Preliminary Investigation   (PI-0025)

Caltrans Division of Research, Innovation and System Information

DRISI

Construction Materials Management Systems: Survey of State Practice

Requested by
John Hancock, Division of Construction

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Background

The Caltrans Division of Construction is seeking to implement a materials management system (MMS) that allows external and internal users to enter material sampling, testing and certification data into electronic forms specific to a project. (This type of system is also referred to as a laboratory information management system, or LIMS.) System data is used to track, monitor and report on materials, laboratories and personnel at the project and program levels. Of interest to the division is an application that can perform the necessary calculations for material acceptance and comparison, testing turnaround and payment processing, and that can generate notices to affected parties. The new system, which will replace a range of paper-based processes currently in use across Caltrans' districts, is expected to expedite testing turnaround and improve tracking, monitoring and reporting.

To inform Caltrans' selection of a new MMS/LIMS, CTC & Associates conducted a survey of state departments of transportation (DOTs) expected to have experience with these systems. Survey results are presented below; documentation from survey participants along with the results of a limited literature search supplemented survey findings.

Summary of Findings

Online surveys about the use of MMS/LIMS were distributed to two groups of transportation agencies: those using AASHTOWare Project SiteManager and those using other systems. Survey results for each group are summarized below.

AASHTOWare Project SiteManager Systems

Seven transportation agencies using SiteManager as an MMS/LIMS—Alabama, Arkansas, Colorado, Kentucky, Missouri, New Jersey and New York—responded to the survey.

System Description and Implementation

Six of the DOTs surveyed (Alabama, Arkansas, Colorado, Kentucky, Missouri and New York) are currently using the client-based version of SiteManager; New Jersey DOT is the only agency using the web-based version. All but two of the survey respondents (Arkansas and Missouri) use the LIMS function in the SiteManager product, and all agencies use SiteManager in conjunction with another system or tool.

The primary reasons given by respondents for electing to use SiteManager instead of developing a custom system were product development and technical support. SiteManager, according to one respondent, is a more stable product that is updated frequently and supported consistently. Other reasons for choosing the system were the ability to keep records in a central location, cost, seamless data transfer for agencies already using AASHTOWare products, and use by other states.

The amount of time and the cost required to implement the system varied by agency, in part related to whether the agency implemented the system using internal staff or using a vendor. Most of the state DOTs surveyed have customized SiteManager to address specific agency needs, primarily applications related to business processes, the user experience and system

security. These customizations were made by both in-house staff and vendors. The frequency of system updates and the approximate time to install requested updates also varied by agency.

Respondents provided details on the number of system users and the value of construction projects completed each year by the agency. The number of internal and external users ranged from 150 (Alabama) to more than 2,600 (New York). The annual value of completed projects reported ranged from $400 million (Colorado) to $2 billion (New Jersey and New York).

<u>Application for Smart Devices</u>

Only one agency—New York State DOT—using SiteManager uses an application (app) for smart devices to gather materials-related information during testing and inspection. The DOT uses Mobile Inspector by Info Tech, Inc. to capture construction field data for daily work reports. The app can be used with a smartphone or tablet, and can be used offline.

<u>System Assessment and Future Plans</u>

Flexibility, reliability, consistency and ease of use were among the strengths of SiteManager that were most commonly reported by respondents. The Arkansas DOT respondent noted that the collaborative development of both SiteManager and AASHTOWare Project Construction & Materials enables these systems to accommodate most Federal Highway Administration (FHWA) and AASHTO requirements. With customizations, the systems become very flexible and can accommodate most state-specific requirements. The Missouri DOT respondent said that the setup and administration of the client-based SIteManager are relatively straightforward and efficient, adding that the system provides excellent speed and control over appearance and function that make data entry intuitive and efficient in ways that web-based systems cannot.

Challenges with SiteManager reported by participating agencies were aspects of functionality, particularly in states with areas that have poor or no internet connectivity. System updates and modifications also provided challenges to some agencies.

Nearly all agencies using SiteManager have plans to transition to another MMS or LIMS. Five states (Arkansas, Kentucky, Missouri, New Jersey and New York) plan to implement AASHTOWare Project Construction & Materials. Alabama DOT is developing a web-based system, CAMMS, that is usable in the office and in the field. Implementation of this new system is expected by July 1, 2018.

<u>Recommendations for Implementing a New System</u>

Planning—identifying business processes and information needs within the agency—is a key first step for agencies that are preparing to implement a new MMS/LIMS. Other recommendations from respondents were related to implementation practices and user training.

Other Materials Management Systems

Nine state DOTs using internally developed MMS/LIMS or customized commercial systems—Florida, Illinois, Maine, Minnesota, Pennsylvania, Rhode Island, Virginia, Washington and Wisconsin—responded to the survey.

System Description and Implementation

Four agencies use a commercial off-the-shelf (COTS) product customized for the agency:

- Illinois DOT's web-based system, iPDWeb by ExeVision, Inc., is currently being implemented to replace the agency's mainframe materials database. Implementation is expected to be complete by 2020.

- Minnesota DOT uses LabVantage (LIMS) and Transportation Automated Control Electronic Project Management (TRACS), a client-based system implemented in the mid-1990s. LabVantage required customization to meet both user demands and testing and reporting needs, such as incorporating specifications. Annual maintenance costs entail labor plus storage and processing costs related to use of an Oracle database.

- Electronic Construction and Materials Management System (eCAMMS) in Pennsylvania, implemented in 2013, supports more than 3,000 internal and external users. Implementation costs for the system are unknown, however, the initial estimate was approximately $3 million. The system provides materials management and also interfaces with the agency's Engineering and Construction Management System (ECMS). The agency designs and builds custom apps for tablets that are used to gather materials-related information during testing and inspection.

- Rhode Island DOT's client-based system is a combination of Microsoft Access and SQL Server that is used exclusively for materials management. Implementation of Access began in the late 1990s; the integration of SQL Server into Access has taken much trial and error, and is still in development.

Five state DOTs use custom software developed specifically for the agency:

- Florida DOT uses a web-based system, Materials Acceptance and Certification (MAC), that supports 5,000 internal and external users. The system was implemented in 2015 at a cost of more than $3.8 million; annual maintenance costs are approximately $170,000. In addition to materials management, the system interfaces with the agency's contracts systems for contract, project and pay item information; its Approved Products List; and the Construction Training and Qualification Program database.

- The Testing Information Management System in Maine is client-based. It was implemented in 2002 for approximately $200,000; annual maintenance costs are approximately $100,000.

- The Asphalt and Aggregate sections of Virginia DOT use Materials Information Tracking System (MITS) and Producer Lab Analysis and Information Details (PLAID), a centralized online database that allows users to submit hot-mix asphalt and central mix aggregate job mixes and sample results for approval. The Asphalt section system was implemented in 2013 followed by implementation of the Aggregate section system in 2014. There were no implementation costs; annual maintenance costs are unknown. The system supports about 1,200 internal and external users.

- Washington State DOT's client-based system, Materials Testing System (MATS), was implemented in 2005. Cost of implementation was approximately $1.3 million; annual maintenance costs are approximately $120,000.

- Wisconsin DOT uses three materials tracking software programs: Materials Reporting Software (MRS), Materials Information Tracking (MIT) and Materials Tracking System (MTS). Information from these programs is sent to the Highway Quality Management

System (HQMS) web site, which updates programs to reflect current specifications and required test methods. Implementation, which began in 2011, is ongoing.

Five agencies (Florida, Maine, Virginia, Washington and Wisconsin) chose to develop a custom system rather than use a COTS product because of the lack of a suitable COTS product at the time their agency's system was developed. Additional reasons for developing a custom system were cost, efficiency and use of the agency's approved vendors.

<u>System Features and Functions</u>

Respondents were asked to indicate which of 16 features were supported by their MMS/LIMS. Two features—manages specifications and test methods, and produces reporting—were supported by all of the systems. Other commonly supported features:

- Allows for review of mix designs.

- Generates notifications to external users.

- Manages review and authorization of samples.

- Manages testing workflows.

- Generates notifications to internal users.

- Provides access to external users.

The least commonly supported features:

- Certifies technicians.

- Generates invoices.

- Manages new product evaluation.

- Monitors instrument calibration and maintenance.

- Processes payments.

Pennsylvania DOT's eCAMMS and Illinois DOT's iPDWeb were the more robust of the nine systems, with Pennsylvania's system supporting 14 features and Illinois' system supporting 12 features. Systems supporting the least number of features were Rhode Island DOT's Microsoft Access and SQL Server (4) and Maine DOT's Testing Information Management System (3).

<u>System Assessment and Future Plans</u>

When asked to identify the strengths of their agency's MMS/LIMS, most survey respondents cited efficiency, including the respondent from Illinois DOT who noted that the system currently being implemented will streamline many processes. Other system strengths reported were user-friendly systems that are flexible and transparent, and that provide customized reporting and tracking.

Challenges with these systems generally arose from issues with limited functionality, system complexity and compatibility issues.

Six of the nine states reporting use of an internally developed system either have plans to transition to another MMS/LIMS or are considering adopting a new system. Three DOTs (Minnesota, Virginia and Wisconsin) will migrate to AASHTOWare Project or Project

Construction & Materials, and one state (Washington) is considering AASHTOWare along with other software packages. Maine DOT recently selected a vendor to develop a new system. Illinois DOT is currently transitioning from the agency's mainframe materials database to iPDWeb.

Recommendations for Implementing a New System

As with SiteManager users, this group of survey respondents encouraged planning and research to understand an agency's business processes and information needs before implementing a new system. Other recommendations from respondents addressed implementation practices and user training.

