BEYOND THE BLUEPRINT

NAVIGATING THE FUTURE OF CONSTRUCTION DIGITAL DELIVERY AT MDOT

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16. Abstract

MDOT embarked on this initiative with the goal of assessing potential impacts of technology solutions to enhance its operations – including improved outcomes and worker safety, reduced time to resolve issues, increased collaboration, and cost savings. A project team led by CRAFT, Michael Baker International and Spicer Group evaluated MDOT's construction processes, seeking to better understand the department's needs; investigated technology and equipment used by other DOTs in addition to out-of-industry case studies; conducted field demonstrations to test potential solutions; and developed a series of recommended actions to enable MDOT to realize its digital delivery as part of its Digital Vision.

The digital landscape is undergoing a transformation, driven by rapid technological evolution and shifting societal norms. This marks a turning point in how DOTs operate and underscores an urgency for agencies to adopt a digital-first approach – not only to keep pace with – but also to anticipate and shape the future of transportation in an increasingly connected world. MDOT's own research indicates approximately 33% of its workforce will retire within the next year. The next generation of talent values a technology-driven and innovative workplace. MDOT is meeting this gap by prioritizing its evolution with the introduction of a Digital Vision strategy.

Michael Baker International and Spicer Group provided deep subject-matter expertise in the transportation and infrastructure sectors, leveraging their experience working with MDOT and other DOTs while CRAFT contributed broad, cross-sectoral perspective about how companies are using digital innovation to drive operational improvements. The team researched case studies from both the public and private sectors (both primary and secondary sources), and conducted field investigations and in-person workshops – informing a view of how digital solutions can be implemented to meet MDOT's challenges now and in the future.

Key to advancing digital delivery at MDOT was to understand the department's pain points, allowing the project team to develop solutions tailored toward addressing gaps and issues. Through a process that included a series of conversations with MDOT staff, the team mapped key observations across the four core components of the FHWA BIM for Infrastructure roadmap: people and skills, policy and process, tools and technology, and data and standards. Common themes include:

- Enhance adaptability across all positions to ensure workers possess the necessary skills
- Streamline processes by minimizing redundancies
- Eliminate redundant data entries and refine deliverables
- Improve data transfers and network accessibility

The report is designed to be put into action to enable field staff through the digital transformation. In preparing for the report, the project team was guided by an understanding that the success of MDOT's digital delivery efforts is about more than introducing new technology into everyday use. Just as important are considerations about people and process. Who bears the ultimate responsibility for executing each task associated with this plan, and who might be held accountable for ensuring recommendations are implemented? To answer these questions, the report expands on the idea of change management, focusing on the implementation of processes to review, evaluate, and coordinate change. It aims to maximize user benefits, reduce errors, and overcome institutional and cultural barriers to encourage more staff to accept change.

Digital delivery has the potential to enable a more intuitive connection between MDOT's workforce and technology, representing a real opportunity to change the way MDOT operates for the better. If executive effectively, a digital delivery strategy can improve the way field staff approach their work, improving their safety, and ultimately, making their jobs more efficient and fulfilling.
As MDOT continues its journey through digital evolution, the findings of this digital delivery research project have the potential to become a foundational turning point that will allow MDOT to better meet public infrastructure and transportation needs, stay relevant, address talent shortages, and streamline overall operational efficiencies.

End users will find that the results and recommendations of this research can:
- Equip field staff with digital data capabilities tailored to their specific roles.
- Streamline user experience with state-of-the-art tools and improved processes for enhanced safety, efficiency and cost savings.
- Enhance connectivity with AASHTOWare for improved project documentation and execution.
- Improve integration with other tools (SYNCHRO, BIM360, vGIS, Sitevision, and Quadri).
- Optimize current technology use to support digital delivery outcomes.
- Identify new tools, software, and hardware to improve MDOT's digital efforts.
- Align digital delivery with broader mobility trends in Michigan for improved infrastructure.
- Improve statewide collaboration across different TSCs.
- Enable MDOT to regularly update its practices to keep pace with technology advancements.
- Guide budgetary decisions for sustainable technology funding.

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CHAPTER 1 **ABSTRACT AND INTRODUCTION**

Technology is evolving rapidly, creating opportunities for innovation, improved efficiency, and cost savings across virtually every enterprise. This includes the transportation sector, which is undergoing a profound transformation in the construction of bridges and roadways.

Digital delivery for infrastructure projects refers to the use of digital technologies to streamline and enhance the planning, design, construction, and maintenance of infrastructure projects. It encompasses the integration of digital tools, processes, and data management practices throughout the project lifecycle with the aim of improving project efficiency, reducing costs, enhancing collaboration among stakeholders, and increasing the quality and sustainability of construction projects.

Meeting the moment, in 2023, the Michigan Department of Transportation (MDOT) embarked on a landmark digital delivery initiative with the goal of assessing the potential impact of a suite of technology solutions on its operations. "Digital delivery" describes the integration of digital technologies and processes across a project's lifecycle to enhance efficiency, collaboration, and outcomes. While its applications vary widely, some fundamental truths about digital delivery remain. When implemented as part of a holistic strategy, digital delivery has the potential to improve outcomes, reduce time to resolve issues, improve worker safety, increase collaboration, and deliver significant cost savings.

In support of these construction digital delivery and technology research and planning efforts, a project team led by CRAFT, Michael Baker International, and Spicer Group spent more than a year evaluating MDOT's construction processes, seeking to better understand the department's needs. During this period, we also investigated common technology and equipment in use by other departments of transportation in addition to relevant "out-of-industry" case studies from sectors like logistics and testing, inspection, and certification. We conducted field demonstrations to test potential solutions, such as survey equipment powered by light detection and ranging (LiDAR), photogrammetry, and other data collection systems. And finally, in close consultation with MDOT, we developed a series of recommended actions to enable MDOT to realize its digital delivery as part of MDOT's Digital Vision. This complete body of research, along with our key findings, are summarized in the pages of this report.

In preparing this report, we were guided by a keen understanding that the success of MDOT's digital delivery efforts is about more than introducing new technology into everyday use. Just as important are considerations about people and process: Who bears the ultimate *responsibility* for executing each task associated with this plan, and who might be held *accountable* for ensuring that its recommendations are implemented? To answer these fundamental questions, this report expands on the idea of change management, focusing on the implementation of processes to review, evaluate, and coordinate change. It aims to maximize user benefits, reduce errors, and overcome institutional and cultural barriers to encourage more staff to accept change. Furthermore, recognizing that digital delivery requires a significant upfront investment, the report recommends a series of funding strategies to pay for upgrades to current and future tools, technologies, software, and hardware.

Digital delivery has the potential to enable a more intuitive connection between MDOT's workforce and technology, representing a real opportunity to change the way MDOT operates for the better. If executed effectively, a digital delivery strategy can improve the way field staff approach their work, improving their safety, and, ultimately, making their jobs more efficient and fulfilling. As MDOT continues its journey through digital evolution, the findings of this digital delivery research project have the potential to become a foundational turning point that will allow the department to better meet public infrastructure and transportation needs, stay relevant, address talent shortages, and streamline overall operational efficiencies.

FROM PLAN TO ACTION: WHAT WE SEEK TO ACCOMPLISH

This plan is designed not just to exist on paper but to be put into action to enable field staff through MDOT's digital transformation. Therefore, it serves as a dynamic blueprint for MDOT, guiding it through the steps necessary to translate a vision of a digital future into a reality. Through a shared commitment to execution and continuous evaluation, MDOT can ensure that the strategies outlined within these pages will have a tangible impact, driving real progress and innovation across Michigan.

These are some of the main objectives of this action-oriented planning process:

- **Equip MDOT field staff with digital data capabilities tailored to their specific roles.**
- **Streamline user experience with state-of-the-art tools and improved processes for enhanced safety, efficiency, and cost savings.**
- **Enhance connectivity with AASHTOWare for improved project documentation and execution.**
- **Improve integration with other tools like SYNCHRO, BIM360, vGIS, Sitevision, and Quadri.**
- **Optimize current technology use to support digital delivery outcomes.**
- **Identify new tools, software, and hardware to improve MDOT's digital efforts.**
- **Align digital delivery with broader mobility trends in Michigan for improved infrastructure.**
- **Improve statewide collaboration across different Transportation Service Centers (TSCs).**
- **Enable MDOT to regularly update its practices to keep pace with technology advancements.**
- **Guide budgetary decisions for sustainable technology funding.**

1.1 **HOW TO USE THIS REPORT**

MDOT, CRAFT, Michael Baker International, and Spicer Group have closely collaborated to develop this report, which presents a comprehensive set of recommendations for the deployment of a digital delivery solution. This initiative aims to prepare MDOT field staff for a future that embraces technology in the construction of Michigan's bridges and roadways. This report is more than just a compilation of leading tools and technology. Rather, it includes important considerations about processes that will equip field staff with the funding and resources needed to achieve the desired outcomes of a digital delivery strategy. Its primary objective is to eliminate redundancies with the overall goal of increasing MDOT's capacity to deliver on its mission of "serving and connecting people, communities, and the economy through transportation."

We encourage everyone at MDOT to keep in mind that there is "freedom within the framework" of this guide. This is especially true because of how rapidly immersive technologies tend to evolve — and because new solutions and vendors are likely to manifest in the coming years. To that end, we have provided guidance in this report that will enable MDOT to continually evaluate new tools and equipment available. This will also help MDOT identify and evaluate future funding and grant opportunities that may help accelerate the department's ability to implement emerging technologies.

1.2 **WHAT THIS REPORT IS NOT**

The needs of a technology transformation program will always vary and evolve depending on stated goals and expected outcomes, and this digital reality solution implementation guide is certainly no different. Therefore, our current understanding of this solution might shift as we progress through the implementation stages. Additionally, the rapid pace of technological advancement and the emergence of innovative technologies, such as artificial intelligence (AI), necessitate continuous exploration beyond the immediate boundaries of this project.

This once again reinforces the concept of "freedom within the framework," underscoring the importance of utilizing this guide as a set of flexible recommendations rather than hard, fast rules. Consequently, this document should be viewed not as a one-size-fits-all blueprint but as a foundational resource for deploying a range of digital solutions at MDOT.

By embracing flexibility, MDOT can better navigate the complexities of digital transformation, leveraging emerging technologies to enhance its capabilities and service delivery. This document can serve as a vital tool in the journey, providing guidance while accommodating the evolutionary nature of technology and the unique challenges and opportunities that may arise during implementation.

1.3 GLOSSARY OF TERMS

The following glossary clarifies common terms you'll find throughout this document:

3D MODELING

The process of creating a three-dimensional representation of an object or system using specialized software.

ACCOUNTABLE VS. CONSULTED VS. RESPONSIBLE

Accountable roles are involved with setting strategy, direction, and governance at a director or manager level, ensuring tasks are completed by providing overarching leadership.
Consulted roles might be included in the chain of decision-making authorities before a strategy is finalized but do not share responsibility for developing or executing strategies.
Responsible roles pertain to the obligation to execute assigned tasks at a grassroots implementation level.

AUGMENTED REALITY (AR)

A technology that superimposes a computer-generated image on a user's view of the real world, providing a hybrid view of a technologically enhanced environment.

BLUEBEAM

A software application that provides advanced PDF solutions for markup, editing, and collaboration in the architecture, engineering, and construction industries.

BUILDING INFORMATION MODELING (BIM)

A collaborative work method for structuring, managing, and using data and information about transportation assets throughout their lifecycle.

A process supported by various tools, technologies, and contracts involving the generation and management of digital representations of physical and functional characteristics of places.

CASE STUDY VS. USE CASE

A *case study* is an in-depth analysis of a particular tool or project highlighting the processes, challenges, and outcomes to draw insights and lessons.

A *use case* is a detailed scenario describing how a product or system can be used to achieve a specific goal or solve a problem from the end-user's perspective.

CHANGE MANAGEMENT

The implementation of processes to review, evaluate, and coordinate changes to products, applications, and systems, with a strategy aimed at maximizing user benefits, reducing errors, and overcoming institutional and cultural barriers to encourage staff acceptance of progress.

COMPUTER-AIDED DESIGN (CAD)

A technology used for creating, modifying, analyzing, and optimizing designs with precision and efficiency through computer software.

DATA COLLECTORS

Devices used in the construction industry to gather and store various types of spatial location data, such as measurements, conditions, and progress, to enhance project management and decision-making.

1.3 **GLOSSARY OF TERMS**

DATA EXCHANGE
The process of sharing and transferring data between different people and components within an organization to enhance interoperability, efficiency, and decision-making across geographies, departments, and projects.

DATUMATE
A construction technology company providing a cloud-based photogrammetry platform, DatuBIM, that leverages drone mapping and data analytics to enable efficient monitoring, collaboration, and management of infrastructure projects.

DIGITAL AS-BUILT (DAB)
A comprehensive 3D model that represents the exact current state of a building or infrastructure, created using technologies like laser scanning, photogrammetry, or conventional collection methods to document changes and aid in management and improvement efforts.

DIGITAL DELIVERY
The process of utilizing digital processes, tools, and platforms to streamline and enhance the distribution and implementation of services, products, or content, ensuring efficient, accurate, and timely delivery to end-users or stakeholders.

DIGITAL REALITY
An umbrella term that encompasses a spectrum of reality-creating technologies, including AR, virtual reality, 360-degree video, etc.

DIGITAL TWIN
A virtual representation of an object or system that spans its entire lifecycle, is updated in real-time using live data, and uses simulation, machine learning, and reasoning to help inform decision-making.

DRONE PHOTOGRAMMETRY
The science of using a remotely operated flying device to take measurements from photographs. In construction, applications include surveying, monitoring construction progress, and capturing high-resolution images or data of sites. Aerial drones are piloted by drone operators who are responsible for navigating drones, ensuring safety, and managing the collection of accurate and useful information.

GEOSPATIAL INFORMATION SYSTEM (GIS)
Computer- and database-driven tools used to store, visualize, analyze, and interpret geographic data.

IMMERSIVE TECHNOLOGIES
Tools such as AR and VR that enable users to view or interact with simulated environments or objects.

KNOWLEDGE MANAGEMENT (KM)
Methods of organizing, creating, sharing, using, and managing the collective information of an organization.

LIDAR VS. PHOTOGRAMMETRY
LiDAR (Light Detection and Ranging) collects data that can be used to create detailed 3D models for various applications and industries.

Photogrammetry is a technique that uses photographs to measure and create accurate 3D models or maps of physical objects and environments.

1.3 GLOSSARY OF TERMS

OPENROADS DESIGNER
A software solution offered by Bentley Systems for civil infrastructure design.

POST-PROCESSED KINEMATIC (PPK) VS. REAL-TIME KINEMATIC (RTK)
Post-Processed Kinematic (PPK) is a GPS correction technology technique that calculates the precise location of data points collected by a GNSS receiver. Unlike real-time methods, PPK requires data to be analyzed after collection, allowing for corrections to be made by comparing the recorded data to that of a base station's known location, thereby achieving high levels of accuracy in positioning.

Real-Time Kinematic (RTK) is a GPS correction technique that provides real-time corrections to location data as it is being collected by the GNSS receiver. This method uses a fixed base station and a mobile unit to transmit corrections, enabling centimeter-level precision in positioning. RTK is beneficial for applications requiring immediate and highly accurate geographic information.

PROOF OF CONCEPT VS. PILOT PROGRAM
A *proof of concept* is an initial phase of exploration and discovery that precedes a pilot program, aimed at establishing whether an idea is fundamentally viable without necessarily proving its ultimate feasibility.

A *pilot program* is the implementation of a specific project under defined specifications and guidelines to validate the feasibility of an idea, building upon the outcomes of a proof of concept.

PROPELLER
A cloud-based workspace where project and production teams meet to map, measure, and manage site activity with survey data. Built around an easy-to-use platform, it combines GIS and survey technologies into an interactive map that everyone can understand and use to make informed decisions.

SYNCHRO
Construction management software from Bentley that helps teams plan and manage people, materials, and equipment. It's a digital platform that helps streamline and synchronize the entire construction lifecycle, from field to office.

TRIMBLE
A provider of AR solutions, including software, hardware, and services that support several global industries including building and construction, agriculture, government, and transportation.

VGIS
An augmented reality platform that transforms GIS data into immersive visualizations, enhancing asset location, infrastructure design, and project implementation through tailored, mixed-reality applications.

VISUALIZATION
Any technique for creating images, diagrams, or animations to communicate a message.

1.4 **MDOT PAIN POINTS**

Key to advancing digital delivery at MDOT is understanding the department's pain points, allowing the project team to develop solutions tailored toward addressing critical gaps and issues. Through a discovery process that included a series of conversations with MDOT staff, the project team systematically mapped key observations across the four core components of the Federal Highway Administration (FHWA) BIM for Infrastructure roadmap: people and skills, policy and process, tools and technology, and data and standards. This approach aimed to identify and address the core challenges that hinder the effectiveness and efficiency of MDOT's digital delivery mechanisms.

COMMON THEMES AND OBJECTIVES THAT EMERGED FROM THIS PROCESS ARE OUTLINED BELOW:

Network access and data transfers aren't seamless in my location. **How can this be fixed?**

There's got to be a way to improve workflow with fewer redundancies for tracking and data entry.

How can I find the file I need?

How can I get large files onto the data collector without having to break them into smaller files for USB?

Remind me how the data collectors work for an old project I worked on.

PEOPLE AND SKILLS
Enhance adaptability across all positions to ensure workers possess the necessary skills to effectively utilize various tools and equipment.

TOOLS AND TECHNOLOGY
Eliminate redundant data entries and refine deliverables to reduce or eliminate the need for segmenting large files for transfer via USB drives.

POLICY AND PROCESS
Streamline processes by minimizing redundancies, simplifying the steps required to complete tasks.

DATA AND STANDARDS
Improve data transfer and network accessibility, recognizing that digital delivery methods may vary in effectiveness across different regions of the state.

When adopting new technologies and processes, it is important to be mindful of certain requirements and limitations to ensure the success of a digital delivery initiative. This is especially true in the public sector, where government agencies are ultimately accountable to the citizens who entrust them with the responsibility of acting in society's best interests.

For instance, the utilization of aerial drones and advanced data visualization tools emerged as an early solution in our research. Yet, this necessitates careful navigation of data-sharing agreements, which are critical to delineate ownership, usage rights, and the permissible scope of data utilization by vendors, especially when MDOT's data is integrated into external environments or tools. Consequently, robust security considerations and formal agreements are indispensable to safeguard MDOT's interests and data integrity. Furthermore, participants in this study have made it clear that making recommended solutions accessible via cloud-based platforms could facilitate ease of access and integration into MDOT's existing systems. This suggestion brings network security to the forefront, demanding stringent security measures for any cloud-based solutions to protect against potential breaches and ensure data privacy.

Security and privacy are hardly the only requirements and limitations of this digital delivery effort. Additionally, the successful adoption of these technologies hinges on workforce engagement through comprehensive training and onboarding programs. This underscores the importance of change management strategies that not only address the technical skills needed but also foster an organizational culture adept at navigating technological shifts. Ensuring continuous training and developing an action plan for long-term sustainability are vital components to maintain the momentum of MDOT's digital transformation efforts, guaranteeing that the department remains equipped and agile with future shifts in the world of technology.

CHAPTER 2 **BACKGROUND & PRELIMINARY RESEARCH**

The digital landscape is undergoing a profound transformation, driven by rapid technological evolution and shifting societal norms. This evolution marks a turning point in how departments of transportation operate and underscores a pressing urgency for agencies to adapt to a digital-first approach. This broad view of technology's advancement emphasizes the critical need for DOTs to not only keep pace with — but also to anticipate and shape — the future of transportation in an increasingly connected world.

> **ACCORDING TO MDOT'S OWN INTERNAL RESEARCH, APPROXIMATELY 33% OF ITS WORKFORCE IS ELIGIBLE TO RETIRE WITHIN THE NEXT YEAR, POTENTIALLY EXACERBATING A SKILLS GAP THAT HAS ALREADY WIDENED IN RECENT DECADES.**

However, the industry faces several challenges that further compound the urgency for digital transformation. A significant workforce deficit, exacerbated by an aging workforce, is just one obstacle. According to MDOT's own internal research, approximately 33% of its workforce is eligible to retire within the next year, potentially exacerbating a skills gap that has already widened in recent decades. Government agencies like MDOT are also searching for new ways to adapt to shifting work dynamics, including the growing popularity of remote and flexible worker arrangements that are impacting all industries. While this has limited applicability in the construction sector — for example, engineers might be able to perform some work remotely, whereas field staff cannot — providing room for flexibility, when possible, is essential. The next generation of talent prioritizes flexibility and values a technology-driven and innovative workplace.

Seeking to develop a foundational understanding of the evolving digital landscape and the potential impacts and opportunities it presents for MDOT's digital delivery journey, the project team took a collaborative approach. Michael Baker International and Spicer Group provided deep subject-matter expertise in the transportation and infrastructure sectors, leveraging their experience working with MDOT and other departments of transportation, while CRAFT contributed broad, cross-sectoral perspective about how aerospace, mobility, energy, service-based, and technology companies are using digital innovation to drive operational improvements. The inclusion of multiple case studies from both the public and private sectors creates a 360-degree view of how digital solutions can be realistically implemented to meet MDOT's challenges — both today and in the future.

2.1 **BEYOND DOTS: PRIVATE SECTOR CASE STUDIES**

It is essential for those in the public sector to draw inspiration and best practices from the private sector, whose approach to technology adoption and innovation tends to operate within an accelerated innovation cycle thanks to a greater tolerance for accepting risk — especially where there is potential to maximize revenue growth.

In this section, we explore relevant case studies from eight different private-sector companies — including e-commerce giant Amazon; energy corporation Exelon Clearsight; and testing, inspection, and certification company Bureau Veritas — and summarize key takeaways for MDOT in its pursuit of a digital future.

2.1.1 MINIMIZING RISK WITH REMOTE INSPECTIONS

Company: Bureau Veritas
Industry: Testing, inspection, and certification (TIC)
Use Case: Robotic and remote inspections
Benefits: Derisk, save costs, reduce manpower

There is a heightened level of risk associated with conducting manned inspections of any industrial site. To minimize the chance of worksite accidents, Bureau Veritas — a global leader in the TIC sector — is pioneering new ways to survey project sites using robotics and VR headsets.

For its telecommunications clients, Bureau Veritas' proprietary RopeScan® robotic device attaches itself to broadcast towers, combining high-definition digital cameras with the power of magnetic flux leakage technology to give inspectors both a visual and scientific reading on the health of structural guy wires. The company deploys similar technologies to survey bridges, post-tension tendons, cracks, and columns, bringing the benefits of robotics to clients that work in building, roadway, and infrastructure maintenance.

For its oil and natural gas clients, Bureau Veritas is leveraging Microsoft HoloLens, an untethered mixed reality headset, to remotely connect technicians and engineering teams to collaborate on diagnostics testing, reducing the number of people deployed in the field. The smartglasses, which offer mixed-reality capabilities, present an AR hologram that allows inspection engineers to visualize components, comprehend inspection criteria, and examine cross-sections of assets. Moreover, by introducing defects, Bureau Veritas can expand the training scope and offer unprecedented learning opportunities. This use case was proven to be especially relevant during the pandemic, enabling collaboration amid a public health crisis, and its use has only expanded in recent years as more people are working remotely across greater distances.

Bureau Veritas works across many industries, including building and infrastructure. They have found that workplace safety can be significantly improved and accidents can be prevented when the use of humans is limited in certain inspection scenarios. By deploying robotic and remote inspections, companies can also experience significant cost savings, contributing to their future financial health.

[READ MORE]

2.1.2 BUILDING CONFIDENCE THROUGH DRONE INSPECTIONS

Company: Exelon Clearsight
Industry: Energy
Use Case: Remote inspections
Benefits: Derisk, save costs, reduce manpower

Maintaining the safety of the world's nuclear facilities relies on periodic inspections, which help identify potential defects in nuclear infrastructure before they're allowed to develop any further. However, inspections of nuclear sites can be complex, expensive, and high-risk due to potential exposure to radiation. Inspectors must follow specific codes that lay out the guidelines and requirements for conducting inspections.

One of the more complicated nuclear inspections is that of a nuclear site's containment building, which must be done according to American Society of Mechanical Engineers (ASME) code. To address these challenges, inspection experts from Exelon Clearsight conducted a containment building inspection using the Elios 2, an indoor inspection drone by manufacturer Flyability that is specifically designed to perform inspections in confined spaces. This approach was safer, more efficient, and less resource-intensive, reducing the need for inspectors to directly collect visual data. In two weeks, using a team of just four people, they inspected all 40,000 square feet of the containment building, taking high-resolution photographs of over 150 areas of interest, and ensured 100% coverage of the structure.

The use of the Elios 2 drone by Exelon Clearsight enabled their client to improve safety, speed, access, and data quality, while also reducing work hours and overall complexity. This successful project shows how technology can be used to address complex problems and achieve better outcomes.

