SCAN TEAM REPORT

NCHRP Project 20-68, Scan 22-02

Experiences in the Use of Digital Construction Management in the Highway Industry

Supported by the

National Cooperative Highway Research Program

Acknowledgments

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The purpose of each scan, and of Project 20-68, is to accelerate beneficial innovation by facilitating information sharing and technology exchange among the states and other transportation agencies and identifying actionable items of common interest. Experience has shown that personal contact with new ideas and their applications is a particularly valuable means for such sharing and exchange. A scan entails peer-to-peer discussions between practitioners who have implemented new practices and others who are able to disseminate knowledge of these new practices and their possible benefits to a broad audience of other users. Each scan addresses a single technical topic selected by AASHTO and the NCHRP 20-68 Project Panel. Further information on the NCHRP 20-68 U.S. Domestic Scan program is available at

https://www.trb.org/NCHRP/USDomesticScanProgram.aspx

This report was prepared by the scan team for *Domestic Scan 22-01 Recent Leading Innovations in the Design, Construction, and Materials Used for Concrete Bridge Decks*, whose members are listed below. Scan planning and logistics are managed by Arora and Associates, P.C.; Harry Capers is the Principal Investigator. NCHRP Project 20-68 is guided by a technical project panel and managed by Sid Mohan, NCHRP Program Manager.

The scan team members include the following individuals:

Bryan Cawley,
Team Co-chair, FHWA

John Hancock,
Team Co-chair, Georgia DOT

Shawn Smith,
Maine DOT

Tyler Carlson,
Nebraska DOT

Eric Chaston,
Utah DOT

Jace Mecham,
Utah DOT

Ramon Hopkins,
California DOT

John S Dunham,
Connecticut DOT

Damon Zeltinger,
South Dakota DOT

Wei H. Johnson,
South Carolina DOT

Charles Bauer,
Wyoming DOT

Christopher Newman,
Subject Matter Expert

Disclaimer

The information in this document was taken directly from the submission of the authors. The opinions and conclusions expressed or implied are those of the scan team and are not necessarily those of the Transportation Research Board or its sponsoring agencies. This report has not been reviewed by, and is not a report of, the Transportation Research Board or the National Academies of Sciences, Engineering, and Medicine.

Scan 22-02
Experiences in the Use of Digital Construction Management in the Highway Industry

REQUESTED BY THE

American Association of State Highway and Transportation Officials

PREPARED BY SCAN 22-02 TEAM

Bryan Cawley,
Team Co-chair, FHWA

John Hancock,
Team Co-chair, Georgia DOT

Shawn Smith,
Maine DOT

Tyler Carlson,
Nebraska DOT

Eric Chaston,
Utah DOT

Jace Mecham,
Utah DOT

Ramon Hopkins,
California DOT

John S Dunham,
Connecticut DOT

Damon Zeltinger,
South Dakota DOT

Wei H. Johnson,
South Carolina DOT

Charles Bauer,
Wyoming DOT

Christopher Newman,
Subject Matter Expert

SCAN MANAGEMENT

Arora and Associates, P.C.

Lawrenceville, NJ
September 2023

The information contained in this report was prepared as part of NCHRP Project 20 68 U.S. Domestic Scan, National Cooperative Highway Research Program.

Table of Contents

List of Appendices

List of Figures and Tables

Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
AGC	Association of General Contractors
AI	Artificial Intelligence
ARTBA	American Road and Transportation Builders Association
BIL	Bipartisan Infrastructure Law
BIM	Building Information Modeling
CMS	Construction Management System
DCM	Digital Construction Management
DIME	Data Interchange for Materials Engineering
DOL	Department of Labor
DOT	Department of Transportation
ECMS	Electronic Construction Management System
EEO	Equal Employment Opportunity
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
IIJA	Infrastructure Investment and Jobs Act
LiDAR	Light Detection and Ranging
MMS	Materials Management System
MTLS	Mobile Terrestrial Laser Scanning
MWRTK	MidWest Real Time Kinematic
NCHRP	National Cooperative Highway Research Program
OJT	On the Job Training
PCC	Portland cement concrete
QA	Quality Assurance
ROI	Return On Investment
SHA	State Highway Agency
STIC	State Transportation Innovation Council
TIDP	Technology and Innovation Deployment Program
TRB	Transportation Research Board
UAS	Unmanned Aerial Systems

Executive Summary

Introduction

Digital Construction Management (DCM) builds upon a variety of emerging and existing technologies and techniques, including 3D Modeling, e-Construction, Digital As-Builds, e-ticketing, Unmanned Aerials Systems (UAS), Smart Work Zone Project Coordination, and Strategic Workforce Development innovations. DCM helps State Highway Agencies (SHA) and industry integrate electronic construction management processes to enhance safety, efficiency, and effectiveness of highway construction. The integration of these tools has occurred at various levels and with different SHA and industry partners. Documenting and communicating adoption of innovations throughout the highway community will assist in the accelerated deployment of the innovation, techniques, consistency, and methods of integration for DCM.

The benefits of this domestic scan are the identification and accelerated deployment of proven DCM configurations, highlighting organizational characteristics that demonstrate institutional readiness with success in the adoption and implementation of innovative technologies and techniques. As these practices are deployed nationally, they will assist transportation agencies having an equitable workforce to deliver a safe, timely, and quality highway construction program.

Scan Purpose and Scope

The benefits of this domestic scan are the identification and accelerated deployment of proven DCM configurations, highlighting organizational characteristics that demonstrate institutional readiness with success in the adoption and implementation of innovative technologies and techniques. As these practices are deployed nationally, they will assist transportation agencies having an equitable workforce to deliver a safe, timely, and quality highway construction program.

From the beginning, the technical panel agreed that the focus of the Domestic Scan should be not on the technical elements of the DCM innovations themselves, but rather serve as an exploration of the process through which agencies identified DCM innovations for adoption, and the challenges and opportunities agencies faced in the process. Consequently, the technical panel used a two-phase approach to assess which DCM innovations had the broadest application among states, and to gauge the extent of innovation adoption and implementation by state agencies.

Through desk scan survey, workshop, and group discussion, the technical panel of the Domestic Scan intended to identify shared attributes among agencies that have achieved success in effectively implementing DCM innovations. The technical panel identified a group of states that were successful in the implementation of some of the most employed DCM innovations. This was followed by a 5-day workshop in June 2023 for the states to present their experiences and how the DCM implementation affected their department's operation, processes, and performance.

DCM Innovation	States
Software interconnectivity / standards	Maryland
Electronic systems for subcontracts, payroll verification, prompt payment, EEO and Davis Bacon interviews, et.al.	Maine and Wyoming
Project site documentation (photos, videos, scans, and retention policies)	Georgia, Pennsylvania, and Utah
Surveying (with digital devices and quality assurance)	Nebraska and South Carolina
Unmanned Aerials Systems (UAS) for inspection, mapping, et.al.	California and South Dakota

Table 1: Phase 2 survey tool innovation groupings and state DOT distribution

The Domestic Scan team anticipated that success on an organizational level could have a cascading effect, offering valuable insights for other SHAs and local transportation agencies seeking to implement and expand the use of DCM within their construction programs.

General Findings and Observations

During the workshop held June 5–8, and a final day on June 21, 2023, ten states presented on the DCM innovations as listed in **Table1**.

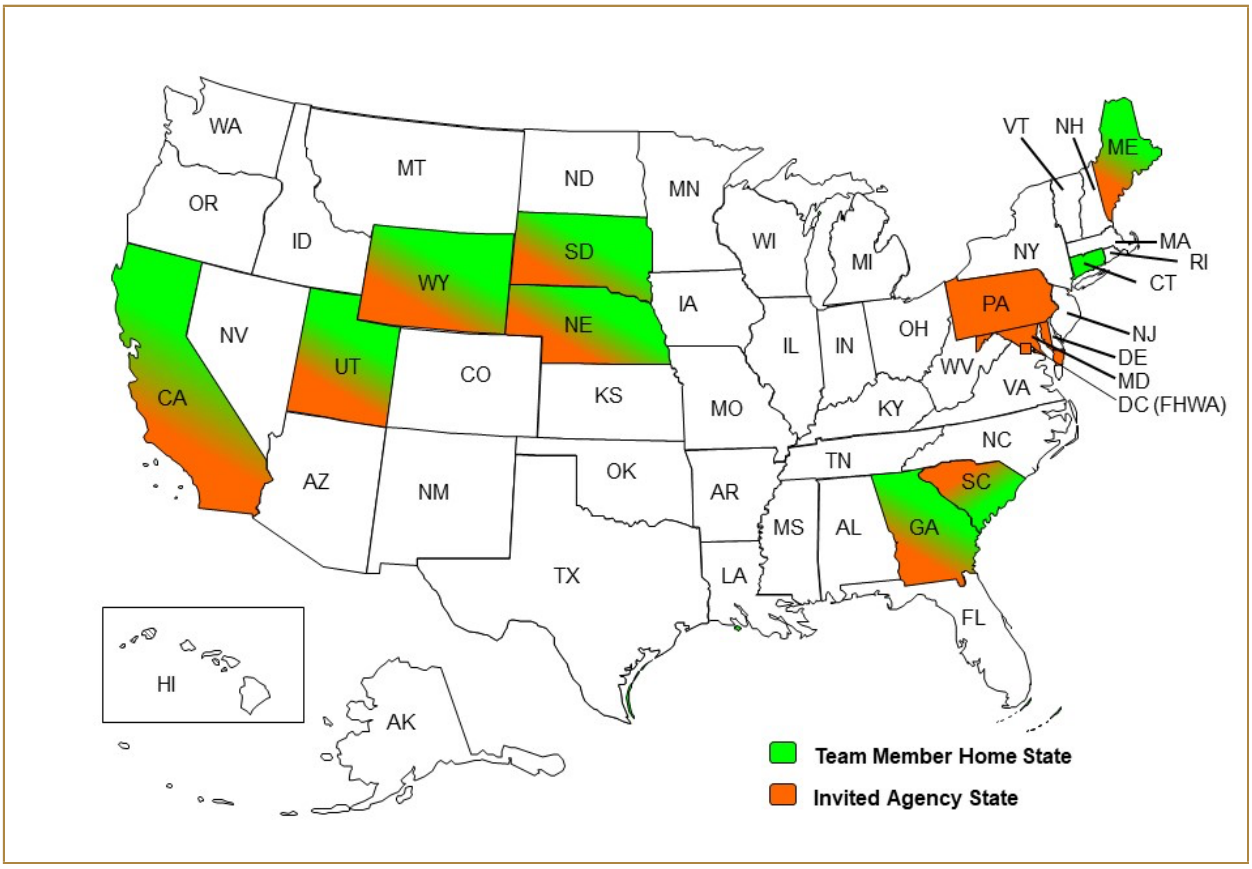

Figure 1. SHA participation in the Domestic Scan Workshop

Throughout the presentations, questions and answers, and subsequent discussions, the technical panel noted the emergence of common elements of agencies' success. The technical panel met at the conclusion of the workshop to refine the findings according to the following themes for success in implementing DCM innovations:

1. Fostering a Culture of Innovation
2. Securing Leadership Support
3. Partnering with Industry and Other Stakeholders
4. Managing Change – Training and Support
5. Integrating Information Systems
6. Addressing Data Storage Needs
7. Sharing Resources with Other Agencies (peer exchanges)
8. Finding the Motivation for Adoption
9. Mainstreaming Innovation
10. Overcoming Challenges
11. Identifying the Next Stages of Development (timeliness)

Each of the 11 findings is supported by observations from the workshop's state presentations, represented by experiences among multiple SHAs (see Section 2).

Team Recommendations

The technical panel met at the conclusion of the workshop to refine the findings according to lessons learned through the journey of the domestic scan. DCM is the use of electronic innovation to enhance efficiency and effectiveness of highway construction management. Some leading DCM innovations identified were software interconnectivity, electronic systems, project site documentation, surveying, and Unmanned Aerial Systems (UAS). The following elements capture the lessons learned to be successful on the journey of embracing DCM:

- Fostering a Culture of Innovation (It is an investment, not a cost)
  - Securing leadership's support.
  - Partnering with industry, solution providers, and other stakeholders.
  - Sharing innovations and resources with others (peer exchanges)
  - Motivating the innovation
    - Updating law, regulation, or policy

        - Funding and staffing
        - Strategic initiative
        - Identifying and supporting champions
    - Managing Change
        - Supporting and fostering training networks
        - ntegration of construction management systems
            - Address organizational needs along with user considerations in systems access management
            - Ensure that new systems work seamlessly and effectively link to or accurately replace legacy systems
            - Update policies to reflect need for short- and long-term data storage
            - Ensure accessibility for data collection, analysis, and usage
        - Overcoming challenges
        - Mainstreaming innovation
    - Building a culture of embracing innovating Construction Management
        - Identifying and advancing innovation for consideration
        - Identifying opportunities, inventing, and investing in solutions

Recommendations are summarized as follows:

- Invest in the existing proven DCM innovations and incorporate them into your business.
- Build the organizational structure that supports a culture of adopting DCM.
- Invest in the creative minds of your organization to invent and advance DCM innovation.