Gaps in Findings

While most survey respondents provided a significant level of detail about their MMS/LIMS, additional information could be solicited from these or other agencies not participating in the project's survey. Follow-up inquiries that target specific areas of interest to Caltrans may lead to valuable additional information.

Next Steps

Moving forward, Caltrans could consider:

- Reviewing the MMS/LIMS described by survey respondents to identify systems with attributes of interest to Caltrans. Follow-up discussions with these agencies could provide more information about the benefits and challenges of these systems.

- Contacting agencies preparing to transition to AASHTOWare Project or Project Construction & Materials (Arkansas, Kentucky, Minnesota, Missouri, New Jersey, New York, Virginia and Wisconsin) to learn about the decision-making process for choosing the product.

- Contacting agencies currently considering implementing a new MMS/LIMS (Maine and Washington) to learn more about the request for proposal process used or the general approach to evaluating systems.

- Reviewing AASHTOWare's Project Construction & Materials software to identify how it might meet Caltrans' needs.

- Investigating other MMS/LIMS commercial products not identified by survey respondents that might be of interest to Caltrans.

Detailed Findings

Survey of Practice

The Caltrans Division of Construction is seeking to implement a materials management system (MMS) that allows external and internal users to enter material sampling, testing and certification data into electronic forms specific to a project. (This type of system is also referred to as a laboratory information management system, or LIMS.) System data is used to track, monitor and report on materials, laboratories and personnel at the project and program levels. Of interest to the division is an application that can perform the necessary calculations for material acceptance and comparison, testing turnaround and payment processing, and that can generate notices to affected parties. The new system, which will replace a range of paper-based processes currently in use across Caltrans' districts, is expected to expedite testing turnaround and improve tracking, monitoring and reporting.

To inform Caltrans' selection of a new MMS/LIMS, CTC & Associates surveyed other state departments of transportation (DOTs) expected to have experience with these systems. Online surveys were distributed to two groups of DOTs: those using AASHTOWare Project SiteManager and those using other systems. Appendix A provides the questions from both surveys.

Survey results are presented in two topic areas:

- AASHTOWare Project SiteManager systems.

- Other materials management systems.

Supplementing these survey results are findings from a limited literature search, which are provided in **Related Research and Resources** beginning on page 37.

AASHTOWare Project SiteManager Systems

Summary of Survey Results

Seven state DOTs using SiteManager as an MMS/LIMS responded to the survey:

- Alabama.
- Arkansas.
- Colorado.
- Kentucky.
- Missouri.
- New Jersey.
- New York.

Survey results are presented below in the following topic areas:

- System description.
- System implementation.
- Program size.
- Application for smart devices.

- System assessment.

- Recommendations for implementing a new system.

- Related resources.

<u>System Description</u>

Six of the DOTs surveyed (Alabama, Arkansas, Colorado, Kentucky, Missouri and New York) are currently using the client-based version of SiteManager. New Jersey DOT is the only agency using the web-based version; the survey respondent reported no concerns using this version.

All but two of the survey respondents (Arkansas and Missouri) use the LIMS function in the SiteManager product. All agencies use SiteManager in conjunction with another system or tool. The table below summarizes survey responses.

AASHTOWare Project SiteManager System Description			
Client- or Web-Based	**State**	**Use LIMS Function**	**Use With Another System or Tool**
Client	Alabama	Yes	Migrating to CAMMS (Construction and Materials Management System), a web-based system developed in-house.
	Arkansas	No	Multiple small Microsoft Access applications developed in-house (using Open Database Connectivity (ODBC) connections to interface with SiteManager): • *Qualified Products List* (maintain with an SQL Server backend): Documents compliance with construction projects. Most of the materials documentation is done in SiteManager. • *Asphalt application* (an Excel application developed in-house): Documents testing of asphalt volumetric and density properties. Test results are input into the application, uploaded to agency network and stored in an SQL Server backend. Custom interface creates records in SiteManager to document creation of asphalt test reports. • *Lab management software*: Tracks materials tested in agency's central lab. The custom-built software does not interface with SiteManager, but is used in tandem with SiteManager.

AASHTOWare Project SiteManager System Description			
Client- or Web-Based	State	Use LIMS Function	Use With Another System or Tool
Client	Colorado	Yes	Trns•port to obtain design quantities after a contract has been awarded through BAMS/DSS (AASHTOWare Project's data warehouse and decision support system (bid analysis) module).
	Kentucky	Yes	• *Kentucky Qualified Testers and Labs (KQTL) interface*: Schedules and tracks all materials sampling and testing classes. Tracks qualified lab information. Passes all data to SiteManager. • *KYTAG*: Interfaces with agency accounting software. Creates files from SiteManager information to upload establishments, contract modifications (change orders) and pay estimates to eMARS accounting system.
	Missouri	No	Excel to enter, retrieve and analyze data from SiteManager.
	New York	Yes	AASHTOWare Project suite of products.
Web	New Jersey	Yes	Materials Qualified Products lists (aggregate is separate).

Reasons for Choosing SiteManager

We asked respondents why their agency elected to use SiteManager instead of developing a custom system. Product development and technical support were cited by Arkansas DOT and Kentucky Transportation Cabinet. The Arkansas respondent reported that the agency's experience with custom systems "had not been overwhelmingly positive." Simple systems developed without the agency's information technology (IT) staff have been somewhat successful, but complex systems that require intense programming can quickly become outdated, and finding technical support to maintain or upgrade these systems is difficult. In contrast, SiteManager provides the agency with a more stable product that is updated frequently and supported consistently. The Kentucky respondent noted that support from the Project User Group community is beneficial.

Additional reasons that respondents' agencies chose SiteManager over a custom system follow:

- *Central location (Alabama)*: The agency wanted to keep its construction and materials records in the same system.

- *Cost (Colorado)*: The respondent noted that the cost of developing a stand-alone product to match the agency's business practices would be extremely high.

- *Seamless data transfer (Colorado)*: The agency uses a number of other AASHTOWare products, so a seamless transfer of data is possible.

- *Use by other state DOTs (New Jersey)*.

<u>System Implementation</u>

We asked respondents for detailed information about the implementation of the agency's system, including the amount of time and the cost to implement. Arkansas DOT, which implemented SiteManager using in-house staff, reported taking less than one year. Three agencies (Kentucky Transportation Cabinet and Missouri and New York State DOTs) reported implementing the system in one to less than two years. Implementation at three agencies (Alabama, Colorado and New Jersey DOTs) lasted three years or longer.

Respondents also reported on in-house and consultant costs related to system implementation and annual maintenance. The table below summarizes survey responses.

System Implementation				
State	**Year Implemented**	**Time to Implement**	**Implementation Cost**	**Annual Maintenance Costs**
Alabama	After 2003	3 years or more	Unknown	Annual licensing fees only[1]
Arkansas	*SiteManager*: 2003. *Materials Module*: 2008.	6 months to less than 1 year	Staff and training costs only	License fees, indirect costs associated with system administration and system/ hardware maintenance
Colorado	July 2014	3 years or more	Approx. $500,000 to consultants plus internal staff[2]	Approx. $100,000 for internal forces and annual license
Kentucky	*SiteManager*: 2004. *Materials/LIMS*: 2007.	Construction: 1 year to less than 2 years; Materials: longer.[3]	Unknown	2018 licensing costs for SiteManager and LIMS: $224,000. Project super site license (includes Preconstruction and CRLMS licensing: $462,000.
Missouri	2000	1 year to less than 2 years	Unknown	Approx. 3.2% of users (not including hardware, licensing, etc.)
New Jersey	*Construction*: 2007. *Materials*: 2011.	3 years or more	$1.3 million in 2011	$475,000 (includes construction and materials)

System Implementation				
State	**Year Implemented**	**Time to Implement**	**Implementation Cost**	**Annual Maintenance Costs**
New York	Phased implementation begun April 2007. Currently 90% to 95% complete.[4]	1 year to less than 2 years	$7.5 million (SiteManager Construction and Materials with LIMS)	Annual license fee: approx. $220,000. Consultant fees: Unknown.

1   Since implementing CAMMS, Alabama DOT has not improved or upgraded its system.

2   Colorado DOT did not track the hours or the costs for internal resources. Training cost is ongoing.

3   Kentucky Transportation Cabinet plans to implement AASHTOWare Project Construction & Materials in the next few years (see **Future Plans**, page 16). In that upgrade, the respondent noted that the Materials portion will also be the critical path.

4   New York State DOT plans to begin a project to implement a web-based application in the near future.

System Customization

Most of the state DOTs surveyed have customized SiteManager to address specific agency needs, primarily applications related to business processes, the user experience and system security. These customizations were made by both in-house staff and vendors. Details about each agency's customization efforts follow:

- Alabama DOT rewrote a significant portion of LIMS to manage the agency's business processes. For many years, the agency employed full-time consultants (InfoTech, Inc.) to lead the process using multiple service units.

- Arkansas DOT developed more than 100 custom test templates. To simplify the user experience, the agency also customized various data windows in SiteManager to hide fields or functionalities that weren't used. This measure has prevented users from entering data in the wrong field. All customizations were completed by the Systems Administration Section in the Construction Division. Users can also access Arkansas DOT's system through a Citrix portal, a remote desktop application that provides access to the program. For some users in remote districts, this provides an increase in performance speed and allows access when not physically connected to the agency's network.

- Colorado DOT has created incentive and disincentive programs for hot-mix asphalt and portland cement concrete pavement, as well as applications for generating reports. These customizations were completed by the agency's Office of Information Technology.

