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Methods to Identify Problematic Carriers and Prevent Infrastructure Damage

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16. Abstract
Routinely collected Massachusetts data sets, including overweight permit applications and commercial truck inspections, are underused in safety and infrastructure analysis. Data warehousing and computing capabilities are advancing to allow live-time trend monitoring which could enhance enforcement efforts of overweight vehicles through proactive analysis and outlier identification. This project collected, examined, and used a variety of transportation data sets to establish expertise, document nuances, and execute linkage hypotheses. Key informant interviews, an information synthesis of current practices, and a literature review informed the selection of the canisters' fields of interest. The experiential process of requesting data from other agencies and departments resulted in lessons learned on time-delay and compromises in desired format, breadth, and depth. Ultimately, this research and feasibility study was confirmed with the successful development of three data set-canister linkages, demonstrating that decoupled data sets can be used to comprehensively examine overweight vehicle and carrier trends, and normalize analyses for improved problem identification.

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Methods to Identify Problematic Carriers and Prevent Infrastructure Damage

Final Report

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Executive Summary

This study of Methods to Identify Problematic Carriers and Prevent Infrastructure Damage was undertaken as part of the Massachusetts Department of Transportation (MassDOT) Research Program. This program is funded with Federal Highway Administration (FHWA) State Planning and Research (SPR) funds. Through this program, applied research is conducted on topics of importance to the Commonwealth of Massachusetts transportation agencies.

Since this project's initiation on June 2, 2022, UMassSafe has worked to assist MassDOT in a feasibility study to support the future development of improved processes for enhancing safety and preserving infrastructure. Using a variety of relevant data sets, including the Federal Motor Carrier Safety Administration (FMCSA) Census, FMCSA Safety Measurement system (SMS), MassDOT Oversize Overweight Permitting and Routing Application (OASIS), Massachusetts State Police (MSP) SafetyNet Crash and Inspection, and MassDOT Registry of Motor Vehicles (RMV) Division Crash and Citation, UMassSafe has determined ways in which these disparate data sets can be linked to provide a more detailed understanding of problem carriers and their associated trends, as well as identify possible ways these linkages can be used to assist in expanding the identification of overweight vehicles to prevent infrastructure damage.

Identifying and quantifying oversize/overweight (OS-OW) trucking operations in Massachusetts, as well as their violation types and rates, is necessary to improve roadway safety and prevent further damage to the Commonwealth's aging and evolving bridge and roadway systems. As a result, UMassSafe conducted research into these operations to establish the current use and availability of relevant data sets, methods of access, and integration nuances related to OS-OW trucking. Challenges stem from idiosyncratic schemas, inconsistent unique identifiers, data ownership, methods, and policies of sharing, as well as data quality.

The project's goals consisted of a feasibility study to support expanding relevant stakeholder access to and understanding of underused CMV and citation data sets. Ultimately, this study can function as a foundation for enhancing statewide efforts toward decoupling the data hub model, and monitoring data trends across freight planning, permitting, infrastructure, real-time use, and enforcement realms.

This study was accomplished by compiling a comprehensive classification of relevant state and federal data sources, fields, and their frameworks of interoperability, followed by the development of recommendations and procedures for utilizing multiple data sets as a means of identifying problematic OS-OW-restricted infrastructure, as well as carrier and/or vehicle-specific trends. Expanding access to underused CMV and citation data sets has the potential to enhance the statewide effort toward a decoupled data hub model. State data-access initiatives can be further leveraged with specifications of other existing user interfaces comprehensively documented. Ultimately, the awareness and integration of these specialized fields could enhance the identification of problematic trends across freight planning,

permitting, infrastructure, real-time use, and enforcement realms, adding operational safety value. This initial research and feasibility phase of a multiphase plan has identified stakeholders for collaboration across multiple departments and agencies. In the following phase, data architects will rely on these results for future integration into a decoupled state data hub.

Upon completion of this phase, MassDOT data users, analysts, and planners will be able to immediately use procedures to target problematic uses of the Commonwealth's vulnerable height and/or weight restricted transportation infrastructure. In future phases, models and software systems could be developed to run in live time with proactive analysis and identification.

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List of Acronyms

Acronym	Expansion
A&I	Analysis & Information
AAMVA	American Association of Motor Vehicle Administrators
AASHTO	American Association of State Highway and Transportation Officials
AVI	Automatic Vehicle Identification
BASIC	Behavior Analysis and Safety Improvement Categories
BIMS	Bridge Inspection Management System
CAD	Computer-Aided Design
CB	Citizen's Band
CDL	Commercial Driver's License
CDLIS	Commercial Driver's License Information System
CDS	Crash Data System
CMV	Commercial Motor Vehicle
COOPR	Colorado Oversize Overweight Permitting and Routing
CRSS	Crash Report Sampling System
CSA	Compliance Safety Accountability
CSMS	Carrier Safety Measurement System
CSP	Company Safety Profile
CSV	Comma-Separated Values
CVIEW	Commercial Vehicle Information Exchange Window
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operations
D20	Data Element Dictionary for Traffic Records Systems
DCR	Department of Conservation and Recreation
DEP	Department of Environmental Protection
DOR	Department of Revenue
DPU	Department of Utilities
DSRC	Dedicated Short-Range Communications
EC	Education Contacts
EIN	Employee Identification Number
ESAL	Equivalent Single Axle Load
FARS	Fatality Analysis Reporting System
FBF	Federal Bridge Formula
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulations
GAO	Government Accountability Office
GCWR	Gross Combination Weight Rating
GIS	Geographic Information System
GPS	Global Positioning System
GVWR	Gross Vehicle Weight Rating

Acronym	Expansion
HM	Hazardous Material
HMR	Hazardous Materials Regulations
HOS	Hours of Service
HPMS	Highway Performance Monitoring System
HSIP	Highway Safety Improvement Program
HVCRL	Heavy Vehicle Confidential Reporting Line
HVNL	Heavy Vehicle National Law
IAP	Intelligent Access Program
IFTA	International Fuel Tax Association
IMPACT	Interactive Mapping Portal for Analysis and Crash Tracking
IRP	International Registration Plan
ISS	Inspection Selection System
LCV	Light Commercial Vehicle
LPR	License Plate Reader
MassDOT	Massachusetts Department of Transportation
MCMIS	Motor Carrier Management Information System
MCSAP	Motor Carrier Safety Assistance Program
MIRE	Model Inventory of Roadway Elements
MMUCC	Model Minimum Uniform Crash Criteria
MSP	Massachusetts State Police
MSP CVES	Massachusetts State Police Commercial Vehicle Enforcement Section
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NCHRP	National Cooperative Highway Research Program
NCR	Noncompliance Report
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NHVR	National Heavy Vehicle Regulator
NYSDOT	New York State Department of Transportation
NYS	New York State
OASIS	Oversize Overweight Permitting and Routing Application
OCR	Optical Character Recognition
OOS	Out of Service
OS-OW	Oversize/Overweight
PBS	Performance-Based Standards
PHFS	Primary Highway Freight System
PHMSA	Pipeline and Hazardous Materials Safety Administration
QR	Quick Response
RFI	Request for Information
RMV	Registry of Motor Vehicles
SAFER	Safety and Fitness Electronic Records
SDLA	State Driver Licensing Agency
SEA	Safety Evaluation Area
SI&A	Structural Inventory & Appraisal

Acronym	Expansion
SMS	Safety Measurement System
SPR	State Planning and Research
SR/CR	Safety/Compliance Reviews
SSN	Social Security Number
TAM	Trucking Association of Massachusetts
TRB	Transportation Research Board
UCR	Unified Carrier Registration
USDOT	United States Department of Transportation
VIN	Vehicle Identification Number
WIM	Weigh-in-Motion

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1.0 Introduction

This study of Methods to Identify Problematic Carriers and Prevent Infrastructure Damage was undertaken as part of the Massachusetts Department of Transportation (MassDOT) Research Program. This program is funded with Federal Highway Administration (FHWA) State Planning and Research (SPR) funds. Through this program, applied research is conducted on topics of importance to transportation agencies within the Commonwealth of Massachusetts.

The ability to accurately identify and quantify oversize/overweight (OS-OW) trucking operations in Massachusetts, as well as their violation types and rates, is necessary to prevent further damage to the aging and evolving roadway infrastructure in Massachusetts. To achieve this, research is required to establish the current use and availability of relevant data sets, methods of access, and integration nuances. Currently, there is much variance across the available data sets without an intuitive way to harmonize them for effective analysis toward the prevention of infrastructure damage, causing siloes in their use. Challenges stem from idiosyncratic schemas, inconsistent unique identifiers, data ownership, methods, and policies of sharing, as well as data quality.

1.1 Project Goals

The project goals were the following:

- Expanding access and understanding of underused commercial motor vehicle (CMV) and citation data sets to relevant stakeholders.
- Enhancing the statewide effort working toward a decoupled data hub model; and
- Monitoring data trends across freight planning, permitting, infrastructure, real-time use, and enforcement realms.

1.2 Main Objectives

These goals were accomplished through the project's main objectives:

- Compile a comprehensive classification of relevant state and federal data sources, fields, and their framework of interoperability; and
- Develop recommendations and procedures for the use of multiple data sets to identify problematic size/weight restricted transportation infrastructure, as well as carrier/vehicle-specific trends.

1.3 Project Outcomes

Expanding access to underused CMV and citation data sets has the potential to enhance the statewide effort toward a decoupled data hub model. State data-access initiatives can be further leveraged with specifications of other existing user interfaces comprehensively documented. Ultimately, the awareness and integration of these specialized fields could enhance the identification of problematic trends across freight planning, permitting, infrastructure, real-time use, and enforcement realms, adding operational safety value. This initial research and feasibility phase of a multiphase plan has identified stakeholders for collaboration across multiple departments and agencies. In the following phase, data architects will rely on these results for future integration into a decoupled state data hub.

Upon completion of this phase, MassDOT data users, analysts, and planners can employ immediate-use procedures to target problematic uses of the Commonwealth's vulnerable height and/or weight restricted transportation infrastructure. In future phases, models and software systems could be developed to run in live time with proactive analysis and identification.

2.0 Research Methodology

2.1 State of the Practice

The first task consisted of a comprehensive literature review, Massachusetts-specific key informant interviews, and information synthesis of other states' practices to identify and quantify OS-OW trucking and enforcement operations. This included an examination of the following data practices:

- DOT awareness and collaboration with Federal Motor Carrier Safety Administration (FMCSA) Motor Carrier Management Information System (MCMIS) partners
- Internal DOT composition of relevant self-supported data sets
- Public-facing data access sources - relevant uses and unrealized benefits

Existing efforts to identify vulnerable-infrastructure usage were examined. Best practices and challenges were determined to inform the Massachusetts-specific data analyses to explore. The process included interviews with various commercial vehicle and infrastructure stakeholders within Massachusetts to provide insights into relevant data sources, departmental roles in management and use, current resources to prevent roadway infrastructure damage and carrier-specific abuse, as well as challenges specific to enforcing OS-OW permits. Questions were asked relevant to the specific departments represented, specifically, how their data is collected, used internally, shared externally, and other essential topics related to problem carriers or data improvements. Interviews were conducted with the following individuals:

- MassDOT Bridge Rating and Overload Unit: Bridge Load Rating and Overload Engineer
- MassDOT Bridge Inspection: Bridge Inspection Engineer
- ProMiles: Government Account Representatives
- MassDOT Geospatial Technology: Manager of GIS Services
- MassDOT Office of Transportation Planning: Multimodal Planning
- MA State Police Commercial Vehicle Enforcement Section: Research Analyst

A technical report detailing the state of the practice on OS-OW carrier monitoring was created as a deliverable for the tech transfer initiatives associated with this project.

