NCDOT TSMO Statewide Strategic Plan

Programmatic Plan

July 31, 2023

Final

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Introduction

As defined in the Strategic Plan, the overall Transportation Systems Management and Operations (TSMO) Strategic Plan Suite of documents includes three layers of guidance documents. This document is the Programmatic Plan and continues the bulk of the supporting data to deliver the Strategic Plan and guide the implementation of the Service Layer Plans.

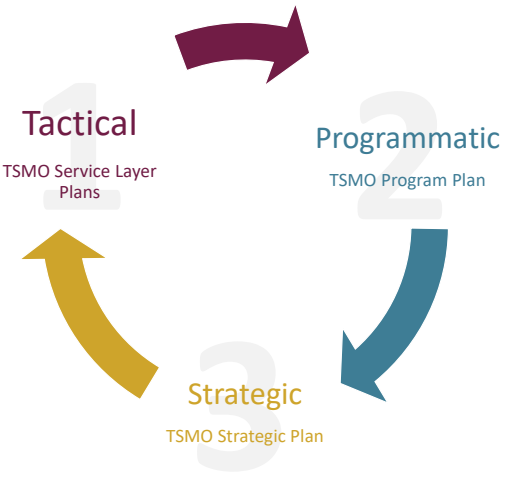

Figure 1. Correlation of TSMO Strategic Plan Layers

- **Strategic** – Provides an overview of TSMO while making a business case. This is a single plan that includes mission and vision, goals and objectives, and performance measures. The audience includes all levels of staff from NCDOT and partner agencies.
- **Programmatic** – Describes the TSMO program objectives, overarching or programmatic focuses, and presents the list of services layers that are the focus of the tactical layer. This single plan includes roles and responsibilities, business processes, an overview of services layers, and resources. The audience for the programmatic layer includes the program managers within NCDOT and key partner agencies.
- **Tactical** – Summarizes the action plan and targeted focus for each TSMO service layer. This layer is a suite of individual service layer plans with specific activities derived from the gap assessment. The audience includes those that will lead these activities and move the TSMO Program forward to the next level of maturity.

Program Overview

The Traffic Systems Management & Operations (TSMO) Program oversees the operations of all freeway and arterial corridors in North Carolina. The North Carolina Department of Transportation (NCDOT) is one of the largest government agencies in the state and is responsible for the operations of approximately 80,000 miles of roadway statewide. NC has the ninth largest overall population with the third highest rural vehicle miles traveled (VMT) in the nation[1]. NCDOT partners with other first responders to leverage a range of TSMO strategies capable of promoting safety and mobility on the transportation network. TSMO strategies are effective tools for maturing the state's ability to achieve a more proactive approach to active traffic management.

TSMO is a systematic approach to address mobility, reliability, and safety issues by capitalizing on the existing infrastructure investment. It centers on the guiding principles of active, integrated, and performance-driven management and operations.

[1] *Table VM-2 - Highway Statistics 2016 - Policy | Federal Highway Administration (dot.gov) (2020 data)*

Core Focus Areas

A coordinated and comprehensive statewide approach to active traffic management supports a better quality of life for the public living in and traveling through NC. This approach enables informed decisions regarding upcoming and current trips. Active traffic management allows for improved mitigation of impacts from incidents and reduce the likelihood of secondary incidents. The active traffic management and maintenance component of the TSMO program is comprised of the following core focus areas.

- **Traffic Incident Management (TIM):** A collection of strategies that focus on leveraging multiagency communications and on-scene management tactics to achieve quicker incident detection, quicker incident clearance, and improved situational awareness.
  - **Incident Management Assistance Patrol (IMAP):** NC's safety service patrol supports safe, quick clearance of incidents and debris in coordination with law enforcement and other first responders. The IMAP Program has evolved from motorists' assistance only into a mature traffic management solution supporting first responder and motorist safety using techniques like emergency traffic control (ETC), on-scene management, and quick clearance.
  - **Coordination with Emergency Responders**: On-scene coordination involves effective communication between all partners during responses to an incident.
  - **Towing Program:** NCDOT has matured their strategies and partnerships with the towing industry to include incentivized towing contracts that reduce incident clearance times.
- **Traffic Management Centers (TMC):** TMC's are the communication hubs of the program for incident response coordination and planned events. They include the Statewide Transportation Operation Center (STOC) and Regional Traffic Management Centers (TMC) across NC. STOC/TMC's communicate to IMAP, field responders, partner agencies, and motorists.
- **Intelligent Transportation Systems (ITS):** ITS includes all field devices (e.g., closed-circuit television (CCTV) cameras, message signs (DMS/CMS), highway advisory radios (HAR), or detection devices) and the communication infrastructure that connects those devices with the TMCs.
- **Traveler Information:** Traveler information provides real-time information to transportation system users to make informed decisions for safe and efficient travel. This information can be related to congestion, incidents, road work, or unsafe conditions due to weather or other unexpected events. NCDOT and partner agencies share this information via dynamic message signs, agency websites (e.g., DriveNC.gov), social media, 511, navigation companies, or directly to connected vehicles.
- **Signal System Timing and Operations:** Arterial and signal operations focus on signalized arterial routes which play a significant role in the performance of North Carolina Department of Transportation's (NCDOT's) comprehensive transportation network. Arterial management emphasizes system coordination, real-time traffic signal system management, timing strategies, and performance measures.
  - **Signal System Timing**: NCDOT is responsible for the timing and operation of the coordinated signal systems located across the state. Building on the Signal Modernization project, the upgraded field hardware, controller software, and central software will support better signal connectivity and signal timing implementation. Using

performance data, NCDOT will be able to better prioritize which corridors require attention.

- **Signal Modernization**: NCDOT's signals currently use antiquated "legacy" signal controller hardware and run a legacy signal software platform that is non-compliant with the National Transportation Communications for ITS Protocol (NTCIP). Upgrading this controller equipment and software will allow NCDOT to leverage the latest technological advances in traffic signal safety, operations, and maintenance, like Connected Vehicle connectivity and ATSPM.

- **Emergency Weather Traffic Operations:** Emergency weather traffic operations includes the agency's preparedness for impacts from significant weather (e.g., hurricanes and winter weather) or unplanned events. This includes activities that should occur prior to, during, and after the event. Agencies typically involved are transportation agencies, emergency management, state police, local law enforcement, and others that can provide real-time data related to impacts or resources during different phases of the event.
- **Active Work Zone Management / Planning for Operations:** Cross-cutting focus area that integrates coordination efforts between planning, programming, project development, design, construction, and operations to ensure NCDOT is effectively implementing active traffic management or TSMO strategies that align with the objectives for safety and mobility.
  - **Active Work Zone Management:** Active Work Zone Management is an important tool during the construction phase of the project delivery. It includes strategies that actively manage traffic disrupted by incidents in work zones using a network-based approach. These strategies can leverage capacity on the freeway and the arterials to support quicker incident clearance and active traffic management tools in response to incidents. Active work zone management includes aspects of managing traffic during construction that is necessary to minimize traffic delays, maintain motorists and worker safety, complete roadwork in a timely manner, and maintain access for businesses and residents. Effective active work zone management includes assessing work zone impacts and implementing strategies for mitigating impacts.
  - **Planning for Operations:** Program Delivery involves all facets of project development from concept, planning, design, construction, operations, and maintenance. Planning for Operations focuses on educating everyone involved including executive management, supervisors, staff, and field forces. Discussing TSMO strategies in all phases of project development increases the overall awareness and education on the benefits of TSMO strategies: improve travel time reliability, reduce delay, and reduce congestion. Projects can leverage TSMO strategies to increase the effective use of existing capacity and support better implementations of new capacity investments.
- **Mobility Performance Measurement**: Data-driven, performance-based decision-making is a cornerstone of making informed choices that best impact traffic management strategies. NCDOT is responsible for reporting quantitative metrics to state and federal agencies including the North Carolina General Assembly and the Federal Highway Administration (FHWA).
- **Data Purchases (Probe Data)**: Data acquisition is a cross-cutting activity of the TSMO Program. NCDOT is integrating purchased data, particularly via probe data, to inform performance-based decisions about traffic performance and the impacts of implemented responses.

Coordination and Collaboration

None of the focus area activities occur in isolation. Instead, significant overlap and coordination is essential. TMCs serve as communication hubs for incident response coordination during traffic incidents or planned events.

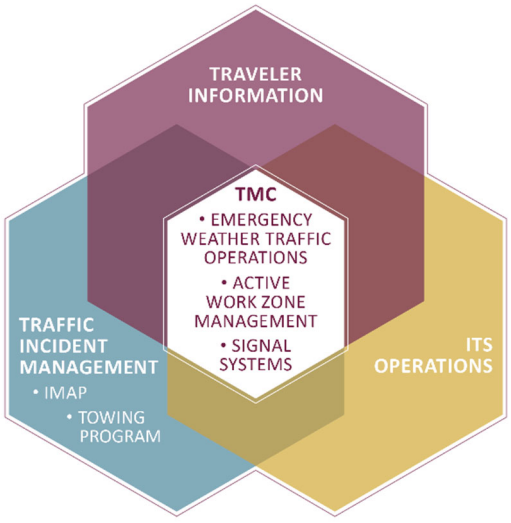

Figure 2. Venn Diagram of Core Focus Areas

NCDOT applies a suite of strategies to support actively managing traffic on the State's roadways. The strategies include interagency coordination and planning meetings, incident detection and verification (CCTV cameras, detection, third party data, etc.), traveler information (message signs, DrivenNC.gov, etc.), optimization of signal timing (timing strategies, proactive maintenance, etc.), and quick clearance of incidents in coordination with field forces like IMAP. These strategies keep traffic flowing, expedite incident clearance, open the roadway, and restore normal traffic flow as quickly as possible – all to achieve maximum utilization of an expansive roadway infrastructure.

Roles and Responsibilities for the TSMO Program

Both statewide and local resources manage different elements of the program. This requires an intentional effort to ensure that the core focus area alignment. Statewide staff manage statewide efforts (e.g., contracts, budgets), coordinate across the Regions and with other states, and oversee the documentation of standard operating procedures (SOPs), policies, and guidelines. Regional staff manage daily responsibilities in the field with IMAP patrols, interagency relationships, coordination with the STOC/TMC, and incident management activities. Although there are a few exceptions, the STOC manages daily operations of the Triangle TMC, and all rural areas not covered by a Regional TMC.

Statewide and Regional

Statewide staff focuses on consistency and strategic level goals. Statewide staff develops SOPs, policies, and guidelines used by regional forces in their daily activities. In addition, statewide can deliver training courses and be a resource to support specific activities, outreach, and relationship building efforts. Statewide staff also develop, administer, and manage contracts that support different elements of the program including extension of staff, statewide procurements, and support development of contracts to support local staff (such as incentive tow contracts). As Regions experience turnover in staff and higher demands, statewide staff can provide support across a range of functions. Statewide can periodically support regional staff to help bridge gaps, whether this is through supplemental funding, the development of guidance for signal system timing, program assessments, or collaboration with external or state level partners.

