than one ticket (batch queuing of tickets), and associated MDMS data, per JSON message.

(f) MDMS vendors will provide source, fleet, and Hauler data to Veta MDMS in 4 minutes or less of point of sale.

(g) Veta MDMS will provide MDMS data (source, fleet, Hauler, Agency and Contractor data) to AWP in 15 minutes or less.

4.2. *Pre-Construction Activities*

4.2.1. *Source Identification Data*

4.2.1.1. Enter source identification data per Table 6 into Contractor's MDMS, along with other needed startup information.

4.2.2. *Internet (or Satellite) Connectivity*

4.2.2.1. Set up internet (or satellite) connectivity at all sources used to provide material to contract.

4.2.3. *Geofences*

4.2.3.1. Contractor will set up the following geofences in Contractor's MDMS:

4.2.3.1.1. Source Geofence(s)

4.2.3.1.2. Contract Geofence(s)

4.2.3.1.3. Mobile Dump Geofence(s) – Set up mobile geofence around boundaries of equipment that material is being delivered to such as paver, pickup machine, or material transfer device, etc.

4.2.3.2. Engineer will set up the following geofences in Veta MDMS:

4.2.3.2.1. Project Geofence(s) – Create project geofences when the contract contains one or more projects.

4.2.3.2.2. Category Geofence(s) – Create category geofences in place of a project geofence for instances where a project contains more than one category (i.e., funding group).

4.2.3.3. Contractor and Engineer will name geofences using the standardized naming convention per Table 10.

4.2.3.4. See Figure X3 for example of source, contract, project and category geofences and names.

Table 10—Geofence Standardized Naming Convention

Geofence	Standardized Naming Convention	Example(s)
Source	SourceID_CountyName	BP001_StLouis
Contract	ContractID [a]	CN200078, CN200078_W, CN200078_E
Project	ProjectNumber_CountyName	SP3101-37_Itasca, SP6901-29_StLouis
Category	ProjectNumber_CountyName_Category	SP6931-01_StLouis_CAT0001, SP6931-01_StLouis_CAT0002

[a] Contract geofence may be split into smaller subsections for larger contracts to assist with more accurate flow rate calculations. An acronym can be added to geofence standardized naming convention by adding an underscore and needed distinguishing acronym.

4.2.4. *Training*

4.2.4.1. Provide training to Engineer no later than 7 calendar days prior to start of work requiring MDMS.

4.2.4.2. Training will include instruction and viewing of a minimum of the following:

4.2.4.2.1. Contractor's MDMS web- and/or application- based platforms.

4.2.4.2.2. Geofence boundaries and naming conventions used for contract and source.

4.2.4.2.3. Data fields included in Contractor's MDMS data collection and export.

4.2.4.2.4. Real-time viewing of items listed in section 4.1.1.6.4.

4.2.4.2.5. Playback of breadcrumb trails.

4.2.4.2.6. Example export of Contractor's MDMS data per section 4.1.4.

4.3. *System Failure*

4.3.1. System failure occurs when the MDMS does not collect and/or store data per the requirements of this Standard or when data cellular coverage is limited.

4.3.2. Notify Engineer when system failure occurs and immediately after resolution of issues. Provide Engineer with a resolution to the issues and an acceptable time frame for completing the resolution prior to resuming the next day's paving operation.

4.3.3. Source will revert to other means, which is approved by the Engineer, for sharing source data during system failures.

4.4. *Independent Field Verification*

Note 19—It is recommended that the Engineer uses paper weight tickets for reconciling quantities during pilot stages of the MDMS solution until confidence is achieved with MDMS set ups, system stabilities, training and Contractor and Engineer experience.

4.4.1. Engineer will randomly verify source and Hauler data provided in the MDMS.

Note 20—Source data is randomly reviewed each day to ensure no issues are present with the MDMS and that source data stored within the MDMS is accurate for use in yield checks and reconciling of quantities. Field verification information is also later used to verify that the final data export, used for reconciling quantities, reflects those originally reviewed in the field.

Note 21—Establish the frequency and metrics used for determining when independent field verification is completed. For example (see Figure 8), the Engineer will complete independent field verification within delivery of first 10 loads of material and 1,000-ton lots thereafter. Use Engineer approved random number generator to determine independent field verification tonnage for each lot. The Engineer's independent field verification will consist of the following:

(1) Review of source and Hauler data contained within MDMS to verify that all required fields, per Table 1, are available and accurate.

(2) Compare Engineer's estimated net weight of material delivered by truck to net weight contained in MDMS. Record Engineer's estimated net weight and net weight provided in MDMS for later use in verification of net weight included in the final MDMS data export used for reconciling quantities.

(3) If source data is invalid, the Engineer will report the system failure to the Contractor. The Contractor will provide the Engineer with a resolution to the issues and acceptable time frame for completing the resolution prior to resuming the next day's paving operation. The Engineer will complete independent field verification within delivery of the first 10 loads of material and 1,000-tons lots thereafter, upon resolution of the system failure. In the future, stricter requirements will be added with respect to system failures when paper tickets are no longer used for reconciling quantities.