- Kentucky Transportation Cabinet has made minimal customizations, all performed by the vendor (Info Tech). In-house staff has made configuration updates using PowerBuilder files.

- Missouri DOT modified existing windows to include fields or filters that weren't available. Some of these modifications provided additional data security or segregated sensitive information. Internal IT staff performed the coding at the agency's direction.

- New Jersey DOT has customized SiteManager to allow for the production of Crystal Reports and interface with its Qualified Products List.

System Updates

Respondents also reported on the frequency of system updates and the approximate time required to implement requested updates. In Arkansas, the DOT determines how often to install SiteManager updates, which AASHTOWare releases regularly. The agency also periodically releases new or revised test templates and updated customizations. These revisions occurred frequently initially, but are much less frequent now.

Kentucky Transportation Cabinet updates its system whenever new versions of SiteManager are released. It typically takes the agency about six months to fully install and completely test new versions before going into production. This process could be faster, depending on available testing resources and if the update was critical to fix an issue. At New Jersey DOT, requested updates are implemented quickly. According to the respondent, "They shut down on a Friday and it's up [and] running by Monday." The table below summarizes survey responses.

System Updates		
State	**Frequency**	**Time to Implement Update**
Alabama	Approx. every 6 months	Approx. 1 year
Arkansas	*SiteManager updates*: Determined by agency. *Test templates/ customizations*: As needed.	*Major software upgrades*: Weeks or months. *Test templates/ customizations*: Hours.
Colorado	Approx. three times a year	Approx. 1 year, depending on the complexity of the enhancement
Kentucky	*SiteManager updates*: Release of new versions	Approx. 6 months for testing through production
Missouri	*Software updates*: Once each year	Approx. 3 weeks for testing through production
New Jersey	Approx. every 2 years	Two to three days
New York	Approx. every 2 years	Not provided

Program Size

The table below provides information about the number of users with access to an agency's system and the annual value of completed construction projects.

Project Delivery and Program Size				
Annual Value of Completed Construction Projects	State	Actual Value of Completed Projects	Number of System Users	
			Internal	External
Less than $500 million	Colorado	$400 million	100	250
$500 million to less than $1 billion	Alabama	Approx. $700 million to $800 million annually[1]	150	0
	Missouri	$750 million	500	15
$1 billion to $2 billion	Arkansas	More than $1 billion (2017)[2]	600	112
	Kentucky	Approx. $1.1 billion (average over past four fiscal years)	822 active accounts; 615 recent password changes	All users are either agency employees or consultant inspectors who are treated as employees
	New Jersey	$2 billion	1,100 internal and external users	1,100 internal and external users
	New York	$2 billion	2,500+	Approx. 100

1 Alabama DOT currently has 400 active projects worth over $2.2 billion.

2 From 2010 to 2017, Arkansas DOT let, on average, $745 million to contract (minimum: $550 million in 2011; maximum: $1.2 billion in 2016).

Application for Smart Devices

New York State DOT is the only agency participating in this survey that uses an application (app) for smart devices to gather materials-related information during testing and inspection. The agency uses Mobile Inspector, offered by Info Tech, which captures construction field data for daily work reports. The app can be used with a smartphone or tablet, and can be used offline.

On a scale of 1 to 5 (where 1 = not at all satisfied and 5 = extremely satisfied), the New York State DOT respondent gave the app a 5 rating for ease of use, a 4 rating for reliability and a 3 rating for flexibility. Overall satisfaction with the app was rated 4.

The respondent also noted an interest in implementing Mobile Materials Inspector, a soon-to-be-released app from AASHTO.

Alabama DOT is developing an app to use with its new web-based system (see **Future Plans**, page 16) so that the system is usable even without internet access. The agency anticipates implementing the system by July 1, 2018.

System Assessment

System Strengths

Respondents were asked to describe the strengths of SiteManager as an MMS/LIMS at their agency. Flexibility, reliability, consistency and ease of use were among the strengths most commonly reported by respondents.

The Arkansas DOT respondent noted that both SiteManager and AASHTOWare Project Construction & Materials (SiteManager's successor), like all AASHTOWare systems, are collaboratively developed with the input and direction of state DOTs. Out of the box, these systems can accommodate most Federal Highway Administration (FHWA) and AASHTO requirements. With customizations, the systems become very flexible and can accommodate most state-specific requirements. Arkansas DOT has tried to stay actively involved in the collaborative development process, which has given the agency a voice in how the software is developed. It has also made use of the software's customization ability to meet agency needs. The SiteManager Materials Module has standardized materials testing documentation statewide. It has also brought a high level of support to the agency's local resident engineer offices since the module provides searchable ways for engineers to ensure they are meeting all of a project's testing requirements without having to develop a checklist for each project. The software has also provided a high level of confidence in the reliability and accuracy of agency materials testing data. The DOT can now query test results and conduct analysis since all the raw test results are stored in a database.

The Missouri DOT respondent said that setting up SiteManager without the LIMS add-on is relatively straightforward, and it can be administered efficiently. Because it's a client-based software, it provides excellent speed and control over appearance and function that make data entry intuitive and efficient in ways that web-based systems cannot.

The table below summarizes all agency responses.

System Strengths		
Strength	**State**	**Description**
Consistency	Alabama	Provides consistency and reliability.
Ease of use	Missouri	Provides intuitive data entry.
Efficiency	Colorado	Provides uniformity of business processes.
	Missouri	Provides relatively straightforward setup and efficient administration.
	New Jersey	Connects labs, headquarters, regional materials offices, construction and other areas.
Flexibility	Arkansas	With customizations, can accommodate most state-specific requirements.

System Strengths

Strength	State	Description
Flexibility	New York	Provides flexibility to model processes and workflows.
Reliability	Alabama	Provides consistency and reliability.
	Arkansas	Provides high level of confidence in accuracy of materials testing data.
Tracking and reporting	Colorado	• Tracks project-related tests. • Oversees current tester qualifications.
	Kentucky	• Gathers detailed data on all materials samples and tests. • Stores data in the same database as other construction payment and contract information, which aids in reporting.

System Challenges

Respondents were also asked to describe any challenges their agency experienced using SiteManager. Issues with aspects of functionality were most commonly cited, particularly in states with areas that have poor or no internet connectivity. Inspectors working in these areas of Arkansas have had to rely on the stand-alone functionality of SiteManager, which can lead to a higher probability for introducing error in the data since inspectors must ensure their stand-alone version is kept up-to-date.

System updates and modifications also provided challenges. Because Alabama DOT's processes were different from SiteManager, the agency was required to make significant modifications.

The table below summarizes survey responses.

System Challenges

Type of Challenge	State	Description
Functionality	Arkansas	• Ineffective service in remote areas with poor or no internet connectivity. • Higher probability of data entry error. • Lack of coordination in LIMS workflows with central lab.
	Colorado	Ineffective service in remote locations without cell service.

System Challenges		
Type of Challenge	**State**	**Description**
Functionality	Missouri	• Lack of behavior consistency when zooming. • No real geospatial abilities. • Inability to natively support segregating sensitive information. • Poor connection between internal or external linked documents and records.
	New Jersey	Difficulty fixing poorly entered data.
Performance	New York	Agency network speeds make SiteManager run slowly.
System updates and modifications	Alabama	Modifications require a lot of time and effort.
	Kentucky	• Pushing software upgrades to all users with the client software. • Customizations can be costly.
	Missouri	• Initial program required fixes (a slow process). • Routine updates often "break" unrelated areas of the software.
Training users	Colorado	Training new users.

Future Plans

Nearly all of the state agencies using SiteManager have plans to transition to another MMS or LIMS. Five states (Arkansas, Kentucky, Missouri, New Jersey and New York) plan to implement AASHTOWare Project Construction & Materials:

Note: AASHTO developed the Project Construction & Materials software to replace the "client/server construction, materials and laboratory information management functionality of existing AASHTOWare Project modules including AASHTOWare Project SiteManager, AASHTOWare Project FieldManager and AASHTOWare Project Construction Administration." See page 40 for more information about the Construction & Materials product.

- Arkansas DOT plans to begin implementation within the next year.
- Kentucky Transportation Cabinet has begun transitioning from SiteManager and LIMS to Project Construction & Materials, and expects this process to take at least 24 months. All construction and materials data will migrate to one unified database that includes the agency's AASHTOWare Project Preconstruction, Civil Rights & Labor, and Estimation data.

- Missouri DOT is currently working to fully implement the web-based version by this summer. The agency will use a stepped or limited migration for construction projects and a complete changeover for materials-related elements of the system. The respondent noted that this upgrade will be an overall improvement to SiteManager, although "not perfect by any means." He added that the Materials portion is very complex and powerful but lacks the usability SiteManager had as a mature client program.

- The New Jersey DOT respondent did not identify a time frame for the agency's transition to the new system.

- New York State DOT plans to implement the system in the next few years.

Alabama DOT is developing a web-based system, CAMMS, that is usable in the office and in the field. Implementation of this new system is expected by July 1, 2018. The agency is also developing an app so that the system is usable without internet access.

Recommendations for Implementing a New System

Several respondents provided recommendations for agencies that are preparing to implement a new MMS/LIMS. Planning—identifying business processes and information needs within the agency—is a key first step recommended by nearly all respondents. Below are highlights of survey responses by topic.