Regional staff address the daily needs and deliver the program. They provide relevant local knowledge to support better application of the strategies and programs available. They are the "boots on the ground" and coordinate closely with neighboring Regions, using statewide to supplement resources when larger incidents reach outside their borders. They also coordinate closely with statewide staff to ensure the sharing of all local information. Even though the roles are similar, the Divisions or Regions may vary in their staffing approach of these roles. Additionally, some Regions require additional coordination within some of the functions. For example, the Triangle and Metrolina Regions are responsible for maintaining relationships with NC Turnpike Authority (NCTA) as they support or coordinate with staff that manage traffic on toll facilities.

Figure 3 provides a snapshot of the program framework of statewide and regional positions and the functions that align with each of those positions in larger urban Regions. This graphic focuses on a comparison of the statewide and regional roles within some of the core focus areas: TIM, TMC, ITS, and Traveler Information.

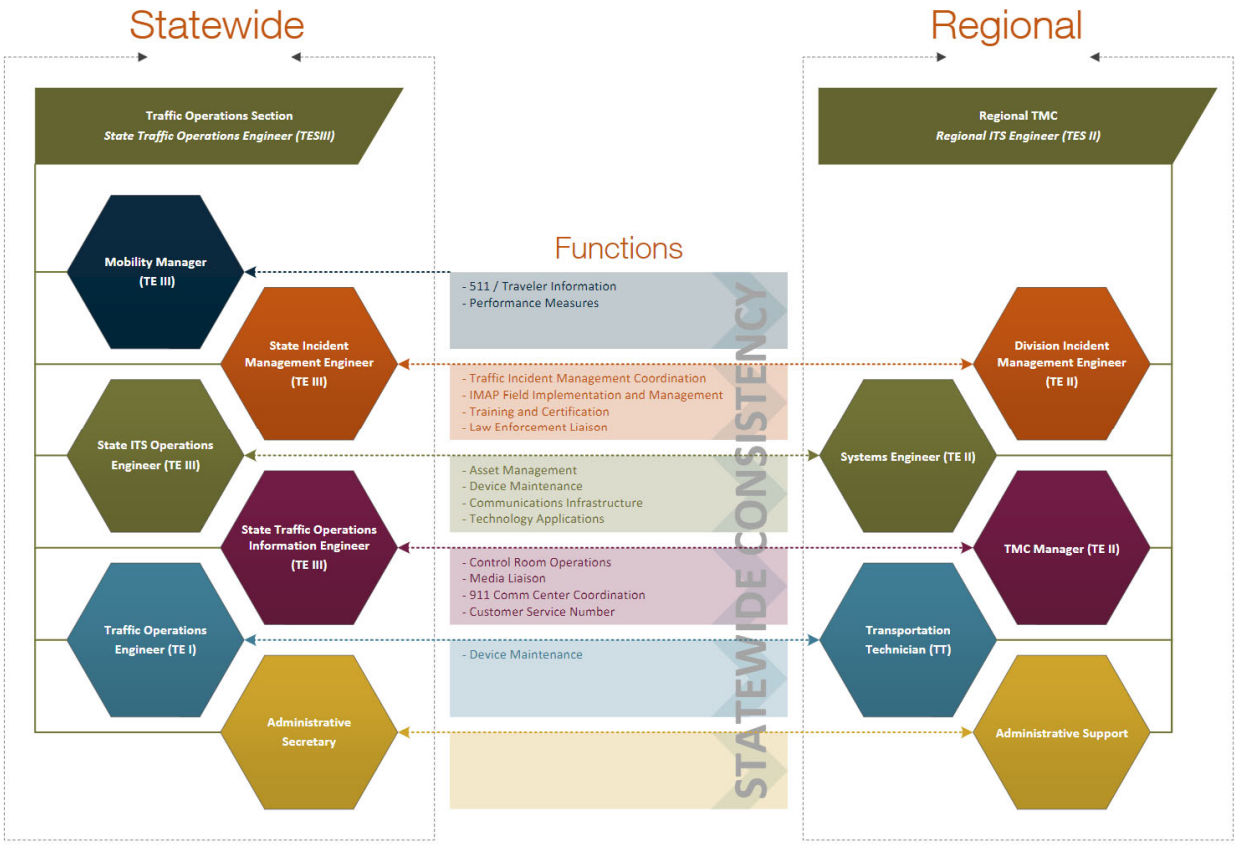

Figure 3. Example Comparisons for Statewide and Regional Roles

IMAP and STOC/TMC

Effective collaboration between IMAP and the STOC/TMC are critical for the quick and efficient coordination of resources. IMAP provides situational awareness of condition at the scene for the control room to better respond with traveler information based on the anticipated clearance times. The control provides advance warning to motorist approaching the scene and has broader perspective of traffic impact to the roadway network. The STOC/TMC can use this information to optimize the allocation of

resources for the response and improve information shared with the public and other responder agencies. The most efficient means of communication between IMAP and STOC/TMC personnel is through use of the VIPER (Voice Interoperability Plan for Emergency Responders) radio system. Direct communication between the two groups is not only essential for incident/congestion management, route surveillance, incident response, and information sharing – communication is the lifeline between IMAP Responders and the STOC/TMC.

Maturing the TSMO Program

The ***Service Layer Plans*** are a deliberate plan structured to guide the Department through the next phases of maturity and growth. There are seven unique service layers that support the programmatic and strategic plans for the TSMO Program. The layers align with the core focus areas and include arterials and signal operations, emergency response and resiliency, TIM, TMC, traveler information, ITS and communications, and planning for operations. Each Service Layer Plan builds on the CMM assessment, gaps identified, and action items defined to mature that component of the TSMO Program. The service layer prescribes ***actionable steps*** to address some of the defined gaps over the next five years. **Appendix C: Existing Conditions** includes details of the existing conditions for each of the Service Layers. The Service Layers acts as a roadmap to guide decision making for operations, procurement, partnering, project development, and project deployment in alignment with the goals of the TSMO Program.

Completion of an Annual TSMO Report documents the state's progress towards achieving its goals within the TSMO Program.

The Department has committed to a ***proactive level of traffic management***. through dedicated ***resource allocations that support this level of service***.

A ***consistent and dedicated funding stream*** allows the TSMO Program to recover from years of under-funding, mature to a proactive management approach, and modernize the program to accommodate future technological advances.

The TSMO Program is comprised of a statewide coordinated, division led approach to actively manage traffic on the network. Currently, the TSMO program budget has been migrated to being centrally managed and coordinated with the Divisions and Regions. This shift to a centrally managed budget included the following benefits:

1. Emphasizes the dedication of TSMO funding to resources for TSMO purposes
2. Allows funding of statewide and local needs without shifting money outside of the program
3. Encourages all groups within the Department to spend TSMO funding in the TSMO areas
4. Allows the prioritization of needs across the state with Division input
5. Simplifies and provides agility for more frequent resource sharing
6. Reduces the opportunity for misappropriating Federal Funds

The Department employs an active budget management strategy as outlined in **Figure 4.** This cyclical process of planning, executing, and assessing allows the program to continuously mature the budget administration in response to program needs. Applying this active management approach to a centrally managed budget ensures more consistency within the program by reducing the number of touchpoints between the budget and staff working to deliver the TSMO program.

Figure 4. Actively Managed Budget Cycle

The current approach supports an invested culture and collaborative process for determining where to apply resources. It drives investment decisions programmatically and geographically based on experienced impacts and proven benefits. For example, NCDOT revised the incentivized towing contracts annually based on lessons learned and localized knowledge of how the contract best impacts a specific corridor.

Previously the TSMO Program had to focus on its most critical needs due to limited resources. Insufficient funding caused significant infrastructure maintenance challenges and exposed the agency to associated risks. Moving forward, the Department has committed to investing in a manner that supports a proactive traffic management program. During the transition from the limited funding phase to a proactive approach phase, the Department will be in a reactive approach phase. **Figure 5** outlines the progression from limited funding to a proactive approach. It also aligns this progression with the maturity levels of the CMM. The proactive approach to traffic management provides the highest level of benefit as it involves a continuous approach to process improvements that optimizes each of the TSMO function.

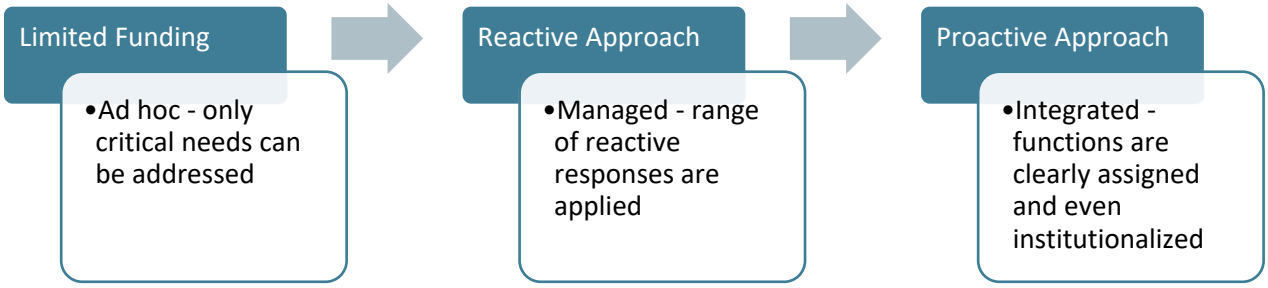

Figure 5: Funding Phases

Table 1 relates core focus area actions to the past limited funding phase, the current reactive phase, and the future proactive phase. While a few of the core focus areas have existing activities that NCDOT can be consider reactive or proactive, the program will require focused energy to elevate most activities into proactive categories. The limited funding phase column includes risks associated with this funding level, to highlight the benefits of investment in the TSMO Program.

