IDAHO TRANSPORTATION DEPARTMENT

RESEARCH REPORT

Business Analysis for Idaho's Next Transportation Investment System

RP 298

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ITD Research Program, Planning and Development

Highway Development

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Technical Report Documentation Page

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16. Abstract The OTIS software was launched in 2015 to replace "Project Tracking," the Access-based application ITD first developed to manage STIP-related data. Since then, users have experienced numerous foundational issues with OTIS that cause significant delays and occasional errors. Specifically, there is a two-part, mutually-dependent problem with the software involving 1) functionality and design for users, and 2) insufficient cybersecurity measures. Consequently, ITD is seeking to replace the current version of OTIS with a more reliable, supportable software application for tracking the multi-year multi-million-dollar portfolio of transportation projects. The future system is referred to as the Transportation Investment System (TIS) throughout this report. To ITD with this sizable effort, High Street Consulting Group (High Street or the consultant) collected and compiled information on current OTIS implementation, workflows, underlying data, and functionality to generate recommendations for the TIS. The goal of this work is to help ITD offices like Financial Planning & Analysis (FP&A) and Enterprise Technology Services (ETS) understand the technical challenges and requirements for a future system to inform decisions, options, and software capabilities. This report compiles the findings from this research project.			
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Technical Advisory Committee

Each research project is overseen by a Technical Advisory Committee (TAC), which is led by an ITD project sponsor and project manager. The TAC is responsible for monitoring project progress, reviewing deliverables, ensuring that study objectives are met, and facilitating implementation of research recommendations, as appropriate. ITD's Research Program Manager appreciates the work of the following TAC members in guiding this research study.

- Project Sponsor: Justin Collins

- Project Manager: Rod Reed, Brenda Haskell

- TAC Members: Chris Bray, Brent Hendry, Colleen Wonacott, Hydee Ruhle, Rebecca Penrod, Sharon Matthies

- FHWA-Idaho Advisor: Ed Hansen

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List of Abbreviations and Acronyms

AASHTO   American Association of Highway and Transportation Officials

AC   Advance[d] Construction

ADOT   Arizona DOT

API   Application Programmable Interface

CIO   Chief Information Officer

COG   Council of Governments

COMPASS Idaho   Community Planning Association of Southwest Idaho

DBAs   Database Administrators

DOT   Department of Transportation

ePM   Electronic Program Management

ERP   Enterprise Resource Planning

eSTIP   Electronic Statewide Transportation Improvement Program (see STIP)

ETL   Extract, Transform, Load (aka, data migration)

ETS   Enterprise Technology Services (ITD's IT group)

ETS PMO   ETS Project Management Office

FP&A   Financial Planning & Analysis

FHWA   Federal Highway Administration

FMIS   Fiscal Management Information System (FHWA software)

FS   Financial Services

FTA   Federal Transit Administration

FY   Fiscal Year

GARVEE   Grant Anticipation Revenue Vehicles

GIS   Geographic Information Systems

Highways PMO   Highways Program Management Office

Iowa DOT   Iowa Department of Transportation

IT   Information Technology

ITD   Idaho Department of Transportation

KMPO   Kootenai Metropolitan Planning Organization

LHTAC   Local Highway Technical Assistance Council

LRS	Linear Referencing System
MassDOT	Massachusetts Department of Transportation
MnDOT	Minnesota Department of Transportation
MPO	Metropolitan Planning Organization
NCDOT	North Carolina DOT
NEPA	National Environmental Policy Act
ORM	Object Relational Mapping
OA	Obligation Authority
OTIS	Office of Transportation Investment System
PIO	Public Information Officer
PSS	Project Scheduling System
RD&T	Research, development, and technology transfer
RFP	Request for Proposals
SaaS	Software as a Service
SME	Subject Matter Expert
SP&R	State Planning & Research (FHWA program)
SSO	Single Sign-On
SSRS	SQL Server Reporting Services
STIP	Statewide Transportation Improvement Program (see eSTIP)
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TAMS	Transportation Asset Management System
TPCB	Transportation Planning Capacity Building
TECM	Transportation Expansion and Congestion Mitigation
TIP	Transportation Improvement Program
TIS	Transportation Investment System
TLS	Transfer Layer Security (for web browsers and web-based software)
TOP3S	Transportation Online Planning, Prioritization, and Programming System
TPMS	Transportation Program Management System
UDOT	Utah Department of Transportation
VPN	Virtual Private Network

WisDOT   Wisconsin Department of Transportation

WRAP   Work Request Abstract Proposal

Executive Summary

The Office of Transportation Investment System (OTIS) is the software system that the Idaho Transportation Department (ITD) uses to capture federally required State Transportation Investment Program (STIP) schedules and obligations. OTIS houses all state transportation projects in a 7-year program cycle. It contains all pertinent data related to each active project in the STIP and all historical data related to any project that has appeared in a STIP. OTIS holds locations, scope, project milestones (e.g., environmental, right-of-way, etc.) and tags (i.e., project properties), budget details and summaries, work authority, financial obligations, project history, and associated project documents such as "Change Project Reports."

Background

The OTIS software was launched in 2015 to replace "Project Tracking," the Access-based application ITD first developed to manage STIP-related data. Since then, users have experienced numerous foundational issues with OTIS that cause significant delays and occasional errors. Specifically, there is a two-part, mutually-dependent problem with the software involving 1) functionality and design for users, and 2) insufficient framework measures (supported versions). Consequently, ITD is seeking to replace the current version of OTIS with a more reliable, supportable software application for tracking the multi-year multi-million-dollar portfolio of transportation projects. The future system is referred to as the Transportation Investment System (TIS).

To assist ITD with this sizable effort, High Street Consulting Group (the consultant) collected and compiled information on current OTIS implementation, workflows, underlying data, and functionality to generate recommendations for the TIS. The goal of this work is to help ITD teams like Financial Planning & Analysis (FP&A) and Enterprise Technology Services (ETS) understand the technical challenges and requirements for a future system to inform decisions, options, and software capabilities. This report compiles the findings from this research project and reflects the best, most complete information available at the time of its publication.

Research Approach

The research approach for this was comprised of seven main tasks. Following each task, the consultant submitted at least one deliverable including technical memos, presentation slides, and spreadsheets. The written deliverables were drafted such that they would later become a component of this final report. All tasks have a corresponding chapter in this report with the exception of the last one, which describes this report and the corresponding final presentation. The team had one year (January – December 2022) to complete this research project. Each task and its general timing is presented in the figure below.

2022
March

| Literature Review |

↓

| Current OTIS Implementation Business Process Review |

↓

| ETS Technical Review |

↓

June

| State DOT Comparison |

↓

| Replacement System Business and User Requirements |

↓

| Synthesize System Requirements and Make Recommendations |

↓

| Final Report and Presentation |

December
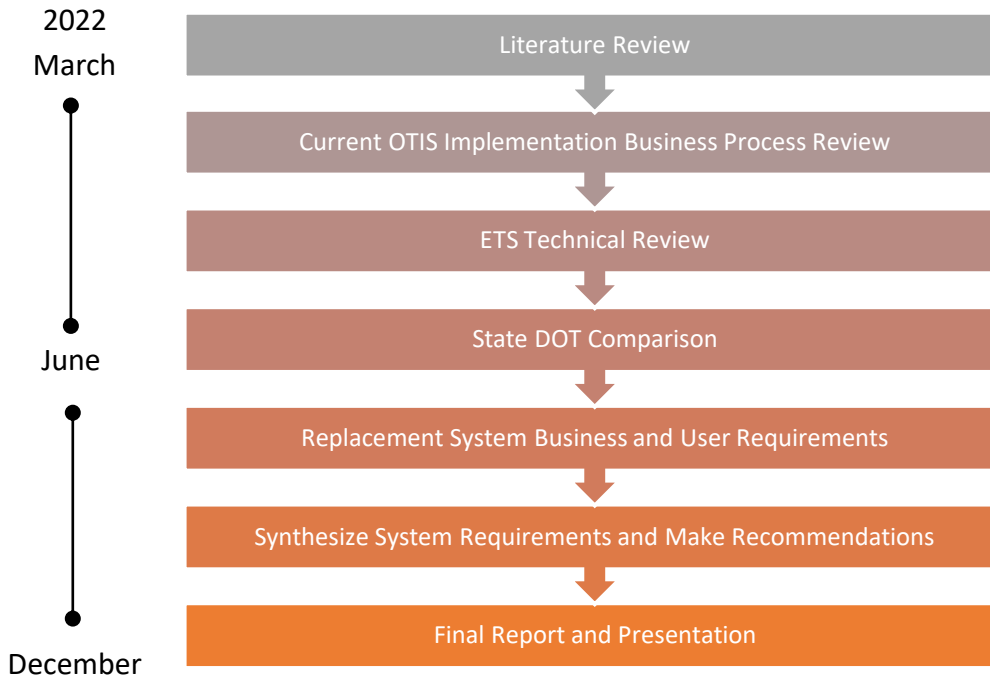
Key Takeaways

The consultant's top recommendation is an off-the-shelf software product, especially if there is a single system that meets all or most of the ITD's business needs. Multiple systems could be a viable option, too, as long as the number of combined systems is minimal, and the integration is straight forward. Any system will need to be substantially customized (i.e., development involving new code) to achieve the functionality ITD has expressed wanting during this research project. Before making a final decision, it may also be worth exploring the feasibility of developing a fully customized system built by an external consultant or software development company.

Findings and Recommendations

The consultant identified six options for ITD's next Transportation Investment System. These system solutions appear in the far-left column in the decision-making matrix below and were assigned a "low," "medium," or "high" assessment relative to one another based on each of the five criteria that appear across the top. The far-right column shows the consultant's recommendation for a given solution.

Assessment criteria are defined below. Note that the list of specific items included in each category is not exhaustive or mutually exclusive. Further, some costs will be solution-specific and vary widely, and all solutions will likely require some degree of customization. The consultant did not consider the time value of money or financing options in this high-level analysis, but ITD should be prepared to think about

their implications when they are deciding on a final course of action. The consultant assumes that all the options presented would meet minimum federal requirements.

- **Initial Cost** – Upfront costs associated with procuring a new software system such as initial licensing fees, third-party development fees, in-house time and labor costs, new servers or other hardware, enterprise systems integration, configuration and testing, data migration, and other costs accrued during the few years of the new system procurement.

- **Recurring Costs (aka, Total Cost of Ownership)** – Ongoing costs associated with system maintenance, support, hosting, version updates, bug fixes, staffing and labor, licensing (if applicable), maintenance of other software applications in the suite for the main product, and other tasks necessary to keep the system up and running smoothly over the long term.

- **Integration Complexity** – The anticipated level of difficulty, number of parties involved, potential for issues, and other factors contributing to the ease of which a solution may be executed. Complexity increases with higher levels of implementation effort, time, and labor demand on ITD staff and their contractors.

- **User Satisfaction –** Whether the new system is expected to be relatively easy to learn, satisfy user requirements, and be generally viewed as "making work easier" for system users. This criterion incorporates anticipated ease of transitioning to a new system for users, the complexity of the system itself, software design, and estimated system maintenance needs.

- **Viability of Support Approach** – The combination of the frequency with which system support will be required, the expected availability and quality of support, and the anticipated cost.

Transportation Investment System Solution Decision-making Matrix

System Solution	Initial Cost	Recurring Costs	Integration Complexity	Viability of Support	User Satisfaction	Recommendation
Off-the-Shelf Software	☹️ High	😐☹️ Medium/High	☹️ High	🙂 High	😐🙂 Medium/High	🙂 High
External TIS Development	😐 Medium	🙂 Low	😐 Medium	😐 Medium	🙂 High	🙂 High
Low-Code	😐☹️ Medium/High	😐☹️ Medium/High	😐 Medium	😐 Medium	😐 Medium	😐 Medium
Multiple Systems*	😐☹️ Medium/High	😐☹️ Medium/High	☹️ High	😐🙂 Medium/High	😐 Medium	😐 Medium
Internal TIS Development	🙂 Low	🙂 Low	😐 Medium	☹️ Low	😐 Medium	☹️ Low

System Solution	Initial Cost	Recurring Costs	Integration Complexity	Viability of Support	User Satisfaction	Recommendation
OTIS Life Support	☺ Low	😐 Medium	☺ Low	☹ Low	☹ Low	☹ Low

*Multiple systems may be feasible depending on the number and type of systems involved. Two might be workable, but the complexity would increase with the number systems integrated into the overall TIS structure.

Off-the-Shelf Solution

ITD purchases a single off-the-shelf system that will meet all business requirements and needs.

Pros
- A single piece of enterprise software is designed to handle all transportation investment activities.

- As more states use vendor-provided solutions, ITD may benefit from the knowledge-sharing, feature upgrades, and ability to gain FHWA acknowledgement that accompanies a wide user group.

- The vendor offers support in managing the software and data.

- The platform is likely to host data in the cloud, which reduces the burden on ITD's database maintenance and administration staff.

- Vendor system updates and upgrades are likely to occur on a regular basis.

- System will be up to date with modern cyber security best practices, enterprise system interface capabilities, and multiple browser functionality.

Cons
- It is unknown whether a system exists that meets all ITD transportation investment business requirements and needs.

- The initial and recurring costs will be high, but ITD is already spending money to support a contract with Experis, servers & other hardware, and other expenses.

- ITD could experience "vendor lockdown," meaning the department could be wholly dependent on the vendor to maintain the system and data.

- Porting current business data to the new system schema and layout could be a large, complicated task, depending on how tidy and consistent the existing data are.

An off-the-shelf solution would ensure that the new system is well-supported and managed. While it is unknown whether any one system exists that covers all business needs and requirements, if ITD can find that system then it would be an obvious solution. The consultant team strongly recommends this option.

External TIS Development

ITD hires an external software development or consulting firm to build a new, custom Transportation Investment System.

Pros

- A modern software development firm with appropriate resources and expertise will be able to efficiently build a custom solution that meets all OTIS user needs. Current cybersecurity standards would be met and modern software frameworks and packages could be used.

- ITD can help design a tailored system that fits most or all business requirements, rather than having to tailor their STIP and other business process to accommodate a vendor solution.

- While initial costs will be high, recurring costs can be kept low if ETS can manage the software after it has been built and deployed.

- External enterprise software systems can be integrated into the application during development.

- Flexibility in decision-making and defining exact features and functions.

Cons

- Development firms may lack sufficient understanding of the transportation industry to fully grasp and accommodate ITD requirements, processes, and culture.

- The initial software investment may be high.

- ITD will receive a custom system that may not include off-the-shelf support without a separate contract, if it is an option at all.

- There is increased risk for delay and technical issues building a bottom-up software solution.

- There is potential for the new TIS to have similar challenges around executive staff and IT buy-in as OTIS.

- There is potential for long-term dependence on developer for support, training, upgrades, etc.

- There are robust TIS products already in the marketplace; some employ former DOT and FHWA staffers. Some make design and function decisions in strong partnership with clients.

Hiring an external, technology company to design and build the TIS would help ensure that ITD business requirements and needs are met by the new system. While a custom build would have a high initial cost, recurring costs could be kept low if the system does not require routine maintenance or upgrades. The consultant team recommends this as a viable option.

Low-Code

Replace OTIS with a low-code development platform.

A low-code development platform allows developers to create drag and drop workflows within a user interface, which are turned into executable code by the platform. These platforms are supposed to reduce the level of effort for those building and maintaining applications that use the technology.

Pros
- Experis built the current vintage of OTIS, and now has a new low-code development framework. If ITD stayed with this company, they would be familiar with ITD's needs and business processes.

- ITD receives a replacement to OTIS that is theoretically easier for software developers to maintain.

- Custom functionality may be easier to implement, depending on the complexity of the business requirements.

Cons
- Tools like OTIS may be too complex to develop in a low-code environment.

- It is unlikely that a low-code platform could execute all required business needs without significant custom development.

- The initial investment and recurring cost structure is unknown.

Consultant Recommendation
If Experis or another company can demonstrate the feasibility of their low-code option, this could be a potential path forward. The consultant does not have enough information to make a recommendation on this option.

Multiple Systems

ITD generates multiple RFPs and secures several pieces of software to cover all transportation investment business requirements and needs. The TIS will not be a single system, but a network of systems. ITD forgoes a one-size-fits-all approach and secures specialized software for each business requirement.

Pros

- It's possible that ITD already has some software or systems that handle transportation investment business needs that could be integrated into the TIS.

- There may potentially be cost savings if some elements of the system already exist through other software or can be developed in-house.

Cons

- Cost structure is unknown and could become difficult to manage.

- Integrating multiple systems will be challenging, especially with ETS downsizing.

- User workflows could become challenging or confusing if users must interact with multiple pieces of software.

- Software updates and bugs could have ripple effects across the TIS.

- Writing multiple RFPs, securing multiple pieces of software from various vendors, and integrating those platforms into a cohesive system will be a long, technical, and costly process.

- This solution will require significant in-house expertise.

- The consultant found that similar systems at other DOTs are often clunky.

Consultant Recommendation

Depending on the number and type of system(s) involved, this option may be far too complicated and costly to be worthwhile. The consultant team does not recommend this option unless the number of combined systems is minimal, the integration is straight forward, and there's not a single system in the marketplace that would suffice.

Internal TIS Development

ETS software developers and ITD subject matter experts design and build a new, custom Transportation Investment System in-house.

Pros

- Initial and recurring costs are kept relatively low.

- Rapid development may be possible since information and business requirements will not need to be transferred to external parties.

- There is a precedence for in-house development with OTIS; ITD can apply lessons learned.

- ITD can design a system that fits all business requirements.

- People designing the system (i.e., ITD) may have a more thorough understanding of needs, context, requirements, and workflow compared to new external parties.

Cons

- Staff resources will be constrained due to ETS downsizing.

- It is uncertain whether ETS currently has the development skillset and staff to build the application properly. As mentioned elsewhere, turnover of IT staff at state agencies is a chronic issue.

- There may be a huge opportunity cost for ETS, FP&A, the ETS Project Management Office (PMO), and other staff assigned to this project. Work on this project will interfere with other tasks and priorities.

Consultant Recommendation

The consultant team does not believe that ETS has the appropriate / sufficient software development staff to build the transportation investment system in-house. Additionally, with the consolidation of IT professionals across state agencies and the corresponding drawdown of IT staff within ETS, supporting a piece of software developed in-house would be difficult. The consultant team does not recommend this option.

OTIS Life Support

ITD continues to use the current vintage of OTIS in perpetuity. No plans are made to replace or modify the software. Continuing current operations is the only focus.

Pros

- Internal application support by ETS and FP&A will keep costs down and knowledge in-house.

- User workflows will remain unchanged, which will eliminate the burden of learning a new system for ITD employees.

- Current documentation and training are solid.

Cons

- OTIS does not work with most modern web browsers; Internet Explorer is the only browser guaranteed to be compatible with OTIS.

- Several pieces of the foundational platform are out of support and would need to be significantly updated or replaced. Due to the number of pieces, this would be quite challenging.

- Major application upgrades, bug fixes, and support will be difficult, if not impossible, due to ETS downsizing.

- Current issues and bugs will remain or be difficult, slow, and costly to resolve.

- Other ITD software systems (e.g., Advantage) will be upgraded, modernized, or replaced while OTIS stays static. Data interfaces with these systems will be affected with these changes.

- Cyber security standards will become more innovative and stringent. Meanwhile, in its current state, OTIS cannot be upgraded to meet these specifications.

- There is a high likelihood that OTIS will become unusable without a significant investment within the next two to five years. Cybersecurity issues and ETS's high turnover rate, future downsizing, and capacity to support OTIS are the software's most significant threats. Furthermore, other systems that OTIS relies on may change and the data interfaces will have to be updated accordingly.

- Some users have lost confidence in OTIS data; without significant improvements, it will be unlikely to recover from this loss of trust.

Consultant Recommendation

Continuing to use OTIS in perpetuity with no plans to replace or modify the system is a non-starter. The system will eventually undergo catastrophic failure and become unusable, which will have ripple effects across ITD business units. The consultant team does not recommend this option.

1. Introduction

Project Overview

The Office of Transportation Investment System (OTIS) is the software system that the Idaho Transportation Department (ITD) uses to capture federally-required State Transportation Investment Program (STIP) schedules and obligations. OTIS houses all state transportation projects in a 7-year program cycle. It contains all pertinent data related to each active project in the STIP and all historical data related to any project that has appeared in a STIP. OTIS holds locations, scope, project milestones (e.g., environmental, right-of-way, etc.) and tags (i.e., project properties), budget details and summaries, work authority, financial obligations, project history, and associated project documents such as "Change Project Reports."

The OTIS software was launched in 2015 to replace "Project Tracking," the Access-based application ITD first developed to manage STIP-related data. Since then, users have experienced numerous foundational issues with OTIS that cause significant delays and occasional errors. Specifically, there is a two-part, mutually dependent problem with the software involving 1) functionality and design for users, and 2) insufficient cybersecurity measures. Consequently, ITD is seeking to replace the current version of OTIS with a more reliable, supportable software application for tracking the multi-year multi-million-dollar portfolio of transportation projects.

The future system is referred to as the Transportation Investment System (TIS) throughout this report.

Purpose and Goal

To assist ITD with this sizable effort, High Street Consulting Group (the consultant) collected and compiled information on current OTIS implementation, workflows, underlying data, and functionality to generate recommendations for the TIS. The goal of this work is to help ITD groups like Financial Planning & Analysis (FP&A) and Enterprise Technology Services (ETS) understand the technical challenges and requirements for a future system to inform decisions, options, and software capabilities. This report compiles the findings from the tasks discussed in the research approach presented in the next section and reflects the best, most complete information available at the time of its publication.

Research Approach

The research approach for this was comprised of seven main tasks. Following each task, the consultant submitted at least one deliverable including technical memos, presentation slides, and spreadsheets. The written deliverables were drafted such that they would later become a component of this final report. Each task is briefly described below. All tasks have a corresponding chapter in this report except the last one, which describes this report and the final presentation.

Literature Review

The literature review involved a thorough examination of existing OTIS-related documentation internal to ITD. The consultant also researched other state systems and best practices, STIP/electronic STIP (eSTIP) resources, technical requirements, and the vendors currently in the transportation project and STIP management software environment.

Current OTIS Implementation Business Process Review

This task was designed so that the consultant could develop a basic understanding of current OTIS features and functionality, and to document system strengths and shortcomings. The consultant conducted an OTIS-user survey and held multiple rounds of interviews with internal and external OTIS users.

ETS Technical Review

The goal of the technical review was for ITD and the consultant (the project team) to gain a better understanding of the current goals and challenges within ITD's ETS office and to further explore technical problems with the OTIS system. The project team met with several key ETS employees. Additionally, the team conducted a case study on the ITD transition to Esri's Roads and Highways Linear Referencing System (LRS).

State Department of Transportation (DOT) Comparison

For the State DOT comparison, the consultant arranged meetings with employees from three peer state DOTs: Massachusetts, Utah, and Iowa. These states were selected based on ITD's interest in their existing project/STIP management solutions, geographic similarities to Idaho, and their reputation for incorporating general best practices.

Replacement System Business and User Requirements

The focus of this task was to compile as many known business and user requirements for the TIS as possible. Sources included the original OTIS requirements files, interviews and email communications with key ITD staff and external OTIS users (e.g., Metropolitan Planning Organizations (MPOs)), other ITD software procurement documents, and other state DOTs. The consultant submitted the draft requirements in an Excel-based template provided by ITD.

Synthesize System Requirements and Make Recommendations

Research synthesis was ongoing through the project. However, there were three deliverables that resulted from this task. Those included an outline for this report, a decision-making framework meant to guide ITD through the solution comparison process, and a roadmap based on the consultant's recommended path forward.

Final Report and Presentation

The culminating deliverable is this State Planning and Research (SP&R) final report and a summary presentation.

