



ODOT Advanced Traffic Management System (ATMS) **Feasibility Study**

Prepared for:



OHIO DEPARTMENT OF
TRANSPORTATION

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List of Acronyms

ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation	JDF	Joint Dispatch Facility
ATM	Active Traffic Management	LRS	Linear Referencing System
ATDM	Advanced Transportation and Demand Management	MARCS	Multi-Agency Communications System
ATMS	Advanced Traffic (or Transportation) Management System	MDSS	Maintenance Decision Support System
AV	Automated Vehicle	MMS	Multimedia Message Service
AVL	Automated Vehicle Location	MPO	Metropolitan Planning Organization
BMV	Bureau of Motor Vehicles	NextGen	Next Generation
CAD	Computer Aided Dispatch	NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
CAV	Connected and Automated Vehicle (also CV/AV)	OBU	Onboard Unit, e.g., for DSRC
CCTV	Closed Circuit Television	ODOT	Ohio Department of Transportation
CFR	Code of Federal Regulations	OHGO	Ohio's traveler information system (not an acronym)
ConOps	Concept of Operations	OSHP	Ohio State Highway Patrol
COTS	Commercial off the Shelf	OTIC	Ohio Turnpike and Infrastructure Commission
CV	Connected (or Commercial) Vehicle	RAD-IT	Regional Architecture Development for Intelligent Transportation
DAS	Department of Administrative Services	RITIS	Regional Integrated Transportation Information System
DDMS	Destination Dynamic Message Sign	RSU	Roadside Unit, e.g., for DSRC
DMS	Dynamic Message Sign	RTSMIP	Real-Time System Management Information Program
DOT	Department of Transportation	RWIS	Road Weather Information System
DPS	Department of Public Safety	SE	Systems Engineering
DSRC	Dedicated Short Range Communication	SEA	Systems Engineering Analysis
DSS	Decision Support System	SET-IT	Systems Engineering Tool for Intelligent Transportation
EMA	Emergency Management Agency	SMS	Short Message Service
EOC	Emergency Operations Center	TMC	Traffic Management Center
ESS	Environmental Sensor Station	TMDD	Traffic Management Data Dictionary
FSP	Freeway Service Patrol	TRIP	Towing and Recovery Incentive Program
GIS	Geographic Information System	TSMO	Transportation Systems Management and Operations
GPS	Global Positioning System	UAV	Unmanned Aerial Vehicle
HAR	Highway Advisory Radio	VSL	Variable Speed Limit
HSR	Hard Shoulder Running		
IDE	Integrated Development Environment		
IEEE	Institute of Electrical and Electronics Engineers		
iPeMS	Iteris Performance Measurement System		
IT	Information Technology		
ITS	Intelligent Transportation System		

1 Introduction

The Ohio Department of Transportation (ODOT) continuously strives to operate the state transportation network as safely and efficiently as possible. At the center of these ongoing efforts is the Transportation Systems Management and Operations (TSMO) Program, which encompasses the Statewide Traffic Management Center (TMC) and its Advanced Traffic Management System (ATMS). The ATMS is a collection of hardware and software, both within DOT facilities and extending into the field, that supports many different activities for managing and operating the transportation network. The physical hub of this activity is the TMC, operating around the clock and ensuring real-time monitoring and response to changing traffic conditions.

ODOT completed a comprehensive TSMO Plan in 2017 that captures the vision, mission, and seven strategic goals for TSMO in Ohio.

Vision: TSMO strategies and principles guide the efficient management of a safe and reliable transportation system that supports Ohio's economic vitality.

Mission: To provide easy movement of people and goods from place to place: Make our system work better.

Goals: Safety, Reliability, Efficiency, Access, Coordination, Integration, Security

The TSMO Plan lays out objectives, actions, and measures for moving ODOT toward these goals, and the TMC is envisioned as the central hub for operating and coordinating many of the recommended initiatives. This makes the ATMS essential for TMC operations and related TSMO activity, but existing limitations restrict ODOT from moving forward with the mission to *make our system work better*.

The existing ATMS consists of various components, largely referred to as BuckeyeTraffic, which has evolved over many years and has until recently adequately sustained TMC operations. Other in-house systems, vendor software, and communications components supplement BuckeyeTraffic. BuckeyeTraffic went live November 8, 2007 and was developed in-house as desktop-only support for TMC operations. This initially advanced TSMO for ODOT, and it has been an essential part of TMC operations for 12 years, but it is increasingly inflexible, lacks dedicated support, and is costly to extend or expand.

The proposed Next Generation (NextGen) ODOT Statewide ATMS will replace and consolidate a variety of standalone applications in the TMC located at the ODOT headquarters building in Columbus. The replacement of the ATMS will enable ODOT to manage existing subsystems more efficiently and accommodate emerging and new technologies. The ATMS will support a set of services in coordination with other systems within and bordering Ohio to address traffic management, emergency response, construction and maintenance coordination, traveler information, transportation security, traffic safety, and cooperative automated transportation.

The timeline for the initial steps of the ATMS project is shown in **Figure 1**. This document in part captures the efforts in the first row of the diagram, through much of 2018.