[READ MORE]

2.1.3 OPTIMIZING BUILDING CONSTRUCTION WITH DIGITAL DELIVERY

Company: Procore
Industry: Construction management software
Use Case: Project management
Benefits: Enhance communication, save time

The building construction industry is undergoing a significant transformation, with developers and contractors assembling more data than ever before. Powered by technologies like 5G, BIM, and on-site sensors, building owners, contractors, and subcontractors have never had as many digital tools at their disposal. However, how they make use of this data will determine their success, regardless of whether they are a small regional operator or a large multinational corporation.

Despite the trend toward digitalization, around one-third of the construction industry still uses paper to capture, track, and manage data, according to construction management software company Procore. This inefficient use of data and lack of access to appropriate technology means that many are missing out on immense efficiencies and falling behind the global trend.

Companies like Procore are helping the building construction industry better connect project stakeholders to one another, break down silos, and build trust by centralizing access to a single, shared data exchange. The platform includes a full suite of project management tools, such as timelining and task assignments, along with instant access to reliable BIM data on any device. It's changing the way project stakeholders approach their work, resulting in as much as 49% more construction volume and saving an average of 15 days on construction projects, according to one study.

[READ MORE]

2.1.4 USING ROBOTICS TO MAINTAIN ROADWAYS

Company: SealMaster and Pioneer Industrial Systems
Industry: Sealant manufacturer and robotics company
Use Case: Road construction
Benefits: Derisk, increase efficiency, reduce manpower

Centers for Disease Control and Prevention (CDC) data reveals that traffic crashes result in more than 100 roadside construction worker deaths each year. Driven by the opportunity to save lives, SealMaster and Pioneer Industrial Systems developed the CrackPro Robotic Maintenance Vehicle (RMV) to automate crack sealing on roads, which minimizes labor and keeps crew members safe.

The RMV features an AI vision system, a robotic arm, and a heated hose that dispenses crack sealant after the automated blower system cleans cracks for sealing. The vehicle is equipped with a FANUC R2000 robot, generator, integrated blow-off system, and LED safety lights.

According to the company, the RMV can seal cracks more quickly than a manual crew. It only requires a driver to operate the truck and a worker to monitor the sealant application and refill the crack sealant tank, reducing the number of workers needed to repair roadways.

[READ MORE]

2.1.5 EXPANDING INTERNET ACCESS WITH CRADLEPOINT/IMCON IOT-ENABLED BACKPACKS

Company: Imcon International and Cradlepoint
Industry: Communications
Use Case: Remote Internet access
Benefits: Reliable Internet connectivity, network security

Across the public sector, first responders and other workers in remote areas worldwide rely on Internet access to get the job done. Built with these critical audiences in mind, Imcon International, an immediate connectivity solutions provider, developed self-contained Internet Backpacks that enable connectivity outside of wired networks.

Imcon relies on edge networking solutions that match the agility, reliability, and robustness of their proprietary services, and uses Cradlepoint's cloud-delivered mobile networking solutions — which include cellular-enabled multi-WAN routers, NetCloud Manager, and 24x7 support — in all of its Internet Backpacks. This is the most efficient and cost-effective way to help users stay connected from almost any location on the planet.

Imcon's self-powered and self-contained Internet Backpacks are equipped with various technology tools, including a high-powered lithium-ion battery, a 50-watt foldable solar panel for recharging the battery when standard AC recharging is unavailable, off-grid communication devices, power adapters, AC adapters, USB cables, international converters, at least two smart devices such as cell phones or tablets, and a small satellite connectivity device. To bring all of these pieces together and keep key apps connected, Imcon required an all-in-one edge routing solution that supports cellular-based broadband, satellite, Wi-Fi, and GPS.

Imcon knew that the global distribution of these Internet Backpacks required a robust network management system that would enable its IT team or its customers' in-house teams to remotely monitor and troubleshoot connectivity challenges. In case of any issue with connectivity or Imcon's edge solution, the company relies on Cradlepoint's 24/7 support services, which offer phone and online assistance. Additionally, Cradlepoint Connect, a community platform comprising best practices, how-to guides, and expert advice from both Cradlepoint professionals and industry peers, is also available for collaborative interaction.

[READ MORE]

2.1.6 SIMULATING REAL-WORLD CONDITIONS USING UNREAL ENGINE

Company: Unreal Engine
Industry: Computer graphics
Use Case: Simulation and training
Benefits: Derisk, save costs, save time

Researchers at the University of Warwick (Coventry, England) have combined real-world driving with simulation technology to safely and cost-effectively test autonomous driving software. The university's Intelligent Vehicles Group built the 3xD Simulator, which allows researchers to test autonomous systems in a synthetic environment.

The simulator links a vehicle to a simulated environment, which is displayed on a 360-degree screen via eight projectors. The simulator's approach allows researchers to include humans in the loop as drivers or passengers to determine how they interact with the technology and how much they trust it. It also allows researchers to test autonomous emergency systems by putting a person inside a physical car that they operate as if driving.

The simulator was built on Unreal Engine, an open and advanced real-time 3D creation tool for photoreal visuals and immersive experiences. Using Unreal Engine afforded researchers the flexibility to adapt the simulator as required to implement specific sensor or noise models or to have things in the virtual environment interact in a specific way. This model is applicable beyond the world of autonomous vehicles as a training tool that enables workers to interact with any number of real-world circumstances in a safe environment.

[READ MORE]

2.1.7 MINIMIZING INEFFICIENCIES AT BOEING USING AR

Company: Boeing
Industry: Aircraft
Use Case: Visualization
Benefits: Create efficiencies, reduce error rates

Each Boeing airliner contains an astounding 130 miles of wiring. This translates to tens of thousands of miles of wiring and millions of work hours required to fulfill a year's worth of aircraft orders. Boeing had transitioned from paper manuals to PDFs on laptops, but the same basic problems remained. Workers had to constantly look away from the asset to get directions and cross-check diagrams and schematics, and troubleshooting often required senior staff to perform on-site consultations.

To address these challenges, Boeing implemented AR-powered smartglasses. The glasses guide wiring technicians step-by-step through assembly and repair, enabling them to view how-to videos in their field of vision and keep their hands free to do the work. When extra help is needed, technicians simply turn on the "See What I See" video stream and share their views with engineers or other remote experts.

The smaglasses have enabled Boeing to cut production time by 25% and lowered error rates to nearly zero.

[READ MORE]

2.1.8 INTRODUCING NEXT-GENERATION ROBOTICS AT AMAZON FACILITIES

Company: Amazon
Industry: E-commerce
Use Case: Robotics
Benefits: Create efficiencies, derisk

Over the past decade, Amazon has made significant strides in incorporating robotics and technology into its operations to improve productivity, safety, and the overall customer experience.

The company's acquisition of robotics company Kiva in 2012 marked a pivotal moment in the company's digital innovation journey, and their commitment has continued with the introduction of several new technologies. Proteus, the first fully autonomous mobile robot, has been designed to navigate facilities safely and collaborate with employees. Its initial deployment will involve handling GoCarts — the non-automated, wheeled transports used to move packages through Amazon facilities — allowing employees to focus on more rewarding tasks. Cardinal, another robotic workcell, utilizes AI and computer vision to select, lift, read labels, and place packages in GoCarts, reducing the risk of employee injuries and improving sorting efficiency. Amazon Robotics Identification (AR ID) is an AI-powered scanning capability that streamlines package scanning, giving employees greater mobility and reducing the risk of injury. Additionally, the Containerized Storage System optimizes the retrieval of items by delivering them to employees in a more ergonomic and efficient manner.

Throughout the past 10 years, Amazon has maintained a steadfast commitment to enhancing the well-being of its employees and providing top-notch service to customers. Contrary to speculation, Amazon has not replaced people with robots but has instead added over a million jobs worldwide while integrating more than 520,000 robotic drive units across its facilities. The company's vision has always been about people and technology working together harmoniously to meet customer needs.

[READ MORE]

2.2 FIELD SCAN: RELEVANT RESEARCH FROM THE TRANSPORTATION SECTOR

When it comes to technology innovation in the transportation sector, the existing body of research is substantial. We began this project by conducting a national field scan to uncover relevant research from within the industry to gain a high-level understanding of how transportation agencies are addressing digital delivery. This section includes more than two dozen studies we analyzed as part of this project. It offers a summary of recent research conducted by MDOT along with national entities, including the FHWA and the American Association of State Highway and Transportation Officials (AASHTO).

2.2.1 MDOT SPR-1680: 3D HIGHWAY DESIGN MODEL COST BENEFIT ANALYSIS (2019)

A 2017 research project analyzed MDOT's use of 3D models to streamline project delivery and communicate design intent for highway construction. The study identified and evaluated costs and benefits through surveys, interviews, and historical data analysis, revealing that project sizes of $5 million to $20 million benefit the most from the use of 3D models, producing lower bids and fewer change orders than 2D plans. The calculated net benefit for MDOT's implementation of 3D models as reference information documents (RID) for the years 2012-2016 was over $18 million, resulting in a 32% ROI, meaning that for every dollar invested in 3D models, MDOT received a return of $1.32 cents. MDOT estimated that they would break even after just one year.

The research recommends education, collaboration, and a framework for internal collaboration and contractual 3D models to optimize benefits, including automated machine guidance (AMG), constructability reviews, public outreach visualization, survey layout, quantity take-off, and risk management. The findings emphasize the need for continued collaboration throughout design and construction, and provide supporting information for the development of a special provision that can be used as a fundamental step toward providing digital data as part of the construction contract. The recommendations were intended to help MDOT advance data integration and civil integrated management (CIM)/ BIM for Infrastructure, optimize the design documentation process, and improve processes for better risk management throughout digital project delivery.

[READ MORE]

2.2.2 DIGITAL REALITY SOLUTION IMPLEMENTATION PLAN FOR MDOT'S BLUE WATER BRIDGE (2023)

In 2019, the Blue Water Bridge (BWB) and MDOT began exploring a cutting-edge digital reality solution with HNTB, CRAFT and Michael Baker International, that could improve BWB operations and maintenance. MDOT's BWB is a large international crossing with challenging infrastructure to maintain. The facility faces limited resources and time, and maintenance crews rely on outdated, manual documentation processes that make it difficult to access maintenance knowledge. Meanwhile, design information has evolved significantly over the last 50 years, and the available workforce has become more limited. MDOT's BWB leadership and Engineering Support Services recognized the need to modernize their operations and support a range of engineering and maintenance workflows, making digital transformation and innovation a necessity for future success.

After four years of exploration and the development of the *Immersive Technology Integration Feasibility Study: Exploring Solutions for MDOT's Blue Water Bridge* in 2021, MDOT and BWB selected vGIS, a leading high-accuracy augmented reality software for CAD, BIM, GIS, and 3D scan, as the core platform for the solution. In the spring and summer of 2022, they conducted a proof of concept phase and drafted the *Digital Reality Solution Implementation Plan for MDOT's Blue Water Bridge*, which includes a detailed set of recommendations for deploying vGIS technology at the BWB. By equipping BWB staff with the ability to manage and maintain critical infrastructure, the solution can bring many benefits, including improving business outcomes, reducing time to resolve issues, reducing risk, increasing collaboration, and delivering cost savings.

The implementation plan is versatile and scalable and can be adapted for other technology deployments. It allows for "freedom within the framework" and can be customized for other technology projects across the MDOT enterprise, as new solutions and vendors are likely to emerge in the future. While the implementation plan is tailored to the deployment of vGIS as the digital reality solution for MDOT's BWB, it also serves as a customizable blueprint for similar technology projects.

[READ THE FEASIBILITY STUDY]

[READ THE IMPLEMENTATION PLAN]

2.2.3 BWB UTILITY MODEL (2018)

MDOT commissioned the design of a 3D utility model for the BWB, which connects Port Huron, Michigan, to Point Edward and Sarnia, Ontario. They selected the firm T2 Utility Engineers (T2ue), which specializes in managing and mitigating risk in the utilities industry, to provide subsurface utility engineering (SUE) services for the project.

T2ue's model covers all utilities in, on, and near the bridge, BWB properties, and the toll plaza. LiDAR was used to generate a single-point cloud and design survey of the U.S. toll plaza and surrounding properties. T2ue identified 100,000 linear feet of buried utilities and provided electronic depth measurements. They also assisted in identifying utilities in the utility tunnel beneath the toll booths.

The project faced scheduling challenges due to the COVID-19 pandemic, but the bridge is now fully operational, connecting the U.S. and Canada.

[READ MORE]

2.2.4 **TPF-5(372): BIM FOR BRIDGES AND STRUCTURES POOLED FUND (2017)**

The American Association of State Highway and Transportation Officials Committee on Bridges and Structures (AASHTO COBS) has embarked on a project to standardize the use of BIM for Infrastructure. While BIMs have been used in commercial and vertical construction, their use in transportation infrastructure is limited due to a lack of standardization.

To take advantage of the efficiencies associated with the use of BIM in transportation structures, AASHTO COBS is developing a comprehensive strategic plan. The initiative — called "BIM for Bridges and Structures" — will involve the identification of a governance structure overseen by AASHTO's technical committee on technology and software (T-19), in collaboration with the AASHTO Joint Technical Committee on Electronic Engineering Standards (JTCEES), FHWA, and various stakeholders. The initiative has used the Industry Foundation Classes (IFC) data model to develop an Information Delivery Manual (IDM) that provides IFC developers with the requirements about bridge elements and their properties. This enabled the IFC developers to generate a Model View Definition (MVD) compliant data exchange schema for the design-to-construction exchange.

The pooled fund project has provided primary funding for governance and stewardship of "BIM for Bridges and Structures." The work has included developing national standards, guidelines, and manuals for the use of IFC as an exchange standard in BIM for Bridges and Structures on bridge projects. The initiative also collaborated with stakeholders to provide timely updates of IFC data dictionaries for common bridge elements; design training for model development, management, and usage; and provided technical support for pilot/demonstration projects for bridge owners.

The project aims to provide a work plan, progression schedule, and coordinate web and face-to-face meetings with T-19 on the development and implementation of BIM for Bridges and Structures. The ultimate goal of the initiative is to encourage and accelerate the adoption of BIM for Bridges and Structures, and provide time and cost savings to transportation bridges and structures owners.

[READ MORE]

2.2.5 **FHWA DABS (2021)**

DABs are an initiative introduced by the FHWA's Office of Transportation Workforce Development and Technology Deployment in 2021. The initiative aims to shift transportation professionals toward a digital data-oriented process for tracking, documenting, and archiving asset information created during project delivery, with the promise of improving quality, accelerating project delivery, saving costs, and enhancing safety.

Digital asset data consists of structured, semi-structured, and unstructured data ranging from geometric objects, attributes, proprietary/open formats, document/flat files, and unstructured data. These data provide useful lifecycle facility asset inventory information for data management that are accessible, searchable, geospatial, contextual, reliable, durable, extractable, and interoperable. DABs have many essential uses, such as the geospatial location of assets, 2D/3D visual model use in the field, verification of field quantities linked to pay quantities, survey/model with attributes to systems of record, and survey/model asset extraction to/from GIS/asset management software (AMS). These are key in the handover from the design-construction project information model (PIM) to the asset information model (AIM).

The project is part of Every Day Counts 6 (EDC6), an initiative of the FHWA designed to identify and deploy innovation aimed at reducing the time it takes to deliver highway projects, enhancing safety, and protecting the environment.

[READ MORE]

2.2.6 AASHTOWARE DATA INTEGRATION FRAMEWORK (2018)

AASHTO initiated the AASHTO Data Integration Project in 2018 to identify interfaces that AASHTOWare products should have with each other and with other enterprise systems at State DOTs. WSP worked with the AASHTO Data Oversight Committee, Technical and Applications Architecture (T&AA) Committee, and State DOTs that use AASHTOWare products to identify the AASHTOWare interfaces that should be developed. The next step is to create the foundation for the development of these interfaces.

During Phase 2B, most AASHTOWare contractors will be available to work on concrete implementations resulting from the Swagger production environment.

The goal of the AASHTO Data Integration Project is to simplify the deployment of AASHTOWare products at State DOTs and ensure that best practices in data governance and management can be used for supporting AASHTOWare business users and processes.

[READ MORE]

2.2.7 NCHRP SYNTHESIS 20-05/TOPIC 52-19: TECHNOLOGICAL CAPABILITIES OF DOTS FOR DIGITAL PROJECT MANAGEMENT AND DELIVERY (2022)

A 2022 National Cooperative Highway Research Program (NCHRP) synthesis report examined the use of advanced digital construction (ADC) systems and technologies by U.S. DOTs.

The report found that there is no shortage of technology solutions available to DOTs, including those that support planning, design, maintenance, and asset management. An electronic survey, distributed to voting DOT members of the AASHTO Committee on Construction (COC), revealed programmatic and advanced use of technologies, such as electronic bidding, electronic construction document management systems, mobile devices for inspection and acceptance, and construction administration software. However, only five DOTs noted the existence of a strategic data-management approach or plan.

The report highlighted a disconnect between perceived benefits and those that have been quantified or realized. While benefits such as cost savings, reduced delays, reduced change orders, and reduced claims were highly noted as perceived benefits, few DOTs stated that they have actually quantified those benefits. Numerous challenges to ADC use were also noted, including high costs for hardware and software, insufficient knowledge or training for office staff and inspectors, and inadequacy of information technology infrastructure. Despite these challenges, the report finds that not a single DOT stated that their experiences have resulted in no performance improvement, and survey respondents stated that their use of 15 of the 16 ADC technologies or systems would expand or increase from current levels of use.

[READ MORE]

2.3 LESSONS FROM OUR PEERS: DIGITAL DELIVERY AT OTHER DOTS

The true test of digital delivery's potential lies in its real-world use. As MDOT looks for new ways to incorporate technology into its construction practices, it can benefit from learning how other DOTs have approached their digital delivery journeys — and the ways in which technology has enabled them to streamline routine processes and create safer and more productive workplaces.

In this section, we present case studies from five peer DOTs: the Minnesota Department of Transportation (MnDOT), the Florida Department of Transportation (FDOT), the Iowa Department of Transportation, the Utah Department of Transportation (UDOT), and the Georgia Department of Transportation (GDOT). These case studies are based on extensive surveying of each DOT and interviews with leaders from each agency, which took place in early 2023. We are grateful to these DOTs for their participation in this study.

EVALUATION CRITERIA

To fairly evaluate and compare each DOT's journey, we began by establishing a common framework for evaluating the success of various digital delivery efforts. We invited each DOT to complete a matrix, rating from 1 to 5 its level of satisfaction with various tools and equipment, with 5 being "very satisfied." Recognizing the critical importance of funding in supporting agencies' digital transformation, a third section asked agencies to rate their experience with several funding mechanisms commonly used by DOTs to fund technology integration.

This unified approach was meant to ensure consistency across our study but has clear relevance beyond this report, potentially aiding MDOT's ability to measure, evaluate, and benchmark its own digital delivery efforts going forward. Consequently, as we progressed through the research phase and our observations evolved, so too did this evaluation criteria, which are presented in this report. It may continue to evolve throughout the lifespan of MDOT's digital delivery journey; MDOT can adjust the evaluation criteria accordingly.

Use Cases	Tools (1–5 Rating)	Equipment (1–5 Rating)	Funding (1–5 Rating)
GPS locationing			
Payment collection / reporting			
Material certification / acceptance			
• Manufacturer / supplier			
• Test report			
Pay certification (quantity verification and calculation)			
• Lump sum			
• Each			
• Linear			
• Area			
• Volume			
TAMS collection			
Remote inspection / maintenance			
Virtual collaboration			
Data visualization			
Data exchanges			
• GIS to ORD			
• ORD to AASHTOWare			
• AASHTOWare to asset management software			
Data / File / Model storage			
Data collection			
• Pavement surface evaluation and rating			
• Roadway alignment			
• Cut and fill			
• Survey data			
• Ancillary structures			
• Weather data			
Payment collection / reporting			

For detailed information and complete matrix, including insights into how each DOT rated various tools, equipment, and funding, contact the MDOT project manager.

2.3.1 NAVIGATING CHURN IN MINNESOTA WITH STANDARDIZATION

Agency: MnDOT

USE CASES		BIM FOR INFRASTRUCTURE COMPONENTS	
	DATA ACCESSIBILITY		PEOPLE AND SKILLS
✓	DATA TRANSFER	✓	DATA AND STANDARDS
	FEED IDR	✓	POLICY AND PROCESS
	FEEDING TAMS		TOOLS AND TECHNOLOGIES
	CLOUD-BASED FIELD ACCESS		
	WORK TYPE ADAPTABILITY		
✓	ADJUSTING DELIVERABLES (LOCATION NEEDS)		

TOOLS:

Visualization:
- Trimble
- TrimbleConnect
- Investigating SYNCHRO
- Rover RTK systems

AMS:
- AgileAssets

Data Storage:
- AASHTOWare
- eTicketing
- ProjectWise

Data Exchange:
- AASHTOWare OpenAPI
- Rover RTK systems
- XML files
- USB/Network drives

EQUIPMENT:

- Windows-based tablets
- Laptops
- Mobile phones
- Trimble TSC7 and T100

BENEFITS:

- Standardized processes
- Improved workforce adoption
- Field adjustment adaptability
- Improved efficiencies
- Speed to implement
- Improved data accuracy and accessibility

COST:

- Medium

CURRENT PHASE:

- Internal testing and feasibility investigation

ADOPTABILITY:

- Moderate to difficult
- Months, years

KEY RELEVANCE:

- Standardized processes
- Usability and accuracy
- Similar data to construction issues as MDOT
- Create reliable models
- Workforce adoption and training

Narrative:

In Minnesota, a large number of state transportation workers have approached retirement age. Grappling with churn and recognizing that processes and practices can no longer reside only with individual staff members, the Minnesota Department of Transportation (MnDOT) has been focusing its efforts on standardization. Their goal: retaining institutional knowledge, ensuring smooth transitions, and streamlining operations across the department.

MnDOT's strategy focuses on three primary pillars: data standardization, process standardization, and technology standardization. To enhance data interoperability, MnDOT emphasizes the use of open APIs, facilitating seamless data exchange between systems. This approach ensures that data flows consistently and accurately from one system to another, reducing manual data handling and errors. In asset management, standardized data collection, storage, and usage practices ensure uniformity and reliability across the agency.

Centralizing processes is another key component of MnDOT's strategy. By establishing uniform procedures, MnDOT can easily train and implement standardized practices across different teams and districts. This reduces dependency on individual expertise and ensures a consistent approach to project execution. MnDOT is also fostering a cultural shift from individual-driven solutions to standardized, process-driven methods. This includes educating staff on the importance and benefits of adhering to standardized procedures.

On the technology front, MnDOT is standardizing the use of specific tools and equipment, such as Trimble software and Bluebeam for construction management. This ensures all teams are using the same technology, simplifying training and enhancing collaboration. Centralizing contracts for software and tools allows all teams to access the latest versions and benefit from new features and improvements. This approach not only improves efficiency but also ensures that the technology used is consistent and reliable across the organization.

The implementation of these standardization efforts follows a phased approach. Initial phases have involved internal testing and feasibility studies to gather feedback and assess practicality. Successful tests lead to proof of concept projects, where new processes and technologies are applied in real-world scenarios to validate their effectiveness. Once proven, these concepts are rolled out statewide, ensuring that all teams adopt the standardized practices. This phased approach allows MnDOT to gradually introduce changes while ensuring their viability and effectiveness.

The benefits of MnDOT's standardization efforts include improved efficiency, enhanced training and onboarding processes, consistent data management, and increased organizational resilience. By reducing the reliance on individual expertise and promoting standardized practices, MnDOT ensures that knowledge and processes are retained within the organization, making it more resilient to workforce changes. This proactive approach not only addresses the immediate challenges posed by workforce churn but also positions MnDOT as a forward-thinking organization capable of maintaining high standards of service delivery despite the evolving workforce landscape.

Contact the MDOT project manager for additional resources, including this DOT's responses to the evaluation matrix, a link to the recordings of our interview, links to state standards, and relevant research and information.

