ENTERPRISE Transportation Pooled Fund Study TPF-5 (231)

E N T E R ⟲ P R I S E

Real-Time Integration of Arrow Board Messages into Traveler Information Systems

EVALUATION PLAN

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Acknowledgements

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1.0   Introduction

Longer duration construction and maintenance activities are typically manually entered into Road Condition Reporting Systems (RCRS) and/or Advanced Traffic Management System (ATMS) to alert TMC operators and the traveling public. However, fast changing and shorter duration activities can be challenging and time consuming to enter and therefore these events are not always entered to alert TMC operators or the traveling public of lane or should closures.

This ENTERPRISE project "Real-Time Integration of Arrow Board Messages into Traveler Information Systems" outlines an effort to integrate Arrow Board status information (e.g. direction of arrow) from the field into existing and future traveler information systems to alert TMC operators and travelers in real-time of for example a lane closure. Per direction from the ENTERPRISE Board, the project was separated into three phases in order to properly assess needs and potential solutions before deployment and evaluation at one or more ENTERPRISE agency sites.

Phase 1 of this project involved agency collaboration (i.e. ENTERPRISE Pooled Fund members) to generate Model Concept of Operations and Model Requirements documents for a system to report Arrow Board status information to TMC staff for improved traveler information dissemination and performance reporting, that would not require significant agency staff time in the field or at the TMC. These model systems engineering documents were developed for ENTERPRISE agencies to use and modify when implementing solutions to integrate active work zone notifications into their current traveler information dissemination systems. These model documents are likewise expected to enable Arrow Board manufacturers and third-party integrators to develop systems that are flexible to meet the various needs of multiple agencies.

The objective of this Phase 2 project is to generate an Evaluation Plan for examining the process, effectiveness, lessons learned, and benefits of Arrow Board Reporting Systems once they are deployed. This Evaluation Plan is expected to guide future evaluations of one or more pilot deployments conducted by ENTERPRISE agencies. Potential benefits from a deployment that could be examined as a part of this evaluation include:

- Detailed, consistent, and reliable real-time information about lane closures disseminated to travelers upstream of the closure through Dynamic Message Signs (DMS), traveler information mediums, and connected vehicle applications;

- Improved situational awareness by TMC operators of real-time lane closures in the field;

- Improved construction management opportunities, including the ability to verify contractor work status to document lane closure times for use on lane rental projects or enforce restricted hours or to cross check any lane closure updates that are required of the contractor;

- Increased archived data available for evaluation, performance management, and research to better understand work zone mobility impacts and exposure for reporting purposes, use for future work zone planning efforts, analysis of Transportation Management Plans (TMPs), and for performance-based specifications.

- Foundational communication technology for Arrow Boards to broadcast display status and lane closure-related information to Connected and Automated Vehicles.

- Depending on the amount of manual involvement by field staff, the potential for faster response time in the field for maintenance needs, including times when a trailer-mounted Arrow Board was hit by a passing vehicle or blown out of place by strong winds, given notifications to field staff of system functionality.

- The reporting of Arrow Board usage may improve quality of the device, i.e., the system can report if the Arrow Board is level and plumb, and the location can be more readily verified by field personnel.

This Evaluation Plan will be used in Phase 3 of this project to facilitate and evaluate deployments of this concept in select ENTERPRISE member states. **It is recommended that each deploying agency develop a concept of operations and requirements document based on the model documents as well as conduct a separate, detailed verification test to document requirements that are met (or not met) to establish a baseline for the evaluation in understanding the variations and capabilities of deployed Arrow Board Reporting Systems.** Additionally, it is important to note that the developed evaluation strategy and plan is for use by each agency testing a deployment, however components may be modified once deployment details for an individual agency are finalized.

This Evaluation Plan document represents the final product of this Phase 2 effort, and contains the following sections:

2.0 Variations for Real-Time Integration of Arrow Board Messages into Traveler Information Systems – several use cases to highlight variations in possible deployments.

3.0 Summary of Test Deployments – as currently envisioned or being procured and deployed by Minnesota DOT, Iowa DOT and Michigan DOT.

4.0 Evaluation Strategy – overall evaluation goal and specific objectives for the evaluation.

5.0 Evaluation Plan – details on data collection, analysis approach, and specific measures of effectiveness (MOEs) for addressing each evaluation objective.

2.0 Variations for Real-Time Integration of Arrow Board Messages into Traveler Information Systems

A couple member agencies of the ENTERPRISE Pooled Fund Program are planning to deploy and evaluate technology solutions allowing for the real-time integration of arrow board messages into traveler information systems. In general, the Arrow Board Reporting System is comprised of two largely independent systems, as depicted in *Figure 1*: 1) Arrow Boards and 2) traveler information dissemination systems and data archives that comprise the databases, RCRS, and ATMS used by transportation agencies to collect, process, disseminate, and store traffic data and information for use by the traveling public and agency stakeholders. However, the Model Concept of Operations and Model Requirements documents were written with flexibility for agencies to deploy customized Arrow Board Reporting Systems according to their needs.

A Summary of Test Deployments, as currently envisioned, is described in the next section. However, because these deployments could change or additional ENTERPRISE member states may also deploy Arrow Board Reporting Systems, it is important for this Evaluation Plan to also include any additional questions that might be necessary to verify system performance when deployed in different settings than those currently envisioned.

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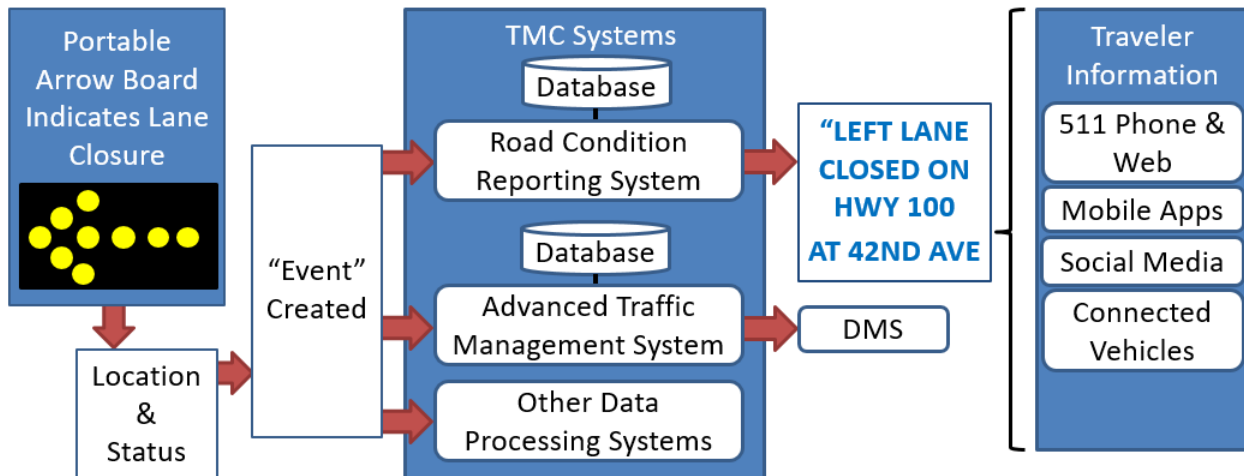
Figure 1: The systems of interest for this ConOps include Portable Arrow Boards, Road Condition Reporting Systems, Advanced Traffic Management Systems, and traveler information dissemination systems.

Section 2.1 presents high-level variations of how equipped arrow boards may be designed, Section 2.2 discusses various deployment settings in the field, and Section 2.3 identifies high-level variations for how the Arrow Board Reporting System information may be received by TMC Systems and used by transportation agencies. These variations are summarized in Table 1 and will inform the development of evaluation objectives, measures, and data collection needs that can then be assigned to each test deployment, as applicable.

Table 1: Variations of Arrow Board Reporting System design, integration with the TMC, and deployment

Variation	Option 1	Option 2	Option 3
Arrow Board Reporting System Variations			
Device Type	Truck-Mounted	Trailer	-
Data Processing Capabilities	None	Present	-
Communication Mechanism	To TMC	To 3rd-Party Server	To DOT Staff
Connected Vehicle Capabilities	None	Present	-
Deployment Setting Variations			
Area	Urban	Rural	-
Roadway Type	Freeway	Arterial	-
Work Zone Type	Stationary	Mobile	-
Lanes Closed	Single lane	Multiple lanes	-
Work Zone Duration	Short (hours)	Medium (days, weeks)	Long (months)
TMC System Variations			
Integration with TMC Systems	RCRS	ATMS	ATIS
Level of Automation	Manually generated	Manually approve recommendations	Fully Automated
Staff Notification Recipients	Field staff	Operator staff	-
Staff Notification Mechanism	Text	E-mail	TMC interface
Staff Notification Events	Activation/De-activation	All display status changes	-
Archived Database	Existing archive	New archive	-

2.1 Arrow Board Reporting System Variations

The four types of Arrow Board Reporting System variations described below focus on several ways that a developed system might be deployed in the field, which could thus impact how the system operates and how the evaluation is conducted. These variations are not intended to be all-inclusive, but instead highlight some key differences that might be expected for a deployed system.

2.1.1 Arrow Board Device Type

Arrow Board trailers are commonly used as a standalone, independent system in work zones, i.e., transported into position and disconnected from the vehicle, with operations controls for activation and power source being part of the trailer. These devices are more common for longer-duration work zones lasting multiple days. Additional technology to equip the Arrow Board trailer might utilize the power source and data regarding the Arrow Board display, but be required to include all other capabilities that are not present on the Arrow Board trailer, including communications capabilities, as well as data collection capabilities for determining the location of the Arrow Board and direction it is facing.

Truck-mounted Arrow Boards are commonly used for maintenance activities that cause shorter-duration work zones lasting less than a day. These devices are likely integrated with the vehicle systems, including power source and operations controls. Thus, additional data collection and capabilities may be available that would not be required for a developed Arrow Board Reporting System, e.g., a maintenance vehicle may be equipped with automatic vehicle location (AVL) and communications capabilities. Alternatively, these maintenance truck functions could be used as alternate communications channels or to validate data collected by the developed Arrow Board Reporting System.

2.1.2 Data Processing Capabilities

A deployed Arrow Board Reporting System might contain data processing capabilities to transmit information that is more easily digested and understood by the individual or system recipient, e.g., specific roadway and milepost information instead of latitude and longitude coordinates. Additional data processing capabilities might be required if the Arrow Board includes Dedicated Short Range Communications (DSRC) to support connected vehicle applications and/or the transmission of notifications to DOT operators or field staff directly from the Arrow Board, as further detailed in the Communication Mechanism and Transmission and Connected Vehicle Applications variations.

2.1.3 Communication Mechanism and Transmission

It is expected that agencies will use either radio or cellular communications for the Arrow Board Reporting System to be consistent with agency practices. Arrow Board data messages could then be transmitted directly to the TMC, directly to a third-party server, or as requested from the TMC or third-party server. Additionally, the system could be designed for notification messages to be transmitted directly to DOT operators and/or field staff, particularly if Data Processing Capabilities are included, as described above. Note also that DSRC capabilities could be added for connected vehicle applications, as described in the Connected Vehicle Applications variation.

2.1.4 Connected Vehicle Applications

In anticipation of the future connected vehicle environment, a developed Arrow Board Reporting System may include DSRC capabilities. Additional consideration should then be given to what additional data

processing tools and application support may be needed to support connected vehicle applications for in-vehicle messaging. While some of these capabilities may reside at the TMC, others would likely be within the Arrow Board Reporting System in the field. The development and analysis of any connected vehicle application functionality, aside from DSRC-related data transmission capabilities, is beyond the scope of this effort.

2.2 Deployment Setting Variations

Any developed Arrow Board Reporting System is expected to be designed for operations in a variety of deployment settings. Although the MOEs would generally be the same for most of these variations, deployment of Arrow Board Reporting Systems in each of these settings should be evaluated to confirm its utility.

2.2.1 Area

Arrow Boards are deployed in both urban and rural settings. It is possible that different challenges could arise with deploying Arrow Board Reporting Systems in each of these areas. For instance, higher traffic volumes and a denser roadway network with more access points could be a challenge in urban areas, while rural areas would be more likely to experience difficulties with communications reliability.

2.2.2 Roadway Type

The type of roadway an Arrow Board Reporting System is deployed on could similarly have different challenges. Determination of the lane closure configuration on a divided freeway would likely be more easily ascertained than a lane closure on a non-divided arterial, particularly if turn lanes are present and an Arrow Board is used to split traffic traveling in the same direction.