Table 1. Traffic Management Approach by Core Focus Area

Core Focus Areas	Limited Funding	Reactive	Proactive
Arterials and Signal Operations	▪ Assessing and revising signal timing plans on established 3–5-year cycle ▪ Address signal performance based on complaints or observed conditions ▪ ***Risk: System timing plans do not address existing conditions causing unnecessary delay and underutilization of roadway capacity***	▪ Assess and revising signal timing plans on established 3–5-year cycle ▪ Address signal performance based on complaints or observed conditions ▪ Partial entry of systems in central software for remote access	▪ Use of automated traffic systems performance measures (ATSPM) to proactively manage signal performance in real-time ▪ Data driven approach to proactively time systems in real-time ▪ Ability to augment holistic approach to active traffic management for incidents ▪ NCDOT culture committed to active traffic management
Emergency Weather Traffic Operations	▪ Emergency preparedness threatened by lack of resources ▪ Partnerships weakened by lack of coordination ▪ **Risk: Limited trained staff to respond appropriately to emergencies; increase in recovery or service to partners**	▪ Respond to emergencies with marginally prepared staff ▪ Delay in routing and resource sharing with compromised situational awareness	▪ Fully trained and prepared staff during emergencies ▪ Established relationships with partners and consistent multi-agency training ▪ Real-time routing and resource sharing based on projected impacts to network for continuity of operations ▪ Well documented response for resiliency ▪ NCDOT culture committed to active traffic management
ITS and Communications	▪ 50% of ITS devices inoperable ▪ 50% of ITS devices at end of life ▪ Limited redundancy in communications infrastructure ▪ Unable to align with emerging technologies ▪ Immature asset management program ▪ Gaps in device coverage ▪ Limited expertise ▪ ***Risk: Complete loss of ITS Devices and connectivity due to lack of repair or end of life***	▪ Replace or repair field equipment when it breaks ▪ React to changes in technology once they impact operations ▪ Devices mapped with status unknown ▪ Address critical needs for devices ▪ Limited expertise	▪ Life Cycle Replacement Program for field equipment ▪ 95% of devices operational and maintained through performance-based programs ▪ Adequate device coverage ▪ Use advanced technology to monitor, manage, and assess programs ▪ Mature asset management program ▪ NCDOT culture committed to active traffic management
TIM	**IMAP** ▪ IMAP vehicles operating beyond end of life, in ill repair, and/or often out of service ▪ Workforce and equipment conditions unable to sustain minimal coverage ▪ Fiscal boundaries hinder ability to optimize equipment usage ▪ Lack of surge staffing capabilities for emergencies ▪ ***Risk: Continued reduction in IMAP services resulting in travel time increase and travel time reliability decrease and increased risk of secondary crashes***	**IMAP** ▪ Replace IMAP Vehicles when inoperable ▪ Sustain marginal IMAP coverage ▪ Fiscal boundaries may hinder ability to optimize equipment usage ▪ Minimal surge staffing capabilities for emergencies	**IMAP** ▪ Life-cycle replacement program implemented for IMAP Vehicles ▪ IMAP coverage annually reviewed and optimized ▪ Equipment usage optimized across boundaries ▪ Nimble surge staffing for emergencies and special events ▪ NCDOT culture committed to active traffic management
	Coordination with Emergency Responders ▪ Emergency Responders Partners do not feel supported ▪ Fragmented roles based on legacy organization and available skills ▪ Relationships on informal, infrequent, and personal basis ▪ Longer incident clearance times due to lack of emergency responder's knowledge of quick clearance strategies ▪ Risk: Relationships wane at regional level impacting incident response and clearance times	**Coordination with Emergency Responders** ▪ Limited incident management teams that focus on special requests ▪ Targeted relationships when requested for urgent needs ▪ Ad hoc training for emergency responders when tragedies occur	**Coordination with Emergency Responders** ▪ Build Emergency Partner Teams and Interagency agreements ▪ High level of operations coordination institutionalized among key players –public and private ▪ Maintained partner relationships through developed regional and statewide teams ▪ Formalized multi-discipline training for emergency responders to prompt quick clearance ▪ NCDOT culture committed to active traffic management
	Towing Program ▪ Rely on NCSHP Rotation with no performance measures (outside of significant construction projects) ▪ Lack of towing capabilities in hot spot locations during adverse weather ▪ Risk: Longer incident clearance times due to lack of trained, incentivized towers (outside of significant construction projects)	**Towing Program** ▪ Rely on NCSHP Rotation with no performance measures ▪ Continue to address significant projects with towing contracts	**Towing Program** ▪ Institutionalized Incentivized Towing Contract for significant construction projects, hot spots, and adverse weather ▪ NCDOT culture committed to active traffic management

Core Focus Areas	Limited Funding	Reactive	Proactive
TMC	▪ Manual operations without an Advanced Transportation Management System (ATMS) ▪ Many TMC operations in temporary facilities without adequate staffing levels ▪ Susceptible to unexpected staffing cuts volatile funding sources ▪ TMC is unable to meet the regional needs ▪ Risk: Immature active traffic management and substandard facilities resulting in travel times increase and travel time reliability decrease	▪ Continue manual operations with no ATMS ▪ Limited expertise and bandwidth to implement active traffic management strategies ▪ Degrading facilities not conducive to advanced maturity ▪ STOC continues to provide the regional support ▪ The TMC confirms the impact of the incident and generates notifications	▪ Automated operations using ATMS ▪ Appropriate number of regional TMCs supporting active traffic management, IMAP coverage, and emergency partner relationships ▪ TMC staffed to support all the functions of active traffic management ▪ Technology investments to enhance detection and response to incidents ▪ Integrated systems provide holistic approach to active traffic management ▪ NCDOT culture committed to active traffic management
Traveler Information	▪ Range of rudimentary tools used to collect and disseminate information ▪ Not maintaining pace with emerging technology ▪ Limited expertise ▪ Risk: Traveler information becomes stagnant and outdated, causing public and partners to lose trust	▪ NCDOT uses readily available data to feed traveler information tools ▪ Responsive to technology advances and pilot opportunities ▪ Manual data entry of data; manual activation of alerts and notifications	▪ Integrated data sources to maintain knowledge of network conditions ▪ Newer strategies implemented to improve program ▪ Real-time and reliable traveler information provided to efficiently utilize roadway capacity ▪ Variety of tools used to serve all audiences ▪ NCDOT culture committed to active traffic management
Planning for Operations	**Active Work Zone Management** ▪ Ad hoc approach to include strategies in construction projects ▪ Strategies included late in project development cycle and compete with limited funds ▪ Risk: NCDOT has not had the capacity to implement active traffic management strategies when and where necessary resulting an increase in travel times associated with work zones. ▪ Risk: Potential increase in secondary crashes due to stopped traffic **Program Delivery** ▪ Ad hoc involvement in project development process ▪ Value of effort not widely understood beyond champions ▪ Risk: Immature processes for project development and program delivery limits operational capabilities resulting in abandonment of effort and less efficiency out of the investment in the physical capacity of the transportation network	**Active Work Zone Management** ▪ Smart Work Zone technology included in some construction projects ▪ Limited effort for preplanned alternate routes and strategies ▪ Inefficient incident response **Program Delivery** ▪ Minimal effort applied to planning for operations ▪ Educate partners when problems arise ▪ Address operational challenges in work zones as they occur and refine work zone strategies during the construction phase of the project	**Active Work Zone Management** ▪ Department determines which traffic operation strategies address work zone challenges ▪ Preplanned and scoped traffic operation strategies funded and implemented ▪ NCDOT culture committed to active traffic management **Program Delivery** ▪ Strategy integration institutionalized and subject to continuous improvement ▪ Active traffic management strategies considered before or instead of capital improvements ▪ Commitment to implement active traffic management strategies to achieve full range of mobility and safety ▪ Feeding operational needs into projects/grants/programs ▪ Systems engineering applied during planning to appropriately account for successful elements of active traffic management strategies ▪ NCDOT culture committed to active traffic management

Performance Measures

Performance Measures are one of the key dimensions within the CMM assessment. NCDOT continues to evolve the strategy towards the use of data to make informed decisions. It is important that the TSMO Program connects each TSMO strategy to effective performance measures that can validate the investment and the actual impact relative to the anticipated return on investment. This focus on an iterative approach to assessing the TSMO Program supports several key elements.

1. Validates where the TMSO Program is making existing investments
2. Affirms leadership and executive management's commitment to the Program
3. Guides how the TSMO Program can make investments for new strategies that demonstrate the largest potential benefit

This plan development included an assessment of performance measures that best support the delivery of the TSMO Strategic Plan. Alignment with the appropriate performance measures optimize resources to collect, process, and report the appropriate data sets to guide data driven decisions. **Figure 6** summarizes the list of performance measures derived from conversations with stakeholders. The table outlines the data source, owner, audience, whether it is already in place, and frequency of assessing. The table maps each of the performance measure to the seven defined service layers and data management. This figure represents a spreadsheet that the service layer working groups can refine as they assess each phase of the program delivery.

Evolving the Performance Measures Program

This table is a first pass based on feedback during the plan development and captures what data the program collects. Each service layer plan includes additional detail. The TSMO Program, and the working groups, take on the Performance Measures component of the program. In addition to the following steps, the working groups should take a deeper dive to confirm the existing metrics, data course, users, and audience that provide the best tools for guiding data-driven decisions.

1. Establish a dashboard based on certain metrics such as the B/C of program investments.
2. Refine the "Evaluation" portion of the matrix to guide how performance measure management.
    a. Owner: Who is responsible for collecting, assessing, and sharing the data?
    b. Audience: Who is going to reference the data for making decisions?
    c. Intent: Identify data-driven decisions.
    d. In Place: Is this data already collected and shared?
    e. Level of Effort: How complex is the data collection, assessment, and reporting?
    f. Frequency: How often should the data be reports? (real time, weekly, monthly, etc.)
3. Ensure how the performance metrics connect back to the TSMO Program and the overall budget.
    a. Provide input into the TSMO Annual Report
    b. Document the traceability of the data to specific components of the program.
    c. Clearly articulate the value of the investments.
4. Confirm which national performance metrics does the TSMO Program impact.