2.2 Classification of Data Sources, Fields, and Framework of Interoperability

A deliverable, "Dataset_Compilation.xlsx," was prepared for stakeholders as part of this project's tech transfer initiative. Within, each relevant data set was detailed, with field

names, data types, supplemental schema information, and a sample of data content or list of attributes by field included. An "Identifying Field of Importance" column was included to designate the potentially relevant fields to facilitate linkages across sources at the incident, vehicle, and carrier levels. Additionally, the column "Fields of Topical Interest" was included to itemize fields worthwhile for OS-OW analytics.

Using the knowledge gained through the examination and documentation of the relevant data sets, a secondary task in this project involved the classification of data sets and fields. This was necessary to establish the constraints for developing a framework of cross-source interoperability. Data sets, including FMCSA Census, MassDOT Oversize Overweight Permitting and Routing Application (OASIS) Permits, Massachusetts State Police (MSP) SafetyNet inspection, as well as MassDOT Registry of Motor Vehicles (RMV) Division Crash and Citation, were collected, cleaned, organized, and consolidated. This collection and integration task aimed to obtain two to three of the most recent years' data from data owners that would be used to conduct a classification of schema components and data types, as well as an analysis of time-delay completeness for each data source to ensure a fair representation.

Data sets were obtained through a variety of methods including web system portals and manual extraction. Therefore, with the lack of systemization, researchers experienced varying levels of usability as well as supporting documentation. Project adaptations were implemented to focus efforts on the obtainable data. Unforeseen complications provided a unique exercise for researchers working with various agencies and departments to allow use and physically obtain their data sets. Collection and consolidation of the various data sets were described in preparation for the development of canister analyses.

2.2.1 FMCSA Census Data set

This data set is downloadable from FMCSA as a flat file that itemizes all motor carriers by their United States Department of Transportation (USDOT) number; the USDOT number is issued by this agency and serves as the most common way to identify a carrier across all platforms. As of the June 30, 2023, extract, the data set included 2,033,886 interstate, intrastate, and hazmat motor carriers. The file is comma delimited, with one carrier per row. Data set nuances and notes for future replication were itemized.

2.2.2 OS-OW Permit Application Data

UMassSafe's methodology for extracting overweight permit data from the OASIS portal involved the use of a Python-based web scraping tool, the Selenium WebDriver. This tool programmatically navigated the OASIS portal, interacted with web elements, input necessary credentials, and efficiently extracted necessary data records, as outlined:

1. Initial Setup and Browser Automation: UMassSafe initiated the process by setting up the Selenium WebDriver with Chrome Options to maximize the browser window for optimal interaction. The WebDriver was directed to navigate to the OASIS portal's login page.

2. Login Process: Automated input of user credentials into the login form fields was implemented. This step was crucial for gaining access to the restricted areas of the portal where permit data is stored.
3. Navigation and Data Selection: Post-login, the script navigated through the portal's interface. This involved selecting specific drop-down options to filter the search criteria, specifically targeting Permit-related data. The date range for data extraction was set by automatically inputting a predefined date in the portal's date field.
4. Data Extraction Process: Once the search criteria were set, the tool initiated the data extraction process. This involved a looped sequence where the script selected and printed reports page by page. The extraction process was optimized to handle pagination by automatically clicking through pages until all relevant data was captured.
5. Error Handling: Error-handling mechanisms were established, particularly for scenarios where expected web elements (such as buttons or checkboxes) were not found. This ensured that the script operated smoothly and could handle unexpected web page structures or changes.
6. Data Compilation and Termination: Extracted data, filtered based on predefined criteria, was compiled for further processing. The script concluded its operation by terminating the WebDriver session, ensuring no resources were left engaged.

For the 2022 data extraction from the OASIS portal, the process resulted in 1,196 Excel files, each comprising up to 100 records of overweight permit data. To efficiently consolidate these files into a unified spreadsheet, UMassSafe used a Python script integrated with an open-source library tool, Pandas, for analyzing and manipulating data. This consolidation process included the following steps:

1. Environment Setup: The script operated in a pandas-equipped Python environment, targeting a specific directory where all Excel files were stored.
2. Iterative File Reading: Each Excel file in the directory was read individually. The script ensured that only files with an ".xlsx" extension were processed.
3. DataFrame Aggregation: As each file was read, its contents were converted into a Pandas DataFrame and added to a list. This approach facilitated efficient management and organization of data from numerous files.
4. Data Concatenation: After processing all files, the individual DataFrames were concatenated into one large DataFrame, merging all separate records into a unified data set which was then exported to a new Excel file, resulting in a single comprehensive spreadsheet of all extracted data.

2.2.3 MSP SafetyNet Inspection Data

The objective of this step was to query all inspections of commercial vehicles conducted since January 1, 2022, and identify the specific carriers and vehicle identification numbers (VINs). This data query aimed to support a future analysis focused on the number of inspections and violations experienced by carriers with overweight permits.

Massachusetts State Police Commercial Vehicle Enforcement Section (MSP CVES) provides their self-collected inspection records via FMCSA, which is also fed into the UMassSafe Traffic Safety Data Warehouse. The UMassSafe Traffic Safety Data Warehouse is a tool for maximizing the use of highway safety data and includes "administrative" data sets collected by state agencies and other organizations, including crash, citation, roadway inventory, and so forth. Currently, twelve such data sets are housed in the Data Warehouse, with over 16 years of data available. Analyses utilizing data sets such as crash, citation, ambulance trip, and roadway inventory data have expanded findings that allow analysts to consider the comprehensive crash experience, including driver behavior, crash characteristics, roadway environment, and crash.

The initial query process used to use this data involved selecting MSP SafetyNet records for all relevant inspections conducted from January 1, 2022. This query was designed to extract detailed information about each inspection, including the carrier and vehicle involved. Data nuances were documented for future replication efforts.

2.2.4 MassDOT RMV Merit Rating Board Citation

Violation data is supplied to the UMassSafe data warehouse on a monthly basis as.txt file. Python coding parses the records so that each violation is its own record, and those which were issued on the same ticket would have the same citation number for linking and attribution purposes. Violation records were queried utilizing Postgre SQL. Limitations due to the simplistic record-level schema were found and documented.

2.3 Interoperability Linkages

2.3.1 Canister #1 OS-OW Permits Linked with Carrier Census

UMassSafe's methodology focused on accurately linking overweight permit data from the MassDOT OASIS portal with the FMCSA carrier Census database. This process required sophisticated matching techniques to ensure the correct alignment of records between the two data sets. To accomplish this, UMassSafe used the Python programming language and libraries such as pandas and FuzzyWuzzy for data manipulation and fuzzy string matching. Fuzzy string matching is a technique of identifying alphanumeric character strings, such as a company name, which match a designated character string only partially. This is used to identify field entries that may have misspellings, or in other cases, company names that have been altered slightly.

The first step involved importing the combined overweight permit data from the OASIS portal (stored in "CombinedData.xlsx") and the FMCSA carrier census data (from "FMCSA_CENSUS1_2023Jun.txt") into Pandas DataFrames. Company names were preprocessed in both data sets, converted to uppercase to standardize the data and facilitate better matching. UMassSafe used the FuzzyWuzzy library to create the get_highest_fuzzy_match function. This fuzzy string-matching function compared a given company name from the OS-OW data set with all company names in the FMCSA census data set, returning the highest similarity score and the corresponding company name.

To optimize the matching process, UMassSafe segmented the census data based on the initial letter of company names. This approach reduced the search space for potential matches, enhancing the efficiency of the fuzzy string-matching process. UMassSafe iteratively processed each record in the OASIS data set. For each company name, the script first attempted a direct match based on the USDOT number. If a direct match was found, it was recorded with a 100% match score. In cases where a direct match was not found, fuzzy string matching was employed. A match was considered found if the fuzzy string match score was 98% or higher. This threshold was determined by a manual inspection of fuzzy string-matching scores, and 98% was determined to be the lowest possible number to maintain "True" matches.

The results of the matching process, including the USDOT numbers, company names, permit IDs, match status, and match method, were compiled into a new DataFrame. This method effectively linked the OS-OW permit data with the FMCSA carrier census database, using both direct and fuzzy string-matching techniques to ensure a high level of accuracy in the linkage. The methodology highlighted the potential of combining traditional data matching approaches with advanced fuzzy string-matching logic to manage complex data matching scenarios.

2.3.2 Canister #2 OS-OW Permits Linked with MSP SafetyNet Inspection

The objective of this task was to use the MSP SafetyNet inspection data within the UMassSafe data warehouse to extract detailed information about each inspection, including the carrier and vehicle involved and their outcomes. The inspection pairing was reliant on carrier identifiers as well as vehicle VINs which exist in both data sets. This linkage aimed to provide inspection findings of interest matched with those carriers with overweight permits.

The inspection data set was acquired through the UMassSafe data warehouse. Existing familiarity with the interconnected tables relative to the different aspects of an FMCSA inspection helped streamline this process. Although interconnected tables may imply a more sophisticated schema, there were still significant limitations in the organization of the vehicle and violation table records that were not attributed to a specific carrier. The multiple tables were interconnected on the verification of the vehicle to provide a custom view that would then source relevant canister analyses.

Weight-relevant data recorded within the inspection data set was limited. The most common attributes are at the inspection level, but multiunit vehicles such as tractor-trailers are itemized with two separate vehicle records associated with a single inspection weight. Intended OW-OS flagging was limited because there is no direct way to determine the allowable weight based on the vehicle and inspection attributes provided. Alternatively, the gross combination vehicle weight is available at the inspection level, which would account for both vehicle units in a multiunit vehicle inspection, such as a tractor-trailer. Interestingly, while MSP SafetyNet Inspection data was used in this process, an alternative nationwide Inspection data set supplied by FMCSA does include a weight rating at the vehicle level.

An additional structural limitation occurs where, if there are two carriers in a multiunit vehicle inspection, it is not possible to directly determine which carrier belongs to which vehicle unit. With the carrier recorded at the inspection level rather than the vehicle level. This poses a challenge in linking specific carriers to specific VINs within the context of a single inspection. In scenarios where an inspection involved multiple vehicles and potentially multiple carriers, the database structure did not support a straightforward method to associate each vehicle with its respective carrier.

This structural limitation impacted the ability to accurately determine which carrier was associated with which vehicle during an inspection. As a result, analyzing the inspection and violation history for carriers, especially those with overweight permits, became more complex. The challenge was to infer or approximate these associations given the database constraints.

2.3.3 Canister #3 Inspection Records Linked with RMV Citation

The third and final linkage canister was to connect the RMV citation data housed in the UMassSafe data warehouse to the inspection records from MSP SafetyNet. This additional linkage provided access to unique fields such as the dollar amount assessed and whether the charge was adjudicated. The linkage was conducted in SQL using the RMV citation number, which exists in both data sets. The main challenge of this linkage was that the citation number would only appear with one of the violation records from a given inspection in the SafetyNet data set, meaning an advanced query was needed to ensure that all violations associated with a specific citation were accurately captured.

3.0 Results

UMassSafe engaged with willing stakeholders across the Commonwealth to understand what initiatives and programs are in place currently related to oversize-overweight commercial motor vehicle travel. Additionally, relevant best practices and publications of other states initiatives to monitor OS-OW carriers were researched.

Because many essential databases have not been adapted to serve emerging live-time and trend monitoring needs, one aspect of this study has been to determine ways in which disparate data sets work together to serve new functions. The results of this effort provided an exercise in of itself, resulting in findings to share relative to the process and nuances learned, as well as successes of what was possible with preliminary linkages. These findings are described below.

3.1 State of the Practice

UMassSafe initiated this study with several sessions of interviews. These interviews were conducted individually with representatives from MassDOT, specifically the bridge load rating and overload engineer, the bridge inspection engineer, the manager of Geographic Information System (GIS) Services, a multimodal planning professional, and a transportation systems management and operations professional as well as a ProMiles government account representative, and an MSP CVES research analyst. Key findings of these interviews are outlined next.