As next steps for implementation, the Domestic Scan Review team has developed technology briefs, presentations, and storyboards to share agencies' experiences about how DCM has improved safety, efficiency, and effectiveness of highway construction.

The Domestic Scan Review team will look for further opportunities to share the knowledge they have gained through others and build enthusiasm about DCM.

The Domestic Scan Review team will look for areas for improvement in highway construction management and solutions and assist in identifying champions to further advance DCM.

Details of the Implementation Plan can be found in Section 4 of this report.

Introduction

1.1 Background

Digital Construction Management (DCM) builds upon a variety of emerging and existing technologies and techniques, including 3D Modeling, e-Construction, Digital As-Builds, e-ticketing, Unmanned Aerials Systems (UAS), Smart Work Zone Project Coordination, and Strategic Workforce Development innovations. DCM helps State Highway Agencies (SHA) and industry integrate electronic construction management processes to enhance safety, efficiency, and effectiveness of highway construction. The integration of these tools has occurred at various levels and with different SHA and industry partners. Documenting and communicating adoption of innovations throughout the highway community will assist in the accelerated deployment of the innovation, techniques, consistency, and methods of integration for DCM.

1.2 Objectives, purpose, and scope of scan

The benefits of this domestic scan are the identification and accelerated deployment of proven DCM configurations, highlighting organizational characteristics that demonstrate institutional readiness with success in the adoption and implementation of innovative technologies and techniques. As these practices are deployed nationally, they assist transportation agencies having an equitable workforce to deliver a safe, timely, and quality highway construction program.

Through survey, workshop, and group discussion, the technical panel of the Domestic Scan identified attributes among agencies that have achieved success in effectively implementing DCM innovations. The Domestic Scan team anticipated that success on an organizational level could have a cascading effect, offering valuable insights for other SHAs and local transportation agencies seeking to implement and expand the use of DCM within their construction programs. Applying the lessons learned, avoiding pitfalls, employing alternative approaches, and improving preparation and planning for implementation efforts can help mitigate potential risks and costs associated with adopting new technologies.

1.3 Scan team members

Bryan Cawley –Team Co-chair
Division Administrator
Wyoming Division Office
FHWA

John Hancock –Team Co-chair
State Construction Engineer
Georgia Department of Transportation

Shawn Smith
Senior Project Manager
Maine Department of Transportation

Tyler Carlson
Construction Systems IT Supervisor
Nebraska Department of Transportation

Eric Chaston
Director of Construction
Utah Department of Transportation

Jace Mecham
State Construction Engineer
Utah Department of Transportation

Ramon Hopkins
Chief, Division of Construction
California Department of Transportation

John S Dunham
Construction Administrator
Connecticut Department of Transportation

Damon Zeltinger
Construction Specialist
Office of Operations Support
South Dakota Department of Transportation

Wei H. Johnson Ph.D., P.E.
Construction Metrics Engineer
Director of Construction Office
South Carolina Department of Transportation

Charles Bauer, PE
Construction Staff Engineer
Wyoming Department of Transportation

Christopher (Chris) Newman – Subject Matter Expert

1.4 Scan approach and planning

To refine the scope of the Domestic Scan, the technical panel held an initial meeting in September 2022, to discuss the Scan's objectives and initial screening. The technical panel agreed that the focus of the Domestic Scan should be not on the technical elements of the DCM innovations themselves, but rather serve as an exploration of the process through which agencies identified DCM innovations for adoption and the challenges and opportunities agencies faced in the process. Consequently, a two-phase approach was devised to assess which DCM innovations had the broadest application among states, and to gauge the extent of innovation adoption and implementation by state agencies.

Phase 1 – Survey of all SHAs

To identify the state of practice and level of implementation among state transportation agencies, the technical panel prepared a survey for state transportation agencies to self-identify their stage of implementation across a range of DCM innovations. This provided the panel with a metric of agencies implementation of DCM innovation. It also identified innovations of interest with national application.

The framework of the Phase 1 survey provided a listing of innovations, generated through discussion of the technical panel Assuming familiarity of recipients with the FHWA Every Day Counts program, the panel proposed to use its scale of innovation deployment stages as a measurement (**Figure 2**).

Innovation Implementation Stages

Not Implementing	The State is not using the innovation anywhere in the State and is not interested in pursuing the innovation.
Development Stage	The State is collecting guidance and best practices, building support with partners and stakeholders, and developing an implementation process.
Demonstration Stage	The State is testing and piloting the innovation.
Assessment Stage	The State is assessing the performance of and process for carrying out the innovation and making adjustments to prepare for full deployment.
Institutionalized	The State has adopted the innovation as a standard process or practice and uses it regularly on projects.

Figure 2. FHWA EDC Innovation Implementation Stages

On September 8, 2022, a technical panel chair submitted a request through AASHTO Committee on Construction to survey state members on the degree of implementation for the list of innovations. States were asked to rate their degree of implementation for each innovation on the EDC scale of 1–5. The Phase 1 survey tool is presented in **Figure 3**.

Digital Innovations	Implementation Stage				
	1	2	3	4	5
e-Construction					
e-Ticketing, material certificates, and resource management					
3D Modeling Plans as Contract Documents					
Electronic systems for subcontracts, payroll verification, prompt payment, EEO and Davis Bacon interviews, et.al.					
Connected or Autonomous Equipment and Vehicles					
Unmanned Aerials Systems (UAS) for inspection, mapping, et.al.					
Digital As-Builts					
Smart Work Zone Coordination					
Laser scanning for inspection and construction scheduling					
Robotics					
Project Simulation and Staging					
Tracking of contract progress and performance (including dashboards)					
Work Zone Data Exchange					
Surveying (with digital devices and quality assurance)					
Underground utility locating, mapping, and sharing with others					
Augmented Reality/Virtual Reality (AR/VR) for project visualization					
Automated Design process through rapid engineering modeling					
Project site documentation (photos, videos, scans, and retention policies)					
Connectivity between innovation, equipment, systems, and people.					
Single point data management and usage across program areas (i.e. users, contractor, owner, construction, finance, management, project development, emergency services, utilities)					
Software interconnectivity / standards (e.g., AASHTOWare)					
Cross disciplinary organization support and unification of information systems (people side)					
Institutional process to advance, consider, pilot, and adopt innovation					
Training program for innovation					
Document and data retention policies and processes					
Others (please add and list as appropriate)					

Figure 3: Phase 1 survey tool

In total, the survey generated interest and a strong degree of response – the technical panel received completed surveys from **38** states. Innovations written in as "Other" through the survey were intelligent compaction with thermal profiling, electronic systems for materials certifications, electronic systems for request for information (RFI) and shop drawings, and quality assurance for digital surveying. The technical panel tabulated and reviewed the information from the collective responses. Review of the data allowed the technical panel to:

- Highlight most-adopted innovations, and
- Highlight states with the greatest degree of adoption of innovation.

Both were considered for follow-up activities for the amplifying questions to be asked during Phase 2. The results can be found in **Appendix G** and the collective states' responses were the basis for further exploration under the second Phase of the desk scan. From this phase of the desk scan, the technical panel saw that the top DCM innovations adopted by states included:

- Document and data retention policies and processes
- e-Construction
- Project site documentation (photos, videos, scans, and retention policies)
- Electronic systems for subcontracts, payroll verification, prompt payment, EEO and Davis Bacon interviews, et.al.
- Software interconnectivity / standards (e.g., AASHTOWare)
- Unmanned Aerials Systems (UAS) for inspection, mapping, et.al.
- e-Ticketing, material certificates, and resource management
- Surveying (with digital devices and quality assurance)
- Tracking of contract progress and performance (including dashboards)
- Digital As-Builts

Further investigation under the second phase of desk scan would use these as the focus, enabling the technical panel to proceed with a smaller group of DCM innovations, and a group with which many state agencies were seen to be familiar.

Phase 2 – Amplifying questions to agencies

This phase of the desk scan focused on the process that goes into implementation of DCM innovations. Rather than delving into the technical aspects of each innovation (on which many other resources

and research exists), the panel sought to illuminate elements of an organization's success in implementation. It aimed for better understanding of cultural factors such as internal processes, communication, enlisting leadership engagement and support, as well as technical elements along the lines of data management/ storage, impacts on/ connection to legacy systems, and sustainability. This phase was conducted through contact with a more limited group of states, as opposed to a nationwide survey.

Selection of states for further examination was based on analysis of the first phase survey and responses. The technical panel wanted to identify DCM innovations with the greatest degree of implementation nationwide, so the ranking for each responding states (1 through 5) was summed, and the survey was ordered from highest total to lowest total (see **Appendix G** for the results of the survey and its analysis).

The technical panel noted that six DCM innovations stood out as most implemented by states; for each of the six, the technical panel identified two to three states among the respondents that had indicated an implementation level of "4" or "5". Those states would be the target for amplifying questions under Phase 2. The amplifying questions were developed to provide more details of their agency's experience with the implementation of a particular innovation.

For each of the six identified DCM innovations, the technical panel chose one state with a high overall degree of innovation implementation (many responses of 4 or 5 during Phase 1), along with another state with a lower overall degree (few responses of 4 or 5 during Phase 1). The technical panel recognized that such an approach creates an opportunity to contrast experiences and examine possible organizational and institutional factors that influence adoption and implementation of innovations and new technologies.

At the same time the selection process took place, the technical panel developed the amplifying questions. A first draft was prepared, and panel members reviewed, edited, and commented to refine the questions. The amplifying questions document included a set of general questions to describe the states' organization and transportation system properties for context. It also had 11 questions to be answered relative to a particular innovation for the recipient state.

Below is the final list of Amplifying questions used in the second phase of the desk scan:

Agency Questions

1. *What is the general size ($, road miles, vehicles, etc.) of the agency transportation program?*
2. *Please describe how your agency is organized (centralized or decentralized for project development and construction)?*
3. *Please describe the extent of consultant usage for project delivery and construction*
4. *Please describe approaches you have used to advance innovation in your agency, such as training, demonstration, incentives, etc.*

Targeted DCM Innovation Questions

Please share some information and experiences regarding the deployment and implementation of DCM innovation:

1. *Breadth of innovation usage:*
    a. *How long has it been used (years)?*
    b. *Approximate number of construction contracts*
    c. *On what contract value of projects?*
    d. *Type of projects?*
    e. *On alternative delivery contracts?*
2. *Speed of deployment? Innovation support? Has the approach changed over time?*
3. *How did the agency evaluate success?*
4. *Notes on the results of using that innovation – performance, savings in time or money, safety improvements? How did that compare with the cost of implementation, and what sense of return on investment?*
5. *Did your agency experience any difficulties in using this innovation?*
6. *How did the agency choose the application of the innovation? What limitations were applied, if any?*
7. *Were there organizational, institutional, or legal obstacles to applying this innovation?*
8. *What involvement did industry have in innovation selection or application?*
9. *What information systems does your agency use that relates to this technology? What approach was necessary for data integration of the innovation to the existing system?*
10. *What sort of support is provided to field staff once they start using the technology? Is training available as needed?*
11. *Do you have a data governance framework that facilitates data integration? Does it include the gathering of metadata? Is the data geo-located?*

In total, amplifying question surveys were emailed to a total of 16 states on October 10, 2022 (**Table 2**). The survey was distributed to the individual who had responded for their state's response to the Phase 1 survey, in the interest of providing continuity and for additional context and support. Innovation

Innovation	States
Software interconnectivity / standards	Maryland, Massachusetts, and Virginia
Digital As-Builts	Iowa and New York
Electronic systems for subcontracts, payroll verification, prompt payment, EEO and Davis Bacon interviews, et.al.	Maine, Montana, and Wyoming
Project site documentation (photos, videos, scans and retention policies)	Georgia, Pennsylvania, and Utah
Surveying (with digital devices and quality assurance)	Nebraska and South Carolina
Unmanned Aerials Systems (UAS) for inspection, mapping, et.al.	California and South Dakota

Table 2: : States receiving the Amplifying Questions under the second phase of the desk scan

Conclusions and preparation for Domestic Scan Workshop

The initial survey provided the technical panel with valuable information, clearly demonstrating widespread adoption of certain DCM innovations and highlighting potential for greater effort on others still to be employed by many states. Further, it reinforced the sense that some transportation agencies are on the forefront of application of innovative technologies, and the opportunity exists for this Domestic Scan to illustrate some of their internal practices which can be of benefit to other agencies. Further, the Amplifying Questions have provided a strong sense of challenges overcome, systems employed, and metrics to demonstrate success. The ability to share information about processes and results related to these stands to be a great outcome of the Domestic Scan's workshop and ultimately of the Scan's proceedings.