State and Federal Reporting Requirements

NCDOT is responsible for providing several metrics to the North Carolina General Assembly and Federal Highway Administration (FHWA) including:

- Maintenance Operations and Performance Analysis Report (MOPAR), which provides the following performance measures
  - Travel Time Index – the variability of travel time during rush hour
  - Average Number of Congestion Hours – the number of hours that speeds are slow
  - Travel Time Reliability – the variability of travel time on a "bad day"
- Moving Ahead for Progress in the 21st Century (MAP-21) administered by FHWA, assesses the following reliability targets:

Performance Measurement	2018 Actual	2019 Actual	2020 Actual	2021 Actual	Proposed 2023 Target	Proposed 2025 Target
Percent of person-miles traveled on the Interstate that are reliable	**88.8%**	**88.7%**	**98.2%**	**96.6%**	**75%**	**75%**
Percent of person-miles traveled on the non-Interstate National Highway System (NHS) that are reliable	**91.3%**	**91.8%**	**96.0%**	**95.7%**	**70%**	**70%**
Truck Travel Time Reliability Index	**1.40**	**1.43**	**1.23**	**1.27**	**1.70**	**1.70**

Figure 6. Performance Measures Summary Table

Performance Measure	Definition	Data Source		Evaluation													Service Layers							
				Audience																				
		Available	Source	Executive Leadership	Senior Management	TSO Management	Daily TMC Operations	Daily IMAP Operations	Divisions	Resiliency Contractor	Public	Other	Intent	In Place?	Level of Effort	Frequency	ITS and Comms	TMC	Trav Info	Arterials and Signals	Data Mgmt	Planning for Ops	TIM	Em Resp
Number of device failures																								
Number of CCTV failures	Timestamped count of CCTV failures	Yes	Device testing database			X	X		X	X				Yes		Daily	X							
Number of DMS failures	Timestamped count of DMS failures	Yes	Device testing database			X	X		X	X				Yes		Daily		X						
Average time to report device failure	Average time to report device failure	FUTURE	ATMS			X	X		X	X				No			X	X		X				
Percent of device failures reported in real time		Yes	Device testing database											Yes		Daily	X	X		X				
Percent of incidents detected versus known incidents reported	Percent of incidents detected versus known incidents reported	Yes	Known incident reports			X	X		X	X				No				X						
Percent of total incidents detected by IMAP patrol	Percent of total incidents detected by IMAP patrol	Yes	Detection Source in IMAP Logs			X			X					No									X	
Age index	Age of specified device or average age of all devices	FUTURE	Asset Management			X	X		X	X				No			X	X		X				
Average age of fiber	Average age of fiber	FUTURE	Asset Management				X		X	X				No			X							
Average age of field equipment	Average age of field equipment	FUTURE	Asset Management				X		X	X				No			X							
Number of maintenance calls per time period	Number of maintenance calls per time period	FUTURE	Asset Management			X	X			X				No			X	X		X				
Percent of device uptime																								
Percentage of DMS uptime	Percentage of DMS uptime	Yes	Device testing database			X	X		X	X				Yes		Daily	X							
Percentage of CCTV uptime	Percentage of CCTV uptime	Yes	Device testing database			X	X		X	X				Yes		Daily	X							
ATMS Performance		FUTURE	ATMS			X	X		X	X				No			X							
Average travel time	Average travel time	Yes	RITIS			X	X	X	X					Yes			X							
Max queue length	Max queue length	Yes	RITIS			X	X	X	X					Yes			X							
Vehicle Miles Traveled (VMT)	VMT change pre- and post-ATMS implementation					X	X	X	X					No			X							
Funding	Amount of money acquired to progress the program	Yes	NCDOT Funding Distribution	X	X	X								Yes			X	X	X	X	X	X	X	X
DMS usage		FUTURE	ATMS			X	X		X	X				No				X						
Total TMC operating hours	Number of operating hours	Yes	Hours of Operations			X	X							Yes		Monthly		X						
Staff retention	Average tenure					X	X	X						No				X						
Percent turnover	Retention rate					X	X	X						No				X						
Average time to complete activity		FUTURE	ATMS				X	X						No				X						
Time to activate special alerts	Time to active special alerts or Amber/Silver alert						X							No				X						
Training time	Number of infield training hours					X	X	X	X					No				X						
Adherence to SOPs						X	X	X	X					No				X						
Customer feedback rating				X	X	X	X	X	X					No				X	X		X			
Customer satisfaction for TMCs	Likert scale	Yes	Customer Service Database			X	X		X					Yes				X						
Customer satisfaction for IMAP	Likert scale	Yes	IMAP Customer Surveys			X		X	X					Yes									X	
Customer satisfaction for Traveler Information Alerts	Likert scale					X	X		X					No					X					
Customer satisfaction acquiring information from NCDOT	Likert scale					X	X		X					No							X			

Performance Measure	Definition	Data Source		Evaluation													Service Layers							
				Audience																				
		Available	Source	Executive Leadership	Senior Management	TSO Management	Daily TMC Operations	Daily IMAP Operations	Divisions	Resiliency Contractor	Public	Other	Intent	In Place?	Level of Effort	Frequency	ITS and Comms	TMC	Trav Info	Arterials and Signals	Data Mgmt	Planning for Ops	TIM	Em Resp
Number of missed incidents		FUTURE				X	X	X	X					No				X						
Data accuracy		FUTURE				X	X	X	X					No				X						
Response time						X	X	X	X					No				X						X
Clearance time																								
Incident clearance time		Yes	IM Quarterly			X	X	X	X					Yes		Monthly		X						
Incident clearance time in IMAP areas		Yes	Major Incident Report			X	X	X	X					Yes		Monthly		X						
Incident clearance time in Active Work Zone						X	X	X	X					No								X		
Percent AVL equipped	Percent AVL equipped across fleet					X		X						No					X				X	
Lag time between incidents and public knowledge				X	X	X	X	X	X					No					X					
Number of calls from other staff on updates (incidents)						X	X							No					X					
Website hits	Website hits	Yes	TSMO Quarterly			X	X							Yes		Real Time			X					
Number of calls	Number of calls	Yes	TSMO Quarterly			X	X							Yes		Quarterly			X					
Percent accuracy of automated alerts						X	X							No					X					
Amount of CV data collected		FUTURE				X	X							No						X				
Signal Performance Data																								
Amount of real time turning movement counts	Amount of real time turning movement counts	FUTURE	ATSPM			X						Signals groups		No						X				
Amount of remote communications	Amount of remote communications					X						Signals groups		No						X				
Amount of center to center communications	Amount of center to center communications					X						Signals groups		No						X				
Data Management																								
Frequency of updates	Frequency that data is updated and validated					X	X							No							X			
Number of downloads	Number of downloads						X							No							X			
Average download time	Average download time						X							No							X			
Average upload time	Average upload time						X							No							X			
Average report generation time	Average report generation time						X							No							X			
Size of data stored	Size of data stored						X							No							X			
Percent of work zones in system	Percent of work zones in system	FUTURE	ATMS			X	X		X					No								X		
Crash reduction factor						X	X	X	X					No								X		
Use of alternative routes						X	X	X	X					No								X		
Tow contract BCA	Benefit cost analysis of actual cost to reduced clearance time	Yes	Invoices; Incident Clearance Reports	X	X	X	X	X	X					Yes		Quarterly						X		
IMAP coverage (mileage)	Percent of IMAP coverage on miles across network	Yes	GIS		X	X	X	X	X					Yes		Annually							X	
IMAP coverage (time)	Percent of IMAP coverage (time)	Yes	GIS		X	X	X	X	X					Yes		Annually							X	
Evacuations																								
Evacuation route effectiveness				X	X	X	X	X	X					No										X
Number of closures due to various factors	Number of lane closures due to flooding, weather, etc.	Yes	IMAP Quarterly			X	X	X	X					Yes		Quarterly								X
Traffic volumes	Number of vehicles on evacuation routes					X	X	X	X					No										X
Total																	14	22	9	9	9	6	6	5

Data Management and Sharing for TSMO

The benefits of TSMO strategies are dependent on an effective and coordinated approach to data management. This approach includes preparing the Department for the integration and ability to identify, assess, and manage the data needed to assess those impacts. The Department will need to take a variety of actions to prepare including:

- Recruit and train existing staff on data science,
- Create new roles for data scientists within the TSMO program,
- Develop processes to mine, manage, visualize, and analyze relevant data,
- Refine data evaluation and dissemination methods,
- Confirm the physical infrastructure to support data management, and
- Explore emerging data sets and technology for analytics

The data management strategy defined for the TSMO program should integrate the following components.

Pilots

Recent pilot projects have demonstrated the opportunities to partner with the private sector as successful ways to vet emerging technologies and data sources. These pilots should align with the Department's Vision and confirm their applicability to solve a problem or enhance the user's experience. Other partnerships with universities or local agencies can further increase the number of available pilot opportunities and potentially reduce costs.

Sharing Data with Public Agencies

The Department produces a lot of TSMO data that may be useful for other Departments and local partners. Sharing data between public agencies can provide benefits and cost savings to all involved. For example, acquiring and sharing probe data may help local jurisdictions use vetted, standardized big data to streamline information sources and assess performance measures.

Sharing Data with Private Companies

There are several benefits to partnering with the private sector entities to make data readily available. This collaboration increases the accuracy and applicability of the data by having more users, who often introduce additional quality control metrics. The open data sharing also increases the number of methods that agencies can share real time data to the end users so they can make better informed decisions. It can also increase the data available to the Department and partner agencies further enhancing their practices and performance measure capabilities.

One recent example is the Department's partnership with Waze—an app that travelers can use to navigate—to bring real-time traffic information across the state. Waze can alert travelers to avoid crashes, travel on alternative routes, or provide information travel time.

Service Layer Plan Implementation

Capability Maturity Model

The Capability Maturity Model (CMM) Assessment guides agencies through a self-evaluation regarding key processes and capabilities related to their effectiveness. The six dimensions include:

- **Business Processes** including formal scoping, planning, programming, and budgeting
- **Systems and Technology** including use of systems, engineering of systems, and architecture standards
- **Performance Measurement** including measures definition, data acquisition, and utilization
- **Culture** including technical understanding, leadership, outreach, and legal authority
- **Organization and Staffing** including programmatic status, organizational structure, staff development, recruitment, and retention
- **Collaboration** including relationships with public safety agencies, local governments, MPOs, and the public sector

The working groups completed the TSMO CMM assessment. Each of the six dimensions includes four distinct levels of capability that may reveal current strengths and weakness of an agency, and further provide a starting place for action. Each level emphasizes establishing a program with documented practices in each dimension. Levels range from performing ad hoc activities (Level 1) to more institutionalized and optimized programs (Level 4), as shown in Figure 7. As an agency progresses through each level, its mission, process, management, and approaches become more effective and efficient. The program must achieve each level of criteria to mature to the next level of capability.