3.1.1 Bridges

To ensure the safety of the traveling public, it is essential that a bridge is load rated to determine its load-carrying capacity, with that capacity posted, if necessary. Each bridge in the National Bridge Inventory must be rated and posted as required by National Bridge Inspection Standards (NBIS), so long as the maximum unrestricted legal loads in each state exceed the operating rating for the bridge. In Massachusetts, MassDOT is responsible for determining maximum load capacities for municipal bridges on public highways, as ordered by M.G.L. Chapter 85 Section 35. Additionally, M.G.L. Chapter 85 Section 34 requires that an entity owning a bridge, be it MassDOT, a municipality, another state agency, or an owner of another type, is responsible for the installation and maintenance of maximum weight signage. To comply with both NBIS and M.G.L., MassDOT is responsible for rating all bridges greater than 10 ft, while also conducting inspections and maintaining inventories. Results of these inventories and inspections are reported to the FHWA for all bridges greater than 20 ft in length for inclusion in the National Bridge Inventory (NBI) data. For municipal bridges, the state bridge engineer determines weight limit postings, and informs municipalities accordingly. For MassDOT-owned bridges, weight limits are posted by official action of the MassDOT Highway Administrator based on recommendations by the state bridge engineer.

The MassDOT Bridge Rating and Overload Unit is also responsible for providing information and advice to multiple other MassDOT Units and Districts. The MassDOT Highway Division Bridge Inspection Management System (BIMS), supported by commercial 4D database software, refreshes data for the geoDOT mapping platform bridge layer on a biweekly basis. MassDOT is working on a system, with a tentative completion date of April 2024, wherein this bridge information would be posted to Mass511.com and refreshed daily. Stored within the BIMS 4D system is the safe load-carrying capacity of each bridge, for multiple truck configurations. These, as well as bridge condition and various other elements, are part of the data reported to FHWA. Bridge models are stored separately. Weight restrictions are physically posted via signage prior to a bridge structure using vehicle load rating values from the design vehicles known as the H20 truck, the Type 3 truck, and the Type 3S2 truck.

Bridge inspections are conducted routinely, as well as when damage or repair occurs. When a bridge is struck by a motor vehicle, the Highway Operations Center will notify the district, who then coordinates an inspection of its beams and overall condition and conduct a road rating analysis. When any inspection road rating analysis determines a bridge or structure is not functioning, weight and traffic restrictions will be reviewed and adjusted.

The required data to be collected during an inspection is itemized in the Bridge Inspection Handbook. Worth noting, only Chapter 9 of the handbook is entirely specific to Massachusetts. Other Massachusetts-specific requirements are included as well, which, up until the most recent NBIS update, were more restrictive than the federal requirements, while others generally mirror federal guidelines. A unique identification number is issued from the bridge department and used to record the relevant data, known as a structure number. When a large structure has multiple bridges, it will be segmented, keeping the first six digits the same. Current initiatives to expand data include recording the minimum underpass vertical clearance, specific to the travel direction of the roadway, compared to prior data specification of one measure point per segment.

A limitation to consider is that the various bridge and inspection data sets exist for different, primary audiences, so are constructed and stored with different parameters. When an inspection of an overloaded structure occurs, the determination to adjust any affiliated bridge inventory element's values may not be immediate or may be made by an alternate party and not comprehensively tracked. As a result, when future routine inspections occur there is potential that the baseline bridge element data may not be the most recent. The research team's effort to introduce bridge data as a relational OS-OW factor, at the roadway level, was not successful due to such complexities and lack of institutional and thematic knowledge.

3.1.2 Oversize/Overweight Permits

MassDOT has contracted ProMiles, a web-based permitting and highway access system developer/vendor, to provide a platform, known as OASIS, which accepts permit applications and facilitates the review process. Some permits are auto-issued if they meet required thresholds, whereas a permit agent reviews and issues most others. Including Massachusetts, permitting and routing systems developed by ProMiles are currently used in twenty-two states, providing a customer-facing platform for carriers, as needed or with paid

memberships. By inputting load and delivery details, OASIS will route the permit vehicle and output the authorized roadways, as well as note any exceptions, on the permit. There are current efforts being conducted by MassDOT to align OASIS with the Commercial Vehicle Information Exchange Window (CVIEW) to confirm valid carrier safety ratings, on behalf of the state, before issuing a permit.

When a carrier submits a permit application, OASIS will automatically process it if it falls within the auto-issue threshold set for the state. "Industry recommended" minimum thresholds for dimension and weight, published in FHWA's Best Practices in Permitting Oversize and Overweight Vehicles—Final Report, prescribes the recommended values of 14 ft wide, 14 ft 6 in. high, 110 ft long, and 150,000 lb. gross weight (*1*). Currently, Massachusetts mostly exceeds those standards and sets auto-issue for loads under 12 ft wide, 13 ft 6 in. high, 80 ft long, and 130,000 lb. gross weight. Loads exceeding these thresholds initiate a manual review by a permit agent, where the prescribed roadways are vetted to compare carrier-indicated load specifics with roadway/bridge data points. Some OS-OW permits may necessitate a more in-depth survey to be completed by a third-party, often to validate bridges that are not state-owned or state-maintained, which MassDOT has no authority to permit loads on. Additionally, allowance of superloads of greater than 130,000 lb. require approval by the state bridge engineer.

There is an effort underway to retrieve live MassDOT roadway inventory data to validate changes against the existing ProMiles mapping layer which determines the prescribed route. Additionally, the permit department will inform ProMiles of changes to relevant bridge restrictions and clearances. This includes vertical clearance data, for which ProMiles establishes a 3-in. buffer (although this may vary from state to state). Future development efforts have the potential to retrieve relevant 511 integrations to notify existing permit holders of affected routes for improved safety.

Some other states' traffic information systems are effectively integrated with ProMiles' systems to provide more robust enforcement and forecasting capabilities. For example, the Colorado Oversize Overweight Permitting and Routing (COOPR) system captures weigh-in-motion scale data at the state's point-of-entry, with digital identification to look up permit status. More robust communication loops are in place to notify enforcement entities of incoming vehicles and the automatic ability to flag vehicles that may be violating weight or route restrictions. Additionally, planning and highway operation entities can more effectively forecast capacity and future needs based on permit requests.

Currently, permit data is not systematically shared for proactive enforcement efforts. Future utilization of live permit data has the potential to improve planning and highway operation center efforts. Currently, law enforcement agency supervisors can log into a portal via OASIS to examine permits and assess escort requests. That said, without cause, law enforcement may only visually inspect the driver's permit copy or, more rarely, validate via a quick response (QR) code.

3.1.3 MassGIS

The MassDOT Transportation Planner/GIS/computer-aided design (CAD) specialist coordinates the ongoing development of a "trucking network" layer in geoDOT, a state GIS platform. Traditional roadway inventory data is used to create a trucking-specific layer, with freight corridor designations and relevant fields integrated into the geoDOT mapping portal. GeoDOT facilitates the updates made to the statewide roadway inventory data. When a data element changes due to inspection, data review, transfer of authority, or construction, a formal request by a relevant engineer is submitted via a web form. The proposed change is first vetted by the MassDOT district and then implemented by the geoDOT team into the statewide layers. However, when a route survey determines that a road segment has a limiting factor that creates a travel restriction, that adjustment is not, by default, implemented into the roadway layer as an inventory update.

In the next project task, this layer was cataloged to identify relevant OS-OW exclusion elements. Examination of the auto-permit OASIS system assessed route determination specifications and itemizing of restrictions, compared to the level of detail available via geoDOT.

Currently, this layer is not accessible to the public for routing purposes, but a public-facing version of this layer is intended for future development. This data will generate opportunities to integrate relevant OS-OW travel information into third-party mapping software such as Google Maps and TruckerPath. Further state agency efforts to align with the trucking network layer, relevant to the permit office, route surveyors, OASIS, and so forth, will improve the uniformity and consistency of the data.

3.1.4 Multimodal Freight Planning

The MassDOT Office of Transportation's Multimodal Planning section works closely with regional planning agencies and with other MassDOT Divisions to identify study needs, execute the studies, and implement the recommendations. Working within the Multimodal Planning section, the freight planner participates in regional and national freight coordination efforts and manages the development and implementation of the freight plan. The 2023 Massachusetts freight plan identified bottleneck locations and documented a truck parking inventory (*2*). Additionally, the freight planner monitors and responds to multimodal freight trends, funding opportunities, legislation, and rulemaking, including participating in the request for information (RFI) for the national redesignation of the primary highway freight system (PHFS). Although these roles are integral for planning and specialized analysis relevant to OS-OW, they do not directly grant or enforce permits. Rather, their purpose is to provide oversight and a leading role in efforts to expand data capabilities across departments and agencies.

3.1.5 Massachusetts State Police Commercial Vehicle Enforcement Section

The MSP CVES implements the FMCSA Motor Carrier Safety Assistance Program (MCSAP) for Massachusetts, with the goal of reducing CMV-involved collisions, serious injuries, and fatalities by applying consistent, uniform, and effective commercial vehicle safety enforcement and other associated safety programming. The CVES collects data and

uses multiple databases including CVIEW and Commercial Driver's License Information System (CDLIS) to research carrier safety status during traffic stops.

These key informant interviews assisted UMassSafe researchers in identifying specific strengths and weaknesses of data sets, which aided in understanding potential issues when establishing data linkages.

3.1.6 Description of Relevant Data Sets

Massachusetts maintains a variety of databases that support state infrastructure management, crash and violation incidences, and specialized commercial vehicle focused crash and inspection. The crash data system (CDS) is maintained by the RMV, containing all police and operator crash reports for the Commonwealth. The crash report includes a section specifically for large truck information; however, it is often of poorer quality. CMV crash data is collected or reviewed by the MSP CVES and housed in their SafetyNet Crash database; because this is more specialized and cleaned and managed by relevant experts, this data set is considered more reliable for crash and carrier attributes. Additionally, the MSP CVES also maintains the SafetyNet inspection database, consisting of findings from CMV driver and vehicle inspections. The RMV Merit Rating Board maintains the RMV citation database, consisting of motor vehicle-related violations (including warnings and civil infractions). The Road Inventory file is a GIS-based asset management system, maintained by the MassDOT Office of Transportation Planning, containing information on mileage, identification, characteristics, and condition for all Massachusetts roadways. The geoDOT Trucking Network consists of a collection of relevant map layers for assessing trucking operations within the Commonwealth, including OS-OW restrictions, roadway exclusions, and freight corridors.

Other data sets examined in the state of the practice deliverable include a variety of tables administered by the FMCSA focused on the safety fitness of commercial trucks and buses, as well as hazardous material carriers that are subject to Federal Motor Carrier Safety Regulations (FMCSR) and the Hazardous Materials Regulations (HMR). Most comprehensively, MCMIS consists of crash, inspection, census, and company safety profile (CSP) data, and is made publicly available through the MCMIS Data Dissemination Program. CVIEW, which is a state data exchange component of the FMCSA's Commercial Vehicle Information Systems and Networks (CVISN), acts as a repository for commercial vehicle operations (CVO) safety and credentials data, categorized by carrier, vehicle, and driver. It should be noted that CVIEW contains the greatest number of interconnected relevant data sets that can be accessed from one specific source, most beneficially the carrier's safety rating. CDLIS functions as a nationwide clearinghouse for commercial driver's license (CDL) information; a primary function of state driver licensing agencies (SDLAs) is to use CDLIS to determine whether each commercial driver has only one driver's license and one complete driver record.

3.1.7 Permit Types and Related Regulations

The majority of OS-OW permit applications in this sample data set were nonreducible single trips. One example is a large piece of machinery that must be transported intact.

Nonreducible single trip permits accounted for more than half of permit application records examined (65,092 of 119,585), as shown in Table 3.1. It is important to note that there were substantial challenges in obtaining an OASIS data set; alternatively, these findings were based on an export of permit application records to demonstrate the intended process and demonstrate hypothetical results.

Issued permits are valid for one trip within five days. OS-OW travel on state highways, with valid permit, is allowed from Monday morning at 12:01 a.m. to noon on Saturday, and Sunday morning from 12:01 a.m. to noon, disallowing Saturday/Sunday travel from noon to midnight.