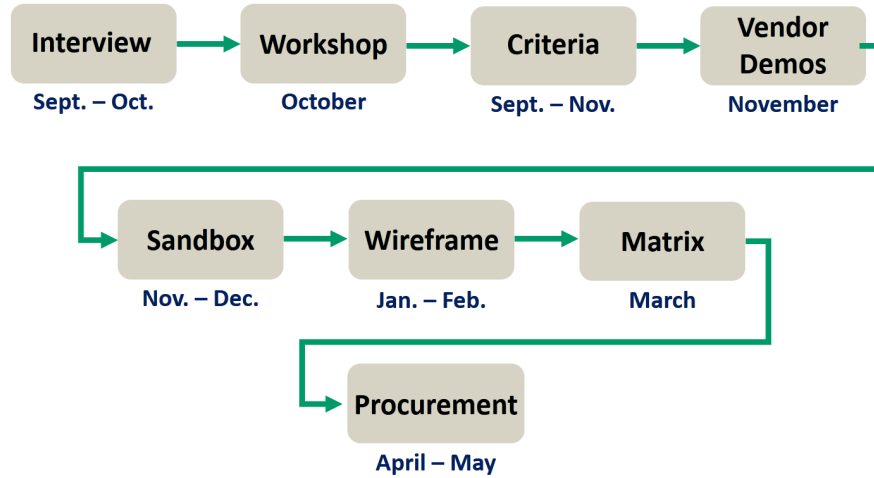


Figure 1. ATMS Project Timeline (2018-2019)

Through this project, ODOT is evaluating alternative solutions for the ATMS, with stated objectives to move to a more **centralized and comprehensive ATMS solution** that consolidates the services and functions of the current collection of components to the extent feasible. Many options are readily available, including several robust commercial offerings.

The phase of the project that this document captures is referred to as the Feasibility Study and Concept Exploration, which is an early part of the systems engineering (SE) development process, depicted as the V diagram in Figure 2.

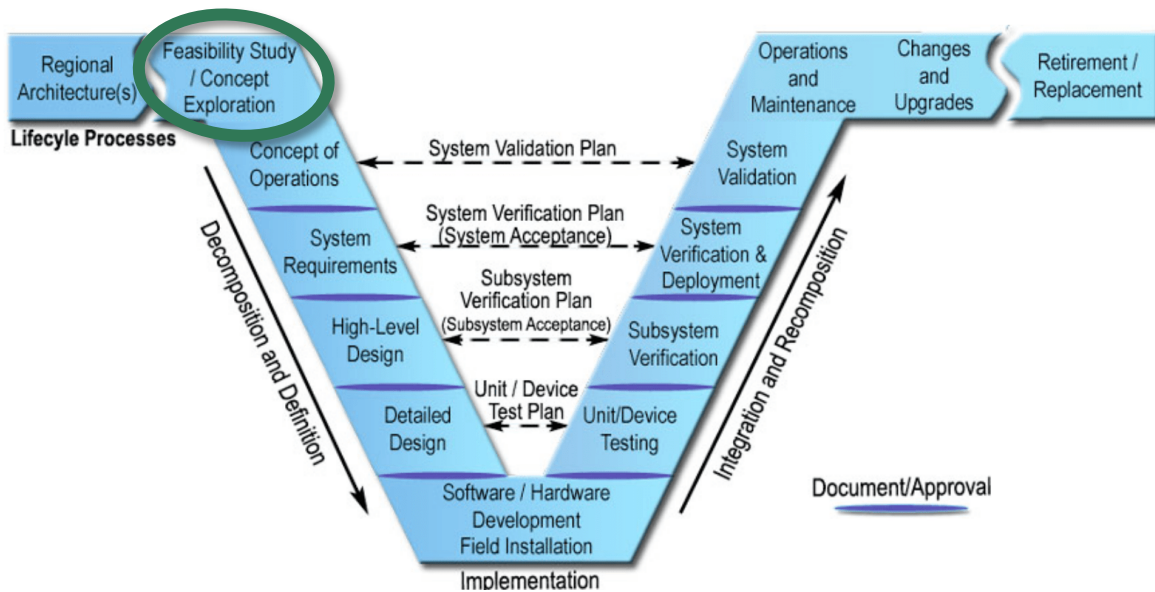


Figure 2. Systems Engineering Development Process

Preceding this phase is the Regional Architecture, which forms the basis of the development process, identifies existing system elements and stakeholders, and outlines the overall ATMS scope. The Architecture captures essential functions and services for the ATMS and the

connections among system elements and stakeholders. This is documented in the ATMS Project Architecture Report.

The Feasibility phase builds the case for alternative ATMS concepts (not specific products), explores viability of the overall concept, and helps gather stakeholder input. The subsequent phase includes the Concept of Operations (ConOps), wherein user needs are refined, and more specific objectives and constraints are defined. The ConOps has a more explicit link to the architecture than does the Feasibility Study.

The Feasibility Study is organized into five sections.

1. This introduction section.
2. Overview – builds on the introduction, captures the handoff from the Regional Architecture, provides a synopsis of the ATMS, lists and briefly describes various stakeholders, and notes key resources and references.
3. System Needs – documents the needs laid out so far and efforts to capture and understand stakeholder needs; these are organized into high level evaluation criteria, constraints, and expectations for evaluating alternative concepts.
4. Needs Validation – this section centers on a robust evaluation of alternative solutions – including the do-nothing and enhance-existing options – and commercial offerings for Ohio’s ATMS, evaluated at an initial high level across the criteria defined in the previous section.
5. Candidate Comparisons – the document concludes with narrative about the alternative concepts and the overall viability and business case for the recommended alternative, to be advanced in the ConOps.