The team had one year (January – December 2022) to complete this research project. The general timing of each task is presented in

Figure 1.
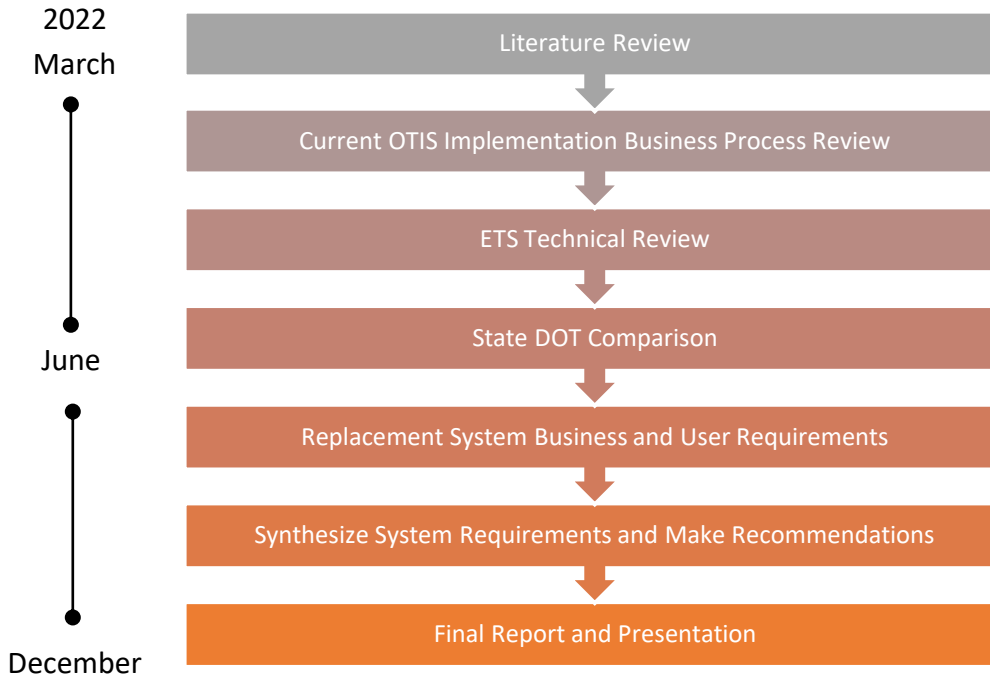
Figure 1. Transportation Investment System Business Analysis Research Project Timeline

2. Literature Review

Task Purpose

The consultant began the research by conducting a literature review. In addition to seeking out resources on federal and state handling of STIP data and systems, the consultant reviewed ITD's existing OTIS-related documentation, examined published information about systems used at other state departments of transportation (DOTs), and thoroughly studied and summarized technical OTIS resources to understand basic operations, functionality, technical requirements, and the systems relationship to the STIP submission process. The sections that follow describe the findings from these document reviews.

Existing ITD OTIS-Related Documents

The 30+ resources reviewed for this section contain a mix of historical documents, system architecture and security requirement information, past OTIS assessments, OTIS issues and solutions logs, guides, email threads, and other documentation relevant to this project provided by ITD to the consultant.

Information about each file was added to an Excel workbook called the "ITD OTIS Documentation Compendium" with the following information:

- Filename (Type) and Author/Owner (if known)

- Year

- SharePoint Folder (i.e., file location)

- Description

- Applicability to Project

- Level of Importance (Low/Medium/High)

File dates range from 2013 (e.g., High-Level OTIS Design) to 2022 (e.g., OTIS Issues Log). The "level of importance" assigned to a document reflects the consultant's assessment of its potential role in this project. Figure 2 is a screenshot of the compendium and shows sampling of the most important files. Among these files were any addressing past and future business requirements, past assessments and stakeholder interviews, and technical documentation. The "ITD OTIS Documentation Compendium" Excel file was delivered to ITD with complete details on each document.

File Name (Type) & Author/Owner	Year	SharePoint Folder	Description	Applicability to Project	Level of Importance
ArchiveOfSolutionExamples_COPY (Excel)	nd	Research and General Information	Detailed archive of OTIS issues and requests for functionality. Sheets contain a new "issue" and includes solutions, recommendations, screenshots, and other details. Organized by OID number (issue/case #?) Related to "SolutionList_20190429_COPY" - seems like once a solution is found/applied and documented in this file, the corresponding OID sheet is moved to the Archive file.	Good source of information on both OTIS shortcomings and potential new system requirements	High
Boilerplate Architecture Requirements 11.30.2021 (Word)	2021	Architecture	General architectural design outline; ensures specific functionality and requirements are met. Includes Architecture requirements in the following categories: Business, System, Integration, and Network. Provides details for Identity and Network Requirements. Provides the information required to build a robust and user friendly application.	Provides foundation that the application can be built on top of. Helps end users to understand the technical requirements and business needs simultaneously.	High
Boilerplate System Requirements 11.30.2021 (Word)	2021	Architecture	System Security Requirements Outline. Includes:1.) Authentication and Password Management 2.) Authorization and Role Management 3.) Audit Logging and Monitoring 4.) Network and Data Security 5.)Data Center 6.) Code Integrity and Validation Testing 7.) Cryptography and Key Management 8.) Data Validation and Sanitization 9.) Third Party Component Analysis 10.) Incident Management and 11.) Software Update Procedures	The OTIS replacement software must meet the system security requirements detailed in this document. Provides a starting point for developing OTIS upgrade or replacement requirements.	High
Business requirements grid_OTIS_grants mgt_20210517 (Word)	2021	Requirements Research and General Information- -> Business Requirements_over_ time	Created when ITD was considering looking for a software system that would perform both grants management and OTIS-related functions, to illustrate the level of commonality. Compares the business requirements for each system side-by-side.	Useful resource for creating business requirements for the OTIS upgrade or replacement system.	High

Figure 2. Sample View of the OTIS Documentation Compendium

STIP/Electronic STIP (eSTIP) Resources

The consultant did not find a large body of research analyzing STIP management and development software systems. Of those found, three STIP/eSTIP resources were thought to be relevant and were synthesized for the literature review. Each one is briefly summarized in the sections that follow.

Rhode Island DOT Peer Exchange on e-STIP Transition

In 2018, the Rhode Island Department of Administration and the Rhode Island DOT hosted a Transportation Planning Capacity Building (TPCB) peer exchange (a joint program led by Federal Highways Administration (FHWA) and the Federal Transit Administration (FTA)) to gather input on improving their Access-based STIP database and the corresponding online STIP map viewer. The final report provides a summary of findings on STIP/ Transportation Improvement Program (TIP) management processes and software capabilities for the Massachusetts DOT (MassDOT), North Carolina DOT (NCDOT), and the Delaware Valley Regional Planning Commission (the Philadelphia region's MPO). The MassDOT and North Carolina DOT findings are the most applicable to ITD, thus main takeaways for these two agencies are included in this report.

View the full Rhode Island report.

Key Takeaways: MassDOT

- Approach Evolution – Basic spreadsheets (pre-2014) → Access database (2015) → Incorporated scoring criteria (2016) → eSTIP (2019) (Developed by third-party software vendor, PMG)*

- System Evolution – Static project information system, "PINFO" (2014 and prior) → Esri GeoDOT, Massachusetts Project Intake Tool (MaPIT), and automated notifications (2017):

    o GeoDOT enables project geolocation and tracks changes as they occur

    o MaPIT is an Esri-based tool that provides municipalities and project proponents with a mapping interface to identify needs and initiate projects

- Maintenance Evolution – Ad hoc STIP maintenance (2014 and prior) → Governing Standard Operating Procedures (2017) → Quarterly queueing of amendments (2018)

*MassDOT was selected for the peer state DOT research phase of this project. More information on their experience with PMG's eSTIP solution is provided in section five of this report titled State Department of Transportation (DOT) Research.

Key Takeaways: North Carolina DOT

- Approach Evolution – Access database (1998) → still used today, managed by original creator → Transportation Online Planning, Prioritization, and Programming System (TOP3S) Tool (>2018)

    o TOP3S will integrate long-range plans, STIP, and prioritization process

    o TOP3S will serve as a starting point for STIP updates and scenario analysis as well as assist NCDOT with project scoring, cost estimating, and reporting

- System Evolution – SPOT On!ine → Excel and Geographic Information Systems (GIS) project prioritization results → STIP Access database

    o MPOs, Rural Planning Organizations, and Divisions enter project data into SPOT On!ine, the GIS-based web app that captures project information

    o TOP3S meant to replace SPOT On!ine

- Maintenance Evolution – Changes occur first in "sandbox" STIP database used for future STIPs → "amendments" database updated monthly to produce "live STIP"

Statewide Transportation Improvement Program Management (Dynamic e-STIP)

In 2021, the Wisconsin DOT (WisDOT) also hosted a state and federal agency TPCB peer exchange. The peer exchange participants presented ways to enhance processes and software capabilities in the management of e-STIPs. This resource provides the summary findings of the peer exchange, which are briefly outlined below.

e-STIP Defined

The WisDOT defines a dynamic e-STIP as one that:

- Continues to include TIPs by reference

- Improves user interface for STIP updates and amendment reviews and approvals, including the ability to download reports or datasets to meet operational goals

- Provides real-time project data

- Provides read-only access to FHWA-WI and MPOs

- Provides appropriate access to MPOs to instill greater ownership in the TIP/STIP processes

Key Takeaways

- A dynamic e-STIP improves the effectiveness and transparency of the TIP/STIP processes

- e-STIPs can be improved through increasingly automated processes that allow for up-to-date information and interactive sites featuring GIS maps and visual tools

- For some states, an in-house e-STIP solution may be more effective:

  o Developing an e-STIP in-house ensures an e-STIP is tailored to the specific state DOT, rather than having the state DOT tailor their STIP process to accommodate a vendor solution

  o In-house development may be more cost-effective long-term

  o When developing an e-STIP internally, it is important to prioritize staff needs over staff wants, and avoid any unnecessary add-ons, until there are more resources available

- There is detailed, state-specific information available for New Jersey, Oregon, and New Mexico in the report

The e-STIP: Using Technology to Support the STIP

This guidebook, published by FHWA in 2015, discusses ways in which state DOTs can enhance STIP management and development processes by moving to an e-STIP. The guide aims to assist STIP managers interested in moving toward automation of this complex process. It also includes next steps for developing an action plan for moving forward.

Access the FHWA guidebook.

Key Takeaways

- e-STIP Definition – Electronic submission, processing, and approval software tool that supports the development and management of the STIP

- Benefits of an e-STIP Solution

  - Reduced administrative burden and increased accuracy throughout the STIP development process

  - Improved access to project-related data

  - Increased collaboration with key partners (e.g., MPOs) and transparency about current and upcoming projects

- Capabilities of the Software

  - **Minimum** – At minimum, e-STIP systems should manage the generation of STIPs and obligated project lists, electronic processing of amendments and modifications, and real-time status updates of each STIP action item.

  - **Advanced** – More advanced functions allow users to generate reports and information that support STIP processes, enable the automation/streamlining of programming and STIP creation/management, and enable searchability by internet users as a public involvement tool.

- Basic Functions

  Basic functionality of a collaborative e-STIP system should support seven elements:

  - Generation of the eligible projects list
  - Creation of the e-STIP
  - Electronic processing of modifications

  - Electronic processing of amendments
  - Generation of the list of obligated projects
  - Financial reporting
  - Performance reporting

- Implementation Steps

  State DOTs should include at least the following elements in an implementation plan. This document will guide the agency through the e-STIP conversion process.

  - Create business case
  - Define initiative goals

- Map STIP workflows (automated vs. outside e-STIP) and interfaces

- Determine features and functionality

- Define data and database requirements

- Develop a training plan to support deployment

- Develop a change management plan

- Determine schedule with associated resources (staff time and funding)

- Challenges

  The guidebook identifies several potential challenges to e-STIP implementation that DOTs should be aware of. These include, but are not limited to:

  - Thoroughly and accurately documenting existing and desired STIP business processes

  - Coordinating and standardizing STIP and TIP business processes among all partners

  - Ensuring data quality (i.e., avoiding inconsistent and incomplete data)

  - Identifying staff with appropriate technical and subject matter expertise

  - Managing staff turnover

  - Managing resistance to change both internally and externally

  - Managing system security

  - Accommodating user constraints such as MPO staff or technology resources

State DOT Research

The consultant considered past research on STIP management and developments solutions conducted both internally at ITD and by other states. ITD's research efforts are summarized first, followed by summary of a survey effort by the Wisconsin DOT.

ITD Research Efforts

In fall 2021, ITD emailed contacts at 41 state DOTs asking about the type of systems they use to capture their STIP data. Twenty-two state DOT representatives responded with varying degrees of thoroughness.

The email survey asked the following four questions:

1. What system does your organization use?

2. Did your organization purchase an on off-the shelf system, contract for these services or were they created in-house?

3. On a scale of 1 to 10 (10 being highest) how would you rate your satisfaction with the system?

4. Is there any additional information you might like to provide?

Key Takeaways

Of the 22 state DOTs responding:

- 9 reported developing their systems in-house

- 5 rated the in-house system 7/10 or above; others did not provide ratings, or the ratings submitted were unclear

- 6 reported using a vendor/off-the-shelf products*

- 5 rated the vendor's system 6 or above; 1 did not rate

- Washington State rated its in-house system a 9

- Iowa recently updated its system in-house and rated it a 7**

- Massachusetts rated its vendor eSTIP system a 9**

* Based on the research for this project, there seem to be far more than six states using vendor or off-the-shelf products for some kind of STIP-related planning activity.

**Both Iowa and Massachusetts were selected for the peer state DOT research phase. More detail on their systems is available in section five of this report titled State Department of Transportation (DOT) Research.

Other State DOT Research

In 2014, Minnesota DOT (MnDOT) was preparing to transition away from their internally developed Program and Project Management System (PPMS) software system used to track funding for transportation expenditures. MnDOT wanted to replace their current system with one that would be robust enough to adapt to state and federal funding changes and that could produce a STIP that would be approved by FHWA.

To bolster their research, MnDOT conducted a state DOT survey to gather information on how other states and public agencies manage and track the funding streams they receive. The results were summarized in a report called *Transportation Research Synthesis: Software Programs and Processes for Tracking Capital Program Funds.* Key takeaways are described below.

Key Takeaways

Eleven of the 16 state DOTs that responded (69%) in 2014 indicated that they use multiple software programs. Of 16 State DOTs, Figure 3 shows how their *primary* software program was developed. A Hybrid program includes in-house development and software purchased from an outside vendor.
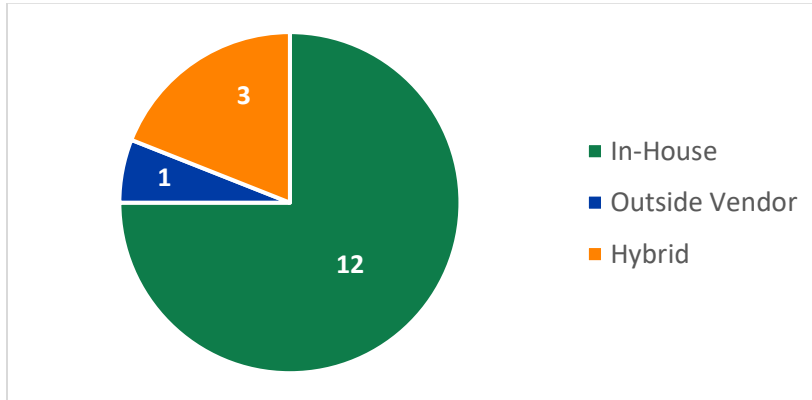
Figure 3. Breakdown of Primary Software System Development

In response to the question, **How satisfied is your agency with your software program for tracking capital program funding?** there were 16 responses with the distribution shown in Figure 4. Nine of 16 state DOTs (56%) indicated that they would recommend their software program and/or processes for use by another state DOT. Thirteen of the states (81%) reported being very satisfied or satisfied with their agency's software program.
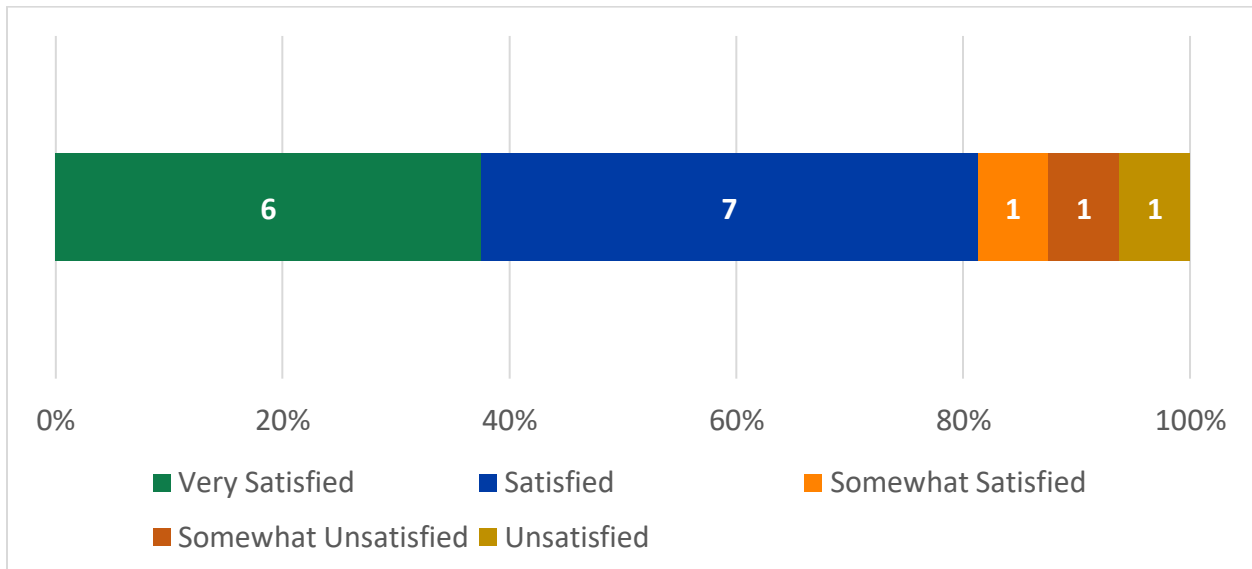
Figure 4. Level of Capital Program Funding System Satisfaction

Software Vendors and Case Studies

The consultant integrated case studies from two of the software vendors that offer solutions that may satisfy ITD's needs: Aurigo and EcoInteractive. High-level, publicly available information and case studies from these vendors were considered because they deal specifically in the transportation industry and published case studies were easy to access. Further, one of the vendors has a contract with all three states considered in the peer state DOT research phase of this project, though not necessarily for STIP management and development processes. The consultant does not endorse one vendor over another and encourages ITD to conduct a thorough request for proposals (RFP) process.

Aurigo

Aurigo is a technology company that offers capital planning software products to public sector agencies. Their flagship product is cloud software called Masterworks, which can be used for tasks involving Capital Planning, Bidding, Contract Management, Field Inspections, and Out-year assessments.

> - Learn more about Aurigo Masterworks Cloud suite
>
> - View the Utah DOT Case Study
>
> - View the MassDOT Case Study

Sample Functionality

- Configurable to meet federal standards

- Integration with existing environment and applications

- Entire program can be developed within the software and STIP extracted

- Funding sources and categories can be managed

- AASHTOWare Integration

- Custom workflows and dashboards

- Modules can be purchased independently

- Six- to eighteen- month deployment cycle

- Ability to render CAD drawings

- Esri integration

- Internal project scoring functionality

User Case Study Highlights

Utah DOT replaced a 14-year-old home-grown system used for capital planning and construction project management. They integrated the Aurigo software as a service (SaaS) solution with their existing on-site systems for bidding, civil rights, payroll, and enterprises project management. They have 3,000+ users and they use the system to share information with contractors and external stakeholders.*

MassDOT managed projects using Access and Excel spreadsheets. They've since configured Masterworks Cloud to automate its project approvals, federal aid number requests and assignments, to streamline plans, specifications, and estimates approvals, and integrate data with its federal aid office, the State Controller's Office, and FHWA. They also eliminated manual data entry into FHWA's Fiscal Management Information System (FMIS) portal.*

*This information is derived from the vendor website, not from the DOT itself.

EcoInteractive

EcoInteractive is a Software as a Service (SaaS) provider that offers transportation and capital planning software. Their flagship product is cloud software called ProjectTracker SaaS.

Modules include:

- Project Tracking
- Reporting
- GIS
- Interface with FHWA's FMIS
- Call for Projects

- Long Range Plan
- Document Management
- Public Management
- Project Delivery

- Learn more about EcoInteractive ProjectTracker SaaS.
- Download the Arizona DOT Case Study.

Sample Features and Functions of the Project Tracking Module

- Used for programming, updating, and managing TIPs/STIPs

- Enables collaboration among local, state, and federal agencies with multi-level user access

- Automatic updates when project status changes

- Preserves historical project data

- Cloud system consolidates project information into one single record of truth

- Modules available separately

User Case Study

Arizona DOT (ADOT) used several disparate systems and data formats on STIP/TIP amendments. Their old system was time-consuming and required significant manual review and reconciliation. The DOT selected EcoInteractive's ProjectTracker SaaS cloud-based eSTIP tool and all stakeholders (including MPOs and FHWA) have access. Stakeholders can use the tool to submit project changes and receive updates and approvals in real time. They incur no internal IT or physical infrastructure costs and consolidated multiple workflows into one process. Data is updated in real time and the standard look for ADOT's STIP has made it easier for FHWA to review. *

*This information is derived from the vendor website, not from the DOT itself.

3. Current System Business Process Review

Task Purpose

The purpose of the Current OTIS Implementation Business Process Review task was for the consultant to develop a basic understanding of current OTIS features and functionality, and to document system strengths and shortcomings from a user perspective.

The approach to this task was three-pronged (Figure 5):

1. The consultant reviewed historical, OTIS-related documents containing software assessments, staff feedback and recommendations, and descriptions of major issues;

2. The consultant circulated a survey, which was used to gather basic information (e.g., name, position, tenure at ITD), collect foundational information about how users interact with OTIS data, and understand general attitudes towards OTIS performance; and

3. The consultant conducted a series of virtual stakeholder interviews to investigate and document the current OTIS user experience.

Figure 5. Three-pronged Task Approach

This chapter summarizes the findings of each of these three subtasks.

Historical Documentation

ITD has tracked OTIS problems, issues, solutions, and other software assessment details since the software launched. The department shared several of these documentation files with the consultant for review and historical context. Though some of these files are outdated, a few contain information pertinent to this task. These include bug reports, notes from staff interviews and OTIS assessments, and the Work Request Abstract Proposal (WRAP) for the OTIS Planning Rewrite vs. Replacement Project.

The consultant reviewed the following historical documents for this section:

- Change Request 22406_OTIS bug_2021 0812 (2021)

- Enviro dates_OTIS bug_2021 0601 (2021)

- FY downloads errors_OTIS bug_2021 1222 (2021)

- Notes from OTIS Interviews_EC, (2016)

- OTIS 2pt0_planning WRAP_20210908 (2021)

- OTIS Assessment 12 15 2016 (2016)

Note: These files include a mix of Excel, Word, and PowerPoint files.

Review Summary

The most relevant takeaways from the historical document review are summarized below:

- A recent (2021) bug involving environmental milestone dates provides an example of how the internal (used by ITD staff) and external (used by non-ITD stakeholders like MPOs) OTIS sites

aren't always in synch. In this case, users tried to remove data in the environmental "decision" and "date" fields, but OTIS would not accept the date change. Browser compatibility (optimization for Internet Explorer) was the issue. It was eventually resolved, but the initial fix only impacted the internal site and the problem had to be handled separately on the external side. In Figure 6**Error! Reference source not found.**, the image on top is the internal view showing the dates while the image on the bottom is the external view showing no data in these fields.

Figure 6. Internal vs. External OTIS Site Discrepancy

- OTIS generated erroneous data upon downloading. As recently as December 2021, a project's status was set to "Awarded" in October 2020. During the FY21 download, however, the project status was inadvertently reset to "Development."

- ITD identified several significant problems with OTIS that, to some degree, still appear to be occurring today. These include:

  - Data was perceived to be unreliable and extensive manual data entry is required, resulting in users losing confidence in the data.

  - The merge process is unpredictable and occasionally results in data loss.

  - Scenario batch processing is unstable, causing the system to lock and forcing users to restart the data entry process.

  - Users said that "managing funds in OTIS is ridiculously complicated."

- Two years after OTIS was built, ITD considered options, similar to those it is looking at today: reengineering or replacing OTIS. Although today, ITD would need to completely rewrite the software rather than just reengineer it to remove complexities.

- OTIS support staff noted that the application was put into production before it was ready and was described as "over-engineered." It was also taking more staff time to support than it should have.

- Interview notes from 2016 state that "When we went live with OTIS, we should have kept both systems running in parallel for one full year."

- In the early days of OTIS, Brent Hendry worked full time troubleshooting OTIS, interfering with other work tasks. In Project Tracking, he spent about one hour per week.

- Interview notes from 2016 state that, the "coders" that work in OTIS would like to have the batch process go away.

- Per Nathan Hesterman (OTIS subject matter expert): the Local Highway Technical Assistance Council (LHTAC), FHWA, and COMPASS Idaho wanted to go back to Project Tracking.

- There were over 600 requirements when OTIS was originated. It was potentially over architected.

- OTIS System Administrators noted that, "When designing OTIS, it had to be a web application (that was one of the requirements) – OTIS does not lend itself well to be a web application." It is implied here that the software was not well-designed as a web application, perhaps because it was expected to do too much.

- OTIS System Administrators noted that, "There are disparate requirements for OTIS, the tool just can't do it all."

- A federal-aid officer at LHTAC noted that, "OTIS is frustrating, have to look at several reports to get a warm fuzzy that the data is accurate. Can't ever just look at data and trust it."