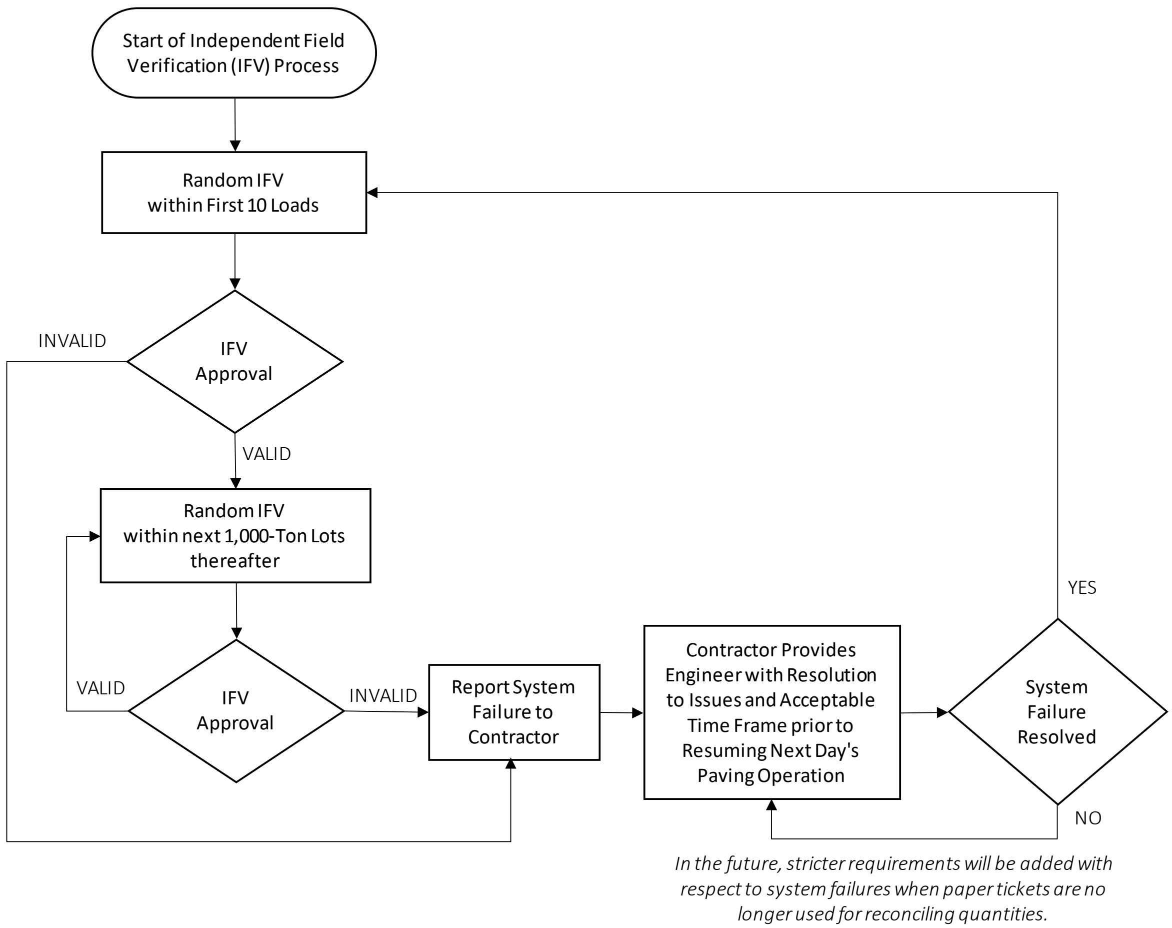


Figure 8— Example Independent Field Verification Workflow.

5. BASIS OF PAYMENT

5.1. Interruptions in availability of data cellular coverage and/or satellite signals used with this system will not result in adjustments to the "Basis of Payment" for any construction items or to Contract time.

Note 22—Agency should consider including a pay item with the MDMS during initial years of deployment. It is up to the Agency as to whether the technology continues to use a pay item during future years or becomes incidental. Costs associated with this technology include the following: data entry of project information, set up of appropriate MDMS components, system set up to push source data into Contractor's MDMS, internet connectivity at permanent and portable sources, set up of geofences, system monitoring, assigning and distribution of truck asset trackers, monitoring of yields rates recorded by MDMS, remote server storage, cloud-based software accessibility and data package plans.

6. REPORT

6.1. (Blank)

7. KEYWORDS

7.1. Material delivery management system, MDMS, Asphalt; Asphalt paving; E-Ticket; E-Ticketing; E-Ticketing system; fleet; fleet data; source; source data; plant; plant data; Agency data; global positioning system; GPS; global navigation satellite system; GNSS; quantities; reconciling quantities; building information monitoring; BIM; Veta; Veta MDMS; net weight; computer-generated weight ticket; paper weight ticket; bill of lading; paper ticket; independent verification; independent field verification, dielectric profile method; density; quality control; quality assurance; paver mounted thermal profile method; PMTP; thermal profiling; intelligent compaction method; IC; OAuth; OAuth RFC; API; application programming interface; HTTP; hypertext transfer protocol; JSON; REST; RESTful; Civil Rights; Labor Compliance; prevailing wage; audits; disadvantaged business enterprise; DBE; goal setting hours; race neutral; Federal Davis Bacon Law.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES FOR USE OF FLEET AND HAULER DATA

X1.1. *Dump Location – allows capturing of the following:*

X1.1.1. Dump geofence name for use in tabulation of quantities and costs associated with contracts with more than one project and/or funding category (see Appendix X2). Additionally, the dump geofence name is used to assist with prevailing wages.

X1.1.2. Location material was placed (i.e., latitude, longitude and station) is used for:

X1.1.2.1. Referencing failing materials for remove and replace limits, or for use in evaluation of long-term pavement performance.

X1.1.2.2. Tracking mix design (material code) changes for use with the dielectric profile method (i.e., [PP-98] verification of calibration curves), troubleshooting density issues and long-term pavement performance.

X1.1.2.3. Overlaying MDMS data in Veta MDMS for: (1) correlation with the dielectric profile method (PP-98), PP-80 and PP-81; (2) generation of heat loss curves using temperatures from source, Contractor and Agency data, PP-80 and PP-81.

X1.1.3. Paver identification to assist with reconciling quantities for placement activities using the same mix design (e.g., mainline paving, shoulder, entrances, etc.), echelon paving, etc.

X1.2. *Overweight Quantities*

X1.2.1. Monitoring of overweight weight quantities to help ensure that these quantities are not paid for by Agencies that cannot pay for these quantities.

X1.3. *Monitoring Flow Rates – Improved Workmanship*

X1.3.1. Monitoring of flow rates to assist with mitigating thermal segregation as measured with the paver mounted thermal profile method (PP-80), to improve compaction efforts (PP-81), and increase pavement smoothness.

X1.4. *Contract Closeouts*

X1.4.1. Mitigates the potential for missing prevailing wage reports. Obtaining all missing trucking reports is often the number one reason for delay in closing out contracts. Additionally, DBE, or Small Business Close out, can delay contract finals which holds up a Contractor's Bond.

X1.5. *Contract Audits – Independent Verification of E-Ticket*

X1.5.1. Time stamps assist with documentation of prevailing wage hours, along with independently verifying that loads indeed made it to contract limits and were dumped. Additionally, questionable time stamps can assist with investigating (and or verifying) whether entire loads (or partial loads) potentially were delivered to other contracts or locations.

X1.6. *Labor Compliance Audits (Davis Bacon and Related Acts Compliance) / State Prevailing Wage Statutes*

X1.6.1. Trucking is one of a Contractor's top expenses.

X1.6.2. Completion of prevailing wage reports are complex and require a significant amount of time and resources to complete correctly. Collection of fleet data would assist with prevailing wage compliance.

X1.6.3. Many haulers often have limited time to complete this documentation, and consequently, is often not completed in a timely manner.

X1.6.4. It is the Contractor's responsibility to ensure that the prevailing wage reports are completed correctly, ensure truck hauler is paid correctly and to take appropriate actions to ensure compliance with the contract.

X1.6.5. Connecting hauler information to the E-Ticket assists with monitoring and documentation of the Craft / Classification / Trade.

X1.6.6. Labor compliance audits can take months or years to complete, making it difficult to gather needed documentation.

X1.6.7. The fleet data would aid with determining whether additional documentation and reporting is needed for Federal Davis Bacon Law.

X1.7. Fleet data would aid in Civil Rights Activities

X2. VETA MDMS – DUMP GEOFENCE NAMES

X2.1. Veta MDMS will record geofence name for location where material is dumped within per Table X2.1.