2.3.2 CREATING A FLEXIBLE — AND FORWARD-THINKING — APPROACH IN FLORIDA

Agency: FDOT

USE CASES		BIM FOR INFRASTRUCTURE COMPONENTS	
	DATA ACCESSIBILITY	✓	PEOPLE AND SKILLS
	DATA TRANSFER		DATA AND STANDARDS
	FEED IDR	✓	POLICY AND PROCESS
	FEEDING TAMS	✓	TOOLS AND TECHNOLOGIES
✓	CLOUD-BASED FIELD ACCESS		
	WORK TYPE ADAPTABILITY		
✓	ADJUSTING DELIVERABLES (LOCATION NEEDS)		

TOOLS:

Visualization:
- Trimble (Quadri, Connect Viewer and Business Center)
- SYNCHRO
- AR–Sightvision with LuminRT with Occulus
- Bentley OpenRoads Designer
- Civil 3D

AMS:
- TBD

Data Storage:
- Internal custom database

Data Exchange:
- Manual processes and XML formatting
- DOT custom-developed data connection

EQUIPMENT:

- iPads
- SurfacePros
- Leica and Trimble data collectors
- USB flash drives
- Email
- Portable hard drives
- FTP
- Bluetooth
- Cloud
- Document management system

BENEFITS:

- Saves lives, saves time, increases data, increases quality and accuracy of data, better collaboration and communication, cost savings

COST:

- High

CURRENT PHASE:

- Proof of concept, statewide implementation

ADOPTABILITY:

- Moderate to difficult
- Months, years

KEY RELEVANCE:

- Standardization of processes, people, and data exchange and looked back to organize internal structure to support a digital delivery / BIM culture
- Have a good feedback loop approach with continuous improvement embedded into their processes

Narrative:

Leveraging state resources, FDOT has advanced digital delivery and BIM for Infrastructure to a scale that exceeds many transportation departments across the country. This effort began a decade ago, when FDOT made the transition toward model-centric, 3D designs and created a set of initiatives to govern their digital delivery efforts across the state. They began with developing a digital delivery roadmap for the design team and immediately observed how modeling created a path toward better-quality designs.

Leveraging the success of their efforts in design, FDOT then expanded implementation from design to construction, recognizing that their contractors' work was bogged down by translating physical, 2D designs into 3D models. They began creating files for AMG and deployed them in the field. More recently, they have also tendered models as legal documents, creating efficiencies across yet another step in their process.

According to FDOT's staff, the key to their success has been piloting, testing, and gathering feedback. They gained acceptance through trial, which led to a happy medium that combines physical plans with digital assets that they have coined "NextGen Plans." Because they rely heavily on consultants to conduct design, they have also built flexibility into their process, creating expectations that are agnostic of the tools and methods needed to fulfill their objectives. This enables the state to partner with a wide range of contractors.

In terms of data collection, their procedures are evolving. FDOT has assembled construction, engineering, and inspection (CEI) teams that have identified readily available technology, developed CEI scope language, and identified more than 20 pilot projects throughout the state, with at least one project per district, for the first phase of the implementation plan. This phase was completed in Spring 2024 and involved using GNSS rovers, which provide golf ball-sized accuracy, for CEI verification and measurements alongside traditional methods to ascertain data at different levels of accuracy (LOA) standards, depending on the project scope. To ensure quality control, their CEI scope language involves a survey modeler, who will verify the information collected in the field — no matter the method of collection. The teams have found several benefits to advancing 3D CEI for digital collection and digital as-builts, including saving lives, time, and money; increased data, quality, and accuracy; and better communication and collaboration. At the time of this report, their recommendations are being summarized and will be used to develop the next phase of implementation. However, their initial findings conclude that rovers can be used, but should not be required, in lieu of traditional methods for field records as long as minimum requirements for field records are met.

The department has also created a broad set of digital delivery standards. They are one of the few State DOTs that do not use ProjectWise to advertise projects; instead, they archive CAD files from the design process and post the plans, project specs, and estimates in a different bidding server that contractors can access. Once a project is completed, the construction team uploads digital as-builts into a construction EDMS server, where they are stored indefinitely in a "digital filing cabinet." Furthering their commitment to flexibility, the contractor can either use a cloud platform or traditional USB drive to hand off data.

In terms of other emerging technologies, they have the capacity to use AR/VR with an Oculus headset, such as AltaVista and Trimble SiteVision, and recognize its benefits — especially when it comes to digital review. However, the technology is still emerging and isn't yet useful at the scale they need. Furthermore, they have found that some staff were not paying as close attention to where they were walking during their pilot of SYNCHRO, which could create a safety issue in the field. They have observed the same issue with physical plans, which underscores the broader importance of identifying a solution or safety process that accounts for awareness of surroundings.

As far as funding is concerned, they have a large work program budget with ample state funding, so they do not typically look for any federal grant funding. They contribute program funds toward pilot projects to support the testing of tools, and as they mature a concept out of the pilot, they add a percentage to their budgets to incorporate specific tools in the long run. They also look to add funding if downstream users are happy with the solution.

Contact the MDOT project manager for additional resources, including this DOT's responses to the evaluation matrix, a link to the recordings of our interview, links to state standards, and relevant research and information.

2.3.3 PILOTING A PATHWAY TO FULL ADOPTION OF DIGITAL DELIVERY IN IOWA

Agency: Iowa DOT

USE CASES		IMMERSIVE TECH POTENTIAL	
	DATA ACCESSIBILITY		PEOPLE AND SKILLS
	DATA TRANSFER	✓	DATA AND STANDARDS
	FEED IDR		POLICY AND PROCESS
	FEEDING TAMS	✓	TOOLS AND TECHNOLOGIES
✓	CLOUD-BASED FIELD ACCESS		
	WORK TYPE ADAPTABILITY		
✓	ADJUSTING DELIVERABLES (LOCATION NEEDS)		

TOOLS:

Visualization:
- AR tools including vGIS, SYNCHRO
- GIS
- Pix4D
- OnStation

AMS:
- Esri

Data Storage:
- Doc Express

Data Exchange:
- USB + ProjectWise

EQUIPMENT:

- Drones
- Data collectors
- AR tools
- Tablets
- Suitcase antenna booster signal

BENEFITS:

- Standardized data
- Improved field accessibility
- Industry-wide adoption of digital delivery
- Clash detection

COST:

- Medium to high

CURRENT PHASE:

- Internal testing and feasibility investigation, proof of concept

ADOPTABILITY:

- Moderate to difficult
- Years

KEY RELEVANCE:

- Use of Wi-Fi booster backpack, feedback on piloted processes

Narrative:

The Iowa Department of Transportation has made significant progress in incorporating digital delivery into its operations. Through a combination of Accelerated Innovation Deployment (AID) grants, State Transportation Innovation Councils (STIC) funding, and other federal and state funds, they have leveraged a rollout strategy that emphasizes the importance of thoroughly piloting tools and systems before making a firm commitment to one process or approach over another.

The Iowa DOT's digital evolution has been guided by a four-point roadmap to digitization, which prioritizes the following objectives:

1. Include output data to ArcGIS map, linear referencing system (LRS), and the Roadway Asset Management System (RAMS). Use 2D and 3D modeling technology to develop project information models sufficiently accurate for supporting models as legal documents.

2. Leverage existing department portfolio technology as much as possible and explore new tools when appropriate to support specific use cases.

3. Expand the data collection to manage asset inventory by capturing accurate digital models that represent the as-built conditions accepted during construction.

4. Develop and implement new information management processes that align with the department's data management goals.

Early on, Iowa DOT's digital delivery efforts illuminated the need for reliable Internet access in the field to support electronic ticketing. The department initially evaluated the potential of satellite communications but recognized that latency issues and data caps would stand in the way of the broad adoption of this technology. Instead, they utilized cellular networks and partnered with utility companies to adjust antennas according to where their technicians would need to gain signal access.

To further strengthen connectivity to the cellular network, they contracted RCN to deploy signal-boosting "suitcases" that can be deployed in areas where signal strength is unavailable. Based on technology that has been put to use in hurricane zones, the suitcases — which each contain a dual SIM, high power antenna — have proven successful in ascertaining a signal "where nothing else gets a signal." Iowa DOT obtained eight units (two for locals and one for each district) that can each be remotely managed by an administrator who has access to information about data usage and can troubleshoot issues as needed. The department leveraged an initial budget of $40,000, of which approximately $18,000 can be attributed to data subscription costs.

Iowa DOT does not have broad standardization of data accessibility, exchange, and process across the entire state. The department is still using FieldBook/FieldManager to handle payment, but for data transfer, their teams use a disparate combination of USB drives and ProjectWise. All other project information is uploaded and available for e-signature using Doc Express, which has fully replaced the need to exchange physical documents. They have experienced some latency issues with their use of these technologies in the field, especially when accessing large files using ProjectWise, due to the necessity of using a VPN. Therefore, the department's field staff has found it necessary to break down large models into smaller files in order to download them while on project sites.

In terms of data visualization in the field, Iowa DOT is testing several tools, including Bentley SYNCHRO (three pilot projects), vGIS (two bridge projects), and OnStation (two pilot projects). They have found some limitations with each tool, including SYNCHRO, whose interface makes it difficult to manipulate models, but they like the documentation capabilities of vGIS and the accuracy offered by OnStation. Iowa DOT's survey teams utilize TopCon surveying equipment for field collection and display the information using MAGNET software. They also leverage PIX4D for drone mapping and advocate PIX4Dcatch, which enables their inspectors to utilize their mobile phones as professional 3D scanners.

Iowa DOT describes its current approach as a "hybrid" model that combines digital and paper plans. Even as the agency's own staff makes progress with the adoption of digital delivery, contractors have been a barrier to the full rollout of their digital delivery roadmap. According to Iowa DOT, contractors like to physically mark up documents, and they are seeking greater data precision than vGIS can offer. To jumpstart a shift in thinking and develop a broader justification for going digital, Iowa DOT has leveraged industry-wide data and standards that show how the use of technology is creating efficiencies for other agencies. Iowa DOT acknowledges the need for more training and are also pursuing automation to expedite workflows and eliminate redundant efforts, which they hope will further strengthen the case for digital delivery.

Contact the MDOT project manager for additional resources, including this DOT's responses to the evaluation matrix, a link to the recordings of our interview, links to state standards, and relevant research and information.

2.3.4 REACHING MATURITY WITH DIGITAL DELIVERY IN UTAH

Agency: UDOT

USE CASES		IMMERSIVE TECH POTENTIAL	
	DATA ACCESSIBILITY	✓	PEOPLE AND SKILLS
✓	DATA TRANSFER	✓	DATA AND STANDARDS
	FEED IDR	✓	POLICY AND PROCESS
✓	FEEDING TAMS		TOOLS AND TECHNOLOGIES
✓	CLOUD-BASED FIELD ACCESS		
	WORK TYPE ADAPTABILITY		
✓	ADJUSTING DELIVERABLES (LOCATION NEEDS)		

TOOLS:

Visualization:
- ARCGIS
- Trimble
- SYNCHRO
- BIM360

AMS:
- Esri
- ATOM

Data Storage:
- ProjectWise
- SharePoint

Data Exchange:
- Primary: Cloud, FME
- As needed: Email or Document Management System to transfer specific cross-section or profile data

EQUIPMENT:

- Tablets
- ARCGIS
- SYNCHRO
- BIM360
- Drones
- SiteVision
- Datumate
- Propeller
- Sitescan
- vGIS

BENEFITS:

- Standardized data transfer process
- Improved accessibility
- Risk reduction
- Workforce readiness / competence related to technology usage

COST:

- Medium to high

CURRENT PHASE:

- Proof of concept, statewide implementation

ADOPTABILITY:

- Moderate
- Months, years

KEY RELEVANCE:

- Standardized process
- Workforce engagement

Narrative:

Among State DOTs, the Utah Department of Transportation (UDOT) stands out with one of the most mature digital delivery programs. Having investigated and tested many different tools and technologies over the years, they have developed broad awareness of the availability and feasibility of various tools, equipment, and processes.

The UDOT digital delivery journey began in 2013 with the adoption of what eventually became known as "BIM for Infrastructure." They initiated a series of workshops to discuss making electronic files available for current projects, which led to the pilot of a model-based contracting approach as part of a small project in southern Utah. Based on key learnings, they eventually rolled out a statewide process to advertise projects with models as the legal document, which led to a 25% reduction in project duration for their initial pilot project. They continue to use this model-based delivery strategy for all project types.

As the agency phased in the use of electronic documents, they initiated a statewide policy where they are no longer cutting sheets by default for pre-construction or construction. Instead, they prioritize providing the model as the primary document and are working toward a future where a complete set of files are attached from the moment a project is first advertised. They aim to build a culture where contractors ask for only what they need, and therefore, they only provide PDFs or RIDs as backups if necessary. UDOT's contractors have been critically involved in the department's digital delivery rollout, which has helped build trust and compliance from the start. They have also prioritized flexibility in their approach to digital delivery, empowering their contractors to utilize whatever tool works best for them.

Even as UDOT makes strides in standardizing processes and procedures at the state level, they have yet to find a visualization tool that meets all of their needs. For example, they initially piloted vGIS for a project but found that its capabilities were somewhat limited to mapping underground utilities. Wanting a tool that could be deployed across an entire project, they also piloted Trimble SiteVision, Bentley SYNCHRO, and Propeller but encountered similar challenges. As of early 2023, they are back at a stage of piloting many of these same tools to determine whether the technology has evolved enough to be applicable to their circumstances. In the meantime, they are effectively using GIS as a backup plan to fill gaps in technology.

UDOT and its contractors have increasingly adopted electronic devices such as laptops, tablets, and mobile devices to access information in the field. Rather than hiring surveyors on staff, UDOT relies on contractors to subcontract surveying work, minimizing the need to accumulate state-owned equipment. UDOT owns drones, powered by Site Scan for ArcGIS, resulting in significant cost savings. However, using drones comes with a technical burden, as many project sites intersect with airspace restrictions, requiring the state and its contractors to obtain permits before flight.

In the next chapter of its digital delivery journey, UDOT is focused on uniting the data they collect as an overarching priority. They are using the asset management database ATOM as their core interfacing tool, which leverages mobile LiDAR to populate the system and replace data with project information. To transfer and store data, a combination of email, cloud services, and ProjectWise is utilized. While ProjectWise is a useful system, the staff sometimes hesitates to use it due to slow speeds and bandwidth issues.

UDOT views its digital delivery journey as an iterative process, meaning they are focused on continuous improvement rather than aiming for perfection on the first attempt. Their ability to innovate is largely driven by the availability of resources, with the state seeking funding through STIC and the Infrastructure Investment and Jobs Act (IIJA). They also received an AID grant from the FHWA, which funded the development of an FME script to extract OpenRoads Designer data that can be imported into GIS. This funding has enabled UDOT to scale up its capacity by forming more collaborative partnerships with contractors, putting the agency on a path toward a more synchronized future across all stages of the construction lifecycle.

Contact the MDOT project manager for additional resources, including this DOT's responses to the evaluation matrix, a link to the recordings of our interview, links to state standards, and relevant research and information.

2.3.5 **EARLY ADOPTION IN GEORGIA**

Agency: GDOT

USE CASES		IMMERSIVE TECH POTENTIAL	
	DATA ACCESSIBILITY		PEOPLE AND SKILLS
✓	DATA TRANSFER	✓	DATA AND STANDARDS
✓	FEED IDR		POLICY AND PROCESS
	FEEDING TAMS		TOOLS AND TECHNOLOGIES
	CLOUD-BASED FIELD ACCESS		
	WORK TYPE ADAPTABILITY		
	ADJUSTING DELIVERABLES (LOCATION NEEDS)		

TOOLS:

Visualization:
- Trimble R12VSC

AMS:
- ProjectWise

Data Storage:
- Investigating AASHTOWare app
- ProjectWise
- SiteManager

Data Exchange:
- Phone hotspots
- USB drives
- Trimble R12VSC

EQUIPMENT:

- Laptops
- USBs
- Tablets

BENEFITS:

- Minimize duplicative effort
- Cost savings
- Standardized hardware

COST:

- Low to medium

CURRENT PHASE:

- Internal testing and feasibility investigation

ADOPTABILITY:

- Easy to moderate
- Weeks to months

KEY RELEVANCE:

- Minimizing duplicative effort,
- Investigating similar tools such as OnStation and SYNCHRO and using BlueBeam for DABs

Narrative:

GDOT is in the early stages of its digital delivery journey, relying on a network of consultants and vendors to pilot different tools and equipment.

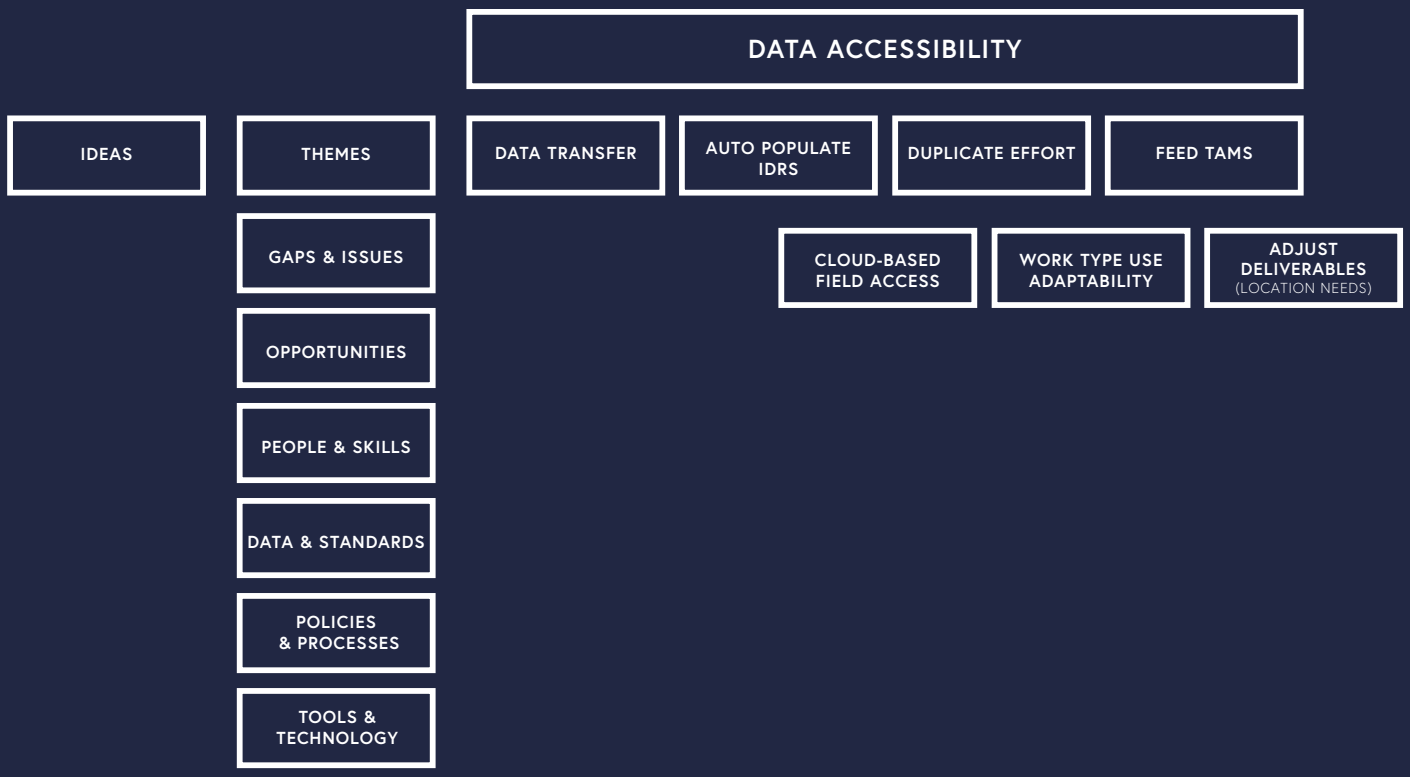
The agency is heavily interested in 3D modeling and has deployed STIC grant funding to develop a statewide implementation plan. Their current process involves using SurfacePro and Getac tablets, but they were not as effective as anticipated, leading to a shift toward using laptops instead. Internet connectivity is facilitated through mobile phone hotspots, with staff generally downloading information prior to going out into the field.

GDOT is currently experiencing a shortage of surveyors in the field, resulting in minimal rover use, but there is hope to expand the use of rovers and GPS units by leveraging contractor setups. They are piloting the Trimble R12VSC receiver with plans to integrate the AASHTOWare app for collecting location data. Although they have piloted OnStation and other systems, GDOT found many of these tools duplicative. In cases where rovers are deployed by GDOT, they provide inspectors with files and then download .csv or .txt files to spot-check different aspects of the work that was performed. ProjectWise is primarily used for file storage, and GDOT is discouraging the use of USBs for security purposes.

Generally speaking, field staff on the pilot projects are open to trying new tools, but they do not want to enter the data twice. Therefore, GDOT is framing all pilots as opportunities to eliminate redundant work. To date, their pilots have been conducted by vendors and consultants as part of their projects, although there is some interest in seeking Accelerating Advanced Digital Construction Management Systems (ADCMS) grants to expand pilots in future projects.

GDOT has approved the purchase of rovers for each district. Two districts have already acquired them, and the others are expected to request funds in the next fiscal year to purchase the rovers.

2.4 VIRTUAL WHITEBOARD SESSIONS: SETTING THE STAGE



In an effort to benchmark MDOT against its industry peers, the project team convened a series of virtual whiteboard sessions focused on the current challenges and potential opportunities within the department's construction operations. This phase brought together a diverse group of MDOT personnel, including project managers, field inspectors, construction engineers, and centralized support staff, to provide valuable insights. Combined with other research conducted during this phase, their collective input has played a central role in our efforts to prioritize organizational needs and identify avenues for enhancing digital delivery processes both today and in the future.

To systematically gather this information, these sessions employed a structured approach, evaluating key barriers like data accessibility, cloud-based feed tools, work type adaptability, and the need for adjustments in deliverables and location-specific requirements. These issues were then cross-referenced with the four BIM for Infrastructure components: people and skills, policy and process, data and standards, and tools and technologies. This analysis revealed that most identified gaps and opportunities were related to components other than tools and technologies, highlighting the significant role of change management in facilitating improvement.

The findings from these sessions are summarized in this section. Contact the MDOT project manager for a comprehensive version of the white board session.

KEY ISSUES

- MDOT aims to enhance file delivery methods to improve accessibility for all stakeholders.
- The transition from OpenRoads Designer to AASHTOWare requires a focus on integrating field-collected inspection data reports (IDRs) into AASHTOWare for better data visualization and management.
- MDOT is exploring alternative methods to make files and information accessible without the need for USB devices, emphasizing efficient data transfer solutions.
- The organization is working to standardize the storage of information collected by field staff, ensuring uniformity across all data sets.
- MDOT plans to manage and synchronize two methods of generating pay certifications — one utilizing data collectors and the other using traditional approaches — to streamline the process.
- Ensuring consistency in asset data access across various departmental areas is a priority for MDOT, aiming to improve data usability and reliability.

OPPORTUNITIES

- MDOT can ensure data accessibility, transfer, storage, and sharing through cloud-based field access tailored to operational needs.
- MDOT is actively exploring software solutions to streamline data transfer between design, central offices, and field teams.
- Designers are proactively filling in asset information and attributes before transferring them to field staff, ensuring data accuracy and consistency.
- MDOT is developing a centralized database or a common data environment to consolidate files, such as design and survey documents, from multiple sources.
- MDOT is focusing on establishing data governance, standardizing processes, and enhancing understanding of information requirements across its systems.

2.5 **SUCCESS CRITERIA**

The project team developed a series of success criteria to standardize the evaluation of a range of tools and equipment tested in the field through demonstrations. Originating from the evaluation criteria matrix utilized during our discovery interviews with various DOTs, referenced in previous sections of this report, these success criteria were further refined to incorporate MDOT's feedback, focusing on desired technologies and establishing consistent metrics for assessing their efficacy across multiple categories. These categories echo the themes discussed during virtual whiteboard sessions and DOT interviews, including data accessibility and management, onsite locationing, data visualization, and remote assistance and collaboration, among others. Additionally, we added new success measures, such as training and workforce safety, user experience, and the precision of data collection and pay certifications.

The practical application of this document has led to ongoing revisions that make the success criteria matrix more user-friendly and streamlined, facilitating its use in ongoing field demonstrations and future assessments.

The findings from these sessions are summarized in this section. Contact the MDOT project manager for a comprehensive version of the white board session.

MEASURES OF SUCCESS:
8 Criteria to Guide the Evaluation of New Technology

The following success criteria offer a qualitative method for evaluating the progress and effectiveness of newly implemented tools. Developed as part of a matrix, which allows for a systematic comparison, these criteria can help MDOT accurately assess and understand the impact of new tools on its operations.

The findings from these sessions are summarized in this section. Contact the MDOT project manager for a comprehensive version of the white board session.

1. **Data accessibility:** Includes data requirements, integration of different data environments (i.e., autopopulate IDRs and feed TAMS), data transfer, streamline or standardize data exchange (i.e., eliminate duplicate effort and redundancy), and cloud-based field access.
2. **Data management:** Includes data environment, security features, data updates, and access.
3. **On-site asset locationing:** Includes work type use adaptability (e.g., "Can it be used to inspect tasks in construction phase?"), low-accuracy locationing based on consumer-level handheld devices (vs. high-accuracy locationing), and quality level (i.e., trusting the data).
4. **Data visualization:** Includes system flexibility and field data analysis.
5. **Remote assistance and collaboration:** Includes communications, connectivity, and team interaction.
6. **Training and worker safety:** Includes KM capabilities and other features.
7. **User experience:** Includes ease of use, integration across platforms and systems, and data processing speed and lag issues.
8. **Data collection and pay certification:** Includes each tool (e.g., ancillary structures, signs, etc.), linear information (e.g., roadway alignment, C&G, etc.), area (e.g., pavement, surface evaluation / pay, etc.), volume (e.g., cut / fill, etc.), and weather conditions (automated input with data).