Planning

- Define system needs—both input and reporting—and "don't settle for less." (New York)

- Research agency requirements to make sure the system functions as needed or be willing to change agency business practices. (Alabama)

- Evaluate the functionality of off-the-shelf software and in-place processes and policies. There are limitations with both customizing software to accommodate current policies and practices and with modifying policies to correspond with the software. Be willing to modify both to create "a strong marriage" between software and agency policy. (Arkansas)

- Develop a system in-house or find a company that can rewrite or modify its product to match agency processes. It will cost more upfront, but will save on user training since the business processes will still be familiar. (Alabama)

- Reduce or eliminate customization. Some work should be done internally. Meet with field personnel often to understand what is actually needed in the system and to reduce the amount of work required of IT staff. (Colorado)

- Keep the system strategy simple. Pare down the information tracked in SiteManager to only that which is likely to be queried or needed for a business function. "Some business functions are still better handled on a piece of paper." (Missouri)

- Develop a good scope of work and have a very good understanding of the vendor's MMS/LIMS capabilities. (Colorado)

Implementation

- Take charge of as many implementation decisions as possible. (New York)

- Implement Project Construction & Materials rather than SiteManager/LIMS. Be prepared to spend at least a year or more, and devote sufficient resources to set up necessary reference data in the system. (Kentucky)

Training

- Provide lots of user training. (New Jersey)

Related Resources

Publications and resources about systems and tools used by survey respondents are provided below.

Arkansas

SiteManager User Guide for Resident Engineer Offices, Release 3.13a, Arkansas State Highway and Transportation Department, February 2014.
See [Attachment A](#).
This user guide presents essential information for using the SiteManager Construction Management System, from startup through contract administration, daily work reports, change orders and the Materials Module.

Colorado

SiteManager Materials (LIMS), Engineering Applications, Colorado Department of Transportation, undated.
https://www.codot.gov/business/engineeringapplications/project-materials
Details about Colorado DOT's materials tracking software are provided in three areas: access to SiteManager Materials (LIMS) for contractors, user training schedules and contacts, and system documentation.

Related Resource:

> **AASHTOWare Project SiteManager Training Guide for CDOT: Materials Management and LIMS**, Colorado Department of Transportation, June 2015.
> https://www.codot.gov/business/engineeringapplications/assets/sitemanager-training-guide-for-cdot-materials-management-and-lims-for-samplers-and-testers
> *From the guide*: The student guide is divided into chapters. Each chapter consists of:
>
> - Multiple Topics and Instructor-Led Exercises
>
> - Quick Reference
>
> - Review Exercise
>
> Each topic has a short description of the SiteManager function being covered, one or more general procedures about how to perform an action in SiteManager, and an instructor-led exercise for the topic. … Instructor-led exercises are very explicit and detail the specific steps and data to be used in performing the action.

Kentucky

Construction, Division of Construction, Kentucky Transportation Cabinet, undated.
https://transportation.ky.gov/Construction/Pages/default.aspx
This web site provides access to the agency's SiteManager documents along with new user login requests and technical support.

Related Resource:

Trns•port SiteManager and LIMS Training Guide for KYTC, Student Edition, Kentucky Transportation Cabinet, February 2009.
https://transportation.ky.gov/Materials/Documents/LIMS_Training_Manual_Student.pdf
This training guide includes step-by-step instructions and training exercises that address the main functional areas of the agency's LIMS, including receiving samples, reviewing and entering test results, reviewing samples and creating sample records.

Missouri

Quick Reference Guides (QRGs), Category: 101 Standard Forms, Missouri Department of Transportation, May 2018.
http://epg.modot.mo.gov/index.php?title=Category:101_Standard_Forms#Quick_Reference_Guides_.28QRGs.29
Scroll down to "Quick Reference Guides (QRGs)" to see a range of SiteManager reference information.

New York

About AASHTOWare Project, New York State Department of Transportation, undated.
https://www.dot.ny.gov/main/business-center/trns-port/section-index
This web page provides links to various aspects of AASHTOWare Project, including the SiteManager/LIMS module.

Mobile Inspector, Info Tech, Inc., 2018.
https://www.infotechfl.com/mobile_inspector
From the web site:

What it is: An app for construction field data collection available for download for most mobile devices that facilitates your e-Construction initiatives.

What it does: It provides a simple way for a field inspector to collect data needed for daily reporting for any size contract.

Why it's better: It's a focused, intuitive tool that requires no training and can be implemented quickly. It's the only app that works with the FieldManager software.

Other Materials Management Systems

Summary of Survey Results

Nine state DOTs using internally developed MMS/LIMS or customized commercial systems responded to the survey:

- Florida.
- Illinois.
- Maine.

- Minnesota.
- Pennsylvania.
- Rhode Island.

- Virginia.
- Washington.
- Wisconsin.

Survey results about each agency's MMS are presented below in the following topic areas:

- System description.
- System features.
- System implementation.
- Program size.
- Application for smart devices.
- System assessment.
- Recommendations for implementing a new system.
- Related resources.

System Description

Most state DOTs surveyed for this Preliminary Investigation use an MMS/LIMS that is either based on custom software developed specifically for the agency or is a commercial off-the-shelf (COTS) product customized for agency use.

Five state DOTs (Florida, Illinois, Pennsylvania, Virginia and Wisconsin) use a web-based system; four agencies (Maine, Minnesota, Rhode Island and Washington) use a client-based system.

A brief summary of each agency's system is provided in the table below. Following the table are additional details about some of the survey participants' systems.

Materials Management System/Laboratory Information Management System Description			
System Type	**State**	**System**	**Client- or Web-Based**
COTS product customized for agency use	Illinois	iPDWeb (ExeVision, Inc.)	Web-based
	Minnesota	LabVantage (LIMS) and Transportation Automated Control Electronic Project Management (TRACS)	Client-based

Materials Management System/Laboratory Information Management System Description			
System Type	**State**	**System**	**Client- or Web-Based**
COTS product customized for agency use	Pennsylvania	Electronic Construction and Materials Management System (eCAMMS)	Web-based
	Rhode Island	Microsoft Access and SQL Server	Client-based
Custom software developed specifically for agency	Florida	Materials Acceptance and Certification (MAC)	Web-based
	Maine	Testing Information Management System	Client-based
	Virginia	Materials Information Tracking System (MITS) and Producer Lab Analysis and Information Details (PLAID)	Web-based
	Washington	Materials Testing System (MATS)	Client-based

	Wisconsin	• Materials tracking software programs:
		
		   o Materials Reporting Software (MRS).
		
		   o Materials Information Tracking (MIT).
		
		   o Materials Tracking System (MTS).
		
		• Web site: Highway Quality Management System (HQMS) (stores MRS, MIT and MTS data).
			Web-based

Illinois DOT's iPDWeb system is currently being implemented to replace the agency's mainframe materials database. Implementation is expected to be complete by 2020. Several other agencies plan to transition to AASHTOWare Project in the future, including Minnesota DOT, which is configuring AASHTOWare Project as a construction and materials software tool, and Wisconsin DOT (see **Future Plans**, page 33).

Virginia DOT's Asphalt and Aggregate sections use MITS/PLAID, a centralized online database where hot-mix asphalt and central mix aggregate job mixes and sample results are submitted and approved. Both Virginia DOT and the producer can view these results (the agency through MITS, the producer through PLAID). MITS allows Virginia DOT staff to approve job mixes, enter quality assurance (QA) testing data and project information, see contractors' submitted data, close out lots and projects, and run lot adjustments and comparison reports. PLAID allows producers to submit job mixes, sample data, test results and tonnages; view Virginia DOT testing results; run control charts and a report of all their submitted data; and submit daily summary sheets to the district materials office.

In Wisconsin, MRS, MIT and MTS are all client-based; Highway Quality Management System (HQMS) is web-based. All information is sent to the HQMS web site, where selected project staff can edit some of the data. The agency does not have a software program for laboratory management.

Reasons for Developing a Custom System

When asked why their agency chose to develop a custom system rather than use a COTS product, most respondents (Florida, Maine, Minnesota, Washington and Wisconsin) cited the lack of a suitable COTS product at the time their agency's system was developed. The Florida DOT respondent reported that the agency evaluated several COTS products but all required more customization programming than developing an enterprise application specifically designed for the agency's business processes. While Minnesota DOT's system (LabVantage) was an off-the-shelf LIMS product, it required customization to meet both user demands and testing and reporting needs, such as incorporating specifications.

Additional reasons that respondents' agencies chose to develop a custom system follow:

- *Use of approved vendors (Illinois)*: The agency used its request for proposal (RFP) process to select a vendor (ExeVision).

- *Cost (Rhode Island)*: The DOT evaluated several COTS products that were not cost-productive and did not meet the lab's testing needs.

- *Efficiency (Virginia)*: The agency needed an efficient, comprehensive system that included elements meeting all of the DOT's specifications and saved time by gathering information in one central location. With MITS/PLAID, the agency can take immediate action when discrepancies are found between the agency's and producer's test results.

Use With Another System or Tool

Most states use their MMS/LIMS in conjunction with another system or tool. Only three states (Rhode Island, Virginia and Washington) use the MMS/LIMS exclusively for materials management. The table below summarizes survey responses.

Use With Another System or Tool		
State	**System**	**Description**
Florida	MAC	Interfaces with: • Contracts systems for contract, project and pay item information. • Approved Products List. • Construction Training and Qualification Program database for qualified personnel.
Maine	Testing Information Management System	Interfaces with Trns•port and uses an unspecified mobile application for field data collection.
Minnesota	LabVantage and TRACS	Extracts information from the Oracle database using Access or Excel. Information then provided through the agency web site.
Pennsylvania	eCAMMS	Interfaces with Engineering and Construction Management System (ECMS).
Wisconsin	MRS, MIT, MTS/HQMS	Used to maintain an external laboratory approval web site and an approved laboratory list.