2.2.3 Work Zone Type

The designed Arrow Board Reporting System should be fully functional for either a stationary or mobile work zone. However, a mobile work zone scenario would allow for the evaluation of different features. These features include the system capability for determining that an Arrow Board is part of a mobile work zone based on location data, as well as data collection and transmission at more frequent intervals than a deployment in a stationary work zone.

2.2.4 Number of Lanes Closed

The provision of multiple Arrow Boards within a single construction area for closing a shoulder and adjacent lane, or multiple lanes is another example of a more complex work zone. Deployment of Arrow Board Reporting Systems in different work zone configurations would test the data processing capabilities more broadly to ascertain various different and complex lane closure scenarios in the field.

2.2.5 Work Zone Duration

A designed Arrow Board Reporting System is generally expected to function the same regardless of how long a work zone remains in place. A particularly short-duration work zone that may be in place for one to four hours is likely not going to be associated with an event in an agency RCRS or ATMS. A short-duration work zone that is in place for a few days or weeks is more likely to be planned in advance, known at the TMC, and be associated with an RCRS or ATMS event, although specific details about the event start and end dates and times may be unknown. A longer duration work zone lasting months is even more likely

to be associated with an RCRS or ATMs event. However, it also creates a scenario where the Arrow Board Reporting System would be continuously active for an extended period of time, with potentially no interaction with field staff and a reduced likelihood of active monitoring, particularly if few operational changes take place while the lane closure is active. Additionally, an Arrow Board Reporting System that is deployed in a stationary, long-term work zone for several months could be designed to send less frequent messages.

2.3 TMC System Variations

The four types of TMC System variations described below focus on ways that a developed system might be deployed at the TMC, which would thus impact how the system operates and how the evaluation is conducted. These variations are not intended to be all-inclusive, but instead highlight some key differences that might be expected for a deployed system.

2.3.1 Integration with TMC Systems

While any developed Arrow Board Reporting System is intended to be integrated with TMC Systems, which may include a RCRS, ATMS, and advanced traveler information systems (ATIS) such as 511 or traveler information websites. Some agencies may not have all of these systems, or decide not to integrate Arrow Board Reporting System information with all of these systems. Additionally, the organization of DOT operators that manage the various systems will influence the expected roles and responsibilities, as well as the configuration, design, and recipients of Arrow Board notifications.

2.3.2 Level of Automation

The level of automation for creating new events and modifying or closing existing events in the RCRS, ATMS, or ATIS will vary according to the deploying agency's confidence with the Arrow Board Reporting System, as well as agency policies, procedures, and system capabilities. Following receipt of Arrow Board Reporting System data, it is expected that TMC Systems will process this data, potentially searching for and identifying existing, related events in the RCRS, ATMS, and/or ATIS. At some agencies, a TMC operator might be required to manually take action for creating a new event or modifying an existing event, as necessary. However, the developed, integrated system may be able to create a new event or modify the existing, related event, as needed. Some agencies may require a TMC operator to manually approve the system-generated recommendations before it is posted or updated in the RCRS, ATMS, and/or ATIS. Other agencies may allow the system-generated recommendations to be automatically posted or updated in the RCRS, ATMS, and/or ATIS.

2.3.3 Staff Notifications

Notifications are expected to be sent to DOT staff regarding changes in Arrow Board operational status, such as when an Arrow Board is activated, display is changed, moved, or de-activated. These notifications are expected to be configurable in various ways. First, these notifications may be displayed on the ATMS or RCRS user interface for DOT operators in the TMC, or sent via email or text message. Second, these notifications may be issued to various DOT operator staff, as well as field staff. Third, the types of information included in these notifications will likely vary. Finally, the types of Arrow Board status changes that trigger the transmission of a notification may vary by agency and within agencies, e.g., field staff may receive only activation and de-activation notifications, while DOT operator staff may receive notification for other status changes that occur in the field.

2.3.4 Archived Database

It is anticipated that raw and processed data related to the Arrow Board Reporting System will be archived. Some agencies may accommodate this within existing databases for RCRS, ATMS, and/or ATIS logs, while other agencies may develop a new archive for this information.

3.0   Summary of Test Deployments

This Evaluation Plan is expected to be applied to deployments currently being planned in ENTERPRISE member states. The Minnesota DOT is currently working to procure and deploy Arrow Board Reporting Systems, and other DOTs are considering their own deployments, which would allow for testing in real-world conditions in different types of work zones, with different reporting requirements for each agency's RCRS and/or ATMS software, and with different uses for the reported information. That said, it is envisioned that the overall objectives, measures, and data collection needs described in the Section 4.0 Evaluation Plan could readily be adapted to evaluate other deployments in other states that vary in how they are implemented.

3.1 Minnesota Test Deployment

The Minnesota Department of Transportation (MnDOT) is currently working on a project to deploy equipped Arrow Boards for integrating real-time notifications into TMC Systems. Specifically, the project intends to deploy a total of 20 Arrow Boards with status reporting capability in the Twin Cities Metro District, both truck-mounted Arrow Boards and Arrow Board trailers. These Arrow Boards will be equipped and deployed primarily for shorter-duration maintenance activities that last several hours. The equipped Arrow Boards are expected to be used primarily in urban settings for mobile work zones. MnDOT will be renting the Arrow Board Reporting System technology from Street Smart Rental, LLC.

The Arrow Board data will be collected and aggregated by a third party (Street Smart Rental, LLC). Specifically, data collection will occur at the Arrow Board onboard system. The onboard system will passively monitor the Arrow Board status and write this status to a database (i.e., proxy server). The database will be polled every two minutes by the Street Smart Rental Smart Arrow Board (SMARTAB) web-based system, which will populate the Arrow Board information to a hosted/secure web-based application. This application will publish the Arrow Board information to a real-time user interface designed to allow Arrow Board system users to monitor and manage the application, and have full access to the data. Additionally, an Incident File feed that is compliant with the MnDOT ATMS, i.e., Intelligent Roadway Information System (IRIS), will be provided for ingest to MnDOT servers through the external incident feed interface. When an Arrow Board is operational, a file will be written to the incident; when an Arrow Board is non-operational, an incident feed is not written to the master incident file. Any time an Arrow Board is powered-down the onboard system will log the power down event, transmit a message, and continue to send telemetry information. These events will be available via the local onboard system log and the SMARTAB system reporting. However, when an Arrow Board is completely powered down with no power provided to the onboard system, messages will not be able to be transmitted, which will be reflected in the event log.

The Arrow Board Reporting System is expected to have data processing capabilities such as determining the arrow board coordinate location, direction the arrow board is facing, arrow board status (left arrow, right arrow, or caution mode), and whether the arrow board unit is in the up or down position. However, determination of the roadway and milepost or address will take place at a third-party server.

Regarding integration at the TMC, MnDOT will ingest the compliant incident file feed into IRIS when an Arrow Board is in operational mode. This will then be transferred to be ingested by MnDOT's RCRS. DOT operator staff will receive in-line notifications that are queued by the SMARTAB web application, as well as triggered email and text messages that come from SMARTAB. Field staff may receive notifications via mobile web to a tablet or phone. Finally, both log files and database records will be retained for a data archive. When the rental period expires, MnDOT will receive a copy of the database and log files from Street Smart Rentals.

The MnDOT pilot deployment is expected to occur during the months of October 2017 through April 2018. This period will include installation and preliminary testing on four Arrow Boards during the initial six months, followed by a one-year testing period on a total of 20 Arrow Boards.

3.2 Other Potential Test Deployments

The Iowa DOT and Michigan DOT (MDOT) are both currently considering the procurement of Arrow Board Reporting System technology, but details are preliminary and may change.

Some potential considerations for Iowa DOT's pilot deployment include:

- Either purchasing or renting equipment to add-on to existing Arrow Boards.
- Arrow Board Reporting Systems might be deployed in one or both of the following settings:
  - Adding the Arrow Board Reporting System devices to lane-marking equipment, which would be used in a variety of settings but primarily for short-duration maintenance activities (i.e. mobile work zones.)
  - Deploy Arrow Board Reporting Systems on the I-380 corridor, which is being used for connected and automated vehicle research, and could be integrated with connected vehicle applications. This I-380 corridor is primarily a rural, 4-lane, divided interstate roadway.
  - Using the Arrow Board Reporting System in conjunction with a project being conducted by Iowa State University that uses Here data.
- Using archived data from Arrow Board Reporting system to create an inventory of when lane closures are occurring.
- It is not likely that the Arrow Board Reporting System would integrate with Iowa DOT's ATMS since the agency is currently in the process of procuring a new ATMS/ATIS system.

Preliminary ideas for Michigan DOT's pilot deployment include:

- Procurement options, which would impact where and how the Arrow Board Reporting System is deployed:
  - Deploy Arrow Board Reporting Systems on a discreet construction work zone through procurement with road construction project.

- o Deploy Arrow Board Reporting Systems on lane-marking equipment and truck-mounted arrow boards, which would be used primarily for short-duration maintenance activities (i.e. mobile work zones.)
  - o Deploy Arrow Board Reporting Systems in discreet MDOT maintenance areas, with a wide variety of urban and rural settings including 4-lane divided freeways, 2-lane roads, and local streets.
- Use Arrow Board Reporting Systems to create notifications (e.g. text/email) to MDOT operations staff who are responsible for posting to Mi Drive, MDOT's traveler information system platform.
- Implement a third-party system as verification tool initially, then eventually provide a feed to ATIS potentially integrating into the Mi Drive app.
- It is not likely that Arrow Board information would integrate with ATMS in a pilot deployment.

3.3 Test Deployment Summary

Overall, plans for deployments in Minnesota, Iowa, and Michigan tend to be fairly similar. Although details at all agencies are preliminary and may change, all agencies currently envision an approach to deploy Arrow Board Reporting Systems on either truck-mounted arrow boards and/or arrow board trailers for short-duration maintenance activities and mobile work zones on a variety of roadways.

Some key differences to note:

- Only MnDOT expects to integrate Arrow Board Reporting System information with their ATMS and RCRS for the initial pilot deployment. This functionality would be added later for both Iowa DOT and MDOT, given other factors.
- MnDOT expects to deploy Arrow Board Reporting Systems in mostly urban areas, Iowa DOT would likely be more rural corridors, and MDOT might be both urban and rural settings and could include city streets.
- MDOT would consider deploying Arrow Board Reporting Systems on two-lane roadways.
- Iowa DOT would consider integrating the Arrow Board Reporting System information for use by connected and automated vehicle applications.

4.0   Evaluation Strategy

4.1 Intent of the Real-Time Integration of Arrow Board Messages into Traveler Information Systems Evaluation

The intent of the ENTERPRISE Evaluation is to plan, execute, and report on a series of deployments that will help ENTERPRISE member agencies understand the potential for developed systems to integrate Arrow Board messages into traveler information systems in real time. Specifically, there is an interest in an evaluation to determine whether the system can work in various situations. The evaluation can help to assess the overall potential of designed Arrow Board Reporting Systems to become a standard technology, given successful findings in multiple settings with different vendors. Evaluation findings could also encourage additional agencies deploy different approaches, which would further help industry professionals understand where, when, and why developed Arrow Board Reporting Systems experience issues, in order to invest in improvements where they are needed.

4.2 The Role of the Real-Time Integration of Arrow Board Messages into Traveler Information Systems Evaluation

This Evaluation Plan defines a series of MOEs that, when applied to both known deployments being planned and future deployments, will evaluate the overall project objectives. The initial pilot Arrow Board Reporting System deployment may not meet all of the requirements or objectives, and as such this Evaluation Strategy is intended to be flexible to meet the goals and objectives of each deploying agency. However, determination of all the objectives and variations will help ENTERPRISE member agencies understand the process, effectiveness, lessons learned, and benefits of the deployed Arrow Board Reporting Systems.

This Evaluation Plan is not intended to be a Test Plan that examines whether each specified requirement selected for a given deployment is met, i.e., those described in the Model Requirements document. It is recommended that each deploying agency conduct a detailed verification test to document the requirements that are met (or are not met) in order to inform the evaluation for how each deployment varies and improve the understanding of the deployed Arrow Board Reporting System capabilities. Instead, this Evaluation Strategy defines goals and objectives for taking a higher-level approach to examine the utility and overall benefits of a deployed and integrated Arrow Board Reporting System.