A total of 15 states responded to the Amplifying Questions. Among them were several states represented by members of the technical panel. The technical panel met to discuss results of the two-phase desk scan and consider the detailed information on innovation implementation and deployment it provided. Based on those discussions, several alternatives were proposed to cover the content of the six priority DCM innovations, as well as providing an opportunity to include the 15 states surveyed under Phase two of the desk scan. The model devised for the Workshop was predicated on comparison and contrast of how states of varying size and innovation experience went about the selection and implementation of specific innovations. The intention, therefore, was to organize the presentation days according to the "pairing," facilitating dialogue and discussion among participants.

The technical panel considered the alternatives and recommended planning for a 5-day virtual workshop spread across two weeks (agenda included in Section 4), that would involve presentations from 10 of the 15 states. The format provided for a half-day approach for each of the selected DCM innovations, including presentation time for states along with roundtable discussion and questions and answer among participants.

The states selected to participate in the 5-day workshop, and their corresponding DCM innovation, were as follows:

DCM Innovation	States
Software interconnectivity / standards	Maryland
Electronic systems for subcontracts, payroll ver-ification, prompt payment, EEO and Davis Ba-con interviews, et.al.	Maine and Wyoming
Project site documentation (photos, videos, scans, and retention policies)	Georgia, Pennsylvania, and Utah
Surveying (with digital devices and quality assurance)	Nebraska and South Carolina
Unmanned Aerials Systems (UAS) for inspection, mapping, et.al.	California and South Dakota

Table 3: Phase 2 survey tool innovation groupings and state DOT distribution

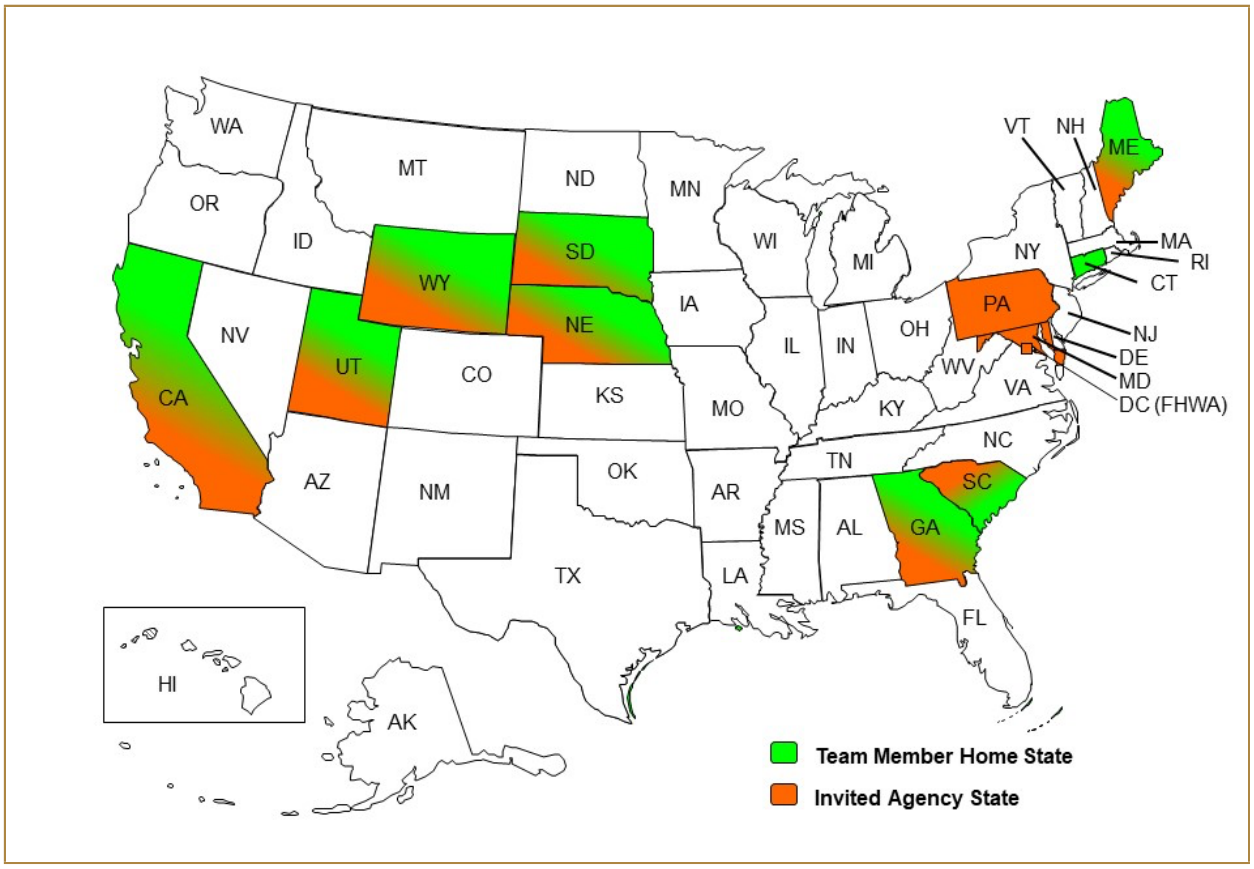

Figure 4. SHA participation in the Domestic Scan Workshop

The representation of states among the technical panel and those selected for presentation in the workshop is shown in **Figure 4**, above. A complete list of agency presentations and summary of key topics can be found in **Appendix F**.

Scan Findings and Observations

During the 5-day workshop in June 2023, ten states presented on the topics as listed above. Throughout the presentations, questions and answers, and subsequent discussions, the technical panel noted the emergence of common elements of agencies' success. The technical panel met at the conclusion of the workshop to refine the findings according to the following elements or themes exemplifying the practices leading to success in implementing DCM innovations:

1. Fostering a Culture of Innovation
2. Securing Leadership Support
3. Partnering with Industry and Other Stakeholders
4. Managing Change – Training and Support
5. Integrating Information Systems
6. Addressing Data Storage Needs
7. Sharing Resources with Other Agencies (peer exchanges)
8. Finding the Motivation for Adoption
9. Mainstreaming Innovation
10. Overcoming Challenges
11. Identifying the Next Stages of Development (timeliness)

Each of the 11 findings are supported by observations from workshop's state presentations, represented by experiences among multiple SHAs.

1. Fostering a Culture of Innovation
    a. California: Innovation is not a cost to the organization; it is an investment in efficiency and effectiveness. Caltrans supports multiple internal groups that review and guide the development and implementation of the innovation. It has established measures of how the construction program is advancing and tracking progress of projects. Dashboards are used internally, and Caltrans is exploring means to share information more effectively with industry partners.

b. Maryland: Established a robust internal software development team, and the state notes the effectiveness of having that staff rapidly respond to the agency's needs.

c. Nebraska: Advancements in surveying innovation and adoption is helping them achieve their goal of digital project delivery.

d. Maine, Utah, and Wyoming: Implementation of electronic construction forms systems reduces paperwork and increases efficiency.

e. Pennsylvania: Take the risk – see the benefits. Getting executive support is key to long-term commitment. The panel saw several examples from District 11 as forward thinking and willing to pilot innovation. Leadership supports trying new innovations for success.

f. South Dakota: The SHA selected three items to demonstrate for proof of concept – low-hanging fruit that they know could be done successfully: stockpile measurement, aerial imagery, and topographic surveys. South Dakota DOT is evolving a culture of innovation through demonstration of success.

g. Several states noted that application of technology has positive benefit for recruiting and attracting young workforce - it's consistent with what they've grown up with.

h. Several states note that an impediment to changing culture can be the funding restrictions that some states are facing.

2. Securing Leadership Support

a. California: Leadership (Director) supports the development and implementation of e-Construction and e-Project Delivery – Caltrans provides necessary funding and staff resources. Deployment of digital construction management is supported by management with staff and funding of innovation. The additional staffing and resources support various initiatives; for example, Caltrans utilizes 200+ drone pilots (which is not their primary job duties), with training requirements in place to maintain their skills.

b. Connecticut: ConnDOT addressed an issue of having fully equipped contractors by making the systems web-based. This allows contractors and consultants to equip their own staff accordingly to administer DOT work effectively and efficiently.

c. Georgia: DOT and consultant staff are equipped with IT equipment to perform their job electronically (leadership supports the dedicated funds for this). Contracting provisions ensure that the consultants come with tools that are interoperable with the state's.

d. Nebraska: Were able to sell management on investment in the system by preparing a methodology to demonstrate that it would save money in the long run.

e. South Dakota: Federal restrictions have been enacted which restrict or ban the purchase of electronics from foreign countries (including China). This created a challenge to the DOT for procurement of their desired equipment. The DOT ultimately appealed and had a security risk evaluation done for their Autel® UAS. As this was a considerably less expensive option, it was desirable for the DOT pilot. The result of the evaluation was that the Autel equipment would be permitted for use if it was not connected to system servers.

f. Challenge: Budget requests need to accommodate restrictions or changes when building a program based on tech needs that are constantly changing.

3. Partnering with Industry and Other Stakeholders

   a. California: Caltrans has created an innovation task group comprised of contractors and state representatives to collaborate on the implementation of e-Construction. This group is developing contractual specifications for the implementation of e-Construction best practices. This demonstrates the value of stakeholder input and involvement and a commitment to effective implementation of e-Construction. Caltrans is exploring opportunities to improve collaborative sharing of information between the Department and Contractors by improving dashboards to display current project information. They are working closely with the small business community to meet the needs of all contractors while implementing e-Construction.

   b. Georgia: DOT and consultant staff are equipped with IT equipment to perform their job electronically. Contract provisions are in place to make sure the consultants come with tools that are interoperable with the state's. GDOT uses a customized Bentley product. Bentley personnel are embedded with GDOT for implementation, which greatly improved the process and results. This enables staff to mold into a more efficient system but use the same appearance for forms. It is not complicated to make the state-specific tailoring of the system.

      Some material suppliers are resistant to change and the transition to paperless documents. The document management system allows restricted access to contractors.

   c. Maine: Within the prompt payment system, the contractor must verify payments. This helps in the reminding and tracking of prompt payment. It is set up as a benefit to both DOT and contractor operations and compliance.

   d. Maryland: Started the journey with DCM about 7 years ago. They started with state forces, then other contractors and consultants were engaged.

   e. Nebraska: Arranged reciprocal-use agreements with Digifarm and Topcom, to make best use of the available service. This results in having two survey networks at the disposal of the DOT, which eliminates downtime they experienced when they relied solely on one network.

   f. Nebraska: Set up so far on larger quantity jobs. Contractors have been pushing to expand modeling into smaller projects, even some rehab or pavement 3R jobs; in those the level of detail in the model may be lacking because of "density." Nebraska is using a subscription-based service for Trimble® equipment instead of an equipment-based license.

   g. South Carolina: As the construction program expands, an increasing number of consultants and contractors are collaborating with SCDOT. This presents an opportunity for enhanced collaboration and synergy among consultants, contractors, and the state DOT, particularly in terms of training and equipment. There is potential for improved partnerships and coordination to ensure that all stakeholders are equipped with the necessary training and resources, fostering efficiency and productivity in project execution.

h. Utah: Material testing and CMS were developed independently by UDOT, but ongoing discussion with their AGC has revealed some good ideas. "Count on the contractors to be innovative, and that helps the DOT to progress." UDOT's relationship with their AGC is good. The Material Management System serves as a single source of information for material acceptance, payment, and QA Testing.

i. Wyoming: Prompt payment tracking and subcontractor verification of payment received. This is helpful to both DOT and contractors.

j. Several states note that the 20% match funding for FHWA programs is sometimes restrictive to smaller local agencies, and thus they may be less likely to seek federal funding for projects.