The carrier must have relevant permits approved prior to entering the state. When operating with these permits, movement is not allowed on New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas. Furthermore, no movement is allowed between noon of the day preceding and noon of the day following New Year's Day, Independence Day, and Christmas. Additional specifications exist in specific urban and high-volume areas, restricting peak-time travel or travel in darkness.

Table 3.1: OS-OW permit applications, CY2022 records

Permit Type	Number	Linked (%)
Nonreducible Single Trip	65,092	96
Reducible Annual	39,477	93
Nonreducible Single Trip Modular Homes	6,156	98
Nonreducible Single Trip Self-Propelled Equipment	3,299	99
Nonreducible Annual Construction Equipment	2,681	93
Superload	1,560	99
Nonreducible Annual Self-Propelled Crane	479	95
Nonreducible 6 Month Intermodal	318	99
Nonreducible Annual Boat	174	83
Nonreducible Annual Utility Poles	99	0
Nonreducible Single Trip Cask	76	91
Special Hauling Fuel	64	97
Special Hauling Tandem Trailer	51	96
Special Hauling Explosives	41	80
Nonreducible Single Trip Intermodal	17	100
Nonreducible Annual Fire Truck	1	0
Grand Total	119,585	95

As shown in Table 3.2, reducible annual permit applications accounted for 34% of the data set sample. These permits are typically for hauling aggregates which can adjust the load as needed but operate with a higher weight limit routinely.

Table 3.2: Gross Weight Indicated, CY2022 records

Permitted Gross Weight	Number	Percentage (%)
"0" (reducible annual)	40,087	34
1–79,000	21,487	18
80–120,000	48,043	40
120–130,000	9,595	8
Superload	373	0
Total	119,585	100

The gross weight of vehicles in regular operations (i.e., operating without a special permit) is governed by the state axle limits, the state bridge formula (adopted from the Federal Bridge Formula [FBF]), and other provisions of the Massachusetts General Law (MGL) and Code of Massachusetts Regulations (CMR), which specify truck weights. Table 3.3 provides a summary of Massachusetts's dimension allowability under regular or permitted operations.

Table 3.3: Legal and routine permit dimensions

Legal Dimensions	Routine Permit Limits
Length: 60 ft	Length: 134 ft 11 in.
Width: 8 ft 6 in.	Width: 14 ft 11 in.
Height: 13 ft 6 in.	Height: 14 ft 11 in. (Over 13 ft 8 in. requires a height survey)
Weight: 80,000 lb.	Weight: 130,000 lb.

Any dimensions exceeding the routine permit limits in Table 3.3 are considered superloads, a different permit type. Superloads with a weight over 130,000 lb. require structures to be surveyed by either MassDOT (for certain routes that are state-owned and maintained) or a third-party engineering entity (for routes involving municipal roads or structures); the latter of which can cost several thousand dollars, depending on the route and number of structures. Height surveys may be required for both routine and superload permits, whenever exceeding 13 ft 8 in. Height surveys are typically a few hundred dollars, also completed by an engineering third-party (Table 3.4).

Table 3.4: Oversize escort requirements

Length	Width	Height
Over 80 ft 1 in.: one escort	Over 12 ft 1 in.: one pilot car	Over 13 ft 9 in.: height survey required and preceding pilot car
Over 95 ft: two escorts	Over 13 ft 9 in.: two pilot cars	Over 14 ft: two pilot cars
Over 135 ft: two escorts plus two state police	Over 16 ft: two pilot cars and two state police	Over 15 ft: two pilot cars and two state police escorts

Note: In the city of Boston, if over legal dimensions, one escort plus city police, in addition to Boston City occupancy permit and company bond requirements.
On Cape Cod, if width over 12 ft: two escorts, one front, one rear.

Signs, flags, and lights requirements consist of the following:

- "Oversize Load" sign on rear of an oversize vehicle that does not require an escort.
- Red flags mounted on extremities and corners for any over-width or over-length vehicle.
- A flashing amber light above the vehicle's highest point and visible from the front and rear of the vehicle for all oversize loads operating in darkness.

There are also restrictions on the vehicle's height depending on the route it is traveling. Table 3.5 provides the maximum heights allowed per way; there are no exceptions for any tunnel heights. A height survey is required for any vehicle over 13 ft 6 in. traveling on the Turnpike. All other locations not specifically listed require a height survey when exceeding 13 ft 8 in.

Table 3.5: MA maximum allowed vehicle height

Way	Maximum Vehicle Height	If Exceeding
Turnpike	13 ft 6 in.	Height survey required
Other Locations Not Listed	13 ft 8 in.	Height survey required
Ted Williams Tunnel	13 ft 6 in.	No exceptions
Callahan Tunnel	13 ft 6 in.	No exceptions
Sumner Tunnel	13 ft 6 in.	No exceptions
O'Neill Tunnel (I-93)	13 ft 6 in.	No exceptions
CANA (City Square) Tunnel	13 ft 6 in.	No exceptions

Table 3.6: MA maximum allowed vehicle length

Type of Vehicle	Maximum Vehicle Length (ft)
Motor vehicle not listed	33
Vehicle combination not listed other than semitrailer	60
Articulated bus	60
Auto home	40
Automobile transporter (traditional)	65
Automobile transporter (stinger-steered)	75
Boat transporter (traditional)	65
Boat transporter (stinger-steered)	75
Boat transporter (truck trailer)	65
Bus or school bus	45
House trailer	40
Saddlemount combination	75
Semitrailer	53
Trailer in tractor-trailer combination	53
Trailer not in tractor-trailer combination	33
Truck	40

3.2 Literature Review

A literature review of best practices and guidelines was conducted to identify and quantify OS-OW trucking operations and enforcement initiatives. While most publications are focused on implementing weigh-in-motion (WIM) and electronic/auto permitting, enforcement of special permit rules is also acknowledged as a critical component of a successful permitting system. Many agencies allow special permits to be revoked for noncompliance with the terms and conditions of the permit, which serves as an incentive to carriers to recognize the importance of maintaining good records. Strategies intended to ensure safety and efficiency also require close coordination between the regulating body and carriers. Permit fees are often tied to pavement preservation costs.

3.2.1 Guidelines and Data Standards

As the use of computerized data systems for motor vehicle programs increases, the need to transfer data between those systems and organizations also increases. Various Massachusetts data initiatives are ongoing, realigning many state data sets to accommodate relevant federal specifications or guidelines. Motivation behind data enhancements can be attributed to the Highway Safety Improvement Program (HSIP), where each state must have in place a safety data system that can be used to perform analyses supporting strategic and performance-based goals [23 U.S.C. 148 (c)(2)].

The state of the practice literature review and key informant interviews found a common trend of state agencies acknowledging the need to align with national data standards to further meet recommended guidance as well as further develop a data set's organization, specificity, and usability.

- The FHWA NBI will be expanding its element-level bridge condition data, based on the American Association of State Highway and Transportation Officials (AASHTO) Manual for Bridge Element Inspection. Most relative to OS-OW permitting and associated oversight, this will require the bridge inspection data to specify travel direction and lane number for vertical clearances and restrictions.
- With ongoing growth and safety modifications on Massachusetts roadways, the roadway inventory file is a living document, updated annually. This provides the opportunity to align data fields with the federal Model Inventory of Roadway Elements (MIRE), which provides a list of recommended elements and attributes.
- Driver licensing, motor vehicle inspection, registration and titling are intended to align with the American Association of Motor Vehicle Administrators (AAMVA) Data Element Dictionary for Traffic Records Systems (D20) standards, which contains terminology, data element definitions and coding instructions to promote uniformity of data elements exchanged between organizations. With inability to obtain access to the RMV state data sets, adherence to these is speculative.
- Crash records are modestly aligned with the Model Minimum Uniform Crash Criteria (MMUCC) National Highway Traffic Safety Administration (NHTSA) guideline, which identifies a voluntary, minimum set of motor vehicle crash data elements and

their set of attributes that states can consider collecting and including in their electronic crash data systems, to feed the Fatality Analysis Reporting System (FARS) and the Crash Report Sampling System (CRSS) more efficiently and effectively.

- Regarding OS-OW permitting, oversight, and regulation, there are currently no national guidelines, and permitting practices vary significantly from state to state. A 2015 statement, issued by the Government Accountability Office (GAO), recommended that the Secretary of DOT should direct FHWA to conduct the necessary research and develop a best practices guidance document with an emphasis on automated permitting systems.

3.2.2 Evaluations

A 2014 study of regulatory issues impacting truck freight in the Midwest considered weight compliance enforcement and OS-OW permits as two key factors to examine (*3*). In the policy and regulation review, weight enforcement practices, levels, and severity of penalties (for exceeding weight limits) were found to be problematically different among various states. Recommendations included the need for more streamlined regulatory services along freight corridors, such as an OS-OW permit portal (e.g., www.gotpermits.com), and the reversal of a statewide prohibition of light commercial vehicles (LCVs), dependent on benefit–cost analysis. Discussions with private sector interests and state regulatory agencies noted that vehicle size and weight (including OS-OW permits) were of primary concern.

A 2014 National Cooperative Highway Research Program (NCHRP) scan of current practices also resulted in recommendations surrounding automatic permitting systems (*4*). These systems are dependent on an accurate geographical database that contains current network restriction information such as clearances and weights that would affect routing decisions.

A 2016 Transportation Research Board (TRB) study outlined areas for national and state efforts to improve movement of OS-OW loads, strongly noting the technological variances which exist in automatic permitting and route planning (*5*). Specifically, there is a need for better information and improved communication of roadway restrictions to carriers with open permits, which would result in a change in permit status in situations where work zones, weather events, or traffic incidents may affect traditionally designated permitted routes.

Although many initiatives have laid the groundwork for state needs involving permit issuance, there has been little discussion of methods to conduct enforcement or develop investigative techniques beyond implementing WIM.

3.2.3 Best Practices

A literature review of best practices was conducted to identify and quantify OS-OW trucking operations and enforcement. While most publications are focused on implementing WIM and electronic/auto permitting, enforcement of special permit rules is also a critical component of a successful permitting system. Many agencies allow special permits to be revoked for noncompliance with the terms and conditions of the permit, which serves as an incentive to

carriers to recognize the importance of maintaining good records. Strategies intended to ensure safety and efficiency also require close coordination between the regulating body and carriers. Permit fees are often tied to pavement preservation costs. By instituting a graduated fee structure, the intention is to provide compensation for the longer, heavier vehicles' wear and tear on roadways.

A 2018 research synthesis from Minnesota surveyed local county engineers from ten states to document their OS-OW permit fee structure and authority *(6)*. Interestingly, more than half of the respondents indicated their county assesses and retains the permit fees for OS-OW loads in addition to state fees, while others, like Arizona, are superseded by a state-issued permit. These local agencies assessing fees commonly use a fee structure authorized through their state statutes, while some have developed their own cost recovery formulas, focusing on the administrative effort and/or anticipated maintenance/construction costs. Specifically, Jackson County, Minnesota conducted a study to determine their own fees based on construction costs per equivalent single axle load (ESAL) per mile for pavement and aggregate base. These progressively higher-cost fees have since been adopted by many other county agencies for implementation.

A simultaneous assessment was done of New Mexico's fee structure relative to other western states, which highlighted the major differences in fees, fines, and weight limits. The resulting recommendations were to overhaul the permit structure to better compensate for increased demand for higher maximum permitted weights to rebuild and maintain infrastructure. This assessment also pointed to enforcement and fines, as a significant part of OS-OW vehicle traffic regulation, to ensure that trucks comply with the permitting rules established by the state they are crossing. A frequently proposed solution that institutes universal graduated fees and fines was contradicted, in that the determination of sufficient funds to maintain infrastructure at an appropriate level of service will vary significantly from state to state, with each state's infrastructure needing to be evaluated to assess the funds required to maintain bridges and pavements at acceptable service levels.