- There was discussion about removing the merge process from the application to reduce complexity. The drawbacks would be that districts would no longer have the "what-if" capability and would have to make changes to projects one at a time. It was noted that, "the batch process runs very well and there is logic built into it so that certain processes trigger others, and it doesn't step on itself."

Noteworthy Considerations

The consultant encourages ITD to keep the following points in mind from the historical document review:

- Some users expressed lack of trust in OTIS data, which is still the case today. Reestablishing trust should be a top priority for the replacement system.

- A simpler system was desired. It seems that OTIS was designed to be more complicated than was necessary.

- OTIS was not well-architected to be a web application. ITD should take the time to understand the modern architecture requirements for a web application.

- Some users expressed preference to "Project Tracking," but this could have been because it was more familiar at the time.

- OTIS may have been designed to "do it all," but this was likely an unrealistic expectation. ITD should pay close attention to the real limits of the future software system. A future system may need to be "modular" or require an additional platform.

User Survey

In advance of the OTIS User Experience Interviews, the consultant launched a short survey to collect general participant information (e.g., name, office, and tenure), main job functions that require using OTIS, and basic sentiments about the software. The consultant used the online platform SoGoSurvey to collect survey responses (see Appendix A for the actual survey). The survey included four main questions and took about 5 minutes to complete. The consultant shared the survey with 27 individuals and received 20 responses. Participants represented six ITD headquarters offices, three ITD districts, and two non-ITD agencies. The survey was open from March 22 until May 13, 2022. The next four sections provide a summary of the main survey takeaways, results visualizations and discoveries, additional comments organized by topic, and noteworthy considerations.

Main Takeaways

The main takeaways that emerged from the survey data are listed below. More detail is provided in subsequent sections.

- ITD employees who have worked at ITD for more than 10 years reported feeling almost twice as good about staying with OTIS for another 5 years versus learning a new system compared to employees who had worked there fewer than 10 years.

- ITD employees with less than 10 years of tenure had the most confidence in OTIS as a system that manages STIP information; non-ITD participants had the least.

- ITD employees with less than 10 years of tenure reported feeling the least comfortable using OTIS.

- ITD employees with less than 10 years of tenure were the least likely to believe that OTIS served its intended functions well.

- OTIS was the most difficult to learn for ITD employees with more than 10 years of tenure.

- Heavy users are the most comfortable using OTIS.

- Light users have the most confidence in OTIS as a STIP management system.

- 78% of respondents reported reading OTIS data (not editing), the most common way of interacting with OTIS data.

- 50% of respondents report editing OTIS data.

- 56% of respondents use OTIS reports and 50% generate reports from iReport, an enterprise business intelligence software application used to create and manage reports, or other non-OTIS report tools that contain OTIS data.

Results and Discoveries

The sections that follow summarize results from survey responses organized into three topic areas: System Uses, Data Interaction, and Usability and Confidence Ratings.

System Uses

Question one was open-ended and asked: **Please list your job functions or responsibilities that require you to work with OTIS.** The purpose of this question was to gather comprehensive information on the ways in which OTIS users of all types (i.e., heavy, light, internal, external) interact with the software to fulfill their job requirements.

The word cloud in Figure 7 provides an at-a-glance snapshot of the most important words that emerged from survey respondent answers. The larger the word appears in the cloud, the more significant the "weight" and the greater number of times it was mentioned in the collective analysis of the comments. While it's not possible to discern much nuance, intention, context, or connotation, the graphic helps communicate the overall focus of the comments and points to topics where it might help to dig deeper. Among the most frequently used words were "program," "project," "budget," "reports," "entered," "approve," "update," and "support." Irrelevant, unimportant words (e.g., the, and, like) were removed.

Appendix B contains detailed survey responses to the question about how OTIS is used.

Figure 7. OTIS Use Word Cloud

Data Interaction

Question two asked: **Please tell us how you interact with OTIS data.** Respondents were encouraged to select all choices that apply from the seven options available. They could also select "Other" and enter data-related activities not mentioned in the list. The idea behind this question was to break down OTIS data interactions into specific activities and understand the frequency with which these interactions.
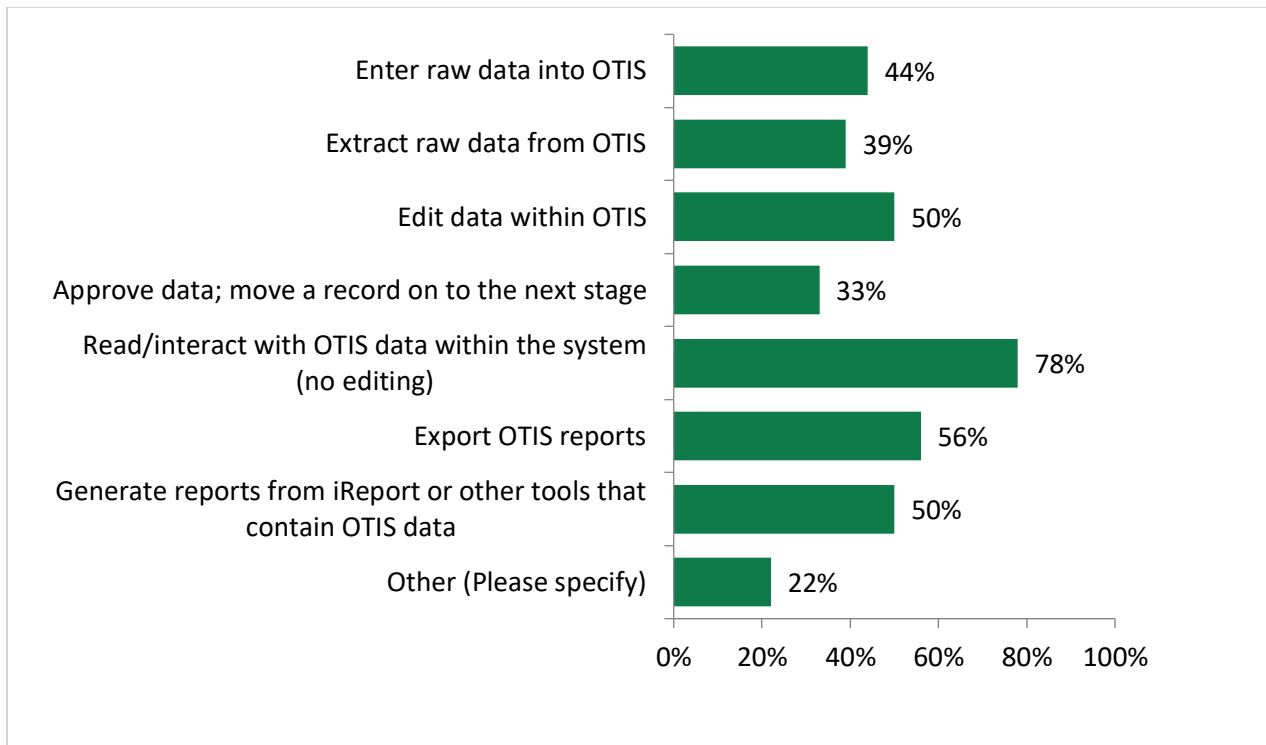
Figure 8. Breakdown of OTIS User Data Interactions

Several respondents reported other ways of interacting with OTIS data aside from those listed in the survey. These actions include:

- View OTIS to help understand tech issues

- Look at OTIS reports that others generate or reports from a non-OTIS tool like iReport that obtains data from Advantage, OTIS, and other software apps

- Monitor application's functions and external interfaces, research application errors/bugs, make application code fixes, make direct data updates, and deploy reports

- Extract and/or view data via Access link to OTIS database

- Create, edit, and administer scenarios

- Set up new financial codes and accounts

- Manage account balances

Usability and Confidence Ratings

Question three asked: **Please rate your OTIS experience with respect to the questions below, if 0 = bad/low/very hard and 5 = good/high/very easy.** There were six questions nested within the main one

that asked respondents to assess their attitudes toward OTIS and provide ratings on topics like ease of use, functionality, and confidence in data storage and management. Results are presented in Table 1 and are organized by survey question, agency, and tenure at ITD. Table 2 shows results by "user type." User type for each individual was provided by ITD, and is generally defined as follows:

- Light – Uses OTIS approximately a few times a month or less

- Moderate – Uses OTIS about every week

- Heavy – Uses OTIS almost daily

Table 1. Average Ratings by Tenure and Agency

Survey Question	All (N=20)	At ITD >10 Yrs. (N=9)	At ITD < 10 Yrs. (N=8)	Non-ITD (N=3)
How well do you think OTIS serves its intended functions?	3.2	3.5	2.8	3.3
How comfortable are you using OTIS?	3.4	3.7	2.8	3.7
How confident are you in OTIS as a system that stores and manages federally required STIP information?	3.4	3.4	3.7	2.7
How easy is OTIS to use once you are trained up on it?	3.2	3.2	3.2	3.3
How easy was it to learn how to use OTIS?	2.7	2.6	2.8	3.0
How would you feel about using OTIS for another five years versus going through the challenges of switching to a revised/new system?	2.9	3.4	1.8	3.7

Table 2. Average Ratings by User Type

Survey Question	All (N=20)	Light Users (N=6)	Moderate Users (N=5)	Heavy Users (N=9)
How well do you think OTIS serves its intended functions?	3.2	3.4	3.3	3.4
How comfortable are you using OTIS?	3.4	3.4	3.2	3.9
How confident are you in OTIS as a system that stores and manages federally required STIP information?	3.4	3.8	3.1	3.6
How easy is OTIS to use once you are trained up on it?	3.2	3.5	3.3	3.3
How easy was it to learn how to use OTIS?	2.7	2.7	3.0	2.7
How would you feel about using OTIS for another five years versus going through the challenges of switching to a revised/new system?	2.9	2.8	3.5	2.7

Note: Several "light" users responded "N/A" to these questions.

Additional Comments

Fourteen (14) respondents provided additional information in response to the fourth and final question on the survey: **Please tell us more about any of your responses to the questions above.** Survey comments are organized by theme. In some instances where one comment covered multiple themes, comments were dissected and categorized accordingly. Comments broadly fell into five categories: **Ease of Use, Training and Learning, Functionality, Frequency and Purpose, and Desired Features and Functions.** Where appropriate, comments were further organized by overall sentiment – generally positive and generally negative.

Ease of Use

Generally Negative
• OTIS has a lot of faults; more efficient system needed to take its place.
• Not easily interpreted by personnel that are not familiar with it.
• I often need to explain the fields to others.
• Not intuitive. The data is there, but extracting that data is cumbersome.
• Everything feels clunky.
• The user interface needs a ton of work for quick review of projects.
• Can be challenging to navigate.

• The saving /merging problems require a lot of effort to navigate.
• There are errors in some data and trying to make corrections is very difficult.
• OTIS is awkward and not very intuitive; seems to have design limitations.

Training and Learning

Generally Positive
• Have attended 3 training sessions; very accessible & inviting.

Generally Negative
• OTIS was not easy to learn; there are a lot of different screens / fields.

Functionality

Generally Positive
• Compared to its predecessor, OTIS provides better information.
• Good functionality.
• If you spend some time looking through OTIS, you easily find the information. Overall, the program is acceptable and works well.
• I feel that I would be comfortable using OTIS for the next 5 years.
• There are improvements that can be made in OTIS to allow us to continue using it.

Generally Negative
• Serves intended functions, but many aspects are difficult to maintain
• Simple functions are made more complex than necessary.
• The parameters for pulling reports are too convoluted.
• OTIS has quite a few glitches or bugs and could do better with more reports/ macro data.
• Don't have much faith in everything being accurate.
• I use other programs to verify or gather information I cannot get out of OTIS.

Frequency and Purpose

- I do not directly use the OTIS but am familiar with it

- Just use OTIS to find basic project data

- Have not been trained on OTIS/only logged in a handful of times; hard to answer questions

- Rarely use OTIS; can't comment on usability /onboarding

Desired Features and Functions

- Pull all projects within a district and see an overall planned spending and obligations per year

- "Compare" features to save time

- Overview screen

- Match Advantage terminology

Noteworthy Considerations

The consultant encourages ITD to keep the following points in mind from the survey:

- There are some contradictory or inconsistent results in the survey data. This may be because ultimately, people don't know exactly what they want.

- The results are a mixed bag– there are some frustrations and OTIS definitely has its shortcomings. However, big picture, these results are generally neutral.

- It's probably safe to assume that the breakdown of data interaction in the future system will be similar to that of OTIS.

- ITD should consider a system that's easier to learn than OTIS was.

- OTIS users differ on using OTIS for another 5 years depending on how long they've worked at ITD.

- More than half of OTIS users depend on the reporting function. This function will need to be preserved and improved upon in the future system.

User Experience Interviews

The consultant conducted virtual group interviews with 26 OTIS users beginning in late March and extending through early May 2022. Interviewees represented eight offices at ITD headquarters, three district offices, and external OTIS users from LHTAC and COMPASS Idaho. The purpose of these interviews was to research OTIS use cases, collect general sentiments about the software, uncover frustrations and roadblocks, discuss OTIS strengths and weaknesses, and discover features and functions that should be preserved as much as possible in a system rewrite or an off-the-shelf software product. Participants were encouraged to share as openly as they felt comfortable doing.

Table 3 provides the complete list of OTIS users who participated in the user experience interview series. User type was provided for each individual by ITD, and is generally defined as follows:

- Light – Uses OTIS approximately a few times a month or less

- Moderate – Uses OTIS about every week

- Heavy – Uses OTIS almost daily

Table 3. OTIS User Experience Interview Participants

Name	ITD Office/ Agency	Role	User Type	Interview Date
Chris Bray	FP&A	Financial Manager	Light	5/4/2022
Justin Collins	FP&A	Financial Officer	Light	5/4/2022
Mike Ebright	Bridge	Engineer Manager 1	Light	4/8/2022
Jillian Garrigues	District 3	Public Information Officer	Light	4/27/2022
Gary Genova	FS	Financial Manager	Light	4/8/2022
Amy Schroeder	Highways	Transportation Expansion and Congestion Mitigation (TECM)/ Grant Anticipation Revenue Vehicles (GARVEE) Bonding Program Manager	Light	4/25/2022
Aubrie Spence	Communications	Senior Public Information Officer	Light	4/27/2022
Dennis Wagner	Right-of-Way	Senior Right-of-way Agent	Light	4/19/2022
Bradley Wolfinger	Highways Program Management Office (PMO)	Program Manager, ITIP	Light	4/25/2022
Tevrin Fuller	COMPASS Idaho	Resource Development Data Specialist	Moderate	4/25/2022
Craig Herndon	LHTAC	Assistant Federal-Aid Engineer	Moderate	4/25/2022
Ted Mason	Highways PMO	Geometric/Standards Engineer	Moderate	4/8/2022
Jennifer Miller	FS	Senior Financial Specialist	Moderate	4/8/2022
Wendy Terlizzi	Highways	Environmental Manager	Moderate	4/19/2022
Toni Tisdale	COMPASS Idaho	Principal Planner	Moderate	4/25/2022
Christy Brooks	LHTAC	Federal-Aid Financial Officer	Heavy	4/25/2022
Crystal Craig	Highways	Deputy Program Manager	Heavy	4/25/2022
Marvin Fenn	District 1	Engineering Manager	Heavy	4/26/2022
Michael Graham	ETS	Software Engineer	Heavy	3/29/2022
Brent Hendry	FP&A	Senior Research Analyst	Heavy	3/29/2022
Donna Hunsinger	Highways PMO	2101 Reviewer	Heavy	3/24/2022
Brad Richards	District 6	Program Manager	Heavy	4/26/2022
Hydee Ruhle	FP&A	Financial Specialist	Heavy	3/24/2022
Simone Webb	FS	Financial Technician	Heavy	4/19/2022
Jole Wells	District 2	Planner	Heavy	4/26/2022

Colleen Wonacott	FP&A	Senior Transportation Planner	Heavy	3/24/2022

Structure

With a few exceptions, interviews were conducted in groups of two or three. Groups usually included people from the same ITD office or individuals whose OTIS-related tasks overlapped. District and non-ITD agency representatives from LHTAC and COMPASS Idaho were also grouped together. At least one member of the ITD project management team attended each meeting. Meetings were about an hour long.

The consultant prepared a selection of questions before each meeting, while allowing the time and flexibility to follow conversation threads and encourage follow-on questions. Appendix C provides the complete "universe" of interview questions from which the consultant pulled questions for each meeting.

Synthesized interview information is presented in the sections that follow and is organized by these five topics:

- Main Issues

- Strengths & Likes

- Weaknesses & Dislikes

- Other System Solutions

- Future System Requests

Main Issues

Main issues are those that were mentioned by multiple interview participants, occurred frequently, had the most damaging implications, or seemed to generate significant time investments to resolve.

Confusing Advanced Construction Numbers

Advanced Construction (AC) is an FHWA term for funding a project prior to the programmed federal funding year, or to fund a shortage of federal-aid funds with local funds to keep a project on track. All ITD Grant Anticipation Revenue Vehicles (GARVEE) projects are AC and bonds are issued on an as-needed basis to ensure that funds are available through the duration of a contract. Interviewees reported that in OTIS, program codes are perceived to be inaccurate for a bonded project and that AC projects with multiple years of funding are the worst offenders. Others reported getting "funky numbers" for AC projects and that some of the screens for projects have negative obligations. The OA

Summary screen is an example of where AC field names may result in confusing project numbers or information that may not be presented clearly or easily understood for all users. The consultant learned that unfortunately, OTIS wasn't built with functionality to accommodate AC funding, nor can it be changed to reflect it without intervention from a programmer.

The example in Figure 9**Error! Reference source not found.** shows that ITD expended over $6 million for the project with key number 23079, but the "Scheduled and Obligated" values in the budget window are only $1.4 million. The numbers don't add up.
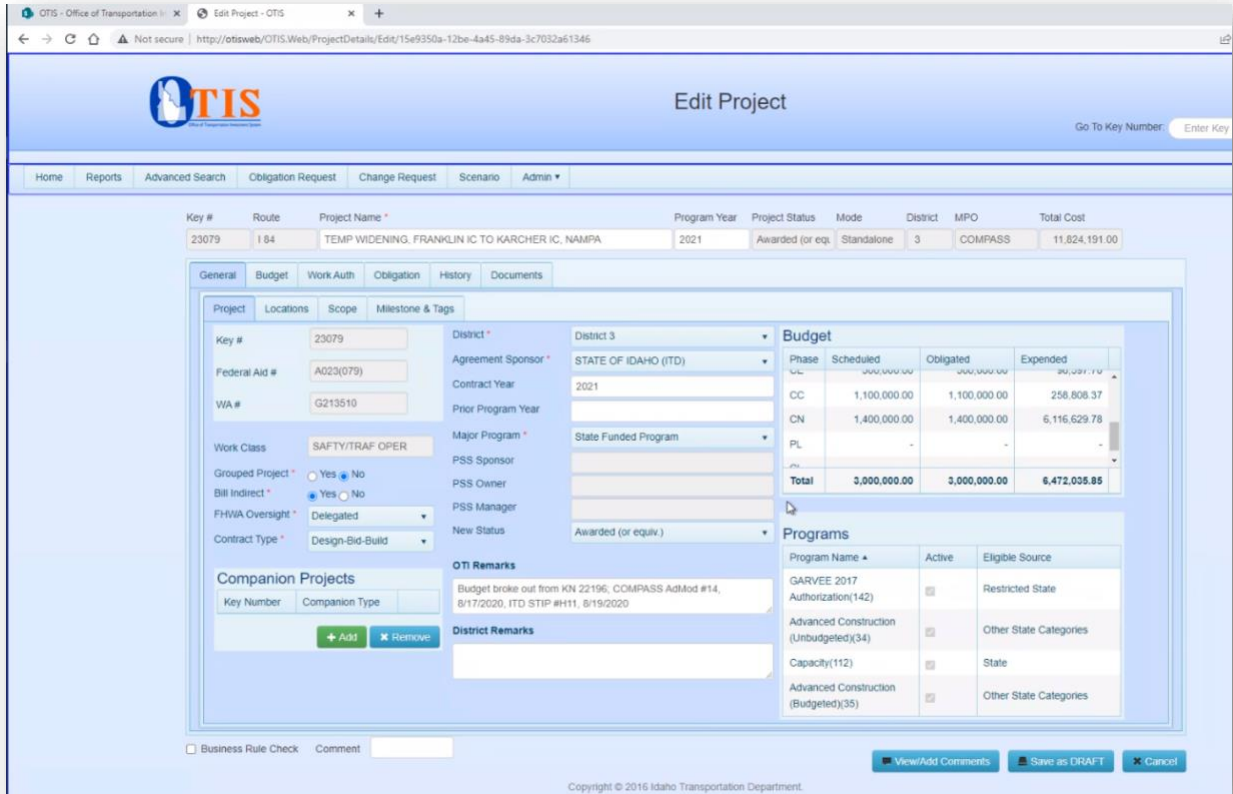

Figure 9. Example of an Advanced Construction-related Discrepancy

Buried, Confusing, or Lack of Summary Information

Districts, executives, and staff seeking quick answers to simple questions expressed the need for reliable summary screens. However, interviewees often reported that "information is buried" in OTIS. For example, the Obligation Authority (OA) summary screen has been problematic since staff began using OTIS. The OA table includes data on multiple project phases over multiple years and funding types, and it potentially displays the wrong information. As a result, Districts may think that there is way more money available then there actually is. When you drill down, data "usually adds up," but it's not displayed correctly on the summary screen.

Interviewees also mentioned the AC summary screen as an example of a summary table displaying confusing information. "I don't always trust the scheduled portion," one staff member reported, and "changes to a budget don't always show correctly."

In the example in Figure 10, there is a difference between the Total Cost of $143 million at the top right of the screen and the "Scheduled," "Obligated," and "Expended" values in the "Budget" window (two each at around $40 million and one at around $48 million). The confusion comes from the fact that the $40 - $48 million values are specific to key number 20788, while the Total Cost of $143 million is not about just key number 20788, but rather three key numbers combined. Because Total Cost appears at the top of the summary screen where Key # is the first field, it seems to apply only to key number 20788, causing confusion.
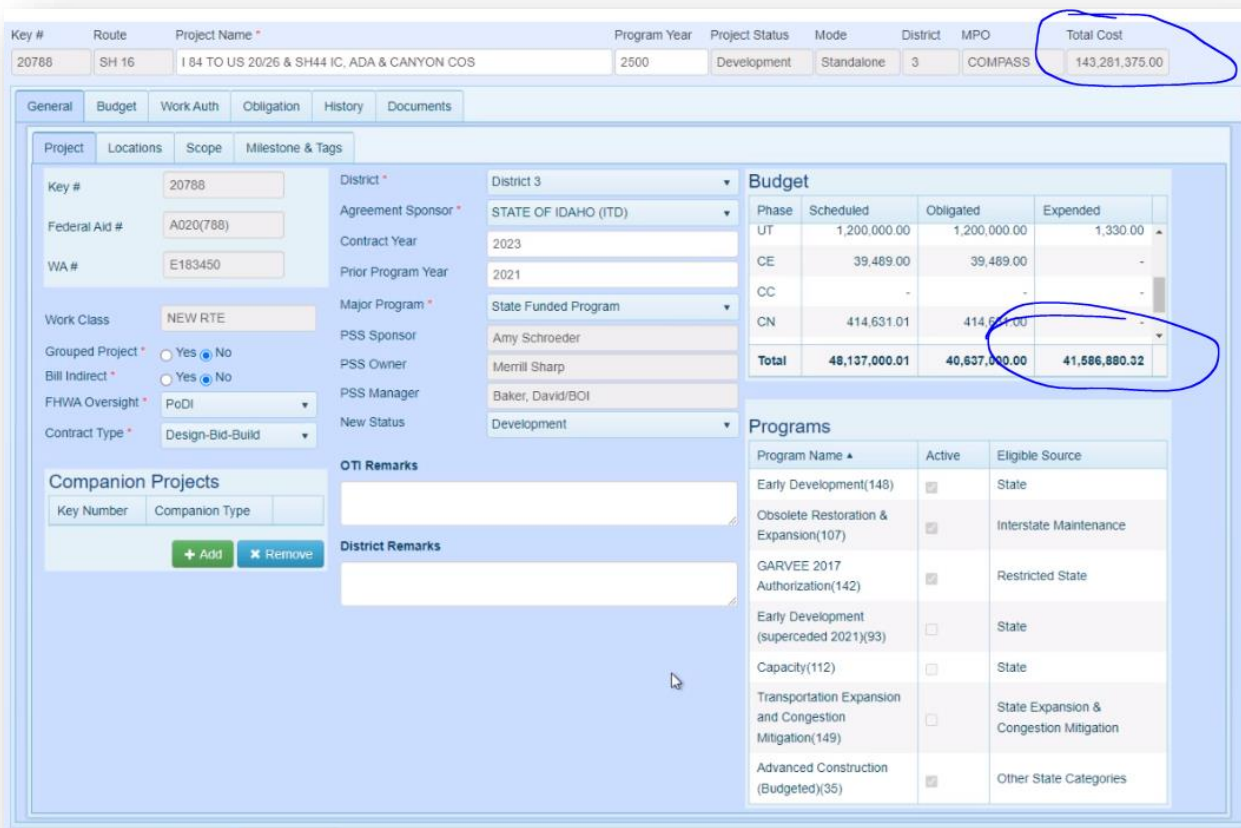
Figure 10. Example of Confusing Summary Screen Information

Manual Data Entry

Every year around February or March, the programming process starts over, and ITD makes a copy of the current, base OTIS records. This copy becomes a "working copy" that is used by Districts to create scenarios and work in projects for an additional program year. This iterative process goes throughout

the summer. When this step is complete, the program information that each District entered is rolled into a statewide version. Part of the complication is the "secret invisible system" copy that exists in addition to the base working copy. The main issue is that OTIS does not update the original version of the program at the same time that the copy is updated. Instead, data must be manually entered twice, once into the original, base version and once into the working copy. Each manual data entry step introduces room for error. Another example of manual data entry is change and obligation requests.