Table X2.1—Required Dump Geofence Name

Dump Location Description	Dump Geofence Name [a]
Project where dump location resides within contains one category.	Project Geofence Name
Project where dump location resides within contains more than one category.	Category Geofence Name

Notes:
[a] See Table 10 for standardized project and category geofence naming conventions.

X3. EXAMPLE OF STATIC GEOFENCES

X3.1. Figure X3.1 illustrates an example of static geofences for a contract that contains more than one project (SP6901-29 TH1, SP3101-37 TH1 and SP6931-01 TH73) and a project (SP6931-01 TH73) that contains more than one category (funding categories 0001 and 0002).

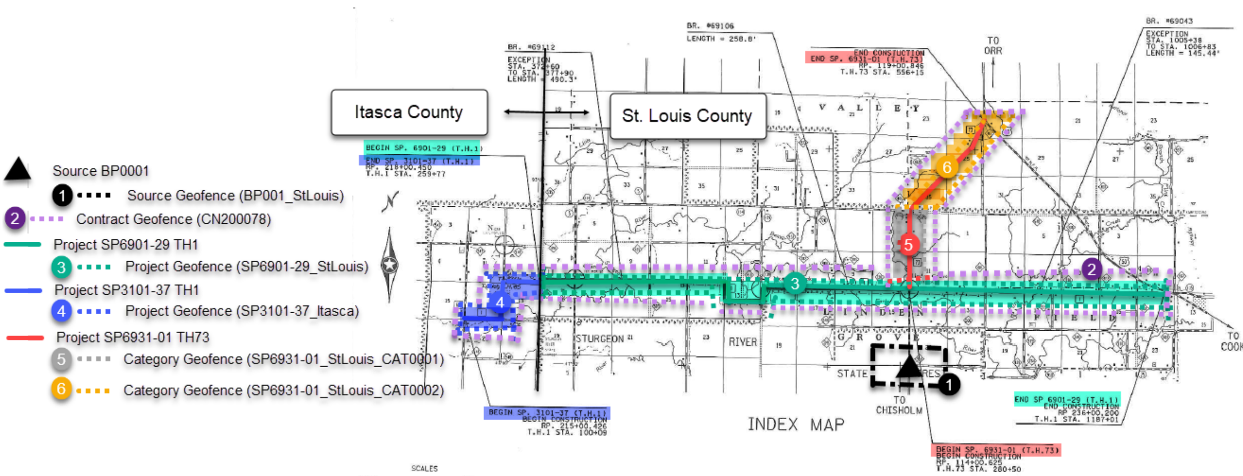


Figure X3. Error! Main Document Only.— Example of Source, Contract, Project and Category Geofences

X3.2. Table X3.1 lists examples of time stamps, transit times and geofence names for the example presented in Figure X3.1.

Table X3.1—Example Time Stamps, Transit Times and Geofence Names for Figure X3.1.

Dump	3	4	5	6
TicketNum	101	102	103	104
SourceGeoName	BP001_StLouis	BP001_StLouis	BP001_StLouis	BP001_StLouis
TruckEntersSourceGeoDateTime	2020-04-05T10:00-02:00	2020-04-05T10:40-02:00	2020-04-05T11:30-02:00	2020-04-05T12:05-02:00
LoadDateTime	2020-04-05T10:05-02:00	2020-04-05T10:45-02:00	2020-04-05T11:35-02:00	2020-04-05T12:10-02:00
TruckExitsSourceGeoDateTime	2020-04-05T10:10-02:00	2020-04-05T10:50-02:00	2020-04-05T11:40-02:00	2020-04-05T12:15-02:00
TimeAtSource	00:10:00	00:10:00	00:10:00	00:10:00
SourceToContractTime	00:05:00	00:05:00	00:10:00	00:10:00
ContractGeoName	CN200078	CN200078	CN200078	CN200078
TruckEntersContractGeoDateTime	2020-04-05T10:15-02:00	2020-04-05T10:55-02:00	2020-04-05T11:50-02:00	2020-04-05T12:25-02:00
TruckExitsContractGeoDateTime	2020-04-05T10:35-02:00	2020-04-05T11:25-02:00	2020-04-05T12:00-02:00	2020-04-05T12:35-02:00
TimeAtContract	00:20:00	00:30:00	00:10:00	00:10:00
ContractToSourceTime	00:05:00	00:05:00	00:05:00	(Blank - truck did not return back to plant)
PaverGeoName	Mainline_23456	Mainline_23456	Mainline_23456	Mainline_23456
DumpGeoName	SP6901-29_StLouis	SP3101-37_Itasca	SP6931-01_StLouis_CAT0001	SP6931-01_StLouis_CAT0002
DumpDateTime	2020-04-05T10:25-02:00	2020-04-05T11:10-02:00	2020-04-05T11:55-02:00	2020-04-05T12:30-02:00

X4. EXAMPLE JSON

X4.1. The following is a sample ticket included in the JSON request body:


```
{
 "messageTimestamp": 1526495318,
 "ticketData":
  {
   "AgencyProjNum": "SP6931-01",
   "ContractID": "CN200078",
   "SourceID": "BP001",
   "ScaleID": "A2",
   "SiloID": "A3",
   "SourceOperName": "John Doe",
   "SourceOperCertNum": "234768",
   "SourceNote": "Last Load",
   "MixDesignID": "01-2020-184",
   "MatlCode": " SPWEA340C",
   "TicketNum": "19823-1",
   "LoadNum": {
    "value": 10
   },
   "TruckID": "RA4-23",
   "TrailerD": "46TR4",
   "VoidedTicket": "Valid",
   "LoadDateTime": "2007-04-05T12:30-02:00",
   "GrossWt": {
    "value": 31.19
   },
   "GrossWtUnit": {
    "value": 2
   },
   "NetWt": {
    "value": 17.26
   },
   "NetWtUnit": {
    "value": 2
   },
   "TruckTareWt": {
    "value": 13.93
   },
   "TruckTareWtUnit": {
    "value": 2
   },
   "DailyRunningTotalByMixDesignWt": {
    "value": 166.95
```

```
        },
        "DailyRunningTotalByMixDesignWtUnit": {
          "value": 2
        },
        "ContractTotalByMixDesignWt": {
          "value": 166.95
        },
        "ContractTotalByMixDesignWtUnit": {
          "value": 2
        }
      }
    }
```

[1] This provisional standard was first published in 2022.

APPENDIX B: MNDOT’S MATERIAL DELIVERY MANAGEMENT SYSTEM SPECIAL PROVISION

S-1 (2016) QUALITY MANAGEMENT – E-TICKETING (MATERIAL DELIVERY MANAGEMENT SYSTEM)

NEW WRITE-UP 03/02/21 ◄DO NOT REMOVE THIS. IT NEEDS TO STAY IN FOR THE CONTRACTORS.