3.2.4 Enforcement Technologies

Strategies and technologies to evaluate and monitor OS-OW permits are developing at unprecedented rates as the enforcement workforce is dwindling while heavy vehicle travel is increasing. Enforcement initiatives include education, monitoring, and punitive actions, intended to encourage adherence to statutory requirements and OS-OW permits. Former enforcement practices were reliant on static truck weigh stations placed along borders/ports of entry, followed by the development of portable wheel-load scales, allowing law enforcement officers to patrol the state's highways and weigh as needed.

WIM systems consist of sensors installed in the roadway and the supporting roadside electronics needed to store, process, analyze, and transmit the data. WIM systems can be used to determine a vehicle's gross weight, speed, axle weight, and axle spacing. Electronic screening allows commercial vehicles to pass a check point at regular speeds without stopping, while an automatic vehicle identification (AVI) system is used to pull information related to the vehicle credentials, including registration, permitted weight, and safety ratings. Data from the WIM and AVI systems can be used to identify unpermitted overweight

vehicles to be intercepted for inspection. Virtual weigh stations can enhance this capability by monitoring from another location with cameras.

Common practices at weigh stations include the use of dedicated short-range communications (DSRC) transponders between the weigh station (static or portable) and truck, confirmed by an AVI reader, commonly referred to as a weigh station bypass. The system checks the truck's safety status and will send a signal to the truck. A green light means bypass the weigh station, while a red light means stop for inspection. This technology is supported by third-party vendors such as Drivewyze and PrePass. Communications are available through smartphones and tablets, as well as integrated into fleet mobility technologies. Bypass enhancements are particularly beneficial to freight companies, allowing trucks to proceed through without stopping, with proper safety ratings and credentials on file.

Optical character recognition (OCR) and license plate reader (LPR) technology is used to read USDOT or license plate numbers and expedite manual screening at both fixed locations and in mobile enforcement activities.

Bridge collision avoidance technologies are over-height detectors with infrared beams or radar that can be connected to warning signs that will illuminate for vehicles approaching low-clearance bridges. Additionally, the low-tech solution of hanging a sign over the roadway to make noise on the roof of an over-height vehicle is increasingly less common. A less common self-enforcement technology uses remote axle load measurements where vehicles will transmit their gauge readings automatically. Often, axle load measurements are paired with a more comprehensive telematics system. Using global positioning system (GPS) navigation and informatics of vehicle movements, trucking companies can track their vehicle fleet and status. Future regulatory development could use this technology to enhance OS-OW enforcement, by providing both the weight and location in comparison to the prescribed permit restrictions. Meanwhile, some agencies may play a more active role when monitoring specialized or superload permits by issuing a tracking device as a term of the permit.

3.2.5 Enforcement Challenges

Enforcement of OS-OW loads is even more specialized than traditional CMV-focused enforcement initiatives, requiring a high level of experience and the time/ability to complete a detailed roadside FMCSA inspection. Beyond the direct need for more enforcement availability, challenges were also documented in driver and legislative aspects.

With driver-to-driver communication a common practice in trucking, both by citizen's band (CB) radio and internet groups, news of a mobile or sporadic enforcement activity is shared quickly, resulting in some drivers deviating from their route to avoid interacting with law enforcement. In Florida, to curb avoidance, WIM/LPR systems were installed at exit ramps prior to the inspection site to monitor for evading vehicles (*7*).

Additionally, alternative methods of enforcement such as automated speed and weight gantries are challenged by institutional barriers at the state-level, as many states have not legislatively authorized remote enforcement.

3.2.6 Other Related Initiatives

Best practices relevant to enforcement of OS-OW trucking are largely focused on innovative technologies being implemented, in contrast to this project's initiative of identifying ways to better use data for enforcement. Nonetheless, a single example of a state's efforts to identify and intervene with problematic OS-OW carriers was found in New York (*8*). The New York State Department of Transportation (NYSDOT) distributes notifications to carriers cited for OS-OW violations, stressing the opportunity to work with the OS-OW Permit Program to develop a cooperative effort to ensure the safety of the public and protect state infrastructure while also supporting the carrier's economic needs. Carriers whose violations are particularly severe or egregious, or who have persistently violated OS-OW laws and regulations, will receive a Notice of Violation, which may require payment of a civil penalty, appearance before an administrative law judge at a NYSDOT hearing, suspension of permitting privileges, or another action.

New York had estimated the effects of overweight trucks on NYSDOT pavements and bridges. A data mining algorithm is used to categorize truck data collected at several WIM stations around the state of New York based on the trucks' adherence to the state's legal weight limits. The data indicates that about 11% of the trucks traveling on New York highways may be carrying divisible load permits, 1% may be carrying special hauling permits, and about 6% may be illegally overweight.

A monetization of the safety margin utilization due to the combined overstress and cyclic fatigue shows that trucks carrying divisible load permits may be responsible for $50 million per year in New York State (NYS) bridge infrastructure cost, trucks with special hauling permits may be responsible for $2 million per year in additional cost, while illegally overweight trucks may be responsible for $43 million per year for a total of $95 million per year. The cost allocation study performed on the NYS pavement network shows that the cost to NYS pavements due to overweight trucks is about $145 million per year, specifically accounting for $78 million related to divisible load permits, $7 million related to special hauling permits, and $60 million for illegally overweight trucks.

Colorado is one of many states with robust permitting systems, which include access to a library function of carrier information, power unit and trailer configuration, previous routes and permits granted, which could be used to conduct ad hoc analysis. Colorado uses a comprehensive permit and roadway restriction website in an integral effort to ensure the most accurate information is available to better inform carriers. Additionally, Colorado has a publicly available map interface with both state and local roads, with the relevant weight/size restrictions accessible in various interfaces. Permanent route restrictions are hard coded into the system and will route carriers around a route restriction as feasible. The Colorado system also receives updates from the DOT districts and the state's 511 system on route restrictions created by construction, work zones, weather events, and incidents such as crashes or rock falls. These updates are received by the permit office and uploaded into the system as they are verified. Future permits are routed around these restrictions, while active permits are tracked and notified of any route restriction changes. Permits are auto issued in combination with a compliance check for no out-of-service (OOS) orders in CVIEW.

The Colorado system tracks open permits and generates an email notice to a carrier of any change in route restrictions within the previous 24 hours. Each applicant must supply an emergency contact email address, and the notice advises the carrier that there is a problem with the route and the carrier must cease operations and contact the permit office immediately.

Unlike the United States, Australia has uniform permitting across the country. Vehicles are assessed through performance-based standards (PBS), consisting of sixteen minimum performance/safety standards to ensure the vehicle demonstrates stability and the ability to stop and turn safely. Furthermore, the National Heavy Vehicle Regulator (NHVR) regulates through four infrastructure protection standards, requiring that vehicle models be built according to required design elements, or that they be individually assessed by numerical modeling or field testing. Specialized vehicle registration plates for large/heavy vehicles are required as well. National-level identity verification is used to register users and drivers. Likewise, a publicly available app allows operators and enforcement to check registration.

The Route Planner is a tool powered by Open Street Maps that provides near-real-time roadway data to heavy vehicle operators in Australia. It is primarily used to plan heavy vehicle routes and identify where an access permit must be applied for. When permits require a local entity's authorization, NHVR will contact the local government authority for consent. The Heavy Vehicle National Law (HVNL) requires that NHVR seek consent from all road managers involved in a permit route proposal, with the road manager for the "first and last mile" of most routes often being local government. The NHVR is working extensively with local government road managers to obtain preapproved consent for several routes as a means to reduce turnaround times, as well as ease the administrative burden for local governments. Because of the base maps' open data model, users can also download routing information to be used in spatial systems. The portal specifically caters to heavy vehicle operators and the needs of such vehicles, allowing for more accurate heavy vehicle routing while minimizing routing errors. Efficiencies are monitored with web data visualizations.

Australian permits or notices may require enrollment in the Intelligent Access Program (IAP). IAP is a national framework for managing heavy vehicle access using GPS technology and in-vehicle diagnostic systems (i.e., telematics) to plot vehicle movement. Location, time, and vehicle/operator identity are tracked by satellite and wireless communication via in-vehicle systems. IAP allows participating operators to access roads or bridges, operate at greater masses, or use larger or heavier vehicles than would otherwise be allowed, in return for IAP monitoring with road manager access conditions. Vehicle operators are responsible for coordinating the installation of an in-vehicle diagnostic unit. When a vehicle operates outside permitted access networks or conditions, IAP data is sent to road agencies and a noncompliance report (NCR) is issued. Once NCRs are reviewed and validated, further action may be taken. Safety infractions regarding heavy vehicle transport industry (or its supply chain) procedures, practices or conditions can be reported to the NHVR's Heavy Vehicle Confidential Reporting Line (HVCRL).

3.3 Classification of Data Sources and Fields

Massachusetts state–specific and federal data sets vary significantly from one another, as each was constructed for specific and unique purposes. It was essential to catalog the purposes, characteristics, and specific fields of each data set and determine possibilities for interoperability. State and federal data sets used for analysis in this study are detailed next.

3.3.1 Massachusetts RMV Crash Data System

All police and operator crash reports are collected by the RMV, which then stores the data within the CDS which feeds a user-view portal for data visualization.

For a motor vehicle crash to qualify as reportable, it must meet one of the following criteria:

- The crash resulted in a fatality; or
- The crash resulted in an injury; or
- The crash resulted in at least $1,000 in damage to any vehicle or other property.

Crash reports contain data elements depicting the circumstances of the crash, the motor carrier, and the vehicles involved. Key elements include (but are not limited to) carrier name, crash location, date and time, and crash consequences (fatalities and injuries). Additionally, the Commonwealth of Massachusetts Motor Vehicle Crash Report includes a section specifically for truck and bus information. For a crash to qualify as a truck or bus crash, the crash must involve one of the following:

- A truck with a gross vehicle weight rating (GVWR) greater than 10,000 lb, or a gross combination weight rating (GCWR) of more than 10,000 lb. that is also used on public highways; or
- Any vehicle with seating to transport at least nine people, including the driver; or
- Any vehicle displaying a hazardous materials placard (regardless of weight).

The truck/bus crash must also involve

- A fatality: any person killed in or outside of any motor vehicle involved in the crash, or who dies within 30 days of the collision as the result of an injury sustained during the crash; or
- An injury: any person injured as a result of the crash, who immediately received medical treatment away from the crash scene; or
- A tow away: any motor vehicle or trailing unit disabled as a result of the crash and transported from the scene by a tow truck or other vehicle.

Table 3.7 outlines the important CDS crash fields for technical linkage development. The vehc_unit_number is a unique identifier necessary to pair with both the CRASH.TRUCK_BUS table and CRASH.VEHICLE table.

Table 3.7: Crash linkage fields of importance

Schema Table Name	Field Name	Field Description, Notes or Alias Name
CRASH	Crash Number	Data set unique identifier
CRASH	City Town Name	Event location
CRASH	Crash Date	Event date
CRASH	Document IDs	Internal RMV report-specific unique identifier
CRASH	Crash Report IDs	Internal LEA unique identifier
DRIVER	Vehicle Unit Number	Data set unique identifier to align vehicle with relevant occupants and truck/bus details which reside in separate tables
VEHICLE	Vehicle Registration state	Registration plate state used to identify specific vehicles in other data sets
VEHICLE	Vehicle Registration Type	Registration plate type used to align with registered vehicle data
CRASH.TRUCK_BUS	Crash Number	Data set unique identifier
CRASH.TRUCK_BUS	Vehicle Unit Number	Data set unique identifier to align vehicle with relevant occupants and truck/bus details which reside in separate tables
CRASH.TRUCK_BUS	Carrier Name	Freeform company name
CRASH.TRUCK_BUS	USDOT Number	Freeform company USDOT
CRASH.TRUCK_BUS	State Number	Former state-specific carrier identifier
CRASH.TRUCK_BUS	State Number Issuing State	Former state-specific carrier identifier
CRASH.TRUCK_BUS	Carrier Address City	Can assist in determining correct carrier
CRASH.TRUCK_BUS	Carrier State	state_prvn_code
CRASH.TRUCK_BUS	Carrier Address Zip Code	carrier_addr_zip_code
CRASH.VEHICLE	Vehicle Unit Number	Data set unique identifier to align vehicle with relevant occupants and truck/bus details which reside in separate tables
CRASH.VEHICLE	Vehicle Registration Plate Number	vehc_reg_plate_numb
CRASH.VEHICLE	Vehicle Owner	vehc_owner_nown
CRASH.VEHICLE	Vehicle Owner Zip Code	owner_addr_zip_code

Fields of topical interest can be used to better understand the nature of a crash, as well as its location characteristics. Because of the robust nature of this data set, the various fields can be explored for future utilization using the MassDOT's Interactive Mapping Portal for Analysis and Crash Tracking (IMPACT) tool. This tool contains a "Look Up Table Values" feature which itemizes various topical fields and their attributes, including fields from the roadway inventory, as well as those specific to vulnerable road users, drivers, crashes, occupants and

vehicles. IMPACT provides a method to retrieve the relevant fields based on crash location or that are query-specific, allowing for immediate-use variables in an information investigation that would traditionally need to be matched after-the-fact. Problem identification information may include weather conditions, roadway contributing factors such as traffic congestion, and pavement structural condition.