4.3 Evaluation Goals

The overarching goal for evaluating Arrow Board Reporting System deployments is to understand the potential of these systems to provide improved traveler information and to increase efficiency of DOT staff responsible for posting lane closure information to traveler information mechanisms. It is important to note that the potential deployments described in Section 3 are expected to be "proof-of-concept" level, and therefore the evaluation of each is intended to test the overall effectiveness and usefulness of the deployed systems.

Though each agency deployment is likely to differ in design and level of integration with TMC systems, the evaluation goals below are expected to be universal for all pilot deployments, regardless of the specific design selected, deployment setting, or level of integration with TMC Systems.

- **Goal #1: The equipped Arrow Board will be able to automatically collect and report sufficient information for determining its status and location.** This will be accomplished in the field.
- **Goal #2: The Arrow Board Reporting System will be able to process information collected at the Arrow Board to determine its current status and location.** This may take place at the Arrow Board, a third-party server, or at the TMC.
- **Goal #3: The Arrow Board current status and location information will be received by DOTs for providing improved real-time information within RCRS, ATMS, and ATIS, with improved efficiency to DOT staff.** This Arrow Board information may be viewed via a third-party website, notifications received by text or email to DOT staff, and/or within the agency ATMS or RCRS. The degree of integration and automation will vary by each deploying agency.

4.4 Evaluation Objectives

Seven evaluation objectives have been identified to assess the extent to which the developed Arrow Report Reporting System solutions address the primary functions presented in the Model Requirements. However, the evaluation objectives may vary depending on how an agency ultimately decides to deploy Arrow Board Reporting System and specific goals for the deployment. For example, some agencies may

not initially integrate the Arrow Board Reporting Systems with their TMC Systems, in which case Objective #5 would not be included in the evaluation for that deployment. The seven identified evaluation objectives are:

- **Objective #1: Arrow Board data collection capabilities** – encompassing accuracy, reliability, completeness;
- **Objective #2: Arrow Board communications capabilities** – including timeliness and reliability;
- **Objective #3: Arrow Board data processing capabilities** – focuses on the ability to process Arrow Board data to accurately determine the operational status, e.g., facing direction, roadway / milepost, status change, mobile work zone, activation/de-activation, maintenance needs;
- **Objective #4: Arrow Board-related notifications capabilities** – concentrates on the communication mechanisms to field and TMC staff, including the configurability, functionality, and usefulness of different variations;
- **Objective #5: Integration with existing TMC Systems for reporting capabilities** – includes creation of new reports, when warranted; identifying, updating, and closing existing, relevant reports; interfaces and displays of information within each of the integrated TMC Systems, as applicable, compared to the current processes used to document and report lane closure information:
  - ATMS;
  - RCRS; and
  - ATIS.
- **Objective #6: Traveler information impacts** – focuses on the changes to ATIS events based on availability of new Arrow Board information for the provision of additional, more specific information, and potential benefit to the traveling public. This is regardless of whether Arrow Board information is integrated with the ATIS or manually input to the ATIS by TMC staff who receive the Arrow Board information via other TMC Systems or interfaces.
- **Objective #7: Data archiving capabilities** – focuses on the availability and usefulness of archived raw and processed Arrow Board data.

4.5 Data Sources and Analysis

This Evaluation Plan proposes to examine the capabilities described in the seven Evaluation Objectives by using the following eight data sources for a comprehensive evaluation:

1. **Arrow Board data** – raw and processed data generated by the Arrow Board Reporting System that is archived at the TMC.
2. **Error logs** – DOT staff manually document instances where Arrow Board Reporting System data or recommendations generated by the TMC Systems are inaccurate.
3. **ATMS/RCRS/ATIS logs** – existing archives of events for the agency RCRS, ATMS, and/or ATIS.
4. **Notification logs** – archived notifications, likely from the TMC Systems, that are issued to DOT operator staff and field staff.
5. **Traveler Information System interfaces** – observations of information available via the ATIS interfaces, i.e., phone or website.
6. **AVL data** – as available on DOT maintenance trucks for equipped truck-mounted Arrow Boards.
7. **System Integrator feedback** – interview with in-house or vendor staff responsible for integrating the Arrow Board Reporting System information within the TMC Systems.

8. **DOT staff feedback** – interviews with DOT field staff, operator staff, traveler information staff, and traveler information managers that work directly with the Arrow Board Reporting System in the field and at the TMC.

This Evaluation Plan proposes a data analysis approach that consists of the following four approaches, depending on the MOEs that are developed:

1. **Full quantitative data analysis** – assess available archives of raw and processed Arrow Board data; RCRS, ATMS, and ATIS events; and DOT staff notifications for the full evaluation period.
2. **Partial quantitative data analysis** – requires a second data source that will be unavailable for the full evaluation period, likely involving staff manually documenting Arrow Board status.
3. **Qualitative verification of findings** – DOT staff will corroborate all quantitative findings and provide additional context wherever possible.
4. **Qualitative summary** – relies on DOT staff interviews and includes lessons learned.

Figure 2 presents a high-level summary of evaluation objectives, data elements, and analysis approaches that are envisioned for conducting this evaluation.
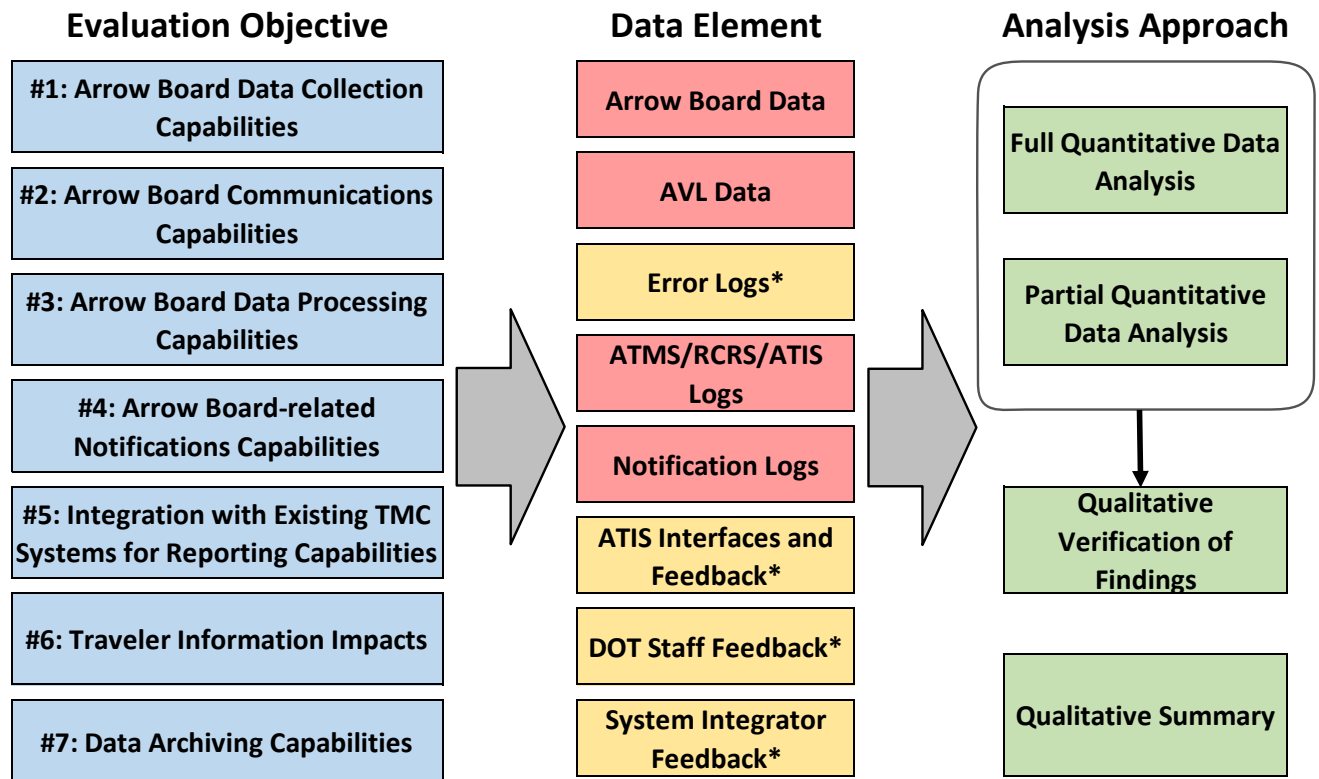
*Data elements collected specifically for evaluation purposes; others used as available from agency archives

Figure 2. Each Evaluation Objective will be Examined through the Collection of One or More Data Elements and Selected Analysis Approach

5.0   Evaluation Plan

This section is divided into three parts:

- 5.1 Data Collection Plan – details each of the eight data elements that will be available for the evaluation and the approach for collecting each.
- 5.2 Data Analysis Plan – presents the four analysis approaches that will be used to evaluate all of the collected data.
- 5.3 Detailed Analysis Approach and Measures of Effectiveness by Evaluation Objective – provides the specifics of how each Evaluation Objective will be analyzed with the available data that was collected.

5.1   Data Collection Plan

There are eight primary sources of data needed for a comprehensive evaluation that will be described in greater detail in this section. These data include:

- Arrow Board data
- Error logs
- ATMS/RCRS/ATIS logs
- Notification logs
- Traveler Information System interfaces
- AVL data
- System Integrator feedback
- DOT staff feedback

An evaluation period is expected to occur for several months for each given deployment. Given this timeframe, some MOEs are unrealistic to examine fully quantitatively. These MOEs may instead be examined using a subset of quantitative data and detailed observations for a short period, and then examined on an ad-hoc basis or as issues arise and are logged by DOT staff for the duration of the evaluation period. For example, it unrealistic for evaluation team staff or DOT field staff to constantly monitor and verify the accuracy of Arrow Board operational status as reported and logged at the TMC for the duration of the evaluation period. Instead, there are several approaches for analyzing the accuracy of reported Arrow Board status:

- A focused monitoring and verification effort may be conducted by evaluation team staff in the field for a short period of time, e.g., three days.
- DOT field staff could actively verify received Arrow Board notifications with TMC Staff for a short period of time to confirm accuracy, e.g., several days to two weeks.
- DOT staff at the TMC might verify the Arrow Board operational status with DOT field staff at irregular intervals, e.g., once per week, and then document a log of identified errors.

All of the above situations are labelled as "partial" in the analysis column of Table 2 through Table 8 to indicate that the evaluation is not expected to comprehensively capture all instances, but only a subset of the full evaluation period.

Specific details of data elements available for the evaluation are expected to vary for each agency, depending on the details of the deployment and specific requirements and settings in which the equipped Arrow Boards are used.

5.1.1 Arrow Board Data

This data source broadly refers to both raw and processed data that will be generated by the Arrow Board Reporting System and archived at the TMC. Understanding that each agency will likely deploy Arrow Board Reporting Systems differently, the exact number and precise names of data elements are not certain at this time. Additionally, processed Arrow Board data may not be directly archived, but found within RCRS, ATMS, and/or ATIS event logs.

Depending on how an agency deploys Arrow Board Reporting Systems, including how many units are deployed, the frequency of data messages, and how data is archived, as well as the duration of the evaluation period, a comprehensive, quantitative analysis for each MOE may not be possible given the volume of data to examine.

The specific data collection plan for Arrow Board data is as follows:

1. All Arrow Board data to be collected and archived by TMC Systems 24 hours per day, 7 days per week during the evaluation period, as available from all Arrow Boards when they are operational in the field.
2. Data shall include all data elements, as designed by each deploying agency. This is expected to include unprocessed location coordinates and display status, for example.
3. The evaluation team will coordinate with the deploying agency to establish a mechanism to access the archived files, either as a file transfer or guest access to the data archive system.
4. Some data elements will be analyzed for MOEs based on availability of verification from the field. Evaluation team staff may be available for several days to monitor and document Arrow Board status and location for comparison to the received Arrow Board data.
5. All Arrow Board data records received during the evaluation period will be examined for completeness, as designed by each deploying agency.

5.1.2 Error Logs

Given the challenges in verifying the operational status of an Arrow Board in the field, error logs are expected to be an integral part of the evaluation. Specifically, while the evaluation can examine data produced by the Arrow Board Reporting System and subsequent events within the RCRS, ATMS, and/or ATIS, without verification from the field by a member of the evaluation team or field staff, the accuracy of the data and events cannot be ascertained. Although the format of this log could vary by deploying agency, this evaluation plan assumes that DOT operator staff will manually document instances where Arrow Board Reporting System data or recommendations generated by the TMC Systems are inaccurate. Examples include instances where DOT operator staff could document where Arrow Board Reporting System data or recommendations conflict with reports from field staff or CCTV verification.