SP2018-xx

Use this provision if District requests the use of the Material Delivery Management System (MDMS) (E-Ticketing) for use with MnDOT 2360 Plant Mixed Asphalt Pavement, 2363 Permeable Asphalt Stabilized Base (PASB) and 2365 Stone Matrix Asphalt (SMA).

Full deployment of this technology is scheduled for 2024, and therefore, this technology is not required for inclusion on all projects at this time. However, should a district elect to include MDMS directly into a contract prior to 2024, please review the following project selection recommendations.

1. *Projects Anticipated to Use Centralized Plants (metro and possibly some adjacent district projects): Do not include MDMS directly into contract. Further enhancements are needed with various MDMS vendors for allowing MDMS solutions to connect to the data exported from the loadout software of centralized plants. Feel free to contact Rebecca Embacher to obtain updates on the status of the needed enhancements.*
2. *Projects Anticipated to Not Use Centralized Plants: Contact Rebecca Embacher to determine whether project is a good candidate to incorporate the technology and to obtain the latest version of the special provision, as it is not currently available via the boiler plates.*
3. *Permanent and Portable Plants require internet connectivity.*
4. *Inspection staff will not be able to view the MDMS data when truck exchanges occur in areas with no data cellular coverage. The Engineer will need to contact source should the digital ticket information be needed at these locations for yield checks.*
5. *Some Contractor plants are still running DOS-based load-out software that may not be compatible with MDMS.*

S-1.1 DESCRIPTION

This work will consist of capturing source, fleet, hauler, Agency and Contractor data associated with the delivery of material to a contract, for asphalt paving applications, in a standardized, digitalized format.

A Definitions

For the purpose of the Work specified in section 2016, "Quality Management – E-Ticketing (Material Delivery Management System)," the Department defines:

AASHTOWare Project (AWP)
Web-based software that provides a comprehensive series of software modules designed to address phases in the construction lifecycle beginning with project definition, followed by cost estimation, bidding/letting process, and construction and materials management. The software is built on a unified database that allows for easy access to data for use in decision-making, reporting, and tracking of various information (i.e. historical bid prices, civil rights and labor management, etc.).

Agency Data
Data generated by the Engineer, such as sampling information, split load and contract administration information (e.g., wasted material, rejected loads, field notes).

Application Programing Interface (API)
Software interface that allows multiple platforms to connect to each other.

Breadcrumb Trail
Latitude, longitude and associated time stamp for the truck's location recorded at pre-defined intervals.

Category Geofence
Static virtual perimeter around a subsection of a project with different funding sources.

Centralized Suppliers
Suppliers that provide material to multiple Contractors.

Contract Geofence
Static virtual perimeter around the limits of the work to be completed in the contract (e.g., boundary of jobsite).

Contract to Source Time
Duration of time spent in transit between contract and source as calculated using time stamps of when truck exits contract geofence and enters source geofence.

Contract Total by Mix Designation Weight
Cumulative weight per mix designation and contract.

Contractor Data
Data generated by Contractor, such as sampling information, split load and contract administration information (e.g., wasted material, rejected loads, field notes).

Daily Running Total by Mix Designation Weight
Cumulative daily weight per mix designation.

Digitalized
Data provided in a database format.

Dump
Delivery of source material.

Dump Geofence Name
Name of geofence where material was dumped within.

E-Ticket
Exportable, digitalized source data.

Fleet Data
Data generated such as dumping details, geofence names, date and time stamps, and durations.

Geofence
Virtual perimeter that indicates when a mobile device enters or exits a predefined area.

Hauler Data
Data generated by the hauler for the given contract shift (e.g., shift start/end times, truck ID, driver name, broker name, DOT number, etc.). The Hauler for the given truck identification may be the Contractor, Independent Truck Operator (ITO), or Managed Truck Operator (MTO).

Hypertext Transfer Protocol (HTTP)
Protocol used for transmitting data over the internet.

Independent Field Verification
Engineer randomly verifies source data contained within MDMS each day to ensure no issues are present with the system and that source data is accurate. Additionally, field verification information is used to verify that the final, exported MDMS data, used for reconciling quantities, reflects those originally reviewed in field.

Independent Field Verification – Estimated Net Weight
Estimated quantity of material delivered to project for load being verified for instances where an independent scale is not being used for independent verification.

Independent Field Verification – Notes
Details describing why an independent field verification was identified as "Invalid". For example, Truck ID contained in the source data does not match that on the truck, Net Weight contained in the source data does not match the quantity of material delivered in the field, the mix designation contained in the source data is incorrect, etc.

JavaScript Notation (JSON)
JavaScript object notation in a lightweight, human-readable data-interchange format.

Material Code
Mix designation of material being delivered, including binder grade.

Material Delivery Management System (MDMS)
System that manages source, fleet, hauler, Agency and Contractor data associated with delivery of material to a contract.

Mix Design Identification
Mix designation report number.

OAuth 2.0
Industry standard protocol for authorization.

Overweight Weight
Weight of material exceeding the maximum allowable gross weight.

Paper Weight Ticket
Also called Bill of Lading. Printed copy of weight ticket created by load-out software.

Project Geofence
Static virtual perimeter around a subsection of the contract with specialized geographic designations (e.g., control section numbers).

REST
Acronym for Representational State Transfer. REST is an architectural style that applies the standards in the HTTP protocol creating the capability of exposing APIs over the internet.

RESTful
REST requires the following 6 guiding constraints to be considered RESTful: 1) client server; 2) stateless; 3) cacheable; 4) uniform interface; 5) layered system; 6) code on demand (optional).

Source Data
Data generated by the source's loadout software, such as contract, Agency project and source identification, material code, loading and weight information. This data is considered as the E-Ticket.

Source Geofence
Static virtual perimeter around boundary of source (e.g., boundary around plant).

Source Identification
AASHTOWare Project assigned source identification (e.g., plant identification, BP0001).

Source to Contract Time
Duration of time spent in transit between source and contract as calculated using time stamps of when truck exits source geofence and enters contract geofence.

Split Load
Loads that are split at delivery for use at more than one location, such as for patching, field and farm entrances, etc.

Time at Contract
Duration of time spent inside contract boundary as calculated using time stamps of when truck enters and exits contract geofence.

Time at Source
Duration of time spent at source as calculated using time stamps when truck enters and exits source geofence.

Truck Driver Classification
Description of truck classification as defined by the Federal Wage System. For example: Tractor Trailer Driver; Four or More Axle Unit, Straight Body Truck; Three Axle Units; or Two Axle Unit.

Veta
Standardized intelligent construction data management (ICDM) software that stores, maps and analyzes geospatial data resulting from intelligent construction technology (ICT) such as intelligent compaction, thermal profiling, dielectric profile method and spot test data (e.g., density, moisture). This software can perform standardized data processing, analysis and reporting to provide project summary results from various ICT manufacturers. In particular, the software can provide statistics, histograms, correlations for these measurements, document coverage area and evaluates the uniformity of the ICT measurements as part of the project quality control operations. Veta can be downloaded from the AMT Website.