Bugs and Technical Problems

Several OTIS users reported experiencing software freezes, long processing times, or other technical problems. The word cloud in Figure 11 offers an at-a-glance overview of the issue topics that arose during interviews and may need further examination. Among these themes are "changes," "requests," "process," and "saving." There are also several temporal-themed words of note including "time" and "week," which could imply mentions of the time needed to resolve technical problems.

Detailed descriptions of OTIS problems that were mentioned during interviews are listed by category, in the sections following the word cloud. The most common types of issues involved performance speed and mysterious problems that could never be explained.
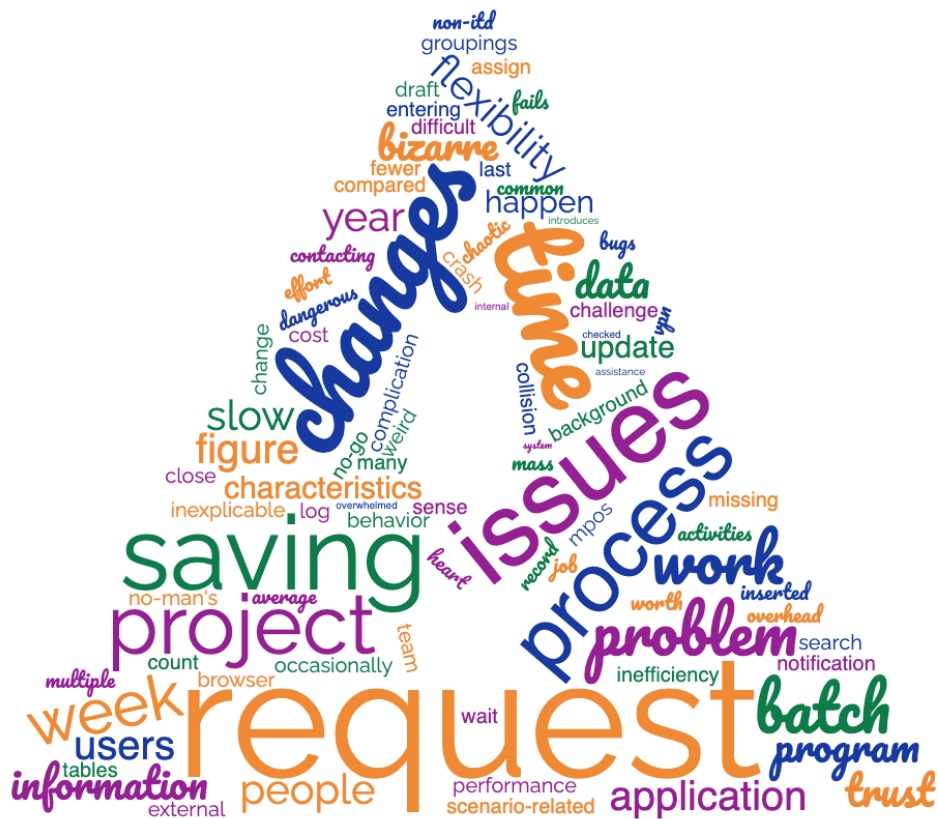

Figure 11. OTIS Problems Word Cloud

Change Requests

- OTIS becomes overwhelmed with too many changes requests at once; forced to close the browser
- Collision between two requests where one request takes on some characteristics of another. The bridge table is an example where the Project ID for one project got inserted into another record and stared showing those characteristics.

Delays, Freezes, and Slow Operations

- External application performance is often especially slow compared to internal application
- The scenario-related activities and be a challenge/ really slow, especially on the VPN
- Users must wait for batch processing
- Multiple users at the same time are a no-go; MPOs are assigned a time slot, which is an obvious inefficiency
- Difficulty entering mass data because OTIS will crash

Inexplicable or Strange Behavior

- Occasionally, there are issues that make no sense/ seem to happen only once where staff can't figure out the cause
- Batch processing fails and no one knows what happened; overhead cost of batch process not worth the effort
- Program update is the biggest, most dangerous set of issues; lots of "bizarre behavior" over the past year
- If it's not saving changes, it introduces trust issues
- If a project doesn't get checked in properly, hangs out in "no-man's land"

Frequency

- Lots of bugs have been ironed out, fewer people contacting Brent for support
- On average, probably count on a problem with OTIS about once per week
- Last year about every other week, staff couldn't log in to OTIS; no one has ever figured out why

Groupings

- Grouping projects by program or eligible source allows for the flexibility needed to accommodate FHWA changes. However, it adds complications because groupings can be "chaotic."
- Setting up multiple apportionment codes is cumbersome and prone to error. To set up a code means setting up at least 10 groupings in a type.

Data Not Saving

Last year (2021), Districts experienced instances where scenario entries were either not saving correctly or not saving at all. There was no indication that changes hadn't been saved and nobody could figure out why this was happening. That said, there haven't been reports of this problem in 2022 and, so far, the program update process appears to be going smoothly.

Issues also arise if more than one user is in a scenario at a time. Districts are encouraged to save scenarios first, then come back and edit later. However, it can take hours, or even a day or more, for scenarios to save. So once Districts save scenarios for the day, they can't do much more work on them. Instead, users must go back the next day to verify everything is still there and accurate. The general attitude among users is if they don't save their work frequently, they risk losing it.

COMPASS Idaho reported having frequent issues with data not saving on the update side. Again, there is no indication when information hasn't been saved properly. The only way they can find out if something has changed is to do a manual check. They also reported saving a scenario, but that it would "get jammed up" in the server. The only way to recover the scenario in this instance was to call Brent Hendry to "get the scenario back." The Kootenai Metropolitan Planning Organization (KMPO) mentioned that this was the best year for the program so far and that it was the first time they didn't lose data.

Unfriendly for Occasional Users

Several "infrequent users" (i.e., monthly to yearly) report that OTIS is cumbersome and "not user friendly for people who don't use it very often." These users are not able to retain the OTIS operation information and are relearning every time they log in. Even good trainings are often ineffective with these types of OTIS users. To summarize, OTIS is "not an easy system to use if you're not familiar."

Public Information Officers (PIOs) often need quick access to basic information such as project timeline, budget, and the name of the project manager. Most of the time, PIOs go directly to the project manager to get this information rather than looking it up in OTIS. This type of potential user avoids using the software altogether, but they mentioned the possibility of using it more if they knew what information was available, how to access it, if there were navigational tips and/or documents integrated into the system, and if it were quick and easy to find what they needed.

Overreliance on Specific Individual ITD Staff

There are four ITD staff with nearly exclusive OTIS knowledge or who perform activities in OTIS that no other staff know how to do to the same extent. This is a precarious position for the agency due to the high risk of losing institutional knowledge.

Colleen Wonacott – Colleen is a senior transportation Planner in FP&A. She is the STIP lead and is the only staff person who can see the status of the STIP. Because there is no option in OTIS to export the

STIP, she compiles STIP data outside of OTIS in Access. If the STIP is a work in progress, the only way for other ITD staff to check on the status is to contact Colleen. It's also difficult for any other staff to perform a quality check on STIP data.

Donna Hunsinger – Donna is a 2101 reviewer in the Highways Program Management Office (PMO). She's been described as the "bridge" or "human interface" between Districts and OTIS. She manually copies information from District Obligation Requests, or 2101s, into OTIS. She also keys in changes requests. Donna is the only person at ITD that does this, although Hydee Ruhle has some knowledge of it. She is also one of the main the points-of-contact for Districts and MPOs (in addition to Brent Hendry).

Michael Graham – Michael Graham is a software engineer in Enterprise Technology Services (ETS). He is the OTIS authority and subject matter expert, the developer who had been involved with OTIS for the longest time. Michael was the troubleshooter for "deep" OTIS problems and if he was not available, there was likely no one else at ITD who could assist. Michael Graham retired from ITD in June 2022. Two ITD staff developers took his place as OTIS support; one has since left ITD and the other is very new to the agency.

Brent Hendry – Brent Hendry is a senior research analyst in FP&A. Brent collects problems from OTIS users and translated them into terms that made sense to Michael; he also collaborated with Michael on solutions. He is the interface between OTIS users and ETS OTIS support. Brent is also one of the main points-of-contact for Districts and MPOs (in addition to Donna Hunsinger).

Rainer Thierauf – Rainer Thierauf is a software engineer at Experis. He developed OTIS, so he was in all the business design and requirements meetings since the conception of OTIS. Rainer is the primary resource for any code changes to OTIS.

Data Trust

In nearly every interview, the consultant asked interviewees whether they generally "trusted the data in OTIS." Responses are summarized in the following table, broadly organized by sentiment – generally positive or generally negative. Overall, OTIS users seem evenly split on the question of data trust, although some of the more positive responses have some qualifications or exceptions. In other words, it's rare that anyone trusts 100% of the data 100% of the time. Some staff are especially prone to OTIS data mistrust for fear of inaccurate information being presented to the legislature or governor. Such experiences have precipitated time-consuming, information-gathering processes when time-sensitive, high-stakes requests come in. The general feeling is that OTIS data is not a reliable source of data in these situations.

Generally Positive
• We trust OTIS because it's the system of record, however we back check it.
• We trust the data. Assume everything in the 2101 is accurate and approved.
• Very trustworthy when it is all there. No complaints if a 2101 is filled out completely.

• Information is reliable.	
• Generally, I trust data. Many eyes on data to catch errors. But, data may be correct and be interpreted differently.	
• I can usually rely on it. If I need to find out the ROW date that did not get into the 2101, I call Brent. Other than that, I'm 100 percent confident.	
• Overall, I feel fairly trustworthy. The exceptions are 1. the advanced construction budget data 2. Comparing two "bucket systems" in Obligation Agreement report.	
• In general, I trust the data. It's a rare occasion that I take a second look at things.	
• I trust the data quite a bit. I put it in, so I know the data and I see it through until the project is in built phase.	
• I do trust the data. I heavily rely on it, and I never find it to be in error. Data errors are usually due to data entry.	

Generally Negative
• We don't trust the summaries or any of the reports that come out.
• I don't always trust the scheduled portion.
• A change in the budget doesn't change the scheduled cost right away, but when you dig into the numbers, they are usually correct.
• I have the least trust when looking at OA balance. Every year, there's somewhere where the math doesn't work.
• We don't trust OTIS for actual expenditures. We use Advantage for verifying expenditures.
• Use it as a reference to put out a fire; to spot check amendments. For anything important I go right to the source. When I'm going to the source, I'm pulling Colleen, Brent, or Hydee off of their jobs to help me do something that I should be able to do.
• Not downloading data and putting it directly into any documents because I don't trust the information enough.
• Been on the tail end of a report that went to the Governor's office and data was not correct. Two people looked at it and still forwarded it on.
• Inconsistencies on how much information is available project to project / the amount of detail may be different from one thing to the next.
• If there's a question on the program side, I know it's going to take longer than it should to find the answer.

Strengths and Likes

The consultant asked interview participants to share the features and functionality they liked about OTIS. This list will be an important reference for ITD when it is time to replace the system with the new one. ITD should consider preserving as many of these features as possible.

- Outward facing information and partner access makes communication easy

- Huge, powerful database filled with valuable information

- Project budget screen link to Advantage (ITD's enterprise financial software system)

- Day-to-day change request functionality

- Look and feel; OTIS is "easy on the eyes" and "user friendly"

- Ability to attach documents like agreements

- 2101 "work flow" section is useful for knowing who worked on it and when

- Descriptive project information

- Advanced Search feature

- Reporting system – relatively easy to create and add reports; easier in this system than the last system

- Ability to track a project back and see who touched it when; notes and comments are very helpful

- Ability to reverse an obligation line item

- Flexibility that the grouping function offers. For example, Pavement Preservation is split out into Commercial and Non-Commercial; groupings feature combines them into a single Pavement Preservation program

- Historical data as far back as possible; very important

- Maps and geolocation data such as segments and mile markers

- Matrix screen

- If I were to create a new OTIS, I would create it nearly identical to the way it is now.

Weaknesses and Dislikes

The consultant asked interview participants whether OTIS makes them less able to do their jobs efficiently, where it slows them down or causes roadblocks, and where it interferes with productivity. Answers to these question types are summarized in the list below.

- Doesn't handle the reconciliation well; process "breaks OTIS," creating a massive cleanup operation

- Multiple years of construction with big budgets contain reporting errors

- OA Balance Report – Schedules and Obligations – should be transparent, but it's a "black box"

- Reports don't work well in Chrome or Edge unless they are exported; OTIS is optimized for Internet Explorer

- Won't update scenarios and approved STIP at the same time; requires manual entries

- Not very communicative; no way of knowing if something is or isn't working

- Not trustworthy enough to answer simple, time-sensitive questions; staff would rather "break the deadline" than send information perceived to be incorrect or untrustworthy

- Lots of conflicting information

- Lots of duplicated information when entering or adjusting a 2101

- Need ability to "flag" or "tag" projects that are funded through "Leading Idaho" program, in addition to Transportation Expansion and Congestion Mitigation (TECM) corridor projects; need to identify both

- Missing program number impacts Right-of-Way (ROW) certification; can't find ROW date

- Difficult to track state versus federal fiscal year

- Elusive, buried information

- Link to view Matrix link is hidden

- Finicky behavior during program update

- Too many tabs and subtabs

- A lot of clicking and mental math to see all fund sources

Other System Solutions

Some OTIS users have developed work-arounds or systems outside of OTIS to perform their job tasks. Users develop these systems for several reasons, including missing OTIS functionality, lack of trust in the software, and familiarity with and ease of use of other systems. Examples of these solutions are summarized below. This list is not exhaustive.

- Highways PMO tracks the "Color of Money" (funding types) in Excel because it's "easier." However, it's "not easy to reconcile OTIS reports" with these spreadsheets because the color-coding system in the spreadsheets does not directly translate to the OTIS reports (note: this observation applies to other sources, too, not just OTIS).

- Financial Services keeps a program snapshot in Excel, as well as monthly financials. They are "hard entering" (manually) this information into Excel.

- FP&A gets a lot of requests for data from legislature. Because of the lack of trust in OTIS reports, staff use SQL to build custom reports.

- COMPASS Idaho manages projects in their own Access database.

Future System Requests

While the next generation of OTIS or replacement system research regarding feature and business requirements is the focus of a future project task, the consultant began gathering preliminary information during the user experience interviews. This information will be critical to consider during the software rewrite or procurement process.

- Synchronized updates to "base" and "working copy" of the program

- Fewer overall clicks

- Less redundant information

- Ability to flag different funding programs; for example, TECM Bonding

- OA Balance screen – split out local portion of highway match in the Highway Infrastructure Exempt line; currently lumped in with ITD funding

- Syncing terminology between Advantage and OTIS. Or a glossary similar to that of the statewide Luma project

- OTIS data fed into Advantage tables. Currently entered manually.

- Connection to SharePoint and other programs that pull data from OTIS

- Easier data pulls (e.g., GIS)

- More accessible matrix view

- Import companion projects assigned in AASHTOWare

- Bundling key numbers into an umbrella key

- Knowing what's going on in the background; avoid the "black box"

- Flexibility to keep up with federal requests and changes

- Condensed reports tailored to time-sensitive information (e.g., requests from Idaho legislature)

- Reliable, printable executive-level reporting

- Customizable reports; more flexibility in tailoring a report to a request

- Looking at information across years

- Change notifications

- More granularity; ability to flag programs

- Different buckets/colors of money appropriation codes

- Pop-up info boxes

- Easy-to-print program matrix

- More user-friendly Advanced Search feature

- Easy access to timelines, cost, budget, location, and PM names (to assist ITD's PIOs)

- Auto-populate data into ITDprojects.org

- Email pings to external users at certain data update events

- Ability to compare two versions of the same record

Noteworthy Considerations

The consultant encourages ITD to keep the following points in mind from the user experience interviews:

- Easily accessible, reliable reports and summary pages are fundamental requirements for the future system.

- Lack of trust in OTIS data results in the inefficient use of employee time.

- A more user-friendly system was deemed a high priority among nearly all OTIS users.

- The future system should do a better job at tracking "colors of money" and flagging programs.

- Flexibility and customization may inevitably result in a more complicated system. It could be difficult to have one without the other. There will be configuration no matter what direction ITD chooses.

- As much as possible, the future system should interface with other ITD applications. Users should be clear on when data-exchanges occur, whether in real-time, nightly, or other.

- Ideally, the future system will require less manual data entry and redundant information.

- ITD should immediately begin addressing the overreliance on just a few key staff for OTIS support.

- ITD should focus on a system that minimizes processing time, operates consistently for all users, allows for multiple users at once, and enables users to troubleshoot on their own as much as possible.

- The future system should preserve decades of all historical data.

4. System Technical Review

Task Purpose

The purpose of the Enterprise Technology Services (ETS) Technical Review was to better understand the current goals and challenges within the ETS office and to further explore technical problems with the current OTIS system. The approach to this task involved a series of interviews with several key ITD ETS employees. The conversations and topics ranged from the high-level ETS trajectory to the structure and components of OTIS. The consultant also performed a case study centered around the Linear Referencing System (LRS) transition project from Agile Asset's Network Manager to Esri's Roads and Highways platform for its similarity to the upcoming OTIS replacement project.

The consultant interviewed the following ETS staff for this task:

- **Mark McKinney**, IT Administrator/Chief Information Officer

- **Wendy Bates**, GIS Manager

- **James Palmer**, IT Manager

- **Michael Graham**, IT Software Engineer

This chapter summarizes the findings of each of these interviews and the case study.

Key Takeaways

Several key themes that directly impact the OTIS replacement emerged during the consulting team's conversations with ETS staff:

- Leadership within ITD and ETS are engaged and communicating about needs across the organization.

- ETS is actively implementing new technologies and procedures to reduce the workload, complexity, and redundancy burden on ETS staff.

- Finding and retaining ETS staff, specifically software developers, is challenging and threatens ETS's ability to maintain systems and applications. This is the case for all state agencies. The state's Division of Human Resources worked on a specific hiring, retention, and career-path project regarding state IT staffers several years ago and continues to discuss market vs state salaries with the legislature on an annual basis.

- Knowledge silos exist within ETS that threaten ETS's ability to maintain operations.

- Replacing older, complicated systems and applications requires extensive planning and resources.

- Some systems, like OTIS, require dedicated resources and hands-on maintenance by ETS staff.

- An experienced project manager was leveraged to keep the Roads and Highways project on time, within scope, and on budget.

Enterprise Technology Systems (ETS) Technical Landscape

ITD's Chief Information Officer (CIO) Mark McKinney provided high-level narrative on ETS initiatives, OTIS and the transition to a new system, and the department's technology goals. Update: Mark McKinney has moved on from ETS since this interview was conducted in May 2022.

Contemporary Landscape

The initial phase of the project team's conversation with Mark McKinney touched on ETS's current role within ITD and challenges facing the department. Some of the conversation topics most applicable to the OTIS replacement project are summarized below.

Data Transfers

Many applications, systems, and data streams are dependent on or integrate with other technical resources. ETS has historically used a variety of different methods to move data between systems including direct database connections and Extract Transform Load (ETL), a procedure that pulls data from one system, augments that data in some way, and then inserts it into another system. However, to streamline operations and standardize the way data is transferred between systems, ETS is moving toward a point where they only, or at least primarily, rely on an Application Programmable Interface (API) structure, where data is served via an endpoint that is accessible over the internet. As is, ETS uses APIs in addition to other methods of facilitating data exchange (e.g., ETL, direct database updates). An API is a set of tools that enable applications to interact with software systems. They make software development and innovation easier by allowing programs to communicate data and functions quickly and safely.

OTIS moves data between other systems and within the application in several ways, including APIs, direct database connections, and ETLs. This creates a virtual spiderweb of dependencies that needs to be understood and managed by ETS staff. A change or retirement of a system that pushes data to or pulls data from the application can create a ripple effect of failures if interfaces are not updated proactively as part of the change or retirement. Moving toward a fully API-driven data exchange will help to simplify systems and reduce the level of development effort to maintain systems.

Agile Integration

ETS is integrating an Agile software development approach (Figure 12) to increase the breadth and depth of skills across ETS employees and to increase the efficiency and transparency of the application development and deployment process.
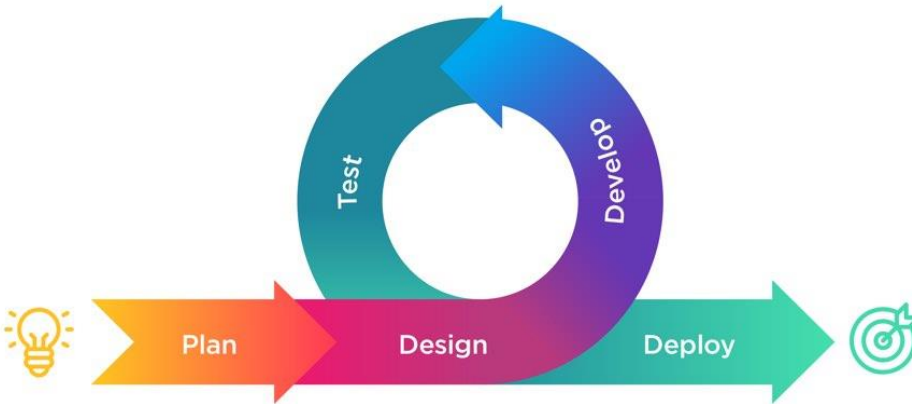
Figure 12. Agile Software Development Process

Image Source: Digital Treed

The integration of an Agile approach to project planning and management will likely have a positive impact on the TIS in several ways:

- Application development projects will be well planned out, and flexibility will exist due to the Agile methodology. Improvements and new features discovered during the project lifecycle could be integrated into the project if it makes fiscal sense and is possible given the timeline.

- ETS junior staff will experience greater skillset distribution since they will have the opportunity to work on multiple systems for varying time periods under the guidance of senior staff.

- Applications like the TIS will be developed and managed in predesignated sprints. These short-term development periods will be marked by regular deployments.

- A regular deployment cycle allows end users the ability to work with the new system and communicate their needs as the software is being developed.

ETS Application Support

ETS currently supports over three hundred applications at ITD. The sheer number of applications being managed, variations in technologies within those applications, and understaffed ETS workforce create a scenario where individual ETS employees – by necessity – become sole subject matter experts (SME) on a particular piece or pieces of technology with little to no overlap in skillsets amongst other ETS employees.

The heavy reliance on such key staff creates an environment where individual SMEs become fundamental to maintaining and persisting applications managed by ETS. The minimal availability of cross training and knowledge transfer creates several other challenges:

- Should a key employee retire or leave ITD, applications maintained by that person may cease to work or experience significant setbacks.

- Application support staff may become so overwhelmed with maintenance and continuing operations that new features cannot be added.

- Fixes and functionality improvements will be implemented more slowly since they will fall onto a single employee.

- The department may have to incur unforeseen expenses to maintain systems.

- When a bench is too thin, there aren't enough valuable viewpoints to assist with well-considered ideas and solutions.

OTIS currently falls into the category of applications where only a very small number of ETS staff have the technical ability and background to successfully work on the system.

ETS (IT) Staff

The ability to properly manage over three hundred separate systems and develop new ones is largely dependent on ITD and ETS's ability to attract and retain quality information technology and software development professionals. As is the case with many government entities and teams within those entities, competing for talented staff against private organizations is difficult for a multitude of reasons:

- According to Mr. McKinney, certain IT job categories within ETS are being paid roughly 70% - 80% the salary of individuals with similar jobs who work in private industries.

- It's difficult to find new, talented employees to work on older or legacy systems. Expensive, niche contractors may be required.

- After providing training and professional experience for new software developers, ETS has difficulties retaining those employees.