2 Overview

The project goal is to replace the current BuckeyeTraffic and associated components and expand on the functionality via a centralized and comprehensive ATMS that can adapt to emerging technology and growing demands.

The current core BuckeyeTraffic includes system interfaces to intelligent transportation systems (ITS) field equipment, operator interfaces to traffic speeds, dynamic message signs (DMS) (e.g., Daktronics products), and even speed alerts, but there are several other activities TMC operators must regularly attend to, including:

- Email
- SharePoint repository for TMC information
- Milestone for camera control and monitoring
- OHGO traveler information
- Google Maps and Waze for ad hoc crowdsourced information
- Current Exit Guide
- SafetyTrack to monitor freeway service patrol vehicles
- Centrac to control traffic signals
- Multi-Agency Communications System (MARCS)
- Variable speed limit (VSL) system in the Cleveland region
- Radio log
- Manually checking ODOT construction projects
- Destape for determining location on state roads

This does not constitute a complete list; for a complete system inventory, see the ITS Project Architecture Report, which includes a list of services and context diagrams. The ConOps will contain a complete catalog of existing components as well.

Business Case

The TMC is responsible for 24/7 transportation operations and response, staffing and training, communications and protocols, system uptime and security, interagency coordination, contingency planning, and resource management. ODOT's TSMO Plan addresses all these facets of the TMC. The focus of this project is to ultimately define a path forward to modernize the existing ATMS, which is the critical enabler of much of the TMC activity. As mentioned in the introduction, the existing BuckeyeTraffic is restricting further TSMO initiatives and improvements to TMC operations. While possible to invest more in BuckeyeTraffic, there are other more effective concepts to consider in support of TMC needs and ODOT's expectations. An excerpt from the TSMO Plan captures the high expectations the ATMS must support:

“The TMC is the command and operational control center for TSMO strategies. Its goal will be to provide reliable network mobility to Ohio's transportation system users. It will utilize the latest technology for surveillance and monitoring of the transportation system and be capable of real-time transportation demand management. The TMC will monitor,

manage, and react to the real-time needs of the transportation system. It will lead ODOT's traffic incident management program to facilitate incident clearance and restoration of traffic flows, monitor the performance of various systems across the state, and provide real-time adjustments to maintain reliability of the transportation network.

The TMC is also expected to continue to grow as new TSMO functions are brought on line such as hard shoulder running, variable speed limits, ramp meters, advanced traffic signal systems management, truck parking information systems, and CV/AV. With each step in its growth, resources will be needed in the form of equipment, software, and personnel."

These are significant expectations that rely on a high quality, cost effective, stable, and versatile ATMS. The existing BuckeyeTraffic has served ODOT since 2007, but its viability continues to wane. The current lack of flexibility makes incorporating new features or adding new ITS devices intractable, e.g., variable speed limit (VSL) control must rely on a separate vendor, and there has been substantial difficulty with integration into ODOT operations and ensuring safe fallbacks during instances of VSL malfunction. The lack of a spatial component is a hindrance, which is increasingly important for working with naturally spatial transportation data. There is also limited ability to track, process, and utilize performance measures as part of improved business strategy and accountability, which needs to extend to work zones, incident management (especially better tracking of clearance times and secondary crashes), travel reliability, and adverse weather operations. ATMS-enabled data connected with crash reports could facilitate better after-action reporting and performance improvement.

The ATMS project seeks a solution that centralizes, streamlines, and automates TMC activities and functions to the maximum extent feasible, to improve response time and effectiveness in reacting to traffic delays, minimizing their impacts, and restoring capacity and mobility. Just as BuckeyeTraffic served for over 10 years, ODOT seeks a new ATMS to enable advances in TSMO for at least the next 10 years.

ODOT's TSMO Program development plan has five prongs: data, programming, policy, organization, and systems, the last of which includes a new ATMS. Goals include network preservation and efficiency. Moving toward better network preservation involves deliberate planning for complex, multi-year or phased enabling efforts, of which a new ATMS is a prime example. In support of efficiency, a program objective is to expand TMC management capabilities, but doing so is beyond the capability of the existing BuckeyeTraffic.

Expanding TSMO field applications will enable ODOT and partners to pursue more advanced TSMO strategies, such as integrated corridor management (ICM) or hard shoulder running (HSR). The TSMO Plan emphasizes advanced transportation and demand management (ATDM), of which HSR is a key example, but if HSR is to be efficiently operated via the TMC as recommended, a new ATMS is best suited to enable that. Regarding the goal of improved coordination, highway and arterial operations involving different jurisdictions can be aided with new ATMS functionality. A new ATMS will underpin these advances and help broaden the reach of the TMC throughout the state.

BuckeyeTraffic has not been able to keep up with the increasing emphasis on data-driven decisions. This includes evolving practices in performance management as well as more technical and real-time decision support systems (DSS). The TSMO Plan recommends DSS development, citing the following benefits (Policy Action ST8):

- The TMC can harness DSS information in real-time to enhance work flow and improve decision-making.
- DSS will help ODOT transition from a reactive to a proactive approach.
- Data-driven decisions lead to more effective use of resources.
- Enhanced situational awareness for TMC operators and field crews.

Empowering operators to leverage real-time DSS information will benefit safety and mobility. However, the strategy action for building TMC DSS cannot occur with BuckeyeTraffic and requires the NextGen ATMS to be in place.