Additionally, it is possible that the TMC Systems may generate an error for certain situations, which could then be archived. An error might be detected by the absence of expected data from transmitted Arrow Board Reporting System messages or failure to receive a message from the Arrow Board Reporting System within the expected timeframe.

The specific data collection plan for error log data is as follows:

1. Errors may be documented in one or more of the following ways:
   a. It is assumed that system errors identified by the DOT operator staff or DOT field staff will be manually documented <u>as they are observed</u> by DOT operator staff 24 hours per day, 7 days per week during the evaluation period. This is not expected to be comprehensive of all errors that may occur, but only those that are noticed by DOT staff.
   b. Some system errors (e.g., absence of expected data, failure to receive message from the Arrow Board within the expected timeframe) may be identified by the TMC Systems and documented as they occur, either within the TMC Systems or by DOT operator staff upon receipt of an error notification generated by the TMC Systems 24 hours per day, 7 days per week during the evaluation period.
   c. It is assumed that DOT field staff may not be available to monitor the accuracy of the Arrow Board Reporting System during the full evaluation period, if at all, but will report incidents of inaccuracies when they are observed.
2. All errors that are logged shall include time, Arrow Board ID, and description of the error and how it was corrected.
3. The evaluation team will coordinate with the deploying agency to establish a mechanism to access the documented error logs, e.g., via email.
4. The error logs will be used to compare against other data elements to help identify the cause for the error.

5.1.3 ATMS/RCRS/ATIS Logs

This data source relies on the existing archives of events for the agency RCRS, ATMS, and/or ATIS. Arrow Board Reporting System recommendations for new or modified events will be compared against the events that are ultimately posted within these systems.

The specific data collection plan for ATMS/RCRS/ATIS logs is as follows:

1. It is assumed that all ATMS, RCRS, and ATIS events are currently archived by TMC Systems 24 hours per day, 7 days per week and will be available to evaluation team staff for the evaluation period.
2. The evaluation team will coordinate with the deploying agency to understand how their ATMS, RCRS, and/or ATIS logs are organized and available data elements, and discuss how to query lane closure events that are related exclusively to equipped Arrow Boards, as well as lane closure events from the previous year for a comparison.
3. The evaluation team will coordinate with the deploying agency to establish a mechanism to access the desired archived files, either as a file transfer or guest access to the data archive system.
4. Data shall include all available data elements in the ATMS, RCRS, and/or ATIS log pertinent to events related to the Arrow Board Reporting Systems.
5. Some data elements will be analyzed for MOEs based on availability of verification from the field. Evaluation team staff may be available for several days to monitor and document Arrow Board status and location for comparison to the received Arrow Board data.

5.1.4 Notification Logs

This data source assumes that notifications issued to DOT operator staff and field staff will be archived by the Arrow Board Reporting System or TMC System, for analysis. This log will be used to compare against observed changes in Arrow Board operational status from the Arrow Board data to verify that notifications are being issued to appropriate DOT staff when warranted, as designed.

The specific data collection plan for notification logs is as follows:

1. It is assumed that all notifications issued to field staff and operator staff during the evaluation period will be archived by the Arrow Board Reporting System or TMC System and available to the evaluation team for analysis.
2. The evaluation team will coordinate with the deploying agency to establish a mechanism to access the desired archived files, either as a file transfer, guest access to the data archive system, or recipient of issued notifications during the evaluation period.
3. Data shall include all available data elements in the notifications.

5.1.5 ATIS Interfaces and Feedback

This data source relies on observations of available information via the ATIS interfaces, i.e., phone or website. It is expected that members of the evaluation team would call or visit the ATIS to examine the availability and usefulness of information related to the Arrow Board Reporting System. Existing archives of ATIS may also be examined, but are not expected to provide the same utility for analysis, depending on the nature in which this information is archived.

The specific data collection plan for traveler information system interfaces is as follows:

1. It is assumed that the evaluation team will utilize the interfaces available to the traveling public, e.g., mobile applications, full websites, and/or phone lines used as traveler information systems.
2. The evaluation team will coordinate with the deploying agency to understand when and where Arrow Board Reporting Systems are active in order to view related events in each available ATIS.
3. The evaluation team will periodically access the traveler information system interfaces throughout the evaluation period, e.g., monthly, to assess the availability, utility, and completeness of information pertaining to events related to deployed Arrow Board Reporting Systems.
4. If desired, the evaluation team can develop and manage a brief survey using a website like SurveyMonkey for traveler information managers to post a link on the traveler information website for the traveling public to respond and provide feedback. Multiple choice questions for this survey might be similar to the following:
   - Q1: How frequently do you view lane closure information on the traveler information website? [a) >10 times per month; b) 1-10 times per month; c) <1 time per month; d) I do not view lane closure information] *End survey if respond "d".*
   - Q2: [*Display text or graphic of general lane closure information <u>without</u> Arrow Board input*] If you planned to drive on this route, is this information useful for planning your trip? [a) Yes; b) No]
   - Q3a: [*Only if respond "Yes" to Q2*] Would you change your trip time or route based on this information? [a) Yes; b) No]

- Q3b: [*Only if respond "No" to Q2*] What additional information would help you plan your trip? [a) More precise time of lane closure; b) Expected delays caused by lane closure; c) More precise location of the lane closure; d) Other (text box for input)]
- Q4: [*Display text or graphic of general lane closure information <u>with</u> Arrow Board input*] If you planned to drive on this route, is this information useful for planning your trip? [a) Yes; b) No]
- Q5a: [*Only if respond "Yes" to Q4*] Would you change your trip time or route based on this information? [a) Yes; b) No]
- Q5b: [*Only if respond "No" to Q4*] What additional information would help you plan your trip? [Text box for input]
- Q6: Please provide any additional comments you have about lane closure information on the traveler information website. [Text box for input]

5. The evaluation team will conduct an interview at the end of the evaluation period with traveler information system managers and operators to assess their satisfaction and opinions of the usefulness and added value of the new and updated information available as a result of deploying the Arrow Board Reporting System.
6. The evaluation team will develop a qualitative assessment of the usefulness and availability of reported events that utilize Arrow Board Reporting System information.

5.1.6 AVL Data

If available on DOT maintenance trucks, this data source would be examined if Arrow Board Reporting Systems are deployed on truck-mounted Arrow Boards to verify the location reported within the received Arrow Board data. In situations where Arrow Board trailers are used, available AVL data from DOT maintenance trucks could be used as a proxy for verifying Arrow Board location, although this method would not be as reliable.

The specific data collection plan for AVL data is as follows:

1. It is assumed that all AVL data is currently archived by TMC Systems 24 hours per day, 7 days per week and will be available to evaluation team staff for the evaluation period.
2. The evaluation team will coordinate with the deploying agency to understand the data elements within the AVL data and relevant vehicle IDs associated with a truck-mounted Arrow Board and, if determined to be a good proxy given a known association and proximity, Arrow Board trailers.
3. The evaluation team will coordinate with the deploying agency to establish a mechanism to query and access the desired archived AVL files, either as a file transfer or guest access to the data archive system.
4. Data shall include all available AVL data elements associated with vehicles with an established association with the Arrow Board Reporting Systems.
5. AVL data elements will be analyzed for MOEs related to the Arrow Board location and status as reported by the Arrow Board Reporting System.

5.1.7 System Integrator Feedback

This data source is envisioned to rely on a brief phone or email interview with individuals responsible for integrating the Arrow Board Reporting System information within the RCRS, ATMS, and ATIS, either in-house DOT staff and/or contract vendors who maintain and make upgrades to these TMC Systems. The evaluation team will prepare a brief questionnaire to guide this discussion. It is expected that only one interview would be required at the conclusion of the evaluation period for each system integrator, i.e., an agency may have two different integrators responsible for the RCRS and ATMS. This interview would cover a brief discussion of the level of effort and challenges of integrating Arrow Board Reporting System information with the respective TMC system.

The specific data collection plan for System Integrator Feedback is as follows:

1. The evaluation team will generate a questionnaire to use as a discussion guide for an interview with the System Integrator(s).
2. The evaluation team will coordinate with each System Integrator team at the end of the evaluation period to schedule an interview (i.e., if there is a different integrator responsible for the RCRS and ATMS, the evaluation team will schedule a separate interview with each integrator).
3. The evaluation team will conduct and provide a qualitative summary of the findings from the interview.

5.1.8 DOT Staff Feedback

This data source broadly entails a series interviews with various DOT staff that are expected to work directly with the Arrow Board Reporting System in the field and at the TMC. A series of questionnaires will be drafted by the evaluation team to guide discussions with each group of interviewees to gather anecdotes, satisfaction, lessons learned, challenges and issues, and general comments as related to all evaluation objectives and MOEs.

The expected DOT staff groups are expected to include:

- DOT field staff, including individuals who interact with the Arrow Board Reporting System devices in the field at construction projects, as well as those at the maintenance shop where the devices are installed and repaired.
- DOT operator staff, including individuals who interact with all applicable ATMS, RCRS, and ATIS interfaces, notifications, and event recommendations generated by the designed Arrow Board Reporting System.
- Traveler Information staff, including managers and individuals with an awareness of customer usage and satisfaction with .

Taken together, these interviews will be used as a qualitative analysis of each MOE in this evaluation to either: 1) directly analyze, or 2) verify at a high-level the quantitative assessment, as described in further detail in Section 4.5.

The specific data collection plan for DOT staff feedback data is as follows:

1. The evaluation team will generate two questionnaires to use as discussion guides for interviews with the DOT field staff and DOT operator staff.
2. The evaluation team will coordinate with each DOT staff group at the end of the evaluation period to schedule an interview.
3. The evaluation team will share findings from MOEs that have been analyzed for review by DOT staff who will be able to verify the findings or provide further insights.
4. The evaluation team will conduct and provide a qualitative summary of the findings from each interview.
5. The evaluation team will use DOT staff comments to caveat and inform the findings from other analyses to provide an enhanced assessment of each MOE.

5.2   Data Analysis Plan

The data analysis plan relies on four basic approaches to examine available data in order to address each identified MOE, as described below.

5.2.1 Full Quantitative Data Analysis

Whenever possible, the evaluation team will attempt to quantitatively analyze MOEs for the full evaluation period. This analysis will rely on the archives of raw and processed Arrow Board data, as well as relevant logs of RCRS, ATMS, and ATIS events and notifications that were sent to DOT operator and field staff. This analysis will examine the completeness and timeliness of data and notifications, given the agency-specific design of the data elements and transmission frequency for the various messages and notifications.

This analysis may vary in its approach, depending on the format of the data received. In general, this analysis is expected to take place using Excel worksheets in order to leverage functions that are available to take a count of data elements in a message and identify the time elapsed between each transmission of Arrow Board data. Notifications to DOT operator and field staff will be analyzed against Arrow Board status changes that are identified in the Arrow Board data to ensure transmission when expected.

To help examine the relative benefit of Arrow Board information within TMC Systems, a quantitative analysis will attempt to document and compare:

- Total number of lane closure events in the TMC Systems (i.e. RCRS, ATMS, ATIS) during the evaluation period for the area where Arrow Board Reporting Systems are deployed.
    - The number of these events that included a lane closure during a peak hour.
    - The percentage of these events that included a lane closure during a peak hour.
- Number of lane closure events created in the TMC Systems (i.e. RCRS, ATMS, ATIS) during the evaluation period for the area where Arrow Board Reporting Systems are deployed based on the new system, as well as:
    - This value as a percentage of all lane closure events.
    - The number of these events that included a lane closure during a peak hour.
    - The percentage of these events that included a lane closure during a peak hour.
- Number of existing lane closure events in the TMC Systems (i.e. RCRS, ATMS, ATIS) during the evaluation period for the area where Arrow Board Reporting Systems are deployed that were modified based on the new system, and a breakout for the types of information that were added to the events.
    - This value as a percentage of all lane closure events.
    - The number of these events that included a lane closure during a peak hour.
    - The percentage of these events that included a lane closure during a peak hour.