- The natural employment path for developers at ETS doesn't allow for much progression. ETS managers and leadership may stay in their positions for extended periods of time limiting opportunities for junior staff. Note: This longevity may not be a reality given the higher salaries currently offered by the private sector and the sizable increase of software jobs.

- A previous funding mechanism that was used to hire contractors to bolster ETS staff has largely been exhausted and will not be available in the foreseeable future. The salary differential

typically offered to developers in the private vs. public sector explains some of why contractors might be easier to attract and retain compared to regular state staffers. However, the exhaustion of this "pot of money" may result in fewer external contractors being leveraged in a variety of capacities.

ETS is modifying the way that it searches for new employees and integrates them into the office to alleviate the load on current employees and ensure that new employees are set up for success:

- A focus on target versions and systems is now part of the ETS hiring process. ETS is trying to find individuals who have previous experience or are interested in learning the platforms the office intends to use.

- New employees will be trained on several systems to help eliminate vertical skill silos and ensure that applications and systems can be supported by multiple employees.

ETS's current staffing situation and the new methodologies meant to attract and retain employees affect the TIS in two main ways:

- A single ETS software developer is currently acting as the primary and only technical application support team member. Cross training new employees on technologies used within OTIS and the TIS will help to spread knowledge and increase the number of developers who can work on the system.

- Update: This developer (Michael Graham) retired a year before the original plan; his last working day was 6/3/2022. Some cross-training with two existing developers occurred, prior to his departure. One of those subsequently announced his own departure; his last working day was 6/24/22.

Given the complexity of the OTIS system, the number of technologies utilized in that system, the approximately one dozen interfaces, and the length of time required to become competent with those technologies, retaining employees who become experts for both the current and new system is paramount.

Update: In August 2022, Mr. McKinney informed the consultant that the state's central IT department has been consolidating IT staff from various agencies for the past few years and that ITD is targeted for this consolidation this fiscal year. Thirty-six of ITD's ETS staff (about 40% of all ETS staff) staff will lose their jobs and must reapply elsewhere by June of 2023. The impacted staff includes all networking, server, architecture, administration, managers (eight, including all ETS senior managers and his own position as CIO), project management, cyber security, and some service desk staff. The DevOps teams, database administrators (DBAs), GIS, automated systems managers, and most of the service desk staff will remain. DevOps is a hybrid team of employees consisting of developers and operations staff such as systems administrators and DBAs.

Mr. McKinney predicted that ETS will suffer higher than normal attrition rates, especially in the thirty-six targeted positions. This is already being observed. Without project management, architecture, senior management, and data center infrastructure staff, any project the size and scope of OTIS will become increasingly challenging to complete successfully.

Future Landscape

To better understand ITD's future technical landscape, the consultant and Mark McKinney touched on a series of topics that will directly impact an OTIS replacement.

Low-/No-Code Solutions

ETS has been researching and reviewing platforms that require as little custom software development and configuration as possible. These platforms, typically referred to as low- or no-code solutions, allow users to create drag and drop workflows within a user interface, which are turned into executable code by the platform. These platforms are supposed to reduce the level of effort for those building and maintaining applications that use the technology. These solutions lend themselves to business applications that require less flexibility and more standard operations than are involved with OTIS business processes. They also require custom coding (via Java, for example) following the original low- or no-code framework creation.

Existing Platforms

Rather than build in-house solutions with new and emerging technologies not yet in ITD's development environment, ETS is reviewing the array of technologies currently available at ITD to see if applications like OTIS could be migrated to existing systems like Microsoft's Dynamics enterprise resource planning/client relationship management platform. These off-the-shelf systems may or may not be adequate platforms for a complex, feature-rich application like OTIS.

Conclusions

ETS is making actionable progress toward increasing its ability to support business applications and deploy reliable solutions to its downstream customers. However, several big-picture issues remain concerning.

The following Strength, Weakness, Opportunity, Threats (SWOT) analysis was derived from the information collected during the project team's conversation with Mark McKinney.

Strengths

- ITD leadership and ETS staff are engaged at all levels.

- Department executives are actively assessing the department's technical landscape and tweaking plans.

- FP&A, Highways, and ETS groups are actively communicating about business needs and requirements for the TIS.

Weaknesses

- State-agency IT shops, including ETS, struggle to attract new talent and retain those employees.

- The volume of applications and systems being managed makes it difficult to cross train ETS employees on multiple technologies.

- ITD and ETS pay scales make it difficult to compete with private entities.

- It is difficult to identify and maintain budget approval for contractors, thus limiting the ability to augment staffing levels during times of high turnover.

- Further, in a complex IT environment, contractors are not a solid resource solution unless they can be retained on a long-term basis.

Opportunities

- Moving toward an API standard for distributing data will speed up development and simplify maintenance.

- Low- and no-code platforms could provide cost and resource savings.

- Vendors like Aurigo and PMG offer product suites that perform functions that ITD's OTIS handles, and would support other business areas as well, such as Civil Rights (HR) and Right of Way (Highways).

Threats

- Seasoned staff and subject matter experts who leave the department cannot transfer knowledge and skills easily.

- Applications could become obsolete or inactive if they can no longer be supported by ETS due to staffing challenges.

Case Study: Esri Roads and Highways

The following case study documents ITD's transition from Agile Asset's Network Manager Linear Referencing System (LRS) to Esri's Roads and Highways LRS. Understanding some of the challenges and

requirements of a large-scale, intricate-technology project at ITD was the focal point of the study. The information gleaned from the consultant's conversation with Wendy Bates can be used to help determine a level of effort and budget requirements for an OTIS replacement.

A Linear Referencing System is a key component of a spatial data management system, like a GIS. Due to the issues outlined in the Project Catalyst section, Wendy Bates, the manager of ITD's GIS team, which was contained within the Highways division at the time, began having conversations in 2014 with ITD's leadership about transitioning from the Network Manager LRS to the Roads and Highways LRS. Conversations about replacing the LRS spanned multiple years and teams within ITD. Moving all ITD's abundance of spatial data from one system to another was a large, technical undertaking. Furthermore, business processes and the GIS data underlying many systems would change, leading to ripple effects within ITD staff's day-to-day operations. It also impacted external users – essentially anybody that used or consumed ITD's GIS data would have been impacted.

Project Catalyst

Before the Roads and Highways LRS upgrade, the ITD GIS team used Agile Asset's Network Manager LRS to manage their spatial data. The GIS team generally thought that Network Manager was a decent product. ITD's Transportation Asset Management System (TAMS), which was also an Agile Assets product and contains a multitude of different datasets used to steer decisions on maintenance, highways, and planning operations, was reliant on Network Manager to maintain correct and reliable spatial reference points for the many datasets within the system. However, Agile Assets intended to end their support for Network Manager and sunset the product in the future to focus on integrating Esri's Roads and Highway LRS into their software. The deprecation of Network Manager by Agile Assets created the potential for a key data management system underlying other systems, like ITD's Transportation Asset Management System, to become obsolete and unsupported, which would eventually hinder or obstruct downstream business processes.

Further, FHWA indicated states should implement certain GIS functions -- such as dual carriage way -- as a result of federal legislation in 2012 called MAP21 – "Moving Ahead for Progress in the 21st Century." Network Manager was deprecated by Agile Assets due to not enough clients having purchased the product. Had Agile Assets kept Network Manager in their project portfolio, it's possible they would've made it compliant with FHWA guidance regarding MAP21 - as they have done with the replacement Roads and Highways LRS product. Absent that, ITD needed to replace.

Leadership Support

To secure funding for the LRS upgrade, the GIS team had to make a business case for Esri's Roads and Highways system to communicate the technical prowess of the system and complexities associated with the upgrade. Support within ITD leadership became strong after the importance and impact of the project was communicated, though leadership changes had taken place during the onset of the project which created potential for challenges in the future.

Project Cost

The GIS team and ETS determined that a budget of $250,000 would be required for software procurement for the LRS upgrade.

The original software procurement cost for these components within the overall vendor platform (desktop and server side) came in under budget, at just under $100,000. Ongoing software maintenance is $20,000 per year. These reflect volume pricing and state-level contract incentives.

Additionally, expenses for the prototype product co-developed with the vendor in 2015 totaled approximately $250,000 for external vendor project management, architecture, GIS, software development, hosting, business analysis, and technical writing.

Over the next 3 years (prototype plus implementation of final product), external project management services were approximately $500,000, and external architecture, GIS, software development, fixed costs were close to $650,000. With the annual software price included, this comes out to:

- Prototype cost in 2015 of approximately $250,000

- Production amount for 2016-2018 of close to $1,250,000

- Cost for all 4 years (including the prototype) was near $1,500,000

Important notes: The LRS and the proposed TIS projects are comparative but not at all identical. For example, agency staff time and ongoing ITD infrastructure (servers, databases, patches, increased capacity) and are not accounted for in the above numbers. Neither are development and configuration of external integrations (interfaces, whether ETL, API, or other), which were handled as separate projects with distinct budgets. Further, the LRS project expenses don't reflect data cleansing that is a significant portion of a move to a new software system. That's because that 2-year process had happened prior to this project, due to other circumstances.

Project Management and Staffing

The core project team was composed of the five teams or individuals shown in Figure 13.
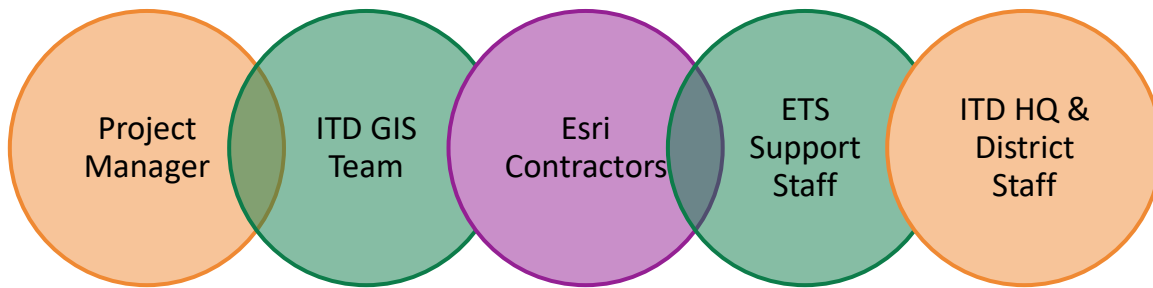
Figure 13. LRS Transition Project Team

Project Management. ITD decided that the project's scale and complexities would require a project manager (PM) with advanced project management experience and technical understanding; ITD decided to hire a contractor to act as PM and set the overall project tone and direction. Reasons included:

- There wasn't sufficient staff on the ETS project management team.

- ITD did not have a GIS specialist on staff with sufficient project management experience or expertise.

- ITD was not in a position to remove operational workload from any existing staffers, in order to allow them to focus full-time on the very significant enterprise effort needed for a project of this magnitude.

- In the domain combining both GIS and Highways, it's very challenging to find a specific individual within a DOT who has deep expertise in both areas and has available time.

ETS, GIS, and Highways staff were on the selection panel for hiring an external contractor for the project manager role.

GIS Expertise. The GIS team was split into sub teams for the project. A single team member acted as the internal project manager for all sub teams. Members were asked to learn how to manage new, complex roles so they could support and manage the system.

Esri. ITD retained three Esri contractors as part of the project agreement with the software company. Each contractor had a staggered start date and different role within the project. The contractors were liaisons between Esri and ITD for the duration of the project and they provided support, guidance, and technical knowledge to ITD staff.

The GIS team and Esri team each had their own project managers and technical leads who worked in concert.

ETS. Different groups at ETS were part of the project team including the database, infrastructure, and systems teams. Key ETS staff supported the project in a variety of different ways.

District Staff. A team of ITD employees in the districts was assembled to provide project support and communicate the needs and requirements of the district employees whose workflows would be altered or affected by the upgrade.

Challenges

The following section outlines several challenges that were identified by Wendy Bates and the project team regarding the Roads and Highways LRS transition project.

- **Drafting new standards and requirements.** Creating a list of standards and requirements for the new LRS was difficult considering the number of different business units and teams affected. These decisions would have ripple effects to other systems and workflows. To address this issue, the project team had to consider many different scenarios to gain new perspectives on different aspects of ITD's operations.

- **Data migration.** To provide context for users and maintain consistency for GIS systems, ITD's GIS team used a data schema for Network Manager. This schema standardized the layout and naming conventions for all datasets. Esri's Roads and Highways required a new schema that conformed with the expectations of their system. Migrating data to the new LRS would be a long and complex task undertaken by the GIS team and Esri contractors. Each dataset would have to have spatial operations performed on it to migrate the data to the new LRS.

- **Organization and workflow changes.** Network Manager was a mainframe-style LRS system that had existed for years, and it was not designed to support a modern approach of serving spatial data over the internet. Esri had adopted a more cloud and web-based approach to their services, so ITD GIS staff had to learn about all the new systems and software before the official transition could take place. This learning process was crucial to supporting operations and business unit needs. The organizational and workflow changes created by the LRS upgrade was a large and demanding task to manage.

- **Teaching the Esri components.** Training ITD business staff to use the new Esri services and data was another challenging task. Employees of the different business units had become accustomed to aspects of the LRS that required change, like Segment IDs and Reference Points. These changes have had lasting impacts on staff (e.g., there was lots of turnover during the system transition period so it was difficult to manage change, some employees still access Network Manager to verify data, and there are semantic differences between the old and new system) even though the overall transition process went well.

Synergy

Some significant similarities between the LRS upgrade project and the OTIS replacement are listed below:

- Both systems contained data that was depended upon by multiple teams and services at ITD.

- Both projects will create business changes that ripple across the organization for years.

- An external project manager helped keep the LRS project on track and within budget. It is likely that the TIS would require advanced project management requirements too.

- Network Manager and OTIS faced becoming obsolete due to technology changes and updates largely out of ITD's control.

- Given the scale and complexities of the projects, project budgets are substantial and need to provide funding for a multitude of project requirements and team members.

- Having strong communication and understanding between sub-teams is critical for project success. ITD's GIS team and ETS worked closely during the LRS project to support business operations. Concurrently, ITD's Financial Planning and Analysis (FP&A) office and ETS have team members who work directly together to support OTIS and are on the OTIS replacement project team.

- Both projects will require data to be effectively mapped for it to function properly in the new system.

Conclusions

The transition from Network Manager to Roads and Highways was a large technology project that touched many different aspects of ITD's operations. The multifaceted project team had to manage requirements and needs across multiple organizations and teams. At the end of the project much had changed about ITD's GIS capabilities and product offering. Additionally, the GIS team was ultimately absorbed into ETS after the Roads and Highways transition was complete. The Roads and Highways LRS and associated products from Esri are more modern, sophisticated pieces of technology which are helping ITD employees solve problems every day. ITD's GIS team was ultimately recognized by Esri at a large GIS conference for their professionalism during the project.

The LRS replacement project offers several important lessons that can be leveraged for the TIS implementation.

Project Management

Leveraging an external project manager helped keep the LRS upgrade project on track and deliverables executed while the Highways staff focused on educating staff on the new system (The project manager

was a separate entity from Esri, the project's software vendor). Given the complexity and impact of an OTIS replacement, an external project manager will have the knowledge and skillset to help ensure that the multifaceted project is successful.

The ITD GIS team and the external contractor team defined key task management roles to ensure that task deliverables were clearly defined and executed. Under the direction of an overall project manager, the OTIS replacement would benefit by having FP&A, ETS, Highways, and/or external contractor task leads. These positions would ensure that synergy exists between the different entities, and tasks are clearly defined and executed.

Change Management

The implementation of change management strategies was critical to the LRS upgrade project. Further, as noted by Wendy Bates, the drafting of new standards and requirements was a strategically difficult part of the LRS upgrade. There was also lots of turnover at ITD during this period, which complicated the process further. It will be important that the OTIS replacement project team to work on change management throughout the project and to keep in mind that even though the project itself is "done," the transition impacting staff is not complete and will be ongoing.

The TIS is going to create a vast number of workflow and technical changes at ITD. Creating adequate requirements, documentation, and training will be a necessity for a successful project and application rollout. Working across offices is encouraged and may help expedite learning.

Interdepartmental Synergy

The LRS upgrade required staff and leadership from Highways and ETS to be aligned for a successful project. The TIS will be no different.

For a successful TIS implementation to occur, conversations involving FP&A, Highways, and ETS leadership and staff should continue until the technical project kicks off, and throughout the lifecycle of the system transition.

Enterprise Technology Systems (ETS) Development Part I

The consultant spoke with James Palmer, one of three software development managers within ETS, and Michael Graham, senior software developer in ETS and the lead OTIS developer, about current challenges within the OTIS system.

OTIS Technological History

OTIS initially existed as a homegrown application built on top of Microsoft Access by members of the office that predated FP&A. This OTIS precursor was largely created and managed by a single employee

within Highways. At the start of the 2010s, Experis, an external technology company, worked with ETS and ITD to turn the Access database application into the instance of OTIS that exists today.

OTIS application was built by a team consisting of Experis and ITD/ETS staff. The initial launch of the system was quite buggy and meant to include several features that were not implemented entirely or at all. A long list of outstanding items beset the project from the launch and required continual updates to the code base to implement functionality and resolve outstanding issues. It is only in the last year or so that it has become less buggy and more stable. However, some functions have never been built. Two significant examples: an interface with FHWA's FMIS, and functionality for advanced construction; the latter cannot be built due to underlying platform constraints.

Several internal assessments of OTIS have been completed since it was originally deployed. These assessments have yielded a variety of positive and negative results regarding OTIS and its functionality.

OTIS Architecture

The following section touches on the organization of the OTIS application including some of its components, how they interact with each other, and the environment that it exists in, otherwise known as application architecture.

Separate Integrated Applications

OTIS consists of four separate application components that are integrated together. The redundancies that exist due to this architecture decision have caused issues since the application was originally deployed. The application components that exist are:

- **Application Programmable Interfaces (APIs)** – APIs allow for the programmatic transfer of data across systems.

- **Batch Processor** – The batch processor "listens" for changes to the data from within OTIS at regular intervals and initiates data updates within the application if there are differences detected.

- **Internal Application** – A user interface specifically designed for use within ITD's internal network. This portion of the application was designed for ITD employees specifically.

- **External Application** – A user interface designed for use outside of ITD's internal network. This portion of the application is designed for external parties such as COMPASS, LHTAC, KMPO, and FHWA. It's also for use when ITD's internal network cannot be reached, such as a staffer having VPN issues when teleworking.

Structuring OTIS as four separate entities introduced several challenges. Two of the main challenges are described below.

- **Separate applications → different base code.** Because the internal and external applications are separate entities, ETS must maintain two different code bases and integrate new functionality into both applications. Further, when issues that involve both applications arise, ETS must fix the issue in both applications.

- **Inconsistent batch processing.** The batch processing portion of the application is a key component used to process large quantities of data. The batch processor is relatively inconsistent in terms of picking up on changes within the application and executing its duties. This creates issues when OTIS users believe that data processing is occurring within the application, when in actuality it is not.

Technologies

OTIS is built on top of several pieces of technology. Some of the core technologies are summarized in Table 4.

Table 4. OTIS Technology Components

Technology	Description	Current Version
.NET	Microsoft application development framework – foundation for the applications	4.5
Entity Framework	Object Relational Mapping (ORM)	5.0
TELERIX	Proprietary user interface controls embedded in the applications	-
SQL server	Microsoft relational database	2014
SQL Server Reporting Services (SSRS)	Microsoft web reporting application	2012

At the time of application development, these technologies likely paired well and worked in concert to fulfill the business requirements. Technology issues have risen over time, however, as the components have aged and not been updated to current versions.

Challenges

The following section touches on current challenges that exist within ETS as noted by James Palmer and Michael Graham.

Support Staff

Little overlap exists at ITD in terms of the technical skills and business knowledge required to maintain OTIS and assist its users. OTIS is mainly supported by a software developer within ETS and a member of FP&A. Each employee, largely by default, has become a subject matter expert in different domains

related to OTIS. They both provide hands-on support to the application and regularly help users navigate issues.

The two main OTIS support staff are seasoned ITD employees who are approaching retirement. If one or both leave the organization without being able to adequately train other ITD employees on the technologies or business functions contained within the application, OTIS could encounter a series of troublesome issues that will be difficult for ITD/ETS to resolve. The worst-case scenario is that the application becomes obsolete or unusable, which would hamper ITD and external entities.

Adding to the staffing challenge is that fact that ITD has only a very small group of people – within both FP&A and ETS – that know OTIS in a deep and trustworthy way. This type of knowledge is crucial for troubleshooting complicated problems with the software and fixing issues efficiently and reliably. These staffing limitations would continue to occur if ITD chooses to proceed with another in-house application. A third-party solution, conversely, may include the possibility of introducing a robust user group in the clients/states that use the software, along with the vendor support staff.

Finally, it is important to note that a move from an in-house tool to a third-party vendor won't be moving from a "free" model to one that "costs" money to support. Rather, ITD sustains a support contract with Experis, the company that originally built OTIS.

Transport Layer Security (TLS)

TLS is a cryptographic protocol used to encode data and assist authentication between clients and servers. Securing applications that serve over Hypertext Transfer Protocol Secure (HTTPS) is one of the most publicly visible applications of TLS protocol.

Over the years, to safely secure modern web applications and internet traffic, TLS requirements have become more robust. When OTIS was originally launched, the application was TLS 1.0/1.1 compliant. However, the requirements to safely encrypt data being transferred across the internet have become more stringent, and new standards were created and released with the TLS 1.2 and TLS 1.3 versions.

Unfortunately for OTIS, the .NET version 4.5 framework being used does not natively support TLS 1.2 and/or TLS 1.3 protocol. To compound matters, many internet browsers are removing support for TLS 1.0 and TLS 1.1.

In the short term ITD/ETS are going to attempt to reverse proxy TLS 1.2 and TLS 1.3 encrypted traffic through a load balancer, effectively reducing the level of encryption to TLS 1.1 which can be accepted by OTIS. In the long run, OTIS will either need to be replaced by a vendor system that supports modern cryptography practices or the .NET framework being used will need to be upgraded to a version that accepts current TLS encrypted web traffic. Figure 14 summarizes the current OTIS TLS support and the future direction needed.

Current TLS Support			
1.0/1.1	Lacks modern security and encryption controls	Modern browsers are beginning to not support older TLS traffic	.NET 4.5 does not organically support TLS 1.2/1.3

Future TLS Support			
1.2/1.3	More modern approach to cryptography and encryption	World is already moving in this direction	Requires upgrade to higher version of .NET framework
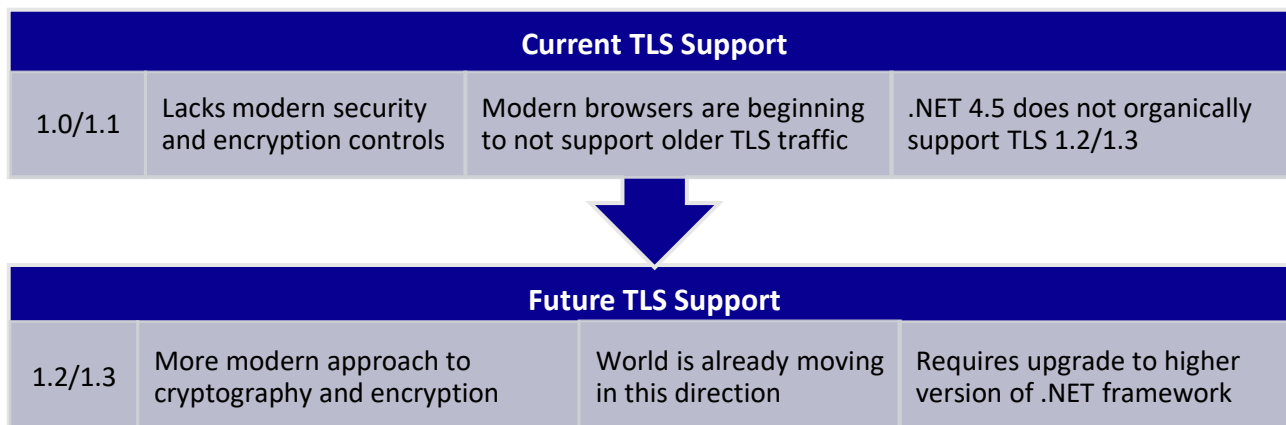
Figure 14. Current OTIS vs. Future TLS Support Details

.NET Upgrade Effects

Technologies are tightly bound within OTIS and upgrading .NET to a version that supports modern TLS traffic creates a ripple effect of issues within the application. The two most critical issues that arise from a .NET upgrade are:

- Entity Framework version 5.0, the Object Relational Mapping used to communicate between the application and database, is not compatible with more current .NET versions that accept TLS 1.2 and TLS 1.3 traffic.
  - o Entity Framework version 5, which was bundled with Active Server Pages (ASP) .NET 4.5, used Entity Data Model (EDMX) management functionality within Visual Studio to implement the entity objects.
  - o Entity Framework version 5 was removed from the core install of .NET 4.6 + and turned into a standalone application for future .NET releases.
  - o Entity Framework version 6, the newest version of Entity Framework, uses a completely different design pattern than Entity Framework version 5.
  - o If the .NET framework is upgraded to accept higher levels of TLS traffic, the Entity Framework will also need to be replaced.
- The OTIS instance contained proprietary TELERIK user interface controls.
  - o These controls will not function properly with an upgraded .NET framework.
  - o User interface controls would need to be rewritten.