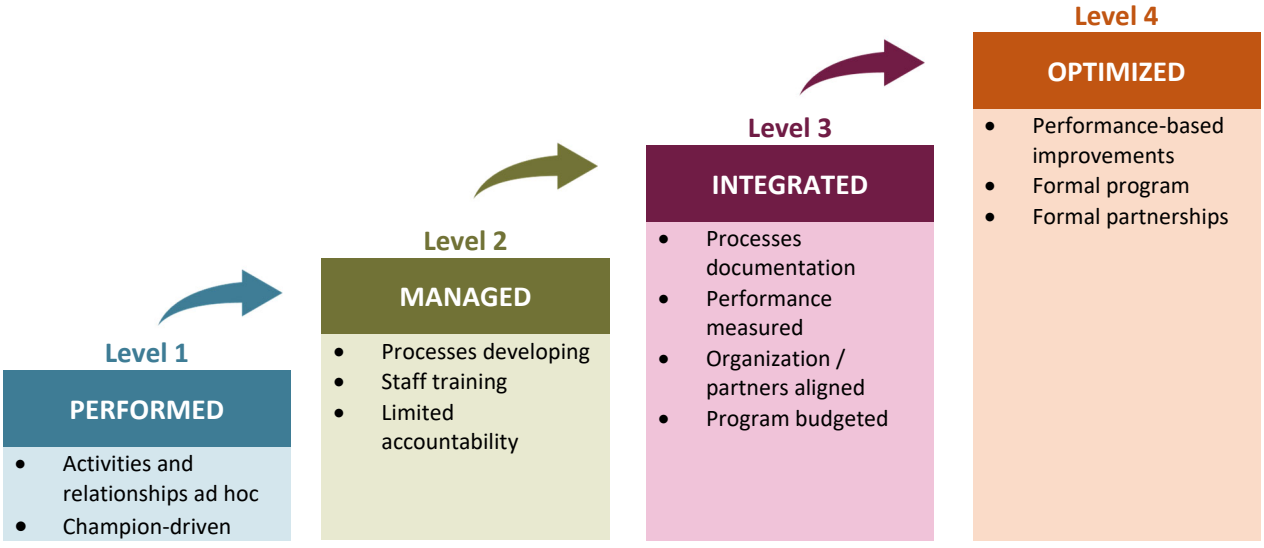

Figure 7. Capability Maturity Levels

Appendix A: Capability Maturity Model Matrices shows the current assessment level for the six dimensions. The matrices include documentation of existing conditions, shown "What is placing us in our current tier?" and the gaps, shown as "What is keeping us from advancing to the next level?" These gaps supported the derivation of the action items presented in each Service Layer Plan.

The Working Groups' assessment also identified several cross-cutting themes, listed below.

- Mature the continuous improvement process for the TSMO Program
- Institutionalize TSMO roles and responsibilities across the Program
- Integrate TSMO strategies and emerging tools in all phases of project delivery and traffic management
- Implement a performance measurement program with clearly defined goals that support the continued maturity of the TSMO Program
- Grow the skillset and talent pool to support the Program

Service Layer Working Groups

Finalization of this plan is the first step on growing this portion of the TSMO Program. The working group's structure empowers the subject matter experts and other champions to tackle the identified action recommendations. This document does not prioritize the activities, and they can change over time in response to opportunities or urgent needs. It will benefit the working group and NCDOT to remain agile through this process. Each working group should collaborate and partner with other working groups as needed and report, as appropriate, on progress.

The initial working group membership is based on Service Layer Workshop attendance. As roles change, the participation may also evolve. **Appendix B: Working Group Members by Service Layer** provides the roster for each of the working groups involved in the plan development.

Active and invested stakeholders would make up each of the working groups to ensure success of the activities and the overall program. Responsibilities of the working group include:

- Meet at a regular interval
- Prioritize the objectives and actions for the Service Layer
- Coordinate with stakeholders as needed to move actions forward or get direction and feedback
- Keep a pulse on potential funding opportunities and assign staff to lead efforts to secure those funds
- Identify partners both in the public and private sector to advance the objectives of the Service Layer
- Develop an ongoing strategy to deploy applicable projects and activities
- Ensure alignment remains consistent with the programmatic and strategic layers
- Coordinate with other Service Layer working groups as needed

Appendix A: Capability Maturity Model Matrices

There are six capability maturity model matrix dimensions: business processes, systems and technology, performance measurement, culture, organization and staffing, and collaboration. The project applied the CMM assessment to each dimension for the focus areas listed below:

1. Traffic Incident Management (TIM)
2. Traffic Management Centers (TMC)
3. Intelligent Transportation Systems (ITS)
4. Traveler Information
5. Signal Systems Timing and Operations
6. Emergency Weather Traffic Operations
7. Active Work Zone Management/Planning for Operations
8. Mobility Performance Measurements
9. Data Purchases (Probe Data)

Traffic Incident Management

Definition: **Traffic Incident Management** is the intersection of many different TSMO strategies to respond to and manage incidents on the roadways safely and efficiently. NCDOT can implement Traffic Incident Management at any setting or location and involves high levels of collaboration between agencies. A maximized TIM program includes rapid detection and verification of incidents location and severity, quick response to the scene, safe management at the scene, and quickly clearing the incident to reopen the lanes. Each of these tasks can take many forms and includes various activities.

	What is placing us in our current tier?	What is keeping us from advancing to the next level?
	• NCDOT is introducing new tools which will improve program management (IMAP Dashboard, Tow Contract BCA) • A formal multidisciplinary TIM program has dedicated staff with position levels, job descriptions, etc. • The state has authority removal and driver removal laws • Strong partnership with State Highway Patrol and the towing industry • Performance measures integrated with position descriptions for some positions • There is a mature SSP Program • There is a training and certification program for responders	• NC does not have the data capability to measure or study the impacts of secondary crashes; NC does define other crash data in an extensive crash database • There is room to improve the VIP goals for the IMAP responders and supervisors • There is room to improve culture to help employees feel ownership for their roles • NC does not have a widely distributed standard policy for alternate routing or signal timing • Not all incident management positions integrate performance measures with position descriptions • Training and certification do not exist for all incident management positions • Room to improve local agency relationships across the state • Not all agency partners are able to allocate resources or funding towards the program • Overall funding is not sufficient for the program needs • Lack a Video Management System to support seamless video sharing

	Level 1	Level 2	Level 3	Level 4
Strategic	TIM activities are ad hoc, and no formal TIM program exists. Activities are reactive only. Agency funds TIM activities independently from the operational budgets of partner agencies.	Agency has established a single agency TIM program with one or two key initiatives. TIM planning is mostly ad-hoc.	There is a multidisciplinary TIM program that meets at a semi-regular interval. The leadership is clear with routine participation from key agencies. NCDOT includes TIM in regional transportation plans at a high level and funds some activities annually.	Dedicated staff support a formalized multidisciplinary TIM program, and routinely meet. There is a full-time position dedicated to the TIM program. Regional planning is routine and integrated. The TIM program is well-funded.
Performance Measures	Agency does not typically measure performance measures. Data are present but not accessible or useful. Agency has not established performance targets. Agency generally accepts status quo.	NCDOT measures some performance measures (RCT, ICT) routinely and integrates some data, but only for a small subset of incidents. Agency has established subjective or qualitative targets for RCT and ICT.	Agency routinely measures and reports on performance measures. NCDOT collects data for a significant proportion of incidents. Agency has established quantitative, data-driven performance targets.	Agency routinely measures and reports on performance measures. Agency uses performance measures to improve the system or region-wide outcomes.
Tactical	There is no authority removal law or driver removal law in place. There is minimal outreach and education. There is no formalized incident response program or procedures.	An authority removal law and driver removal law are in place but may not be effective language or complete. A simple SSP provides motorist assistance only along some major roadways based on volumes or incident frequency. NCDOT gives some consideration to incident response procedures.	An authority removal law and driver removal law are in place but require additional education for application and enforcement. A mid-level SSP is in place that provides services beyond motorist assistance. Procedures for incident response are well-documented though not universally understood or followed.	Agency has integrated an authority removal and driver removal law that agencies use on a regular basis. There is a sustained and fully functional SSP that provides motorist assistance, clearance and recovery services, and emergency traffic control assistance. Procedures for incident response are well-documented and adopted.
Support	Program makes minimal investment into public safety agency coordination and incident monitoring. There is no preplanned alternate routing or support for signal timing adjustments. Detour planning happens on-scene and is based on responder knowledge of the area.	There is some video sharing with the public but no or minimal NCDOT access to CAD software and systems. There is some pre-planning for alternate routes.	Video sharing is available between agencies but not all agencies are aware. TMC views CAD information on a dedicated system or monitor. A standard policy is in place for alternate routing and signal timing, but partner agencies do not widely distribute or view.	Agency routinely shares TIM related data/video among all responding agencies. Systems electronically transmit CAD data to TMC/TOC and populate data fields in TMC/TOC software. Alternate route and signal timing policies are widely known, and agencies follow comprehensive guides.

Traffic Management Centers (Previously Freeway Management)				
Definition: **Traffic Management Centers** have two key operational functions: real-time active monitoring and coordination, and traffic management strategy implementation. Staff and systems work together to accomplish these functions. TMCs provide a safer transportation system for users by being both responsive to incidents and innovative in technologies to accomplish that goal.				
	What is placing us in our current tier?		**What is keeping us from advancing to the next tier?**	
	• Clearly defined Standard Operating Procedures • Peer-to-Peer Exchange for ICM • Well-documented training procedures • Co-located TMC with EM and SHP • Some performance measures used to populate statewide dashboard • Single contracting mechanism for TMC staffing across the state • Staff contract allows for support staff beyond TMC operator roles		• Lacking redundancy across the state • Systems engineering process not fully mainstream • Lack of statewide ATMS • Agency decisions not fully driven by performance measures • Not integrated early in all major projects • Inconsistent funding source • Challenges around staff retention • Partner agencies lack knowledge of TMC role beyond specific events	
	Level 1	**Level 2**	**Level 3**	**Level 4**
Business Processes	Ad-hoc planning for TMC functions, vision not well defined; agency has not documented TMC processes specific to NCDOT	Some planning for asset management; processes for specific corridors or region, but not consistent statewide; some TMC processes documented	TMC operations needs captured in budget, standardized processes, consistent review/update of TMC strategic direction	DOT business integrates the TMC vision in all aspects of DOT business; Planning for Operations is standard practice; asset lifecycle cost is part of five-year programming processes; processes are regional
Systems and Technology	Ad hoc approaches to system implementation; systems engineering (SE) not applied consistently; procurement processes; ITS architecture is outdated; individual systems not integrated	Some elements of SE are used, including ConOps, architectures, developed and documented with costs included; TMC monitors some field systems; SE process applied to some aspects of TMC operations; some emerging technology considerations	Systems, technology standardized and integrated on a regional/corridor basis; statewide SOPs updated used; integrated statewide network; TMC business practices have mainstreamed SE process; integrated systems	Architectures and technology routinely upgraded to improve performance; systems integration/ interoperability maintained on continuing basis; Strong support for adopting advanced technologies
Performance Measurement	Some outputs measured and reported for some aspects of TMC operations; typically, historical performance information	NCDOT tracks and reports some elements of TMC performance; focus is primarily on usage/activity reports assessing trends; NCDOT uses some real-time data for operational decision-making at the TMC	Performance outcomes guide recommend operational improvements; real-time data routinely used for decision-making; TMC uses some real-time data from other centers/sources	Operational decisions based on multi-jurisdictional real-time information; performance management strategy guides innovation at the TMC.
Culture	Individual staff champions promote operations; TMC operations priorities based primarily on champion focus areas; TMC not often included in work zone (WZ) or event planning, incident debriefing, etc.	Role of TMC acknowledged but everyone does not recognize the connection to core ops areas; TMC engaged in pre-planning for WZ, TIM and PSE based on individual relationships	TMC is a core program, agency values TMC role and input to key processes, TMC operating needs factored in early as part of other planning/scoping decisions	TMC highly integrated with many processes, agency sees TMC as an asset, high value on TMC data
Organization and Staffing	Individual staff champions promote operations; TMC functions learned mostly OJT; program limits TMC career path and not well defined	Core KSA's identified and help support TMC ConOps; program defines roles for in-house and contractor staff; some training, but limited external training opportunities; fragmented and event-based communication between DOT and contractors	NCDOT clearly defines TMC career path; established and successful training program; performance standards are clear and documented; good communication between staff and contractors	Commitment to ongoing training and professional development; strong retention of staff due to career path and advancement opportunities; strong and well-known performance standards
Collaboration	Relationships ad hoc, and on personal basis (public-public, public-private)	Collaboration with external partners is formal, and usually driven by specific needs, TMC roles still fragmented and event-based; real-time collaboration with public safety for incidents	Multi-agency and coordinated operations for planned events; some partnerships for key corridors; TMC role defined and understood	Program mainstreams TMC operations into multi-agency response strategies; operating processes and procedures documented and used frequently