5.2.2 Quantitative Data Verification

Some MOEs will require a second source of data to verify the accuracy of the data source being examined. This may be accomplished in various ways:

- A truck-mounted Arrow Board may be on a vehicle that has a separate data collection and transmission mechanism for AVL data that could be leveraged to verify the location accuracy as communicated in the Arrow Board data.
- Evaluation team staff may be present in the field for several days to document the Arrow Board location and display status for every instance that the Arrow Board operational status changes in order to verify the Arrow Board data.
- DOT operator staff may be able to view the Arrow Board on CCTV cameras, and could verify the location and display status being reported in the Arrow Board data.
- DOT operator staff may periodically contact field staff in order to verify the location and display status reported in the Arrow Board data.
- DOT field staff may contact DOT operator staff upon receipt of an Arrow Board notification that contains incorrect location or display status information.
- The TMC System may generate an automated error log in instances where there are unexpected anomalies in the data, e.g., the Arrow Board location unexpectedly shifts to an unrealistic location such as a roadway overpass above the lane closure.

This will result in two types of findings:

1. The frequency of errors for the short-duration that DOT field staff or evaluation team members are available to frequently document the Arrow Board status; AVL data may be available for a longer part of the evaluation period to verify Arrow Board location data.
2. An incomplete list of the number and quantity of identified errors documented only as noticed. This list will not be all-inclusive, given the inability to verify all conditions in the field.

5.2.3 Qualitative Verification of Findings

All evaluation findings from the quantitative analysis will be shared with DOT operator staff and DOT field staff. A quantitative analysis has a risk of overlooking critical issues that may not be apparent in the archived data. As such, it is expected that DOT staff may be able to provide additional context, anecdotes, or experiences to better inform the findings, or otherwise verify that the quantitative analysis reflects their experiences with the deployed system.

5.2.4 Qualitative Summary

Responses from each conducted interview, including those with DOT operator staff and DOT field staff will be organized and summarized for the evaluation. Interview summaries will concisely address the respective MOEs, and also feature lessons learned, anecdotes, experiences, and other supporting evidence that contributes meaningful findings for understanding the effectiveness of the developed Arrow Board system.

5.3   Detailed Analysis Approach and Measures of Effectiveness

A detailed analysis approach is presented for each Evaluation Objective in a separate sub-section below. A figure is presented first to depict the high-level relationships between the Evaluation Objective and what data elements and analysis approach will be needed. Specific MOEs and details about the analysis approach are then presented in the following table.

Note that each agency will have a different way to measure success of a deployed Arrow Board Reporting System, particularly for a demonstration test. That measure of success may be defined as meeting a specific threshold or more subjectively by operator satisfaction, for example. This Evaluation Plan proposes capturing as much detail and specific feedback as possible through a comprehensive series of MOEs, however it is up to each agency to use these as guidelines to more specifically define what will make their deployment successful.

5.3.1 Evaluation Objective #1: Arrow Board Data Collection Capabilities

Figure 3 depicts the data elements and analysis approach to examine **Evaluation Objective #1: the ability of the Arrow Board Reporting System to reliably and accurately collect all required data elements**, as designed. Table 2 presents additional details on the MOEs, data sources, and analysis approach for this evaluation objective.
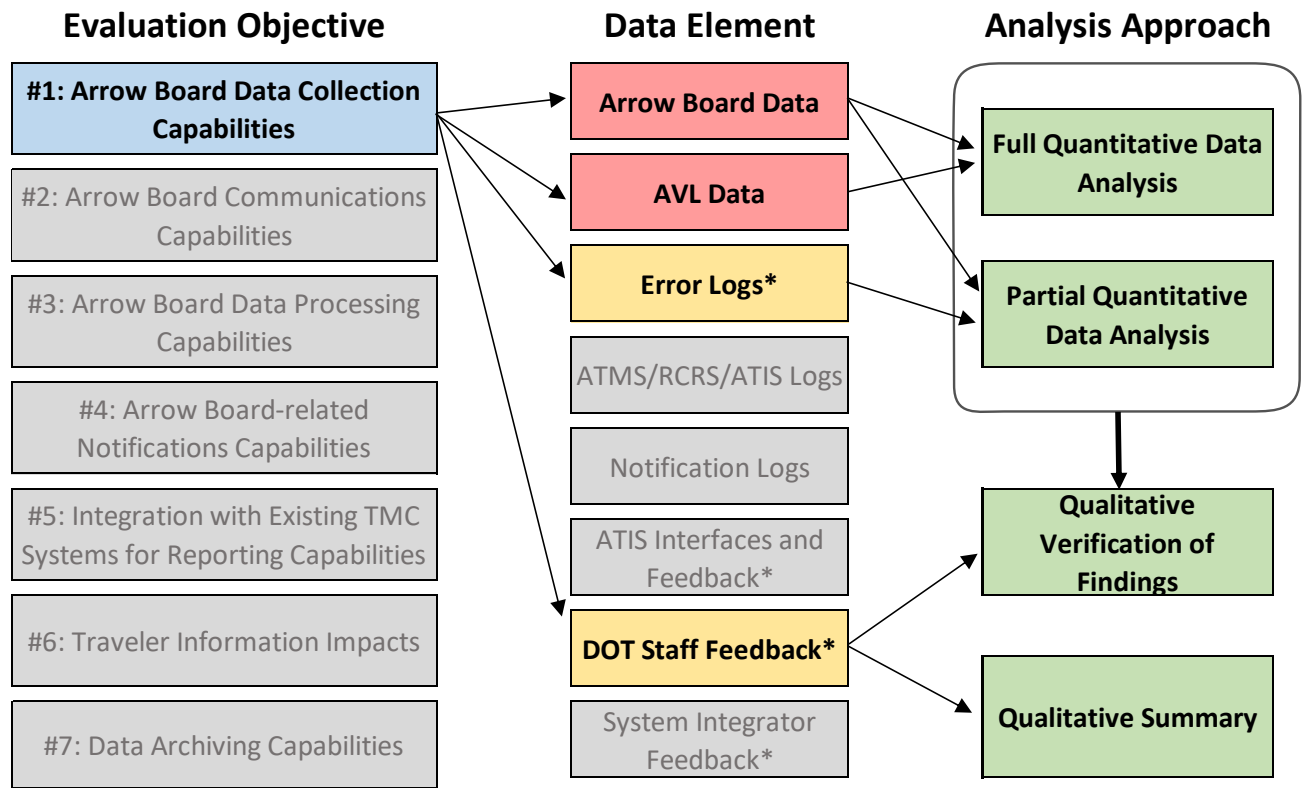
*Data elements collected specifically for evaluation purposes; others used as available from agency archives

Figure 3. Relationship of Data Elements and Analysis Approach for Evaluation Objective #1: Arrow Board Data Collection Capabilities

Table 2. Evaluation Measures, Data Needs, and Data Analysis Method to examine Arrow Board Data Collection Capabilities

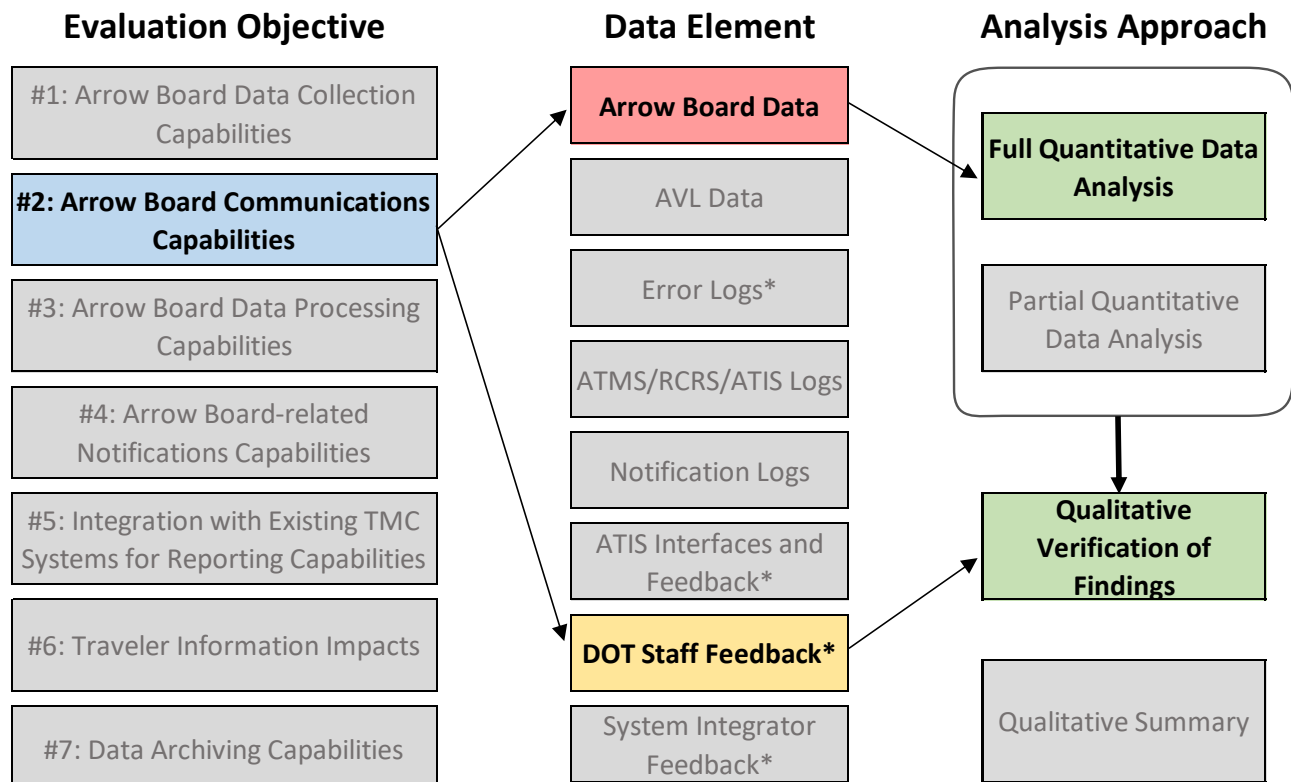| Evaluation Objective #1: Arrow Board Data Collection Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
1.1 Percent of received Arrow Board status messages with complete required data.	• List of agency-defined required Arrow Board data elements • Complete Arrow Board raw data archive	***Full quantitative data analysis:*** Compare agency-defined data to Arrow Board raw data archive.
1.2 Occurrences of missing data element(s).	• List of agency-defined Arrow Board data elements • Complete Arrow Board raw data archive	***Full quantitative data analysis:*** Compare agency-defined data against Arrow Board data archive.
	• DOT operator staff interview	***Qualitative verification/summary:*** Document DOT operators' perceptions of whether frequency of incomplete/missing Arrow Board data is acceptable.
1.3 Occurrences of reported Arrow Board location being insufficiently accurate, as required by the system design.	• AVL location, timestamp, and vehicle ID • Location data from Arrow Board raw data archive	***Full quantitative data analysis:*** If AVL location data is available, compare this to Arrow Board location data.
	• Error Logs	***Partial quantitative analysis:*** Error logs document instances when reported locations are inaccurate throughout the evaluation period by DOT staff and via a targeted verification test by staff in the field.
	• DOT operator staff interview • DOT field staff interview	***Qualitative verification/summary:*** DOT staff indicate whether reported locations are sufficiently accurate.
1.4 Occurrences of inaccurate reports of Arrow Board display status (left arrow, right, arrow, caution mode) and operational status (Arrow Board on or off).	• Error logs	***Partial quantitative data analysis:*** Error logs document instances of inaccurate display status and operational status (on/off). Error logs completed throughout the evaluation period by DOT staff and via a targeted verification test by staff in the field.
	• DOT field staff interview	***Qualitative verification/summary:*** DOT staff indicate whether display status and operational status are sufficiently accurate.

5.3.2 Evaluation Objective #2: Arrow Board Communications Capabilities

Figure 4 depicts the data elements and analysis approach to examine **Evaluation Objective #2: the reliability of the Arrow Board Reporting System for transmitting status messages within the timeliness expected by the chosen communications mechanism**. Table 3 presents additional details on the MOEs, data sources, and analysis approach for this evaluation objective.