Enterprise Technology Systems (ETS) Development Part II

The consultant spoke with James Palmer, a software development manager within ETS, and Michael Graham, a senior software developer in ETS and the lead OTIS developer, about the current state of the

software development team within ETS, and the complexities associated with rewriting OTIS internally or purchasing an off-the-shelf solution.

ETS (IT) Staff

Recruiting and retaining software developers and other IT professionals at ITD has historically been difficult for several reasons. Among the most important reasons are pay and benefits, lack of career development opportunities, and new skill requirements. Each topic is briefly discussed in this section.

Pay and Benefits

ITD is currently paying roughly 70% - 80% of the market value for software developers. The pay differential when compared to private entities is exacerbated by

- The drastic increase in inflation compared to wage growth at ITD and other state agencies;

- Additional benefits like stock options, equity, profit sharing, and performance-based bonuses available in private business; and

- The flexibility associated with semi or fully remote positions.

- Cost-of-living factors such as the exorbitant local housing market are causing some developer candidates (as well as in other careers, such as police officers, teachers, and EMTs) to withdraw from consideration.

Career Progression Opportunities

There are a limited number of classifications and positions that developers can move into to advance their careers. This is the case with many state agencies; it is a not a problem unique to ITD. ETS software developers lack a well-developed career progression path. The office has experienced several instances where junior developers join the organization, obtain skills and experience, and then move to different positions at other state agencies or with a private company. This is costly for ITD and creates an environment where key organizational information cannot be easily transferred to new employees. Additionally, the state's financial management practices are skewed to discourage "double fills" (hiring the replacement before the employee's departure), which would allow overlap and knowledge transfer.

New Skills

The movement toward cloud infrastructure requires different skills, abilities, and knowledge. Many applications and systems at ITD exist locally, so finding developers who are competent at both local development and cloud development can be a challenge.

OTIS Rewrite v. Replacement

Most of the conversation was focused on how ETS would plan for and implement an OTIS replacement project. Some of the main commonalities between the two options, key differences, and approximate costs are outlined below.

Common Themes

- ITD should retain an external project manager who oversees the entire project.

- ITD should continue to maintain the product owner role external to ETS. Currently, this role is filled by two staff members within FP&A; they are an integral part of the project.

- Most of the project staff would consist of contractors with support and guidance from ITD staff.

- It would likely take at least a year to release a beta version an OTIS replacement system OR migrate data to a new off-the-shelf system and stand up the interfaces to other ITD applications.

- Either option requires that OTIS be maintained and supported until the new system is ready to replace it, and ideally for quite some time afterward, as is industry standard following transitions.

- The ability to separate current system maintenance and onboarding the new system will be dependent on ETS staff levels and abilities.

- Migrating to either an off-the-shelf or an in-house system would require that OTIS data be mapped and migrated to work in the new system.

Key Differences

- Development costs associated with writing a new TIS internally would be far higher than those associated with migrating to a new system, though ITD will need developers working on software interfaces and data migrations (ETL) either way.

- Integrating interfaces with an off-the-shelf system would require assistance from the vendor and ITD developers.

OTIS Rewrite Details

A rewrite of OTIS would likely require the staff specified below. Mr. Palmer and Mr. Graham expect that the majority of these roles will be filled by external contractors due to the limitations within ETS discussed previously. However, these recommendations are certainly flexible and are by no means final.

- Project Manager (contractor)

- Product Owner (FP&A)

- Four Software Developers (three contractors and one internal)

- Business Analyst (contractor)

- Support Staff (internal)

A first-year budget of roughly $1.5 million would likely be required to cover contractor costs and any additional technologies or licensing required by the project to get the new software into production.

OTIS Replacement Details

A migration to an off-the-shelf solution would likely require the following staff:

- Project Manager (contractor)

- Product Owner (FP&A)

- Two developers focused on data transformations for new system (contractors or internal)

- Developer focused on API integrations (contractors or internal)

- Business Analyst (internal, external, or provided by vendor)

- Support Staff (internal)

A first-year budget of roughly $200 to $500 thousand would be required to cover contractor costs to assist with tasks like the data exchange and standing up APIs. Additional costs associated with licensing or procuring the new system are unknown.

5. State Department of Transportation (DOT) Case Studies

Task Purpose

For the State DOT Software System Comparison task, the consultant was asked to engage at least two peer states in a discussion about the systems they use for STIP-related processes and procedures. The intent was to gain an understanding of industry practices, in terms of workflows, features, software, and solutions that align with the ITD's business needs as the agency prepares to replace or rewrite OTIS.

The project team held meetings with at least one staff member with requisite knowledge and expertise from each DOT. In some cases, meetings were supplemented with additional information via email or in supporting documents. The project team selected three state DOTs for this research phase:

- Massachusetts Department of Transportation (MassDOT)
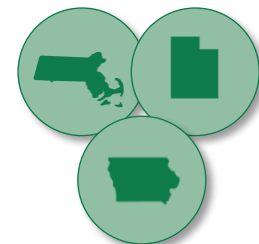
- Utah Department of Transportation (UDOT)

- Iowa Department of Transportation (Iowa DOT)

This chapter summarizes the outcomes of the state DOT meetings. Information in each section includes an explanation of why the team selected each state agency, a description of the STIP management system(s) that the state uses, and the most notable observations.

Key Takeaways

- **A one-size-fits-all vendor-provided solution was not identified.** None of the DOTs that the team interviewed relies on an out-of-the-box vendor solution to meet all of their STIP-related business needs. Specifically, MassDOT's version of PMG's STIP Manager is highly customized and Iowa DOT's version of Aurigo Masterworks Cloud is only used to manage statewide, DOT-led projects that appear in the Iowa Transportation Improvement Program (Iowa TIP), the state's five-year program.

- **STIP preparation and data-storage systems are highly state-specific.** State DOTs, including ITD, have differing internal processes, staffing availability and resources, staff knowledge/know-how, system interface requirements, and software security and architectural structures to list a few of the reasons why systems are customized to varying degrees.

- **Other state DOTs are generally willing to share information.** The project team was quite successful at soliciting responses to inquiries about each DOT's software, decision-making processes, and future system plans.

- **Coordination with other software systems within the agency may save on resources and improve efficiency.** For example, if the contracts and payments, reporting, and STIP management systems can use the same software, the DOT may be able to save on vendor contracting and maintenance costs, staff resource allocations, and time. An all-in-one solution may not be realistic for all agency needs, but the more coordination, the better. A single software subscription may cost the agency several thousands of dollars a month, but paying for multiple different subscriptions could add up to tens or hundreds of thousands every year. Further, maintenance of interfaces, redundant data entry, and confusion about terminology among disparate software tools, can have efficiency, data integrity, and even financial costs.

- **ITD is not alone in the STIP system transition process.** All three peer DOTs were either still in the research phase (UDOT) or had just acquired a new STIP system or system component (MassDOT and Iowa DOT). This status is likely true for DOTs nationwide. This is due, in part, to the relatively recent arrival in the marketplace of financial planning products that are suited to the creation of STIPs. Consequently, it was difficult to find a DOT with multiple years of experience with an off-the-self solution.

Massachusetts Department of Transportation

MassDOT was selected after the project team reviewed a recorded demonstration of the department's electronic STIP (eSTIP) solution. The software combination, PMG Software Professionals' products, STIP Manager and STIP Viewer, leverages the agency's existing GIS-based Esri resources and is relatively map-centric, which was of interest to ITD. PMG is one of several vendors offering off-the-shelf transportation planning software products specifically designed for STIP development. The software interfaces with other system solutions within the agency.

The project team met with the following MassDOT staff on July 21, 2022:

- **Derek Shooster**, STIP Coordinator – derek.shooster@state.ma.us

System Description

System Name	Developer/Vendor	Year Implemented	Connection to FHWA's FMIS	Internal Interfaces
eSTIP (STIP Manager and STIP Viewer)	PMG Software Professionals	2019	Yes, but it has not been implemented yet	ProjectInfo – MassDOT's highway project tracking system. (There are likely others not mentioned during the meeting.)

eSTIP is a customized cloud-based GIS solution developed on the Esri ArcGIS Online platform. MassDOT hosts the application on its own server and PMG sends updates as needed. MassDOT chose this software mainly because it had been implemented in other states (e.g., South Carolina and Rhode Island) and because it's customizable. The agency wanted to provide stakeholders (e.g., Metropolitan Planning Organizations (MPOs)) with a single point of truth for project data (e.g., schedule, funding, and budget information) and also a system updated in real time that was accessible by internal and external users.

The sampling of screenshots below shows the PMG eSTIP interface. These include the map view (Figure 15**Error! Reference source not found.**), a project list screen (Figure 16), and the TIP v. TFPC Quarterly Report (Figure 17). Additional screenshots of the MassDOT system are included in Appendix D.

Note: The consultant recognizes that the information shown in the images in this section and in Appendix D is difficult to read. The screenshots were captured during a virtual meeting and are meant to show general user interface design and concept only.
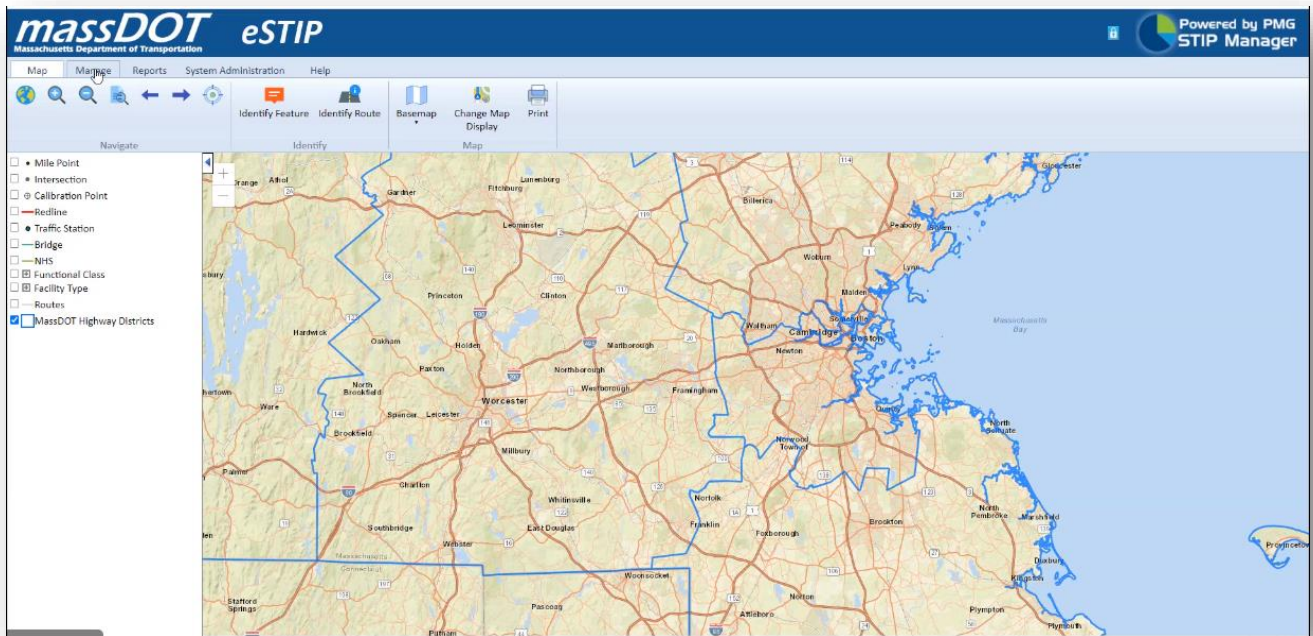
Figure 15. eSTIP Manager Map View
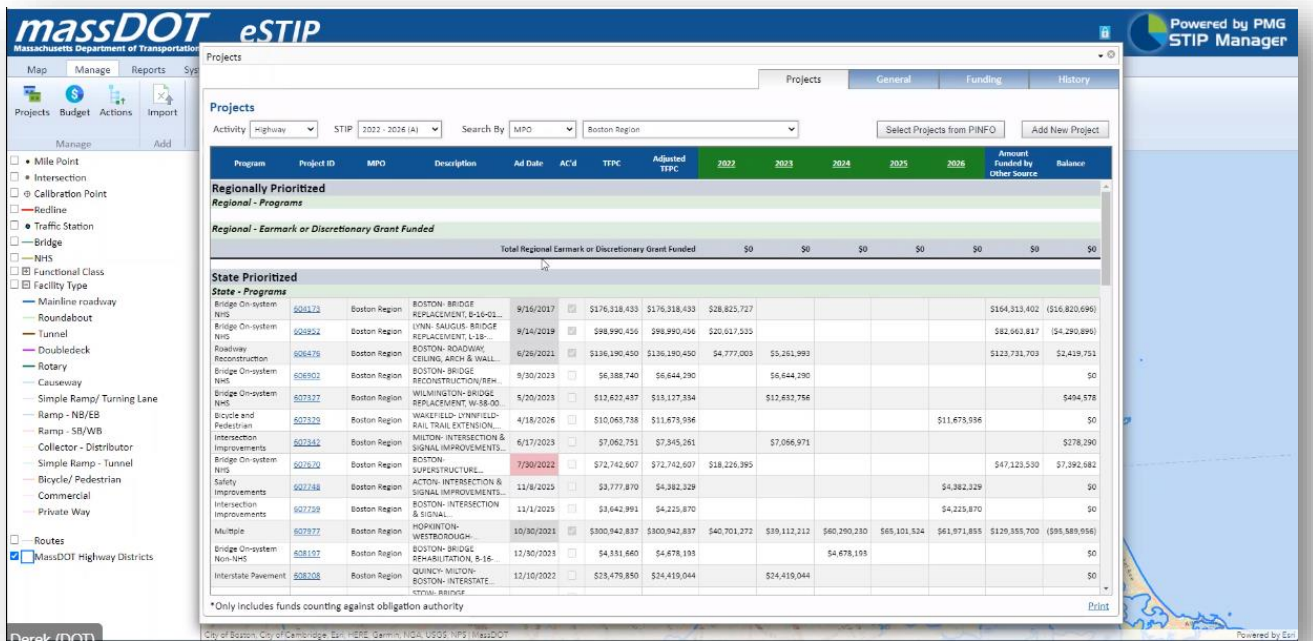
Figure 16. eSTIP Manager Project Screen

Figure 17. eSTIP Manager TIP v. TFPC by Quarter Report

- Find more info about PMG's STIP Manager
- Find more info about PMG's STIP Viewer
- View MassDOT's Project Profile on the PMG website
- Visit GeoDOT, MassDOT's GIS application and data hub

Notable Features, Functions, and Observations

System Overview and Features

- MassDOT uses integrated single sign-on (SSO) authentication, allowing the user to access multiple software systems, including eSTIP, with one login (Figure 18).
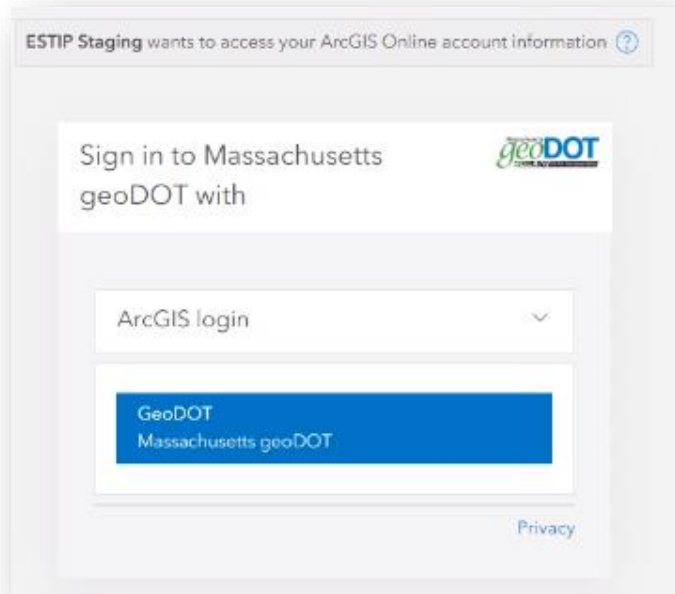
Figure 18. MassDOT's Single Sign-On Pop-up

- Data lives on an Esri feature layer.

- The software tracks program funding type (i.e., "color of money") using a color-coding system; action history is also tracked.

- The functionality of the application is still evolving; MassDOT has a running list of features they'd like to implement over the next five years.

- STIP investments are the most popular report; reports can be tailored (e.g., by MPO).

- South Carolina and Rhode Island also use versions of this eSTIP software.

- MassDOT's Transit STIP development is also available using eSTIP.

User Satisfaction

- Overall, MassDOT staff are pleased with the software and have had a positive experience working with PMG.

- Regional Transportation Improvement Programs (TIPs) are built within the software; MPOs haven't had issues using it so far.

- The application has been very useful for optimizing workflow (e.g., a color-coding feature – red, yellow, green – indicates the type of action needed). Note: While color-coding is helpful for some users, ITD should ask vendors offering this feature whether there are accessible (i.e.,

Section 508 compliant) features that achieve the same function without relying solely on color to communicate information.

Vendor Training and Collaboration

- PMG conducted on-site trainings using a beta version of the software prior to release.

- MassDOT and PMG collaborate frequently on the tool; MassDOT has a beta mode to view improvements and other new features before they are applied to the official version.

- MassDOT has priority categories (i.e., low, medium, critical) that they use to communicate with PMG about the level of importance of requests and issues.

Utah Department of Transportation

The project team met with UDOT staff primarily because the department is known for its exemplary practices and because Utah shares rural, mountainous, and western characteristics with Idaho. UDOT also subscribes to a software vendor of interest to ITD, which it uses to manage the construction phase of its projects.

The project team met with the following UDOT staff on July 29, 2022:

- **Bob Pelly**, STIP Coordinator – rpelly@utah.gov

- **Steve Wilkins,** Data, Technology, and Analytics Division, ePM Support – stevewilkins@utah.gov

System Description

System Name	Developer/Vendor	Year Implemented	Connection to FHWA's FMIS	Internal Interfaces
ePM	In-house, Oracle-based platform	~2002	Yes; data pushes are daily	Maintenance and Finance systems. (There are likely others not mentioned during the meeting.)

UDOT uses Electronic Program Management, or ePM, which is an Oracle-based platform developed specifically for the DOT about 20 years ago. Like OTIS, ePM is already or will soon be outdated. Specifically, UDOT is worried that Oracle won't support the system in the future. The software also confines the DOT since it is no longer as flexible as it needs to be because the DOT's business requirements have evolved over the past 20 years. UDOT would like to move to a more modular system (i.e., one where system functionality is separated into independent modules such as capital planning, project management, and federal aid reimbursement). This approach would allow the agency to combine and customize different systems independent of each other. At the time of the meeting, UDOT staff believe that they'll have multiple tools. It could be a mix of in-house and of-the-shelf solutions or all tools in modules from one vendor.

Notable Features, Functions, and Observations

- Like ITD, UDOT relies on an outdated, in-house developed solution managed by one staff member who is expecting to retire within five years.

- UDOT has been researching replacement solutions for about five years.

- As an agency, UDOT is moving toward a Google Cloud Architecture Framework, which will impact the agency's future software acquisitions. The architecture framework represents design decisions related to overall system structure and behavior. It is the foundation of a software system and profoundly affects the deployment of any new software.

- UDOT senior leadership are expected to look at overall project workflow and decide whether a more comprehensive investment in a new system makes sense. UDOT staff were not sure on the details, but they shared that it may result in a combination of off-the-shelf and in-house developed systems. The DOT has not identified agency-wide needs in enough detail to know whether such an approach makes sense.

- Like OTIS, ePM also has a "draft" parallel program environment that allows users to experiment with a replica version of the STIP without impacting the production environment. This has been the most valuable yet challenging feature to find an acceptable replacement for.

- Funding sources – they use a specific code per source in order to track appropriately, within the software system. They correlate / attach to the FMIS codes that come off the W10A. This is appealing to ITD.

- They receive a daily data dump from FMIS via electronic interface. But the interface doesn't go in the other direction, to FMIS. Instead, they have a person in each of the 6 regions who manually inputs the data in to FMIS.

- They opted to not have the interface from ePM to FMIS, because they felt it would be too challenging. They feel the manual data input that UDOT staff are doing isn't too much work.

- Like OTIS, UDOT relies on some manual data entry within the ePM system (e.g., obligations and deobligations), although staff reported that it is not too much work.

- Utah staff stated that they aren't yet finding anything off-the-shelf to replace ePM because it is so unique.

- For construction management, UDOT uses Aurigo Masterworks Cloud software, which replaced another homegrown system.

Iowa Department of Transportation

While helpful, the general outcomes of the UDOT interviews were not as informative as the project team had hoped due to the fact that the agency is at a similar phase of its system replacement research as ITD. Consequently, the project team decided to meet with one additional DOT. Iowa DOT was selected because they recently entered into a contract with Aurigo Masterworks Cloud (Masterworks), a third-party vendor solution, to manage the DOT's projects within the Iowa TIP, which is only one component of the STIP. (The Iowa STIP is made up of Iowa DOT efforts (i.e., the Iowa TIP) as well as those from each of Iowa's Regional Planning Affiliations (RPAs) and MPOs.) ITD was interested in learning more about their experience with this vendor. Iowa DOT staff also agreed to share their final RFP and business requirements documents with the project team, which will be valued resources as ITD prepares to replace or rewrite OTIS.

The project team met with the following Iowa DOT staff on August 11, 2022:

- **Deanna Maifield**, Project Management Office - Deanna.Maifield@iowadot.us

- **Matthew Chambers**, Program Management – Matthew.Chambers@iowadot.us

System Description

System Name	Developer/Vendor	Year Implemented	Connection to FHWA's FMIS	Internal Interfaces
Transportation Program Management System (TPMS)	In-house, web-based system developed by the Iowa County Engineers Association Service Bureau	2004; last updated in 2019	TPMS does not interface to FMIS. Masterworks does for authorization and the comment below applies to that MW/FMIS interface Yes, however the staff person responsible for the FMIS data entry prefers to do it manually so does not take advantage of this functionality.	Masterworks (There are likely others not captured during the meeting.)

Notable Features, Functions, and Observations

Most of the bullets below focus on the Iowa DOT's experience transitioning to and using the Masterworks software system, as this was the main element of Iowa DOT's approach that is of direct relevance to ITD.

TPMS – User Satisfaction

- Local agencies are very happy with TPMS. It has the features and functions that they need because they were involved in the stakeholder engagement process. Iowa DOT does not see a clear benefit to transitioning to a new STIP management system yet; it is not worth disrupting heavy staff workload to transition to a new software system just for the sake of change.

- Iowa DOT likes their system because it also incorporates the state's transit programming and locally sponsored project development.

- Overall, staff reported that the system works well and provides access for multiple categories of users, including DOT staff, MPOs, Regional Planning Affiliations (RPAs), and project sponsors and their consultants. Easy access to the system is also important to ITD's partnerships with COMPASS, LHTAC, ACHD, and other groups.

Vendor Solution – Overview

- Iowa DOT's IT department had a team of five developers supporting many functions including TIP production. The department required the DOT to go to a vendor product because of the potential staff savings. The IT department wouldn't need to use any internal developers to support the new system.

- The Iowa DOT created a six-year contract with Aurigo for its Masterworks platform. The DOT uses this software to prepare the Iowa TIP, replacing a separate in-house developed system.

- Although their contract does have the capability of creating the STIP, Iowa DOT does not use it for that purpose at this time because the County Engineers Association Service Bureau has a system they like. It is not a priority to replace a system that works and that the Iowa DOT would have to maintain.

- Iowa DOT has been using the Masterworks software for about one year, specifically for scheduling and estimating Iowa TIP projects. They do not use the public involvement component.

- Iowa DOT has about 1,000 Masterworks users.

- Iowa DOT's Masterworks system interfaces with TPMS, AASHTOWare, Workday Enterprise Resource Planning, and FMIS.

Vendor Solution – Procurement Process

- Iowa DOT hired a software company to write the RFP and specifications that resulted in the Masterworks procurement.

- Staff estimate that it took about two years to prepare for and develop the Masterworks system, including data migration, and another year or so to go live.

- The DOT had several responses to the RFP and conducted three interviews. The second-place company was twice as expensive as Aurigo's solution.