INTELLIGENT TRANSPORTATION SYSTEMS (ITS)				
Definition: **ITS and Communications:** Communications networks are the backbone of functional intelligent transportation systems. Since all intelligent transportation systems require communications and an exchange of data, a strong plan for managing all devices, fiber, and assets is essential. Deployment plans and guidelines can document this. One key component of this is identifying risks and vulnerabilities and mitigating those risks.				
	What is placing us in our current tier?		**What is keeping us from advancing to the next level?**	
	• QPL supports consistency in devices across the state • Standards for field equipment installation exist • Recurring coordination meetings with DIT • Broadband and ITS Resiliency projects		• Need to implement asset management strategy • Standards for installation have room for improvement • Broadband not yet complete • Loss of institutional knowledge as people leave the department • Lack of dedicated funding for ITS projects • No real-time system performance monitoring for field devices • No structured maintenance program for field devices	
	Level 1	**Level 2**	**Level 3**	**Level 4**
Business Processes	ITS and Communications activities are ad-hoc and not integrated	There is an ITS and Communications plan, but it has deficiencies.	Programming and budgeting for ITS Communications is standard and documented.	Program has streamlined ITS and Communications processes though still subject to improvement.
Systems and Technology	Deployment of ITS and Communications systems takes place outside of the systems engineering process and is more reactive	Systems engineering employed and used for ITS and Communications documentation	Program has standardized, documented, and trained statewide staff of ITS and Communications systems and technology	Program routinely uses and upgrades ITS and Communications systems and technology to improve efficiency performance
Performance Measurement	There are no regular performance measures for ITS and Communications	Program uses output and after-action analysis to measure ITS and Communications strategies	ITS and Communications outcome measures used to improve strategy	Program management routinely uses and reports on ITS and Communications output internally, externally, and archived
Culture	All players do not understand the value of ITS and Communications	There is an agency wide appreciation of the value of ITS and Communications	There is a formal core program for ITS and Communications to grow the agency value of the program	There is explicit agency commitment to achieve the objectives of the ITS and Communications program
Organization and Staffing	ITS and Communications efforts of the department relies on fragmented roles based on legacy organization and available skills	There is an active effort to staff ITS and Communications related projects. Program has identified core staff capacities	There is a top-level management position and core staff for ITS and Communications	Operations staff for ITS and Communications have certification for core capacity positions including performance incentives
Collaboration	Stakeholders foster relationships on informal and infrequent basis	There is regular collaboration at a regional level	There is a collaborative interagency adjustment of roles/responsibilities by formal interagency agreements	There is a high level of operations coordination institutionalized among key players both public and private

TRAVELER INFORMATION				
Definition: **Traveler Information** provides near real-time information to transportation system users to make informed decisions as it relates to safe and efficient travel. This information can be related to congestion, incidents, or unsafe conditions due to weather or other unexpected conditions. Agencies share the information via dynamic message signs, agency websites, social media, 511, or directly to connected vehicles.				
	What is placing us in our current tier?		**What is keeping us from advancing to the next level?**	
	• Very well documented traveler information processes • Work Zone Data Exchange feed • Redundant knowledge across multiple staff members • Consistency exists for incidents entered at TMCs based on the statewide SOPs • NCDOT monitors the successes of other states and attempts to implement best practices but can sometimes be reactive rather than proactive with new technologies • DOT headquarters maintains a single list of closures due to storms • Documentation of existing tools and procedures exists. • Integrated SHP's newest CAD software as in input to TMC's tools		• No Statewide ATMS • Performance measures are not driving decisions • Some interagency relationships are dependent on individual champions • Reliance on hundreds of division construction and maintenance staff to enter data with minimal accountability, quality control, or formal training	
	Level 1	**Level 2**	**Level 3**	**Level 4**
Business Processes	Traveler information is ad-hoc and unintegrated. Any traveler information initiatives are independent or one-off efforts.	Agency has a partially formed plan for traveler information activities. Agency does not widely distribute the plan. There is some planning or strategy integrated into the plan.	Programming and budgeting for traveler information is standard and documented.	Agency has streamlined traveler Information processes and conducts recurring analysis and improvements.
Systems and Technology	There are no real systems or technology to support Traveler Information.	Basic traveler information systems exist but are not well known or integrated.	Program uses and widely deploys traveler information technology. Some redundancy and resiliency in traveler information exists.	Traveler information technology is advanced, integrated, and used across the state. Traveler Information data sources are varied and redundant.
Performance Measurement	No regular performance measurement occurs.	Performance measurement is based on output or primarily takes place during after action analysis.	Performance measurement is based on outcome. Agency documents performance measures with achievable goals to manage and improve TSMO strategies.	Agency drives the program by key using performance measures for management, reported both internally and externally, and archived.
Culture	There is minimal understanding of the value of traveler information.	The key agency members value the traveler information program.	There is a formal core program that fosters an appreciation for traveler information both internally and externally.	The agency has explicitly committed to achieving the goals of the program through traveler information with widespread support.
Organization and Staffing	Agency delivers traveler information by someone with available skills. There is no formal traveler information staff.	A core staff member has responsibility for traveler information with a clearly defined role.	There is a management position dedicated to traveler information with limited support staff.	There is a staffed team of dedicated traveler information personnel with performance measures dedicated to the role/program.
Collaboration	Collaboration across the agency is infrequent and informal.	There is regular collaboration in some regions. Some informal agreements exist across agencies.	There is regular regional and statewide collaboration. Some formal commitments for data sharing exist across agencies.	There is a high level of coordination across key players, both private and public.

SIGNAL SYSTEMS TIMING AND OPERATIONS				
Definition: **Arterial & Signals Management** focuses on signalized arterial routes which play a significant role in the performance of NCDOT's comprehensive transportation network. NCDOT manages some arterial networks through centralized signal systems that span signalized intersections on multiple corridors, but NCDOT manages an even greater number by interconnected coordinated signal systems located on a single corridor. Arterial management emphasizes signal operations, timing strategies, and performance measures.				
	What is placing us in our current tier?		**What is keeping us from advancing to the next level?**	
	• Procurement and consistent design guidance are well documented and followed • Signals on the statewide system have clear performance measures • There is a high-level champion in the DOT leadership for all mobility and safety activities • Arterial performance tool provides high-level assessment • NCDOT can access and manage all statewide signals remotely • Shared O&M responsibilities with local agencies through Schedule D Agreements • Signal timing philosophy manual documents standard procedures and promotes statewide consistency		• NCDOT needs to be more proactive with updates and rapid detection of operational and service disruptions • NCDOT outreach to the public and media is on an as-needed basis, not on-going • It is not easy for NCDOT to share performance data, but NCDOT intends to achieve real time sharing • Traffic signal management decision-making is not consistently multimodal • Develop institutionalized outcome-based performance measures for arterial performance, signal management, and signal modernization • Asset replacement is a reactive process • Create, implement, and follow a statewide focused signal management plan • Standardize existing agreements and develop guidance for the structure and intent • Grow the skillsets to support Arterials and Signals Operations and mature beyond champion-based advocacy	
	Level 1	**Level 2**	**Level 3**	**Level 4**
Business Processes	Traffic signal management program business decisions and resource allocations are ad hoc and/or compliant driven. Agency focuses resource allocation primarily on keeping the traffic signal system functioning, but not necessarily at its optimum level of performance.	Traffic signal management planning, design, operations, and maintenance decision-making; operate in silos and are not well integrated. Resource allocation decisions are focus primarily on maintaining reliability of infrastructure.	Traffic signal management decision-making is objective-based. The agency has business processes that are flexible to adjust and trade-off resource allocations to extend good basic service beyond traditional operating conditions.	Traffic signal management decision-making is performance-based and multimodal. The agency can replace equipment and systems technologies based on end-of-life predictions.
Systems and Technology	Traffic signal systems and technologies limit the agency's ability to provide good basic service. Systems and technologies have limited capabilities to remotely manage, operate, and maintain the system. Limited use of system engineering concepts has resulted in the procurement of an array of systems and technologies with incompatible features and functions. Agency employs primarily complaint-driven processes for the management and maintenance of systems and technologies is.	The agency has the capability to identify malfunctions and manage operations limited to specific intersections or corridors. The agency can achieve consistency in design and operations through standard practice. The agency routinely deploys advanced signal timing concepts (such a volume density, traffic responsive, actuated coordination, etc.) to achieve operational objectives and can implement pre-planned responses to planned and unplanned events. Tracking of assets and work items performed primarily through spreadsheets.	Agencies connect to traffic signal infrastructure and use a management system which can alert operators to equipment malfunctions and assist with managing timing plans. The agency has capability to remotely manage that system but use operator-driven decisions to manage the system with little automated decision support. Agency achieves consistency in design and operations using standard designs and hardware specifications. Systems and technology can support pre-planned responses and advanced concepts such at transit signal priority, work zone management, etc.	The agency has the capability to dynamically respond to changing operational conditions to support the needs of all stakeholders to meet operational objectives. The agency can automatically identify and respond to service disruptions and can reestablish continuity of service remotely. Procurement policies and practices support the procurement products and technologies that represent "best value" for achieving design and functional consistency. Agency achieves consistency of design and operations through the application of system engineering processes.