4. Managing Change – Training and Support

a. California: The Caltrans Division of Aeronautics worked with the different functional areas and divisions within the department that utilize drones, to establish a Safety Management System that outlines Caltrans specific training requirements for Caltrans staff beyond the acquisition of a FAA Part 107 license. This program has identified the DARTdrone online training as the practical examination preparation tool. After completion of the DARTdrone online training, the staff member must pass the Part 107 Exam and a skills assessment before being approved as a Caltrans Remote Pilot. Caltrans fully provides their own training in this area to Caltrans staff. Caltrans has been purchasing tools to support field staff in the utilization of this technology. Caltrans is also having success in integrating these tools for further 3D analysis of projects for project information. Caltrans also requires contractors to meet minimum standards before utilizing drones on projects. Contractor pilots need to be licensed with the FAA Part 107 license and provide information on pre- and post-flight plans.

b. Georgia: Equipped staff with cell phone and tablet or laptop to ensure availability of the right tools for using the systems.

c. Maine: Their labor tracking system incorporates digital signature, great training, online support, yearly contractor training, can handle both state and federal rates, and includes links to DOL wage rates.

d. South Carolina: Developed training for users with availability "on demand." On-the-job assistance is provided as refresher. The DOT purchased Carlson surveying tools, as their staff are accustomed to the tool. They used the state's standard procurement process to unify equipment and support. Clemson University offers routine surveying training classes to construction field offices during winter. The State Construction Surveyor extends the support throughout the year by providing technical assistance, hardware support, and software support. To maintain consistency, the Director of Construction office procures surveying equipment and software for all construction field offices.

e. South Dakota: In implementation of UAS among DOT operators, the DOT aims for discipline and uniformity DOT ensures all pilots are trained the same way. They note that there is a TRB panel that is working on a national standard.

f. Utah: As part of support for the MMS, inspection checklists are present (but not required) within system to help people that are not knowledgeable about a particular item.

g. Wyoming: DOT is discussing the idea of creating a more streamlined interface (using smartphone). The capabilities of this have been demonstrated by the vendor, and the DOT is going through an internal review to decide upon implementation.

5. Integrating Information Systems

   a. California: Looking for one or two main tools with the ability to expand modularly and replacing one-off systems. Caltrans was in the process of developing Data Interchange for Material Engineering (DIME) ahead of AASHTOWare. They evaluated the AASHTOWare product and found that DIME would address several perceived gaps. Construction Management System, LCPTracker payroll, daily report, and Construction Safety Checklist have all been developed as web-based applications and are accessible on all devices.

   b. Georgia: Bentley system is used for preconstruction activities prior to implementation into construction activities in December 2017. Laptops and tablets were available to all construction staff in December 2017. DOT didn't take the canned version, but instead tailored it to their data fields and processes. They embedded Bentley staff in the project office to adjust the software to make it work with GDOT's prior system. They report ease of reporting data in various formats. Electronic signing of contract documents has documented savings of 30–45 days.

   c. Maine: A lot of up-front work and development on the initial labor and civil rights modules really made it easy to consider expansion for other use by the Construction Office. They reported seamless production with an easy learning curve. The project is manually entered into Elations at the time of the project being setup in Construction Management program. The program is cloud based. Benefits include a built-in collaboration with DOL (wage rates) and audits through the system info.

   d. Maryland: A state can procure off-the-shelf software as an alternative to developing/supporting a unique system.

   e. Nebraska: Using item codes in survey equipment to measure bid items for pay estimate. The survey is also used for digital as-built.

   f. Pennsylvania: They like the systems to speak with one another – their ECMS is the hub for mobile applications and other tools.

   g. South Carolina: Their system provides the ability to update county survey data with .dgn files.

   h. Utah: They use Masterworks for their materials sampling and testing site, contract advertising and award, and construction management. This system is all-in-one and is designed to pay the item once the contractor has a project. The bidding system uses the Excel® import and export function. The Material Management System serves as a single source of information for material acceptance, payment, and QA Testing.

6. Addressing Data Storage Needs

   a. California: Caltrans established a records retention schedule based on policies determined by their Legal Department or as required by legislation on the disposal or permanent retention of construction files. The Department has shifted to an all-electronic data management & storage system by using software provided by tsaADVET for document management. Currently, data is housed on internal servers with a push towards a newer construction management system that would be a SaaS Solution that allows for non-sensitive data to be stored on a cloud-based service. Caltrans has purchased additional servers as an intermittent solution to meet current storage needs. Construction is utilizing data visualization software solutions (Tableau, Power BI, etc.) to monitor project health, data storage and other performance metrics and measures deemed important to their business practices.

   b. Georgia: The State Archives has policies and procedures for record retention and disposal for electronic files. For some systems, the system info is transferred into a database format for long-term viewability.

   c. Utah: Their project management system allows for photo and other electronic document storage. The Material Management System is used for the tracking of approved mix designs and certified testers. Contractors and consultants can see live data as samples advance through testing.

   d. South Dakota: Data storage procedures are a work in progress – they are currently saving everything on an internal drive across multiple locations. SDDOT staff all have access. They recognize that a long-term solution is needed. There is no records retention or disposal policy established for photos. They are starting to move photos and photogrammetry into 3D modeling of structures, stockpiles, borrow pits, and other large earth items.

   e. Different systems have different retention needs. E.g., payroll - mainly useful during the project and for managing potential claims. Consider those needs when developing and adapting info systems.

      Challenge - Management of a significant number of user accounts when a state has many contracts and multiple active contractors. Inspection information saved in programs for review and verification later is good for system longevity usefulness but requires longer-term accessibility and storage. Several states noted potential issues related to long-term data storage and ability to search records, and the ability to still be able to access the information in the future. Data storage requirements, including technical requirements and associated costs, for what could ultimately become voluminous amounts of video/ photo/ survey data/ etc. need to be addressed. Retention requirements are not uniform for such media; there are potential inconsistencies.

7. Sharing Resources with Other Agencies (Peer Exchanges)

    a. FHWA: Advance Digital Construction Management grants are to be advertised and equates to about $17 million a year. The agency anticipates grant awards soon for 2021 applications, and will advertise for new grant opportunities via STIC and aid-grants. State DOT have experience with STIC and aid grants for deploying digital construction management innovation. FHWA is advancing to develop and hold peer exchanges about Digital Construction Management.

    b. Maine: Described a cross-pollination between government agencies to use the same platform – the state's Department of Environmental Protection didn't have to reinvent the wheel. Something to consider for agencies - if not another state, is there another government agency in your state that's doing something you can use?

    c. Maryland: Developed network with peers through FHWA Peer Exchanges. This network helped develop the EMCMS for Maryland.

    d. Nebraska: Phasing their implementation, but they are still able to develop best practices as they go.

    e. Pennsylvania and Wyoming both reported that they used STIC funds for development of information systems.

    f. South Dakota: Took 15 months to develop policies and procedures, even with other states' versions as a model. This helps set expectations. They use stakeholder involvement for review and input.

       South Dakota is identifying peers during events, and then continue communication with their network to help avoid mistakes and capitalize on success. They learned from peer exchange from challenges faced by other states. They revealed that UAS policies and procedures are needed. After a visit to Utah, they determined that the state's approach could be tried if it was scalable.

    g. South Carolina: They are working with North Carolina and Georgia's real-time network to share resources and learn from their experiences.

    h. The technical panel posed the question for further discussion and potentially ongoing NCHRP activity: What can AASHTO and FHWA do to provide further support and resources for conducting peer exchanges – formal and informal?

8. Finding the Motivation for Adoption

    a. California: UAS present an opportunity for safety improvement - "can you keep the workers out of the road?" Implementation of new technologies such as this helps draw in the "next generation" of engineers out of school (workforce development). Also, the ability to use UAS data in claims resolution and/or avoidance helped secure support of the program.

b. Georgia: Since 2021, they have used e-ticketing for all asphalt. Some states implemented this to address social distancing during Covid; others were already making the transition. Seeing the trend that they start with hot-mix asphalt (HMA) and its success leads them to apply it to aggregates and PCC. This requires coordination with the industry for successful implementation.

c. Maine: No audit findings since they started using Elations. Audit finding in 2009 was a driver for the change.

d. Maryland: The benefits of reduced claims, reduced delays in payments, reduced paper usage, and reduced mail charges are intuitive.

e. Nebraska: Has been implementing MidWest Real Time Kinematic (MWRTK) network. There are 48 stations in NE and 38 are owned and maintained by NE DOT. State ownership is a fundamental piece for improving GPS accuracy. In contrast, other states, including Caltrans, use state/industry partnership, and others use a DOT-only, and still others use private-only; there is potential for future research to gauge how best to provide dependable network. Each is different, especially with the datum shift of Nebraska: Benefits include collecting field measurements to make changes to existing as-builts. They will be moving to the creation of digital as-builts.

f. Pennsylvania: Several states reported interest in PennDOT's look at Autodesk Construction Cloud.

g. South Carolina: In 2017, the South Carolina General Assembly passed legislation to incrementally raise the state gas tax by 12 cents over a span of six years, with a gradual increase of 2 cents per year. With the additional funding, SCDOT has increased its work program by quadrupling its construction program by September of 2022. Given this substantial growth in program size, the agency is actively exploring solutions to enhance efficiency.

h. South Dakota: They are looking and exploring ideas to improve ROI with different usage, equipment, and operators.

i. Wyoming: The system supports regular, required reporting, as well as the system flexibility to address ad hoc questions received by the department.

j. The National Spatial Reference System (NSRS) is defined by the Office of Management and Budget's Circular A-16 as "the fundamental geodetic control for the United States" and its use is required for all federal agencies creating geographic information. The National Geodetic Survey (NGS) announced in Federal Register Notice 85 FR 44864 that it will complete modernization of the NSRS by 2025. Modernization includes replacing the North American Datum of 1983, the State Plane Coordinate System of 1983, and all existing NSRS vertical datums with new terrestrial reference frames and a new geopotential (vertical) datum. These new reference frames, state plane system, and vertical datum will be adopted for the entire NSRS and will be more accurate and compatible with modern technology and methods. Agencies with existing data and workflows based on the legacy NSRS will be impacted by NSRS modernization.

9. Mainstreaming Innovation

    a. California: Caltrans is utilizing-cutting edge drone/UAS technology to capture photos and videos of construction projects. Digital scans are being utilized for volumetric analysis of earthwork by constructing 3D models to compare original and finish grade designs. MTLS vehicle-mounted scanners will also be useful in similar digital terrain model comparisons as well as for quick data capture of visual features. Piloting reality is captured from a mixture of UAS, RTK, and mobile scanning where linework and objects are extracted and classified. Initial piloting with Radiometric (thermal imaging) inspection of paving operations has shown a path to future success in streamlining data capture and increasing safety during inspection work. Caltrans is looking into future uses with an expansion towards advanced digital construction management technologies. E-ticketing pilots are showing early successes on pilots that collected HMA load ticket data. They are expanding the E-ticketing pilot to include concrete and aggregates along with HMA, and utilizing GNSS rovers for construction inspection and future digital as-built data captures for certain infrastructure elements. Caltrans is exploring ArcGIS solutions for electronic data capture to eliminate pdf forms and the automation of other business workflows.

    b. Nebraska: Advancements in surveying innovation and adoption are helping the department progress its goal of digital project delivery.

    c. Pennsylvania: They are exploring several innovations, photogrammetry, UAS, augmented reality, apps, Autodesk construction cloud, radio frequency identification (RFID), and handheld LiDAR. Having the model acceptable as a legal document is their goal for 2025.

    d. South Carolina: Applied and used STIC funding for procuring GPS rovers and supporting the advancement of automated machine guidance.

10. Overcoming Challenges

    a. California: Installing GNSS stations statewide as part of the Caltrans Spatial Reference Network (CTSRN). They currently 80% statewide coverage.

    b. The UAS requires cooperation from multiple agencies for regulation and standards development.

    c. Maryland was restricted to some IT options per state specifications.

    d. South Carolina: Contractors are expected to arrive on site knowing the survey tools and system. There is potential to share contract provisions with other states on how this was addressed. Opening training to those companies can facilitate the readiness of their staff. Different platforms and standards can complicate that issue.

    e. Utah: They have no program review of bidding data within the system to optimize advertising or review for illegal activity (unbalanced bids). There is an opportunity to expand the system so it helps fulfill more functions.

f. Wyoming: Collection of information is via "PDF" and not fully data. This can create challenges in locating records or archiving.

g. Importance of data governance and a uniform data dictionary. E.g.: BIM data standard may be different from what your agency has put a lot of effort and resources into. This also applies to technology vendors.

h. System compatibility is an issue since many surveying systems are proprietary. Multiple logins – needing to establish and maintain independent user interfaces is not as friendly to users.

i. Validation of users on a routine basis to preserve firewall integrity and management of a significant number of user accounts when a state has numerous contracts/contractors presents a challenge. This relates to the positive observation about having quality dedicated IT staff.

j. Bureaucracy, rules, regulations can be an issue, slowing down the process. It can be difficult to reconcile with a dynamic tech environment – by the time something gets approved it may already be obsolete. Change management can slow things down, too – within large organizations, it is important to make sure implementation and deployment goes smoothly. Federal restrictions of available technology and products is something that needs to be considered and worked around, if possible.

k. Opportunity to employ signal booster systems when needed for online programs when in remote area (Starlink), or ensure "off-line" capabilities.