Many disruptive technologies and new operational strategies are already upon transportation agencies, and ODOT is not alone in grappling with how to adjust. Coordinated transportation, connected vehicles, automated (autonomous, self-driving, driverless) vehicles, artificial intelligence, ever-expanding data, shared mobility, faster mobile networks, etc. – some call this part of the 4th Industrial Revolution, and it potentially offers significant benefits. Yet these things stress and break old ways of doing business – as well as introducing new challenges with policy, privacy, and cybersecurity – and the current BuckeyeTraffic is not positioned to accommodate these changes.

Stakeholders

Stakeholders with a role in ODOT ATMS are listed and described in this section. The extent of roles, responsibilities, and needs vary substantially. The Architecture and ConOps include additional detail on the roles and responsibilities of each stakeholder.

- ODOT – In the Statewide ITS Architecture, ODOT is a single unified stakeholder, including all offices, 12 districts, and tied to dozens of architecture elements. Select ODOT units are noted here:
 - Traffic Management
 - Traffic Operations
 - Maintenance Operations
 - Office of Permits
 - Work Zone Management
 - Division of Information Technology
 - District Traffic Staff
 - Communications
- Ohio Turnpike and Infrastructure Commission (OTIC) – Separate organization from ODOT, operates 241 miles of toll road along I-80 and I-90.

- DriveOhio – Ohio’s center of smart mobility efforts, bringing together various public and private stakeholders involved in advanced mobility solutions such as connected vehicle applications.
- Department of Public Safety (DPS):
 - Ohio State Highway Patrol (OSHP) – State law enforcement, potential computer aided dispatch connections.
 - Bureau of Motor Vehicles (BMV) – Part of the Department of Public Safety (DPS).
 - Ohio Emergency Management Agency – Including the Ohio Statewide Emergency Operations Center (EOC) / Joint Dispatch Facility (JDF) at the Highway Patrol Dispatch Center in Columbus.
- Department of Administrative Services (DAS) – IT policy and provision, administers MARCS.
- Smart Columbus – organized within the City of Columbus and orchestrates various efforts related to the federal Smart City Challenge award.
- US 33 Smart Corridor – Including the NW 33 Council of Governments, comprising Dublin, Marysville, Union County, and the Marysville-Union County Port Authority, responsible for overseeing and managing development along the US 33 corridor.
- CAV SEA Consultant – With DriveOhio, AECOM is the consultant leading the connected and automated vehicle (CAV) systems engineering analysis (SEA) effort.
- Metropolitan Planning Organizations (MPOs), Cities, or Counties – these may also include transit authorities and operators, public works departments, public safety agencies, emergency management agencies, and emergency operations centers (EOCs).
- Emergency Responders – any personnel and equipment involved in traffic incident management or emergency management.
- Traveling Public – including those in cars, trucks, transit, non-motorized modes, and general public.
- Private Companies – A broad category capturing those providing services to DOT and transportation system users, services involved with the Towing and Recovery Incentive Program (TRIP), and others.
- Intermodal Facilities – Includes port, rail, and air facility operators.
- Public Utilities Commission of Ohio (PUCO) – regulates utilities, rail companies, and trucking companies.
- Universities and Colleges – specifically the units that provide transportation infrastructure or services.
- Neighboring States – particularly the transportation agencies in Michigan, Indiana, Kentucky, West Virginia, and Pennsylvania.

Supporting and Background References

A variety of resources and background information feed into the SE development process.

- Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT), local.iteris.com/arc-it (continually updated)
- Ohio Department of Transportation Statewide Traffic Management Center Concept of Operations, March 2017
- Ohio Department of Transportation Traffic Management Center Operations Manual, December 2011
- Ohio Regional Architectures, www.consystem.com/ohio, December 2016
- Ohio Statewide ITS Architecture (obtained directly)
- Ohio Transportation Systems Management & Operations Plan, May 2017, updated December 2017
- Systems Engineering for Intelligent Transportation Systems, FHWA, January 2007
- Systems Engineering Guidebook for ITS v3, FHWA and Caltrans, November 2009
- The ITS Architecture for the current ATMS project, developed with stakeholder input and the supporting tools Regional Architecture Development for Intelligent Transportation (RAD-IT) and Systems Engineering Tool for Intelligent Transportation (SET-IT), November 2018, and the ATMS Project Architecture Report, December 2018.
- The project team has also reviewed a collection of internal notes, procedures, and working documents related to BuckeyeTraffic

3 System Needs

Stakeholder and user needs for the new ATMS are based on stated goals, objectives, stakeholder input, and technical understanding. The needs are also subject to constraints such as agency policies, the information technology (IT) environment, available contract mechanisms, and resources. As needs are gathered and understood, they are documented, assessed, and prioritized. With the ITS Architecture and the identified needs together, alternative concepts can then be evaluated.

Needs Elicitation

Stakeholder needs were compiled through various means. These include ongoing discussions and meetings with management and staff from ODOT and other stakeholders, and document review such as the 2017 TMC ConOps. The TMC goals and objectives previously laid out in the TMC ConOps relate closely to the ATMS, so those are repeated here for reference in **Table 1**. Most TMC Objectives can be technically addressed directly by the new ATMS. Note that Objective 1.6 is to address staffing, and a goal of the new ATMS is to help alleviate staff burden through streamlining processes and implementing supportive automation.