Florida DOT's IT policy is to retrieve data from the system of record, not to duplicate the data within another database. The exception is its Construction Training and Qualification Program (CTQP) database; the agency receives a nightly copy of CTQP data to speed up the process of checking samplers' and testers' qualifications.

Wisconsin DOT's software programs are populated with project data taken from a project tracking database. Certified testers are taken from a different database. Approved product and source lists are not maintained within the programs.

<u>System Features</u>

Respondents were asked to indicate which of 16 features were supported by their MMS/LIMS. Two features—manages specifications and test methods, and produces reporting—were supported by all of the systems. Pennsylvania DOT's eCAMMS and Illinois DOT's iPDWeb were the more robust of the nine systems, with Pennsylvania's system supporting 14 features and Illinois' system supporting 12 features. Systems supporting the least number of features were Rhode Island DOT's Microsoft Access and SQL Server (4) and Maine DOT's Testing Information Management System (3). The table below summarizes survey responses.

Features and Functions Supported by Respondents' Systems																	
State	**System**	Allows for Exception Tracking	Allows for Review and Management of Producers	Allows for Review and Management of Suppliers	Allows for Review of Mix Designs	Certifies Technicians	Generates Invoices	Generates Notifications to External Users	Generates Notifications to Internal Users	Manages New Product Evaluation	Manages Review and Authorization of Samples	Manages Specifications and Test Methods	Manages Testing Workflows	Monitors Instrument Calibration and Maintenance	Processes Payments	Produces Reporting	Provides Access to External Users
Florida	MAC	X	X		X			X	X		X	X	X			X	X
Illinois	iPDWeb	X	X	X	X	X		X	X		X	X	X			X	X
Maine	Testing Information Management System											X	X			X	
Minnesota	LabVantage and TRACS				X						X	X			X	X	
Pennsylvania	eCAMMS	X	X	X	X		X	X	X	X	X	X	X	X		X	X
Rhode Island	Microsoft Access and SQL Server							X				X	X			X	
Virginia	MITS/PLAID	X	X		X			X	X		X	X				X	X
Washington	MATS	X			X			X	X		X	X				X	

Features and Functions Supported by Respondents' Systems

State	System	Allows for Exception Tracking	Allows for Review and Management of Producers	Allows for Review and Management of Suppliers	Allows for Review of Mix Designs	Certifies Technicians	Generates Invoices	Generates Notifications to External Users	Generates Notifications to Internal Users	Manages New Product Evaluation	Manages Review and Authorization of Samples	Manages Specifications and Test Methods	Manages Testing Workflows	Monitors Instrument Calibration and Maintenance	Processes Payments	Produces Reporting	Provides Access to External Users
Wisconsin	MRS, MIT, MTS/HQMS				X						X	X				X	X

Additional System Features and Functions

Several survey respondents provided information about additional features and functions supported by their agency's MMS/LIMS, such as associating labs, users, production facilities and mix designs with companies (Florida); providing automated quality level analysis and pay adjustments (Maine); and allowing for e-signatures on reporting (Rhode Island).

The table below summarizes information about additional system features and functions provided by survey respondents.

Additional System Features and Functions

State	System	Feature/Function
Florida	MAC	• Tracks qualified laboratories. • Associates labs, users, production facilities and mix designs with companies. • Tracks manufacturers in the Approved Products List (APL). • Tracks testing for some new APL products (but approval tracked in APL). • Assigns product-specific targets to products assigned to non-APL producers (e.g., aggregate products at mines).
Maine	Testing Information Management System	• Provides automated quality level analysis/pay adjustments. • Manages the Independent Assurance (IA) program. • Provides automated notification based on measured quality levels.
Minnesota	LabVantage and TRACS	Allows access to custom database queries from externally facing web site.

Additional System Features and Functions		
State	**System**	**Feature/Function**
Rhode Island	Microsoft Access and SQL Server	Allows for e-signatures on reporting.
Virginia	MITS/PLAID	• Performs statistical calculations using producers' acceptance test results and Virginia DOT's IA sample test results based on agency specifications. • Generates a Quality Management Report.
Wisconsin	MRS, MIT, MTS/ HQMS	• Stores aggregate source approval, mix designs, and materials sampling and testing data. • Calculates incentives and disincentives for selected bid items.

The Wisconsin DOT respondent noted that the agency's HQMS updates programs to reflect current specifications and required test methods. Certified testers are imported into the system from a separate database. Approved product and source lists are maintained outside of the software. The agency has a web site that explains laboratory requirements (all laboratories must be approved) and maintains a list of approved laboratories.

<u>System Implementation</u>

We asked respondents to comment on the length of time required to implement their MMS/LIMS along with costs related to the implementation effort. System implementation at some of the agencies is ongoing. For example, original development and rollout at Minnesota DOT was three years or more to meet user needs, and one to two years to force-fit the application. New procedures and specifications are still being implemented. The integration of Rhode Island DOT's SQL Server system into its established Microsoft Access system, which has taken much trial and error, is still in development. Wisconsin DOT's programs accommodate materials sampling and testing reporting. Every year, the agency enhances these programs to collect additional sampling and testing data that was previously collected in paper format and to accommodate new sampling and testing specifications and reporting requirements.

Several agencies were unable to provide cost information for system implementation in part because these systems were developed using internal resources (Illinois, Minnesota, Rhode Island and Virginia). The cost of implementing Illinois DOT's IPDWeb system was combined with the construction documentation and payment system. Minnesota DOT's LabVantage system was given to the agency after support was discontinued in the late 1990s. In Virginia, an IT professional working part time (1/2 full-time equivalent) developed the agency's system.

Annual maintenance costs were also frequently unknown. The Virginia DOT respondent noted that most of the system changes have been performed as requests through the IT intake system. The table below summarizes survey responses.

System Implementation

State	System	Year Implemented	Time to Implement	Implementation Cost	Annual Maintenance Costs
Florida	MAC	October 2015	3 years or more	$3,816,119[1]	$172,424[1]
Illinois	iPDWeb	Underway	2 years to less than 3 years	Unknown	Unknown
Maine	Testing Information Management System	2002	1 year to less than 2 years	Approx. $200,000	Approx. $100,000
Minnesota	LabVantage and TRACS	Mid-1990s	3 years or more (New procedures/ specifications: ongoing)	Unknown	Labor plus storage and processing costs related to Oracle database
Pennsylvania	eCAMMS	2013	3 years or more	Unknown (initial estimate: approx. $3 million)	Unknown
Rhode Island	Microsoft Access and SQL Server	*Microsoft Access:* Began in late 1990s. *SQL Server:* Approx. 2012.	Ongoing	None	N/A
Virginia	MITS/PLAID	*Asphalt section:* 2013. *Aggregate section:* 2014.	2 years to less than 3 years	None	Unknown
Washington	MATS	2005	3 years or more	Approx. $1.3 million	Approx. $120,000
Wisconsin	MRS, MIT, MTS/ HQMS	2011	Ongoing	Not provided	Not provided

1   Budgeted through a legislative budget request.

System Updates

Six of the state DOTs surveyed perform system updates in-house. Updates are typically the responsibility of the agency's IT department (Florida, Minnesota, Rhode Island and Washington). In Florida, the State Materials Office tracks, manages and prioritizes requests; Application Systems (within the Office of Information Technology) programs and publishes the

updates. Minnesota DOT has a centralized IT group (MNIT) that is responsible for system maintenance and new development, and hosts the system for the agency. Three agencies (Illinois, Pennsylvania and Wisconsin) rely on vendors to conduct system updates.

Frequency of system updates varies considerably. Florida DOT has been updating its system continually since implementation. Minnesota DOT doesn't have the ability to update its entire system, so instead augments and modifies it to fit agency needs.

The table below summarizes survey responses, including the frequency of system updates.

System Updates			
Responsibility for System Updates	**State**	**System**	**Frequency**
In-House	Florida	MAC	Ongoing
	Maine	Testing Information Management System	Minor updates weekly
	Minnesota	LabVantage and TRACS	As needed
	Rhode Island	Microsoft Access and SQL Server	As needed
	Virginia	MITS/PLAID	Every 3 to 4 months
	Washington	MATS	Ongoing
Vendor	Illinois	iPDWeb	To be determined
	Pennsylvania	eCAMMS	Several times per year
	Wisconsin	MRS, MIT, MTS/HQMS	Annually

Challenges With System Updates

Survey respondents reported a range of challenges related to developing and implementing system updates, including issues with functionality, quality control and system security. Survey comments are summarized below:

Business process mapping

- In Florida, mapping business processes took a long time.

Complexity

- The complexity of Florida DOT's MAC system continues to be the agency's biggest challenge. MAC performs every task related to materials acceptance, and it is all connected. With a database this complex, reporting is difficult. The agency has devoted more staff members to creating queries with MAC than it had with LIMS, and these staff members need a higher level of expertise to create and optimize queries to minimize the impact on system resources.

Data transfer

- Florida DOT's IT department created processes and applications to transfer data from its original LIMS system to MAC. Additional time was given to companies to confirm the transferred data before production went live for samples.

- The Florida DOT respondent also noted that the agency quickly realized it could not implement the system in modules because of the interconnectivity of the data. The agency built and tested each module, but upstream modules (like the production facility and lab tables) sat in the production environment until the sample life cycle was finished. As a result, MAC was implemented over more than a year, but it did not become the official system of record until the sample life cycle was complete and the upstream data for plants, labs, technicians, products, MAC specifications and test definitions were complete.