11. Identifying the Next Stages of Development (timeliness)

a. Georgia: Aggregate and concrete are the only things that still use paper tickets. An e-ticketing system is in the works.. Georgia has updated the specification and passed it to AGC; the suppliers' review and input is still needed.

b. Nebraska: Transition from level 2 to level 5; assess how people use digital information. The processes must line up as things start getting more complex. Nebraska desires to improve the data, and make sure the availability/ distribution/ readiness of equipment lines up. An important consideration for the future is whether other DOT systems and their software connect and communicate with input/ output?

c. Pennsylvania: Moving toward virtual asphalt accepting testing which is currently used on 100% of state contracts. Pennsylvania first came up with this approach during Covid (driven by social distancing) and began installing cameras. This evolved to headset approach, which is much less expensive and delicate an operation. The main issue now is the battery life of the headset units.

   Pennsylvania is also exploring emerging AI applications to view real-time activity.

d. South Dakota: Sense of "what next?" and expansion – the DOT started out small, with a low budget to prove concept and get pilots familiar with flying UAS on inexpensive equipment. The program's success can breed further opportunities and improvements.

e. Utah: The construction management and materials testing data are not currently connected to asset management/ performance management. This could be a beneficial enhancement at the departmental level.

Recommendations

The technical panel met at the conclusion of the workshop to refine the findings according to lessons learned through the journey of the domestic scan. Digital Construction Management (DCM) is the use of electronic innovation to enhance efficiency and effectiveness of highway construction management. Some leading DCM innovations identified were software interconnectivity, electronic systems, project site documentation, surveying, and Unmanned Aerial Systems (UAS). The following elements capture the lessons learned to be successful on the journey of embracing DCM:

- Fostering a Culture of Innovation (It is an investment, not a cost)
  - Securing leadership's support.
  - Partnering with industry, solution providers, and other stakeholders.
  - Sharing innovations and resources with others (peer exchanges)
  - Motivating the innovation
    - Updating law, regulation, or policy
    - Funding and staffing
    - Strategic initiative
    - Identifying and supporting champions
- Managing Change
  - Supporting and fostering training networks
  - Integration of construction management systems
    - Address organizational needs along with user considerations in systems access management
    - Ensure that new systems work seamlessly and effectively link to or accurately replace legacy systems
    - Update policies to reflect need for short- and long-term data storage
    - Ensure accessibility for data collection, analysis, and usage
  - Overcoming challenges
  - Mainstreaming innovation
- Building a culture of embracing innovating Construction Management
  - Identifying and advancing innovation for consideration
  - Identifying opportunities, inventing, and investing in solutions

Recommendations are summarized as follows:

- Invest in the existing proven DCM innovations and incorporate them into your business.
- Build the organizational structure that supports a culture of adopting DCM.
- Invest in the creative minds of your organization to invent and advance DCM innovation.

Implementation Plan

The Domestic Scan Review team has developed technology briefs, presentations, and storyboards to share agencies' experiences about how DCM has improved safety, efficiency, and effectiveness of highway construction.

The Domestic Scan Review team will look for further opportunities to share the knowledge they have gained through others and build enthusiasm about DCM.

The Domestic Scan Review team will look for areas for improvement in highway construction management and solutions and assist in identifying champions to further advance DCM.

Audience - Organization	Date/Location	Description/Notes	Lead Scan Team Member
--Completed Dissemination Activities--			
TRB Committee on Construction (AED80)	January 8, 2023	70 attendees	John Hancock
TRB Committee on Construction Management (AKC10)	Jan 10, 2023	50 attendees	John Hancock
TRB AKD70 (Geospatial Data Acquisition) Midyear Meeting	June 26-28, 2023; Irvine, CA	30 attendees	Wei Johnson
Joint Meeting of the AASHTO Committee on Design (Joint Technical Committee on Electronic Engineering Standards)	July 30-Aug 4, 2023; Atlanta, GA		Shawn Smith
--Future Dissemination Activities--			
--MEETINGS--			
AASHTO Comm on Construction Annual Meeting	Sept 17-21, 2023; KC, MO	Update on 9/19.	John Hancock
Construction Management Board	October 24, 2023; Southern CA		Ramon Hopkins
ASBI (Innovation and Technology subcommittees)	November 5-8, 2023; Tucson, AZ		John Dunham
TRB AKC10 (Construction Management)	January 2024		John Hancock
WASHTO Comm on Construction Materials	April 9-11, 2024; Fargo, ND		Ramon Hopkins

Audience - Organization	Date/Location	Description/Notes	Lead Scan Team Member
--POTENTIAL IMPLEMENTATION ACTIVITIES--			
Webinar (TRB) Topic / Theme, Moderator (Bryan Cawley), Speakers (Scan Team member to discuss Digital Construction Management; Caltrans: Drone in the Box, working with Alaska DOT&PF.			
Pilot Projects / Case Studies How PennDOT deployed a new technology. Caltrans. Suitability for agency-wide deployment. Caltrans pilot projects are currently ongoing.			
Workshop / Training			
Peer Exchange Caltrans pilot (UAS) training program. Various technologies related to DCM for current employees.			
Follow-up Research Scan team interested in pursuing.			
Draft legislation related to allowing registered surveyors to act as photogrammetrists.			
Propose input to National Guidelines / AASHTO Standards			
Change to state practice / policy			
Revisions to specifications / manuals			

Table 4. : Dissemination activities planned or conducted by the Technical Panel

Appendix A
Team Member Contact Information

Bryan Cawley –Team Co-chair
Division Administrator
Wyoming Division Office
FHWA
Phone: 307-631-7424
Email: bryan.cawley@dot.gov

John Hancock –Team Co-chair
State Construction Engineer
Georgia Department of Transportation
One Georgia Center
600 West Peachtree St NW, 11th Floor
Atlanta, GA 30308
Phone: 404-631-1970
Email: jhancock@dot.ga.gov

Shawn Smith
Senior Project Manager
Maine Department of Transportation
24 Child Street, 16 SHS
Augusta, ME 04333
Phone: 207-557-1663
Email: shawn.smith@maine.gov

Tyler Carlson
Construction Systems IT Supervisor
Nebraska Department of Transportation
Phone: 402-479-3821
Email: tyler.carlson@Nebraska.gov

Eric Chaston
Director of Construction
Utah Department of Transportation
Phone: 801-910-2531
Email: echaston@utah.gov

Jace Mecham
State Construction Engineer
Utah Department of Transportation
Phone: 435-230-2989
Email: jmecham@utah.gov

Ramon Hopkins
Chief, Division of Construction
California Department of Transportation
Phone: 916-947-0057
Email: ramon.hopkins@dot.ca.gov

John S. Dunham
Construction Administrator
Connecticut Department of Transportation
2800 Berlin Turnpike,
Newington, CT 06131
Phone: 860-594-2680
Phone: 203-410-9632
Email: john.s.dunham@ct.gov

Damon Zeltinger
Construction Specialist
Office of Operations Support
South Dakota Department of Transportation
Phone: 605-773-3263
Email: Damon.Zeltinger@state.sd.us

Wei H. Johnson Ph.D., P.E.
Construction Metrics Engineer
Director of Construction Office
South Carolina Department of Transportation
Columbia, South Carolina
Phone: 803-737-2031
Email: johnsonwh@scdot.org

Charles Bauer, PE
Construction Staff Engineer
Wyoming DOT Department of Transportation
Phone: 307-777-4927
Email: charlie.bauer@wyo.gov

Christopher (Chris) Newman – Subject Matter Expert
725 Gist Avenue
Silver Spring MD 20910
Phone: 301-706-3919
Email: newmanchris888@gmail.com

Appendix B
Team Member Biographic Sketches

Bryan Cawley (Team Co-chair) is a Highway Engineer with the Federal Highway Administration Resource Center. He supports highway construction and maintenance processes by providing technical assistance, technology transfer, training, and interagency coordination to all FHWA Offices, State DOTs, LPA & Tribal Governments, Contractors, and Consultants. He has extensive experience in the delivery of the federal-aid program as the Wyoming FHWA Division Administrator, Construction Management Team Leader in the Office of Infrastructure, Assistant Division Administrator in the Utah Division Office, Engineering and Operations Manager in the Nebraska Division Office, Materials Engineering in the Chicago Resource Center, and Pavement and Materials Engineer in the North Dakota Division Office. He also has a balanced education that brings forward business management skills coupled with the technical knowledge of highway construction and materials: Master's Degree in Business Administration from the University of Nebraska, Master's Degree in Civil and Construction Engineering from Iowa State University, and a Bachelor Degree in Civil Engineering from the University of Utah. Bryan is a licensed Professional Engineer in the state of North Dakota.

John Hancock (Team Co-chair) is the State Construction Engineer for the Georgia Department of Transportation. He started with GDOT in May 1998 and has been the State Construction Engineer since June 2016. In this position, he sets policy and procedures for construction inspections, and maintains the Construction Manual which includes how information is collected and stored for each construction project. He graduated from Florida State University in 1995 with a BS in civil engineering and is a registered professional engineer in Georgia. He is a Chair for the Subcommittee on Roadway and Structures under AASHTO Committee on Construction, a Member TRB AKC10 – Committee on Construction Management, a member of the AASHTO Joint Technical Committee on Electronic Engineering Standards, and the chair for NCHRP 10-112 - Guidelines for Digital Technologies and Systems for Remote Construction Inspection for Highway Infrastructure Projects

Shawn Smith is a Senior Project Manager with the Maine Department of Transportation's Highway Program. Shawn is responsible for estimating, design and construction of capital projects on Maine's interstate system. Shawn also provides statewide construction management support to various other heavy capital projects, as well as the lead on statewide construction staff training. Shawn also serves on MDOT's Work Zone Safety Committee, ADA Committee, Construction Management Group, Digital Delivery and Management Committee as well as several other internal committees. Shawn's direct involvement with digital delivery development is a critical to keep the Department's project development staff in pace with ever growing technology. Shawn has an Associates Degree from Dean College in Franklin Mass, and an Bachelors Degree from the University of Maine at Orono. Shawn is the current Vice Chair of AASHTO's Committee on Construction, and currently is the Region 1 construction representative on AASHTO's Joint Technical Committee on Electronic Engineering Standards. Previously, Shawn was the Vice Chair of the Technical Subcommittee of Roadway and Structures (2018 -2020) in the AASHTO Committee on Construction.

Tyler Carlson is the Nebraska DOT Construction Systems Supervisor in Lincoln Nebraska. Ty manages a team of eight staff who administer systems that support the construction program for the DOT. Systems include but are not limited to: AASHTOWare Project, Haul Hub, SWPPPTrack, ForneyTools, and support a range or reporting done through the DOT report portal. His experience with business processes for highway construction provided this scan team perspectives from many business areas inside the DOT. Prior to working for the Construction Systems team, Ty worked on the Nebraska DOT Roadway Asset team gaining experience on how Nebraska maintains their highway inventory and how that information feeds into all business area decision making of the DOT. He also spent time working as a field technician, prior to Roadway Asset, where he used all the systems his team now administers today. Ty is a graduate of South Dakota State Univeristy and is a current member of the AASHTOWare Project Task Force.

Eric Chaston is the Director of Construction for the Utah Department of Transportation and has been in the highway construction industry since 1995. He started in the transportation industry working for a highway contractor within the intermountain states and transitioned to the Utah Department of Transportation in 1997. Eric has held various roles within UDOT including Design Engineer, Field Engineer, Resident Engineer, District Engineer, and Region Traffic Operations Engineer. Eric holds a Bachelor's of Science in Civil Engineering from the University of Utah.

Jace Mecham is the State Construction Engineer for Utah Department of Transportation . Jace attended Utah State University and earned a B.S. Civil Engineering. He enjoyed a 24 year career with UDOT, working as: Designer, Field Engineer, Resident Engineer, Maintenance Engineer, and currently State Construction Engineer, with the majority of his time with the Department in construction. Jace is a licensed professional engineer.

Ramon Hopkins is the Chief, Division of Construction, for the California Department of Transportation (Caltrans). In this position, Ramon is responsible for the development of policies and procedures governing construction administration practices in California. He leads the planning and implementation of digital construction inspection efforts in Caltrans. He has 25 years of experience managing heavy-civil construction contracts. He received his bachelor's degree in civil engineering from The University of Arizona, Tucson, and is a licensed professional engineer.

John Dunham is the Construction Administrator at Connecticut Department of Transportation and he has overall construction responsibilities for 550 construction staff which are broken up into 5 Construction Districts, a Central Construction Office and the Materials Testing Laboratory. John manages the Office of Construction e-Construction working group which helps develop and manage the electronic applications used by Department's construction offices. He has a Bachelor of Science Degree in Civil Engineering from the University of Connecticut and has worked at Connecticut DOT in various capacities since starting as an engineering Intern over his 34 year career. John is a member of ASSHTO Committee on Construction and is the Vice Chair of the ASSHTO Committee on Construction Contract Administration subcommittee.