S-1.2 MATERIALS (BLANK)

S-1.3 CONSTRUCTION REQUIREMENTS

A Equipment

A.1 Contractor's MDMS
Use system with a minimum of the following components:

- (1) Software to digitalize source data for inclusion as the E-Ticket in the Contractor's MDMS.
- (2) Ability to manually accept dump.
- (3) Portable, or hardwired, GNSS to track truck locations. The GNSS:
  - (a) Is powered independently, and/or through use of an adapter.
  - (b) Provides an indication of instances where there is interruption of satellite signals used to track truck locations.
  - (c) Is associated with corresponding truck identification and ticket number.
  - (d) Breadcrumb Trail
    - (1) Sends and saves breadcrumb trail at 1 minutes, or less, intervals.
    - (2) Playback features to display transit routes for each breadcrumb trail.
- (4) Geofences
  - (a) Static Geofences (when feature available)
    - (1) Establishes static geofence around source(s) and contract(s).

(2) Records geofence name and date and time stamps associated with truck when entering and exiting the *source* and *contract* geofences.
(3) Calculates duration of time spent within the source and contract geofence, and transit times between the "source to contract" and "contract to source".
(4) Allows Contractor ability to create source and contract geofences.

(b) Mobile Geofences
(1) Establishes a mobile geofence around dump location (e.g., paver, material transfer device, pickup machine) for recording of dump time and location. Hardware allows for user defined creation of geofence and an automated method to correctly indicate dump locations within 200 feet.

(5) Cloud storage and cloud computing to allow viewing and export of Contractor's MDMS data.

(6) User Interfaces (Web-, or Application-Based)
(a) When feature available, hauler user interface is available for entry of Hauler data per Table 2016-1 (MDMS).
(b) When interface available, continues to store data in user interface until automatic transfer of data in areas with limited to no data cellular coverage.
(c) When interface available, ability to enter Hauler data at a later date and time.
(d) Engineer has viewing in 3 minutes or less of the point of sale (using a web- or application-based user interface) of the following information in Contractor's MDMS when adequate data cellular coverage is available:
(1) Number of trucks at source, in transit from source to contract, at contract (and/or dump) and in transit from contract to source.
(2) When feature available, tabular summary of ticket status (e.g., ticket number, loaded, in transit, dumped).
(3) Source data per Tables 2016-1 (MDMS) and 2016-6 (MDMS)
(4) When data blocks available, Hauler data per Table 2016-1 (MDMS).
(e) When interface available, Contractor's MDMS will transmit source, fleet, and Hauler data to Veta MDMS in 4 minutes or less of point of sale.

(7) Instrument appropriate components of MDMS on all:
(a) Sources providing material to contract.
(b) Dump locations (e.g., pavers, pickup machines, or material transfer devices, etc.)
(c) Trucks delivering material to contract.

(8) Provide Engineer access to cloud storage and cloud computing prior to start of delivery of material. Cloud storage data is accessible until 90 days after final acceptance of all work per MnDOT 1516.2.

Table 2016-1 (MDMS)
Required Fields in MDMS for each Data Block

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Source	1	ContractID	Contract Identification	190065, R-37463	String
Source	2	ProjID	Agency Project Identification	SP1234-56, 1382810	String

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Source	3	SourceID	Source Identification	BP001 (e.g., Plant Identification)	String
Source	2b	ContractorName	Contractor Name	John Doe Contracting	String
Source	4	ScaleID	Scale ID	2, A2	String
Source	5	SiloID	Silo ID	5, A3	String
Source	6	(Intentionally Left Blank)	(Intentionally Left Blank)	(Intentionally Left Blank)	(Blank)
Source	7	(Intentionally Left Blank)	(Intentionally Left Blank)	(Intentionally Left Blank)	(Blank)
Source	8	SourceNote	Source Notes	First Load, Last Load, Warnings	String
Source	9	MixDesignID	Mix Design Identification	02-2020-184, RMX135-030, (e.g., mix design report number)	String
Source	10	MatlCode	Material Code	SPWEA340C, DMF #1932480001 (e.g., mix designation)	String
Source	11	TicketNum	Ticket Number	5126349, 101R, 539-19	String
Source	12	LoadNum	Load Number	75	Number
Source	13	TruckID	Truck Identification	51.6046, 88tb, T-1, T1	String
Source	14	TrailerID	Trailer Identification	51.6046, 88tb, T-1, T1	String
Source	15	VoidedTicket	Voided Ticket	See Table 2016-2 (MDMS)	String
Source	16	LoadDateTime *	Loading Date and Time	2007-04-05T12:30-02:00	String
Source	17	GrossWt	Gross Weight	44.33	Number
Source	18	NetWt	Net Weight	26.83	Number
Source	19	TruckTareWt ‖	Truck Tare Weight	17.50	Number
Source	20	DailyRunningTotal ByMixDesignWt †	Daily Running Total By Mix Designation Weight	1900.64	Number
Source	21	ContractTotalByMix DesignWt †	Contract Total by Mix Designation Weight	2400.45	Number
Fleet	22	OverweightWt #	Overweight Weight	0.33	Number
Fleet	23	SourceGeoName ‡ #	Source Geofence Name	See Table 2016-10 (MDMS)	String
Fleet	24	SourceLat	Source Latitude	45.072644	Number
Fleet	25	SourceLong	Source Longitude	-93.868772	Number
Fleet	26	TruckEntersSource GeoDateTime *, ‡ #	Truck Enters Source Geofence Date and Time	2007-04-05T12:30-02:00	String
Fleet	27	TruckExitsSourceGe oDateTime *, ‡ #	Truck Exits Source Geofence Date and Time	2007-04-05T12:35-02:00	String
Fleet	28	TimeAtSource ‡ #	Time at Source	HH:MM:SS, 00:05:00	String
Fleet	29	SourceToContractTi me ‡ #	Source to Contract Transit Time	HH:MM:SS, 00:10:00	String
Fleet	30	ContractGeoName ‡ #	Contract Geofence Name	See Table 2016-10 (MDMS)	String
Fleet	31	TruckEntersContract GeoDateTime *, ‡ #	Truck Enters Contract Geofence Date and Time	2007-04-05T12:55-02:00	String
Fleet	32	TruckExitsContract GeoDateTime *, ‡ #	Truck Exits Contract Geofence Date and Time	2007-04-05T12:55-02:00	String