2.6 **FIELD DEMONSTRATIONS: JULY 2023**

Over two days in July 2023, the project team facilitated field demonstrations for TSCs within the University Region, providing MDOT staff with hands-on experience utilizing a range of technology solutions. Day 1 (July 10, 2023) featured in-office presentations at the Lansing TSC and outdoor field demonstrations tied to the I-496 rebuilding project. Day 2 (July 11, 2023) featured in-office presentations at the Brighton TSC and outdoor field demonstrations in the footprint of the I-96 Flex Route project.

The following is a summary of participants in the field demonstrations:

TRIMBLE

Representing Trimble, Adrien Patane provided an overview of Quadri, an advanced collaboration platform for infrastructure projects that empowers real-time collaboration in one central model. Quadri enables users to track changes and access BIM models from anywhere using a cloud-based software.

Following Patane's introduction, the following vendors and partners of Trimble-led demonstrations:

- **SITECH**: John Simmons, James John, and Andrew Steele of SITECH, a global distributor of Trimble solutions, demonstrated multiple Trimble products, including Business Center, which enables surveyors to transform field data into high-quality, actionable information and client deliverables; WorksManager, which facilitates communication with machines and survey crews in real-time; WorksOS, which allows site supervisors and project managers to monitor jobsite activity, including live earthmoving and compaction volume metrics; and Siteworks Positioning Systems, which compares measurements against 3D data sets in the field.
- **Seiler Geospatial:** Greg Larson, Mike O'Grady, and Mark Tenhove of Seiler Geospatial, a supplier of surveying and supply equipment, including Trimble products, conducted an aerial drone demonstration and showcased how LiDAR enables engineers and field staff to view project sites in 3D, measuring and managing volume calculations in a fully-collaborative software.

DATUMATE

Representing technology company Datumate, Tom Jennings showcased how their AI and photogrammetric drone mapping engine turns aerial drone and laser scanning data and images into survey-grade 3D models and maps. Datumate fed demonstration data from an aerial drone test flight into DatuBIM, an automatic, cloud-native software as a service (SaaS) construction data analytics and management platform.

VGIS

Alec Pestov of vGIS showcased their AR platform, which transforms spatial data, including BIM, GIS, and 3D scans, into construction-grade digital twin and AR, and allows workers to communicate in real-time by tagging jobsite tasks and issues in a common data environment.

2.6.1 FEEDBACK AND EARLY SOLUTIONS

This section summarizes common feedback and early solutions that emerged from the field demonstrations in July 2023.

AERIAL DRONES

There seemed to be significant interest in aerial drones among participants from the field demonstrations. MDOT staff noted how photogrammetry could represent significant time savings for field staff, for example, in quickly and accurately measuring restoration work while reducing the likelihood of human error from manual measurements, leading to cost savings. They noted the opportunity for additional cost savings resulting from the ability to identify design deviations from the air earlier in the process. Participants liked the portability of smaller, collapsible aerial drones, commenting on how it felt sufficient for capturing accurate data. They also seemed to prefer the idea of MDOT owning its own aerial drones as a means of conducting more frequent flights; however, this would require MDOT to have licensed drone pilots on its staff.

EARLY SOLUTION IDEA
MDOT could consider piloting an upskilling program to train its field staff, including survey and inspection workers, as licensed aerial drone pilots. Although this would require an upfront investment.

CHANGE MANAGEMENT

Change management emerged as a common theme from the two-day field demonstrations. Noting that there has historically been some resistance to the adoption of technology from within MDOT, participants pointed out the necessity for clear business cases to showcase the value of digital delivery. They emphasized the importance of involving MDOT IT staff early to ensure data compliance, along with concerns about the current state of internal information sharing, which has proven challenging post-pandemic. Effective training will also be essential for the successful adoption of new technologies to avoid inconsistent use, according to MDOT staff, who commented on the skills gaps that exist between the current state and future state. Furthermore, participants noted that the availability of specific equipment can vary significantly across offices and stressed the importance of refining processes and standards for data management over merely introducing new technologies.

EARLY SOLUTION IDEA
MDOT staff commented that the prospect of implementing these solutions across the entire state's roadway network (nearly 10,000 linear miles) felt overwhelming. Instead, MDOT could consider piloting and implementing new technology and equipment on a project or regional basis, rather than standardizing their usage across the entire state all at once.

DATA ACCESSIBILITY

Throughout the two-day demonstration, MDOT discussions emphasized the importance of data accessibility. Team members noted that surface data represents only about 1% of the collected data, underscoring the inadequacy of certain tools to supplant data warehousing for most data. They highlighted the necessity for data to be shared in real-time and universally utilized among all team members, regardless of the collection method (e.g., rovers, drones, tape measures, etc.). There's a keen interest in streamlining data collection to avoid rework, advocating for a system where data is entered once and then distributed as needed. The integration of a single sign-on solution and the reliance on cloud services were identified as critical, although some of the current cloud solutions do not meet MDOT's security standards. Additionally, MDOT desires redundancy measures to safeguard data — an area where current technologies seem lacking — though Datumate indicated efforts are underway to address this concern.

EARLY SOLUTION IDEA
MDOT currently doesn't have a centralized data warehouse. Creating one was a top recommendation cited by staff.

DATUMATE

The MDOT team found Datumate's DatuBIM solution promising. They saw a clear use case for enhancing morning site meetings by identifying deviations or conflicts to prevent rework, with features like model annotation on iPads and quick importation of multiple surface files an added benefit. The technology's capability to automatically remove manmade objects and vegetation (when processed with LiDAR) and to retain manmade objects for safety assessments were highlighted. The accuracy and time-saving potential of 3D cross-section volume reports for stockpile management impressed the team. However, concerns were raised about DatuBIM's dependency on Internet connectivity. MDOT appreciated the ability to compare project phases and quantities over time, seeing potential for comprehensive asset documentation. Despite recognizing Datumate as an interesting tool, MDOT expressed some concerns about the company's relatively recent entry to market.

INTERNET CONNECTIVITY

MDOT staff expressed some skepticism about the effectiveness of using any technology that is dependent on having Wi-Fi access in the field, especially when dealing with large amounts of data. Still, MDOT's use of mobile hotspots to-date — though limited — has delivered promising results. MDOT has existing contracts with both Verizon and AT&T for mobile phones and Wi-Fi hotspots. Encouragingly, one MDOT staff member reported achieving download speeds of 40 Mbps+ using Cradlepoint's IBR900 Series Ruggedized Router with Verizon Wireless service. They also mentioned that they haven't yet encountered a Wi-Fi dead spot, although they alluded to a total of six "dead spots" throughout the state, mainly in the Upper Peninsula. Additional testing is needed to validate the anecdotal feedback offered in these field demonstrations.

EARLY SOLUTION IDEA

MDOT may consider writing dashboard-mounted Wi-Fi units into future contracts with manufacturers of its state-issued vehicles, meaning that Wi-Fi would come standard with its vehicles, similar to the police force.

TRIMBLE

Participants showed enthusiasm for the use of terrestrial scanners for documenting changes to abutments, patches, etc., valuing the capability to quantify material removal. They seemed to appreciate the reporting and asset management features of WorksOS, highlighting its potential as a time-saving tool that allows for better focus on asset verification over contractor supervision. While Trimble's integration with MDOT's existing systems and its user-friendliness compared to Leica were positively received, staff raised concerns about the inconvenience of Trimble Connect devices being linked to individual users and the need for Trimble's heavy data collector and proprietary equipment, which conflicts with MDOT's aim to implement solutions that are technology agnostic.

VGIS

MDOT participants appreciated the vGIS platform for its ability to overlay icons and tag issues for follow-up, recognizing it as a valuable visualization and collaboration tool, though they expressed skepticism of its utility for taking precise measurements. The system is seen as beneficial at the project's outset and conclusion, particularly for identifying conflicts with underground utilities — a critical need given that only approximately 4% of Michigan's utilities are accurately mapped vertically, according to one staffer. However, MDOT views vGIS as more of an asset management and communication tool than one for surveying and inspecting, noting its limitations in offline use and the challenge this poses for widespread adoption. Despite appreciating the mission to democratize data access, MDOT does not see vGIS as a replacement for current practices involving Facetime, texting, and Bluebeam sessions for issue identification and feedback. They also discouraged the use of vGIS with VR headsets due to the safety concerns associated with interfering with workers' sight in active construction zones.

2.7 OTHER TECHNOLOGY EXPLORED

This section summarizes other technologies that the project team explored as part of this project, along with feedback and key discussion items.

DatuBIM follow-up demonstration

Following the field demonstrations in July 2023, MDOT staff expressed interest in further exploring Datumate's DatuBIM technology — a cloud-native SaaS platform designed for digital infrastructure construction data analytics. Datumate granted a small MDOT user group one-month access to DatuBIM for evaluation.

THEIR FEEDBACK IS SUMMARIZED BELOW:

- Based on the accuracy/tolerance levels achievable with drone photogrammetry, the platform may be less practical for construction purposes.
- It proved effective for calculating volumes and managing data compilations, suggesting utility beyond ground survey accuracy requirements.
- Its integration of various data inputs, including LiDAR scans and field pickups, emerged as an advantage. Team members also liked having the ability to visualize project timelines and quantify changes over different phases.
- Although there were concerns about relying solely on DatuBIM for accuracy, its capacity for generating cross-sections and facilitating data collection was welcomed as an advantage.
- The platform demonstrated a clear use case for adopting aerial drones for data collection, with the accuracy being acceptable for certain applications.

Overall, while there were reservations about the platform's precision for construction, MDOT's feedback acknowledged DatuBIM's potential in streamlining data management, enhancing project visualization, and reducing the frequency of construction inspections. There was consensus that the integration of DatuBIM into the project workflow could open new possibilities for project management and stakeholder collaboration.

Bentley SYNCHRO and TxDOT Peer Exchange

We did not evaluate Bentley SYNCHRO during the July 2023 field demonstrations because MDOT's I-696 bridge digital delivery pilot project was already using the construction management software to work with the model files in the field. Instead, on September 21, the project team assembled a virtual peer exchange with the I-696 construction team and held a separate virtual peer exchange with the Texas Department of Transportation (TxDOT) to learn about their use of SYNCHRO. Reflecting on their experience piloting SYNCHRO, users noted that it allowed for coordination in the field to visualize models and determine conflicts using a cloud-based data transfer tool. They found the 2D saved views valuable for their similarity to conventional plan views and saw a clear use case for shop drawings. At the time, SYNCHRO was not able to export IFC files for use with survey equipment, so those were exported from DGN files by the design team. It was also difficult to use SYNCHRO for quantity and pay certification because the dimensions could not be saved for other users. In some cases, the team took screenshots of objects being built to document daily work. Bentley has shared that they are working on addressing these issues.

Trimble Tablet

During a solution design workshop in December 2023, MDOT staff discussed the use of Trimble Tablets, appreciating its design, tilt feature, and user-friendly interface that facilitated intuitive point collection. However, they were concerned about inefficiencies like the need to navigate through multiple menus to access essential functions and the inability to import line work into OpenRoads Designer, resulting in redundant work due to the necessity of redrawing project sites using an XML format for tasks like volume calculation. Additionally, participants critiqued how using the Trimble Tablets with Infotech mobile inspector tool for AASHTOWare limited license holders to a single user per device. This creates operational challenges in scenarios involving multiple inspectors as they would not be able to share the Trimble Tablet as a data collector. The team noted the importance of being able to review data before final submission to avoid errors. In contrast, they highlighted the flexibility offered by Leica, which allows for easy adjustments and the ability to switch between tasks, as a positive feature that Trimble lacked.

Mesa 3 Rugged Tablet

In a solution design workshop held in December 2023, MDOT staff explored the capabilities of the Mesa 3 Rugged Tablet, a Windows device that can run various applications and handle comprehensive surveying and data management tasks directly from the field. Staff were impressed by the tablet's compatibility with Office applications, its ability to interact with OneDrive for efficient data transfer, and its capacity for performing complex calculations like volume metrics on-site. However, they noted a few concerns, including the tablet's touchscreen becoming unusable in rain, the integration of a cumbersome external antenna for total stations, and unreliable Bluetooth connections. Despite these issues, participants noted the Mesa's accuracy, ruggedness, and all-day battery life as advantages over other devices like iPads, which were deemed less reliable in field conditions. Staff also acknowledged the potential challenges of workforce adoption of new technology and the need for a comprehensive management plan to effectively integrate devices like the Mesa. The discussion concluded with the consideration of alternative solutions, including a tablet from DT Research, which might offer comparable performance at a lower cost. This emphasizes the need for further evaluation to determine the most suitable tablet technology for use in the field.

2.8 **DIGITAL DELIVERY SOLUTION DESIGN WORKSHOP**

In December 2023, after nearly a year of conducting preliminary research, building a compelling business case, showcasing technology solutions, and gathering feedback from various stakeholders, the project team convened a solution design workshop with key stakeholders from MDOT, including both field workers and decision-makers.

From a series of in-depth solution design discussions, a common theme emerged: while the adoption and integration of technology are vital to MDOT's construction efforts, the success of such initiatives equally hinges on the department having an effective change management strategy in place.

The workshop underscored the importance of leadership buy-in, the critical role of early adopters, and the need for change advocates. This holistic approach aims to foster the right environment for meaningful and sustainable change within MDOT, recognizing that managing the human elements of change is as crucial as the technological aspects.

THE FOLLOWING IS A SUMMARY OF KEY INSIGHTS THAT EMERGED FROM FOUR SOLUTION DESIGN DISCUSSIONS:

SOLUTION 1: **OPTIMIZING FIELD EQUIPMENT WITH EXISTING TOOLS**

MDOT's success in optimizing field equipment with existing tools hinges on its ability to align the department's structure to support digital transformation — a key conclusion underscored by participants in the first session. Staff members envisioned a dedicated group or person responsible for stewarding the Digital Vision, highlighting the importance of leadership buy-in for the success of the digital delivery program. Such a group would prioritize and be accountable for the digital strategy, moving away from grassroots efforts toward a more coordinated and focused approach. This group would have leadership authority to take decisive action in technology procurement and adoption, breaking down organizational silos to build a unified digital delivery effort.

This strategy is ultimately rooted in communications. It involves establishing clear definitions and expectations around digital delivery and the distinctions between proof of concept and pilot phases. It also requires clear communication from MDOT's leadership, which is responsible for ensuring top-down clarity and alignment. Furthermore, staff acknowledged the need for increased funding for technology initiatives, revising the procurement process, and issuing field equipment based on roles, needs, and current systems, aiming for a standardized approach across MDOT to effectively facilitate digital transformation.

Appendix A: Worksheet for Solution 1

CLICK HERE TO GO TO APPENDIX A

SOLUTION 2: **USING UAS LIDAR AND AERIAL TECHNOLOGIES**

In the second session — focused on utilizing unmanned aerial system (UAS) LiDAR and aerial technologies — the discussion revolved around leveraging these tools more effectively within MDOT projects, rather than relying predominantly on consultants. Through multiple field demonstrations and conversations as part of this research project, MDOT staff gained a clear view of the potential use cases of aerial drones, including regular site documentation, initial project mapping for design purposes, and safety improvements by reducing the need for manual surveying in potentially hazardous situations. For instance, drones could be deployed for bridge inspections or to map out repair areas, with the data being used directly in design processes. Together with the project team, MDOT staff highlighted the need for clear guidelines on drone usage, the selection of appropriate technology levels for short- and long-term needs, and the adherence to specifications for GPS equipment use. They envisioned a pilot program using LiDAR and platforms like DatuBIM or Propeller and Pix4D, to which MDOT already has access, emphasizing the need to continue building out use cases before adopting the technology broadly across the entire state.

Appendix B: Worksheet for Solution 2

CLICK HERE TO GO TO APPENDIX B

SOLUTION 3: **NEW FIELD TOOLS FOR DATA COLLECTION AND VISUALIZATION**

The third session focused on exploring new field tools for data collection and visualization, with the aim of enhancing data accessibility, variability, and visualization, along with facilitating information collection for payment certification. Participants highlighted the challenge of finding a single tool that meets all requirements, acknowledging that while many tools offer promising features, none have yet to comprehensively fulfill every need. Among the tools discussed, MDOT staff indicated that vGIS showed promise for maintenance and as-built documentation. Though it fell short for construction-specific tasks like daily grade checks and volume calculations, participants suggested it has clear relevance as a collaborative, real-time application that could reduce effort and duplication, integrating well with existing workflows. They also recognized the Mesa 3 Rugged Tablet for its cost-effectiveness in improving data transfer while noting how Quadri excels at facilitating design model viewing. The session concluded with a recommendation to continue evaluating preferred tools and equipment through a methodical approach to adoption that includes short-term testing and mid-term piloting of promising technologies.

Appendix C: Worksheet for Solution 3

CLICK HERE TO GO TO APPENDIX C

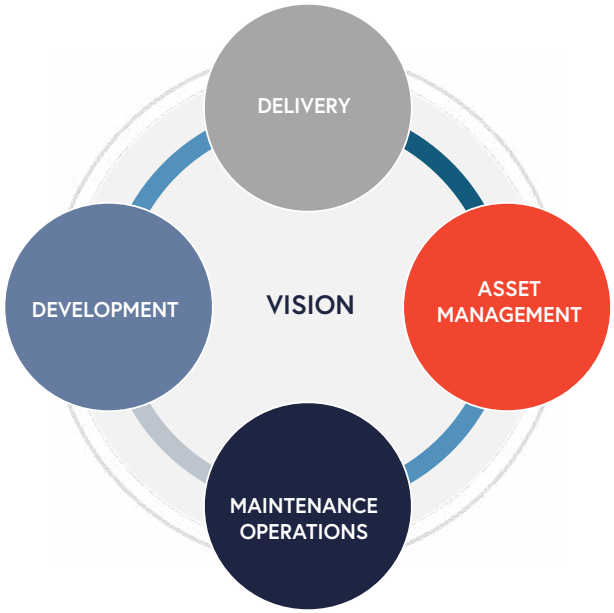
CHAPTER 3 **IMPLEMENTATION PLAN: RECOMMENDATIONS FOR ADOPTING DIGITAL DELIVERY**

Over the course of nearly a year, the project team conducted extensive research and stakeholder engagement with the aim of crafting a comprehensive suite of solutions to guide MDOT's digital delivery journey. These solutions are detailed in the following chapters of this report.

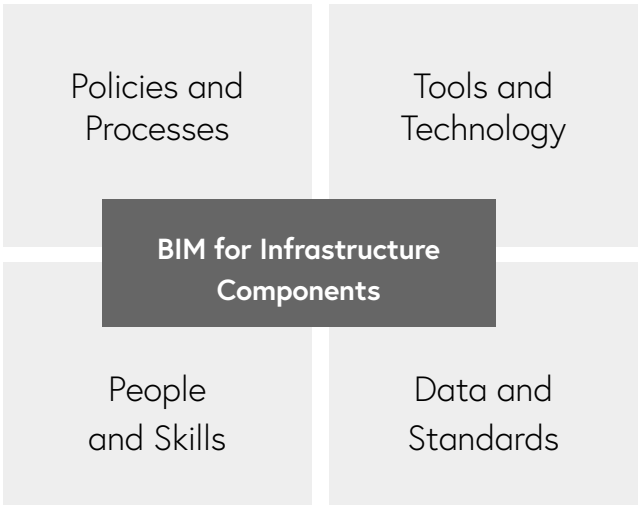
Rather than prescriptive mandates, these solutions are meant to be viewed as recommendations. As such, they are articulated as potential avenues for innovation and transformation, recognizing that the rapid pace of digital innovation demands a fluid approach. Since the beginning of this project, the project team has subscribed to the idea of creating "freedom within the framework," meaning that where clear guidelines, objectives, and standards exist, individuals and teams can be given the flexibility and autonomy to achieve these goals in ways that best suit their skills, methods, and innovative approaches. Likewise, this approach is designed to encourage adaptability and creativity, creating space for MDOT to tailor these recommendations to fit their unique and evolving needs.

MDOT'S DIGITAL VISION

Operating together in one orbit.



We are also mindful of MDOT's capacity to achieve change. As uncovered in the research phase of this project, MDOT is facing a significant skills gap, with as much as 33% of its workforce retiring within the next year. Therefore, MDOT may wish to approach change systematically — over an extended period of time, for example, or region-by-region — rather than implementing each solution all at once. Therefore, our report contextualizes solutions as mere stepping stones toward an ideal future state in which technology enhances the effectiveness of MDOT's teams. In other words, these solutions can be paired any number of different ways and considered in the context of the region, project, and use case in which they are proposed.



Overview of proposed solutions

Policies and Procedures: Chapters 7 / 8
Tools and Technology: Chapters 5 / 6 / 9 / 11
People and Skills: Chapter 4
Data and Standards: Chapter 10

CHAPTER 4 **ROLES AND RESPONSIBILITIES: IDENTIFYING CHANGE AGENTS**

In the lifecycle of digital delivery, the role of change agents is pivotal in steering teams toward success. This section aims to delineate clear roles and responsibilities for both internal stakeholders and external industry collaborators, including consultants and contractors, ensuring a unified approach to achieving the objectives of this project. It responds to critical feedback gathered throughout the research phase of this project, which underscored that the authority for standard processes and technology procurement might be out of balance or misaligned, highlighting the need for a collective understanding and strategic engagement among all stakeholder groups. Therefore, this framework will serve as a foundation to guide the overall solution implementation, with provisions to tailor specific roles as needed to standardize processes while still accommodating variations in individual projects.

Recognizing the importance of leadership buy-in, this section imagines a cohesive structure that fosters effective collaboration and decision-making, ensuring that each member — from internal stakeholders to industry partners — is aligned and committed to the project's success. While we include specific names and titles throughout this section to foster a greater sense of accountability and responsibility, it is important to note that people and roles shift over time. Where mentioned, these roles refer to MDOT's present organizational structure. Future changes may necessitate a realignment between roles and responsibilities.

True progress cannot happen overnight. Therefore, some of the recommendations in this section are framed as short-, medium-, or long-term solutions.

> **These timeframes are defined approximately as follows:**
> **Short-term: 6 – 12 months**
> **Medium-term: 1 – 2 years**
> **Long-term: 2 – 5 years**

4.1 **GENERAL/OVERARCHING ROLES**

The following roles within MDOT's staff will champion the digital delivery solutions recommended in this report:

Short-term: Andrew Block (supervising manager of design services), Glenda Bowerman (survey construction support), Rick McGowan (construction technology innovation analyst), and MDOT's construction technology group can serve as point people on digital delivery processes expanding on data collector equipment and survey support.

Medium-term: A new Digital Vision Committee, also referred to in this report as the "A-Team," can be established under the leadership of Brad Wieferich with the support of Brad Wagner (Structure Project Division administrator) to drive the medium-term execution of Digital Vision implementation plans. This committee can serve as a cross-divisional team that encompasses a broad range of divisions and interests within MDOT, including various stakeholders responsible for bringing Digital Vision to life. Demetrius "Dee" Parker's (director, Bureau of Development) team, including members like Andrew Block (supervising manager of design services) and Glenda Bowerman (survey construction support), can offer design and survey support and could be tasked with delivering outcomes to the Region Bureau Management Team (RBMT). Jason Gutting's (director, Bureau of Field Services) team can support construction and technology efforts, with individuals such as Ken Koepke (engineer of construction operations), Dan Burns (construction technology engineer), Rick McGowan (construction technology innovation analyst), and Mike DeBoer (field operations engineer) also reporting outcomes to RBMT. Additionally, the committee could include representation from regional and TSC construction engineers, who can lead the operational teams, and support from the Enterprise Information Management (EIM) Office — potentially Andy Esch or a delegate — ensuring a comprehensive approach to digital transformation within MDOT.

Long-term: MDOT's RBMT could retain authority over policy, budgeting, and permissible technologies, while the A-Team could be tasked with proposing a comprehensive digital strategy, ensuring that recommended devices are up-to-date and effective, replacing outdated equipment. The A-Team's recommendations can be validated and directed by the Digital Vision Implementation Team, which includes Brad Wieferich and Andrew Block, among other members. Before their recommendations reach RBMT for approval, they might first be endorsed by the State Alignment Construction Team (SACT). This process underscores the recognition of potentially necessary new roles within MDOT, emphasizing the importance of identifying and establishing critical positions for the long-term success and adaptation of the department's Digital Vision.