Evaluation Objective | Data Element | Analysis Approach

Evaluation Objective	Data Element	Analysis Approach
#1: Arrow Board Data Collection Capabilities	**Arrow Board Data**	**Full Quantitative Data Analysis**
#2: Arrow Board Communications Capabilities	AVL Data	Partial Quantitative Data Analysis
#3: Arrow Board Data Processing Capabilities	Error Logs*	
#4: Arrow Board-related Notifications Capabilities	ATMS/RCRS/ATIS Logs	
#5: Integration with Existing TMC Systems for Reporting Capabilities	Notification Logs	**Qualitative Verification of Findings**
#6: Traveler Information Impacts	ATIS Interfaces and Feedback*	
#7: Data Archiving Capabilities	**DOT Staff Feedback***	Qualitative Summary
	System Integrator Feedback*	

*Data elements collected specifically for evaluation purposes; others used as available from agency archives
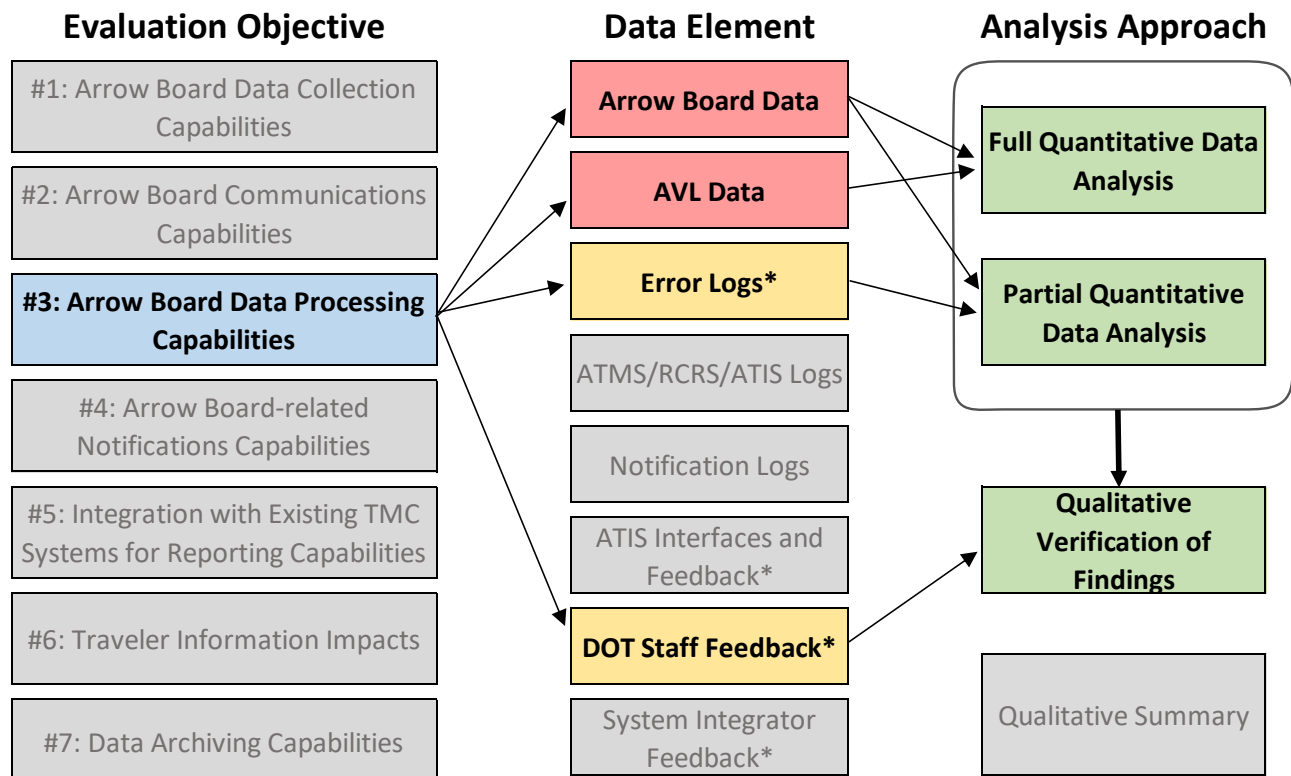
Figure 4. Relationship of Data Elements and Analysis Approach for Evaluation Objective #2: Arrow Board Communications Capabilities

Table 3. Evaluation Measures, Data Needs, and Data Analysis Method to examine Arrow Board Communications Capabilities

Evaluation Objective #2: Arrow Board Communications Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
2.1 Frequency of receiving Arrow Board messages.	• All TMC timestamps for received Arrow Board data • DOT field staff interview	***Full quantitative data analysis:*** Verify frequency of received messages is as designed
2.2 Number of occurrences of unexpected delays in sending messages or missing messages.	• All TMC timestamps for received Arrow Board data • DOT operator staff interview	***Full quantitative data analysis:*** Identify instances where time between messages exceeds design requirements

5.3.3 Evaluation Objective #3: Arrow Board Processing Capabilities

Figure 5 depicts the data elements and analysis approach to examine **Evaluation Objective #3: the ability to accurately determine Arrow Board facing direction, roadway and milepost location, and status changes, including activation and de-activation, mobile work zone, presence of multiple arrow boards, and maintenance needs, given available information**. Table 4 presents additional details on the MOEs, data sources, and analysis approach for this evaluation objective.

Evaluation Objective

- #1: Arrow Board Data Collection Capabilities
- #2: Arrow Board Communications Capabilities
- **#3: Arrow Board Data Processing Capabilities**
- #4: Arrow Board-related Notifications Capabilities
- #5: Integration with Existing TMC Systems for Reporting Capabilities
- #6: Traveler Information Impacts
- #7: Data Archiving Capabilities

Data Element

- **Arrow Board Data**
- **AVL Data**
- **Error Logs***
- ATMS/RCRS/ATIS Logs
- Notification Logs
- ATIS Interfaces and Feedback*
- **DOT Staff Feedback***
- System Integrator Feedback*

Analysis Approach

- **Full Quantitative Data Analysis**
- **Partial Quantitative Data Analysis**
- **Qualitative Verification of Findings**
- Qualitative Summary

*Data elements collected specifically for evaluation purposes; others used as available from agency archives

Figure 5. Relationship of Data Elements and Analysis Approach for Evaluation Objective #3: Arrow Board Processing Capabilities

Table 4. Evaluation Measures, Data Needs, and Data Analysis Method to examine Arrow Board Processing Capabilities
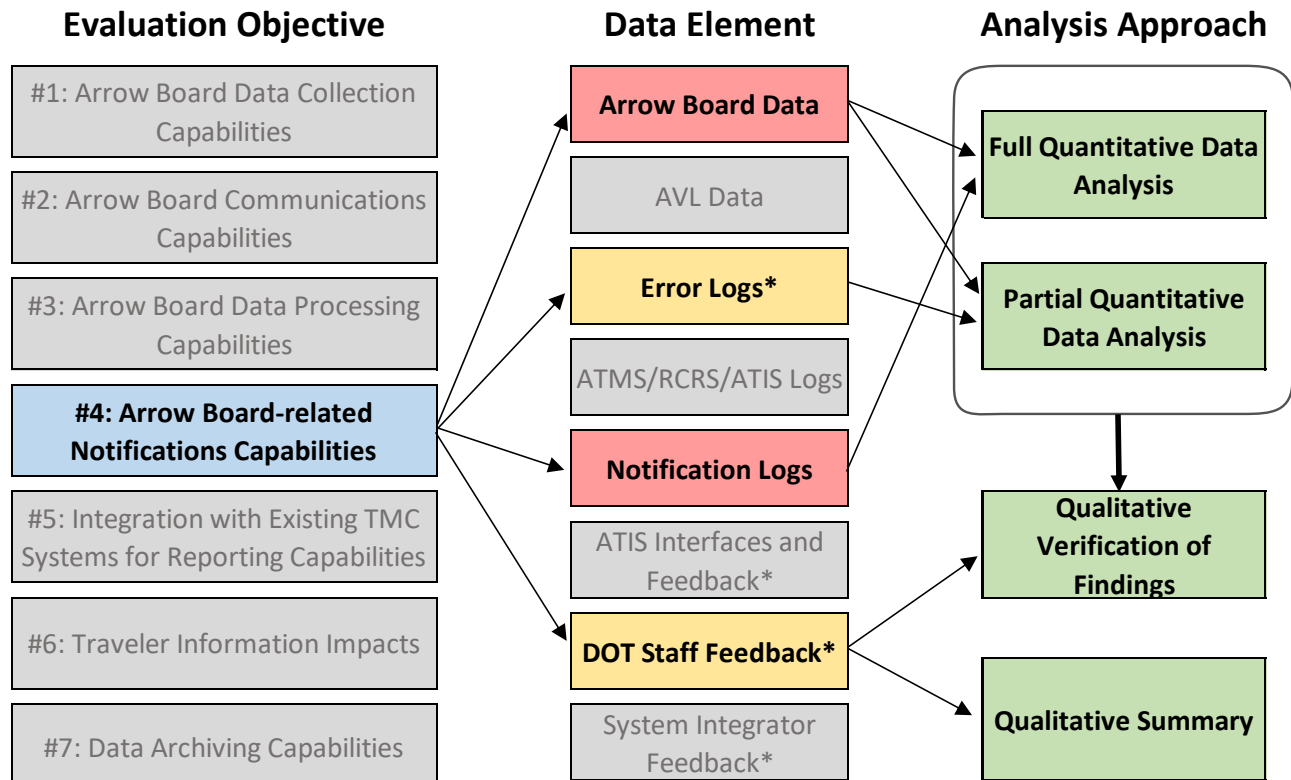
Evaluation Objective #3: Arrow Board Processing Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
3.1 Frequency of accurately identifying the direction Arrow Board is facing.	• Processed Arrow Board direction data • Error logs	*Partial quantitative data analysis:* Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT field staff interview • DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
3.2 Frequency of accurately identifying the correct lane of traffic that is closed when Arrow Board display is activated.	• Processed Arrow Board lane closure data • Error logs	*Partial quantitative data analysis:* Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.

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Evaluation Objective #3: Arrow Board Processing Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
3.3 Frequency of accurately identifying Arrow Board roadway and milepost location.	• Processed Arrow Board location data • AVL location, timestamp, and vehicle ID	*Full quantitative data analysis:* If AVL data is available to compare with Arrow Board data; otherwise partial analysis.
	• Processed Arrow Board location data • Error logs	*Partial quantitative data analysis:* Compare to error logs from evaluation team in field or staff verification when AVL data is not available.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
3.4 Occurrences of inaccurate determination of Arrow Board roadway and milepost location.	• Processed Arrow Board location data • AVL location, timestamp, and vehicle ID	*Full quantitative data analysis:* If AVL data is available to compare with Arrow Board data; otherwise partial analysis.
	• Processed Arrow Board location data • Error logs	*Partial quantitative data analysis:* Compare to error logs from evaluation team in field or staff verification when AVL data is not available.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
3.5 Frequency of accurately characterizing a mobile work zone.	• Processed Arrow Board location data • AVL location, timestamp, and vehicle ID	*Full quantitative data analysis:* If AVL data is available to compare with Arrow Board data; otherwise partial analysis.
	• Processed Arrow Board location data • Error logs	*Partial quantitative data analysis:* Compare to error logs from evaluation team in field or staff verification when AVL data is not available.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
3.6 Frequency of accurately characterizing a work zone with multiple active arrow boards.	• Processed Arrow Board status change data • Error logs	*Partial quantitative data analysis:* Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
3.7 Frequency of accurately identifying the correct Arrow Board status after a change in status.	• Processed Arrow Board status change data • Error logs	*Partial quantitative data analysis:* Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.

Evaluation Objective #3: Arrow Board Processing Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
3.8 Occurrences of inaccurate determination of Arrow Board status.	• Processed Arrow Board status change data • Error logs	***Partial quantitative data analysis:*** Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
3.9 Frequency of accurately identifying Arrow Board de-activation.	• Processed Arrow Board status change data • Error logs	***Partial quantitative data analysis:*** Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
3.10 Occurrences of false alarms of Arrow Board de-activation.	• Processed Arrow Board status change data • Error logs	***Partial quantitative data analysis:*** Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
3.11 Occurrences in excessive delay in determining Arrow Board de-activation.	• Processed Arrow Board status change data • Error logs	***Partial quantitative data analysis:*** Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
3.12 Relative error frequency sorted by the manner in which the de-activation was determined (e.g., method of determination, no message received)	• Processed Arrow Board status change data • Error logs	***Partial quantitative data analysis:*** Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
3.13 Frequency of accurately identifying Arrow Board maintenance needs.	• Processed Arrow Board status change data • Error logs	***Partial quantitative data analysis:*** Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
3.14 Occurrences of false alarms of Arrow Board maintenance needs.	• Processed Arrow Board status change data • Error logs	***Partial quantitative data analysis:*** Compare Arrow Board data to error logs from evaluation team in field or DOT field staff.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.