Vendor Solution – User Satisfaction

- Iowa DOT staff report that the transition to Masterworks has been a "struggle" and a "process," mostly due to timeliness. But they recognize that it is also very complicated, and therefore they can do a lot of things that they couldn't do before.

- Aurigo is a transportation-focused company, so they knew about processes required by the National Environmental Policy Act (NEPA) and right-of-way acquisition. Iowa DOT staff reported that Aurigo are very knowledgeable about transportation.

- Staff reported one significant bug that resulted in data loss of an in-progress 5-year program. Aurigo implemented a better back-up system in response and staff are confident that this issue won't happen again.

- Find more info about TPMS Transit

- View Iowa DOT's Bid Management Participant Guide, written by the Aurigo Training and Documentation Team

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6. Replacement System Needs and Requirements

Task Purpose

For the Replacement System Needs and Requirements task, the consultant collected and compiled a universe of 332 potential business requirements that future system users will need, regardless of the type of solution ITD selects. Business requirements are characteristics of a proposed system. Specifically, they are functions, features, and/or behaviors that the software system must be capable of so that users may efficiently and reliably complete work-related duties. They reflect the system's criteria for success.

Requirements encompassed a range of priorities from critical functions to features that would be nice to have in an ideal world. ITD requested that the requirements be compiled and organized using an internal Excel-based template specific to Requests for Proposals (RFPs) and the state's purchasing process. In addition to collecting the requirements, the consultant drafted RFP-focused directives based on the original phrasing. These specifically worded statements are already tailored for a future RFP, should ITD decide to go this route.

Within the Excel workbook, the consultant added requirements to the sheets called, "Requirement Details" and "Requirement Archive." The "Requirement Details" sheet is the overall collection of business requirements. Conversely, the consultant moved outdated, redundant, or otherwise irrelevant

requirements to the "Requirement Archive" sheet rather than deleting any original OTIS requirements. Among the 332 requirements, there is likely still some overlap and room for further refinement. Figure 19 shows a screen shot of the "Requirement Details" sheet from the business requirements workbook.

Priority	Category	Sub Category	Requirement Description	RFP Directive/Question	Source
		Budget/Planning/ Scheduling		The Transportation Investment System must track appropriation balances by code (obligations and releases).	OTIS 1.0
		Budget/Planning/ Scheduling	AS OTI I need to be able to add appropriation codes to OTIS - accommodate changing federal requirements---OTI obligates funds to specific code	The Transportation Investment System must allow authorized users to add new or update existing appropriation codes.	OTIS 1.0
		Budget/Planning/ Scheduling	Need to keep a comprehensive list of appropriation codes. Current functionality.	The Transportation Investment System must maintain a list of current and historical appropriation codes and associated information.	OTIS 1.0
		Budget/Planning/ Scheduling	Current functionality. Sometimes there is a need to have parent and child codes based on the apportionment of funds and the reporting requirements.	The Transportation Investment System must support a structure of appropriation codes that allows for parent and child (sub) relationships.	OTIS 1.0
		Budget/Planning/ Scheduling	Current functionality. Support accurate reporting.	The Transportation Investment System must display a roll-up of sub-codes based on a parent appropriation	OTIS 1.0
		Budget/Planning/ Scheduling	Scenarios: As staffers move a proposed project to a different year, ensure that the "Eligible Source of Funding" amounts are being sourced for the appropriate year.	The Transportation Investment System must ensure project funding is sourced from the appropriate year.	Core Team Matrix
		Budget/Planning/ Scheduling	Ability to support annual creation of base version of the record set and a working copy for the current year.	The Transportation Investment System must support the annual creation of a "base" version of the record set and a "working copy" of the record set to be adjusted for the current year.	Core Team Matrix
		Budget/Planning/ Scheduling	Ability to update the base version if necessary (to correct errors retroactively discovered, for example) while automatically pushing any such updates from the base version to the working copy.	The Transportation Investment System must offer the ability to update the "base" version of the record set, if necessary, and automatically push such updates from the "base" version to the "working copy."	Core Team Matrix
		Budget/Planning/ Scheduling	As a user (district or HQ) I need the ability to bank cost savings from projects to offset overruns in future projects	The Transportation Investment System must include the ability to "bank" cost savings from projects.	OTIS 1.0

Figure 19. Sample View of the Business Requirements Workbook

Sources for the TIS business requirements reflected in the workbook include the following:

- **OTIS 1.0** – Original OTIS Requirements Excel Workbook (2013)

- **Core Team Matrix** – Word document outlining the ITD's collaborative requirement identification effort; includes "critical" requirements

- **District** – Requirements derived through interviews with and email outreach to select ITD District employees

- **MPO** – Requirements derived through interviews with and email outreach to select MPO staff

- **Luma –** Requirements borrowed from a separate state software procurement effort. Luma is Idaho's Enterprise Resource Planning (ERP) system, so several of the requirements were thought to be relevant to the TIS.

- **Other ITD Staff** – Requirements derived through interviews with and email outreach to ITD staff outside the project team

- **HS** – Recommendations from the consultant

- **Iowa** – Requirements identified from Iowa DOT's collection of finalized requirements from a similar RFP effort. Because these are Iowa-specific requirements, the consultant encourages ITD to reference them primarily for wording and for high-level comparisons.

Business Requirement Categories

The requirements were organized into the 19 categories described in Table 5. The consultant grouped requirements into needs based on a dominant theme; however, many may fit into more than a single category.

Table 5. Categories of Draft Transportation Investment System Business Requirements

Requirement Category	Description
Budget/Planning/Scheduling	System features related to appropriations, project balances, funding source criteria and other information, and budgeting organized by categories such as ITD program, fiscal year, project period, and district.
Change Request	System features related to submitting, editing, approving, tracking, or otherwise modifying project data (i.e., STIP amendments).
Contractor Services	All support services offered to ITD by the system contractor, including minimum up-time for the system and cybersecurity functionalities and certifications.
Grouping	System features that allow users to group data by select criteria (e.g., key number). May also include requirements involving "tags" or methods of aggregating information by topic.
History/Versioning	System features related to project history, archiving program changes and scenarios, and preserving all historical data.
Indirect Costs	System features related to calculating, tracking, and storing indirect cost information such as rates, caps, and effective periods.
Integration	The system supports all necessary interfaces with other internal and external software systems such as FHWA's FMIS.
Notifications	System features related to mass e-mails, alerts, and other user-defined notification functionality.
Obligation	System features related to obligating and de-obligating money and tracking all such transactions by categories such as funding source, project phase, and year.
Platform	General characteristics of the system's operating environment such as hosting locations, authentication requirements, and web browser compatibility.
Project Data	System features related to entering, storing, displaying, uploading, deleting, and otherwise interacting with specified types of project information.
Project Management	Higher-level system features such as attaching files to projects, linking projects to grants or other funding sources, and associating multiple projects to a single unique identifier.
Reports	System features related to robust reporting capabilities that may include elements such as a customizable dashboard, canned reports, auto-generated and customizable reports, and printable views.

Requirement Category	Description
Scenario	System features related to creating, editing, comparing, saving, and archiving multiple program scenarios.
Search	System features related to data search capabilities and parameters.
Store And Track Funding Sources	System features related to tracking and storing funding source data at all phases of a project by dimensions such as fiscal year, calendar year, and percent complete. Also criteria of each funding source, for effective validation when synching projects with funding sources.
Training	System features providing tips, instructions, navigational information, documentation, reference libraries, glossaries, and other explanatory resources related to system use.
User Interface	System features that allow a user to interact with it. Screens may be text based and incorporate visuals such as the OTIS program matrix view. Effective use of drop-down menus vs radio buttons. Clear on-screen navigation tips for how a function works ("select as many as apply").
User Permissions	System features that control the type of functionality and access granted to users. Also, the administrative functions associated with maintaining users and their permissions.

Critical Needs

ITD compiled a list of 11 business requirements that were categorized as "critical" characteristics of the TIS. These must-have features and/or functions, shown in Table 6, are non-negotiables for the future system and should be clearly defined in an RFP.

Table 6. Future System Critical Needs

Requirement Category	RFP Directive
Contractor Services	The Transportation Investment System Contractor must offer full support on the FMIS (FHWA's Financial Management Information System) interface and work proactively with FHWA to understand all upcoming FHWA software (and policy, etc.) changes that will affect FMIS so that the state/FMIS interface is updated appropriately and timely.
History/Versioning	The Transportation Investment System must preserve and be able to report on all historical data, including from past decades. This record will be added to annually, not overwritten.
Integration	The Transportation Investment System must interface directly with FMIS, ideally in both directions. It must also support all necessary internal ITD interfaces.
Obligation	The Transportation Investment System must allow the user to obligate and de-obligate money and to view all such changes and change details (e.g., who made the change, on what date, in what amount, etc.).
Obligation	The Transportation Investment System must allow the user to view current fund balances, displayed in subtotals by categories such as "obligated," "not yet obligated," "obligated and spent," and "obligated and not yet spent."

Requirement Category	RFP Directive
Scenario	The Transportation Investment System must allow multiple users to work in a scenario at any given time and in multiple modes (e.g., view-only versus edit). Users must be able to edit and save the multiple "versions" of a scenario.
Scenario	The Transportation Investment System must allow users to make edits and save changes to a scenario without overwriting another user's work, losing access to the scenario, requiring a system reboot, causing other technical issues, or otherwise inadvertently breaking or changing another user's scenario.
Scenario	The Transportation Investment System must provide a clear and easy way to display the differences between separate versions of a given scenario (i.e., a comparison of the "before" and "after" for each affected field).
Store and Track Funding Sources	The Transportation Investment System must track project funding streams (incoming and outgoing) specific to each source and report accurate obligations, expenditures, and balances in real time.
Store and Track Funding Sources	The Transportation Investment System must diligently track money at multiple levels, including funding source, project, and payroll.
Store and Track Funding Sources	The Transportation Investment System must track funding sources for all phases of a project (e.g., pre-engineering, pre-construction, construction, etc.) in discrete "chunks," while also allowing the user to "roll up" funding information into one record.

7. Recommendations

Task Purpose

The recommendations reflect the culmination and synthesis of information gathered and recorded during the overall project effort. The goal for this task was to conduct a high-level comparison of solutions and make informed recommendations to ITD on a path forward for the TIS. This section includes the pros and cons of each potential solution, the recommended options, and a comparison of market research completed to date on third party off-the-shelf software vendors. Based on these recommendations, the consultant developed a big picture "road map" for an approximate two- to five-year future TIS implementation plan.

Transportation Investment System Solutions Comparison

- The consultant identified six options for ITD's next Transportation Investment System. These system solutions appear in the far-left column in

Table 7 and were assigned a "low," "medium," or "high" assessment relative to one another based on each of the five criteria that appear across the top. The far-right column shows the consultant's

recommendation for a given solution. The sections that follow explain the reasoning behind each solution assessment in greater detail.

Assessment criteria are defined below. Note that the list of specific items included in each category is not exhaustive or mutually exclusive. Further, some costs will be solution-specific and vary widely, and all solutions will likely require some degree of customization. The consultant did not consider the time value of money or financing options in this high-level analysis, but ITD should be prepared to think about their implications when they are deciding on a final course of action. The consultant assumes that all the options presented would meet minimum federal requirements.

- **Initial Cost** – Upfront costs associated with procuring a new software system such as initial licensing fees, third-party development fees, in-house time and labor costs, new servers or other hardware, enterprise systems integration, configuration and testing, data migration, and other costs accrued during the few years of the new system procurement.

- **Recurring Costs (aka, Total Cost of Ownership)** – Ongoing costs associated with system maintenance, support, hosting, version updates, bug fixes, staffing and labor, licensing (if applicable), maintenance of other software applications in the suite for the main product, and other tasks necessary to keep the system up and running smoothly over the long term.

- **Integration Complexity** – The anticipated level of difficulty, number of parties involved, potential for issues, and other factors contributing to the ease of which a solution may be executed. Complexity increases with higher levels of implementation effort, time, and labor demand on ITD staff and their contractors.

- **User Satisfaction –** Whether the new system is expected to be relatively easy to learn, satisfy user requirements, and be generally viewed as "making work easier" for system users. This criterion incorporates anticipated ease of transitioning to a new system for users, the complexity of the system itself, software design, and estimated system maintenance needs.

- **Viability of Support Approach** – The combination of the frequency with which system support will be required, the expected availability and quality of support, and the anticipated cost.

Table 7. Transportation Investment System Solution Decision-making Matrix

System Solution	Initial Cost	Recurring Costs	Integration Complexity	Viability of Support	User Satisfaction	Recommendation
Off-the-Shelf Software	☹ High	😐☹ Medium/High	☹ High	☺ High	😐☺ Medium/High	☺ High
External TIS Development	😐 Medium	☺ Low	😐 Medium	😐 Medium	☺ High	☺ High

System Solution	Initial Cost	Recurring Costs	Integration Complexity	Viability of Support	User Satisfaction	Recommendation
Low-Code	😐 🙁 Medium/High	😐 🙁 Medium/High	😐 Medium	😐 Medium	😐 Medium	😐 Medium
Multiple Systems*	😐 🙁 Medium/High	😐 🙁 Medium/High	🙁 High	😐 🙂 Medium/High	😐 Medium	😐 Medium
Internal TIS Development	🙂 Low	🙂 Low	😐 Medium	🙁 Low	😐 Medium	🙁 Low
OTIS Life Support	🙂 Low	😐 Medium	🙂 Low	🙁 Low	🙁 Low	🙁 Low

*Multiple systems may be feasible depending on the number and type of systems involved. Two might be workable, but the complexity would increase with the number systems integrated into the overall TIS structure.

Off-the-Shelf Solution

ITD purchases a single off-the-shelf system that will meet all business requirements and needs.

Pros
- A single piece of enterprise software is designed to handle all transportation investment activities.

- As more states use vendor-provided solutions, ITD may benefit from the knowledge-sharing, feature upgrades, and ability to gain FHWA acknowledgement that accompanies a wide user group.

- The vendor offers support in managing the software and data.

- The platform is likely to host data in the cloud, which reduces the burden on ITD's database maintenance and administration staff.

- Vendor system updates and upgrades are likely to occur on a regular basis.

- System will be up to date with modern cyber security best practices, enterprise system interface capabilities, and multiple browser functionality.

Cons
- It is unknown whether a system exists that meets all ITD transportation investment business requirements and needs.

- The initial and recurring costs will be high, but ITD is already spending money to support a contract with Experis, servers & other hardware, and other expenses.

- ITD could experience "vendor lockdown," meaning the department could be wholly dependent on the vendor to maintain the system and data.

- Porting current business data to the new system schema and layout could be a large, complicated task, depending on how tidy and consistent the existing data are.

An off-the-shelf solution would ensure that the new system is well-supported and managed. While it is unknown whether any one system exists that covers all business needs and requirements, if ITD can find that system then it would be an obvious solution. The consultant team strongly recommends this option.

External TIS Development

ITD hires an external software development or consulting firm to build a new, custom Transportation Investment System.

Pros
- A modern software development firm with appropriate resources and expertise will be able to efficiently build a custom solution that meets all OTIS user needs. Current cybersecurity standards would be met and modern software frameworks and packages could be used.

- ITD can help design a tailored system that fits most or all business requirements, rather than having to tailor their STIP and other business process to accommodate a vendor solution.

- While initial costs will be high, recurring costs can be kept low if ETS can manage the software after it has been built and deployed.

- External enterprise software systems can be integrated into the application during development.

- Flexibility in decision-making and defining exact features and functions.

Cons
- Development firms may lack sufficient understanding of the transportation industry to fully grasp and accommodate ITD requirements, processes, and culture.

- The initial software investment may be high.

- ITD will receive a custom system that may not include off-the-shelf support without a separate contract, if it is an option at all.

- There is increased risk for delay and technical issues building a bottom-up software solution.

- There is potential for the new TIS to have similar challenges around executive staff and IT buy-in as OTIS.

- There is potential for long-term dependence on developer for support, training, upgrades, etc.

- There are robust TIS products already in the marketplace; some employ former DOT and FHWA staffers. Some make design and function decisions in strong partnership with clients.

Hiring an external, technology company to design and build the TIS would help ensure that ITD business requirements and needs are met by the new system. While a custom build would have a high initial cost, recurring costs could be kept low if the system does not require routine maintenance or upgrades. The consultant team recommends this as a viable option.

Low-Code

Replace OTIS with a low-code development platform.

A low-code development platform allows developers to create drag and drop workflows within a user interface, which are turned into executable code by the platform. These platforms are supposed to reduce the level of effort for those building and maintaining applications that use the technology.

Pros
- Experis built the current vintage of OTIS, and now has a new low-code development framework. If ITD stayed with this company, they would be familiar with ITD's needs and business processes.

- ITD receives a replacement to OTIS that is theoretically easier for software developers to maintain.

- Custom functionality <u>may</u> be easier to implement, depending on the complexity of the business requirements.

Cons
- Tools like OTIS may be too complex to develop in a low-code environment.

- It is unlikely that a low-code platform could execute all required business needs without significant custom development.

- The initial investment and recurring cost structure is unknown.

Consultant Recommendation
If Experis or another company can demonstrate the feasibility of their low-code option, this could be a potential path forward. The consultant does not have enough information to make a recommendation on this option.

Multiple Systems

ITD generates multiple RFPs and secures several pieces of software to cover all transportation investment business requirements and needs. The TIS will not be a single system, but a network of

systems. ITD forgoes a one-size-fits-all approach and secures specialized software for each business requirement.

- It's possible that ITD already has some software or systems that handle transportation investment business needs that could be integrated into the TIS.

- There may potentially be cost savings if some elements of the system already exist through other software or can be developed in-house.

Cons

- Cost structure is unknown and could become difficult to manage.

- Integrating multiple systems will be challenging, especially with ETS downsizing.

- User workflows could become challenging or confusing if users must interact with multiple pieces of software.

- Software updates and bugs could have ripple effects across the TIS.

- Writing multiple RFPs, securing multiple pieces of software from various vendors, and integrating those platforms into a cohesive system will be a long, technical, and costly process.

- This solution will require significant in-house expertise.

- The consultant found that similar systems at other DOTs are often clunky.

Consultant Recommendation

Depending on the number and type of system(s) involved, this option may be far too complicated and costly to be worthwhile. The consultant team does not recommend this option unless the number of combined systems is minimal, the integration is straight forward, and there's not a single system in the marketplace that would suffice.

Internal TIS Development

ETS software developers and ITD subject matter experts design and build a new, custom Transportation Investment System in-house.

Pros

- Initial and recurring costs are kept relatively low.

- Rapid development may be possible since information and business requirements will not need to be transferred to external parties.

- There is a precedence for in-house development with OTIS; ITD can apply lessons learned.

- ITD can design a system that fits all business requirements.

- People designing the system (i.e., ITD) may have a more thorough understanding of needs, context, requirements, and workflow compared to new external parties.

Cons

- Staff resources will be constrained due to ETS downsizing.

- It is uncertain whether ETS currently has the development skillset and staff to build the application properly. As mentioned elsewhere, turnover of IT staff at state agencies is a chronic issue.

- There may be a huge opportunity cost for ETS, FP&A, and other staff assigned to this project. Work on this project will interfere with other tasks and priorities.

Consultant Recommendation

The consultant team does not believe that ETS has the appropriate / sufficient software development staff to build the transportation investment system in-house. Additionally, with the consolidation of IT professionals across state agencies and the corresponding drawdown of IT staff within ETS, supporting a piece of software developed in-house would be difficult. The consultant team does not recommend this option.

OTIS Life Support

ITD continues to use the current vintage of OTIS in perpetuity. No plans are made to replace or modify the software. Continuing current operations is the only focus.

Pros

- Internal application support by ETS and FP&A will keep costs down and knowledge in-house.

- User workflows will remain unchanged, which will eliminate the burden of learning a new system for ITD employees.

- Current documentation and training are solid.

Cons

- OTIS does not work with most modern web browsers; Internet Explorer is the only browser guaranteed to be compatible with OTIS.

- Several pieces of the foundational platform are out of support and would need to be significantly updated or replaced. Due to the number of pieces, this would be quite challenging.

- Major application upgrades, bug fixes, and support will be difficult, if not impossible, due to ETS downsizing.

- Current issues and bugs will remain or be difficult, slow, and costly to resolve.

- Other ITD software systems (e.g., Advantage) will be upgraded, modernized, or replaced while OTIS stays static. Data interfaces with these systems will be affected with these changes.

- Cyber security standards will become more innovative and stringent. Meanwhile, in its current state, OTIS cannot be upgraded to meet these specifications.

- There is a high likelihood that OTIS will become unusable without a significant investment within the next two to five years. Cybersecurity issues and ETS's high turnover rate, future downsizing, and capacity to support OTIS are the software's most significant threats. Furthermore, other systems that OTIS relies on may change and the data interfaces will have to be updated accordingly.

- Some users have lost confidence in OTIS data; without significant improvements, it will be unlikely to recover from this loss of trust.

Consultant Recommendation

Continuing to use OTIS in perpetuity with no plans to replace or modify the system is a non-starter. The system will eventually undergo catastrophic failure and become unusable, which will have ripple effects across ITD business units. The consultant team does not recommend this option.

Off-the-Shelf Software Vendors

The project team conducted targeted online research on several of the off-the-shelf products available in the current market that may meet ITD's needs. The information gathered reflects only what is publicly available, which excludes cost information. Table 8 provides a high-level summary of these findings for seven software vendors, three of which have been discussed in other sections of this report.

Table 8. Third-party Vendor Marketplace Research to Date

Vendor	Product	Link	Interfaces with FMIS	Existing Transportation Clients	Notes
Aurigo	Masterworks Cloud	Aurigo Mastworks Link	Yes; see online Federal Aid Reimbursement product	Iowa DOT Utah DOT Nevada DOT Wisconsin DOT Oregon DOT Dallas Area Rapid Transit (DART) FHWA Ontario Ministry of Transportation Others	Expertise in/experienced with transportation sector In 2021, FHWA signed a 10-year contract with Aurigo for capital planning and management Expansive suite of products and solutions Robust GIS component Large and varied transportation agency portfolio Founded in 2003; in the space for almost 20 years
PMG	STIP Manager/ STIP Viewer	STIP Manager Link STIP Viewer Link	Yes	Massachusetts DOT Rhode Island DOT South Carolina DOT	STIP-specific software Cloud-based GIS solution (Esri) Integrates with MPO TIPs Transportation software company founded in 2006

EcoInteractive	ProjectTracker SaaS	ProjectTracker SaaS Link	Yes; offers an integrated FMIS module	Arizona DOT Nevada DOT Oklahoma DOT New Mexico DOT Various MPOs and COGs Transit Agencies	Knowledgeable about/experienced with transportation sector GIS Module Nightly synchronization updates with FMIS STIP/TIP management-specific software Founded in 2003; started with environmental agencies, then added transportation
Trimble	AgileAssets: Portfolio Analyst module	AgileAssets: Portfolio Analyst link	Unknown; offers an API for enterprise system integration	New Mexico DOT (Pavement Analyst, Maintenance Manager)	Knowledgeable about/experienced with transportation sector GIS Mapping and LRS integration features Founded in early 1990s; leader in transportation asset management software Expansive product documentation for each module ITD uses several integrated AgileAssets products Could be part of a multi-system solution vs. a standalone option.

Kahua	Capital Planning Software	Kahua Capital Planning Software link	Unknown; offers an API for customizable integrations	Pennsylvania Turnpike	Markets to Transportation Industry Dashboard view of funding source summaries Founded in 2009, introduced the first internet-based collaborative project management solution
Intellis	FOUNDATION. Plans	Intellis FOUNDATION.Plans link	Unknown; does integrate with existing enterprise software and systems	Maryland Transportation Authority Major metropolitan transit agency	Plans is one of 4 fully configurable modules Seems largely focused on data collection and asset condition data Founded in 1996 with systems for collecting and analyzing asset condition data; later introduced systems for other components of the built environment ecosystem
Finario	Finario One Capital Allocation	Finario One Capital Allocation	Unknown; offers an API for common enterprise systems (e.g., SAP and Oracle)	Watco (Private railroad company)	Seems targeted at private sector industries Experience with a variety of industry types (28) Founded in 2011; finance-focused company that specializes in capital expenditure (Capex) Offers a monthly public demo

Additional Considerations and Recommendations

- **Explore a comprehensive approach.** ITD should think about opportunities to coordinate on the software systems across multiple teams. If ITD can "go big" and think about this transition comprehensively, it should. MassDOT staff encouraged a go big approach and Utah's leadership is

also considering it. This might look like using a single third-party vendor customized to perform multiple business functions currently executed in several different systems (e.g., creating funding & obligation scenarios, tracking project expenditures and obligations, managing contracts and payments, handling federal reporting (i.e., vendors that offer an FMIS interface), and fulfilling other reporting needs using one system). This approach would require a significant agency-wide resource investment and high-level leadership direction/buy-in.