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Fleet	33	TimeAtContract ‡ #	Time At Contract	HH:MM:SS, 00:05:00	String
Fleet	34	ContractToSourceTime ‡ #	Contract to Source Transit Time	HH:MM:SS, 00:10:00	String
Fleet	35	DumpEquipID [e] #	Dump Equipment Identification	27XVYZLP	String
Fleet	36	DumpGeoName ‡ # §	Dump Geofence Name	See Table 2016-10 (MDMS)	String
Fleet	37	DumpDateTime *	Dump Date and Time	2007-04-05T12:50-02:00	String
Fleet	38	DumpLat	Dump Latitude	45.072644	Number
Fleet	39	DumpLong	Dump Longitude	-93.868772	Number
Hauler	40	ContractorJobNum #	Contractor Job Number	20-10	String
Hauler	41	HaulerCompName #	Hauler Company Name	John Doe Contracting	String
Hauler	42	BrokerName #	Broker Name	Joes	String
Hauler	43	DOTNum #	DOT Number	US DOT 33136	String
Hauler	44	HaulerTruckID # **	Hauler Truck Identification	51.6046, 88tb, T-1, T1	String
Hauler	45	TruckDriverClass #	Truck Driver Classification	See Table 2016-3 (MDMS)	Number
Hauler	46	OverweightPermitNum #	Overweight Permit Number	033I9021331	String
Hauler	47	MaxGrossWt #	Maximum Gross Weight	44	Number
Hauler	48	DriverName #	Driver Name	John Doe	String
Hauler	49	ShiftStartDateTime #	Shift Start Date and Time	2020-04-05T06:00-02:00	String
Hauler	50	ShiftEndDateTime #	Shift End Date and Time	2020-04-05T14:00-02:00	String
Agency	51	AgencySampleId # ‖ ‖	Agency Sample Identification	583	String
Agency	52	AgencyMatlTempAtSource # ‖ ‖	Agency Matl Temperature at Source	290	Number
Agency	53	AgencyMatlTempAtField # ‖ ‖	Agency Matl Temperature at Field	275	Number
Agency	54	AgencyAirTemp # ‖ ‖	Agency Air Temperature	90	Number
Agency	55	AgencySplitLoad1Wt #	Agency Split Load 1 Weight	10.0	Number
Agency	56	AgencySplitLoad1PayItem #	Agency Split Load 1 Pay Item	2260.509, 2231.507, 2105.602	String
Agency	57	AgencySplitLoad1LocNote #	Agency Split Load 1 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Agency	58	AgencySplitLoad2Wt #	Agency Split Load 2 Weight	3.0	Number
Agency	59	AgencySplitLoad2PayItem #	Agency Split Load 2 Pay Item	2260.509, 2231.507, 2105.602	String
Agency	60	AgencySplitLoad2LocNote #	Agency Split Load 2 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Agency	61	AgencySplitLoad3Wt #	Agency Split Load 3 Weight	2.0	Number

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Agency	62	AgencySplitLoad3PayItem #	Agency Split Load 3 Pay Item	2260.509, 2231.507, 2105.602	String
Agency	63	AgencySplitLoad3LocNote #	Agency Split Load 3 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Agency	64	AgencyWastedMatlWt #	Agency Wasted Material Weight	13	Number
Agency	65	AgencyLoadAcceptReject # ††	Agency Load Acceptance and Rejection	See Table 2016-4 (MDMS)	Number
Agency	66	AgencyPartialRejectedLoadWt #	Agency Partial Rejected Load Weight	6	Number
Agency	67	AgencyDumpStationNum #	Agency Dump Station Number	1200+00, 120000	String
Agency	68	AgencyFieldNote #	Agency Field Notes	Load was split for patching work	String
Agency	69	AgencyInspectorId #	Agency Inspector Identification	John Doe, JDJ	String
Agency	70	AgencyDateTime * # ‡‡	Agency date and time	2007-04-05T12:30-02:00	String
Agency	71	IndVerDateTime * # ‡‡	Independent Field Verification – Date and Time	2007-04-05T12:30-02:00	String
Agency	72	IndVerLat # †† ##	Independent Field Verification –Latitude	45.072644	String
Agency	73	IndVerLong # †† ##	Independent Field Verification –Longitude	-93.868772	String
Agency	74	IndVerStation #	Independent Field Verification – Station	1110+00, 111000	String
Agency	75	IndVerEstNetWt #	Independent Field Verification – Estimated Net Weight	15	Number
Agency	76	IndVerIndScaleWt #	Independent Field Verification – Independent Scale Weight	16.25	Number
Agency	77	IndVerIndScaleCert #	Independent Field Verification – Independent Scale Certification	6X23450, 123456	String
Agency	78	IndVerNetWtOnETicket #	Independent Field Verification – Net Weight on E-Ticket	16.25	Number
Agency	79	IndVerDriverName #	Independent Field Verification – Driver Name	John Doe	String
Agency	80	IndVerHaulerCompanyName #	Independent Field Verification – Hauler Company Name	John Doe Contracting	String
Agency	81	IndVerApproval #	Independent Field Verification – Approval	See Table 2016-5 (MDMS)	String
Agency	82	IndVerNote #	Independent Field Verification – Notes	The net weight included on the E-Ticket does not match that which was delivered in the field.	String

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
Agency	83	IndVerInspectorID #	Independent Field Verification – Inspector Identification	John Doe, JDJ	String
Contractor	84	ContractorSampleId # ‖ ‖	Contractor Sample Identification	583	String
Contractor	85	ContractorMatlTempAtSource # ‖ ‖	Contractor Material Temperature at Source	290	Number
Contractor	86	ContractorMatlTempAtField # ‖ ‖	Contractor Material Temperature at Field	275	Number
Contractor	87	ContractorAirTemp # ‖ ‖	Contractor Air Temperature	90	Number
Contractor	88	ContractorSplitLoad1Wt #	Contractor Split Load 1 Weight	10.0	Number
Contractor	89	ContractorSplitLoad1PayItem #	Contractor Split Load 1 Pay Item	2260.509, 2231.507, 2105.602	String
Contractor	90	ContractorSplitLoad1LocNote #	Contractor Split Load 1 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Contractor	91	ContractorSplitLoad2Wt #	Contractor Split Load 2 Weight	3.0	Number
Contractor	92	ContractorSplitLoad2PayItem #	Contractor Split Load 2 Pay Item	2260.509, 2231.507, 2105.602	String
Contractor	93	ContractorSplitLoad2LocNote #	Contractor Split Load 2 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Contractor	94	ContractorSplitLoad3Wt #	Contractor Split Load 3 Weight	2.0	Number
Contractor	95	ContractorSplitLoad3PayItem #	Contractor Split Load 3 Pay Item	2260.509, 2231.507, 2105.602	String
Contractor	96	ContractorSplitLoad3LocNote #	Contractor Split Load 3 Location Note	1210+00, BG Farm Entrance, Mainline Paving, 12L-CL, CL-12R	String
Contractor	97	ContractorWastedMatlWt #	Contractor Wasted Material Weight	13	Number
Contractor	98	ContractorLoadAcceptReject # ††	Contractor Load Acceptance and Rejection	See Table 2016-4 (MDMS)	Number
Contractor	99	ContractorPartialRejectedLoadWt #	Contractor Partial Rejected Load Weight	6	Number
Contractor	100	ContractorDumpStationNum #	Contractor Dump Station Number	1200+00, 120000	String
Contractor	101	ContractorFieldNote #	Contractor Field Notes	Load was split for patching work	String
Contractor	102	ContractorStaffId #	Agency Staff Identification	John Doe, JDJ	String
Contractor	103	ContractorDateTime * # ‡‡	Contractor date and time	2007-04-05T12:30-02:00	String

* Includes UTC offset.
‖ Required when a load cell is used on hoppers beneath a surge or storage bin.
† Data field is provided either by source or Contractor's MDMS. This information is not provided in a digitalized format by some source loadout software.