Damon Zeltinger is a Construction Specialist in Office of Operations Support at South Dakota DOT

Wei Johnson is the Construction Metrics Engineer at the South Carolina Department of Transportation. In this position, she oversees construction survey, construction schedules, construction data analytics, and monthly highway letting reviews. She has been with SCDOT since 2004 holding positions in materials, asset management, and construction. Johnson actively participates in AASHTO, AASHTOWare, TRB, NCHRP, and pooled fund research activities and serves on multiple committees. Johnson received her Ph.D. and Master's degrees in Civil Engineering, along with a second Master's degree in Computer Engineering, from the University of South Carolina. She is a licensed professional engineer in South Carolina.

Charlie Bauer is a Construction Staff Engineer for the Wyoming Department of Transportation. Various duties include serving as a liaison between the district staff, headquarters programs, the executive staff, other governmental agencies, and private organizations, consult with private contractors, architects, engineers, construction experts, commissions, and federal, state, and local government officials on a variety of engineering subjects or special projects, monitor state and federal regulations, policies, rules, plans, and permits and provide recommendations and strategies to ensure Department compliance and coordinate their implementation within the Department, and oversees, directs, and guides the development and maintenance of the Construction Management System (CMS). Charlie has been employed at WYDOT for 30 years with the first 17 years as a project and resident engineer and the remaining years on Construction Staff.

Chris Newman (Subject Matter Expert) is a transportation engineer with over three decades of experience and expertise in highway project development and delivery, funding administration, program oversight, and policy. He retired in 2022 after 34 years with the Federal Highway Administration (FHWA). During his Federal service, he had responsibilities in multiple disciplines including environment, highway construction, pavement preservation, and workforce development His last roles were in the FHWA Headquarters Office of Infrastructure, leading the Federal-aid Programs Team and a newly created team for management and oversight of the Emergency Relief Program. In 2017, he served an 18-month detail to the Senate Environment and Public Works Committee, assisting the Majority Office in their efforts regarding surface transportation. His career with FHWA comprised a combination of headquarters and field experience, including positions in the New Jersey and California Division offices. Since his retirement, he has spent the last year as a consultant to MMO Partners, advising client cities on eligibility and application processes for funding under USDOT competitive grant programs.

He holds a Bachelor's in Civil Engineering from the Catholic University of America, and is a Professional Engineer in Delaware.

Appendix C
Invited Agency Representative Contact Information

California DOT

Colin Doran, P.E.
Office of Performance and Innovation
HQ Division of Construction
Phone: 916-764-9235
Email: colin.doran@dot.ca.gov

Devin Porr
Chief, Office of Performance & Innovation
Division of Construction
Phone: 916-764-6945
Email: devin.porr@dot.ca.gov

Georgia DOT

Jeremy Daniel
Assistant State Construction Engineer
Georgia Department of Transportation
Email: jedaniel@dot.ga.gov

Lenicia Rogers-Lattimore
Assistant State Construction Administrator
Georgia Department of Transportation
Email: l rogers@dot.ga.gov

FHWA

Jeff Zaharewicz
Director Accelerating Innovation Programs
FHWA
Email: jeffrey.zaharewicz@dot.gov

David Scott
Construction Technology Program Engineer
FHWA
Email: david.scott@dot.gov

Maryland DOT

John Hampton
eConstruction Program Manager
Office of Construction
Maryland Department of Transportation, State Highway Administration
Phone: 301-729-8471
Phone: 443-628-7032
Email: jhampton2@mdot.maryland.gov

Stehpen A. Bucy, P.E.
Director, Office of Construction
Maryland Department of Transportation, State Highway Administration
Phone: 443-572-5235
Email: sbucy@sha.state.md.us

David Piasecki
Chief, Contract Payment Division
Office of Construction
Maryland Department of Transportation, State Highway Administration
Email: dpiasecki@sha.state.md.us

John Veronick
Regional Construction Engineer
Office of Construction
Maryland Department of Transportation, State Highway Administration
Email: jveronick@sha.state.md.us

Eloangovan Subramaniam
Senior System Architect/Subject Matter Expert
Office of Information Technology
Maryland Department of Transportation, State Highway Administration
Email: esubramaniam@sha.state.md.us

Maine DOT

George Macdougall
Contracts and Specifications Engineer, Director, Project Development Contracts Section
Maine Department of Transportation
Phone: 207- 624-3353
Email: George.Macdougall@maine.gov

Angela Latno
Research & Planning Associate I, Project Development Contracts Section
Maine Department of Transportation
Phone: 207624-3519
Email: Angela.Latno@maine.gov

Sherry Tompkins
Director, Civil Rights Office
Maine Department of Transportation
Phone: 207-624-3066
Email: Sherry.Tompkins@maine.gov

Jennifer Laliberte
EEO Program Specialist, Civil Rights Office
Maine Department of Transportation
Phone: 207-624-3036
Email: Jennifer.E.Laliberte@maine.gov

Nebraska DOT

Jason Lehn
District Construction Engineer, District 8
Nebraska Department of Transportation
Phone: 402-760-1450
Email: Jason.Lehn@nebraska.gov

Craig Branch
Survey Program Manager
Nebraska Department of Transportation
Phone: 402-479-4415
Email: Craig.Branch@Nebraska.gov

Nathan Sorben
Assistant Roadway Design Engineer
Nebraska Department of Transportation
Phone: 402-479-3780
Email: nathan.sorben@nebraska.gov

Todd Hill
Project Studies & Survey Engineer
Nebraska Department of Transportation
Phone: 402-479-4421
Email: Todd.Hill@nebraska.gov

Pennsylvania DOT

Kelly M. Barber, P.E.
Chief, Bureau of Construction and Materials
Engineering Automation and Services Division
PA Department of Transportation
81 Lab Lane
Harrisburg, PA 17110
Phone: 717-787-5810
Email: keluckenbi@pa.gov

John Myler
Assistant Construction Manager
Engineering District 11-0, Construction Division
PA Department of Transportation
45 Thoms Run Rd, Bridgeville PA 15017
Phone: 412-429-5063
Email: jmyler@pa.gov

Michael Lentz
Construction Services Manager
Bureau of Construction & Materials
Systems Management Division
PA Department of Transportation
400 North Street, 7th Floor
Harrisburg, PA 17120
Phone: 717.787.7899
Email: milentz@pa.gov

South Carolina DOT

Jeff Brown, PLS
State Construction Surveyor
South Carolina Department of Transportation
955 Park Street, Room 332
Columbia, SC 29202-0191
Phone: 803-737-6873
Email: brownrj@scdot.org

South Dakota DOT

Jon Nelson, PLS
Road Design Land Surveyor
South Dakota Department of Transportation
700 E. Broadway Ave.
Pierre, SD 57501
Phone: 605-773-4427
Email: jon.nelson@state.sd.us

Josh Olson
Senior Region Bridge Engineer
South Dakota Department of Transportation
Email: joshc.olson@state.sd.us

Larry Dean
Planning Data Manager
Division of Planning/Engineering
South Dakota Department of Transportation
Email: larry.dean@state.sd.us

Utah DOT

D. Scott Potter
Database and Process Analyst Engineer
Utah Department of Transportation
Phone: 801-647-3459
Email: dspotter@utah.gov

Stacy L. Frandsen
Contracts, Compliance & Certification Manager
Utah Department of Transportation
Salt Lake City, Utah
Email: sfrandsen@utah.gov

Wyoming DOT

Duwane Floy
Senior Project Management Analyst
Wyoming Department of Transportation
Phone: 307-777-4059
Email: Duwane.Floy@wyo.gov

Appendix D
Virtual Workshop

Monday	Day 1 5-Jun		
Time	Session	Speaker	Moderator
* 10:00 am- 11:00am ET (9am -10am CT, 8am -9am MT, 7am -8am PT)	Introduction --Principal Investigator --Team Chair --Self introduction for all participants	Harry Capers Bryan Cawley John Hancock	
*11:00am-1:00pm ET (10:00am -12:00pm CT, 9:00-11:00am MT, 8:00-10:00am PT)	Maryland DOT Presentation	John Hampton Stehpen Bucy David Piasecki John Veronick Elangovan Subramaniam	John Hampton Shawn Smith
*1:00pm - 1:30pm ET (12pm - 12:30pm CT, 11am-11:30am MT, 10am-10:30am PT)	Break		
*1:30pm - 3:30pm ET (12:30pm - 2:30pm CT, 11:30am - 1:30pm MT, 10:30am -12:30pm PT)	South Carolina DOT Presentation	Jeff Brown	Tyler Carlson
*3:30pm - 4:00pm ET (2:30pm - 3:00pm CT, 1:30 pm-2:00pm MT, 12:30pm-1:00pm PT)	Break		
*4:00pm - 4:30pm ET (3:00pm - 3:30pm CT, 2:00pm - 2:30pm MT, 1:00pm - 1:30pm PT)	Daily Wrap up (roundtable)		Bryan Cawley John Hancock Chris Newman

Tuesday	Day 2 6-Jun		
Time	Session	Speaker	Moderator
* 10:00 am- 12:00pm ET (9am -11am CT, 8am -10am MT, 7am -9am PT)	Utah DOT Presentation	Scott Potter Stacy L. Frandsen Jace Mecham John Dunham	
* 12:00 am- 12:30pm ET (11:00am - 11:30am CT, 10:00am - 10:30 am MT, 9:00am - 9:30am PT)	Break		
*12:30pm - 2:30pm ET (11:30am-1:30pm CT, 10:30am-12:30pm MT, 9:30-11:30am PT)	Maine DOT Presentation	George Macdougall Angela Latno Sherry Tompkins Jennifer Laliberte	Jace Mecham
*2:30pm - 3:00pm ET (1:30pm - 2:00pm CT, 12:30 pm-1:00pm MT, 11:30am-12:00pm PT)	Break		
*3:00pm - 5:00pm ET (2:00pm - 4:00pm CT, 1:00pm-3:00pm MT, 12:00pm-2:00pm PT)	Wyoming DOT Presentation	Duwane Floy Charles Bauer	Ramon Hopkins
*5:00pm - 6:00pm (4:00pm - 5:00pm CT, 3:00pm-4:00pm MT, 2:00pm-3:00pm PT)	Daily Wrap up (roundtable)		Bryan Cawley John Hancock Chris Newman

Wednesday	Day 3 7-Jun		
Time	Session	Speaker	Moderator
*1:30pm - 3:30pm ET (12:30pm-2:30pm CT, 11:30am-1:30pm MT, 10:30-12:30pm PT)	Nebraska DOT Presentation	Jason Lehn, Craig Branch Nathan Sorben Todd Hill	Charles Bauer
*3:30pm - 4:00pm ET (2:30pm - 3:00pm CT, 1:30 pm - 2:00pm MT, 12:30pm-1:00pm PT)	Break		
*4:00pm - 6:00pm ET (3:00pm - 5:00pm CT, 2:00pm - 4:00pm MT, 1:00pm - 3:00pm PT)	Pennsylvania DOT Presentation	Kelly M. Barber John B Myler Mike Lentz	Jace Mecham
*6:00pm - 6:30pm (5:00pm - 5:30pm CT, 4:00pm-4:30pm MT, 3:00pm-3:30pm PT)	Daily Wrap up (roundtable)		Bryan Cawley John Hancock Chris Newman

Thursday	Day 4 8-Jun		
Time	Session	Speaker	Moderator
“* 10:00 am- 12:00pm ET (9am -11am CT, 8am -10am MT, 7am -9am PT)”	Georgia DOT Presentation	Jeremy Daniel Lenicia Rogers-Lattimore	Shawn Smith
“* 12:00 am- 12:30pm ET (11:00am - 11:30am CT, 10:00am - 10:30 am MT, 9:00am - 9:30am PT)”	Break		
“*12:30pm - 2:30pm ET (11:30am-1:30pm CT, 10:30am-12:30pm MT, 9:30-11:30am PT) “	South Dakota Presentation	Jon Nelson Josh Olson Larry Dean	Wei Johnson
“*2:30pm - 3:00pm ET (1:30pm - 2:00pm CT, 12:30 pm-1:00pm MT, 11:30am-12:00pm PT)”	Daily Wrap up (roundtable)		Bryan Cawley John Hancock Chris Newman