- **Assume there is no one-size-fits-all product available.** Any off-the-shelf solution that replaces OTIS will likely need to be somewhat, or even highly, customized.

- **Avoid over-reliance on a single staff person moving forward – prioritize redundancy, institutional knowledge preservation, and succession planning.** This single-point-of-failure phenomenon has surfaced at UDOT, Iowa DOT, and at ITD. Often, a Financial Analysis and Planning team is small, with little opportunity to cross-train others outside the group. ITD should make and implement a comprehensive training and knowledge sharing plan prior to the new TIS deployment. Further, a coalition of states using the same product can help create a shared deep-bench situation.

- **Consider a vendor with a robust user group.** A vendor that has a history of significant collaboration with transportation-planning clients will also assist with building deeper benches across agencies.

- **Understand vendor update processes.** Ask software vendors if they update their solution offerings based on the customizations they make for specific clients, and if the customizations they make for transportation agencies are highly unique or do they apply to other customers.

- **Thoroughly document current STIP development and management processes.** This is a critical step for adequate planning, regardless of the selected path forward.

- **Communicate with stakeholders early and often about the future system changes.** This will make for a smoother transition and improve buy-in among system users.

- **Prioritize staff needs over staff wants**. Avoid "luxury" add-ons, at least until more resources available.

- **Improve the ease of use.** This should be a high priority in the future system (e.g., less complication/convolution; more intuitiveness). A heavily complex system can have a very intuitive user interface / design.

- **Plan to keep the current OTIS system running for at least a year.** This will be required while the replacement system is in development / implementation stage(s).

- **Explore national venues (conferences, associations) in which states compare notes.** Topics of interest may include STIPs, legislation, rules, business processes, software, and relevant system solutions.

- **Identify whether the Highway Engineering Exchange Program (HEEP) might have information.** Other options may include upcoming meetings about software used at the federal, state, or local level for STIP-type financial planning work. Visit the [HEEP website](#).

- **Explore the possibility of a custom-built system developed by an external party.**

- **Ask FHWA for software recommendations with respect to integration with FMIS.**

- **Stay tuned to UDOT leadership's decision around department-wide software system adoption.** Utah is considering an agency-wide strategy to software system upgrades. UDOT staff were willing to respond to ITD inquiries about this topic.

- **Follow up with UDOT and Iowa DOT about their experience with Aurigo.** UDOT uses Aurigo for project construction and may be willing to share feedback about their experience working with the vendor.

- **Follow up with peer state DOTs about their agency structures and compare them to ITD.** Specifically, if their FP&A equivalents also execute obligations and track available state and federal funds, then the software they chose might be more appropriate for FP&A, too.

- **Cross check Iowa's RFP and Business Requirement documentation with those prepared for the ITD solicitation.**

- **Continue researching other examples of similar RFPs and best practices for RFP writing.**

Implementation Roadmap

Any solution that ITD selects will take several years to implement. The strategic road map in Figure 20 provides ITD with suggested next steps as they continue planning for an imminent transition to a system that will replace OTIS. While the high-level activities in the figure are organized linearly to simplify communication, many of them will overlap and/or occur in a different order. Finally, the roadmap assumes that ITD will pursue one of the consultant's recommended solutions.

FHWA's e-STIP guidebook, referenced in the literature review, has thorough details on implementation steps, challenges, and resources for e-STIP implementation that ITD staff may find useful no matter what type of new system replaces OTIS. [Access the FHWA guidebook.](#)

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┌─────────────────┐      ┌─────────────────┐      ┌─────────────────┐      ┌─────────────────┐
│  Assign a       │      │  Develop an     │      │                 │      │                 │
│  Transportation │      │  OTIS--> TIS    │      │  Acquire Beta   │      │  Phase Out OTIS │
│  Investment     │      │  Implementation │      │  Version of     │      │                 │
│  System Project │      │  and Change     │      │  New System     │      │                 │
│  Owner (ITD     │      │  Management     │      │                 │      │                 │
│  Staff person)  │      │  Plan           │      │                 │      │                 │
└────────┬────────┘      └────────┬────────┘      └────────┬────────┘      └────────┬────────┘
         │                        │                        │                        │
┌────────┴────────┐      ┌────────┴────────┐      ┌────────┴────────┐      ┌────────┴────────┐
│  Finalize System│      │  Select TIS     │      │  Conduct System │      │  Continue       │
│  Business and   │      │  Contractor(s)  │      │  Testing        │      │  Gradual Release│
│  User           │      │                 │      │  (Ongoing)      │      │  of New Features│
│  Requirements   │      │                 │      │                 │      │  and Functions  │
└────────┬────────┘      └────────┬────────┘      └────────┬────────┘      └────────┬────────┘
         │                        │                        │                        │
┌────────┴────────┐      ┌────────┴────────┐      ┌────────┴────────┐      ┌────────┴────────┐
│  Draft Detailed │      │  Conduct        │      │  Fix Bugs and   │      │  Conduct User   │
│  Scope(s)       │      │  Candidate      │      │  Add New        │      │  Training       │
│  and/or RFP(s)  │      │  Interviews for │      │  Features       │      │  (Ongoing)      │
│                 │      │  Contractor(s)  │      │  (Ongoing)      │      │                 │
└────────┬────────┘      └────────┬────────┘      └────────┬────────┘      └────────┬────────┘
         │                        │                        │                        │
┌────────┴────────┐      ┌────────┴────────┐      ┌────────┴────────┐      ┌────────┴────────┐
│                 │      │  Identify and   │      │                 │      │                 │
│  Publish RFP(s) │──────│  Document       │      │  Migrate Data   │──────│  Deploy TIS     │
│                 │      │  Existing STIP  │      │                 │      │                 │
│                 │      │  Workflows      │      │                 │      │                 │
└─────────────────┘      └─────────────────┘      └─────────────────┘      └─────────────────┘
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Figure 20. Suggested Transportation Investment System Implementation Roadmap

8. Conclusions

When OTIS was first created, people were wary of the new system. Since then, ITD has made substantial progress to improve the system and address problems. Namely, many of the bugs have been ironed out and there is less frequent need for tech support. Compared to last year (2021), the program update process has recently been relatively consistent and smooth. After nearly a decade of tweaks, bug fixes, and new functionality implementations, OTIS is generally well regarded within ITD and externally. The application solves a series of complicated problems and is relatively straight forward to use.

However, architecture decisions made long ago, such as designing the system using four separate components, continue to create problems within the application, including the inability to add at least one significant function. Furthermore, outdated pieces of technology that worked in concert before must be replaced, creating a rippling effect of possible system failures or loss of user functionality. The system is still considered to be too complicated and unreliable among many users. Processing times are slow, there are still instances when data doesn't save properly, and OTIS still seems to take more staff

time to support then it should. Regaining the trust and confidence of OTIS users may be difficult, and the path of least resistance may be for ITD to start from scratch with a new system.

No matter how ITD decides to move forward with the TIS, some complication is inevitable. The consultant's top recommendation is an off-the-shelf software product, especially if there is a single system that meets all or most of the ITD's business needs. Multiple systems could be a viable option, too, as long as the number of combined systems is minimal and the integration is straight forward. Any system will need to be substantially customized to achieve the functionality ITD has expressed wanting during this research project. Before making a final decision, it may also be worth exploring the feasibility of developing a fully customized system built by an external consultant or software development company.

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Appendix A. OTIS User Survey Screens

The following three figures are screenshots of the survey in the SoGoSurvey online platform.

OTIS USER EXPERIENCE PRE-INTERVIEW QUESTIONNAIRE

✳ Required Information

Thank you for agreeing to participate in the OTIS Business Analysis research! This survey is meant to collect some basic information about how you currently use OTIS in addition to some general sentiments about the software. It will also help us tailor questions specifically to your individual or small-group interview. We will not attach names to these written responses if we report results beyond the consultant team (High Street).

1. Please introduce yourself to the consultant team.

✳ Full Name

✳ Email Address

✳ 2. What is your position with ITD and what office do you work in?

Characters Remaining: 100

3. How many years have you worked at ITD?

Characters Remaining: 100

4. Please list your job functions or responsibilities that require you to work with OTIS.

[   ]

Characters Remaining: 500

5. Please tell us how you interact with OTIS data. Scroll down to view all options.

☐ Enter raw data into OTIS

☐ Extract raw data from OTIS

☐ Edit data within OTIS

☐ Approve data; move a record on to the next stage

6.
Please rate your OTIS experience with respect to the questions below, if 0 = bad/low/very hard and 5 = good/high/very easy.

	Lowest 0	1	2	3	4	Highest 5	N/A
(a) How well do you think OTIS serves its intended functions?	○	○	○	○	○	○	○
(b) How comfortable are you using OTIS?	○	○	○	○	○	○	○
(c) How confident are you in OTIS as a system that stores and manages federally required STIP information?	○	○	○	○	○	○	○
(d) How easy is OTIS to use once you are trained up on it?	○	○	○	○	○	○	○
(e) How easy was it to learn how to use OTIS?	○	○	○	○	○	○	○
(f) How would you feel about using OTIS for another five years versus going through the challenges of switching to a revised/new system?	○	○	○	○	○	○	○

7. Please tell us more about any of your responses to the questions above. Again, these written responses will remain anonymous outside of the consultant team.

[   ]

Characters Remaining: 500

Appendix B. OTIS User Survey Responses

This appendix provides the comprehensive list of survey responses about how respondents use OTIS.

- Review obligation requests (2101s) submitted by District and other personnel

- Enter change requests (1414s) submitted by Districts

- Process project obligations

- Adjust budgets and project details

- Interface between OTIS users and ETS OTIS support

- Maintain, improve, and add new OTIS reports

- Query OTIS directly for non-standard data requests

- Application technical support

- Final Voucher = Final project budget and costs reconciliation between FMIS, OTIS, and Advantage.

- Cost Accounting sets up all new programs and budget modifications in Advantage when received through OTIS on the 2101 document.

- Cost Accounting assigns new work authority numbers in OTIS and reviews budgets decreases before they are entered into FMIS.

- Review approved 2101, approve final vouchers, run 2101 and end step reports

- obligation of funds, entering environmental dates into OTIS, looking at project information

- Planning

- Obtaining information for our advantage system. Budget amounts and program coding mainly. I also close programs in OTIS to reflect Advantage

- Verify obligations and expenditures.

- Look up scope of work on programmed projects.

- Entering and approving 2101s & 1414s,

- pulling OTIS reports, changing/updating names, MPs, end dates, etc, pulling iReports to compare to OTIS, balancing and offsetting between multiple projects and funding sources

- ITIP Program funding, funding types, project obligations

- Supervise STIP process, Overall supervision of staff in the former Office of Transportation Investments (OTI)

- Completing all OTIS work relating to the Program Update, pulling reports, printing the Matrix for D2's managers

- Communicate road project impacts to the public. OTIS is a resource to gather project information including budget, mile markers, and project managers involved.

- Support business areas that use OTIS, such as FP&A. I work directly with the main dev on troubleshooting, business analysis, enhancement requests.

- Yearly Program Update to ITIP, State and Local Agreements, Preparing projects for Bidding by ITD, the ITD PSS, AASHTOWare Pre-construction, AASHTOWare Construction Estimates

- Project development, programming, and monitoring

- Monitor and obligate/deobligate all of the money on our projects

Appendix C. Interview Questions

The "universe" of interview questions is presented by topic. The consultant used this main list to tailor questions to interviewees depending on their job requirements and OTIS use.

Productivity

Productive use of OTIS is the ability to execute your job responsibilities efficiently, confidently, and without regular hiccups.

- Do you feel that OTIS makes you more or less able to do your job efficiently? Where does it help productivity and where does it slow you down or create issues for you?

- What are your business requirements related to OTIS? How well does OTIS meet these requirements and in what ways does OTIS fall short?

- Does OTIS offer enough flexibility to meet all your business requirements? For example,

  - Can you easily undo or correct errors yourself or do you have call for support?

  - Is there an appropriate/ logical place to enter the information you need to input?

  - Do you find yourself "stuck" without a clear path for how to proceed? If so, when?

- What functionality does OTIS lack that would help make you more productive?

- Does OTIS operate quickly enough to meet all your business needs?

- What roadblocks, if any, do you encounter when using the OTIS software?

- How often do you contact OTIS support and how effective are they in their responses?

- What additional software do you use, if any, to complete tasks that you believe should be completed in OTIS (i.e., do you use any workarounds, and if so, what are they and why do you use them)?

Onboarding

- As a new employee, how easy or difficult was it to learn to use OTIS?

- How would you describe your OTIS learning curve?

- Was your OTIS onboarding training adequate? Why or why not?

- After being fully trained on OTIS, how comfortable are you using the software?

Simplicity

- How would you describe OTIS usability?

- How easy/hard is it to recover from a mistake?

- How easy/hard is it to determine when another user has made a mistake?

- Would you describe OTIS as effortless and/or intuitive to use?

- Would you describe the system as unnecessarily complex? If so, in what way?

- Are you required to complete redundant processes in OTIS? If so, what are they?

Satisfaction

- In what ways is using OTIS satisfying?

- What OTIS functions work well and meet your needs?

- For what tasks do you dread using OTIS?

- Would you use OTIS for more tasks if you could? If so, for what?

Technical/Business

- What systems and software do you use to collect or manage OTIS inputs?

- What systems or software do you use to manage information that you derive from OTIS?

- What systems or software do you use in place of OTIS as a workaround and for what functionality?

- Does OTIS return consistent results?

- Do you trust the data in OTIS? Why or why not?

- How confident are you that work you complete in OTIS will be saved correctly?

- How easy/hard is the user interface to navigate?

- Are you aware of any features that have been requested be developed in OTIS but have never been implemented? If so, what are they and why haven't they been implemented?

Appendix D. MassDOT eSTIP User Interface

The following additional screenshots of MassDOT's eSTIP Manager were collected by Sharon Matthies, Idaho Transportation Department, during the meeting with Derek Shooster on July 21, 2022. The consultant acknowledges that the information in the images in this Appendix is difficult to read. The screenshots were captured during a virtual meeting and are meant to show general design and concept only.

1. Project Details Screen
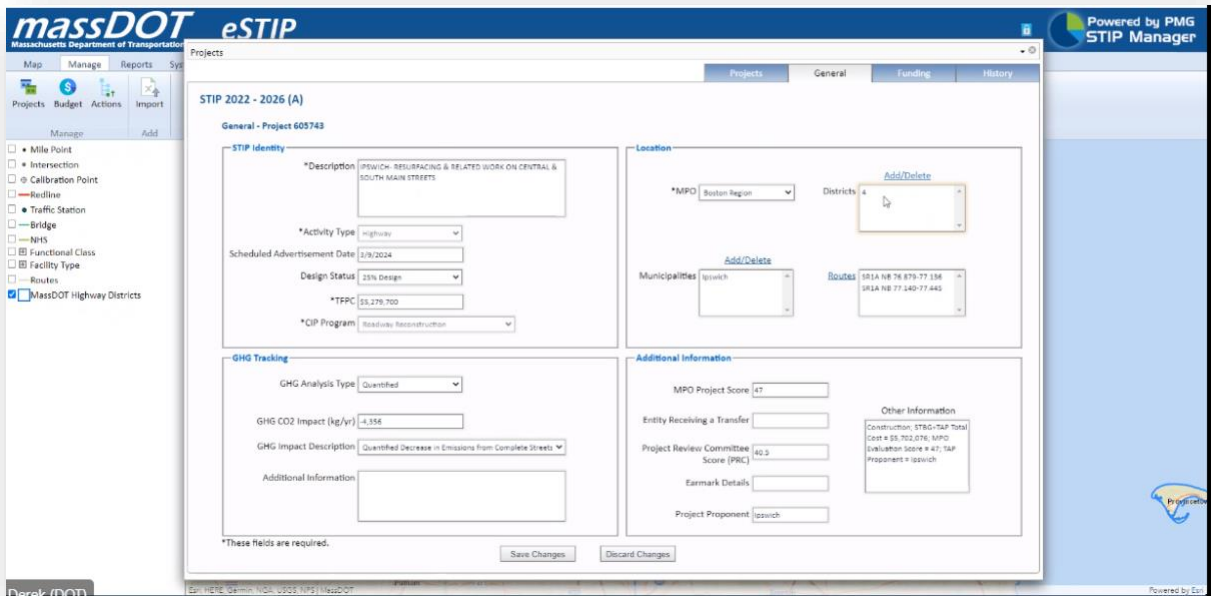
2. Route Details Pop-up Window
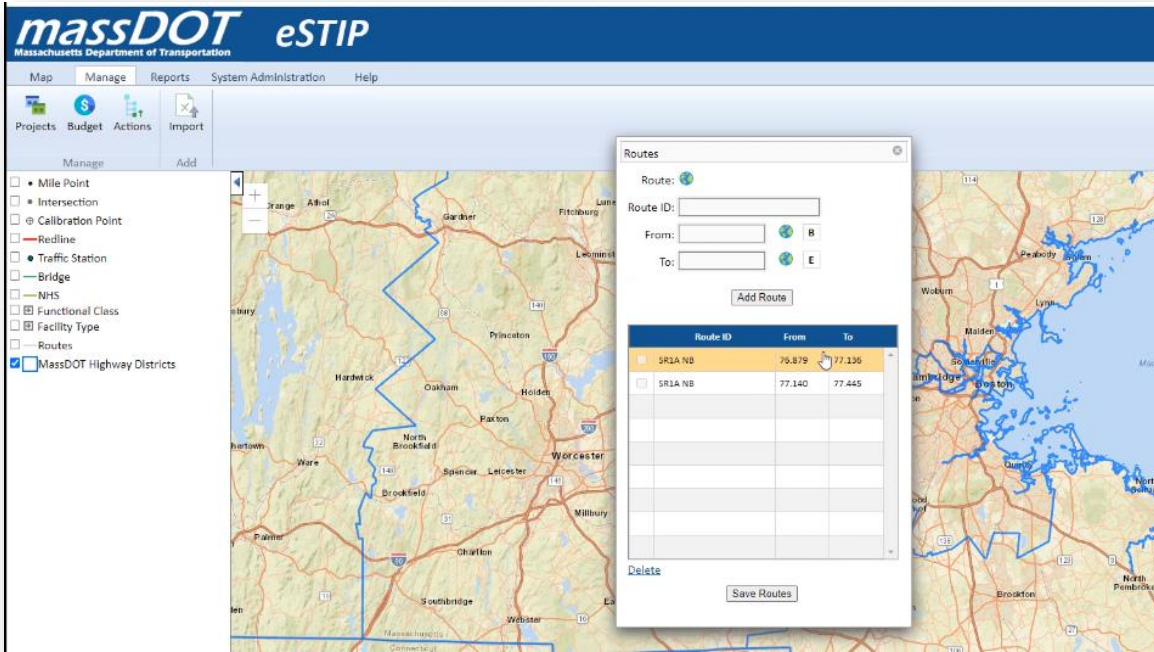
3. Drop-down menu for the Office field with external entities such as MPO, FHWA, RTA, and FTA
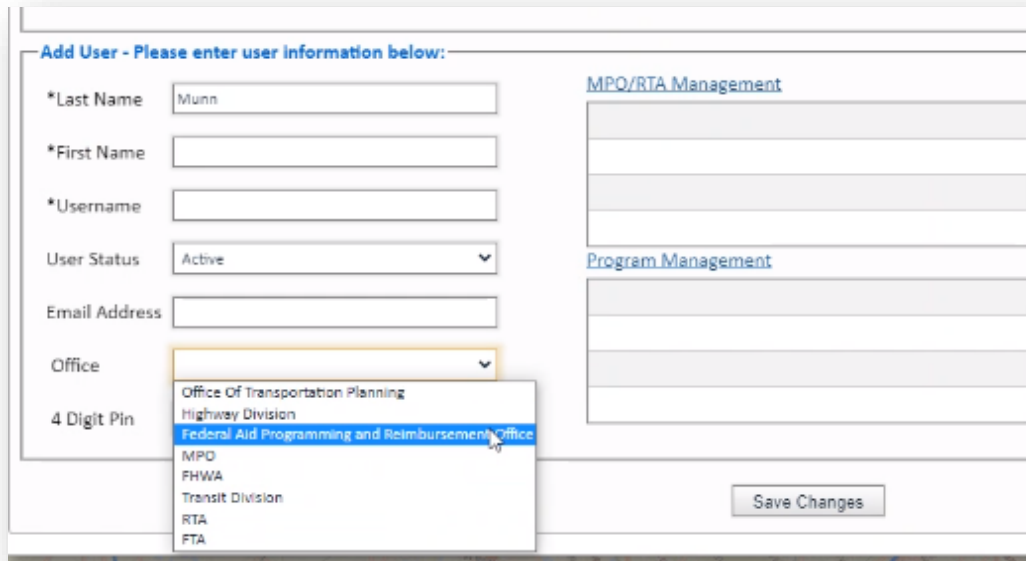
4. STIP for each date range is available as "A" (active), "D" (development), or "H" (historic)

5. Active (A) Sample

6. Development (D) Sample (Shows a dollar amount bumped out to 2025)

Program	Project ID	MPO	Description	Ad Date	AC'd	TFPC	Adjusted TFPC	2023	2024	2025	2026	2027	Amount Funded by Other Source	Balance
Regionally Prioritized														
Regional - Programs														
Bridge On-system NHS	110980	Boston Region	NEWTON- WESTON- BRIDGE REHABILITATION...	2/25/2023	☐	$21,851,750	$22,725,820			$22,725,820				$0
Roadway Reconstruction	603739	Boston Region	WRENTHAM- CONSTRUCTION OF...	1/13/2024	☐	$14,988,350	$15,587,884			$15,587,884				$0
Roadway Reconstruction	605168	Boston Region	HINGHAM- IMPROVEMENTS ON...	1/11/2025	☐	$14,441,250	$15,596,550			$15,596,550				$0
Roadway Reconstruction	605743	Boston Region	IPSWICH- RESURFACING & RELATED WORK ON...	3/9/2024	☐	$5,279,700	$5,490,888		$5,490,888					$0
Intersection Improvements	605857	Boston Region	NORWOOD- INTERSECTION...	11/9/2024	☑	$22,998,028	$24,837,870			$9,000,000	$15,837,870			$0
Intersection Improvements	606130	Boston Region	NORWOOD- INTERSECTION...	7/15/2023	☐	$7,952,280	$7,952,280	$7,952,280						$0
Roadway Reconstruction	606226	Boston Region	BOSTON- RECONSTRUCTION OF...	8/5/2023	☑	$176,570,937	$190,696,612			$32,783,959	$33,500,000	$33,500,000	$65,912,653	$25,000,000
Roadway Reconstruction	606453	Boston Region	BOSTON- IMPROVEMENTS ON...	1/27/2024	☐	$8,331,781	$8,665,052		$8,665,052					$0
Roadway Reconstruction	607244	Boston Region	WINTHROP- RECONSTRUCTION &...	4/1/2023	☐	$6,779,797	$6,779,797	$6,779,797						$0
Roadway Reconstruction	607777	Boston Region	WATERTOWN- REHABILITATION OF...	5/27/2023	☑	$27,250,087	$27,250,087	$24,409,009	$2,841,078					$0
Roadway Reconstruction	607899	Boston Region	DEDHAM- PEDESTRIAN IMPROVEMENTS ALONG...	2/11/2023	☐	$6,314,855	$6,314,855	$6,314,855						$0
Roadway Reconstruction	607981	Boston Region	SOMERVILLE- MCGRATH BOULEVARD...	10/1/2050	☑	$88,250,000	$102,370,000					$20,000,000	$82,370,000	$0
Roadway Reconstruction	608007	Boston Region	COHASSET- SCITUATE- CORRIDOR...	12/16/2023	☐	$12,028,640	$12,509,786			$12,509,786				$0
Roadway Reconstruction	608045	Boston Region	MILFORD- REHABILITATION ON...	1/24/2026	☐	$9,035,371	$10,119,616				$10,119,616			$0
Roadway Reconstruction	608051	Boston Region	WILMINGTON- RECONSTRUCTION ON...	4/5/2025	☐	$22,818,682	$24,644,177			$24,644,177				$0
Intersection Improvements	608067	Boston Region	WOBURN- INTERSECTION RECONSTRUCTION AT...	2/1/2025	☐	$1,440,000	$1,555,200			$1,555,200				$0
Multiple	608348	Boston Region	BEVERLY- RECONSTRUCTION OF...	2/11/2023	☐	$12,594,932	$12,594,932	$12,594,932						$0
Intersection			ASHLAND-											

*Only includes funds counting against obligation authority   Print

7. Historic (H) Sample

8. Fiscal Constraints Screen

9. Transit Project Screen

10. Generating a Report

11. History Tab (Reflects changes in both content and status.)

12. CMAQ Data Screen

13. View of Interstate Pavement Projects