Inflexibility

- According to the Rhode Island DOT respondent, the rigidity of its Microsoft Access and SQL Server system (which doesn't suit the workflow of the lab) has hampered development and led to multiple setbacks.

Project scope

- Scope creep is another challenge, according to the Florida DOT respondent. Hard questions need to be asked and answered about system requirements to keep the project within scope.

Quality control

- The Wisconsin DOT respondent reported a lack of quality control in programming.

Security risks

- Minnesota DOT's LabVantage and TRACS system cannot be updated, which leaves it vulnerable to security risks. The agency has virtualized the system and placed it behind a firewall. Despite those steps, the system does not meet the agency's current IT security standards.

Standardization and scheduling

- Standardizing forms and procedures was challenging at Virginia DOT as was scheduling, although scheduling issues had been anticipated.

Training

- Florida DOT delayed system implementation to provide mass training for all of its end users (most users attended at least one training session). The State Materials Office trained 100 trainers who then trained the users. To ensure system resources could handle the number of users across the state accessing the system and performing the same functions simultaneously, the agency tracked the training teams and attendance in each session. Computer-based training courses were created for users who were unable to participate in the initial training. The DOT also maintains a dedicated training environment so hands-on training can be provided as needed.

The table below provides information about the number of users with access to an agency's system and the annual value of completed construction projects.

Project Delivery and Program Size					
Annual Value of Completed Construction Projects	**State**	**System**	**Approximate Value of Completed Projects**	**Number of System Users**	
				Internal	**External**
Less than $1 billion	Florida	MAC	$922,368,206[1]	1,000	4,000
	Maine	Testing Information Management System	$350 million	Approx. 250	Not provided
	Rhode Island	Microsoft Access and SQL Server	$300 million	6	20
$1.1 billion to $2 billion	Illinois	iPDWeb	$2.2 billion (FY2018)	225	To be determined
	Minnesota	LabVantage and TRACS	$1.2 billion	50	0
	Washington	MATS	$1.5 billion	250	Not provided
$2.1 billion to $3 billion	Pennsylvania	eCAMMS	$2.5 billion	900	2,200
	Virginia	MITS/PLAID	$3 billion	308	878[2]
Other	Wisconsin	MRS, MIT, MTS/HQMS	Not provided	Approx. 1,000[3]	Several hundred[4]

1   Four-year average. Average number of contracts annually: 155.

2   Total includes 492 central mix aggregate and 386 hot-mix asphalt producer-users.

3   Wisconsin DOT employees and consultants.

4   All contractors.

Application for Smart Devices

Only one agency participating in this survey—Pennsylvania DOT—uses applications (apps) for smart devices to gather materials-related information during testing and inspection. (*Note:* Earlier in the survey, Maine DOT mentioned that the agency uses a mobile application for field data collection that interfaces with Trns•port, but the respondent did not provide further details about the app.) Virginia DOT uses AirWatch, an app that allows access to email and the agency's timesheet system.

Custom apps designed and built for Pennsylvania DOT can be used with a tablet and can be used offline. When asked to rate the agency's level of satisfaction with the app (using a rating

scale of 1 = not at all satisfied to 5 = extremely satisfied), the respondent gave the app a 4 rating for ease of use, reliability and overall agency satisfaction, and a 3 rating (satisfied) for flexibility.

While Florida DOT has not developed an app for its system, the agency originally requested a fat client as part of the project scope. (A fat client is a networked computer with many locally installed programs or resources that allow the computer to perform many functions without connecting to a network server.) But the challenges associated with keeping 4,000 external users up to date were too great. Instead, the agency emphasizes internet connectivity because most of the state has good coverage, and the few isolated locations where coverage is minimal can be overcome by connectivity solutions that are less costly. Florida DOT's IT department supports the web browser Internet Explorer 11, but the MAC system was not specifically designed for that platform. It works with most browsers and Android or Apple products. Some Apple product users have reported not being able to access the application, but in those cases, the issue is usually specific to the device's settings and is often addressed by the user's IT department.

<u>System Assessment</u>

System Strengths

Respondents were asked to describe the strengths of their agency's MMS/LIMS. Efficiency was most commonly cited by survey respondents, including the respondent from Illinois DOT who noted that while the agency is currently implementing its MMS (expected completion by 2020), the DOT is optimistic that the new system will streamline many processes. Other strengths reported include user-friendly systems that are flexible and transparent, and that provide customized reporting and tracking. The table below summarizes survey responses.

System Strengths			
Strength	**State**	**System**	**Description**
Cost savings	Minnesota	LabVantage and TRACS	Offers low-cost operation.
Customized tracking and reporting	Maine	Testing Information Management System	Produces numerous decision/workflow management reports.
	Washington	MATS	Tracks materials samples from the field through testing and reporting.
	Wisconsin	MRS, MIT, MTS/HQMS	• Meets agency's materials reporting requirements. • Calculates incentives/disincentives.
Ease of use	Florida	MAC	• Allows business users to manage the day-to-day functions of business processes, leaving IT staff to focus on system resources and coding (such as updates for fixes and enhancements).

System Strengths			
Strength	**State**	**System**	**Description**
Ease of use	Florida	MAC	• Allows business users to update test definitions and checklists used for inspections and evaluations. Only a few specification-related items are hard-coded into a program and require a programmer • Allows State Materials Office users with materials technical expertise to create and update MAC specification entries without a programmer's assistance.
	Rhode Island	Microsoft Access and SQL Server	*Microsoft Access:* Is user-friendly.
	Virginia	MITS/PLAID	Provides agency and external users with current information through online access.
Efficiency	Illinois	iPDWeb	Expects new system to streamline many processes.
	Maine	Testing Information Management System	• Works with agency's complex QA program. • Completes system changes and data queries within hours.
	Virginia	MITS/PLAID	• Analyze materials quality. • Evaluates specific changes in production data. • Evaluates the health of the asphalt program. • Monitors specification compliance. • Monitors acceptance testing results for producers and the agency. • Notifies users when a lab test failure or problem with a production process occurs. • Makes processes consistent, eliminates paperwork and stores information in one location.
Flexibility	Florida	MAC	Uses the MAC specifications[1] concept to drive sample life cycle.
	Rhode Island	Microsoft Access and SQL Server	*Microsoft Access:* Is easily modified to meet agency's changing needs.
Security	Rhode Island	Microsoft Access and SQL Server	*SQL Server:* Provides more data security and an e-signature workflow.
Training	Minnesota	LabVantage and TRACS	Provides training for all staff.
Transparency	Virginia	MITS/PLAID	Offers transparency in testing and converts data into usable information.

1 MAC specifications are electronic replicates of Florida DOT's specifications for material method of acceptance and can change every six months.

Challenges

Respondents were also asked to describe any challenges with their agency's MMS/LIMS. Most of the respondents cited examples of limited functionality along with system complexity and compatibility issues. The table below summarizes survey responses.

Note: Because Minnesota DOT is currently configuring AASHTOWare Project as a construction and materials software tool, the respondent directed his comments to that software. The respondent noted that configuration of the software to fit business practices for both laboratory operations and construction will take a couple of years. The respondent also noted other issues that have or will impact implementation:

- Initially, agency processes weren't documented well enough to move directly into development.

- Integration with construction is difficult since all acceptance practices need to be characterized, including visual review, certificate of compliance and mill certificates.

- The agency uses a certified plant process independent of the construction project, and this program approach becomes more difficult with AASHTOWare since it is more project-based for materials sampling and testing.

- Some gaps in communication occurred between the agency and the vendor (InfoTech).

System Challenges			
Type of Challenge	**State**	**System**	**Description**
Compatibility	Washington	MATS	System is "stove-piped" and differs from the project administration system.
Complexity	Florida	MAC	• Complex database that tracks and connects to all data. • Reporting issues: Staff has to relearn the table structure of a new database to connect related data in a query.
Limited functionality	Maine	Testing Information Management System	• Not web-based. • Lab quality aspects, such as equipment calibration, not supported. • Reports must be emailed. • Unable to lock records; insufficient audit trail. • Supported by one employee with no backup.

System Challenges			
Type of Challenge	**State**	**System**	**Description**
Limited functionality	Rhode Island	Microsoft Access and SQL Server	• *Microsoft Access:* Overall functionality is limited. • *SQL Server:* Rigid; doesn't always meet lab technicians' needs.
	Wisconsin	MRS, MIT, MTS/HQMS	• Not web-based, with various assigned permission levels. • Software enhancements often required on more than one program, resulting in higher costs. • Many related lists maintained externally.
Maintenance	Virginia	MITS/PLAID	Program requires constant maintenance.
Training	Minnesota	LabVantage and TRACS	Migrating to a new system will require a great deal of training.
	Virginia	MITS/PLAID	Training new users.

Future Plans

Six of the nine states reporting use of an internally developed system either have plans to transition to another MMS/LIMS or are considering adopting a new system:

- Three DOTs (Minnesota, Virginia and Wisconsin) will migrate to AASHTOWare Project or Project Construction & Materials and one state (Washington) is considering AASHTOWare along with other software packages:

    o Minnesota DOT is currently configuring AASHTOWare Project as a construction and materials software tool.

    o Virginia DOT will transition to AASHTOWare Project Construction & Materials module, and will develop an interface for the module to MITS/PLAID.

    o Washington State DOT is considering AASHTOWare and other software packages for its contract and testing needs.

    o Wisconsin DOT will also migrate to AASHTOWare Project Construction & Materials, along with several other AASHTOWare project tracking programs.

- Illinois DOT is currently transitioning from the agency's mainframe materials database to iPDWeb. Gap analysis is underway, and customization, testing and delivery are expected to be complete by January 2020.