MDMS Data	Reference Field No.	JSON Field Name	Long Description	Examples	Data Type
‡ Used for calculating truck transit flow rates, independent verification to assist with supporting delivery of material and for Labor Compliance audits, such as monitoring of prevailing wages, disadvantaged business enterprise (DBE) hours, State Small business Requirements, etc. # Data is provided when field is available. § Assists with reconciling pay quantities. ** Truck identification must match that used with source data in E-Ticket. ‖‖ One or more measurements may be recorded. †† Used to manually accept material for instances where an Engineer is present and the truck exchange information is not automatically recorded per Section S-1.3.A.1(4)(b) and to also reject loads. ‡‡ Data is auto-generated by Contractor's MDMS. ## Location service on device must be turned on for collection of this information.					

Table 2016-2 (MDMS)
Lookup Table for Voided Tickets

Source Data Description	Data Block Value
Material not loaded for delivery to project – source ticket number voided	Voided
Material loaded for delivery to project	Valid
Source ticket number generated, but does not have associated material loaded for delivery to project	Orphan

Table 2016-3 (MDMS)
Lookup Table for Driver Classification

Format	Example Index *
Tractor Trailer Driver	602
Four or More Axle Unit, Straight Body Truck	604
Three Axle Units	607
Two Axle Unit	613
* Index reflects Labor Code used for Craft in AASHTOWare Project. Code will vary by Agency.	

Table 2016-4 (MDMS)
Lookup Table for Manual Load Acceptance

Data Description	Data Block Value *
Load accepted for placement	Accepted
Load not accept load for placement	Rejected
Default Value	Null
* By default, field is set as Null.	

Table 2016-5 (MDMS)
Lookup Table for Independent Field Verification - Approval

Description	Data Block Value
Engineer finds no issues with source and hauler data during field review	Valid
Issues found during Engineer review of source and hauler data during field review	Invalid

Table 2016-6 (MDMS)
Required Fields for Source Identification Data

E-Ticket Data	Field Name	Long Description	Examples	Data Type
Source	SourceID	Source Identification	BP001 (e.g., plant identification)	String
Source	SourceName	Source Name	John Asphalt, John Asphalt 3 Burnsville, John Plant 7 (e.g., long description of plant name)	String

E-Ticket Data	Field Name	Long Description	Examples	Data Type
Source	PortablePlant	Portable Plant	See Table 2016-7 (MDMS) for lookup table for portable plant	String
Source	SourceAddress	Source Address	12345 Marvel Street NW, MN 56738	String
Source	SourcePhoneNum	Source Phone Number	777-777-7777	String

Table 2016-7 (MDMS)
Lookup Table for Portable Plant

Portable Plant Description	Data Block Value
Material is from a portable plant	Yes
Material is not from a portable plant (i.e., material is from a permanent plant)	No

A.2 MDMS Data Fields

Each data block of Contractor's MDMS will contain source, fleet, and Hauler data per Table 2016-1 (MDMS) and meet the following requirements:

(1) Load numbers are generated in sequential order and not shared sequences with other projects.
(2) All data fields are automatically populated, with the exception of the following:
  (a) When user interface available, Hauler can real-time manually enter Hauler data per Table 2016-1 (MDMS), when adequate data cellular coverage is available, or at a later time for instances with limited to no data cellular coverage.
  (b) When feature available, ability to enter source identification data, per Table 2016-6 (MDMS), into Contractor's MDMS.
(3) When data blocks available, modifications or deletions to Hauler data can only be made by Hauler.
(4) When feature available, hauler data entered, into Contractor's user interface, is auto-populated into the associated data block fields of the MDMS (per Table 2016-1 [MDMS]), by tying (at a minimum) contract job number, truck identification, and shift start and end times to the Load Date and Time.
(5) Fleet data collected and stored in system separate from Contractor's MDMS must contain Ticket Number in addition to fleet data blocks listed in Table 2016-1 (MDMS).

A.3 Source Data to Contractor's MDMS

Centralized suppliers and Contractor owned sources will provide source data to Contractor's MDMS in 2 minutes or less of point of sale.

Contractor's MDMS will provide source data to Contractor's MDMS user interface in 1 minute or less of receipt of data when adequate data cellular coverage is available.

A.3.a Contractor Owned Permanent / Portable Sources

Contractor owned permanent and portable sources will provide source data through a solution of the Contractor's MDMS or per S-1.3.A.3.b.

A.3.b Centralized Suppliers and Contractor Owned Permanent / Portable Sources

Centralized suppliers and Contractor owned permanent and portable sources will provide source data to Contractor's MDMS per the following method.

Centralized suppliers, Contractor owned permanent and portable sources, and MDMS vendors will use:

(1) REST APIs (secured using the OAuth 2.0 Standard) exposed by the MDMS vendors for transmittal of source data to the MDMS vendor.

(2) JSON data interchange language as the format for data sent and received from the REST APIs.

(3) JSON request body format will contain the source data per ticket per Tables 2016-1 (MDMS), 2016-8 (MDMS) and 2016-9 (MDMS).

Table 2016-8 (MDMS)
Recognized Unit Lookup Table

JSON Field	Unit Description
LoadDateTimeUnit	YYYY-MM-DDThh:mm:ss±hh:mm
GrossWtUnit	Refer to Table 2016-9 (MDMS)
NetWtUnit	Refer to Table 2016-9 (MDMS)
TruckTareWtUnit	Refer to Table 2016-9 (MDMS)
DailyRunningTotalByMixDesignWtUnit	Refer to Table 2016-9 (MDMS)
ContractTotalByMixDesignWtUnit	Refer to Table 2016-9 (MDMS)

Table 2016-9 (MDMS)
Lookup Table for Units used for Weights

Format	Index
Metric Tons	1
US Tons	2
Kilogram	3
Pounds	4

(4) Vendor's MDMS will allow import of more than one ticket per JSON message should batch queuing occur as a result of unexpected issues by centralized supplier or Contractor owned source.