SIGNAL SYSTEMS TIMING AND OPERATIONS				
Performance Measurement	Agency connects performance measures to agency goals and objectives. Agency limits the use of performance measures to special studies (upon request by administration or confirm reported operational deficiency). Agency does not use performance measures to proactively locate where operations and maintenance issues exist. Agency evaluates productivity by tracking activities (e.g., number of maintenance call received, number of signals retimed, etc.)	The agency has defined performance measures to assess project implementations (such as before/after evaluations). The agency may collect output-oriented performance measures for operations and maintenance activities. Operational and management decisions are based on periodic manual observations in the field.	The agency has defined performance measures to assess project implementations. The agency uses outcome-oriented performance measures for operations and maintenance activities. Operational and management decisions are based on real-time, high-quality data accessible from remote locations.	Agency has defined performance measures to assess system performance. Agency monitors system performance on regular, on-going basis. Agency uses automated systems often to collect and assess system performance. Agency uses performance data to identify performance and efficiency trends. Agency uses performance to better allocate resources, identify maintenance deficiencies, and equipment failures, etc.
Culture	Traffic signal management does not have a champion or core group within the organization that can promote traffic signal operations and maintenance concerns and priorities. Leaders have shared responsibilities with other core agency functions. Outreach to stakeholders and media occurs on an ad hoc basis. Agency does not any standardized approaches for communicating with public and policy makers	Agency recognizes traffic signal management as one of many functions within the organization, but no special emphasis placed on performance. The agency supports team dedicated traffic management functions, but no broad acknowledgement or awareness by agency leadership as to what they do. Outreach to the public and policy maker regarding traffic signal operations occurs on an as needed basis, primarily related to projects.	Traffic signal management acknowledged as important function by agency decisions makers. Traffic signal management champion resides at decision-making level. Regular outreach occurs to communicate with policymakers regarding traffic signal operations through traditional means (reports, fact sheets, etc.).	Agency viewed as a progression agency by peers and the entire program staff can serve as a champion for the traffic signal operations issues and concerns. Agency staff unify based on goals, objectives, and priorities of the agency and use them to drive decision-making. Programs continues to function at a high level, even with the departure of key leaders. Agency seeks opportunities to proactively promote agency's mission, goals, and objectives in person before advisory groups, citizenry, and policymakers through both traditional and non-traditional communications media (social media, dashboards, etc.).
Organization and Staffing	Staff maintains minimum level capabilities necessary to do the job. This limits the agency to assign staffing resources only to limited number of activities. Often, engineering and technical staff have other responsibilities other than traffic signal operations.	Key staff is well versed on basic signal timing design and operational concepts. Agency focuses work force development on raising the level of competency of the staff. Programs with the agency reside in structured silos (planning, design, maintenance, operations, etc.) with limited coordination between silos.	Staff is well versed in both basic and advanced traffic signal control and management concepts and can execute solutions on existing technologies. Workforce development efforts focus on expanding breadth of competencies and providing redundancy in core competencies. The agency can dedicate staff resources to high priority corridors/areas on a limited basis.	Staff is highly motivated and qualified and has the capability to develop and deploy innovative solutions to complex operational situations. Workforce development efforts focus on providing a nimble workforce that can adapt to different situations, depending on the needs of the agency. The agency uses a matrix approach to managing traffic signal operations. Staff has capability to perform activities across network and across functional units.
Collaboration	No data sharing exists between regional partners. Collaboration with internal and external stakeholders is rare, often forced upon agency by policymakers or administrators.	Agency archives information and data internally and shares upon request with other stakeholders. The agency collaborates with internal and external stakeholders on a case-by-case or project basis. Stakeholders do not sustain collaborations over time.	Agency uses formal and well-documented archiving system to store collected data. Keyholders can quickly and easily access data through well-documented and standardized electronic format. The agency seeks collaborations with other transportation stakeholders that to capitalize on opportunities to satisfy needs of operational objectives.	Agency routinely collaborates with internal and external stakeholders (e.g., fire, police, transit, advocacy groups, etc.) that allow them to capitalize on opportunities to satisfy needs of multiple stakeholder objectives. Agencies share data in real-time with regional operating partners and use the data to support numerous regional activities (such as regional planning models, support real-time traveler information displays, etc.).

EMERGENCY WEATHER TRAFFIC OPERATIONS				
Definition: **Emergency Weather Traffic Operations** includes the agency's preparedness for impacts from significant weather or unplanned events. This includes activities that should occur prior to, during, and after the event. Agencies typically involved are transportation agencies, emergency management, state police, local law enforcement, and others that can provide real time data related to impacts or resources during different phases of the event.				
	What is placing us in our current tier?		**What is keeping us from advancing to the next level?**	
	• TSMO Program documented formalized business processes • Established processes for balancing resources during major events • Coordination with agencies and data-driven responses supported from multiple platforms • Value understood from a multi-agency response and partnerships • Established consistent funding sources for emergency and non-emergency events		• Lack of agency agility to support the transfer of institutional knowledge • Create redundancy in TMC operations • Integrate Continuity of Operations Plan (CoOP) with TMC and IMAP • Full participation from all agencies involved in emergency response • Integration of TSMO strategies and emerging tools in emergency response management • Implement performance measurement program tied to traffic management during emergency response • Resiliency is an emerging focus for the Department.	
	Level 1	**Level 2**	**Level 3**	**Level 4**
Business Processes	The agency's response is informal and reactive to major events. There is little to no information on the documentation process.	While the response to smaller events is more reactive, agencies nominally assess and plan for major events. Agency has documented the processes. Stakeholders do not consistently use the processes throughout the agency.	Program has established a formal process for emergency response. There is a standardized documentation process. Funding and other institutional barriers prohibit the agency from addressing the immediate needs post-event.	Multiple agencies use a formal documentation process and a database or platform to archive historic information. The historic information is reassessed annually to identify outstanding needs.
Systems and Technology	No standard protocol or systems exists for emergency management or coordination across agencies.	Agency inconsistently uses technology to support planning. There is a standard protocol for emergency response management.	Program uses technology for situational awareness and verification. Program uses available technologies and has established coordination between partnering agencies.	Program fully uses all available technologies. Agencies have established share information as a common practice.
Performance Measurement	There is no formal coordination after major events. Processes do not apply or adequately store collected data.	There is some coordination after major events with multiple agencies involved. There is adequate review of data for pre-event, during, and post-event. Processes apply the data to track progress.	There is a formal coordination process during and after major events with multiple agencies involved. Processes use the data to set pre- and post-goals for the agencies.	Processes integrate formal coordination as common practice. Processes use all available data sources to drive multiagency decisions.
Culture	The value of multiagency coordination is not a priority. There is no adequate funding in place to respond to major events.	Leadership sees the value in multiagency response. There is still need for funding resources (staff, technology, etc.). Processes consider resiliency, but it is not an agency wide high priority.	Leadership recognizes and actively funds resources to enhance emergency response needs. The agency recognizes and actively advocates for resilient planning and standards.	Leadership advocates for more funding to further enhance emergency response needs. Planning for resiliency is a cornerstone of the agency's standards.
Organization and Staffing	There are few, if any, tools in place that allow for expansion of staffing during a major event. There are little to no training tools available.	There are some tools in place that allow for expansion of staffing during an event, but mostly rely on internal staff. There are informal exercises in place to train new staff.	There are tools in place that allow for expansion of staffing levels—internal, partner agencies, and volunteers—during an event. Training tools are reassessed after each event for future responses. There are formalized exercises in place to train new staff.	Response tools are common practice and allow for expansion of staffing levels—internal, partner agencies, and volunteers—during an event. Training tools are reassessed frequently, and all relevant staff participates in these exercises.
Collaboration	The After-Action Review (AAR) includes some key, internal staff. There is limited partnership between agencies.	The AAR includes a few agencies. There is some partnership to balance responsibilities and information sharing.	The AAR includes most agencies involved. There is strong partnership to balance responsibilities and information sharing.	The AAR includes all agencies involved. Strong partnerships exist between agencies and are not dependent on individuals. Agency partnerships leverage well-coordinated information sharing.

ACTIVE WORK ZONE MANAGEMENT/PLANNING FOR OPERATIONS				
Definition: **Active Work Zone Management (AWZM) / Planning for Operations** integrates coordination efforts between planning, programming, project development, design, construction, and operations to ensure NCDOT is effectively employing active traffic management or TSMO strategies that align with the objectives of safety and mobility. It includes program delivery and active work zone management.				
	What is placing us in our current tier?		**What is keeping us from advancing to the next tier?**	
	• Evolving traffic management plans with room to grow • Using more innovative contract mechanisms for smart work zone technologies • Using performance measures for data driven decisions • Partnering with SHP and law enforcement through HAWKS program and MOUs • Updating Incident Management Plans to reflect the integration of TSMO • Providing incident management, emergency traffic control, to expedite roadway clearance within major work zones • Using innovative integrated corridor management (ICM) systems or other smart technologies in major work zone areas • Use performance measures to inform and drive decision making		• This service layer is not at full institutionalization across the agency • Need more outreach to build knowledge across department and agency • Need process for evaluating the effectiveness of technologies • Inconsistent investments across the state in technologies to support work zone management • Formalized training program for work zone management does not exist • Communication network reliant on Internet Service Providers (ISPs) for remote access • Limited staffing and lack of knowledge creates gaps between local agencies and NCDOT • Ad hoc approach to evaluate the effectiveness of existing and new technologies • Limited high-level plan for investments in future infrastructure, particularly fiber and cameras	
	Level 1	**Level 2**	**Level 3**	**Level 4**
Business Processes	Agency has business processes to address system engineering processes and AWZM on a superficial level. Agency considers the fragmented processes ancillary to other agency activities.	Business processes encourage and support some system engineering processes and AWZM on big projects, but application across the agency tends to be uneven and champion driven.	Business processes align and institutionalize AWZM efforts and system engineering processes throughout the organization.	Business processes focus on continuous improvement of institutionalized AWZM efforts and system engineering processes with upper agency management support.
Systems and Technology	Use of technology and systems to address AWZM and transportation management needs generally does not occur.	Procedures to encourage and plan for the use of systems and technology to support AWZM and other technologies to transportation safety and mobility impacts exist, but their application is uneven across the agency.	Use of systems and technology to mitigate transportation safety (particularly in work zones) and mobility impacts as needed is well institutionalized across the agency, but the effectiveness of such use is unknown.	Program regularly evaluates and optimizes planning for integration of processes to use systems and technology to support AWZM and other strategies to mitigate work zone safety and mobility impacts to improve effectiveness
Performance Measurement	Performance measures are non-existent or only output based for WZM and TSMO strategies. Performance measures for planning for operations are non-existent or only output based.	NCDOT has established some outcome-based performance measures. Program occasionally uses measures to make improvements in AWZM and for guide planning level decisions for TSMO strategies.	Program measures outcome-based performance at both project and programmatic levels and uses results to make strategic improvements in AWZM and TSMO strategy implementations.	Program regularly reviews and improves institutional processes that ensure comprehensive planning for technologies and the integration of TSMO within AWZM.
Culture	Stakeholders limit their perceived value of TSMO integration and AWZM efforts throughout the agency, and do not highly regard the efforts to innovate and improve the Program.	Agency emphasizes the value of integrating TSMO at all phases of the project and the impacts AWZM efforts, but unevenly adopts and supports innovations to address safety and mobility through TSMO and AWZM.	Agency establishes TSMO and AWZM as core values across the agency and systematically encourages innovation to integrate TSMO strategies and improve AWZM. Agency documents successes and shares internally and externally.	Processes in place to encourage TSMO innovation and AWZM strategies; Agency regularly reviews processes and improves as needed.
Organization and Staffing	Agency has limited to non-existent efforts to identify, develop, retain, and enhance workforce skills.	Some workforce knowledge, skills development, and retention does occur, but implementation is uneven across the agency to support TSMO integration in project development and AWZM.	Agency institutionalizes the workforce knowledge and skills development, retention, and enhancement across the agency to support TSMO integration in project development and AWZM.	Agency regularly reviews processes for developing, retaining, and enhancing workforce knowledge and skills and improves as needed to support TSMO integration in project development and AWZM.
Collaboration	Coordination and collaboration with external entities on systems engineering processes and AWZM are non-existent or occur in an ad-hoc manner.	Processes to encourage coordination and collaboration with external entities on TSMO efforts and AWZM exist throughout the agency, but adoption is uneven.	Agency institutionalizes processes that strategically encourage coordination and collaboration with external entities on TSMO strategies and AWZM throughout the agency.	Agency regularly reviews processes that strategically encourage coordination and collaboration with external entities on TMSO strategies and AWZM efforts and improves as needed.