Table 1. TMC Goals and Objectives (2017 TMC ConOps)

Goal #1 - Improve TMC Operations	
Objective 1.1	To upgrade the TMC computer systems with state-of-the-art technology
Objective 1.2	To upgrade the TMC system control software to improve TMC operational capability
Objective 1.3	To develop a multifunctional TMC control center to effectively control traffic signals and ITS devices and facilitate traffic information exchange and traveler information
Objective 1.4	To develop a system that allows for remote access and control of signal system and ITS devices
Objective 1.5	To improve system capability in data collection and archiving and provide available information for system performance measurements and monitoring
Objective 1.6	To increase staffing levels to meet project goals
Goal #2 - Improve TMC Scalability	
Objective 2.1	To deploy a system with an open architecture for future expansion and upgrades
Objective 2.2	To adopt national standards as appropriate for future expansion and upgrades
Goal #3 - Improve TMC Interoperability	
Objective 3.1	To improve system integration, coordination, and information exchange with partnering agencies
Goal #4 - Improve Traffic Mobility and Reliability	
Objective 4.1	To effectively implement traffic responsive strategies

Several one-on-one interviews occurred with ODOT staff from August through the end of 2018. In addition to core ATMS functionality, TMC supervisors identified their top needs as decision

support systems (DSS), automation for signs and incident logging, and the integration of BuckeyeTraffic with other programs (e.g., Milestone Systems for video management). Users expressed frustration with the inability of BuckeyeTraffic to become more integrated with new technologies. Others would like a more user-friendly interface, a central hub for information sharing, simplified traffic/maintenance data to share with the public, and an integrated Playbook that can easily be updated for managing detours during significant events.

On August 29, 2018, multiple one-on-one staff interviews were conducted at ODOT's TMC. Five operators were interviewed about day-to-day operations, programs and applications used, and improvements that could streamline their work tasks. Operators voiced an interest in streamlining and consolidation, functionality to auto-populate fields in BuckeyeTraffic, a better consolidated user interface or heads up dashboard, and better notification systems for lane closures.

Gannett Fleming staff observed the TMC during the morning traffic peak around 7:30 a.m. Thursday, August 30, 2018. The operators during this shift are typically the most experienced in TMC operations, policy, and processes. The main programs and systems that were used included BuckeyeTraffic, Milestone, SharePoint, SafetyTrack, maps (Google/Bing), and Twitter. In total, a list of 17 software applications was compiled based on conversations with operators and a supervisor, as well as observation. BuckeyeTraffic and its associated components appear to lack integration and ease of switching between tasks that is now common in contemporary ATMS alternatives.

Three ODOT staff members were interviewed October 5, 2018 to evaluate what they and their staff would require from a future ATMS. These staff members were involved with ITS maintenance, permitting for oversized vehicles and loads, and equipment management and winter maintenance. During these interviews, it was observed that ODOT has released an RFP for a custom Oversized/Overweight (OS/OW) software. A replacement Enterprise Information Management System (EIMS) is also going to be purchased or built. Ability to integrate these with BuckeyeTraffic is uncertain.

Integration was an identified need: integration of data flows from roadside devices into the ATMS, as well as a dashboard that integrates with network monitoring. BuckeyeTraffic is currently used for basic winter road weather reporting. The need was also expressed for GPS automated vehicle location (AVL) for Freeway Service Patrol and maintenance trucks, since not all trucks currently have AVL. BuckeyeTraffic does not have a native spatial component to it. A new ATMS has the potential to make video sharing to third parties (i.e., news media stations and the public) easier for TMC and ITS staff members. Some users said collecting data that is not used to make decisions seems counterproductive. Additional programs were mentioned during these interviews, including Wavetronix (VSL/advance warning), Probase Data (speed tracking/travel time estimates), and other ad hoc tools.

Additional interviews were conducted October 16, 2018 with representatives from the Ohio Turnpike and ODOT's Transportation Information Mapping System (TIMS). The opinion was shared that Turnpike operations, and any agency needing to coordinate with ODOT, could be

improved by the integration of custom congestion alerts into their system; due to cars queuing at toll booths, congestion alerts are generated too frequently. Ideally, data would be more readily available from manufacturers and contractors, so the turnpike could use it to improve safety. TIMS utilizes Midwestern Software Solutions (MS2), which processes traffic data and is integrated with ODOT's system, and Miovision to process video data. TIMS currently does not pull information from BuckeyeTraffic.

An ITS Architecture working meeting was held on site at ODOT October 23, 2018. About 15 people participated in a thorough review of the Architecture, services, system elements, and stakeholder roles. This meeting generated a great deal of feedback that refined the team's understanding of stakeholder needs, revised priorities for the services identified, and adjusted and tailored the detailed elements and interfaces.

A workshop was held October 24, 2018, focusing on the ATMS project architecture. This was organized around the approximately 50 service packages identified during the architecture phase. The service packages are organized into three "blocks" where Block 1 includes packages addressing existing TMC and ATMS services and functions, Block 2 expands the capabilities of the ATMS, and Block 3 includes more advanced and/or future capabilities. These are detailed in the Project Architecture Report and will be carried through the ConOps and requirements.