- Maine DOT recently received five vendor proposals through an RFP bidding process. Although the agency was unable to secure a contract with the vendor that it initially selected (the vendor was unable to commit to all that was promised in the proposal), two vendors from the original group of five provided additional product demonstrations, and Maine DOT selected one of these vendors.

<u>Recommendations for Implementing a New System</u>

Several respondents provided recommendations for agencies that are preparing to implement a new MMS/LIMS. As with SiteManager users, these respondents encouraged planning and research to understand an agency's business processes and information needs. Below are highlights of survey responses by topic.

Planning

- Define business processes and system needs, and let IT design the solutions. Whether purchasing an off-the-shelf product or custom programming, map and optimize business processes so the system can follow the processes (instead of needing to update the processes to match the system). With off-the-shelf products, mapped business requirements will identify gaps that may need custom programming; with custom programming, mapped business requirements can help set the project scope. (Florida, Virginia)

- Understand current workflows and identify desired improvements. Think about what information various users (project engineers, lab supervisors, quality managers) need to do their job. Focus less on features and functions and more on information needs (who needs what information when, who should capture what information, who should be notified). (Maine)

- Consider the current workflow and needs of the laboratory, but remember that contracts can have special provisions that require on-the-fly changes to testing or reporting. (Rhode Island)

- Provide very detailed requirements in an RFP. (Illinois)

- Thoroughly research and consider compatibility and costs of COTS products with other systems. Modifications can get expensive quickly. (Pennsylvania)

- Consider using COTS software systems that can incorporate more business needs and can be utilized by contractors and other outside agencies. (Washington)

- Budget sufficient resources to be able to finish the system. (Virginia)

- Ensure updates can be accommodated easily.(Virginia)

Implementation

- Account for data validation in the implementation when transferring or creating data from scratch, especially for upstream data that will be used in the sample life cycle. (Florida)

Training

- Plan time after development and before implementation to provide training and develop training documents. Develop a draft set of step-by-step instructions for the initial training; follow up with formal documents when the implementation is complete. (Florida, Minnesota)

- Develop web-based, app-oriented, smart-device-oriented employees. (Minnesota)

- Provide redundancy so staff members who replace employees can understand and maintain the system. (Virginia)

Related Resources

Information about in-house systems and other tools used by respondents is provided below.

Florida

MAC Training, Materials Acceptance and Certification Development, State Materials Office, Florida Department of Transportation, undated.
http://www.fdot.gov/materials/mac/training/index.shtm
Training documentation for MAC users is available at this web site, including materials life-cycle information, sample finalization guide checklists, mix designs and contractor quality control plan guidelines.

Note: Florida DOT's Office of Information Technology (OIT) maintains the agency's system documentation. For information, contact Ellik Hawkins, OIT MAC maintenance team manager, elik.hawkins@dot.state.fl.us.

Related Resource:

> **Materials Acceptance and Certification Development**, Florida Department of Transportation, 2018.
> http://www.fdot.gov/materials/mac/
> *From the web site*: The Laboratory Information Management [System] (LIMS) was the previous business application that supported the quality of materials and workmanship for all construction projects through materials sampling, testing and acceptance. While LIMS was mission critical to the Department for over a decade, it was no longer viable from a technology perspective and will have no vendor support after 2015. The Materials Acceptance and Certification (MAC) system is the enterprise application that replaced the current LIMS application.

Illinois

Project Development Solutions, ExeVision, Inc., 2017.
https://www.ipdsoftware.com/about
This vendor web site provides information about the iPDWeb (integrated Project Development) product. Several fact sheets offer details about the vendor's web applications, including preconstruction, estimates, construction and materials.

Pennsylvania

Electronic Construction and Materials Management System (eCAMMS), Pennsylvania Department of Transportation, October 2015.
https://www.nascio.org/portals/0/awards/nominations2016/2016/2016PA2-PA%20Gov%20to%20Business%20-%20PennDOT%20eCAMMS%202016%20-%20FINAL.pdf
From the introduction: Previously, PennDOT had an aging, legacy materials lab system that offered only basic functionality and technical capabilities, was not scalable, and had limited remote access. PennDOT envisioned a replacement application to provide secure online access for business partners, public transparency for suppliers and approved materials, expanded automation and greater efficiency.

To achieve these goals, PennDOT developed eCAMMS, the Electronic Construction and Materials Management System. eCAMMS is a web-based, business partner-accessible and

publicly searchable system that allows users to track PennDOT's decision on the test results, calculate test results, and report on over 17,000 samples every year. Previously, suppliers submitted test data on paper, which was then entered into the legacy system by PennDOT employees [who] waited to receive their test results by mail. Suppliers can now enter the data online and can quickly access their test results electronically. In addition, eCAMMS includes customizable automated workflows to support the materials review and approval process. PennDOT personnel can also view concrete and bituminous material test information online instead of traveling to the producer locations to review test results. Construction project contractors and the public use the search features available in eCAMMS over 5,000 times each week to find information about products and suppliers approved by PennDOT.

eCAMMS is a highly configurable .NET system that enables PennDOT users to add, modify or delete tests quickly and easily in a matter of minutes. Previously, IT personnel would have to spend days or weeks to make changes to the mainframe system because all test parameters were written in COBOL. This means faster processing, quicker testing and continuous communication with suppliers.

Virginia

Managing and Protecting Mobile Email With AirWatch, White Paper, AirWatch LLC, May 2012.
https://www.air-watch.com/downloads/resources/mem-whitepaper.pdf
From the white paper: AirWatch MDM provides email security for mobile devices managed by AirWatch, and this solution is a good way to protect your corporate email infrastructure. AirWatch MDM offers all the basic security features provided by the email provider, as well as additional management options through over the air email profile provisioning.

Related Research and Resources

Below are publications and other resources related to MMS/LIMS from a limited literature search for this Preliminary Investigation. These resources are organized into three categories:

- National guidance.
- State practices.
- Vendor products.

National Guidance

Research in Progress: Guidebook for Data and Information Systems for Transportation Asset Management, National Cooperative Highway Research Program, start date: June 2018; expected completion date: unknown.
Project description at https://rip.trb.org/Results?txtKeywords=08-115#/View/1467319
From the project description: The objective of this research is to develop a guidebook presenting principles, organizational strategies, governance mechanisms and practical examples for improving management of the processes for collecting data, developing useful information and providing that information for decision making about management of the transportation system assets.

NCHRP Report 838: Guidelines for Optimizing the Risk and Cost of Materials QA Programs, Hill International Inc., University of Colorado, Diversified Engineering Services Inc., D'Angelo Consulting LLC, Heritage Research Group and Jo Sias Daniel, 2017.
Report available at http://www.trb.org/Main/Blurbs/175209.aspx
From the abstract:

> The objective of this research was to develop a methodology for establishing a materials QA [quality assurance] program that optimizes risk and cost by providing appropriate types, levels, and frequencies of agency testing and inspection for transportation projects across their full range of type, size, complexity and project-delivery method.

From page 48 of the report (page 56 of the PDF):

> With regard to materials management systems, several agencies have, or are moving towards, custom-built or modified off-the-shelf tools. As the goal of the model is not to replace the steps and procedures that DOTs normally would follow in developing a materials QA plan for a given project, but to enhance or optimize these processes, the optimization model must have the flexibility needed to ensure compatibility with the variety of different materials management systems in use.

Page 76 of the report (page 84 of the PDF) provides survey responses to the following question:

> Please select any materials management and tracking systems used in your agency for statewide materials management and for defining project materials QA requirements. (Please check all that apply.)

Details of agency practices appear in Appendix E: State Interview Summary (page 105 of the report; page 113 of the PDF).

State Practices

The FHWA publications below describe various states' e-Construction practices and the systems used to support them. Results of a 2011 Research Advisory Committee (RAC) survey describe agency use of a LIMS, and two publications describe Maryland DOT's MMS.

Multiple States

e-Construction Peer-to-Peer Exchange: Summary Report, Missouri Department of Transportation and Colorado Department of Transportation, April 2016.
https://www.fhwa.dot.gov/construction/econstruction/peer_exchange/mo_co.pdf
From the introduction: The focus of the peer exchange is e-Construction, which is defined as paperless construction administration delivery processes that include electronic submission of all construction documentation by all stakeholders, electronic document routing/approvals (e-signatures and digital signatures), and digital management of all construction documentation in a secure environment that allows distribution to all authorized project stakeholders through mobile devices.

e-Construction Lead State Profiles, Federal Highway Administration, undated.
https://www.fhwa.dot.gov/construction/econstruction/leadprofiles.pdf
From the introduction:

> This document is intended to provide a brief high-level snapshot of e-Construction practices for 13 lead states. This document is designed to assist exploring states and others interested in implementing e-Construction tools.

Each lead state profile lists the software used by the 13 agencies, including LIMS.

Laboratory Information Management System (LIMS), AASHTO RAC Member Survey Results, January 2011.
https://research.transportation.org/rac-survey-detail/?survey_id=15#
From the survey detail/results:

> This survey was conducted in January 2011. Pennsylvania Department of Transportation (PennDOT) was investigating the possibility of rewriting or procuring a new Laboratory Information Management System (LIMS) for their Materials Testing Laboratory. The purpose of this survey was to discover what other state DOTs have done in this area.

Survey results are available from the web site and include these highlights:

AASHTOWare SiteManager

- Arkansas DOT was implementing SiteManager to replace an in-house system.

- Mississippi DOT used a heavily modified version of SiteManager.

- Missouri DOT used SiteManager. The agency tested SiteManager LIMS and decided not to use the system.