4.2 ACCOUNTABLE ROLES

Roles that are *accountable* in this process are involved with setting strategy, direction, and governance at a director or manager level, ensuring tasks are completed by providing overarching leadership. They are one level higher than the A-Team.

Accountable roles are as follows:

Short-term: Immediate responsibility falls to the TSC construction engineer or Region CE to manage the operational budget, equipment, and data transfer due to the lack of a consistent process for equipping field staff. The Digital Vision Team will provide oversight and guidance as the strategy matures.

Medium-term: The RBMT could assume leadership as organizational changes are made, guiding procurement and the adoption of new devices across field operations.

Long-term: The Digital Vision Implementation Team, which is distinct from — but possibly includes — members of the A-Team, can oversee the comprehensive Digital Vision. This includes determining the tools and equipment necessary for construction processes and guiding MDOT's overall strategy for digital delivery.

4.3 CONSULTED ROLES

Consulted roles might be included in the chain of decision-making authorities before a strategy is finalized but do not share responsibility for developing or executing strategies.

By including consulted roles in this report, we aim to gather diverse perspectives early on, ensuring statewide alignment and minimizing potential obstacles during deployment. Extending beyond the core A-Team, this strategy involves engaging a broader group of stakeholders and identifying champions who can represent wider organizational voices. This inclusive method is designed to enhance the decision-making process by incorporating a variety of insights and expertise.

Consulted roles are as follows:

- Regional surveyors
- Regional inspection staff
- Office of Business Development (OBD)
- Office of Organizational Development (OOD)
- Enterprise Information Management
- American Council of Engineering Companies (ACEC) Transportation Committee
- Statewide Design Alignment Team (SDAT)
- ACEC Survey Task Force
- Information Governance Council (IGC)
- Digital Delivery Work Group

4.4 **RESPONSIBLE ROLES**

Responsible roles pertain to the obligation to execute assigned tasks at a grassroots implementation level. These roles differ based on the project or region.

Responsible roles are as follows:

PROJECT MANAGER:
For consulted work, the role falls to the project and contracts engineer at the TSC.

DESIGN ENGINEER:
Typically, this is the region design engineer and their team, who are responsible for internal work designs.

PROJECT CONSTRUCTION ENGINEER:
This role is occupied by a construction engineer tasked with leading the project, not limited to the region construction engineer.

SYSTEM MANAGER:
The assistant region engineer, responsible for overseeing projects completed by the region, ensuring all projects align with the 5-year plan and the State Transportation Improvement Plan (STIP).

MDOT BIM FOR INFRASTRUCTURE LEAD:
This role is new, as noted below, and would be responsible for implementation of and BIM for Infrastructure related efforts.

4.5 **NEW ROLES**

MDOT COULD CONSIDER INCORPORATING THE FOLLOWING NEW ROLES INTO ITS ORGANIZATIONAL CHART TO MOVE FORWARD THE PRIORITIES OF THIS DIGITAL DELIVERY VISION:

REGIONAL CONSTRUCTION SURVEYOR:
This role would primarily manage the field verification process to ensure location accuracy. It is inspired by Florida's adoption of a survey modeler position.

DIGITAL DELIVERY EQUIPMENT AND TECHNOLOGY OWNER:
This role would be responsible for evaluating, deciding upon, and standardizing the construction equipment necessary for new digital delivery processes. It would involve coordinating equipment portfolios for field staff based on their roles, overseeing funding for technological updates, and acting as a liaison among staff. It would ensure the execution of change management action items, including technical evaluations, DOT peer exchanges, training, communications, and other initiatives on an annual basis.

BIM FOR INFRASTRUCTURE LEAD:
This role would work to align MDOT with national efforts and peer states in the maturity of BIM for Infrastructure and digital delivery. This role would involve setting up processes to manage data from design to construction and onwards, with a focus on enhancing the efficiency, safety, and ease of field staff work through digital delivery and data-driven processes.

As MDOT moves toward executing its Digital Vision, there may be other groupings of roles that will be scaled as the program develops.

Recognizing the rapid pace at which technology evolves, MDOT might consider conducting semi-annual demonstrations with key vendors such as Trimble, Datumate, and vGIS, among others. This technical evaluation process is a cornerstone of our recommendations, supporting all aspects of digital delivery by ensuring that MDOT stays at the forefront of future advancements in the landscape of people, process, technology, and funding.

To streamline this process, MDOT can establish a documentation system for agreements made in previous meetings to serve as a foundation for the core implementation plan. Moreover, MDOT could consider implementing a Digital Vision feedback loop, utilizing a data-driven tool to evaluate the effectiveness of deployed technologies, identify areas of success and improvement, and assess whether strategic goals have been met. This iterative approach to the implementation plan will allow for continuous refinement, ensuring it remains relevant and responsive to both the changing needs of the business and emerging innovations. Construction enablement would be an important category identified as part of the Digital Vision feedback tool.

The responsibility for leading these sessions, which can take place virtually with a field component, as needed, could fall to the Design Services Section. MDOT may also rely on "as needed" consultants — especially early on in its digital delivery timeline — with the objective of eventually passing this process on to the appropriate responsible staff (i.e., BIM for Infrastructure lead). This structured, yet flexible, evaluation process aims to foster a culture of innovation and improvement within MDOT, ensuring that the organization remains adaptable and informed in an ever-changing technological landscape.

CHAPTER 6 **PEER EXCHANGE**

We suggest that MDOT organizes a series of semi-regular peer exchanges with DOTs across various states, including Minnesota, Utah, Iowa, Montana, Georgia, Texas, and others. This process can be integrated into MDOT's technical evaluation process, facilitating a comprehensive understanding of progress, changes, and new implementations in technology and processes among peer institutions. MDOT can utilize the same evaluation matrix developed during the research phase of this report to score and evaluate its peers' digital delivery efforts. This will help ensure that any observations captured and recorded throughout this process are standardized and compared consistently across all DOTs.

Led by the Design Services Section, these targeted exchanges can provide a structured platform for discussing advancements, sharing successful new workflows, and addressing challenges. By aligning in-person exchanges with existing conferences and events, such as the International Highway Engineering Exchange Program (IHEEP) and ACEC conferences, MDOT can develop a cost-effective method for sharing insights across state boundaries. Supplementing in-person conversations, shorter virtual meetings lasting approximately one hour could explore the progress made by DOTs across the country, the evolution of their projects versus expected outcomes, the introduction of new solutions and technologies, and more.

This strategic engagement is designed to foster a culture of continuous learning and improvement within MDOT, leveraging peer insights to refine and advance its own practices.

KEY QUESTIONS TO ASK

The following questions can guide MDOT's conversations with its peer DOTs as part of these peer exchanges:

- **What progress have you made in your digital delivery journey?**
- **How have your expected outcomes changed?**
- **What new solutions and technologies are you implementing?**
- **Are there new processes and workflows that you have established?**
- **What has not worked as well as anticipated, and how are you overcoming these challenges?**
- **What plans are on the horizon in your digital delivery journey?**

CHAPTER 7 **CHANGE MANAGEMENT**

At MDOT, the journey toward embracing a digital future extends well beyond technology. It encompasses a holistic approach to change, recognizing that technology is just one factor that will define the organization's adoption of digital delivery. This is a reality that was reinforced repeatedly throughout this process through interviews with MDOT's peers, conference sessions at the IHEEP Annual Conference, independent research, and input from MDOT's own staff.

Enter change management. Change management involves the implementation of processes to review, evaluate, and coordinate changes to products, applications, and systems, with a strategy aimed at minimizing user impact, reducing errors, and overcoming institutional and cultural barriers to encourage staff acceptance of progress. For complex government agencies, it plays an essential role in fostering an environment where staff are not only prepared for change but are active participants in the change process. This ensures that transitions — however small or large — are embraced and sustained across an entire organization.

RESEARCH INDICATES THAT 70% OF ORGANIZATIONAL CHANGE INITIATIVES EITHER FAIL OR DO NOT RESULT IN SUSTAINED CHANGE.

However, the path to successful change management is fraught with challenges. Research indicates that 70% of organizational change initiatives either fail or do not result in sustained change, a statistic that underscores the difficulties organizations face in shifting long-established norms and behaviors. For MDOT, the key to overcoming these odds lies in adhering to best practices in change management. Among many proven strategies, this includes communicating clearly and transparently, providing adequate training and resources, and creating a culture that values feedback and continuous improvement.

This section explores the role of change management in digital delivery, including the challenges and strategies that underpin successful change management. It highlights how marketing and communications are indispensable in articulating the vision and benefits of change, driving stakeholder engagement and buy-in. Additionally, it emphasizes the critical importance of training, education, and workforce upskilling as foundational elements that equip employees with the skills and knowledge required to thrive in a digital future.

7.1 **ADOPTION CHALLENGES AND KEY CONSIDERATIONS**

The adoption of new technology presents a challenge for any organization — especially for government agencies, where the tide of change often moves slower than in the private sector. This is true for transportation departments, which operate at the crossroads of innovation and tradition, propelled forward by the rapid pace of digital innovation yet steeped in tried-and-true ways of doing business to align with federal and state requirements. Navigating these challenges requires a strategic, thoughtful approach to digital adoption, emphasizing the need for alignment, cultural readiness, and a clear demonstration of value to all stakeholders involved.

These challenges, along with key considerations for MDOT leadership, are outlined below:

- The perception that embracing new technologies is outside the scope of a person's job requirements underscores the importance of aligning digital initiatives with individual roles and responsibilities. Additionally, resistance to change and skepticism toward new technologies point to the need for ongoing education focused on the value of digital innovation, ensuring that digital adoption is not just a theoretical exercise but a practical and beneficial evolution.

- The reality that many employees are already managing the workload of multiple roles raises critical questions about how organizations can motivate their workforce to engage with — and adopt — new technologies and processes.

- The timing of digital adoption strategies may be called into question, especially as a significant portion of the workforce is nearing retirement. Considering projected turnover, MDOT may wish to carefully consider when and how new systems are introduced. Furthermore, MDOT might prioritize the need for KM and transfer into digital processes to ensure that invaluable information is passed down from departing staff.

- Amid a post-pandemic focus on work-life balance in workplaces around the world, employees may be hesitant to exceed their normal duties, which highlights the need for a culture that supports both innovation and employee well-being.

7.2 STRATEGIES FOR SUCCESSFUL CHANGE MANAGEMENT

Effective change management strategies are essential to mitigate resistance, foster a culture of innovation, and ensure the adoption of digital tools and processes across an organization. By focusing on the roles of leadership, communication, training, and stakeholder engagement, MDOT can successfully guide its workforce through the journey of digital delivery, navigating the challenges of digital transformation and harnessing its full potential to improve services and outcomes for the public.

A comprehensive change management plan can be developed with program-level, regional, and enterprise-wide tracks that address the organization's varied and specific needs, including: action planning, leadership alignment workshops, training planning, communications, KM, program marketing, and more.

THESE STRATEGIES ARE OUTLINED BELOW:

- Identifying early adopters and "change champions" is crucial. Their success stories can be captured, shared, and built upon, focusing on what enhances their effectiveness and simplifies their job roles. Solutions involving technology and equipment can empower these individuals, ensuring they are distributed throughout the organization to facilitate widespread change. MDOT has a solid foundation for this evidenced by the champions represented as panel members for this project.

- The adaptability of tools to specific roles is essential. Each tool could be tailored to fit the unique demands of different job functions, ensuring seamless integration into daily workflows. This will ultimately enhance user engagement by providing solutions that are directly relevant to an individual's tasks, increasing the likelihood of widespread adoption and utilization across the organization.

- Regular training sessions are necessary to highlight the benefits of new technology, coupled with a structured process to identify and cultivate hidden skill sets within the organization. The aim is to facilitate a culture where obtaining certification in the use of new tools is seen as an opportunity for professional development rather than a mandatory requirement.

- Developing incentives for adopting new technology and processes can also be effective. This may involve revising compensation structures, rewarding team members who achieve certification in new technologies by offering salary adjustments or advancements in employee classification.

7.3 THE ROLE OF MARKETING AND COMMUNICATIONS IN CHANGE MANAGEMENT

Effective change management hinges on having a cohesive marketing and communications strategy in place. To advance digital delivery within MDOT, the department will want to prioritize clear communication with employees, ensuring they are aware of new processes and available resources. This goes beyond simply communicating change; to be successful, it must foster excitement and advocacy for the program.

We recommend that MDOT implement a mix of launch meetings, ongoing training, and monthly office hours to maintain engagement and facilitate understanding within MDOT's workforce. This may require centralizing communications to craft and disseminate consistent messages about technological advancements, starting guidelines, and support avenues to reduce confusion and enhance program adoption across MDOT. To further support this work, the department can consider developing a marketing and communications toolkit, providing customizable messaging templates that can be tailored to fit the unique needs of different projects and offices within MDOT. This toolkit, coupled with quarterly updates and feedback mechanisms, will help ensure that expectations are clearly communicated and achievements are recognized.

Additionally, the creation of on-demand tutorials — available as videos and how-to guides — and the launch of a digital delivery branding program will not only assist in the onboarding of new staff but also promote a unified approach to adopting innovative technologies. By aligning these efforts with MDOT's broader digital delivery goals, the department can establish a cohesive and streamlined process, ensuring consistent messaging and facilitating smoother transitions as new technologies are integrated into MDOT's operations.

KICK-OFF ANNOUNCEMENT

Publish an MDOT-wide announcement sharing news of what's happening with construction digital delivery. Messaging would provide high-level detail about the program, its benefits, instructions on how potential adopters can get started, link to the main resources page, and contact information.

QUARTERLY ENTERPRISE-WIDE COMMUNICATION

Work with MDOT's Office of Organizational Development when possible and take advantage of MDOT's other internal communications vehicles to effectively communicate your program. Communications can include sharing success stories and use cases, sharing news of deployment and development progress, emphasizing MDOT's commitment to digital transformation, pushing out calls to action (e.g., register for quarterly enterprise knowledge-sharing meetings), and providing links to program resources. This newsletter would be produced by Engineering Support Services.

QUARTERLY ENTERPRISE-WIDE KNOWLEDGE-SHARING

Users would meet quarterly to discuss all aspects of the technology. We recommend opening these meetings to users and people interested in adopting the technology.

LEADERSHIP ALIGNMENT AND ACTION PLAN FRAMEWORK

MDOT can create a simple framework that defines how leaders will support and communicate change throughout the program. Consider building the framework around three key areas:

ATTENDANCE

Identify which leaders will attend which meetings related to change.

ALIGNMENT

Assess the degree of leaders' alignment to the objectives of the transformation and identify steps to correct any misalignment.

ADVOCACY

Clarify the role that leaders will play in driving and accelerating change around new technology.

7.4 THE KNOWLEDGE MANAGEMENT (KM), WORKFORCE TRAINING, AND UPSKILLING IMPERATIVE

Change management is an ongoing journey — a process that demands continuous iteration and adaptation to meet the evolving needs of an organization and its workforce. To be successful, it requires effective KM, workforce training, and upskilling — three critical components of change management that can make or break a project's future.

This section explores these three components and their impact on MDOT's digital delivery initiatives. First, it focuses on how MDOT's aging workforce demands having rigorous policies and practices in place to govern KM — specifically, to ensure that the department retains historical perspective and expertise as employees come and go. Second, it lays the foundation for continuous training, supported by a dedicated internal resource committed to deploying and updating training materials, including the semi-regular technical evaluation process and peer exchange outlined earlier in this report. Third, it complements internal training programs with an upskilling initiative targeting opportunities to adapt MDOT's workforce to engage with a technology landscape that is constantly evolving.

Together, these components can equip MDOT's employees with the skills and knowledge necessary to navigate and contribute to the department's digital delivery initiatives.

7.4.1: Knowledge Management (KM)

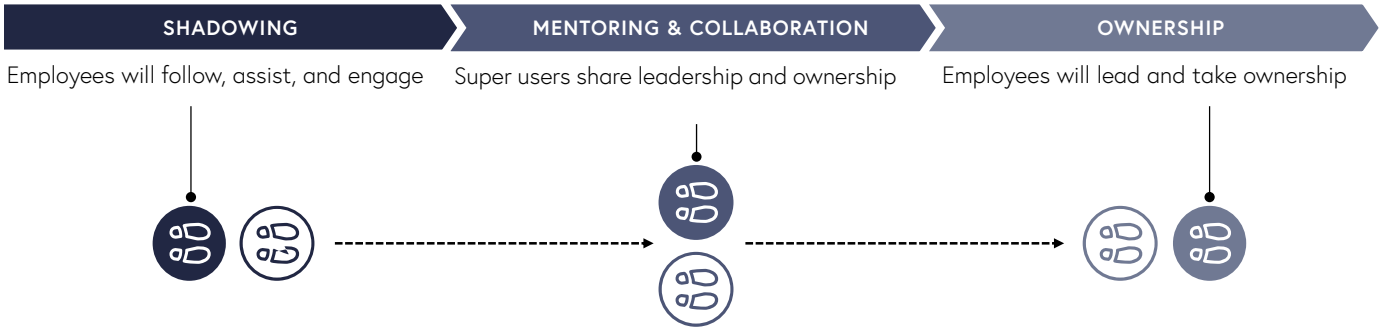
Across the public sector, the reliance on a tenured workforce filled with seasoned employees who carry significant job knowledge "in their head" is a barrier to change management. When these employees depart or retire, they take valuable expertise with them, meaning that critical throughlines may be lost.

This digital delivery initiative presents a crucial chance to transition from this informal knowledge sharing to a structured, repeatable KM strategy. This approach aims to preserve and share critical expertise across the organization, ensuring continuity and efficiency in operations despite changes in staff composition. Their knowledge can be retained by engaging seasoned employees in developing the new digital process.

MDOT can consider the following components of KM when fulfilling the promise of this digital delivery program:

SHADOWING, MENTORSHIP AND COLLABORATION, AND OWNERSHIP

The graphic below indicates the general journey for effective KM. Building a KM strategy around this framework will ensure that all employees have what they need to understand and continually share knowledge about digital delivery that will be shaping and transforming the ways in which they work. It may involve engaging employees early in the process, establishing ways to mentor and collaborate, and providing what team members need to confidently take ownership of the transformation.



IDENTIFICATION OF SUPER USERS AND CHAMPIONS

Super users can be engaged early to learn the technology and become the "champions of change" who can continually engage with and support their peers on the digital delivery journey. Super users might represent a diversity of employees, including seasoned staff, who can be converted from "doers" to "coaches," and who can function as both technology experts and mentors as knowledge and training ramps up for the entire employee base.

DOCUMENTATION AND SUPPORT

Empowering MDOT employees to acquire and retain knowledge around this implementation is not a one-time activity. KM documentation and support could run parallel to every aspect of the program. This would ideally be managed by a set of super users or other employees who can be dedicated to capturing and documenting the knowledge needed to pass to other employees. KM documentation can be facilitated through knowledge agreements (knowledge objectives by employee groups), design documents (application details and functionalities), and progress tracking (regular reviews of KM progress with the team to identify knowledge gaps and opportunities to clarify/improve knowledge).

Additionally, as the digital delivery initiative evolves post-implementation, there could also be a process in place to capture knowledge updates. This is an extension of KM documentation and support.

DEVELOPING AND CENTRALIZING TRAINING MATERIAL

Create centralized resources and training material such as videos, manuals, processes, and documents that will be part of the onboarding package and serve as an extension of KM.

7.4.2: Workforce training and upskilling

For MDOT, capturing insights from the department's seasoned workforce is crucial to developing training programs that reflect the wealth of real-world experiences these employees have accumulated during their tenure. At the same time, it's vital that these training initiatives are designed to engage younger staff members effectively, leveraging seasoned employees' deep knowledge to facilitate the skill enhancement of their younger counterparts.

These are the most important elements of developing a training and upskilling plan:

SKILLSET ASSESSMENTS

MDOT could assess the skillsets they already have and the ones lacking to adopt a digital delivery solution. This assessment will inform training materials and help leadership understand training gaps that could be filled.

GENERAL TRAINING PLAN AND MATERIALS

Training plans and materials can take many forms and could be customized to the project's needs. As the program progresses, MDOT will gain a better sense of what types of training will work and what will not. Considering the skillset assessments, the training plan and materials could include the most efficient ways to train all users, such as an overall onboarding training plan and subsequent training designed for specific user groups.

TRAINING THE TRAINER

Establish training around super users who understand the technology best and can train the larger employee population.

TECHNOLOGY USE IN TRAINING

There are countless technologies MDOT can use to facilitate training. Because this is a digital delivery initiative, MDOT might consider digital resources to conduct training, such as remote assistance and virtual training, that could help guide less experienced users as they learn the technology. A video asset management library could also be a powerful tool in helping to capture basic solution knowledge in an easy-to-digest way. For example, a field worker at a project site could access videos directly related to his or her specific work or needs in real-time. On top of capturing standard procedures on video, MDOT may want to consider collecting a library of tips and tricks from the field — aspects of the technology not typically captured but that serve as valuable on-the-job knowledge for employees.

CHAPTER 8 **TECHNICAL SOLUTIONS**

Until this point, this report has primarily focused on broader change management principles — specifically, how people and process play a critical role in facilitating MDOT's digital delivery vision. The following sections transition to the exploration of technical solutions to fulfill this Digital Vision.

In making this shift, it's crucial to acknowledge that effective change management serves as the foundation for the successful adoption and implementation of new technologies within MDOT. The insights guiding our recommendations are drawn from comprehensive research, insightful discussions, in-depth interviews, interactive workshops, and extensive field visits, all of which underscore the importance of a methodical approach to change management. Yet, the conclusions we draw are not finite. The rapid evolution of technology necessitates a continuous reassessment of the tools and technologies, ensuring MDOT remains at the forefront of innovation and efficiency.

POTENTIAL FUNDING CONCEPTS

The following key is intended to guide the evaluation of the technical solutions presented in this section. It considers that many projects may require funding from different sources, including, but not limited to, those that are listed below. In many cases, these funding sources will not be singular; rather, it might require a patchwork of funding sources.

RANGE	SCALE	SOURCES
$ Low **(Up to $150,000)**	Project Level Leverages current processes	• Purchased as part of CE budget • As-needed contract for support • Purchase through equipment replacement process
$$ Medium **($100,000 - $750,00)**	Proof of Concept Expand champions	• STIC funds ($100k/year) • Vendor-sponsored • Program level as-needed support
$$$ High **($750,000+)**	Larger Pilot Phased statewide rollout	• AID grant • ADCMS grant • IIJA

CHAPTER 9 **UAS**

In July 2023, MDOT staff experienced the capabilities of UAS through aerial drone demonstrations conducted as part of research for this report, which highlighted the potential for drone photogrammetry to enhance operational efficiency, improve accuracy in measurements, and lead to cost savings. Although it was not the first time the department has leveraged aerial drones, these demonstrations sparked interest in how MDOT can independently utilize this technology without relying solely on consultants.

The solution outlined in this section is built around this premise. It focuses on integrating UAS technology into MDOT's operations across Michigan, starting with pilot projects under existing as-needed staking contracts. This approach allows for testing and scaling the use of UAS using aerial images or LiDAR, building on MDOT's current use of technologies such as Pix4D for photogrammetry. However, the National Defense Authorization Act for FY2024 may impact the purchase of drones from specific countries. Despite these challenges, UAS technology is recognized in this report as a crucial element of MDOT's future operations, offering a platform for broader implementation and significant advancements in fieldwork safety, efficiency, and data accuracy.

9.1 **BENEFITS OF UAS**

The use of UAS is revolutionizing the transportation construction industry, presenting a range of benefits that can significantly enhance project outcomes and operational efficiencies.

THESE ARE SOME OF THE LEADING BENEFITS OF UAS:

- **Enhanced safety:** UAS significantly reduces the risk to field workers by eliminating the need for their physical presence in dangerous environments, such as active roadways or areas with high-risk conditions, reducing the potential for traffic crashes and enhancing overall workplace safety.

- **Improved efficiency:** The use of UAS accelerates the process of inspections and maintenance, making these tasks more efficient. Drones can quickly cover large areas, access hard-to-reach locations, and collect data more rapidly than manual methods, streamlining project timelines and reducing downtime.

- **Increased transparency:** Through detailed documentation and the ability to capture comprehensive data from the outset, UAS ensures transparency throughout the full project lifecycle. Stakeholders have access to accurate, up-to-date information, facilitating informed decision-making while maintaining accountability across all project phases.

- **Minimized traffic disruption:** UAS operations can be conducted without the need to close roads or disrupt traffic, serving the public more effectively by reducing congestion and avoiding the inconvenience of road closures.

- **Greater accuracy:** UAS technology provides high-resolution imagery and precise data collection capabilities, leading to improved accuracy in inspections, surveys, and mapping. This precision helps in identifying potential issues early, planning more effectively, and executing construction projects with higher fidelity to the original designs.