A.4 Data Transmittals

A.4.a File Downloads

All Contractor's MDMS source, fleet, and hauler data fields, per Table 2016-1 (MDMS), are compiled into a single database table that is exportable by Engineer as a dbase ASCII, CSV, XLSX, or text format within 15 minutes intervals from Contractor's MDMS. Fleet data, collected in systems separate from Contractor's MDMS, may be exported as a separate table, but must include ticket number for cross referencing to source, fleet, and Hauler data.

A.4.b REST APIs and JSON

When feature available, MDMS vendors will use the following for transmittal of MDMS data:

(1) REST APIs (secured using the OAuth 2.0 Standard) exposed by MDMS Vendors.
(2) JSON data interchange language as the format for data sent and received from REST APIs.
(3) JSON request body format will contain MDMS data per Tables 2016-8 (MDMS) and 2010-9 (MDMS) and the following data fields per Table 2016-1 (MDMS) for transmittal of data from Contractor's MDMS to Veta MDMS: source (1-21), fleet (22-35, 37-39), and Hauler (40-50).
(4) When feature available, MDMS vendors will provide the source, fleet, and Hauler data to Veta MDMS in 4 minutes or less of point of sale.

B. Pre-Construction Activities

B.1.a Source Identification Data

When feature available, enter source identification data per Table 2016-6 (MDMS) into Contractor's MDMS, along with other needed startup information.

B.1.b Internet (or satellite) Connectivity

Set up internet (or satellite) connectivity at all sources used to provide material to the contract.

B.1.c Geofences

Contractor will set up the following geofences in Contractor's MDMS:

(1) Source Geofence(s)
(2) Contract Geofence(s)
(3) Mobile Dump Geofence(s) – Set up mobile geofence around boundaries of equipment that material is being delivered to such as paver, pickup machine, or material transfer device, etc.

Contractor and Engineer will name geofences using the standardized naming convention per Table 2016-10 (MDMS).

Table 2016-10 (MDMS)
Geofence Standardized Naming Convention

Geofence	Standardized Naming Convention
Source	SourceID_CountyName *
Contract	ContractID ‖ †
Project	ProjectNumber_CountyName ‡
Category	ProjectNumber_CountyName_Category #

* Example of Source Geofence Standardized Naming Convention: BP001_StLouis

‖ Contract geofence may be split into smaller subsections for larger contracts to assist with more accurate flow rate calculations. An acronym can be added to geofence standardized naming convention by adding an underscore and needed distinguishing acronym.

† Example of Contract Geofence Standardized Naming Convention: CN200078, CN200078_W, CN200078_E

‡ Examples of Project Geofence Standardized Naming Convention: SP3101-37_Itasca, SP6901-29_StLouis

Examples of Category Geofence Standardized Naming Convention: SP6931-01_StLouis_CAT0001, SP6931-01_StLouis_CAT0002

B.1.d Training

Provide training to Engineer no later than 7 calendar days prior to start of work requiring MDMS. Training will include instruction and viewing of a minimum of the following:

(1) Contractor's MDMS web- and/or application- based platforms.
(3) Geofence boundaries and naming conventions used for Contract and source.
(4) Data fields included in contractor's MDMS data collection and export.
(5) Real-time viewing of items listed in section S-1.3.A.1(6)(d).
(6) Playback of breadcrumb trails.
(7) Example export of Contractor's MDMS data per section S-1.3.A.4.

C. System Failure

System failure occurs when the MDMS does not collect and/or store data per the requirements of this provision and/or when data cellular coverage is limited.

Notify Engineer when system failure occurs and immediately after resolution of issues. Provide Engineer with a resolution to the issues and an acceptable time frame for completing the resolution prior to resuming the next day's paving operation.

Source data will revert to paper weight tickets (or other means, which is approved by the Engineer) for sharing source data during system failures.

D. Documentation

Each truck driver will carry a paper weight ticket that is collected by the Engineer. The Engineer will use the paper weight ticket for generation of density lots and calculation of pay quantities per requirements of MnDOT 2360.

E. Independent Field Verification

Engineer will complete independent field verification within delivery of first 10 loads of material and 1,000-ton lots thereafter. Use Engineer approved random number generator to determine independent field verification tonnage for each lot. The Engineer's independent field verification will consist of the following:

(1) Review of source and hauler data contained within MDMS to verify that all required fields, per Table 2016-1 (MDMS), are available and accurate.
(2) Compare Engineer's estimated net weight of material delivered by truck to net weight contained in MDMS. Record Engineer's estimated net weight and net weight provided in MDMS for later use in verification of net weight included in the final MDMS data export used for reconciling quantities.
(3) If source data is invalid, the Engineer will report the system failure to the Contractor. The Contractor will provide the Engineer with a resolution to the issues and acceptable time frame for completing the resolution prior to resuming the next day's paving operation. The Engineer will complete independent field verification within delivery of the first 10 loads of material and 1,000-tons lots thereafter, upon resolution of the system failure.

S-1.4 METHOD OF MEASUREMENT (BLANK)

S-1.5 BASIS OF PAYMENT

Interruptions in availability of data cellular coverage and/or satellite signals used with this system will not result in adjustments to the "Basis of Payment" for any construction items or to Contract time.

The ton price for (2016) Quality Management – E-Ticketing includes data entry of project information, set up of appropriate MDMS components, system set up to push source data into MDMS, internet connectivity at permanent and portable sources, set up of geofences, system monitoring, assigning and distribution of truck asset trackers, monitoring of yields rates recorded by MDMS, remote server storage, cloud-based software accessibility and data package plans.

A Monetary Adjustment

The Department must apply incentives for (2016) Quality Management – E-Ticketing (Material Delivery Management System). The amounts of these adjustments are deemed reasonable.

A single lump sum payment of $5,000 will be issued when the MDMS collects, stores and exports data with all of the following features and all other requirements of this provision:

(1) S-1.3.A.1(4)(a)
(2) S-1.3.A.1(6)(a)
(3) S-1.3.A.1(6)(b)
(4) S-1.3.A.1(6)(c)
(5) S-1.3.A.1(6)(d)(2)
(6) S-1.3.A.1(6)(d)(4)
(7) S-1.3.A.2(2)
(8) S-1.3.A.2(3)
(9) S-1.3.A.2(4)
(10) S-1.3.B.1.a
(11) Provides data for the fields identified by note "#" in Table 2016-1 (MDMS).

(12) Exports all source, fleet and Hauler data fields listed in Table 2016-1 (MDMS).

S-1.3.A.1(6)(e), S-1.3.A.4.b, and reference field number 36 of Table 2016-1 (MDMS) are not required for receipt of the monetary adjustment as these features require development from an external resource other than that of the MDMS vendor.

B Schedule

The Department will pay for ton item 2016.609 Quality Management – E-Ticketing on the basis of the following schedule:

Item No.	Item	Unit
2016.609	Quality Management – E-Ticketing	Ton