A much broader and well-attended workshop for the ATMS was held October 25, 2018 to review all stakeholder needs and priorities. **Figure 3** summarizes the components involved in the ATMS. These components were discussed and vetted for accuracy, and they will be addressed further in the next phases of the Systems Engineering Development Process. The workshop allowed time to discuss IT and cybersecurity needs and concerns, e.g., hosting alternatives, monitoring, fallback, and user authentication. The broader stakeholder group had the opportunity to review the "buckets" that are explained in the next section of this document. Sufficient time was allowed for discussion, and group consensus was gained on the 13 buckets and the need to consider so many dimensions for such a complex system. There was tacit consensus that the existing BuckeyeTraffic should be replaced by a contemporary ATMS solution.

During the second week of November 2018, approximately 20 stakeholders participated in ATMS vendor demonstrations. Ten different vendors demonstrated their ATMS products in November, with one additional vendor demonstrating during the first week of December 2018. With the do-nothing option of continuing with BuckeyeTraffic as is, plus the option of investing further in the current BuckeyeTraffic in hopes of sufficient improvement, there are at least 13 different alternatives to choose from. Generally, these can be divided into three concepts: existing and improved BuckeyeTraffic, open-source or hybrid options, or fuller featured commercial products maintained by vendors. The stakeholders gained familiarity with product options during these demonstrations and throughout the process. In subsequent meetings, ODOT's needs were further discussed, refined, and prioritized. More on this needs refinement will be documented in the ConOps.

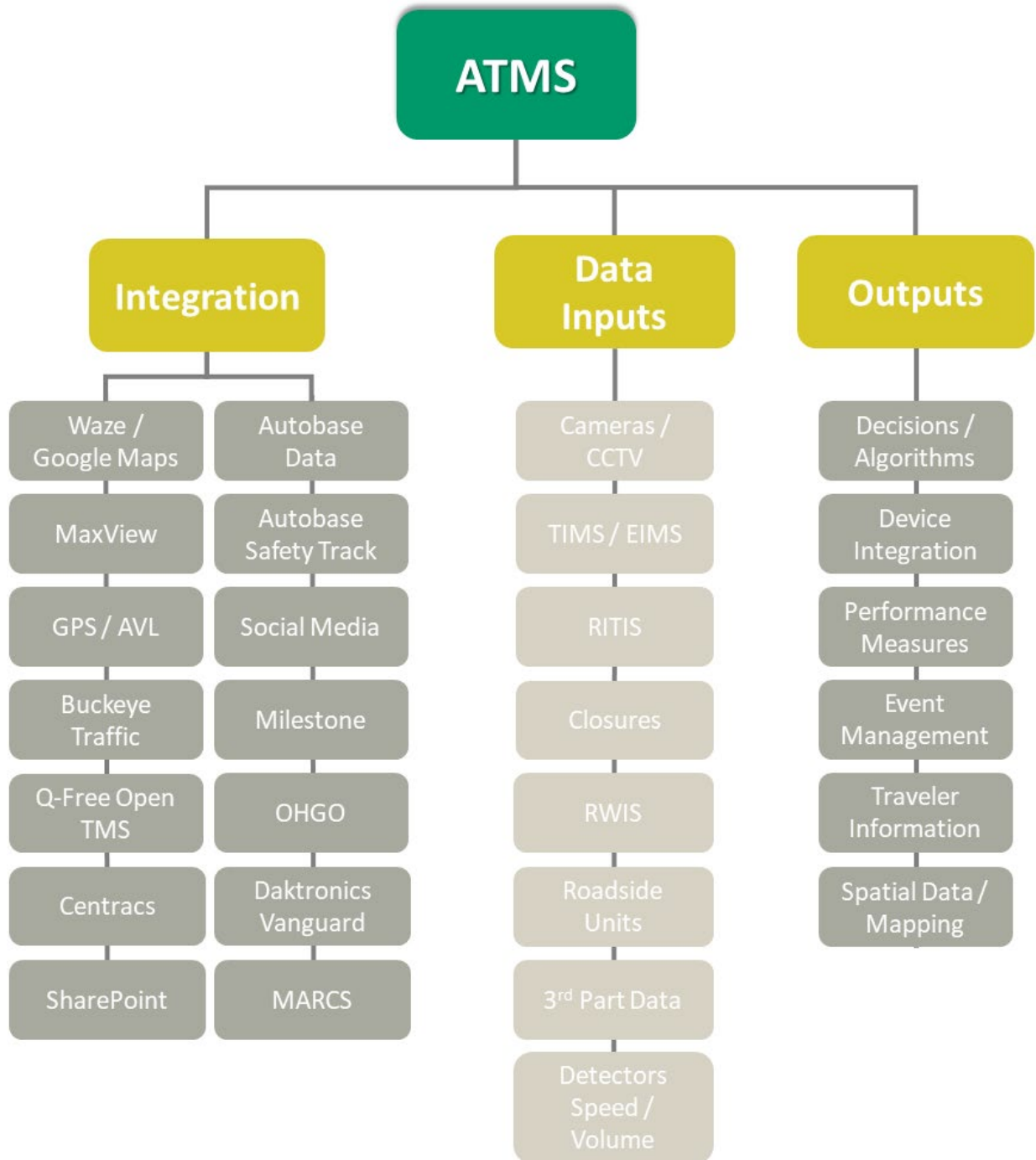


Figure 3. ATMS Components Overview

Needs Evaluation

Stakeholder needs are the basis for evaluating the various alternatives available for improving or replacing BuckeyeTraffic with a new ATMS. The analysis that follows compares needs across several evaluation criteria. Given that this is more than just an in-kind ATMS replacement project, the analysis focuses on the competing solutions' ability to meet stakeholder needs across several dimensions, balancing resources, costs, capacities, and constraints. For carrying through the systems engineering development process, the evaluation criteria are organized into 13 criteria "buckets" as follows.