- **Cost-effectiveness:** UAS reduces the need for field visits, allowing teams to analyze data and make decisions from the office without the time and expense of travel. By bridging the gap between data collection and exchange, UAS improves communication workflows and saves on travel and labor costs.

- **Streamlined data collection:** The use of UAS optimizes the process of gathering data and information, making it faster, more comprehensive, and less intrusive. This streamlined approach improves project management efficiency, enabling quicker responses to changing conditions and requirements.

- **Versatile data usage:** A single drone flight can capture a vast amount of data for multiple purposes, from initial surveys to final inspections. This versatility allows for data to be reused across different project stages, reducing the need for repeated site visits and enabling a more cohesive project management strategy.

- **Historical data cataloging:** With UAS, data is collected in a controlled, validated environment and can be securely stored with accurate timestamps. This archived information becomes a valuable resource for future reference, comparative analysis, or other applications, offering insights into project progress and changes over time.

- **Liability mitigation:** The precise and verifiable data collected by UAS helps clarify responsibilities and outcomes, which is crucial in an industry where liability concerns are prevalent. By providing detailed evidence and documentation, UAS technology aids in resolving disputes, allocating responsibility, and mitigating liability among all parties involved, including state agencies like MDOT, along with consultants and contractors.

9.2 CHALLENGES AND POTENTIAL BARRIERS TO THE ADOPTION OF UAS

While the integration of UAS offers promising benefits, as with any new technology, it also presents potential challenges. For MDOT, understanding these challenges is key to navigating the expansion of UAS with success.

THESE ARE SOME OF THE LEADING CHALLENGES AND POTENTIAL BARRIERS OF UAS:

- **Extended processing times:** The sheer volume, depth, and complexity of data collected by UAS can lead to extended processing times, an issue compounded by network and field connectivity issues. This limitation can hinder the timely utilization of UAS in time-sensitive operations such as pavement work, where immediate data application is crucial.

- **Data validation requirements:** Before UAS-derived data can be effectively used, it must undergo a rigorous validation process to align with pre-established control measures. This necessary step ensures the reliability of the data but introduces additional time and procedural demands.

- **Necessity of check shots:** Even with the use of advanced GPS targets and PPK and RTK technologies, the extraction of accurate results requires initial data validation through check shots. Although this can be seen as a barrier, refining processes and practices can mitigate its impact, maintaining the integrity of grade and alignment specifications.

- **Requirement for targets along model limits:** For extensive projects, especially those spanning long corridors, the placement of targets along both edges is imperative. A possible solution involves the strategic placement of permanent targets throughout the project area, potentially reducing the targeting effort needed for each UAS mission.

- **Federal Aviation Administration (FAA) regulatory challenges:** Navigating FAA regulations is crucial, particularly for projects near airports or within areas frequented by the public. Achieving compliance involves careful planning and adherence to specific protocols, including securing necessary clearances.

- **Public impact concerns:** The operation of UAS near public spaces requires careful planning to minimize disturbance or safety risks. In some instances, avoiding public impact entirely may not be feasible, underscoring the need for effective community engagement strategies.

- **Establishment of localized Continuous Operating Reference Stations (CORS):** Implementing CORS on project sites could standardize control for contractors but also introduces a potential liability, particularly if discrepancies arise related to the established control.

- **Burden of daily control point checks:** To ensure ongoing accuracy, control points established through localized CORS must be verified daily. Incorporating these checks into the project's routine, aligned with the AMG specification, is essential for maintaining data integrity throughout the project lifecycle, even if it adds time to the survey.

9.3 MDOT'S UAS JOURNEY: CURRENT STATE

MDOT is currently leveraging UAS to enhance its operational efficiency and project delivery. With a fleet that includes three drones — one DJI Matrice 300 Enterprise drone equipped with LiDAR, thermal, and high-resolution digital cameras, along with two DJI Matrice 600 drones, one featuring a RIEGL miniVUX-2UAV high-resolution LiDAR system and the other a high-resolution digital camera — MDOT is already on its way to adopting more widescale use of advanced drone photogrammetry technologies. For the North, Southwest, and Superior regions, MDOT is expanding its capabilities with the acquisition of three DJI Matrice 350 Enterprise systems, which are equipped with L2 LiDAR systems and quality photo cameras.

MDOT utilizes these drones primarily for marketing purposes, showcasing completed projects both internally to highlight department achievements and externally to the public for transparency and engagement, while testing preliminary use cases. Beyond marketing, these drones can be leveraged to collect 2D and 3D data and can be considered for various applications to improve project timing and strategy. This dual-use approach — employing drones for both marketing and technical data collection, such as photogrammetry, grade measurements, and quantity calculations — illustrates MDOT's potential to innovate, maximizing the utility of its UAS technology. Despite these advances, there remains a need for improved scheduling and utilization processes to ensure drones are fully leveraged across all possible applications and regions.

The challenge ahead for MDOT involves establishing a more coordinated approach to drone usage across different regions, ensuring equipment availability meets the diverse needs of various projects. With the survey support group leading this initiative, supported by consultants as necessary, MDOT can more comprehensively integrate UAS technology into its standard operating procedures. This could include adding specific language in requests for proposals (RFPs) or special provisions in contracts to standardize data collection practices statewide. The I-94 Marshall and I-475/I-69 reconstruction projects, the I-696 BIM for Bridges Pilot, and the construction of the Gordie Howe International Bridge, have already benefited from drone photogrammetry, showcasing the potential for expanded use across MDOT's project portfolio. By streamlining cross-regional communication and making strategic use of existing resources, MDOT can further enhance its project delivery, safety, and efficiency, setting a standard for transportation departments nationwide.

9.4 KEY USE CASES FOR UAS

UAS can be used across a range of projects at MDOT. Ideal applications range from marketing efforts — where aerial footage can be captured for multiple internal and external casemaking purposes — to more technical tasks, such as grade verification and the quantification of stockpiles.

Initially, smaller projects stand to benefit most from UAS imagery or LiDAR technology, especially for tasks requiring rapid quantification of non-hazardous materials for removal or for maintenance and logging activities. Additionally, UAS equipped with LiDAR and aerial imagery capabilities may prove useful for verifying grades and calculating pay item quantities, particularly for stockpile volume assessments and 2D quantifications of features like lane lines, which not only improve safety by minimizing field staff's exposure to hazardous conditions but also enhance data collection efficiency. As the scope and capabilities of UAS programs expand, their use can also be extended to 3D grade verification for items with less immediate time constraints and for comprehensive asset management and inventory tasks, showcasing the broad potential of UAS technology in transforming project delivery and operational management.

	UAS Image only Solutions	UAS LiDAR + Image Solutions
2D Pay Item Measurement (examples: guardrail, slope restoration, paving limits)	X	
Material Stockpile Volume Measurement (3D)	X	
2D Asset Location	X	
Construction Progress Monitoring	X	
3D Asset Location + Measurement Based Attributes		X
Grade Inspection / Verification*		X
Excavation Material Volume Measurement (3D)		X

**Appropriate technology should be used based on specified accuracies. Example: UAS Solutions will not be suitable for aggregate or final pavement, curb/gutter grade verification. This may change as technology evolves.*

9.5 **TESTING AND IMPLEMENTING UAS**

To effectively test and implement UAS, MDOT can consider taking a structured and phased approach. For example, initially the focus may be on creating an RFP that allows MDOT to outsource its UAS needs to external consultants as a means of accommodating situations where gaps in time, technology, or personnel warrant it. In this and future phases, the aim is to provide flexibility, allowing MDOT and external contractors to choose the most efficient methods while ensuring the incorporation of UAS is always focused on maximizing the viability of construction applications.

THE FOLLOWING ROADMAP OUTLINES A PHASED APPROACH FOR MDOT TO INCORPORATE UAS INTO ITS PROCESS, ACCOMMODATING WORKFORCE, FUNDING, AND OTHER KEY CONSIDERATIONS:

SHORT TERM $

In the short term, MDOT can embark on a series of pilot projects across all its regions, aiming to explore and evaluate the use of UAS within its operations. This approach is designed to test and evaluate the current capabilities of UAS technology by identifying specific use cases where these tools can significantly enhance efficiency, accuracy, and safety. By avoiding the restriction of regions to predefined projects, MDOT can encourage each region to select pilot projects based on their unique needs and the potential impact of UAS technology, ranging from the rapid quantification of non-hazardous materials to intricate grade verifications and stockpile volume assessments.

We recommend the deployment of at least two pilot projects per region, each tailored to demonstrate the versatility and benefits of UAS across a variety of applications, including, but not limited to, marketing, construction monitoring, and critical data collection for maintenance and asset management. This approach not only aims to better leverage the drones currently at MDOT's disposal but also to expand their use into new areas such as slope restoration, seeding, guardrail installation, and more. The diversity of pilot projects — covering everything from local municipality road projects to complex rehabilitation and joint repair works — will provide critical insights into how UAS technology can be integrated more broadly into MDOT's workflows. The emphasis on phased implementation, particularly for 2D pay items using tools like Pix4D for processing aerial photography, highlights the practical approach MDOT is taking to incrementally integrate UAS technology, ensuring a solid foundation for medium- to long-term applications and setting a precedent for innovative infrastructure management and development.

MEDIUM TERM $$

In the medium term, we suggest that MDOT focus on building upon the initial successes of its short-term UAS pilot projects by refining and standardizing the processes and technologies that have proven effective. This phase is crucial for evaluating the practical applications of UAS in a more structured and expansive manner. The focus will be on developing a standardized approach to integrating UAS into MDOT's survey scope of work, creating a flexible — yet consistent — framework that can be adapted across different regions based on their specific needs and the equipment available to them. This includes assessing the required equipment inventory to ensure all regions have the necessary tools to effectively implement UAS technology.

A significant part of this medium-term strategy involves exploring and formalizing the use of software solutions like Datumate, Propeller, OnStation, or Trimble through targeted pilot projects focused on testing the functionality and benefits of such software in enhancing UAS capabilities for tasks like grade certification and aerial imagery analysis. Through this exploratory and evaluative approach, MDOT can expand the use of UAS LiDAR and aerial imagery across more projects, systematically increasing the department's proficiency and comfort with these technologies. By coordinating additional pilot projects with as-needed staking contracts and focusing on proving the utility of various UAS tools and technologies, MDOT can solidify its foundation in UAS usage. This phase is not only about proving the effectiveness of UAS technology but also about scaling and improving the foundational practices established in its short-term phase, ensuring that the adoption of UAS technology is both strategic and beneficial for the long-term enhancement of MDOT's operational capabilities.

LONG TERM $$$

As MDOT progresses toward a long-term solution, the focus can shift to strategies for the implementation of UAS across the entire state, recognizing the unique requirements, resources, and capabilities of each region. This phase demands a continued commitment to freedom within the framework, allowing each region to tailor UAS activities to their specific project needs and objectives.

Central to this approach is the establishment of dedicated oversight for UAS operations, whether through a designated position within MDOT, a dedicated team, or external consultants engaged on an as-needed basis. This will help ensure a consistent, knowledgeable, and strategic application of UAS technology across all levels of operation. The long-term strategy builds upon the foundations laid in the short- and medium-terms, expanding the scope and scale of UAS utilization. By the fifth year, we anticipate that each region can have the necessary personnel or partnerships in place to not only manage — but also certify — the accuracy and reliability of the data collected through UAS, marking a mature and fully-integrated UAS capability within MDOT's operational paradigm. This progression will fulfill MDOT's commitment to leveraging advanced technologies to enhance the efficiency, safety, and effectiveness of its transportation infrastructure projects.

9.6 MAXIMIZING ACCURACY WITH UAS

Capture Type / Control Level	X/Y Accuracy	Z Accuracy
UAS Photogrammetry – w/o RTK w/o control	+-/ 20'	+/- 50'
UAS Photogrammetry – w/o RTK with control	+-/ 0.12'	+/- 0.15'
UAS Photogrammetry – with RTK w/o control	+-/ 0.15'	+/- 0.20'
UAS Photogrammetry – with RTK with control	+-/ 0.08'	+/- 0.08'
UAS LiDAR – no control	+-/ 20'	+/- 50'
UAS LiDAR – PPK	+-/ 0.10'	+/- 0.10'
UAS LiDAR – RTK	+-/ 0.12'	+/- 0.15'
UAS LiDAR – RTK or PPK with control	+-/ 0.06'	+/- 0.06'

Source: Accuracies depicted above are generalized based on industry experience with various sensors. Accuracies will vary greatly depending on sensor specifications, accuracy of survey control, acquisition parameters, and experience of the processing team.

9.7 MDOT UAS BUILD-OUT

The expansion of UAS necessitates a thorough assessment of potential needs and corresponding funding sources to cover MDOT's anticipated costs. An audit of existing equipment is also essential to ensure the proper allocation of resources and identify gaps in current capabilities. Only then can MDOT determine how to approach funding the acquisition of new aerial drone technology — an approach that might include leveraging vendor contracts or project budgets to procure the necessary equipment. For instance, the Grand Region recently allocated funds from a bridge inspection contract specifically for UAS operations to inspect bridge decks post-repair, which serves as just one model warranting further consideration.

THE FOLLOWING CHART SUMMARIZES MDOT'S CURRENT INVENTORY OF AERIAL DRONES AND PROPOSES HIGH-LEVEL RECOMMENDATIONS ABOUT SHORT- TO-LONG-TERM PROCUREMENT PLANS.

CURRENT INVENTORY	SHORT-TERM PROCUREMENT PLANS	MEDIUM-TO-LONG-TERM PROCUREMENT PLANS
DJI Matrice 300 Enterprise, with LiDAR, thermal, and high-resolution digital cameras	3) **DJI Matrice 350 Enterprise**, with L2 LiDAR systems and quality photo cameras	One high-resolution drone per TSC
DJI Matrice 600, with RIEGL miniVUX-2UAV high-resolution LiDAR system		
DJI Matrice 600, with high-resolution digital camera		

CHAPTER 10 **OPTIMIZING EQUIPMENT WITH EXISTING TOOLS**

The conversation about digital delivery's future within MDOT emphasizes the significance of leveraging existing tools and technologies — rather than solely focusing on groundbreaking innovations. This section centers on refining current processes, eliminating redundancies, and optimizing the use of tools already in possession.

MDOT has already made important strides in incorporating technology to manage project workflows, digitize surveying, and enhance infrastructure monitoring through advanced data analytics and reporting tools. MDOT's commitment to a digital future is perhaps best embodied by this initiative, which aims to incorporate digital delivery into MDOT's construction practices. However, given MDOT's reliance on traditional methods, such as USB drives for file transfers, and the challenges posed by limited Internet access in the field, there is a pressing need to enhance the efficiency and effectiveness of available resources. Meanwhile, the introduction of ProjectWise 365 offers a gateway to cloud-based functionalities, while SYNCHRO provides model-based access tailored for field operations, signifying a step toward simplifying interfaces and establishing more streamlined processes and workflows.

In the short term, MDOT's strategy might focus on identifying and implementing the "low-hanging fruit" — or solutions that utilize the technology at hand without necessitating substantial change or investment. These solutions aim to address immediate operational inefficiencies, fostering a culture of continuous improvement and setting a solid foundation for future advancements. By getting the most out of existing technology, survey equipment, and software — and exploring simple enhancements — MDOT can achieve quick wins that build momentum and confidence among its workforce.

These initiatives, framed in this section as recommendations rather than requirements, could pave the way for a more digitally-powered and efficient organization that is ready to embrace longer-term and more complex digital solutions.

PRIMARY GOALS
BY OPTIMIZING EQUIPMENT WITH EXISTING TOOLS, MDOT CAN ACCOMPLISH THE FOLLOWING:

- Leverage current assets like Bentley OpenRoads Designer and Leica Infinity (desktop or office software) and Captivate (field software) more effectively to enhance field operations.
- Aim to eliminate repetitive tasks through smarter workflow design.
- Supply field staff with the tools needed for wireless access to facilitate their tasks.
- Focus on using technology to improve safety protocols for field operations.
- Simplify and optimize procedures to boost overall productivity.
- Ensure seamless interaction between field personnel and central office staff for clearer, more efficient communication.
- Enable champions while enhancing the skill set of the workforce regarding the use of current technologies and tools.
- Encourage wider and more effective use of available technologies and tools among staff.
- Directly provide critical design elements like alignments and profiles from OpenRoads Designer as part of the contract to support short-term objectives and improve the use of field equipment such as Leica devices and tablets for precise measurements and locationing.

10.1 SOLUTION 1: ELIMINATE THE USE OF USB DRIVES AND EMAIL AS FILE SHARING TOOLS $

USB drives and email are currently essential for transferring data to MDOT's data collectors due to the absence of cloud-based storage solutions and the limitations of existing network security measures. This reliance is also driven by the convenience and necessity of sharing information in an environment where network conditions can cause slow access to ProjectWise, particularly in the field. Challenges such as the cumbersome process of delegating emails to the right hands, user security requirements in ProjectWise that limits file placement by consultants, and the increasing absence of USB ports on modern computers underscore the need for a more efficient solution.

WE RECOMMEND THE FOLLOWING SOLUTIONS TO HELP MDOT TRANSITION AWAY FROM THE USE OF USB DRIVES AND EMAILS FOR FILE TRANSFERS:

- **Begin with MDOT staff:** Start the cloud adoption process internally among MDOT staff to refine workflows before expanding it to include external partners. This initial focus will ensure that internal teams are proficient in cloud usage and that any issues are resolved before consultants, vendors, and contractors are involved.
- **Enable cloud-based storage:** Implement iTwin, Leica Cloud Services, and PW365 for cloud storage and file sharing. Testing these platforms with MDOT's current systems will confirm their effectiveness for project collaboration and data transfer.
- **Expand and procure necessary equipment:** Upgrade equipment to ensure compatibility with cloud services. This includes greatly expanding MDOT's field connectivity by providing Internet modems in every state-issued truck.
- **Develop governance and processes:** Formulate governance and standardized processes to facilitate MDOT staff's transition to cloud-based file storage and sharing, ensuring a structured approach to data management.
- **Develop training and resources:** Establish a comprehensive training program and support resources to aid MDOT staff in the adoption of cloud technologies, aimed at building confidence and competence.
- **Leverage phased implementation:** Gradually phase out the use of USB drives as cloud services are tested and scaled, allowing for a smooth transition based on proven effectiveness.
- **Investigate the use of Esri field maps:** Assess the potential of Esri field maps for enhancing data interaction, especially for project elements like alignments and linear items. Despite its 2D limitations, other states like Utah leverage Esri as their primary system.
- **Standardize asset management guidelines:** Work toward a unified asset management approach across all MDOT regions to address disparities and streamline asset management practices.
- **Reevaluate design submittal requirements:** Optimize design submittal protocols to ensure data is accessible and manageable for field staff, including standardizing more consistent packaging approaches that allow for multiple files to be accessed without the use of ZIP files.
- **Finalize a Level of Development (LOD) Standard for Michigan:** Establish a state-specific LOD standard that expands on current model development standards that are part of design submittal requirements to guide model delivery. These LOD standards could aim to minimize risk, reduce redundancy, and achieve cost and time efficiencies.

10.2 **SOLUTION 2: UPDATE AND STANDARDIZE DATA COLLECTORS $$**

Currently, there is no unified standard for the types of tablets and data collectors used in the field across various MDOT projects, with devices ranging from Leica CS20, iPads and Mesa Rugged Tablets to Dell Latitude laptops, leading to a fragmented approach to technology deployment. The acquisition of additional Mesa Rugged Tablets for testing across GIS, construction, and survey departments indicates a recognized need for standardizing equipment to address challenges such as file size limitations and to enhance operational efficiency. However, challenges persist with tablet functionalities, such as limited long-range Bluetooth capabilities affecting the distance from which field workers can operate, alongside issues of durability, battery life, and screen visibility under various environmental conditions. There's also a noted resistance to technology adoption among the workforce, with preferences varying across work types.

TO OVERCOME THESE OBSTACLES, WE SUGGEST THAT MDOT TAKE THE FOLLOWING STEPS
Standardize the use of a single type of data collector across different work types, aiming to simplify the technology used in the field, and encourage broader adoption by reducing the complexity and variability of equipment needs.

- **Find alignment with the procurement cycle:** Aligning field equipment procurement with the state's standard hardware procurement cycle of four years will help ensure that field equipment is consistently funded and standardized across Michigan. This approach will facilitate the acquisition of necessary field equipment, enhancing operational efficiency and ensuring that field staff have access to the latest technology.

- **Ensure access and proper use of equipment:** Focus on addressing disparities in equipment availability and usage to ensure equitable access to technology across regions. The responsibility for activating and effectively utilizing provided technology, such as iPads, could be clearly assigned to prevent underutilization and to guarantee that field staff are fully equipped, trained, and supported. It will be crucial to engage regional business analysts to address statewide inconsistencies and gain uniformity in technology adoption.

- **Further equip field staff with data collectors and/or tablets for testing:** Expand the pilot testing of Mesa Rugged Tablets and DT Systems data collectors in the short term by identifying specific device requirements and selecting a group of inspectors with varying equipment for a comparative analysis. This pilot can evaluate the effectiveness of these devices in the field, with the long-term aspiration of optimizing equipment choices based on pilot outcomes, potentially leading to a more streamlined approach to field equipment use.

- **Create standards and requirements for hardware features and specs:** Establish clear standards for hardware specifications and features, considering the needs and preferences of MDOT staff, such as the desire for external keyboards. By comparing the functionalities of various devices, including Mesa Rugged Tablets, iPads with LiDAR, Dell Latitude laptops, and Leica CS20 field controllers, MDOT can tailor its equipment procurement to best fit the specific needs of its operations and work type adaptability, minimizing the amount of equipment field staff need to carry from project to project while maintaining the flexibility to use additional devices as necessary.

Device Overall Rating

	<- Best	1	2	3	4	5	Worst ->
	BULK	CONNECTIVITY	USABILITY	USER FRIENDLINESS	RUGGEDNESS	INTEROPERABILITY	CLOUD READINESS
Juniper Mesa	3	2	3	3	2	2	2
iPad Pro	2	1	3	1	4	4	2
Dell Latitude	5	2	3	3	2	2	2
Leica CS20	1	4	2	4	1	4	5
DT Systems Tablet	3	2	3	3	2	2	2

Device	Pros	Cons
Juniper Systems Mesa	Ruggedized	Heavy
	Physical keyboard option	Bulky
	Good battery life	No 5G cellular capability
	Data collector	
iPAD Pro with LiDAR	Latest/advanced technology	Overheating issues
	5G cellular options	Glare issues on glossy screen
	LiDAR capabilities	Not rugged
	Smart stylus	Bulky with protective case
		Not a data collector
Dell Latitude Rugged Tablet	Full Windows experience	Bulky
	Customizable	No physical keyboard options
		No 5G cellular capability
		Not a data collector
Leica CS20	Rugged	Outdated technology
	Physical keyboard built in	Limited app options
	All weather option	No 5G cellular capability
	Long range Bluetooth	Outdated operating system
	Data collector	
DT Systems Tablet	Long range Bluetooth	Bulky
	Full Windows experience	No physical keyboard options
	Data collector	No 5G cellular capability

10.3 SOLUTION 3: EXPAND NETWORK ACCESSIBILITY IN THE FIELD $

CURRENT NUMBER OF MOBILE WI-FI HOTSPOTS: 33

An adaptable and consistently updated process is essential to effectively transform lessons learned and feedback from pilot projects and testing into actionable improvements. Unlike Michigan State Police vehicles equipped with mounted units, most MDOT trucks lack modem or Wi-Fi capabilities. A short- to medium-term solution might involve deploying one or two field modems per region to increase the number of trucks equipped with Wi-Fi. In the long term, integrating truck-mounted modems as a standard feature option during truck installations, along with exploring portable Wi-Fi backpacks for added portability, could enhance network accessibility across all MDOT operations.

10.4 SOLUTION 4: STANDARDIZE MDOT'S USE OF BLUEBEAM $

Bluebeam is an integral tool in MDOT's toolbox. Across the state, teams utilize live Bluebeam sessions for documentation, marking up and tracking contributions with initials and timestamps. However, challenges arise with using multiple Bluebeam sessions for a single project, leading to potential issues such as duplicate or missed payments and data redundancy when transferring information from Bluebeam to other platforms. While Bluebeam's user-friendly interface and functionality as a commenting tool are valued, its limitations in pushing information to other applications result in manual work and inefficiencies, particularly in accurately capturing area or linear quantities. This calls for steps to minimize redundancies and streamline processes by standardizing MDOT's use of Bluebeam, ensuring a more efficient workflow and accurate payment and data management system.