5.3.4 Evaluation Objective #4: Arrow Board-related Notifications Capabilities

Figure 6 depicts the data elements and analysis approach to examine **Evaluation Objective #4: the ability of the TMC System to generate Arrow Board-related notifications, as designed, that are configurable, timely, accurate, and useful for field staff and TMC operators**. Table 5 presents additional details on the MOEs, data sources, and analysis approach for this evaluation objective.

Evaluation Objective	Data Element	Analysis Approach
#1: Arrow Board Data Collection Capabilities	Arrow Board Data	Full Quantitative Data Analysis
#2: Arrow Board Communications Capabilities	AVL Data	Partial Quantitative Data Analysis
#3: Arrow Board Data Processing Capabilities	Error Logs*	
#4: Arrow Board-related Notifications Capabilities	ATMS/RCRS/ATIS Logs	
#5: Integration with Existing TMC Systems for Reporting Capabilities	Notification Logs	Qualitative Verification of Findings
#6: Traveler Information Impacts	ATIS Interfaces and Feedback*	
#7: Data Archiving Capabilities	DOT Staff Feedback*	Qualitative Summary
	System Integrator Feedback*	

*Data elements collected specifically for evaluation purposes; others used as available from agency archives

Figure 6. Relationship of Data Elements and Analysis Approach for Evaluation Objective #4: Arrow Board-related Notifications Capabilities

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Table 5. Evaluation Measures, Data Needs, and Data Analysis Method to examine Arrow Board-related Notifications Capabilities

| Evaluation Objective #4: Arrow Board-related Notifications Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
4.1 Field staff satisfaction with and ability to receive useful Arrow Board notifications via the preferred communications mechanism(s) regarding Arrow Board status changes, as designed.	• DOT field staff interview	***Qualitative summary:*** DOT field staff indicate their satisfaction.
4.2 Occurrences of missed notifications to field staff.	• Notification logs or error logs	***Full quantitative data analysis:*** If notification logs present to verify sent notifications when warranted.
	• Processed Arrow Board status change data	***Partial quantitative data analysis:*** Error logs document instances where field staff indicate no message was received when one should have been sent.
	• DOT field staff interview	***Qualitative verification:*** DOT field staff verify findings and identify other specific anecdotal experiences.
4.3 Field staff ability to configure the criteria and mechanism for receiving Arrow Board notifications.	• DOT field staff interview	***Qualitative summary:*** DOT field staff indicate their experiences.
4.4 Field staff time required to operate Arrow Board Reporting System.	• DOT field staff interview	***Qualitative summary:*** DOT field staff indicate their experiences.
4.5 TMC operator satisfaction with notifications within system interface and/or other communications mechanisms regarding Arrow Board status changes, as designed.	• DOT operator staff interview	***Qualitative summary:*** DOT operator staff indicate their satisfaction.
4.6 Occurrences of missed notifications to TMC operators.	• Notification logs or error logs	***Full quantitative data analysis:*** If notification logs present to verify sent notifications when warranted.
	• Processed Arrow Board status change data	***Partial quantitative data analysis:*** Error logs document instances where operator staff indicate no message was received when one should have been sent.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
4.7 Operator ability to configure the criteria and mechanism(s) for receiving Arrow Board notifications.	• DOT operator staff interview	***Qualitative summary:*** DOT operator staff indicate their experiences.

5.3.5 Evaluation Objective #5: Integration with Existing TMC Systems for Reporting Capabilities

Figure 7 depicts the data elements and analysis approach to examine **Evaluation Objective #5: the ability for Arrow Board Reporting System information to be integrated with the DOT-operated software solution(s) without the need to open external software systems; create new events, when warranted; identify, update, and close existing, relevant events, when warranted; and provide usable information on existing TMC interfaces and displays**. All MOEs will be repeated for each of the following:

- ATMS;
- RCRS;
- Advanced Traveler Information Systems (ATIS).

Table 6 presents additional details on the MOEs, data sources, and analysis approach for this evaluation objective.
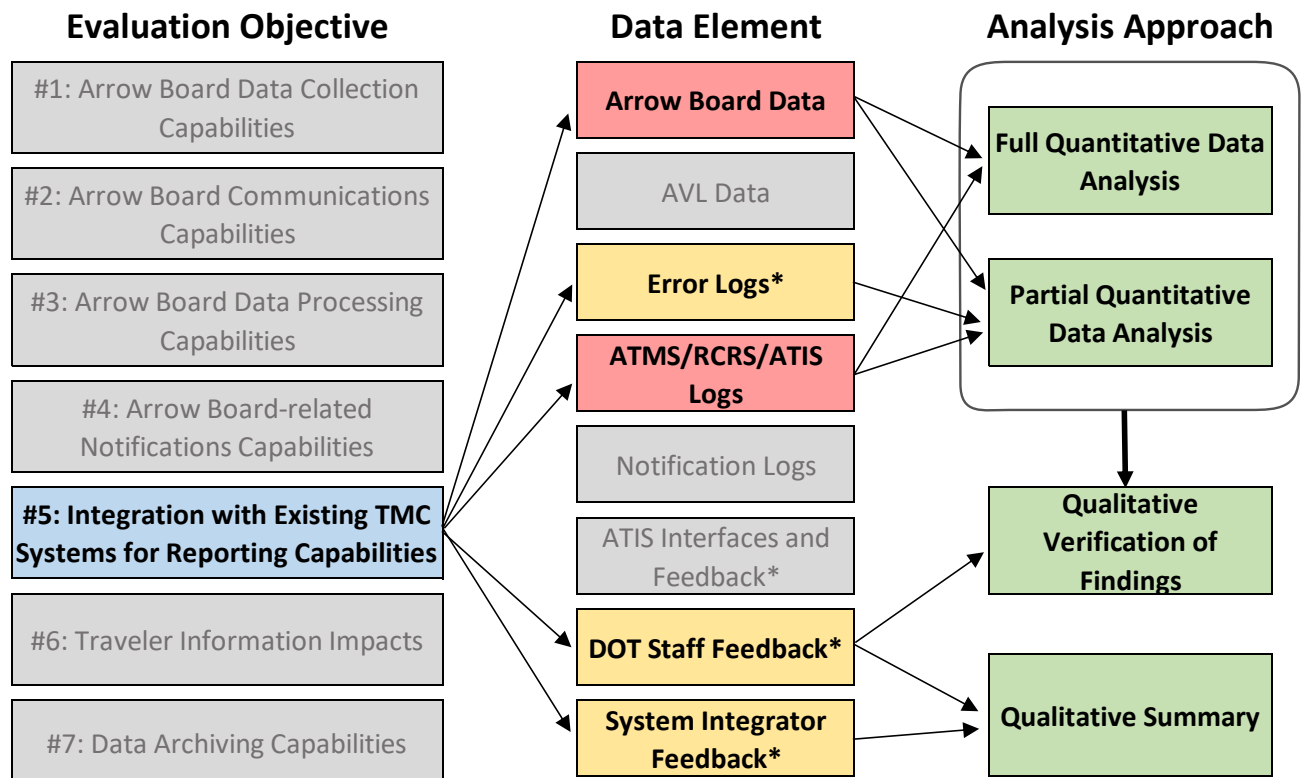
*Data elements collected specifically for evaluation purposes; others used as available from agency archives

Figure 7. Relationship of Data Elements and Analysis Approach for Evaluation Objective #5: Integration with Existing TMC Systems for Reporting Capabilities
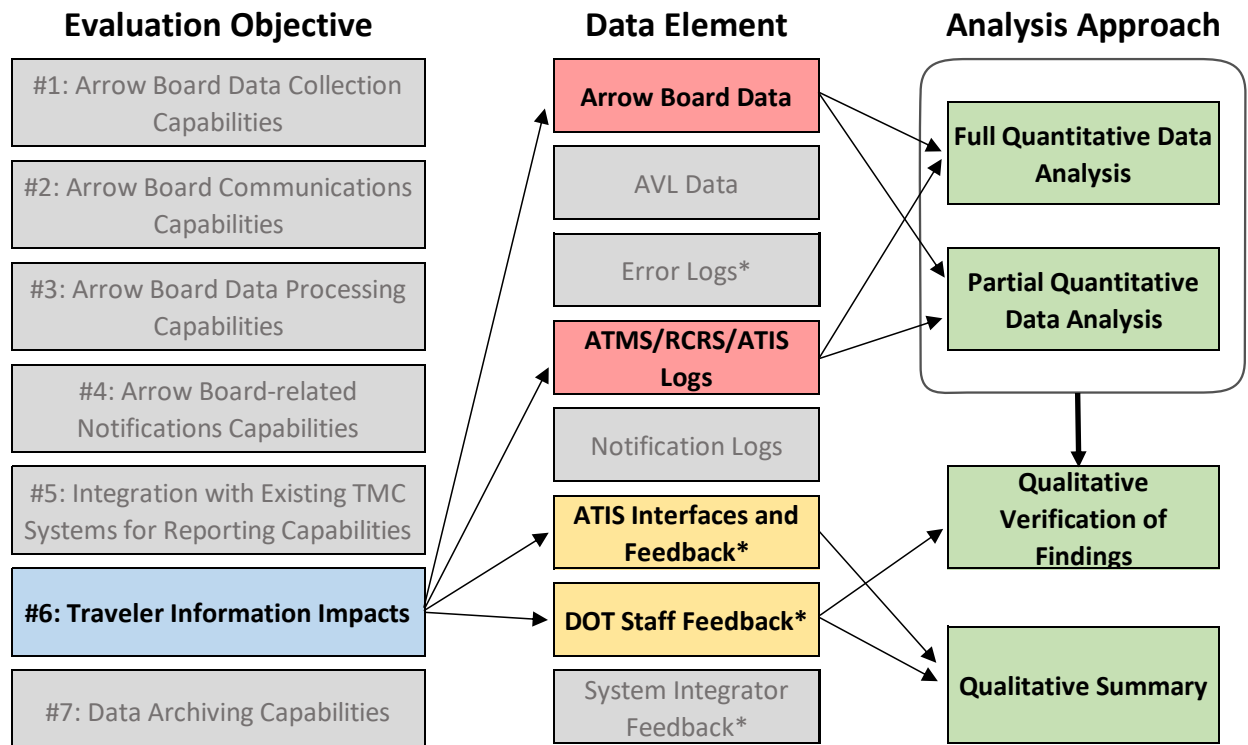
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Table 6. Evaluation Measures, Data Needs, and Data Analysis Method to examine Integration with Existing TMC Systems for Reporting Capabilities

Evaluation Objective #5: Integration with Existing TMC Systems for Reporting Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
5.1 Extent of configurations, modifications, or integration actions required to integrate the Arrow Board information.	• System Integrator interview • DOT operator staff interview	*Qualitative summary:* System Integrator staff and DOT operator staff indicate their experiences.
5.2 Operator ability to select and view Arrow Board information within the interface.	• DOT operator staff interview	*Qualitative summary:* DOT operator staff indicate their experiences.
5.3 Frequency of accurately identifying an existing event in the TMC Systems.	• ATMS/RCRS/ATIS logs • Processed Arrow Board location and status data	*Full quantitative data analysis:* Compare TMC System logs with Arrow Board location and status data.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
5.4 Occurrences of inaccurate link made to unrelated event in the TMC Systems.	• Error logs	*Partial quantitative data analysis:* Error logs completed throughout the evaluation period by DOT operator staff to document instances of inaccurate links to existing events.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
5.5 Occurrences of missed link to an existing event in the TMC Systems.	• Error logs	*Partial quantitative data analysis:* Error logs completed throughout the evaluation period by DOT operator staff to document instances of missed links to existing events.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
5.6 Operator satisfaction with capability of the system to automatically create system-generated new events.	• DOT operator staff interview	*Qualitative summary:* DOT operator staff indicate their satisfaction.
5.7 Average number of edits made to recommended events before posting a new event.	• Processed Arrow Board status and recommendation data • ATMS/RCRS/ATIS logs	*Full quantitative data analysis:* Compare TMC System logs with Arrow Board recommendation data, if available.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.