1. Cost

- Approximate cost range
- Account for ODOT staff resources
- Engineering, integration, and verification
- Ongoing hosting, operations, and maintenance
- Extensibility, modifications, and enhancements

2. Business Model

- Full service, turnkey, commercial off the shelf (COTS), open-source with integrator, others
- Implementation approach, requirements, traceability, acceptance testing
- On-site support, remote support, and training
- Service level agreement
- Documentation
- Architecture enabling hierarchy of users (statewide, interagency, district, local)
- Hosting platform, on-premise, database, server / client, cloud
- Software and source code ownership, licensing, software as a service, escrow

3. Security

- Compatibility with Ohio IT rules and policies
- System security and resiliency
- Uptime, redundancy, continuity of operations
- System and failure monitoring, logging, and notification

4. Device Integration

- Existing, legacy, and authorized products
 - Traffic Authorized Products (TAP), e.g., dynamic message signs (DMS), portable changeable message signs (PCMS), destination dynamic message sign (DDMS), highway advisory radio (HAR), variable speed limit (VSL) signs, road weather

information system (RWIS) and its environmental sensor stations (ESS), ramp meters, controllers (MaxView), closed circuit television (CCTV) cameras, lane control signs, flashers and beacons, and SmartLane technology

- Integrate with standard interfaces and protocols (some legacy equipment may be optional)
- Emerging and future products, e.g., tolling, RSUs, AVL for freeway service patrol (FSP), maintenance vehicles, truck weight monitors, truck parking monitoring and signage, infrastructure monitoring, etc.
- Architecture and configuration management
- Compatibility and middleware configuration
- Communications and control

5. Network Communications

- Standards and Protocols
 - NTCIP, SNMP
 - TMDD
 - Object definitions
- Communications and switch hardware
- Video multi-level switching and user priority
- Notifications
 - Email and SMS
 - Multi-Agency Communications System (MARCS)

6. Data Interfaces

- Detector data
- Weather – atmospheric and surface
- Incidents, Highway Patrol CAD integration
- Work zones, lane closures, monitoring
- Lane closure approval system
- Truck parking information monitoring system
- Interface with asset management, device maintenance, and ticketing
- External data interfaces, e.g., GPS-based probe data, Smart Columbus

7. User Interface

- Ease of use
- Remote access via mobile device for select functions
- System wide mapping displays
- Video retrieval from archive
- Decision support tools

- Social media integration
- Dispatching capabilities

8. Decisions & Algorithms

- Data availability, quality, fidelity, latency, accessibility
- Active traffic management (ATM), traffic responsive or adaptive operations
- Lane control and Smart Lane project
- TSMO/ATMS decision support system (DSS)
- Maintenance decision support system (MDSS)
- Incident detection
- VSL policy, harmonization (future)
- Area wide ramp metering
- Recommended devices
- Slow traffic and queue alerts
- Sign, signal, or device groups

9. Event Management

- Incident and emergency management capability
- Scenario development
- Video archiving
- Routing support for emergency responders
- UAV support (future)
- Predetermined event plans
- Traffic incident logging

10. Spatial Data & Mapping

- ODOT linear referencing system (LRS)
- GPS/AVL integration
- Priority routes
- Heavy duty towing
- Playbook route management
- Device location management
- High definition mapping

11. Traveler Information

- Standards-based information feeds
- 23 CFR 511 (Section 1201 RTSMIP) compliance

- Interfaces with OHGO and 511
- Crowdsourcing

12. Performance Measures

- Real-time monitoring
- Archiving and retrieval tools
- Reporting, dashboard, visualization
- 3rd party data integration, e.g., RITIS, iPeMS, HERE, Inrix, etc.

13. References & Risk

- Qualifications and competency
- Extent and quality of experience with other agencies
- Enhancement costs, successes, or issues with peer agencies
- Anticipated relative risk/uncertainty related to product maturity or deployments with agencies similar to ODOT

Other Considerations

Other evaluation criteria call for additional consideration by stakeholders to minimize cost and allocate additional resources efficiently. The first criterion, part of Cost, is to consider whether additional – or fewer – ODOT staff resources are needed to support a new ATMS. Dedicated staff may be hired in the future to maintain the ATMS after an outsourced maintenance contract expires. Detector data (under Data Interfaces) may also be considered, though other than for local traffic control device control, ODOT does not currently maintain any field detectors that are being used by the TMC or BuckeyeTraffic. Finally, related to Performance Measures, because ODOT already has well established performance measure processes, tools or features for archiving, retrieving, reporting, and visualizing performance data need not be included in the new ATMS. If or as they are integrated into the new ATMS, they need to be built on top of ODOT's Office of Traffic Management data warehouse.

4 Needs Validation

The identified needs and priorities, together with the ITS Architecture, provide the essential basis for assessing feasibility of broad alternative approaches. The identified services and the discussions around them inform the prioritizations of the 13 buckets overall as well as individual items within the buckets. The objective at this point is to identify the most viable high-level alternatives, with specific vendor or product selection left for later, in the formal procurement process.