- New Jersey DOT was preparing to implement SiteManager Materials with LIMS.

- New York State DOT used SiteManager LIMS and an in-house-developed LIMS. The agency planned to transition to sole use of SiteManager LIMS.

- Texas DOT used an internally developed add-on to SiteManager's Construction Management tool with an internally developed LIMS for the agency's testing laboratory.

Custom systems

- Iowa DOT was beta-testing a web-based LIMS developed in-house. The respondent offered to share the in-house system after implementing it in a production environment.

- Maine DOT developed its Testing Information Management System to use a Microsoft-based Access frontend and Oracle backend tables.

- Minnesota DOT used a customized version of a commercial product purchased in the 1990s.

Maryland

Utilizing Automatic Identification Tracking Systems to Compile Operational Field and Structure Data, A.M. Amde, T. Saad, F. Majekodunmi and J. Villatoro, Maryland State Highway Administration, May 2014.
http://www.roads.maryland.gov/OPR_Research/MD-14_SP209B4G_Utilizing-Auto-ID-Tracking-Systems-to-Compile-OFS-Data_Final-Report.pdf
From the abstract: The Maryland State Highway Administration's (SHA) Office of Materials Technology (OMT) ensures that the quality of materials used on Maryland's roadway system are properly designed, produced, and built to the approved codes and standards. The Materials Quality divisions of OMT are structured into the Asphalt Technology, Concrete Technology, Soils and Aggregate Technology, and Structural Materials and Pavement Markings divisions. Each division is responsible for the quality assurance/control testing, evaluation, and clearance of the materials used in transportation facility construction. From the time the materials are sampled in the field, the management of these materials relies on a series of intensive human processes involving sample collection and delivery, written reports and log books to record materials' laboratory test results and track logistical information. As the materials travel throughout the six different laboratories, material information is manually recorded into a localized network database and the Material Management System (MMS) separately. The current amount of human involvement necessary in the generation of sample reports and manual data entry process can be streamlined with the integration of Automatic Identification Technology (AIT). This study investigates past implementations of AIT into civil engineering and construction applications to detail necessary modifications to OMT's existing material clearance and MMS processes; as well as AIT system hardware recommendations, software development and integration considerations, estimated investment costs, and estimated return on investment.

Related Resource:

Materials Management System (MMS) User's Guide, Version 1.1, State Highway Administration, State of Maryland, June 2018.
https://www.roads.maryland.gov/OMT/MMSGuide.pdf

This user's guide provides screenshots and step-by-step instructions for use of the agency's MMS.

Vendor Products

AASHTOWare Project Construction & Materials, AASHTO, undated.
https://www.aashtoware.org/products/project/project-modules/
From the web site: AASHTOWare Project Construction & Materials covers the construction and materials management process, including laboratory information management functionality. It is a powerful application spanning all levels of construction and materials enabling personnel to progress a contract and its supporting documentation from award through finalization. AASHTOWare Project Construction & Materials allows an organization to manage all aspects of a construction project through daily work reports, diaries, stormwater compliance inspections, contract change orders, force accounts, contractor evaluations, design evaluations, plan discrepancies, meeting records, document submission and review, stockpiles and contractor payments. AASHTOWare Project Construction & Materials provides the ability to track materials, approve materials for source and facilities, qualifications (for testers, samplers, calibrators, welders and laboratories), track test equipment and calibrate equipment, withhold payment for insufficient materials, approve mix designs for their design and use on a construction contract. AASHTOWare Project Construction & Materials features a laboratory information management component [that] allows an organization the ability to manage and track progress through each critical step of the material sample life cycle.

Contacts

CTC contacted the individuals below to gather information for this investigation.

States Using AASHTOWare Project SiteManager Systems

Alabama

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Appendix A: Survey Questions

To gather information about state department of transportation (DOT) use of a materials management system (MMS) or laboratory information management system (LIMS), two surveys were distributed based on the type of system used by each state DOT:

- States using AASHTOWare Project SiteManager systems.

- States using other materials management systems.

Survey questions for each of the surveys follow.

States Using AASHTOWare Project SiteManager Systems

System Description

1. Is your agency using the web- or client-based version of AASHTOWare Project SiteManager?

2. *For web-based users:* Have you identified any concerns associated with the web-based version of SiteManager?

3. Are you using the LIMS in the SiteManager product?

4. Why did your agency elect to use SiteManager rather than developing a custom system?

5. Does your agency use SiteManager in conjunction with another system or tool?

6. If available, please provide links to documentation related to your agency's use of SiteManager. Send any files not available online to chris.kline@ctcandassociates.com.

System Implementation, Costs and Update

1. When did your agency implement SiteManager as its MMS/LIMS?

2. How long did it take to implement the system?

    - Less than 6 months.

    - 6 months to less than 1 year.

    - 1 year to less than 2 years.

    - 2 years to less than 3 years.

    - 3 years or more.

    - Other (please describe).

3. What was the total cost to implement the system?

4. What are the ongoing annual maintenance costs for the system?

5. Has your agency customized SiteManager to address specific agency needs? If yes, please describe the customization and who was responsible for it.

6. How frequently are updates made to the system?

7. How long does it take for a requested update to be implemented?

Project Delivery Program Size

1. Please indicate the number of users with access to your agency's MMS/LIMS.

    - Internal users.

    - External users.

2. What is the approximate dollar value of construction projects your agency completes in a year?

Application for Smart Devices

Does your agency use an application (app) for smart devices to gather materials-related information during testing and inspection? If yes, please respond to the following questions:

1. Please name and describe the app(s) your agency uses.

2. What type of device is used with the app(s)? Select all that apply.

    - Smartphone.

    - Smartwatch.

    - Tablet.

    - Other (please describe).

3. Can the app(s) be used offline?

4. Please indicate your agency's level of satisfaction with each system characteristic listed below using the rating scale of 1 = not at all satisfied to 5 = extremely satisfied.

    - Ease of use.

    - Flexibility.

    - Reliability.

    - Overall agency satisfaction with the app.

System Assessment

1. Please describe the strengths of SiteManager when used as your agency's MMS/LIMS.

2. Please describe any challenges your agency has experienced using SiteManager.

3. Does your agency have any plans to transition to another MMS/LIMS? If yes, please describe these plans.

Wrap-Up

1. What recommendations do you have for an agency preparing to implement a new MMS/LIMS?

2. Please use this space to provide any comments or additional information about your previous responses.

States Using Other Materials Management Systems

System Description

1. What is the name of your agency's MMS or LIMS?

2. Please describe your agency's MMS/LIMS.

    - Customized software developed specifically for our agency.

    - Commercial off-the-shelf (COTS) product.

    - COTS product customized for agency use.

    - Other (please describe).

3. *For custom system users:* Why did your agency elect to develop a custom system rather than use an off-the-shelf version of a commercial product?

4. Is the system web- or client-based?

5. Does your agency use its MMS/LIMS in conjunction with another system or tool? If yes, please describe the other system or tool and the interface with your MMS/LIMS.

6. If available, please provide links to documentation related to your agency's MMS/LIMS. Send any files not available online to chris.kline@ctcandassociates.com.

System Features

1. What features and functions are supported by your agency's MMS/LIMS (even if your agency is not currently using them)? Select all that apply.

    - Allows for exception tracking.

    - Allows for review and management of producers.

    - Allows for review and management of suppliers.

    - Allows for review of mix designs.

    - Certifies technicians.

    - Generates invoices.

    - Generates notifications to external users.

    - Generates notifications to internal users.

    - Manages new product evaluation.

    - Manages review and authorization of samples.

    - Manages specifications and test methods.

    - Manages testing workflows.

    - Monitors instrument calibration and maintenance.

    - Processes payments.

    - Produces reporting.

    - Provides access to external users.

2. Please describe other features and functions supported by your agency's MMS/LIMS that do not appear in the list above.

System Implementation, Costs and Update

1. When did your agency implement its MMS/LIMS?

2. How long did it take to implement the system?

   - Less than 6 months.
   - 6 months to less than 1 year.
   - 1 year to less than 2 years.
   - 2 years to less than 3 years.
   - 3 years or more.
   - Other (please describe).

3. What was the total cost to implement the system?

4. What are the ongoing annual maintenance costs for the system?

5. How often does your agency update the system?

6. Who is responsible for system updates?

7. Has your agency experienced any challenges when developing and implementing system updates? If yes, please describe these challenges.

Project Delivery Program Size

1. Please indicate the number of users with access to your agency's MMS/LIMS.

   - Internal users.
   - External users.

2. What is the approximate dollar value of construction projects your agency completes in a year?

Application for Smart Devices

Does your agency use an application (app) for smart devices to gather materials-related information during testing and inspection? If yes, please respond to the following questions:

1. Please name and describe the app(s) your agency uses.

2. What type of device is used with the app(s)? Select all that apply.

   - Smartphone.
   - Smartwatch.
   - Tablet.
   - Other (please describe).

3. Can the app(s) be used offline?

4. Please indicate your agency's level of satisfaction with each system characteristic listed below using the rating scale of 1 = not at all satisfied to 5 = extremely satisfied.

   - Ease of use.
   - Flexibility.

- Reliability.
- Overall agency satisfaction with the app.

System Assessment

1. Please describe the strengths of your agency's MMS/LIMS.

2. Please describe any challenges your agency has experienced using the MMS/LIMS.

3. Does your agency have any plans to transition to another MMS/LIMS? If yes, please describe these plans.

Wrap-Up

1. What recommendations do you have for an agency preparing to implement a new MMS/LIMS?

2. Please use this space to provide any comments or additional information about your previous responses.