3.3.2 FMCSA Motor Carrier Management Information System Census

FMCSA's MCMIS Census files contain the USDOT number, carrier identification, carrier address, type and size of operation, commodities carried, and other operational characteristics for interstate (and some intrastate) motor carriers, intermodal equipment providers, cargo tank facilities, and shippers. Additionally, they include motor carrier PII consisting of social security numbers (SSN) and employee identification numbers (EIN).

Motor carriers include entities that ship hazardous materials (both carrier and shipper), and non-carrier entities that register vehicles. MCMIS assigns a discrete number to each entity record for identification, which is referred to as a record census number. This number is also supplied to the entity in question as the USDOT number. For each census record, MCMIS assigns a status of either active or inactive. Active status indicates the entity is currently subject to the FMCSR, HMR, or is an intrastate nonhazardous material (HM) carrier issued a USDOT number by relevant states. Inactive status indicates that the entity is no longer operational or subject to FMCSR or HMR.

Census records contain the following information:

- Census information, i.e., entity identifying data such as name, address, and so forth;
- Business/Operation data, i.e., operation classification, and type of business;
- Cargo classification, i.e., type of cargo carried;
- Hazardous materials carried/shipped;
- Equipment and driver data, i.e., number of trucks owned, term-leased or trip-leased, number of drivers, and so forth; and
- Carrier review data, i.e., latest review date, accident rate, safety rating, and so forth.

The Census data is sourced from an FMCSA Comprehensive Safety Analysis (CSA) run, which is routinely updated. As of June 30, 2023, it included 2,033,886 interstate, intrastate hazmat, and intrastate non-hazmat motor carriers. The extracted data is a text file and comma delimited, with one carrier per row. The file is extremely large and will not easily open in Excel.

Table 3.8 outlines the fields deemed to be of importance for the framework of interoperability toward canister development. The USDOT number listed in Census is the desired subject-source to match with and should be prioritized over name matches.

Table 3.8: Census linkage fields of importance

Field Name	Field Type	Sample	Field Description or Notes
DOT_NUMBER	Integer	1495283	Unique USDOT number of the motor carrier
LEGAL_NAME	String (variable)	PENTON STUMPGRINDING AND LANDSCAPING	Legal name of a carrier
DBA_NAME	String (variable)	PENTON TREE SERVICE	Carrier's doing-business-as name

In addition to the census fields deemed to be of importance for the framework of interoperability toward canister development outlined above, Table 3.9 outlines additional fields of topical interest. They can be used for normalizing incident counts based on the carrier annual mileage, number of drivers, or number of vehicles. Additionally, Carrier Operation can designate intrastate verse interstate.

Table 3.9: Census fields of interest

Field Name	Field Type	Sample	Field Description or Notes
CARRIER_OPERATION	String (Fixed)	C	Codes identifying carriers' type of Operation; A = Interstate, B = Intrastate Hazmat, C = Intrastate Non-Hazmat
MCS150_DATE	Date (Other *3/14/2012)	4/30/2006	Latest date MCS-150 was filed
MCS150_MILEAGE	Integer	150	Vehicle Mileage Traveled (VMT) reported on the carrier's MCS-150 form
MCS150_MILEAGE_YEAR	Small Int (2)	2006	Year for which VMT was reported
ADD_DATE	Integer	4/30/2006	Date when Carrier information was added to MCMIS Database System
OIC_STATE	String (Fixed)	FL	FMCSA state office with oversight for this Carrier
NBR_POWER_UNIT	Integer	2	Number of power units reported
DRIVER_TOTAL	Integer	1	Number of drivers reported
RECENT_MILEAGE	Integer	0	Carrier's recent VMT based on the most recent data
RECENT_MILEAGE_YEAR	Integer	0	Year for which Recent VMT was reported
VMT_SOURCE_ID	Small Int (2)	1	1 Census; 3 Investigation
PRIVATE_ONLY	String (Fixed)	Y	Y = Carrier's operation classified as private property, driver passenger business, and private passenger nonbusiness but not authorized or exempt for hire
AUTHORIZED_FOR_HIRE	String (Fixed)	Y	Y = Carrier's operation classified as Authorized for Hire
EXEMPT_FOR_HIRE	String (Fixed)	Y	Y = Carrier's operation classified as Exempt for Hire

3.3.3 Registry of Motor Vehicles Citation

Motor vehicle-related violations, including warnings and civil infractions, are recorded, and maintained by the RMVs Merit Rating Board. Massachusetts-sponsored e-citation has an access portal where authorized state agencies can search by various demographics including USDOT number. However, the USDOT data element is not standard in traditional data-sharing exports and will require portal access in task 2 of this project, in order for it to be used.

Citation data consists of two sets of variables: motorist demographic variables, and details about the traffic stop. Motorist demographic variables include age of motorist (calculated as a whole number based on the motorist's date of birth on file with the RMV, compared to the citation offense date); gender of motorist (determined by the self-identified gender on file with the RMV; categories include male, female, nonbinary, and unknown); residence zip code of motorist on file with the RMV; and perceived race/ethnicity of the motorist (categories include African, American, Asian, Asian Pacific, African American, Cape Verdean, Hispanic, Middle Eastern, American Indian, Pacific Islander, Unknown and White). For this last variable, it is important to note that the Massachusetts RMV does not collect information on the race or ethnicity of drivers. As a result, RMV citation data on motorist race/ethnicity is determined by the law enforcement officer's perception.

The second set of variables, "Information About the Stop," includes date and time or of the stop, freeform text entry to document the location of the stop, law enforcement agency conducting the stop, outcome of the stop (written warning, criminal citation, civil citation, or arrest), and whether a search was conducted.

Table 3.10 outlines the RMV citation fields deemed of importance for the framework of interoperability toward canister development. They can be used within the linkage canister strategies. RMV citation data does not contain USDOT number. These violations are collated in this analysis through the inspection linkage by utilizing RMV citation number. Future analyses can use the vehicle plate registration number and/or violator name to construct a more comprehensive data matching methodology.

Table 3.10: Citation linkage fields of importance

Field Name	Field Type	Options/Sample
violation_id	Integer (4)	9058088
date_citation_written	Date	1/1/2020
citation_number	String (Variable)	R0324554
violator_name	String (Variable)	FIRST@LAST
vehicle_registration	String (Variable)	PAN1NLV54GR
vehicle_reg_state	Char (2)	MA
cdl_vehicle_indicator	String (Variable)	Y; N

In addition to the RMV citation fields deemed to be of importance for the framework of interoperability toward canister development outlined above, Table 3.11 outlines additional fields of topical interest. They can be used for examining OS-OW violation assessment amounts and adjudication status.

Table 3.11: RMV citation fields of interest

Field Name	Field Type	Options/Sample
violator_license_class	String (Fixed)	D
cdl_license_indicator	Char (1)	Y; N
loc_of_offense	String (Variable)	Methuen
offense_chap_sec_sub	String (Variable)	909D0
desc_of_offense	String (Variable)	WINDOW OBSTRUCTED/NONTRANSPARENT * c90 9D
violation_assessment_amount	Integer (4)	0–9999
mph_in_a_zone_actual	Integer (4)	0–9999
mph_in_a_zone_limit	Integer (4)	0–9999
citation_type	String (Variable)	W
reversed_indicator	Integer (4)	1; 2; 9

3.3.4 Massachusetts State Police SafetyNet Inspection

The MSP CVES SafetyNet inspection data set contains data from state and federal inspection actions involving motor carriers, shippers of hazardous materials, and transporters of hazardous materials operating in the United States. The majority of the inspections are conducted at the roadside by state personnel under the MCSAP.

The MSP CVES conducts driver and vehicle inspections, divided into eight levels, to ensure that FMCSA regulations are implemented. They include the following:

- Level I: North American Standard Inspection
- Level II: Walk-Around Driver/Vehicle Inspection
- Level III: Driver/Credential/Administrative Inspection
- Level IV: Special Inspections: Usually consists of a one-time examination
- Level V: Vehicle-Only Inspection
- Level VI: North American Standard Inspection for Transuranic Waste and Highway Route Controlled Quantities (HRCQ) of Radioactive Material
- Level VII: Jurisdictional Mandated Commercial Vehicle Inspection
- Level VIII: North American Standard Electronic Inspection

Federal and state field enforcement staff perform inspections on interstate and intrastate motor carriers, shippers, and transporters of hazardous materials. Severe violations of the FMCSR may result in a vehicle and/or driver being placed out of service. The data collected from statewide inspection activity is also collected and stored in the FMCSA repositories.

The SafetyNet inspection database consists of roadside inspection data (including violations) on commercial trucks and buses. This data is primarily reported by state police jurisdictions

to FMCSA, though some federal inspections are also included. It includes identifying information for inspections such as the USDOT number, report number, inspection data, state, and vehicle information.

This database includes information on the findings of these inspections including the level, gross vehicle weight rating, scale readings, carrier details, location, violations, and OOS consequences.

Table 3.12 outlines the SafetyNet inspection fields deemed of importance for the framework of interoperability toward canister development. They can be used within the linkage canister strategies by linking on inspection_id.

There are significant limitations when trying to pull attributes from multiple tables. There is no direct correlation between the carrier record and a specific vehicle unit or resulting violation. One workaround was identified by pairing VEHICLE.vehicleunitnum with VIOLATION.vehicleunitcode which allows users to determine which vehicle unit is associated with a specific violation, such as when determining whether the overweight violation was associated with the truck or the trailer in a multiunit vehicle inspection. Additionally, to account for if the violation was attributed to the driver, VIOLATION.vehicleunitcode would instead contain the value “D.”

Table 3.12: Inspection linkage fields of importance

Technical Name	Sample	Field Description or Notes
INSPECTION.inspection_id	879643	schema unique identifier
VEHICLE.vehicleid	5PVNJ8JVXC4S53500	VIN
VEHICLE.vehiclelicenseid	18198	Vehicle registration
VEHICLE.vehicleunitnum	1	schema unique identifier
VEHICLE.vehiclelicensestatecode	RI	Vehicle registration state
VIOLATION.violation_id	2427338	schema unique identifier
VIOLATION.citationnum	null	A state-agency unique id documented on the actual "ticket" issued as a result of an inspection or traffic enforcement. A citation may have more than one associated violation. Data limitation found that only the first inspection violation record stores this value and will be blank on others from the same inspection; vioseqid may aid in imputing.
VIOLATION.vehicleunitcode	D	violation can be associated with driver (D) or the specific vehicle unit "vehicle.vehicleunitnum" [1, 2, 3; e.g., Tractor (1) Trailer (2)]
VIOLATION.vioseqid	1	itemizes the order of multiple violations per inspection, may aid when trying to determine citationnum (linkable to RMV citation)
CARRIER.carrier_id	653	schema unique identifier
CARRIER.usdotnum	1281776	Carrier-specific unique identifier
CARRIER.carriername	HISTORIC TOURS	Carrier name, all cap, freeform

In addition to the Inspection fields deemed to be of importance for the framework of interoperability toward canister development outlined above, Table 3.13 outlines additional fields of topical interest. These inspection, vehicle, and carrier fields can be used for examining over-represented proportions, comparing OS-OW inspection findings against its baseline. Characteristics which are over-represented by carriers with relevant OS-OW violations can be more efficiently identified for greater understanding and prioritization.