Evaluation Objective #5: Integration with Existing TMC Systems for Reporting Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
5.8 Operator satisfaction with capability of the system to automatically update existing events.	• DOT operator staff interview	***Qualitative summary:*** DOT operator staff indicate their satisfaction.
5.9 Perceived benefits of added details in events that are automatically updated using Arrow Board information.	• DOT operator staff interview • Evaluation team review	***Qualitative summary:*** DOT operator staff and the evaluation team indicate their observations and experiences.
5.10 Frequency that recommended updated events are not posted.	• ATMS/RCRS/ATIS logs • Arrow Board data	***Full quantitative data analysis:*** Identify Arrow Board system recommendations that do not link to any TMC System event update.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
5.11 Average number of edits made to recommended events before posting an updated event.	• ATMS/RCRS/ATIS logs • Processed Arrow Board status and recommendation data	***Full quantitative data analysis:*** Compare TMC System logs with Arrow Board recommendation data, if available.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
5.12 Operator satisfaction with system-generated recommendation to close an event.	• DOT operator staff interview	***Qualitative summary:*** DOT operator staff indicate their satisfaction.
5.13 Frequency that events are not closed following system recommendation.	• ATMS/RCRS/ATIS logs • Processed Arrow Board status and recommendation data	***Full quantitative data analysis:*** Compare TMC System logs with Arrow Board recommendation data, if available.
	• DOT operator staff interview	***Qualitative verification:*** DOT operator staff verify findings and identify other specific anecdotal experiences.
5.14 Operator ability to view timely, accurate, and useful Arrow Board information from all active devices on the system interface, compared to previous information about lane closures.	• DOT operator staff interview	***Qualitative summary:*** DOT operator staff indicate their satisfaction.

5.3.6 Evaluation Objective #6: Traveler Information Impacts

Figure 9 depicts the data elements and analysis approach to examine **Evaluation Objective #6: changes to ATIS events based on availability of new Arrow Board information for the provision of additional, more specific information, and potential benefit to the traveling public**. This is regardless of whether Arrow Board information is integrated with the ATIS or manually input to the ATIS by TMC staff who receive the Arrow Board information via other TMC Systems or interfaces. Table 8 presents additional details on the MOEs, data sources, and analysis approach for this evaluation objective.

Evaluation Objective	Data Element	Analysis Approach
#1: Arrow Board Data Collection Capabilities	Arrow Board Data	Full Quantitative Data Analysis
#2: Arrow Board Communications Capabilities	AVL Data	Partial Quantitative Data Analysis
#3: Arrow Board Data Processing Capabilities	Error Logs*	Qualitative Verification of Findings
#4: Arrow Board-related Notifications Capabilities	ATMS/RCRS/ATIS Logs	Qualitative Summary
#5: Integration with Existing TMC Systems for Reporting Capabilities	Notification Logs	
#6: Traveler Information Impacts	ATIS Interfaces and Feedback*	
#7: Data Archiving Capabilities	DOT Staff Feedback*	
	System Integrator Feedback*	

*Data elements collected specifically for evaluation purposes; others used as available from agency archives

Figure 8. Relationship of Data Elements and Analysis Approach for Evaluation Objective #6: Traveler Information Impacts

Table 7. Evaluation Measures, Data Needs, and Data Analysis Method to examine Traveler Information Impacts

Evaluation Objective #6: Traveler Information impacts		
Measures of Effectiveness	**Data Sources**	**Analysis**
6.1 Number of new events created in TMC Systems using Arrow Board information, and the percentage of these events out of all lane closure events.	• ATMS/RCRS/ATIS logs • Processed Arrow Board status data	*Full quantitative data analysis:* Examine TMC System logs for instances where new events were created using Arrow Board data to help determine added value of system.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences regarding awareness of additional lane closure events.
6.2 Number of existing lane closure events that were updated based on Arrow Board data (not including new events created based on Arrow Board information), and the percentage of these events out of all lane closure events.	• ATMS/RCRS/ATIS logs • Processed Arrow Board status data	*Full quantitative data analysis:* Examine TMC System logs to compare number of instances where events were created or modified using Arrow Board data versus total number of lane closure events to help determine added value of system.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences regarding awareness of additional lane closure events.
6.3 Begin and end times of lane closure events that were new or updated using Arrow Board data.	• ATMS/RCRS/ATIS logs • Processed Arrow Board status data	*Full quantitative data analysis:* Examine TMC System logs to identify numbers and relative percentages of events that were created and modified using Arrow Board data that included a lane closure during peak hours versus those that took place exclusively during non-peak hours to help determine added value of system in periods of high traffic.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences regarding lane closure event times.
6.4 Number of lane closure events with Arrow Board Reporting System compared to previous year lane closure events.	• ATMS/RCRS/ATIS logs	*Full quantitative data analysis:* Examine TMC System logs from evaluation period and prior year to compare number of lane closure events and information provided to help determine added value of system.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other anecdotal experiences regarding other changes that could impact the number of lane closure events and awareness of additional lane closure events.
6.5 Perceived benefits of added details in events that are updated using Arrow Board information.	• DOT traveler information staff and manager interview • Evaluation team review	*Qualitative summary:* DOT traveler information staff and manager, and the evaluation team indicate their observations and experiences.

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Evaluation Objective #6: Traveler Information impacts		
Measures of Effectiveness	**Data Sources**	**Analysis**
6.6 Traveling public ability to view timely, accurate, and useful Arrow Board information from all active devices on the ATIS interface, compared to previous information about lane closures.	• DOT traveler information staff and manager interview	*Qualitative summary:* DOT operator staff indicate their satisfaction.
	• Evaluation team via ATIS website or phone • Evaluation team awareness of active Arrow Board lane closures	*Qualitative summary:* Evaluation team staff document their experiences.
6.7 Traveler Information staff satisfaction with information provided by Arrow Board system.	• DOT traveler information staff and manager interview	*Qualitative summary:* Traveler Information manager and staff indicate their perception of added value of Arrow Board information for traveling public.
6.8 Traveler Information feedback from traveling public	• DOT traveler information staff and manager interview	*Qualitative summary:* Traveler Information manager and staff share knowledge of any feedback received from traveling public about new information from Arrow Board data, e.g., following social media notification, survey posted on website, or news items.

5.3.7 Evaluation Objective #7: Data Archiving Capabilities

Figure 9 depicts the data elements and analysis approach to examine **Evaluation Objective #7: the ability to store Arrow Board-related lane closure information for the purposes of research, performance management, evaluation, and TMP planning purposes**. Table 8 presents additional details on the MOEs, data sources, and analysis approach for this evaluation objective.
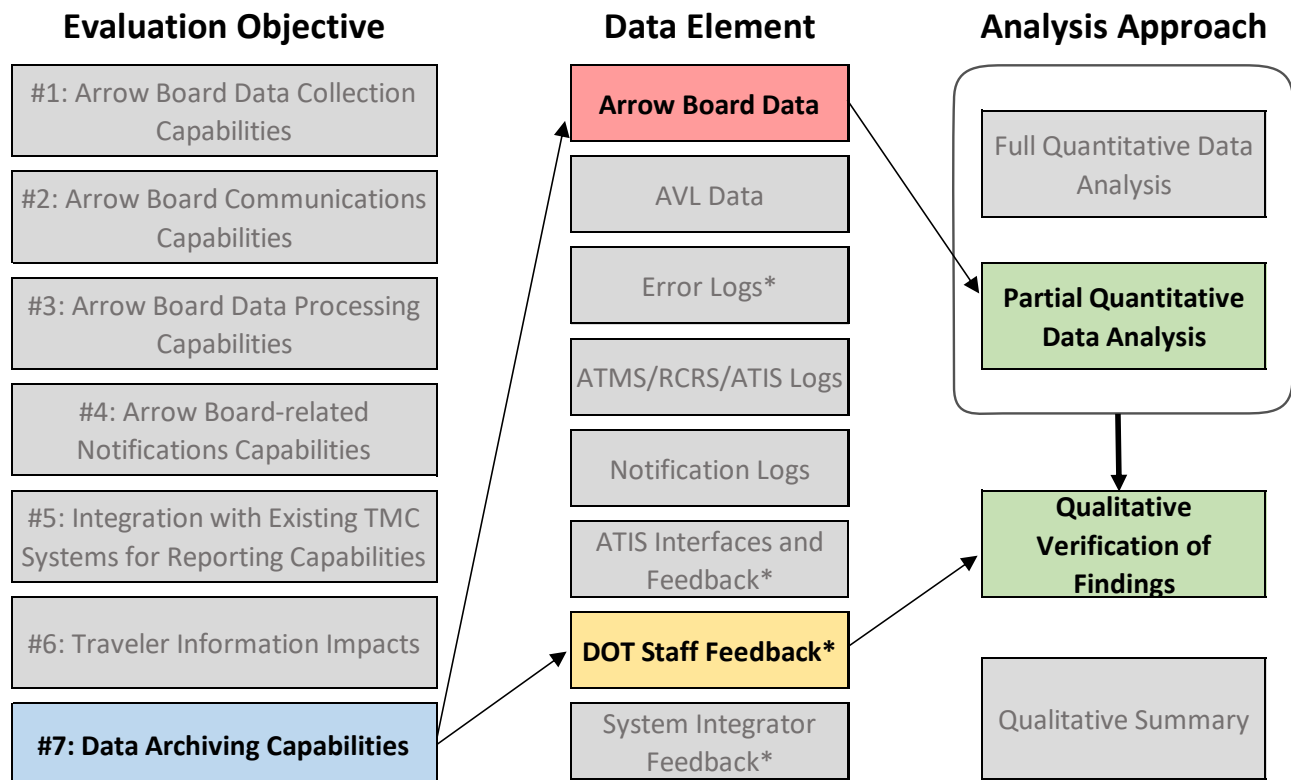
Evaluation Objective

Figure 9. Relationship of Data Elements and Analysis Approach for Evaluation Objective #7: Data Archiving Capabilities

Table 8. Evaluation Measures, Data Needs, and Data Analysis Method to examine Data Archiving Capabilities

Evaluation Objective #7: Data Archiving Capabilities		
Measures of Effectiveness	**Data Sources**	**Analysis**
7.1 Ability of system to store all raw and processed Arrow Board data with appropriate timestamps, operations and status changes, location, and other relevant data.	• All raw and processed Arrow Board data	*Qualitative summary:* Evaluation Team staff document their experiences, given several random samples.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.
7.2 Ability of system to offer DOT staff relatively easy access to archived Arrow Board data.	• All raw and processed Arrow Board data	*Qualitative summary:* Evaluation Team staff document their experiences, given several random samples.
	• DOT operator staff interview	*Qualitative verification:* DOT operator staff verify findings and identify other specific anecdotal experiences.

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Appendix A: Question Guide for Potential Arrow Board Reporting System Deployers

The question guide below was developed by the project team to facilitate discussions with agencies that were considering the deployment of Arrow Board Reporting Systems. For staff at agencies that had not fully considered how an Arrow Board Reporting System might be deployed in their jurisdiction, these questions allowed them to think through the variations a developed system might include.

1. Do you intend to equip Arrow Boards that are truck-mounted, on trailers, or both? How many Arrow Board units do you intend to equip? Both

2. Please characterize the work zones you intend to deploy equipped Arrow Boards, including:
   a. Short-duration maintenance activities (hours), short-duration construction (days), longer-duration construction (weeks-months)
   b. Urban or rural areas
   c. Divided or undivided multi-lane highways - Both
   d. Mobile work zones
   e. In conjunction with multiple equipped Arrow Boards for multi-lane/shoulder closures

3. Do you expect Arrow Board data to be processed at the Arrow Board or the TMC, e.g., roadway and milepost, direction facing, etc.?

4. How do you expect Arrow Board data to be communicated: direct from Arrow Board, via third-party server, upon request from TMC, etc.? At what time intervals? Via radio, cellular, DSRC?

5. Do you expect the Arrow Board to be capable of transmitting a message when it is powered down and inactive?

6. Please characterize how you expect Arrow Board data to be integrated and ingested:
   a. TMC System: processed and used in RCRS, ATMS, traveler information systems?
   b. Degree of automation for creation of events: fully manual, system provides recommendations, manual approval required for posting, fully automated
   c. Displayed on RCRS or ATMS software interface?

7. How do you envision Arrow Board-related notifications to occur:
   a. Sent from the Arrow Board or TMC Systems?
   b. Via text, application, email, and/or via ATMS or RCRS interface?
   c. To field staff?
   d. For status changes only, including activation and de-activation, or also for identified maintenance needs?

8. Do you intend to archive Arrow Board data? Pre- and post-processed data?