Vendors were allowed to give demonstrations of their ATMS products during November/December 2018. Each vendor was provided with the list of needs “buckets” outlined in Section 3 of this report. This was to demonstrate how their products could meet stakeholder needs. These vendor options are in addition to the do-nothing option of retaining the existing BuckeyeTraffic and associated ATMS components, as well as the option to enhance and upgrade the existing situation. The vendors that presented are as follows, alphabetically:

- CoVal Systems (Foundation)
- IBI Group (ATMS)
- Kapsch (DYNAC)
- Kimley-Horn (KITS)
- Parsons (iNET)
- Q-Free (OpenTMS)
- Siemens (Concert)
- Southwest Research Institute (ActiveITS)
- SRF Consulting (IRIS)
- Telegra (topXview)
- TransCore (TransSuite)

Concepts Evaluations

Each potential solution was assessed for its capability and potential to satisfy each collection of needs (buckets) described in the previous section. Stakeholder needs, priorities, and acceptable tradeoffs are a central part of the determination; thus, much of the evaluation thus far is subjective. The evaluation considers whether buckets are relative strengths for a concept, the immediacy with which it can be implemented or addressed, the extent to which a concept is likely to require enhancements and customization, and the anticipated cost and risk of doing so. The time horizon of when a component or service is needed also affects the feasibility of different solutions. For example, integrating with DMS and work zone data is a more present requirement than accommodating evolving connected vehicle applications.

5 Candidate Comparisons

Given prioritization of needs and cost considerations, a preferred concept can be identified for advancement through the remaining systems engineering development process. To reiterate, the final product selection is left for the later procurement process.

These are complex systems with many competing considerations. Nonetheless, stakeholders observe a distinction between three groups of alternatives: the existing or enhanced ATMS, the open source options, and the fully commercialized options.

What the stakeholders found at this point is in part summarized in **Figure 4**. The commercial offerings are wide ranging in their ability to meet the needs of ODOT. While the open source options are likely better than the existing BuckeyeTraffic system, they do not rise to the level of an enhanced BuckeyeTraffic. This includes assessing all buckets.

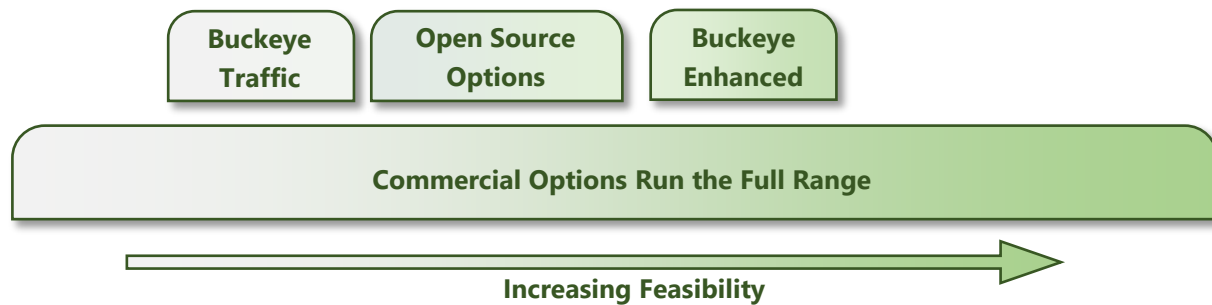


Figure 4. Relative Feasibility of Alternative Concepts

The buckets appearing to drive the biggest differentiators are Decisions & Algorithms and Event Management. While most options are an improvement over BuckeyeTraffic, some commercial options would not be markedly better, while other commercial options would provide vast improvement from day one.

The next tier of differentiating buckets includes Business Model, Security, and User Interface. For these considerations, some options would be a step backward from the existing BuckeyeTraffic. These five buckets together are what cause some commercial options to fall below existing BuckeyeTraffic in terms of feasibility.

The open source options are likely adequate across all dimensions except they fall short in Costs & Resources and Security, positioning them ahead of the existing BuckeyeTraffic but lagging behind an enhanced BuckeyeTraffic. The differentiators among the commercialized options tend to be a) the extent to which each must be modified or extended to meet the needs of ODOT and associated stakeholders, and b) the assessment from observation and experiences with other agencies.

Conclusion and Recommendation

In summary there are three important considerations: first, some options would be a step backward or are not viable because of a key weakness in such things as security or readiness. The TSMO Plan clearly outlines several objectives and actions for improving TSMO and TMC operations, and neither BuckeyeTraffic nor open source options are viable for meeting stakeholder needs and expectations. Key themes repeated throughout the project to this point include streamlining, consolidation, support, flexibility, security, and decisions. The best alternatives explored so far point to a contemporary commercial concept with proven success among peer agencies.

Second, there is no one option that stands out from all the others, rather there are three or four commercial options that appear to have the potential to very capably meet stakeholder needs while balancing cost. While looking beyond BuckeyeTraffic and open source options, work remains to determine the best alternative within the preferred commercial concept. This will be continued through the next steps of the systems engineering development process with the ConOps and requirements development.

And third, ODOT's procurement process and rules define the path to specific product selection. While a sole-source determination could technically be possible, ODOT expects to receive a better solution and cost in the end by proceeding with a request for proposals (RFP), which ODOT intends to move forward on. Regardless, the manner of procurement does not affect the systems engineering development process, which continues with the ConOps next.