Table 3.13: Inspection fields of interest

Technical Name	Field Type	Field Name	Options, Description or Notes
INSPMAIN.inspsizeweightenfflag	flag Y/N	Size/Weight Enforcement	Size weight enforcement flag
INSPMAIN.vehiclegcweightrating	integer	Gross Combination Weight Rating	The combined weight of all vehicle units
VEHICLE.vehicleunittypecode	integer	Vehicle Unit Type	1 - BU - Bus 2 - DC - Dolly Converter 3 - FT - Full Trailer 4 - LM - Limousine 5 - MC - Motor Carrier 6 - OT - Other 7 - PT - Pole Trailer 8 - SB - School Bus 9 - ST - Semitrailer 10 - TR - Straight Truck 11 - TT -Truck Tractor 12 - VN - Van 13 - ZZ - Unknown 14 - Intermodal Chassis
VEHICLE.vehiclegvwrnum	integer	Gross Vehicle Weight Rating	Vehicle unit weight if combination type it will be summed with other to create GCVW
VIOLATION.viofederalregcode	text	Federal Regulation	Decodes via FMCSA_violation support table
VIOLATION.suppviodesc	text freeform	Violation Description	Freeform specific violation descriptive text, ex.: 50 MPH IN 45 MPH ZONE. POSTED, STATIONARY RADAR
CARRIER.carrierinterstateflag	flag Y/N	Carrier Interstate	Y = interstate N = intrastate

3.3.5 Oversize/Overweight Permits: OASIS

MassDOT has contracted ProMiles, a web-based permitting and highway access system vendor, to issue oversize/overweight permits, through the web platform OASIS. Through OASIS, all state-issued OS-OW permits are recorded and maintained. By inputting load and delivery details, OASIS routes the application and outputs the authorized roadways, while also noting any exceptions, on the permit. There is a current effort in Massachusetts to align OASIS with CVIEW to enable the confirmation of valid carrier safety ratings before issuing a permit.

When a carrier submits a permit application, OASIS will automatically process it if it falls under the auto-issue threshold set for the state at 12 ft wide, 13 ft 6 in. high, 80 ft long, and 130,000 lb. gross weight. A truck does not require a special permit if it does not exceed a width, including load, of 8 ft. 6 in., and a height, including load, of 13 ft. 6 in. (if not using tunnels). Loads exceeding set thresholds initiate a survey wherein the prescribed roadways are manually vetted to compare carrier-indicated load specifics with roadway/bridge capacity data points. Some OS-OW permit requests may necessitate a more in-depth survey to be completed by a third-party, often to validate bridges that are not state-owned or state-maintained that MassDOT has no authority to permit loads on. Special considerations are required for superloads exceeding 130,000 lb and only approved by the state bridge engineer.

ProMiles regularly retrieves MassDOT roadway inventory data to validate any changes against their existing map-routing platform. Separately, modifications to clearances and structure restrictions are communicated from the permit office to the vendor, which then requires integration into the OASIS platform. Due to the nature of as-needed communication and manual integration, these changes are sometimes not reflected in a systematic manner, and instead are only adjusted on a specific permit.

Although law enforcement agency supervisors can log into a portal via OASIS to examine permits and assess escort requests, it is not a frequent or common practice. Often, law enforcement will only visually inspect a driver's permit copy or validate via a QR code. Improved data-integration should not only verify the good standing of a carrier prior to the permit being issued but should also provide time-relevant permit statuses to the enforcement officer when conducting a traffic enforcement stop or inspection, in the flow of standard protocol such as when pulling up CVIEW and Inspection systems in the cruiser.

Table 3.14 outlines the important OASIS fields for the framework of interoperability toward canister development. They can be used within the linkage canister strategies.

This data set is only a representation, because the data obtained by the research team was limited to exports that were available in a customer-facing portal. Findings from this data set will not be included in the recommendations because they are likely not relevant. Ultimately, working with a data set that is maintained by a third party can be challenging for a cooperative effort and flawed in that it is not equivalent to what the agency will be utilizing themselves when implementing future developments.

Table 3.14: OS-OW permit fields of importance

Field Name	Field Type	Sample
Permit ID	Integer	222222
Permit number	String (fixed)	23S005152
USDOT number	Integer	1111111
Company name	String (variable)	CARRIER
VIN	String (variable)	10T1K4JH4R1050803
Registration	String (variable)	freeform text: 28196 -and- P1165389 - and- various

In addition to the OASIS fields deemed to be of importance for the framework of interoperability toward canister development outlined above, Table 3.15 outlines additional fields of topical interest. These fields can be used for classifying the permits by gross weight and understanding the load and commodity type.

Table 3.15: OS-OW permit fields of interest

Field Name	Field Type	Options/Sample
Status	String (fixed)	Canceled customer Canceled MassDOT Expired Issued Issued Prior Unsuspended Voided Voided: Refunded
Commodity Type	N/A	N/A (not included in data extract)
Load Description	String (variable)	Transformer
Permit Type	String (fixed)	Nonreducible 6 Month Intermodal Nonreducible Annual Boat Nonreducible Annual Construction Equipment Nonreducible Annual Fire Truck Government Nonreducible Annual Self-Propelled Crane Nonreducible Annual Utility Poles Nonreducible Single Trip Nonreducible Single Trip Cask Nonreducible Single Trip Intermodal Nonreducible Single Trip Modular Homes Nonreducible Single Trip Self-Propelled Equipment Reducible Annual Special Hauling Explosives Special Hauling Fuel Special Hauling Tandem Trailer Superload
Total Fees	Integer	3333.33
Length	Integer	1711
Height	Integer	223
Width	Integer	179
Gross Wt.	Integer	0 - 999999
Front OH	N/A	N/A (not included in data extract)
Rear OH	N/A	N/A (not included in data extract)

Data sets, including MassDOT overweight/size permits, freight restrictions, MassDOT Registry of Motor Vehicles citation, licensed drivers, registered vehicles, and crash, as well as Massachusetts State Police SafetyNet CMV crash and inspection data, were analyzed to determine consistency and usability on mirrored or relational fields. In addition to those data sets, additional data sets including toll records, and roadway inventory were examined.

The deliverable titled Classification of Data Sources, Fields, and Framework of Interoperability consisted of this project's tech transfer initiatives, where each primary data set and their fields were itemized with columns outlined by their fields of interest and identification fields.

Challenges were noted with regard to extracting data through the OASIS portal. The data platform appears to have been primarily designed for a front-end customer and therefore lacks analysis filters and export capabilities. Challenges posed included date range selection, previewing records before download, and unknown progress of the submitted extract request. In addition, it was difficult to determine whether ProMiles possesses the most recent state roadway data to best inform their routing software, particularly issues with the file format and data type compatibility. This reinforces the need for universalized criteria and schematics, including methods for recording relevant clearances, lane numbers, etc. Additionally, an option to query all, or download permit records in bulk form was not available, requiring significant manual efforts, both downloading and merging. The extraction tool provided data in.XLSX format, limiting the use of more efficient data feed opportunities which are most commonly dependent on comma-separated values (CSV) or similar text-based source data.

3.4 Construction of Data Canisters

Utilizing results from the classification of data sources and fields, potential linkages were hypothesized and then tested by compiling mixed-source fields of interest, directed at OS-OW permit-enforcement. Using preliminary deterministic linkage methods, ideal data canisters were developed. Cataloging of each ideal data canister was then implemented to detail implementation factors.

3.4.1 Canister #1 OS-OW Permits Paired with Carrier Census Records

The initial canister was developed using OS-OW permit records to align with a unique carrier and its associated attributes from the FMCSA Census data set. Table 3.16 outlines the fields directly used to construct the linkage.

Table 3.16: OS-OW canister #1 linkage fields

Data Source	Schema/Technical Field Name	Field Significance	Field Name
FMCSA Census	DOT_NUMBER	Carrier Unique ID	USDOT Number
	LEGAL_NAME	Carrier Unique ID	Company Legal Name
	DBA_NAME	Carrier Unique ID	Company DBA Name
OASIS	USDOT Number	Carrier Unique ID	USDOT Number
	Company Name	Carrier Unique ID	Company Name
	Registration	Vehicle Unique ID	Vehicle Registration
	VIN	Vehicle Unique ID	Vehicle VIN

Utilizing OASIS permit data as our primary data set and attempting to match a FMCSA census record to each was an initial procedural step to becoming familiar with the reliability of OASIS. High match rates were anticipated because OASIS has features built into the auto permitting process to verify the good standing of a carrier with FMCSA before allowing the permit to be issued.

The process of linking the OASIS overweight permit data with the FMCSA carrier census database yielded significant results. A total of 119,582 records from the OASIS data set were processed for matching. Of these records, 113,393 were successfully matched in the FMCSA database, representing a high success rate of matching. The majority of these records, 109,289, were matched based on the USDOT number, indicating a direct correlation between the two data sets in most instances. Only 3,692 records were matched based on the precise company name, underscoring the importance of name consistency in record keeping, and highlighting the issue of carriers who intentionally or unintentionally use alternate versions of their company name. In relation to this, some matches were based on a high degree of similarity between company names, with 397 records matching a 98% similarity score, and fifteen records matching with a 99% similarity score. These matches indicate the potential to match companies operating under multiple names when direct matches are not possible. It should also be noted that a smaller portion of 6,189 records did not match at all within the FMCSA database. Importantly, 5,695 of these unmatched records had a USDOT Number entered as ‘0’ within OASIS, which could indicate either missing or incorrectly entered data.

These results highlight the effectiveness of the matching methodology, specifically the utility of fuzzy string matching for cases where direct matches are not apparent. The high rate of successful matches validates the approach used, while the subset of unmatched records points to areas for potential data quality improvement in the OASIS system.

3.4.2 Canister #2 OS-OW Permits Paired with Inspection

A second canister intended to build upon the first was constructed utilizing carrier identifiers that were present in OS-OW Permit records. There is no guarantee that a carrier who obtains an OS-OW permit will have an inspection, so alternatively to match rates, the results of this linkage itemized carriers by their count of permits, count of inspections, and count of violations (Table 3.17).

Table 3.17: OS-OW canister #2 linkage fields

Data Source	Schema/Technical Field Name	Field Significance	Field Name
OS-OW Permits	USDOT Number	Carrier Unique ID	USDOT number
	Company Name	Carrier Unique ID	Company name
	Registration	Vehicle Unique ID	Registration
	VIN	Vehicle Unique ID	Vehicle VIN
MSP SafetyNet Inspection	cmv.inspection_carrier.usdotnum	Carrier Unique ID	USDOT number
	cmv.inspection_carrier.carriername	Carrier Unique ID	Company name
	cmv.inspection_vehicle.vehiclelicenseid	Vehicle Unique ID	Vehicle registration
	cmv.inspection_vehicle.vehiclelicensestatecode	Vehicle Unique ID	Vehicle registration state
	cmv.inspection_vehicle.vehicleid	Vehicle Unique ID	Vehicle VIN
	cmv.inspection_violation.citationnum	Event-Violation Unique ID	Citation number

This data canister has demonstrated a strong ability to provide perspective to the volume of OS-OW inspections happening. The impacts of Massachusetts State Police enforcement efforts extend beyond typical driver/vehicle safety initiatives and also improve infrastructure preservation, by removing vehicles which are found to exceed authorized weight/axle ratios.