Wednesday	Day 5 21-Jun		
Time	Session	Speaker	Moderator
* 10:00 am- 11:00am ET (9am -10am CT, 8am -9am MT, 7am -8am PT)	FHWA Presentation - Grants to assist in deployment * STIC, Aid, and Accelerate Market Readiness Grants * Accelerated Digital Construction Management (ADCM) grant	Jeff Zaharewicz David Scott	Ramon Hopkins
* 11:00 am- 11:30am ET (11:00am - 11:30am CT, 10:00am - 10:30 am MT, 9:00am - 9:30am PT)	Break		
*11:30am - 1:30pm ET (10:30am-12:30pm CT, 9:30am-11:30pm MT, 8:30am -10:30am PT)	CalTrans Presentation	Colin Doran Devin Porr	John Dunham
*1:30pm - 2:00pm ET (12:30pm - 1:00pm CT, 11:30am-12:00pm MT, 10:30am-11:00am PT)	Break		
*3:00pm - 5:00pm ET (2:00pm - 4:00pm CT, 1:00pm-3:00pm MT, 12:00pm-2:00pm PT)	Group Discussion		Bryan Cawley John Hancock Chris Newman
*5:00pm - 6:00pm (4:00pm - 5:00pm CT, 3:00pm-4:00pm MT, 2:00pm-3:00pm PT)	Daily Wrap up (roundtable)		Bryan Cawley John Hancock Chris Newman

FINAL TEAM MEETING	TEAM ONLY	
Friday	**23-Jun**	
Time	Session	Speaker
* 10:00 am- 10:30am ET (9am-9:30am CT, 8am-8:30am MT, 7am-7:30am PT)	*Principal Investigator Opeing comments *Team Chair and SME comments	Harry Capers Bryan Cawley John Hancock Chris Smith
*10:30am - 11:30am ET (9:30am -10:30am CT, 8:30am -9:30am MT, 7:30am -8:30am PT)	Scan Team discussion and finalization of Significant Findings, Conclusions and Recommendations	Bryan Cawley John Hancock Chris Newman
11:30am -12pm ET (10:30am -11am CT, 9:30am -10am MT, 8:30am-9am PT)	Break	Break
12pm-1:30pm ET (11am-12:30pm CT, 10am-11:30am MT, 9am - 10:30am PT)	Scan Team - Development of Report Outline	Bryan Cawley John Hancock Chris Newman
1:30pm - 2:00pm ET (12:30 pm-1:00pm CT, 11:30am-12:00pm MT, 10:30am - 11:00am PT)	Break	Break
2:00pm - 3:00pm ET (1:00pm-2:00pm CT, 12:00pm-1:00pm MT, 11am -12pm PT)	Scan Team - Development of Report Outline (continue)	Bryan Cawley John Hancock Chris Newman
3:00-4:45pm ET (2:00-3:45pm CT, 1:00-2:45pm MT, 12pm -1:45pm PT)	Scan Team - Development of Draft Dissemination Plan	Greg Waidley, CTC & Associates
4:45pm -5pm ET (3:45pm - 4pm CT, 2:45pm - 3pm MT, 1:45pm - 2pm PT)	Adjorn the final team meeting	Bryan Cawley John Hancock

Appendix E
Amplifying Questions

Below is the final list of Amplifying questions used in the Phase 2 survey:

Agency Questions

1. *What is the general size ($, road miles, vehicles, etc.) of the agency transportation program?*
2. *Please describe how your agency is organized (centralized or decentralized for project development and construction)?*
3. *Please describe the extent of consultant usage for project delivery and construction.*
4. *Please describe approaches you have used to advance innovation in your agency, such as training, demonstration, incentives, etc.*

Targeted DCM Innovation Questions

Please share some information and experiences regarding the deployment and implementation of DCM innovation:

1. *Breadth of innovation usage:*
    a. How long has it been used (years)?
    b. *Approximate number of construction contracts*
    c. *On what contract value of projects?*
    d. *Type of projects?*
    e. *On alternative delivery contracts?*
2. *Speed of deployment? Innovation support? Has the approach changed over time?*
3. *How did the agency evaluate success?*
4. *Notes on the results of using that innovation – performance, savings in time or money, safety improvements? How did that compare with the cost of implementation, and what sense of return on investment?*
5. *Did your agency experience any difficulties in using this innovation?*
6. *How did the agency choose the application of the innovation? What limitations were applied, if any?*
7. *Were there organizational, institutional, or legal obstacles to applying this innovation?*
8. *What involvement did industry have in innovation selection or application?*
9. *What information systems does your agency use that relates to this technology? What approach was necessary for data integration of the innovation to the existing system?*
10. *What sort of support is provided to field staff once they start using the technology? Is training available as needed?*
11. *Do you have a data governance framework that facilitates data integration? Does it include the gathering of metadata? Is the data geo-located?*

Appendix F
Summary of Virtual Workshop Presentations

Day 1 – Maryland

Software Interconnectivity/ Standards

Presenters:

- John Hampton, Office of Construction – eConstruction Program Manager
- Stephen A. Bucy, P.E., Office of Construction - Director
- John Veronick, Office of Construction – Regional Construction Engineer
- Elangovan Subramaniam, Office of Information Technology – Senior System Architect/ Subject Matter Expert
- David Piasacki, Office of Construction – Chief, Contract Payment Division

Key Topics

- Transportation Program Overview
  - To provide a safe, well-maintained, reliable highway system that enables mobility choices for all its customers and supports Maryland's communities, economy, and environment
- Evolution
  - Creating efficiency through technology and collaboration for project delivery and construction by implementing innovation solutions
- Technology Stack
  - Web applications, system integrations, hardware, mobile technology, and tools, and their importance for the present and future
- Benefits and Challenges
  - Adopt ideas to improve communication, transparency, increase accuracy, document tracking, field data collection, and project delivery
- Current Implementation
  - Impact of digital tools, integrated mobile learning, Interworks of the eMCMS application
- Technology Upgrades
  - Pros/Cons
  - Benefits
  - Mobile First approach

Day 1 – South Carolina

Surveying with Digital Devices and Quality Assurance

Presenter: Jeff Brown, PLS – State Construction Surveyor

Key Topics:

- State system overview
- Need for systematic management of surveying activities: equipment, people, training, support, and maintenance.
- Partnering with Clemson University for departmental training, plus OJT
- Challenges and lessons learned
- Discussion of ROI
- Establishment of SC Real-time Network (partnership with SC Geodetic Survey)
- Electronic Engineering Data (EED)
- Verifying Plan Data
- Demo of Data Collector Field Examples
- 3D modeling for Quality Assurance
- Scan data examples

Day 2 – Utah

UDOT – Demonstration of Materials Management System Database

Presenter: Scott Potter

Key topics:

- Developed via Argo Masterworks, specifically developed for UDOT
- Separates project-specific information versus non-project-specific information
- Showed functionality (including review, submittal, and approval processes) of non-project (regional) approvals for:
  - Concrete Mix Design Approval Form
  - Hydrated Lime Sample Form
  - Precast elements
- Demonstration of project-specific functionality
  - Example: Aggregate (base, granular borrow, etc.) are all submitted by the contractor for review and approval on each project. Data includes gradation and aggregate properties for each submittal.
  - Example: Asphalt mix design, including supplier source information, dates, and results of testing. Relates to specific pay items connected to this material. Notes that binder is pre-approved regionally.
  - Transparency of submittals and review, with clearly delineated roles and responsibilities.
  - Maintains a record of test results.
  - Differentiates levels of access for users: contractor, state
  - Acceptance testing and payment is also attached to the data within the system
- Demonstration of reporting capabilities
  - T308 report. Example of generating pay adjustment
  - T251 Concrete break report – automatically summarizes relevant data across the project for that pay item
- The system is based on current UDOT specifications, and requirements are manually updated whenever specs are changed
- Batch plant/ producer library
- Qualified Technician Library – licensing and testing, connected to LMS

UDOT Masterworks Estimating and Bidding Module

Presenter: Stacy L. Frandsen, Contracting Services Division – Contracts Compliance and Certification Manager

Key topics:

- Estimating Overview
- Submitting Contractor Bidding Details
- Modifying Contractor Bidding Details
- Withdrawing or Redrafting the Contractor Bidding Details
- e-Bidding for the Addendum
- DBE Commitment Letter
- Bidding Details Report
- Attachments

Day 2 – Utah

Demonstration of UDOT CMS

Presenter: Jace Mecham – State Construction Engineer

Key topics:

- Masterworks system
- Construction project dashboard
- Residents see the projects assigned to them
- Demonstrated data on a particular project
- Managing users roles and responsibilities for each project. Levels of review and approval
- Design. Build projects aren't in the system – working on creating a module to capture alternative contracting (to avoid gaps in data, pricing, etc.)
- Processes for project initiation
  - Setting and locking pay items
  - Establishing key contacts
  - OJT requirements
- Change management
  - Info on each change order, with reviewers, coordination, approvals, and documentation
  - Design change
  - Force account
  - Requests for information
  - Log of use of RE contingency funds
- Progress tracking
  - Daily Progress Report
  - Resident engineer's diary
  - Visual checklists
  - Contractor access to this is limited
- Billings and Payments
  - Asphalt pay adjustment
  - Fuel cost adjustments
  - Pay estimates
- Construction closeout documents
- Compliance records
  - Non-conformance report
  - Stormwater pollution prevention plan (SWPPP) Compliance Inspection
- Robust report-generating capabilities
- Created a new app for Daily Progress Report. UDOT had been using Headlight®. Aurigo® tailored something to build off of desired functions. Demo of its functionality.

Day 2 – Maine

Elation Software

Presenters:

- Shawn Smith, Highway Program – Senior Program Manager
- George MacDougall, Project Development/ Contracts – Contracts and Specifications Engineer
- Angela Latno, Project Development/ Contracts – Research and Planning Associate
- Sherry Tompkins, Civil Rights Office – Director
- Jen Laliberte, Civil Rights Office – EEO Program Specialist
- Mary Bryant, Civil Rights Office – EEO Program Specialist

Key topics:

- Davis-Bacon Labor and Compliance – Capabilities and Perks
- Use of Elation together with residents and consultants
- Certified payroll review and compliance
- Labor compliance interviews
- Prompt payment review
- Project classification requests
- Report preparation
- Technical assistance and support

Day 2 – Wyoming

WYDOT Experience with Electronic Systems for:

- *Subcontracts*
- *Payroll Verification*
- *Prompt Payment*
- *EEO and Davis-Bacon Reviews*

Presenters:

- Duwayne Floy – Senior Project Management Analyst
- Charlie Bauer, P.E. – Construction Staff Engineer

Key topics:

- Overview of WYDOT department and program
- System history and background
- Joint effort between Construction Office and Civil Rights Office
  - Prompt payment
  - Payroll
  - Compliance
- Motivation for system development
- Strengths and weaknesses
- Possible changes

Day 3 – Nebraska

Surveying with Digital Devices

Presenters:

- Jason Lehn, P.E. – District Construction Engineer, District 8
- Craig Branch – Surveying Program Manager
- Todd Hill, P.E. – Project Studies and Survey Engineer
- Nathan Sorben, P.E. – Assistant Roadway Design Engineer

Key topics:

- NDOT System and Construction Program
- History/ evolution of NDOT digital survey
- Current state
  - Implementation of LiDAR survey
  - Development of digital delivery
  - Improvements in design and data
  - Integration enhances capability
  - Technology/equipment management
- Industry demand
- Obstacles of implementation
- Training efforts
- Digital survey benefits
- Example – using GPS in inspection on Lincoln South Beltway
- Survey networks
  - Seiler Midwest Real-time Kinematic Network (MWRTK)
  - Digifarm's High Precision RTL (HPRTK)
  - NDOT reference stations
- Key partnerships
- Model as a legal document
- State of the practice
- Implementation through pilot projects

Day 4 – Georgia

Presenters:

- John Hancock – State Construction Engineer
- Lenicia Roger-Lattimore – Assistant State Construction Administrator
- Jeremy Daniel, P.E. – Assistant State Construction Engineer
- Robert Simpson – State Construction Administration Manager

E-Construction Program and Vision

Key topics:

- Overview of GDOT Program
- e-Bidding – Bid Express
- Digital signatures/ online forms
- Construction management system – AASHTOWare Project SiteManager™ / AASHTOWare Project (AWP)™
- Document Management System
- Mobile devices
- e-ticketing for asphalt (expanding to concrete and aggregates)
- As-builts
- Electronic plans

Electronic Project Site Documentation

Key topics:

- ProjectWise®
- Conversion from legacy system in 2017, using same File Management System
- Consultants (CEI) have been given access to documents for their projects
- Includes videos and photo documentation
- Encouraging electronic delivery of all documentation, including scanning of paper documents
- All construction staff are equipped with laptops/ tablets and iPhones™
- Discuss advantages to processes and efficiency
- Lessons learned
- Office of Design Policy and Support provides technical support to users

GDOT Records Retention Requirements

Key topics:

- Benefits of records retention
- Retention requirements under Georgia law
  - Statute
  - Roles/ responsibilities
  - Records Management Plan
  - Maintenance and destruction of records
  - Security of records
  - Application to electronic information
- Federal requirements – e-Sign Act
- Designing an effective records maintenance program

Day 4 – South Dakota

Presenters:

Larry Dean, Planning Data Manager

Key topics:

- UAS Implementation Timeline. 2019 FHWA peer exchange in ND
- UAS Procedures and Guidelines
  - Procurement
  - Flight requirements
  - Operations
- UAS Committee Members
  - Survey crew
  - Bridge office
  - Bridge supervisor
  - Air, Rail, Transit Administrator
  - FHWA
- UAS Aircraft
  - No dedicated funding – within asset budget
  - Autel Evo Pro II™
  - Skydio™ II Pro
- Part 107 Remote Pilot License
  - Need training and testing, recertification biannually
- 2021 Peer Exchange with FHWA and Iowa
  - Pilot requirements
  - Comparison of organizational structure
  - Equipment and software platforms
  - Funding
  - Privacy concerns
  - Flight review process/ checklist
- Airspace
  - FAA's Low Altitude Authorization and Notification Capability (LAANC)
  - Modified guidelines based on discussions with FAA
- Pre-flight Planning
  - Pilot certification
  - Registration of UAS
  - Software update
  - Flight plan
  - Batteries, weather, etc.
- Insurance
- Moving forward
  - Need authorization to continue purchasing tech from China
  - Updates to training
- UAS is a tool in the toolbox, like many others.