MOVING FORWARD, WE PROPOSE THE FOLLOWING STEPS TO HELP MDOT STANDARDIZE ITS USE OF BLUEBEAM:

- **Ensure proper governance and management:** The introduction of a project-level BIM coordinator or manager for each Bluebeam session or project could enhance governance and management, ensuring consistent and controlled session creation and data entry. As the software administrator, the BIM coordinator can tailor sessions to project specifics, establish rules for sheet design, and manage pay items, thereby reducing redundancy and increasing the accuracy of data. This role will be pivotal in overseeing project workflows and adherence to established standards, ensuring that every aspect of the project data is accurate and efficiently managed.

- **Expand and standardize Bluebeam usage across MDOT:** Enhancing and standardizing the application of Bluebeam across MDOT involves defining clear guidelines on its usage, from session creation to data management. By identifying and incorporating best practices for using Bluebeam and related tools into statewide standard tool sets, fields, forms, etc., MDOT can ensure uniformity in its projects, facilitating smoother workflow and data consistency across the board.

- **Improve accuracy and reduce redundancy:** Developing a comprehensive standard that dictates the use of Bluebeam could streamline project workflows and reduce data redundancy. This includes setting up standardized style guides, toolsets, and categorization methods for comments and pay items, as well as defining attribute usage within the software. Establishing uniform scales and attributions — such as colors, styles, and metadata — across sessions will not only improve data accuracy but also ensure compatibility and ease of integration when transitioning to other systems like SYNCHRO, BIM collaboration format tools, and CAD tools, aiming for a cohesive approach to project management and documentation.

10.5 **SOLUTION 5: STREAMLINE, LOCALIZE, AND IMPROVE DATA COLLECTION AND CALCULATIONS IN THE FIELD $**

This report has noted inefficiencies and opportunities for improvement in MDOT's current workflow for data collection and processing. This includes a disconnect between field collection and data calculation, which is often verified by personnel not directly involved with the collection of the data. This can lead to missed details and errors, as crucial project context may be overlooked. It's a challenge that extends beyond just equipment to encompass process and personnel, highlighting a need for cultural and procedural shifts toward embracing technology across all levels of staff. Despite having a group of tech-savvy technicians willing to perform calculations in the field, a broader acceptance and integration of technological advancements remain essential for mitigating risks and fostering a more cohesive and effective project management environment. Across the board — and throughout each of MDOT's regions — workers could be equipped to perform data calculations while dynamically collaborating with office staff for verification.

TO ADDRESS THIS, WE SUGGEST TAKING THE FOLLOWING STEPS TO STREAMLINE, LOCALIZE, AND IMPROVE DATA COLLECTION AND CALCULATIONS IN THE FIELD:

- **Target efficient data calculation and upload:** By calculating data directly on data collectors and linking to the data rather than relying on screenshots for sharing, MDOT can significantly improve efficiency in data management. Training office technicians on how to directly access this linked information will eliminate the need for screenshot sharing, enhancing workflow and data accuracy through the addition of specific data attributions.

- **Utilize cloud functionalities:** The adoption of ProjectWise 365 and SYNCHRO's cloud functionalities represents a pivotal shift toward more efficient project management. This transition not only facilitates real-time data sharing and collaboration among project teams but also reduces reliance on physical storage devices like USB drives, contingent upon the availability of ProjectWise 365 and robust field network connectivity.

- **Offer comprehensive training for workers:** User training is a crucial component of integrating new technology into any program. For example, it's essential for field and office staff users to receive comprehensive training on key software such as OpenRoads Designer. This approach empowers technicians to perform detailed tasks directly in the field, streamlining the data collection and analysis process.

- **Designate responsibility:** The successful implementation of these technological and procedural advancements may necessitate the creation of a new role or the involvement of a consultant. Consider options such as hiring new graduates, leveraging the Engineering Development Program for rotational assignments, or creating a centralized field role to provide the structured support and innovation needed. Providing incentives and establishing a rotational staff member or consultant to work directly in the field could foster a culture of continuous improvement and technological adoption within MDOT.

10.6 SOLUTION 6: ESTABLISH A GENERAL FEEDBACK LOOP SYSTEM $$

To effectively transform lessons learned and feedback from pilot projects and testing into actionable improvements, an adaptable and consistently updated process is essential. This involves not only immediate changes based on short-term feedback, which often lacks proper documentation, but also a strategic approach to integrating medium- and long-term insights. We recommend that MDOT conduct regular audits or evaluations of its process to make sure it evolves in line with the organization's shifting needs. Establishing a structured feedback loop, complete with triggers, standard changes, and clear goals, is crucial for capturing and applying feedback over various timelines. This system will enable the organization to recall lessons from past projects and implement these insights to foster continuous improvement.

THE FOLLOWING TOOLS CAN ASSIST MDOT WITH ESTABLISHING A FEEDBACK LOOP:

- **SYNCHRO:** Implement SYNCHRO's issues tracking function to categorize issues, such as "programmatic adjustment," with anticipated resolutions tagged as immediate, less than 2 years, or beyond 2 years, for example.

- **Esri Story Map**: Incorporate identified project issues into an Esri Story Map for dynamic programmatic dashboarding, where the anticipated resolution timelines trigger follow-up evaluations and potential adjustments or industry engagements.

- **MDOT's current data stack:** Maximize the existing data infrastructure at MDOT to enhance efficiency and streamline processes.

10.7 SOLUTION 7: INTEGRATE AASHTOWARE WITH LEICA AND OTHER PLATFORMS $

Integrating AASHTOWare with platforms like Leica and Trimble presents certain challenges, notably in facilitating the transfer of location data from survey equipment into AASHTOWare. The process involves not only acquiring location data using survey equipment but also ensuring seamless data transfer across platforms and then translating this data into AASHTOWare. This underlines the necessity for a cohesive strategy to bridge the gap between these platforms and streamline the data integration process.

Trimble and Leica have recently developed applications to address the location data redundancy. MDOT has started training some of their champions that are using AASHTO Construction and Materials. Anticipating when all projects are in AASHTOWare Construction and Materials from vendors in the short term, MDOT can focus on continuing to refine the current processes with the available workflow. There's an expectation that, by the time these practices are standardized, vendors will have further developed solutions for better integration between AASHTOWare and data collection. To stay ahead of this resolution, MDOT can maintain a dedicated staff or adopt an as-needed approach to monitor vendor progress and industry advancements toward improved integration. Furthermore, MDOT could play a proactive role by considering pilot projects in collaboration with Bentley and AASHTOWare to identify practical solutions firsthand. Participating in the solution design process would not only position MDOT as an early adopter but also ensure that the department contributes to shaping a future of cross-platform integration that meets its specific needs and challenges.

10.8 SOLUTION 8: MINIMIZE REDUNDANCY AND DUPLICATION $

ITEM 1: UPDATE THE AMG SPECIAL PROVISION (SP)

MDOT has considered an update to the AMG special provision to establish a standardized process for inspection staff, aiming to integrate it into construction guidance and, ultimately, the contract due to its nature as a contractor responsibility. This initiative seeks to balance the reduction of process redundancy with the maintenance of quality assurance checks, striving for a more efficient workflow that minimizes model duplication without compromising quality.

The current workflow involves three distinct steps that result in the creation of multiple versions of the same model by different stakeholders: designers initially create a design model in CAD, contractors then review and rebuild this model based on design plans, and finally, engineering stakers or inspectors recreate the model to verify the contractor's version. While ensuring accuracy and mitigating liability, this cycle is marked by significant redundancy, leading to increased costs and risk. MDOT's aim has been to refine the process to enhance model quality and streamline operations, thereby reducing unnecessary repetitions and associated costs while still preserving the essential levels of quality assurance and liability management.

MDOT could initiate this by transitioning to spine lines as contractual elements, which includes 3D breaklines of the line strings for alignment, profile, and edge of pavement/back of curb. This approach would necessitate the inclusion of alignment and profile data and 3D line strings as part of deliverables, transitioning away from solely relying on RID. By making these components contractual — consolidated into a single DGN file for ease of access and standardization — the process could eliminate the redundancy of creating multiple models by different stakeholders, from designers to inspectors, contractors and consultants, each tasked with verifying the previous model due to liability concerns. This change, supported by the use of special provisions from recent pilots and targeted initially at projects involving earthwork, could streamline the design and verification process, reducing inefficiencies and aligning with federal and industry guidance on model development. The move toward contractual 3D models, while challenging existing practices, is bolstered by frameworks and recommendations from organizations like FHWA, AASHTO, Michigan Infrastructure & Transportation Association (MITA), and ACEC, providing a foundation for evolving MDOT's approach to model development and integration.

We propose shifting from having multiple individual models based on plans to delivering a contractual spine line model, which would mark a significant step toward clarity and efficiency in project execution. By adopting this approach, the intent of the project is more clearly communicated, allowing inspector stakers to simply augment the existing model with their specific means and methods, rather than recreating it. This proposal advocates for the consolidation of efforts into utilizing one comprehensive model, with the development of special provision language that can be seamlessly integrated into the AMG special provision, facilitating a more streamlined, efficient, and unified project management process.

SHIFTING FROM MULTIPLE MODELS TO DELIVERING A SAME MODEL IS OUTLINED BELOW:

CURRENT PROCESS	PROPOSED PROCESS
STEP 1: The designers create a design model in CAD, cut plan sheets, and then create the plans, which serve as the contract documents.	In order for this proposed process to launch with an efficient cadence for projects incorporating AMG, the design contracts should include design services during construction. **STEP 1:** The designers create a design model in CAD, including the spine lines, which serve as the contract documents in conjunction with the plan sheets.
STEP 2: The contractor reviews the designer's model and contract documents, which may utilize some RID documents. The contractors then rebuild the model based on the design plans (the contract). This is redundant to Step 1.	**STEP 2:** The contractor and the engineer staker/owner's representation go through their review together to do a quality assessment of the design model. Together, they compile comments and agree on what the changes need to be.
STEP 3: The contractor sends the model to the engineering staker/ inspector, who then rebuilds the model to check the contractor's model.	**STEP 3:** They give these comments and relevant files to the designer. The designer makes the changes and updates the model.
KEY TAKEAWAYS: Three stakeholders repeatedly recreate the same model from the contract to ensure accuracy and mitigate liability, each seeking to identify and correct errors.	**KEY TAKEAWAYS:** These suggestions, and their early adoption, are intended to prepare engineers for future obligations such as providing flexibility on who and how DABs are created by establishing partnerships.

ITEM 2: IDENTIFY WHICH PROGRAM IS SUFFICIENT FOR EACH SPECIFIC TASK

Currently, MDOT and its inspectors utilize Bluebeam sessions to track project components like underdrain installations, storm sewers, and slope restoration, while simultaneously compiling a GIS database for storm structures and managing data across various systems for different purposes such as payments and asset management. This fragmented approach, where different stakeholders access the same data through different tools, could be streamlined in the future by transitioning to tools including Leica, SYNCHRO, GIS, or OpenRoads Designer sessions. This would enable stakeholders to access and interact with the same data file, potentially through mechanisms like locking different layers for specific uses, thus enhancing efficiency and reducing the number of tools needed as users become more adept with a unified, long-term solution.

THIS ITEM HAS THREE COMPONENTS AS FOLLOWS:

1. Assign a dedicated individual responsible for overseeing all pay items on a project, ensuring proper management and continuity while championing the role to provide consistent feedback. In the short term, this involves utilizing existing tools to systematically track quantities, with an assistant/tech or consultant designated to manage all data accurately at the project level, establishing clear accountability.

2. Refine the use of programs and software to establish standards for collecting various types of project information, exploring adaptable methods that can evolve over time. Utilizing GPS equipment, or even smartphones, for data collection — from project kickoff to completion — could enable precise tracking and review of progress, including tasks such as underdrain as-builts, slope restoration/seeding, and removals. This approach ensures accuracy in comprehensive data management, whether employing GPS, Total Station or OpenRoads Designer for more detailed survey work, or using simpler tools like tape measures or wheels integrated with software like Bluebeam.

3. Test and pilot different processes and use cases for streamlining. Currently, certain projects within MDOT leverage GPS equipment and asset management practices more extensively than others, embodying a future-oriented vision for GIS and asset management by centralizing data digitally for easy access, rather than relying on paper records. This digital approach facilitates revisiting and utilizing data for informed decision-making. However, while the idea of a statewide database requires data standardization across all asset phases, there's a recognition that data collection could, at the very least, be systematically organized at a local level by region or TSC.

CHAPTER 11 **NEW TOOLS AND VISUALIZATION SOLUTIONS**

During the research phase, we examined various emerging tools with the objective of assessing their effectiveness in field operations, particularly for data collection and visualization. Our focus was primarily on enhancing data transfer and visualization capabilities to ensure work type adaptability for efficient data collection and pay certification processes.

The approach presented in this section represents a short-, medium-, and long-term strategy for phasing in the adoption of new data collection and visualization tools.

11.1 CONTINUE TESTING AND EVALUATING PROJECTWISE 365, SYNCHRO, QUADRI/TRIMBLE BUSINESS CENTER, AND VGIS/ESRI

SHORT TERM $

In exploring data visualization tools for enhancing construction operations, we identified significant differences between vGIS and Esri, particularly in their application and effectiveness. While vGIS stood out for its superior visualization capabilities, the project team deemed it less practical for day-to-day construction management tasks. Consequently, our focus shifted toward elevating Esri's role within MDOT's toolkit, emphasizing its potential for managing short-term 2D visualizations, along with a comprehensive database for storing 2D as-built documentation and associated metadata. To further refine its technology stack, MDOT may consider a pilot program that leverages the Esri field maps to transfer 2D data between CAD and GIS. These pilots could also include comparing SiteVision and vGIS as a visualization tool across various regions to assess their practicality and integration into workflows.

Additionally, the need for efficient data transfer and sharing prompted the project team to evaluate several cloud-based software options. Given the existing use of Bentley systems, SYNCHRO emerges as a logical choice for a pilot project. This next phase of technology assessment might involve comprehensive testing by panel team members and their staff, with an emphasis on practical application and ease of integration. Finding funding for these initiatives will be crucial, as will engaging with key stakeholders such as Statewide Design Alignment Team (SDAT), Statewide Alignment Construction Team (SACT), Executive Operations Committee (EOC), Enterprise Information Management (EIM), and Department of Technology Management and Budget (DTMB) to align MDOT's strategy with broader organizational goals and ensure a cohesive approach to adopting new digital tools. This collaborative and strategic approach will not only enhance operational efficiency but also foster innovation within MDOT's construction management practices.

MEDIUM TERM $ TO $$

In the medium term, we recommend adopting a structured approach to project management and data visualization focusing on the utilization of spine lines as contracts through platforms like ProjectWise 365 and SYNCHRO, alongside pilots integrating SYNCHRO and iTwin via ProjectWise 365. Additionally, we recommend using Quadri and Trimble Business Center and tools based on vGIS or Esri as key components of MDOT's suite of technologies, in addition to evaluating new technologies that emerge in the future.

To ensure a comprehensive evaluation and seamless integration of these tools, we suggest adopting a phased rollout, with spine line contracts serving as the primary focus. This rollout includes conducting two pilot projects each for SYNCHRO, Quadri/Trimble Business Center, and Esri/vGIS, allowing MDOT to test and refine these technologies in real-world scenarios. These pilots can also test or validate how data from internal tools like ProjectWise 365 or SYNCHRO can be consumed by external partners to expand on the optimization of existing tools to simplify deliverables. These pilots can provide valuable insights into the practical application and benefits of each tool, ensuring that MDOT's approach is both innovative, yet grounded in practical utility.

Funding from STIC can play a crucial role in the phased rollout of this approach, ensuring that the adoption of these technologies aligns with broader strategic goals. At the project level, these pilots may also benefit from leveraging consultant testing on existing projects, offering a flexible opportunity to assess the tools' effectiveness and integration capabilities in a variety of settings.

LONG TERM $$$

In the long term, our proposed strategy pivots toward leveraging the insights gained from medium-term pilots to make informed decisions about the adoption of SYNCHRO, Quadri/Trimble Business Center, or tools based on vGIS/Esri. Leveraging a careful, phased rollout that initiates with a single pilot project in regions that were not involved in the medium-term pilots, MDOT can ensure a broad and inclusive evaluation of these technologies.

As this report has emphasized before, this long-term vision is not just about adopting new tools but about systematically transforming MDOT's approach to infrastructure projects, ensuring they are more efficient, effective, and aligned with the latest in digital construction innovation. In the second part of this long-term phase, MDOT may wish to expand the implementation statewide, categorizing projects by type to tailor the technology's application to specific needs and challenges. This expansion can be supported by integrating with MDOT's Digital Vision, underscoring a commitment to enhancing project management and design through cutting-edge technology.

CHAPTER 12 **FINAL THOUGHTS**

This report marks the beginning of an ongoing journey toward the full integration of construction digital delivery at MDOT. It lays down a robust foundation that acknowledges the necessity of further development for complete adoption. Through in-depth research and case-making, it outlines the current state of digital delivery and envisions how people, process, and technology considerations can improve construction management at MDOT. It aims not only to prepare MDOT for immediate action but also to ensure the organization is primed for scalable growth as it navigates through its digital transformation journey. This forward-looking approach is designed to equip MDOT with the knowledge and framework needed to adapt and thrive in an increasingly digital construction landscape.

Beyond the realm of construction, the report's findings have broader implications. They suggest a template for the adoption of similar digital solutions across various facets of MDOT's operations. This underscores the importance of inter-departmental cooperation to explore and expand the scope of digital delivery, advocating for a unified effort to harness technology's potential across the enterprise. This holistic view encourages a shift towards a more integrated and technologically adept organization capable of leveraging digital advancements to enhance efficiency, productivity, and service delivery across all areas of work.

At the same time, the report also cautions that the journey toward technological innovation is never-ending. It emphasizes that embedding a culture of continuous improvement and innovation within MDOT is crucial for the sustainable success of any technology program. It highlights the essential role of internal champions who are committed to driving the integration of new technologies into MDOT's operations, alongside the strategic utilization of external consultants to provide comprehensive support and expertise when it's needed most. This approach will ensure that MDOT remains at the forefront of technological advancements, fostering an environment that is not only receptive to change but, ultimately, capable of leveraging it for improved outcomes and operational excellence.

CHAPTER 13 **ACKNOWLEDGEMENTS**

The project team consisted of representatives from MDOT and leading technologists and professionals working in surveying, engineering, and construction. Working together, the project team sought the best possible outcomes for MDOT, uncovering common construction challenges and leveraging best practices in people, process, and technology to co-design a set of tailor-made solutions. This collaborative process is reflected in this report's recommendations.

We are grateful to the executive leadership of MDOT, whose vision and support have made these advancements toward digital delivery possible.

MDOT
Michigan Department of Transportation

The Michigan Department of Transportation (MDOT) is responsible for Michigan's nearly 10,000-mile state highway system, comprised of all M, I, and US-routes. It is the backbone of Michigan's 120,000-mile highway, road and street network.

The state owns over 4,700 highway, railroad and pedestrian bridges, 665 miles of railroad track, roughly 2,700 miles of nonmotorized trails, and four airports. Additionally, MDOT administers state and federal transportation programs for aviation, intercity passenger services, rail freight, and local public transit services.

Countless individuals from MDOT lent their ideas and expertise to this digital delivery initiative, and we want to begin by acknowledging the Research Advisory Panel (RAP). The project was led by **Andrew Block**, supervising manager of design services; **Glenda Bowerman**, survey construction support; **Dean Kanitz,** transportation engineer; and **Rick McGowan,** construction technology innovation analyst. We would also like to thank **Mike Stoltz, David Brunsting, Brent Johnson**, and **Jason Knauff** for their contributions to the project. We would also like to acknowledge the staff from Lansing, Brighton, and Oakland TSCs for their organization, participation and feedback during the field visits.

PROJECT CONSULTANTS

CRAFT

CRAFT

CRAFT helps companies drive transformational value through digital innovation. Founded by Mona Ketterl, one of the country's leading technologists and workforce transformation experts, it focuses on the importance of change management and building advocacy to achieve buy-in for fresh ideas. CRAFT works with organizations that are entering a new phase in their digital transformation journey, helping them achieve practical transformation one step at a time.

Mona Ketterl is the founder and owner of CRAFT, a consultancy that helps companies drive transformational value through digital innovation. She brings a 360-degree perspective to her role as lead technologist and workforce transformation consultant for CRAFT, having worked with clients across the federal government, consumer goods, automotive, service-based, and high-tech segments.

Dillon Goodson is a technical writer, researcher, and strategic advisor at CRAFT. Drawing on more than 15 years of experience in communications and organizational leadership, he helps clients shape convincing narratives about the impact and opportunities of their work, leveraging critical insights to navigate complex, global change.

Laura Heidrich is a communications professional with 20 years of experience in change communications, process development and training, and technical writing and editing to support CRAFT clients in reaching their goals. On this project, Laura served as communications and program marketing expert and supported research and overall QAQC.

MICHAEL BAKER INTERNATIONAL

Michael Baker International is a leading provider of engineering and consulting services, including design, planning, architectural, environmental, construction, and program management. Based in Pittsburgh, Pennsylvania, and with more than 85 offices nationwide, it serves as a trusted adviser to the communities it serves, making them safer, more accessible, more sustainable, and more prosperous.

John Wilkerson is the digital delivery director at Micheal Baker International. With more than 20 years of transportation experience, he has a passion for transforming the transportation industry by guiding agencies on their BIM for Infrastructure journey.

Cathy Cassar is a BIM\digital delivery specialist with industry-wide experience. She is responsible for developing and leading BIM implementation for transportation projects, training, mentoring, evaluating project needs, creative problem solving, and developing focused training strategies.

SPICER GROUP

Spicer Group provides professional engineering, land surveying, community planning, and architectural services. Founded 80 years ago, it contributes across all aspects of project delivery — from on-demand solutions to long-term planning — consistently incorporating new technology into its work processes and always remaining 100 percent accountable.

Eric Barden, P.S., is the director of surveying and serves as a principal at Spicer Group. With a distinguished career spanning more than 25 years in the architecture and engineering (A&E) sector, he has been instrumental in steering Spicer Group to a leadership position within the surveying industry. Under his guidance, Spicer has consistently been at the forefront of innovation, focusing on streamlining processes and procedures to significantly enhance operational efficiency.

Darrin Wilson is a seasoned project surveyor at Spicer Group with 18 years of specialized experience in the field of construction surveying. Renowned for his expertise, he excels in the application of cutting-edge technology to minimize redundancy and maximize efficiency in construction surveying projects. His innovative approach and deep industry knowledge position him as a leading figure in leveraging technological advancements to enhance project outcomes.

Trenten Cameron is a highly proficient geospatial technician at Spicer Group with more than a decade of experience in aviation, encompassing both manned and unmanned aircraft systems. In addition to his aviation expertise, he has more than five years of specialized knowledge in the surveying and geospatial disciplines. Trenten consistently prioritizes technology and innovation in his strategic approach to problem-solving, ensuring cutting-edge solutions are at the core of his professional endeavors.

CHAPTER 14 **APPENDICES**

APPENDIX A:
WORKSHEET FOR SOLUTION 1: OPTIMIZING FIELD EQUIPMENT WITH EXISTING TOOLS

APPENDIX B:
WORKSHEET FOR SOLUTION 2: USING UAS LIDAR AND AERIAL TECHNOLOGIES

APPENDIX C:
WORKSHEET FOR SOLUTION 3: NEW FIELD TOOLS FOR DATA COLLECTION AND VISUALIZATION

Digital Delivery Solution Design Workshop

December 15, 2023

Session 1: Optimizing Equipment with Existing Tools

Solution Focus 2: *(Tech, equipment, process)*

Optimizing Equipment with Existing Tools
The goal is to optimize the existing equipment and tools that MDOT currently have. Focusing on field operations and data transfer.

Technology and Equipment:
Utilize existing connectivity technology and survey field equipment and software and work to optimize their use for better consistency and efficiency across the enterprise, while evaluating and leveraging simple bolt-on enhancement tools

(1)	**Use Cases** *(check all that apply)*
P	Data accessibility Data transfer Feed IDRs Feed TAMS
P	Cloud-based field access
	On site asset location / Work type adaptability
	Adjusting deliverables
S	Data visualization
P	Data management
S	Remote assistance and collaboration
S	Training and worker safety
S	Data collection and pay certification

(1) P-Primary Focus, S-Secondary Focus, Blank-Indirect Outcome

Notes

Timing *Description of Tech, Equipment, Process, Standard*	**Magnitude** *Description of how the solution will be phase tested and implemented*	**Strategy and Funding** *Identification of potential Needs and funding sources based on anticipated cost.*
Short Term 1. Leica GNSS and TPS surveying equipment 2. Leica Captivate Field software 3. Bentley ORD for alignment file and model file prep 4. Wireless connectivity tools 5. Evaluate Leica Exchange 6. 7. Further equip field staff with tablets to test. Identify the requirements needed for the devices to test. Mesa data collector (tablet) expanded use? State has 3 for testing. Grand Region is buying 2.	1. Work to standardize across the enterprise on the data prep procedures, field job setup, and roles/responsibilities of MDOT users, and surveyor oversight roles 2. Start to evaluate Leica Exchange to facilitate data transfer between field-office and define standard protocols for regular data management/review 3. Roll out more devices to TSC's that are leveraging technology	Can be worked on anytime this winter before 2024 construction season Tablet rollout should focus on early adopters Equipment changes can be put out as a statewide policy, but the purchasing of equipment goes through region BNA and finance. Org structure seems to be the limiting factor with statewide rollout of equipment
Notes Need to run on windows *OneDrive and ProjectWise* *How do we get rid of USB?* *Mesa will help us do that.* *People using bluebeam to track stuff. We need to mindful to capability and time ppl have to dedicate to it. Less duplication is better. How to streamline and not add more work. That Leica exchange should be investigated. Tool can help standardize data and keep things updated throughout construction.*	1. Using mesa tablets today. Need to have more out there now. We bought 3 for testing. Between gis, construction and surveys. And Dave bought 2, and Mike wants two of them. It solves problems with file sizes. DT Systems and Mesa pilot. Short term: get more tablets whether it's DT Systems, and Mesa. Equip them in the field. We need windows ten, external keyboard. ID those needs. How many? Need follow up. Must eval based on user group we currently have…. Have shared mesa devices. 2. How do we procure equipment directly through a project? How and standardize it across the state.	