Utilizing the FY23 available data, of all MSP SafetyNet Inspection violations, 1,336 of an overall 29,773 violations were related to weight (4.5%). Of those inspections indicated as traffic enforcement, 1,007 of the specific 17,282 violations were related to weight (5.8%), whereas roadside inspection violations were 17% weight related (Table 3.18).

Table 3.18: Weight-related roadside inspection violations

Fiscal Year	Inspections	Violations	Total Violations (%)	OOS Violations	OOS (%)
2023	1,261	1,657	17	205	12
2022	1,313	1,543	11	130	8
2021	1,669	1,873	12	258	14
2020	1,399	1,564	10	197	13

Retrieving the location data from overweight-related violations, the following interstate and state routes in Table 3.19 were most common in years 2021–2023 (Table 3.19).

Table 3.19: Top routes with overweight violations

Route Number	Count of Violations
I-90	1,212
I-495	426
I-95	374
I-91	256
I-195	207
US-1	180
US-20	166
MA-2	154
MA-24	115
I-93	103
US-6	93
US-3	87
I-395	80
I-84	64
MA-146	62
MA-138	58
MA-12	50
MA-28	34
I-290	32
MA-16	27
MA-9	24
US-44	24

3.4.3 OS-OW Permits Paired with Inspection and RMV Citation

With the addition of the RMV citation data set into the previous canister, UMassSafe was able to gather more information about the fiscal implications of violations. Namely, UMassSafe was able to quantify fines, count the number of overweight citations, and examine reversal rates of citations. This information, combined with inspection data from SafetyNet, and FMCSA carrier census data, provided a comprehensive picture of carriers who obtain overweight permits in Massachusetts (Table 3.20). These data can be filtered and sorted to examine rates of overweight inspections and fines.

Table 3.20: OS-OW canister #3 linkage fields

Data Source	Technical Field Name	Field Significance	Field Name
OASIS	USDOT Number	Carrier Unique ID	USDOT number
	Company Name	Carrier Unique ID	Company name
	Registration	Vehicle Unique ID	Registration
	VIN	Vehicle Unique ID	Vehicle VIN
MSP Safety Net Inspection	cmv.inspection_carrier.usdotnum	Carrier Unique ID	USDOT number
	cmv.inspection_carrier.carriername	Carrier Unique ID	Company name
	cmv.inspection_vehicle.vehiclelicenseid	Vehicle Unique ID	Vehicle registration
	cmv.inspection_vehicle.vehiclelicensestatecode	Vehicle Unique ID	Vehicle registration state
	cmv.inspection_vehicle.vehicleid	Vehicle Unique ID	Vehicle VIN
	cmv.inspection_violation.citationnum	Event-Violation Unique ID	Citation number
MA Citation	citation.violations.violation_id	Event-Violation Unique ID	Violation ID
	citation.violations.citation_number	Event-Violation Unique ID	Citation number
	citation.violations.vehicle_registration	Vehicle Unique ID	Vehicle registration
	citation.violations.vehicle_reg_state	Vehicle Unique ID	Vehicle registration state
	citation.violations.violator_name	Carrier Unique ID	Violator name

Upon successful execution of these linkage queries, the following fields of interest and thematic categories are used in a demonstration analysis for proof of concept (Table 3.21). Due to the preliminary and sensitive nature of such findings, these findings are available by request only.

Table 3.21: OS-OW canister themes of interest

FMCSA Census	MassDOT OASIS	MSP SafetyNet Inspection	MassDOT RMV Violation
Carrier Operation	Load description	Size/Weight enforcement, traffic enforcement	Driver license class, CDL license
Annual Mileage	Permit type	Gross combination weight rating, Gross vehicle weight rating	Chapter section subsection
Carrier Add Date	Total fees	Inspection level	Citation type
Officer in Charge (OIC) Responsible State	Length, height, width	Vehicle unit type	Description of offense
Number of Power Units	Gross weight	Violation description, federal regulation	Violation assessment amount
Number of Drivers	Status	Total violations, driver/vehicle/OOS	Reversed indicator

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4.0 Implementation and Technology Transfer

Expanding access to underused CMV and citation data sets can enhance the statewide effort toward a decoupled data hub model. State data-development initiatives can be further integrated with coexisting data sets comprehensively documented. Further, the awareness and integration of these specialized fields could enhance problem identification across freight planning, permitting, infrastructure, traffic incident management, and enforcement realms, adding operational safety value. This initial research and feasibility phase of a multiphase initiative has identified stakeholders for collaboration across multiple departments and agencies which may play a role in initiatives such as:

- Utilization of MassDOT ArcMap web layers to better understand freight corridors and permit-excluded roadways.
- Incorporation of a secondary location datapoint for ratio analyses of violation findings of OS-OW inspections by roadway.
- Appending of carrier-level state data related to licensed drivers, registered vehicles, and toll record data sets.

A summary of the project, relevant background information, and hypothetical statistical linkage findings were organized into a poster presentation (*9*).

Next steps may include further exploration of state-regulated virtual weigh station methods, or collaboration with the Commonwealth's legislature to increase OS-OW permit fees and fines.

The experiential process of requesting data from other agencies and departments resulted in lessons learned on time-delay and compromises in desired format, breadth, and depth. The study confirmed three data set-canister linkages, demonstrating that decoupled data set analyses can more comprehensively examine overweight vehicle and carrier trends, and normalize analyses for improved problem identification.

In future phases, models and software systems could be developed to run in live time with proactive analysis and outlier identification for applications such as real-time single-trip OS-OW load monitoring for enforcement agencies. Additionally, analysis results can be used to identify OS-OW carriers by a weight-related violation count per inspection ratio. Furthermore, additional topical fields, including commodity type, number of axles, number of vehicle units by relevant carrier, and route changes and notifications alerted to carrier should be integrated into the canister analyses.

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5.0 Conclusions

The resources necessary for enforcement personnel to conduct weight and safety inspections are limited and will become increasingly strained. Although technologies exist to automatically identify and weigh commercial motor vehicles traveling at normal highway speeds, implementation is slow.

MassDOT and other state agencies have many programs that address motor carrier safety issues associated with OS-OW commercial vehicles and their impact on Massachusetts roadways and permitting including:

- Development and upkeep of data of structures by the MassDOT Bridge Rating and Overload Unit, and maintenance of vertical clearance information by the MassDOT Bridge Inspection Unit.
- Selective auto-permitting using a web-based system integrated with relevant roadway restrictions.
- A "trucking network" ArcMap layer synthesizing relevant freight details hosted on geoDOT.
- Freight planning studies implemented by the freight planner to prioritize needs.
- MSP CVES commitment to conducting weight inspections and furnishing quality SafetyNet data to be used in data-sharing initiatives like CVIEW.

Other states and countries have used a variety of methods to address safety issues and violations related to OS-OW motor carriers, including enhanced route planning, uniformity in permitting and plating, electronic remote monitoring, and notification systems to carriers of roadway restrictions. While the collection of best practices is useful in understanding the underlying concepts and regulatory themes in play, it does not provide actionable next steps without first determining performance of existing enforcement strategies in relation to the frequency and severity of the OS-OW violations.

Massachusetts data sets and their associated fields were classified to create a framework of interoperability between them. Each data set was detailed, with field names, data types, supplemental schema information, and a sample of data content or list of attributes. A column, "Identifying Field of Importance" was created to designate incident, vehicle and carrier-level fields that are essential to establish cross-data set linkages. Another column, "Fields of Topical Interest" was also added to designate fields that could be included in various analysis topics.

Data sets that were thought to have mirrored fields, such as in FMCSA Inspection versus MSP SafetyNet Inspection, as well as MassDOT RMV Crash Data System, MSP SafetyNet Crash and FMCSA Crash all were found to have potential conflicting fields if not interpreted with the proper data-level and schema location. For example, an inspection-level weight field

is the measurement of the entire gross combination vehicle weight; however, in the federal inspection data set there is also a vehicle unit weight rating which is more relevant for OS-OW analyses.

Additionally, the OASIS vendor representatives had spoken at length about the struggles of initially getting Massachusetts roadway data to align to their mapping/routing platform, and their resulting challenges to ensure the roadway inventory data elements remained synced. There was also conflicting information about how changes to such roadway restrictions or structure limits are implemented manually and independently, acknowledging the need for a future investigation into the consistency of roadway and permit-level data sets.

Among the many lessons learned within this project was an enhanced understanding of the evolving nature of data contents and availability. At the onset of the project, UMassSafe had well-functioning data feeds to supply CDS crash data and was anticipating licensed driver and registered vehicle data. However, due to the data owner rebuilding its record management system, extractions were not available, and the impending data structure, timeline and usability was unknown.

Compounding this, as outsider project analysts, extracting data supported by third-party vendors, such as the OASIS permit portal, was extremely challenging. Ultimately the intended data set, which was to include route details and limitations by permit, was substituted for a short collection of data fields available through a customer-facing tool. This data set, although satisfactory to provide a sample population of carrier data for hypothetical analysis, was not comprehensive or comparable to what internal entities are able to use; thus, findings should be used with caution.

Synergistically discovered was the unreliability of internet resources and the conflicting regulatory information. The nuanced specifics of oversize-overweight permitting and accompanying restrictions was not clear, and without the institutional knowledge of skilled departments, much can be misinterpreted. As a result, the Commonwealth has a need to align resources as an educational and informational initiative for both trucking industry and law enforcement agencies.

Ultimately, through the identification of limitations and development of recommendations for better utilizing relevant data sets in future efforts, procedures for the obtainable data were theorized, developed, and documented throughout this project to support the utilization of multiple data sets in conjunction with one another. Table 5.1 summarizes the possible considerations and recommendations for MassDOT to continue its efforts in identifying problem carriers and preventing infrastructure damage.

Table 5.1: Recommendations for future consideration

Improve Data Access Options	Information and Education	Expand Data-Sources	Topical Fields for Future Inclusion	Regulatory
Participate in broad efforts to improve alignment of State agency data-owner and vendor sharing protocols and capabilities. Develop weekly single trip OS-OW permit activity notifications for geographically relevant enforcement agencies.	Identify online sources of information relevant to the trucking industry, confirm that regulatory and safety information is consistent with actual Commonwealth specifics. Consider developing and promoting regulation/safety information relevant to OS-OW permits. Could be disseminated with permit communications, truck associations, during traffic stops and inspections, as well as online resources and trucking-community discussion opportunities.	Use MassDOT ArcMap web layers to better understand freight corridors and permit-excluded roadway trends. Use a secondary location data-point (SafetyNet inspection) to rationalize violation findings of OS-OW inspections by roadway. Incorporate licensed drivers, registered vehicles, and toll record data sets	Commodity type Number of axles Number of vehicle units Route changes Roadway exclusions Relevant 511 notifications Use a secondary location data-point (SafetyNet inspection) to rationalize violation findings of OS-OW inspections by roadway	Continue to explore state-regulated virtual weigh station methods. Continue to follow national initiatives including harmonization of permitting regulations and data structure guidelines. Work with legislature to increase OS-OW permit fees and fines. Consider procedures for permit issuance with relevant outstanding fines.

In summary, UMassSafe conducted a feasibility study of various state and federal data sets relevant to oversize-overweight roadway usage and constructed data canisters yielding results from three state data sets (RMV citation, MSP SafetyNet inspection, OASIS OS-OW permits) and one federal data set (FMCSA census). This exercise was critical in hypothesizing and executing how data sets may be linked to enhance CMV safety and better preserve infrastructure in Massachusetts. This initiative addresses a root challenge in that each of these data sets were created for vastly different purposes, and therefore possess

greatly disparate schemas and nuances, which needed to be accounted for before linkages could be constructed.

This feasibility study determined that expanding access to underused CMV and citation data sets can enhance the statewide effort toward a decoupled data hub model. Furthermore, decoupled data set analysis can more comprehensively examine overweight vehicles and carrier trends and normalize analysis by ratios and ranking methods. In addition, analysis results can be used to compare anecdotal content and expert knowledge against data findings for accuracy and to further develop insights on problem identification methods and thus the prevention of infrastructure damage.

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