Day 4 – South Dakota

Josh Olson – Bridge Inspection

- Current practice is time-consuming, labor-intensive
- Set goals/ requirements for bridge inspection with UAS
  - Resolution
  - Battery life
  - Image stabilization
- Uses for Special and Construction Inspections
  - Demonstration example of nearly $3000 cost savings per inspection
  - Accuracy of views and improved accessibility
  - Ancillary structure inspections
  - Documentation of disaster damage/ flooding
- Next steps
  - Mapping
  - Modeling
  - Data storage plan, records and retention procedures

Jon Nelson

- SDDOT Goals
  - Safety
  - Time Savings
  - Precision
- Prepared proof of concept analysis for SDDOT leadership
  - Stockpiles
    - Increased speed and accuracy of stockpile calculations
    - Ran demonstration of concept and comparison of results
  - Aerial Imagery
    - Collecting aerial photography for use as background imagery for plans
  - Topographic surveys
    - Collecting survey grade data on hard surfaces and areas with limited to no vegetation

Larry Dean – South Dakota UAS Workshop (April 2022). State and Federal partnership in presentations and development of agenda.

Day 5 – FHWA

FHWA Accelerating Technology Programs

Presenters:

- Jeff Zaharewicz – Director, Accelerating Innovation Team, Office of Innovation and Workforce Solutions
- David Scott – Office of Innovation and Workforce Solutions

Key topics:

- Every Day Counts
  - A state-based model that identifies and rapidly deploys proven, yet underutilized, innovations
  - Currently on the seventh round
    - Nighttime visibility for safety
    - Next generation traveler information management
    - Integrating greenhouse gas emission assessment and reduction targets in transportation planning
    - Enhancing performance with internally-cured concrete (EPIC)
    - Environmental Product Declarations (EPDs) for sustainable project delivery
    - Rethinking DBE for design-build
    - Strategic workforce development
  - Last virtual summit was Feb 14–16, 2023: info and "exhibit hall" at http://fhwa-everyday-counts-7-virtual-summit.com

- State Transportation Innovation Councils (STIC)
  - Bring together public and private stakeholders; comprehensively and strategically consider all sources of innovation; and institutionalize innovations that best fit unique program needs
  - STIC Network of State DOT/ FHWA with universities, consultants, contractors, local public agencies, and resource agencies
  - National network for coordination
  - Top 20 innovations 2014–2022: e-Construction, 3D modeling, and UAS were top 3
  - STIC innovation showcase is on the EDC-7 website (see above link)

- Accelerated Innovation Deployment (AID) Demo
  - FHWA funding program to foster a culture of innovation – 114 awards at $86 million (for years 2014–2020)
- Accelerating Market Readiness (AMR)
  - Provides funding to spur the advancement of emerging transformative innovations that have potential to enhance roadway safety, shorten the project delivery process, and improve the performance of transportation infrastructure.
  - States, LPA, academia, and private sector are all eligible to apply – more open-ended.
- Sign up for EDC News and Innovator newsletter at https://fhwa.dot.gov/innovation

Day 5 – FHWA

David Cross – Advanced Digital Construction Management Systems (ADCMS)

- Had hoped to have the Notice of Funding Opportunity(NOFO) for this program out already – still under review. Therefore, the presentation was a little condensed. The NOFO will establish the time for submission and review. FHWA hopes to streamline the process for subsequent years. Tier 3 grant program, so approvals will be at the FHWA administrator level (as opposed to going through the Office of the Secretary of Transportation (OST)).
- $34 million in first round (combines FY 2022 and 2023). Up to $17 million in successive years.
- Created under IIJA/ BIL. Under TIDP funding, $20 million annually 2022-2026 (minus some rescissions in later years).

Day 5 – California

Presenters:

- Devin Porr, P.E., Office of Performance and Innovation – Supervising Transportation Engineer
- Aaron Chamberlain, P.E., Office of Performance and Innovation – Senion Transportation Engineer
- Colin Doran, P.E., Office of Performance and Innovation – Senior Transportation Engineer

Digital Construction Inspection (Emphasis on UAS/ Drone Technology)

Key topics:

- UAS program policy and objectives
- Department-wide Safety Management System
- Uniform, standardized field training program for minimum competency
- Department-wide UAS Pilot Handbook
- Caltrans Spatial Reference Network (CSRN)
- UAS Use Cases
  - Division of Construction UAS Program
    - Digital Construction Inspection
    - UAS HMA Paving Inspection
    - Volumetric analysis
    - Quality Assurance
  - Digital As-builts pilots
  - Caltrans MTLS scanning
- UAS Areas of Success – Direct savings and benefits
- Future growth

e-Construction Overview

Key topics:

- Current e-Construction applications
  - Automated Machine Guidance (AMG)
  - Contract Administration System (CAS)
  - Internet Extra Work Bill System (IEWBS)
  - Falcon Electronic Document Management System (FalconDMS)
  - Construction Safety Checklist (CEM 0606)
  - Safety Meeting Report (PM-S-0110)
  - LCPTracker
  - Electronic Daily Report
  - Electronic Potential Claims Record (ePCR)
  - Dashboards

Day 5 – California

- Piloting and Implementing
  - E-Ticketing
  - Project Data Management System (ProDMS)
  - Electronic Weekly Statement of Working Days (eWSWD)
  - Data Interchange for Materials Engineering (DIME)
- Future Improvements
  - AB1037 – Advanced Digital Construction Management Technologies
  - Currently working on department-wide initiative for Building Information Modeling version 4
  - Developing construction roadmap for contract administration

Appendix G
Summary Table of Desk Scan Survey of State DOTs

Domestic Scan 2022-02: Experiences in the Use of Digital Construction Management (DCM) in the Highway Industry - Summary of Phase I Survey

Innovation	MA	FL	MT	NY	PA	CT	MD	MN	WA	UT	CA	HI	NH	MI	OH	WV	IL	NE	AR	KY	ND	IA	GA	ME	WY	OK	NC	RI	TN	SC	SD	VA	NV	AL	total
Document and data retention policies and processes	5	5	5	5	5	3	5	5	5	5	5	5	5	5	5	3	5	3	5	4	4	1	5	4	5	2	2	2	5	4	2	5	5	2	98
e-Construction	5	5	5	4	5	5	5	5	5	5	3	5	4	5	5	4	5	4	5	4	4	3	5	4	5	4	5	5		3	2	5	1	5	100
Project site documentation (photos, videos, scans and retention policies)	4	5	5	5	5	4	5	5	5	5	5	5	5	5	4	4	2	3	2	4	2	2	5	3	4	2	5	4	5	2	2	5	5	3	93
Electronic systems for subcontracts, payroll verification, prompt payment, EEO and Davis Bacon interviews, et.al.	5	5	5	4	5	5	4	5	4	5	4	3	4	5	5	4	5	4	5	2	4	2	2	5	5	2	2	4	4	2	3		5	1	87
Software interconnectivity / standards (e.g., AASHTOWare)	5	5	5	5	3	3	5	5	4	5	3	5	4	5	5	3	2	5	2	2	3	3	5	3	1	4	3	2	5	3	2	5	5	2	87
Surveying (with digital devices and quality assurance)	4	5	3	5	4	5	5	4	5	5	4	2	4	4	2	5	5	4	5	2	4	3	2	4	5	3	5	2		5	2		1		78
Unmanned Aerials Systems (UAS) for inspection, mapping, et.al.	4	1	5	2	4	4	3	3	4	4	4	3	3	3	2	5	5	4	5	3	3	5	3	2	4	2	3	4	2	2	4	4	4	2	85
Tracking of contract progress and performance (including dashboards)	5	5	3	4.5	5	4.5	5	5	5	4	5	5	4	3	3	2	2	4	2	2	3	3	5	3	1	2	4	2	5	3	1	5	1	1	75
e-Ticketing, material certificates, and resource management	3	5	1	2	4	3	3	4	3	3	3	3	4	3	5	4	5	3	3	2	3	4	2	2	2	3	3	4	4	4	3	3	2	3	80
Institutional process to advance, consider, pilot, and adopt new innovation	5	4	5	4	5	5	5	5	4	5	3	4	3	5	2	2	3	2	1	2	3	2	1	3	1	3	2	2		3	1		1	1	55
Underground utility locating, mapping, and sharing with others	3	3	3	4	2	2	5	4	3	2	3	2	4	1	3	2	4	2	5	2	3	2		2	5	2	2	1		2	2	1	2	1	55
Connectivity between innovation, equipment, systems, and people.	5	5	5	2	5	2	5	3	4	3	3	5	4	2	3	2	3	2	2	3	2	2	2	2	1	2	2	2		1	2		1	2	53
Smart Work Zone Coordination	4	4	4	2	2	4.5	2	3	3	2	2	2	1	2	3	2	4	3	2	2	2	5	2	3	3	5		2	4	2	2	2	1		58
Digital As-Builts	2	3	3	4.5	2	4	5	4	3	4	3	3	2	2	2	2	2	3	1	3	2	5	5	2	1	2	2	1	5	2	2	2	1	1	60
Single point data management and usage across program areas (i.e. users, contractor, owner, construction, finance, management, project development, emergency services, utilities)	3	2	5	3	3	4	3	2	4	3	3	4	4	3	2	3	2	2	5	2	2	2	1	1	4	2	1	2		2	2	1	1	1	55
Cross disciplinary organization support and unification of information systems (people side)	5	5	5	2	3	2	3	2	3	4	3	5	4	2	3	3	1	3	1	3	2		1	3	1	3	1	3		1	2	1	1		51
Training program for new innovation	5	4	1	3	5	4	3	3	3	4	3	5	4	3	2	2	2	2	1	2	2	2	3	3	1	3	2	3		2	2		1	1	55
3D Modeling Plans as Contract Documents	5	4	4	3	3	4	2	2	1	4	2	1	2	3	2	2	4	2	2	2	2		2	1	1	3	2	1	3	1	2	2	1	1	48
Connected or Autonomous Equipment and Vehicles	2	1	5	2	3	3	2	2	1	1	2	2	1	3	2	3	2	2	1	3	3	4	3	1	3	2	2	3	2	1	2	2	1	1	52
Work Zone Data Exchange	4	5	3	2	2	2	2	3	3	1	2	3	4	3	2	2	1	2	2	2	2	3	1	3	1	1	2	1	3	1	2		1	1	46

Domestic Scan 2022-02: Experiences in the Use of Digital Construction Management (DCM) in the Highway Industry - Summary of Phase I Survey																																						
Augmented Reality/Virtual Reality (AR/VR) for project visualization	4	3	2	5	4	4	1	1	1	1	3	1	1	3	2	2	1	2	3	2	2	2	1	1	1	2	2	1	1	1	1	1	2	1	40
Laser scanning for inspection and construction scheduling	4	1		5	1	2	1	3	3	1	3	1	1	1	1	2	1	2	2	2	2	2	1	1	1	1	2	1	2	1	2	1	1	1	36
Automated Design process through rapid engineering modeling	3	5	3	2	2	1	1	1	4	1	2	1	1	1	3	1	1		1	4	1	1	1	1	1	2	1	1	2	1	1	1	1	1	32
Project Simulation and Staging	2	1	2	4.5	2	3	2	2	1	2	3	1	1	2	2	2	1	2	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	34
Robotics	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	3	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	30
State totals	98	92	88	85.5	85	84	83	82	82	80	78	77	75	75	71	69	69	66	65	63	62	61	60	60	59	59	57	55	54	51	48	48	47	34	
	MA	FL	MT	NY	PA	CT	MD	MN	WA	UT	CA	HI	NH	MI	OH	WV	IL	NE	AR	KY	ND	IA	GA	ME	WY	OK	NC	RI	TN	SC	SD	VA	NV	AL