	3. Standardize on a Microsoft enabled data collector.	
Medium Term 1. Same tech as above 2. Add Leica Exchange to the technology stack and begin to pilot its use 3. Based on tablet testing adjust equipment procurement process to implement the tablet that meets the success criteria	1. Each project will need a "Surveyor" in responsible charge (either MDOT or consultant personnel) 2. Pilot Leica Exchange across a few projects	1. Could leverage Region wide as-needed contracts 2. Can be any project or tied in with as-needed contracts 3. Cost for Leica Exchange was so high that it became outside feasibility
Notes	Mesa: change procurement process around what we think is the best. Make recommendation that inspectors have xyz. Organizational structure planning and change management.	
Long Term 1. Evaluate other industry solutions from Trimble, or others 2. Focus on integrations with AASHTOware	1. Identify available solutions in the marketplace 2. Draft an RFP that outlines the goals, available market solutions to test, then select a 1 consultant for each solution so a consultant can be selected that already has the base technology platform (Leica, Trimble, 3rd party).	1. STIC, AID, ADCMS 2. Funding can then be focused on purchasing the software solution without the hardware and the consultants time
Notes		

RACI Development (This represents all the solution focus concepts)

Who is responsible to complete the work?
(Enter both the person's name and their title. This responsibility needs to be reassigned if the person leaves the organization.)

- Short term: Glenda / survey support ; Glenda Bowerman -short term for data collector equipment ; Rick McGowan or Construction Technology Group
- Long term: RBMT ITOT will still set policy, budget and what is allowed ; Digital vision team to suggest master vision, these devices are in the catalogue, not the bad devices you used to have.
- Mid-term: a new team formed under Brad
- Long term:

- Glenda Bowerman – Short term for data collector equipment
- Dan/Rick McGowan or Construction Technology Group – short term data transfer
- A – Team: Research Advisory Panel? Make sure this includes CE's
    - Take plan to SACT then to RBMT
- Dee Parker and Jason Gutting – short term deliver to RBMT

Who is accountable to ensure the task is completed? (*Enter both the person's name and their role.)*

- TSC CE or Region CE– Short Term OH budget, equipment, and data transfer
- RBMT organizational change for medium/long term procurement of devices
- Digital Vision Team – long term

- Short term: TSC CE or Region CE – OH budget, equipment and data transfer
- Dee Parker and Jason Gutting – short term take outcome to RBMT
-
- Medium term: RBMT organizational change for procurement of devices
- Long Term: Digital Vision Team (the team that owns this that must be formed that reports to Brad)
- Ken, Dan Burns – Data transfer ??

Who should be consulted before finalizing?
(Enter both the person's name, title and organization including all directly affected stakeholders.)

- Region Surveyors

- Region Inspection staff
- ACEC Survey Task Force

Who should be informed of the results?
(Enter both the person's name and their title. Err on the side of including a stakeholder.)

Known Issues and/or Challenges to Implementation	Counter Measure / Solution
Technological	
Technological challenges related to hardware and software capability. 1. Interoperability of solutions, data standards 2. SOM technology implementation limitations with DTMB a. Need to manage how the DTMB standard install impacts the usefulness of the equipment	Describe how the identified tech challenge will be managed or circumvented? 1. Work with vendors on universal data exchange, telemetry, communication, etc. 2. ??
Notes ***Procedure for procuring equipment.*** ***Organizational structure*** ***Need to manage how the DTMB standard install impacts the usefulness of the equipment.***	
Procedural	
Procedural challenges are constrained by the cultural or regulatory framework of the agency	Describe how the identified procedural challenge will be managed or circumvented?

1. Proper survey staff oversight 2. Procurement of equipment is through the region budgets so some areas are not able to acquire the tech and equipment they need simply based on the limited budget	1. Develop process for engaging a surveyor for oversight role on every project 2. Support for the vision from director a. Digital vision team is working on designating a position under Greg as the steward of the digital vision b. Dedicated team for BIM implementation c. Adjust that equipment is issued based on tool/need 3. Need a way to manage the unused equipment being reported up as not being necessary.
Notes	
Change Management	
Change management challenges involve training and willingness to adopt new methods or tools. 1. Challenges with willingness to adopt new tech and change tech 2. Staff turnover, attrition	Describe how the identified change management challenge will be managed or circumvented? 1. Continue to educate on the value, training workshops 2. Other?
Notes	

Mona's Notes:

Solution 1:

- Boils down to org structure – organizational structure needs to be aligned. But must start with org structure, and no brainer. How to build it if it doesn't have concrete foundational elements into it.
- Bill Pratt said it too. He talked about where he started.
- Tied into Bureau of Planning.
- **Action: In the introduction.**
  - We need a section in the report around organizational change….
  - What we have in the past and in the future is that we need to have something to give to leadership and to direct it. Tie it to change management.

- Need to have a system that says, the regions must be able to get the right equipment based on business needs.
- Leadership buy-in is critical for the success of our digital delivery program.
- Have a person / group that is dedicated to (like other states) have a group responsible the stewards of the digital vision and their 100% duty to execute and advocate for it. Need dedicated group, that makes it a priority to focus, consolidated group that has a mindset of each aspect based on different groups in the company. This is their 100% focus and accountable for the planning and delivery.
- We've spent our time doing grassroots efforts, but we need a coordinated effort.
- Action: Need to standardize language, definitions, and expectations so we have a common:
    - Understanding of what digital vision is, digital delivery.
    - What is proof of concept: comes before a pilot in MDOT definition (Note: Need Dan Burnes to help in follow up discussions);
    - To DTMB pilot and proof of concept is the same so we must be clear what is what in the report.
    - Proof of concept: No major decisions have been made about tools. Try them out. Test them and figure out what we want to do.
    - Pilot: anything we do on a trial version. No major decisions have been made about tools. Try them out. Test them and figure out what we want to do.

- Because leadership buy in is so important, some thoughts have been discussed around having the digital delivery adoption plan to come from Brad who says we are moving forward in this direction and to set an expectation.
    - i.e., You will issue the mesa tablets, and this is how it will be used.
- Action: Create a Group that reports to director, that can make decisions that do the purchases we need
- Some thoughts that MDOT is siloed and somewhat disconnected today.
- **Communication from the top down is critical.**
- Need a communications plan. Move way from grassroots to a formal strategic cascade of communications.
    - Can we have teams page that collect us?
    - Establish baseline discussion point to exchange going forward. What is not working so we don't keep repeating these things.
- We have separate groups, if we want to do digital delivery moving forward, it can't be different pieces trying to figure it out on it's own. We need a coordinated effort. Digital Vision is going to be a way that brings it all together.
- Under Brad, we need a team or person that has the right authority to do these things as a decision maker.
    - Brad kicked off digital vision before he was the director.
    - Sponsors are bureau heads and it may be a challenge.
- Some thoughts:
    - Need to increase budget on technology.
    - Need to get a mesa in the hands of everyone. And if you couple that with safety, we might be able to have budget.
- Procurement process: Some feelings that equipment purchasing is organizationally incorrect at Michigan and can be improved. "We need to fix it."
- How do we procure equipment directly through a project? How and standardize it across the state.
- Where should BNA reside? For field staff? Moving responsibility somewhere that has the authority. You can't standardize on how people do process in digital age without having consistent equipment to do that process.

- If you have iPad, they sit on a desk because they refuse to use it, and given iPad and then that gets reported that they don't use it.
- Issue equipment based on needs, versus title. Today, issued based on role and title. Wireless

- Medium term: Create a group that reports to Brad that is fully dedicated and measured for the success.
- Short term:
- **Establish a Taskforce: "A team" develops the "thing" (A team = Andrew, Dan, Glenda, > takes to Jason.**
    - Create an A team committee that will in the short term develop a technology standard and recommendation. This team represents the collective interests of the company.

Digital Delivery Solution Design Workshop

December 15, 2023

Session 2: UAS LiDAR and Aerial

Solution Focus: *(Tech, equipment, process)*

UAS LiDAR and Aerial
The goal is to expand the use cases already being developed. Focusing on grade verification.

Technology and Equipment:
UAS LiDAR will initially be used in combination with existing technology and equipment while developing RFP language for broader use on projects. Additional equipment and use of other technology being piloted could be incorporated in the medium and long term.

(1)	**Use Cases** *(check all that apply)*
P	Data accessibility Data transfer Feed IDRs Feed TAMS
	Cloud-based field access
S	On site asset location / Work type adaptability
	Adjusting deliverables
	Data visualization
S	Data management
P	Remote assistance and collaboration
P	Training and worker safety
P	Data collection and pay certification

(1) P-Primary Focus, S-Secondary Focus, Blank-Indirect Outcome

Notes

Timing *Description of Tech, Equipment, Process, Standard*	**Magnitude** *Description of how the solution will be phase tested and implemented*	**Strategy and Funding** *Identification of potential Needs and funding sources based on anticipated cost.*
Short Term 1. UAS LiDAR & Aerial Imagery with existing equipment to verify grade & pay item quantities 2. Develop a scope of work to define technology to be tested and desired outcomes. No SP yet. 3. Focus usage on stockpile volume related tasks (recurring), 2D pay items and 3D grade verification for items where results are not time sensitive. 4. Focus usage also on asset management/inventory	1. Pilot per region using Developed Construction Survey Scope RFP/SP 2. _ Phased implementation focused on 2D pay items Pix4D covers this already a. Make sure we have a pilot for each of main work types b. Research to provide applications c. Slope restoration d. Seeding e. Guardrail f. MOT devices g. milling h. seeding 3. _ Pilots focused on asset management	1. Work with region/tsc staff and select 2-3 projects that have As-Needed Staking contracts in place and insert the scope of work into those contracts. 2. Address concern that a technology/tool focused SP dictates means/methods and doesn't allow for most efficient method to be used. 3. Current technology requires survey control (propeller) and validation (conventional), plus extended processing times. Not great for rapid use and data extraction for 3D grade verification tasks. 4. 2D quantification of things like lane lines can get inspector out of a dangerous situation and streamline collection. 5. Grand is funding through bridge inspection contract to fly bridge decks after the repairs have been marked from sounding.
Notes		

Medium Term 1. UAS LiDAR & Aerial Imagery with existing equipment to certify grade 2. Pilot UAS LiDAR & Aerial Imagery use with Datumate, Propeller, etc.	1. Phased implementation of UAS LiDAR Construction Survey Scope of Work. 2. 2 Pilots for each new technology (Datumate, Propeller, what else? Etc.)	1. Additional pilot projects still coordinating with As-needed Staking contracts 2. Focus on the goal of proving (or disproving) various UAS tools/tech as a method of acquiring required data. But should not be forced if proven to be less efficient. Prove it's use case as an option. Long term, the most efficient method should be used once the scope makes it to widespread use.
Notes		
Long Term 1. Implement UAS LiDAR and aerial imagery internally with Datumate, Propeller, etc. 2. Purchase UAS LiDAR and aerial imagery and chosen technology 3. Update current as-needed staking contract scope of work to include the UAS component.	1. Phased rollout at Region level for Surveyor/Pilot for each Region based on demand. 2. Update standard as-needed scope of work documents to include.	1. Scope of work should dictate outcomes, efficiency, etc., and not specific technology or methods 2. STIC, AID, ADCMS
Notes		

RACI Development
Who is responsible to complete the work? *(Enter both the person's name and their title. This responsibility needs to be reassigned if the person leaves the organization.)* • Glenda Bowerman/Frank Boston or Survey Support • Rick McGowan or Construction Technology Group • Someone from construction?
Who is accountable to ensure the task is completed? (*Enter both the person's name and their role.)* • Lindsey Renner or CFS rep
Who should be consulted before finalizing? Enter both the person's name, title and organization including all directly affected stakeholders. • Digital Delivery Steering Team • Leadership from BOD, Regions, CFS • Region Surveyor • Region Construction Engineer • DDWG • ACEC Survey Task Force

Who should be informed of the results?
Enter both the person's name and their title. Err on the side of including a stakeholder.

Known Issues and/or Challenges to Implementation	Counter Measure / Solution
Technological	
Technological challenges related to hardware and software capability. **1. Extended processing times.** **2. Data validation required before use** **3. Not ideal for long/narrow corridors**	**Describe how the identified tech challenge will be managed or circumvented?** 1. Typical firm workflows will involve the field personnel collecting the data, and office personnel processing the data. The time gap can be closed if field personnel are competent to begin data processing immediately from the field. 2. Check shots will always be required, even if using a type of GPS target(propeller) and PPK/RTK. Results cannot be extracted without the data first being validated. 3. Targets required at model limits. Long corridors require targets along both edges. Possible mitigation would be pre-planned permanent targets placed through the project on areas that will survive the project. This could reduce targeting efforts per UAS mission
Notes	

Procedural	
Procedural challenges are constrained by the cultural or regulatory framework of the agency 1. FAA regulatory challenges still exists flying parts of project that may have live traffic or pedestrians 2. Generally using UAS to verify grade on long projects is not as affective because the processing time is too long. The sand is usually be placed right behind the grading operation. 3. Need to establish localized CORS on project sites. Would help standardize contractor control but would introduce a liability for them to blame the control supplied	**Describe how the identified procedural challenge will be managed or circumvented?** 1. Careful planning required to avoid the public. Sometimes not possible 2. Localized CORS would become part of the RID files a. Regardless of the base the control points need to be checked into at least once per day b. Should be tied into the AMG spec
Notes	
Change Management	
Change management challenges involve training and willingness to adopt new methods or tools.	Describe how the identified change management challenge will be managed or circumvented? 1. Continued education on safety and value

1. **Resistance by people to change or try new tech** 2. **New methods/tools need to create value for use and widespread adoption and buy-in by stakeholders. Cannot use just to use.**	2. Continue demonstration of value to stakeholders.
Notes	

Notes

Mona's Notes

- When we do things as a contractor to get someone onboard we have more flexibility. Consultants use tools daily. They have capability for LiDAR, ariel, drone and MDOT has the tech.
- Focus should be on how to use equipment on MDOT work instead of consultant.
- There are inherent challenges in using UAS, for grade. Evaluate use cases, but salt piles, and others.
- Potential solution: Fly weekly, push to cloud, evaluate progress, and evaluate pay items. Can localize to MDOT project. (ask Eric about this to solution) – There's use cases.
- Use cases:
    - every crew will have drone in the truck, and when you go to construction site (localized site), before you leave, document the site. The processing of that mission becoming so automated, as soon he hops in truck, and by the time engineering is in office, it's on the web, and can see daily progress.
    - fly once at the beginning of the project. And that is all (2D). and realistic uses and save time and safety… instead of having someone shooting lane lines or pull offset stakes to centerlines. Instead throw drone up and map it.

    - Design: do patch logs and imagery of pavement and draw in cad
    - Can leverage drones at MDOT, or consultants can apply to those use cases. We are using MDOT drone on 696 project for 60 rehab bridges. Great idea
    - Grand region marks out bridges. And designers use that as part of drawing to show roughly where patches will be. Funding thru bridge contract. Bridge inspection contract.
    - If we want to use a lot of it, need as needed contract. So you can engage with Eric, and if you don't have it on your engineering as needed contract, we're not doing it. Always throw survey on as needed contract just in case.
    -
- What is the process?
- Create a list of suggestions of what you can use for drones.
    - Short term is X. Medium term is X getting into software….
- Short term: ID Use cases
    - Flight for marketing for another purpose
    - X
    - What level of drone do we need? We must suggest the right drone short term. Long term, cheaper drone….
    - Create use case, and technology needed.
- Need contractors to use and understand AMD?
- Sign waiver? Work from common basepoints (Eric to map out process).
- Localize CORS would become part of the RID document
- Have a requirement, that if your using GPS or equipment that reference network, check into 3 control points beginning of day and end of day. Tie into AMG spec, and if we're using that base station, utilizing AMG specs. So put some language in there – that can be moving to mid term…..
- Pilot: Using LiDAR and Datumate/Propeller. We have pix4D right now.
- Used for measuring slope restoration, or seeding areas. Guard rails, MLT devices. Pix4D cloud lets you pick two diff dates to view and toggle through.
- Short term: Pix4D – MDOT has that today. Desktop version and MDOT and can better use that.

Digital Delivery Solution Design Workshop

December 15, 2023

Session 3: New Field Tools for Data Collection and Visualization

Solution Focus 3: *(Tech, equipment, process)*

New Field Tools for Data Collection and Visualization

The goal is to evaluate maturing field tools for data collection and visualization. Focus will be on Data Transfer and Visualization to have Work Type Adaptability for Data Collection and Pay Certification.

Technology and Equipment:

PW365 and Synchro
Quadri/Trimble Business Center (TBC)
vGIS or ESRI based tool
These tools will be combined with tablets and data collectors as through pilots to confirm the optimal setup.

(1)	**Use Cases** *(check all that apply)*
P	Data accessibility Data transfer Feed IDRs Feed TAMS
S	Cloud-based field access
P	On site asset location / Work type adaptability
	Adjusting deliverables
P	Data visualization
S	Data management
	Remote assistance and collaboration
S	Training and worker safety
P	Data collection and pay certification

(1) P-Primary Focus, S-Secondary Focus, Blank-Indirect Outcome

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Notes

Leica is part of the existing tool optimization.
Data transfer and visualization are key focus
vGIS was a good tool for visualization, but did not seem to meet the construction needs
seemed good for as-builts but not day to day operations
CTUG feedback of Leica with mobile inspector vs Trimble – users that had used trimble did not seemed to like it. It was sticky. Hardware perspective is good but the software is not as well defined.
Want to see what the inspector did and when they did it in real time similar to the bluebeam process Metro has developed.
Need to make sure we focus on the needs of the construction staff at the pay certification process etc.
Real-Time, collaborative, cloud based
Mike noted that Mesa is what they need short term and medium term

As the inspector dumps things into the system/tool everyone needs to be able to see it without using ORD.
vGIS and ESRI are not going to do the grade checks.
Need something to help with grade checks and the things under the ground
These programs are good at looking at the design model, but most of them are not good at using new data from construction unless you bring them through their modeling tool.
Bentley integration server – smartsheets design review is the primary use case
    Plan sheet would look like a pdf but when you click on an element it would give you the imodel data behind it.
ESRI could be moved up the list to be able to track all the measurements the inspectors are taking in one place.
Dan noted that all of these are collectors for AASHTOWare
    More than just quantities and geolocating

Timing *Description of Tech, Equipment, Process, Standard*	**Magnitude** *Description of how the solution will be phase tested and implemented*	**Strategy and Funding** *Identification of potential Needs and funding sources based on anticipated cost.*
Short Term 1. Further test and evaluation of PW 365, Synchro, Quadri, vGIS/ESRI	1. Panel team members and their staff	Should include engaging SDAT, SACT, EOC, EIM and DTMB on strategy
Notes		

Medium Term 1. Spine Lines as Contract using PW 365 and Synchro 2. Synchro and iTwin through PW 365 pilots 3. Quadri/Trimble Business Center (TBC) 4. vGIS or ESRI based tool 5. Open spot for other tools that develop	1. Phased rollout by project type – Spine Lines 2. 2 pilot projects - Synchro 3. 2 pilot projects – Quadri/TBC 4. 2 pilot projects – ESRI/vGIS	STIC for Spine Lines rollout Project Level for pilot projects. Pilots may leverage consultant testing on existing projects. Could start with a tool that Synchro does not do to identify if we like it better Digital measurements being taken by inspectors are compiled in one place.
Notes		
Long Term 1. Synchro Quadri or vGIS/ESRI based on outcome of medium-term pilots	1. Phased rollout starting with 1 pilot project in the regions not part of the Medium-Term pilots. Then expanding statewide by project type.	AID, ADCMS
Notes		

RACI Development
Who is responsible to complete the work? *(Enter both the person's name and their title. This responsibility needs to be reassigned if the person leaves the organization.)*

- Rick McGowan, Luke Arnold, Glenda Bowerman

Who is accountable to ensure the task is completed? (*Enter both the person's name and their role.)*

- CFS and Digital Vision Steering Team

Who should be consulted before finalizing?
Enter both the person's name, title and organization including all directly affected stakeholders.

- Design Services, SACT, SDAT, DDWG, GIS Team

Who should be informed of the results?
Enter both the person's name and their title. Err on the side of including a stakeholder.

- SDAT

Notes

Known Issues and/or Challenges to Implementation	Counter Measure / Solution
Technological	
Technological challenges related to hardware and software capability.	Describe how the identified tech challenge will be managed or circumvented?

1. Interoperability of solutions, data standards 2. SOM technology implementation limitations with DTMB	1. Work with vendors on universal data exchange, telemetry, communication, etc. 2. Initiate Keylight and piloting approvals early.
Notes	
Procedural	
Procedural challenges are constrained by the cultural or regulatory framework of the agency 1. Proper survey staff oversight	Describe how the identified procedural challenge will be managed or circumvented? 1. Develop process for engaging a surveyor for oversight role on every project or at a region level
Notes	
Change Management	
Change management challenges involve training and willingness to adopt new methods or tools. 1. Challenges with willingness to adopt new tech and change tech 2. Staff turnover, attrition	Describe how the identified change management challenge will be managed or circumvented? 1. Continue to educate on the value, training workshops to demonstrate
Notes	

Notes
Mona's Notes:

- About how to make sense of the diff tools you are testing, on different projects to get more consistent feedback. A lot of these things have faults and issues. And we haven't found one that does everything.
- Focus is on data accessibility, variability, data visualization and be able to collect info for pay cert as well.
- To MDOT, Of these tools and of the demos, what did you like the best that you want to see evaluated further and if we missed a tool, what is it?
- We worked to try to prioritize and evaluate what's new.
- Leica exchange: It's already part of existing tools and expand use of those…. make sure Leica exchange – can't use it as we need with PW.
- This solution set his helpful, "Need to know where I am on site…"
  How do I make sure if I collect something in the same system, or able to be transferred to the right system, with the right data flow? These visualization tings might change, and companies might come up with diff things, what are those key things we would need to have?
- vGIS is good program, but when we had demo with them, didn't have a lot of the ways we could use it in construction, but with maintenance, it was powerful. That would be good for As-builts, but for day to day grade checks and area measurements and volume calculations, it's not meeting needs. We want a system, where if we have 5 diff inspectors, they can collaborate and look at the same information and data.
- Leica - To DTMB pilot and proof of concept is the same. No major decisions have been made about tools.
- Evaluate Quadri –
- Needs: Real time, collaborative, cloud based, less effort, reduce duplication. Needs to integrate with PW. Anyone can log in and see it without ORD.
- If I take off 6 weeks. Processes for payment and data transfer? vGIS
- vGIS, Esri (not doing grade checks).
- Short-term solution to help with data transfer: mesa tablet. Buying the state mesa tablets is cheaper than Leica exchange.
- Drone for anything on the earth, all as-builts done with drone
- Synchro, I-twin,
- Quadri – good at viewing design model, but not good for uploading and collecting new data. Unless u take it into cad.
- IFC and vGIS, pulls in model data.
- Bentley integration service -smart sheets, design review, is the primary. Looks like pdf, but it's a digital sheet. You have plan sheet, but when you click on objects on sheet, it has all the info, metadata from cad. Should explore, end of 2024 – it's an iModel. This is getting you into the information.
- when we pilot the software /proof of concept,
- Solution: Short term, further evaluate, to further test.
- We did you like.
  what do you want to see to evaluate if it does it? That would be year 1, then midterm: 2-3 years, do pilots…

Easy to do pilots: PW365 + synchro
Start with ones that drive big change and may have functionality that synchro doesn't have.

MDOT Michigan Department of Transportation
CRAFT
Spicer group
Michael Baker INTERNATIONAL