DATA PURCHASE (PROBE DATA)				
Definition: **Data Management** includes all activities related to collecting, storing, and using data. It also addresses procedures around data security, integration, and resiliency. Data collection should be efficient and effective; analysis should support an overall performance management program, and efforts should clearly align with achieving the agency's identified objectives.				
	What is placing us in our current tier?		**What is keeping us from advancing to the next level?**	
	• There are multiple mature datasets that exist internally to NCDOT • There are multiple private sector data providers under contract with the department • Third-party data providers partnering with NCDOT to optimize their data • There is an existing publicly available API of NCDOT's dataset		• TSMO Program does not audit and refine datasets based on business needs • There are limited processes for data validation • Data processing can delay the availability of datasets • Data assessment and decisions are ad hoc (AAR, post-event) • Need for a single ATMS software to replace the multiple platforms that currently collect and assess date.	
	Level 1	**Level 2**	**Level 3**	**Level 4**
Business Processes	There are no formal guidelines on how NCDOT acquires, stores, and shares data. Contracts with private sector data providers are ad hoc.	TSMO Program has no formal guidance on how to acquire, store, or share data internally. Contracts with private sector data providers reflect agency needs.	There is formal guidance on how and where NCDOT acquires, stores, and shares data both internally and externally. Contracts with private sector data providers align with agency objectives.	Agency institutionalizes guidance on how and where to acquire, store, and share data, both internally and externally. Agency integrates contracts with private sector data providers.
Systems and Technology	There is a lack of awareness of the existing data for both internal and external use. Maintenance is corrective, not preventative.	The data is not easily accessible and housed in multiple locations at the agency level. Maintenance may occur occasionally. TSMO Program segregates individual datasets.	NCDOT houses data in multiple locations at the agency level but easily accessible by partner agencies. Maintenance of the data systems occurs often. TSMO Program integrates some datasets.	The data is well-integrated and housed in a single location that is easily accessible by multiagency staff. Data repository undergoes routine maintenance. Redundancy of central data supports continuity.
Performance Measurement	Data is not readily available to inform data-driven decisions. NCDOT does not validate the data through a formal process.	NCDOT occasionally uses data to inform decisions. There is a lag in accessibility for the most recent data. Data validation occurs on an individual level.	The data supports data-driven decisions that align with agency goals. There is a data validation process in place.	The data is comprehensive and supports data-driven decisions that align with multiagency objectives. There is a well-integrated data validation process.
Culture	Leadership does not recognize the value of acquiring, purchasing, or investing in new or existing data sources. The data acquisition process is not well-funded to keep up with agency needs.	Leadership seldom recognizes the need to acquire, update, and validate data sources. With limited resources, agencies must "make-do" with available information.	Leadership understands the need for more funding to acquire relevant and recent data. The agency has some funds to invest in new data tools or sources.	Leadership advocates for more funding to further the available data for multiagency use. The agency actively invests in using and purchasing the latest data sets.
Organization and Staffing	There is informal training on where and how NCDOT houses internal and external data.	There is some training that provides all internal staff with knowledge of where to find data. There may be some informal guidance on validating sources internally and externally.	NCDOT updates training to reflect the latest data management processes and encourages staff to take it. Agency leadership encourages the use of cross-cutting data sources.	Agency leadership actively invests time and resources to promote new efficiencies. NCDOT encourages staff to participate in training. NCDOT updates training frequently to reflect enhanced processes.
Collaboration	Agencies maintain individual datasets focused on their individual objectives.	Some internal and external coordination occurs for data alignment and limited data integration. Individual agencies coordinate data security and data management protocols.	Significant internal and external coordination occurs for data integration. Some consistency in data security protocols.	There is multiagency consistency in data security protocols and data management. TSMO Program uses cross-cutting performance driven decisions in the larger interest of the agency or region.

Appendix B: Working Group Members by Service Layer

The following individuals were at the workshops and provided input into the service layer development for each core function area.

Traffic Management Center Working Group Members

Title	Name
State Traffic Operations Engineer	Dominic Ciaramitaro
Regional ITS Engineer	Jeff D'Arruda
Deputy Division Traffic Engineer – Signal Unit/IMAP	James Flowers
Highway Division 13 Regional ITS Engineer	Chad Franklin
Statewide Planning and Programming Manager	Joe Furstenberg
Statewide Operations Manager	Bryan Gunter
State Transportation Systems Management & Operations Engineer	Meredith McDiarmid
State Traffic Systems Operation Engineer	Jennifer Portanova
STOC Project Director	Michael Varner
Triad Regional TMC Operations Engineer	Mike Venable
ITS Operations Engineer	Steve Wardle
Traveler Information Engineer	Kelly Wells
STOC Traffic Engineer	Courtney Weeter

Traffic Incident Management Working Group Members

Title	Name
State Traffic Operations Engineer	Dominic Ciaramitaro
Regional ITS Engineer	Jeff D'Arruda
Deputy Division Traffic Engineer – Signal Unit/IMAP	James Flowers
TIM Deputy Project Manager	Amanda Good
Assistant Division Traffic Engineer	Allen Hancock
TIM Regional Coordinator	Doug Hayes
Division 4 Safety Officer II	Tracey Helms
Division 4 Safety Consultant	Debbie Leonard
State Systems Operations Engineer	Jennifer Portanova
TIM Regional Coordinator	Durwin Rice
TIM Statewide Coordinator	Wayne Taylor
Deputy Division Traffic Engineer	Todd Lewis
TIM Program Manager	Jeff Dale

Traveler Information Working Group Members

Title	Name
NCDOT Statewide Operations Manager	Bryan Gunter
NCDOT Chief Engineer's Office	Michelle Long
NCDOT State Transportation Systems Management & Operations Engineer	Meredith McDiarmid
NCDOT State Traffic Systems Operations Engineer	Jennifer Portanova
NCDOT Social Media Coordinator	Aaron Schoonmaker
NCDOT STOC Traffic Engineer	Nathan Webster
NCDO STOC Traffic Engineer	Courtney Weeter
Traveler Information Engineer	Kelly Wells

ITS and Communications Working Group Members

Title	Name
NCDOT Engineering Applications Development Manager	David Alford
NCDOT State Signals Engineer	Meghan LeBlanc
NCDOT State Traffic Operations Engineer	Dom Ciaramitaro
NCDOT Mountain Regional ITS Engineer	Chad Franklin
NCDOT Signal Communications Project Engineer	Gregg Green
NCDOT State Transportation Systems Management & Operations Engineer	Meredith McDiarmid
NCDOT State Traffic Systems Operations Engineer	Jennifer Portanova
NCDOT ITS Operations Engineer	Steve Wardle
NCDOT Division 1 Signal Supervisor	Madison Phillips
Technical Advisor	Cole Dagerhardt
Technical Advisor	Roberto Perez

Emergency Response and Resiliency Working Group Members

Title	Name
State Traffic Operations Engineer	Dominic Ciaramitaro
Disaster Recovery Engineer	Keith Billy
Statewide Operations Manager	Bryan Gunter
Assistant Division Traffic Engineer	Allen Hancock
Eastern WZTC Engineer	Don Parker
State Traffic Systems Operation Engineer	Jennifer Portanova
Engineer III	Charles Smith
TIM Statewide Coordinator	Wayne Taylor
STOC Project Director	Michael Varner
ITS Operations Engineer	Steve Wardle
STOC Traffic Engineer	Nathan Webster
STOC Traffic Engineer	Courtney Weeter
Traveler Information Engineer	Kelly Wells

Arterials and Signals Operations Working Group Members

Title	Name
State ITS & Signals Management Engineer	Matt Carlisle
State Traffic Operations Engineer	Dominic Ciaramitaro
Division Traffic Engineer	J.P. Couch
Senior Systems Engineer	Mohamed Deen
Statewide Planning and Programming Manager	Joe Furstenberg
State Signals Engineer	Doumit Ishak
Highway Division 14 Deputy Division Traffic Engineer	Eric Lovedahl
State Transportation Systems Management & Operations Engineer	Meredith McDiarmid
State Traffic Systems Operation Engineer	Jennifer Portanova
*State Signal Systems Engineer	Meghan LeBlanc

Planning for Operations Working Group Members: Active Work Zone Management

Title	Name
State Traffic Operations Engineer	Dominic Ciaramitaro
Work Zone Traffic Control Engineer	Zachary Clark
Highway Division 13 Regional ITS Engineer	Chad Franklin
Regional Traffic Incident Management Coordinator	Michael Hayes
Central Work Zone Traffic Center Design Engineer	Chris Howard
State Traffic Management Engineer	Joseph Hummer
State Traffic Systems Operation Engineer	Jennifer Portanova
Regional TIM Coordinator	Durwin Rice
*Senior Traffic Operations Engineer	Eric Thomas
TIM Program Manager	Jeff Dale

Appendix C: Existing Conditions

1 Existing Functions

1.1 Traffic Incident Management (TIM)

Traffic Incident Management (TIM) is defined as the systematic, planned, and coordinated use of human, institutional, mechanical, and technical resources to reduce the duration and impact of incidents, and improve the safety of motorists, crash victims, and incident responders. TIM resources focus on increasing the operating efficiency, safety, and mobility of the roadway network by decreasing the time required to detect, verify, and respond to an incident. This includes the implementation of strategies such as quick clearance, advanced on-scene management, and improved relationships with all incident responders.

Some key activities related to TIM are listed below with additional detail provided in the following sections.

- **Incident Management Assistance Patrol (IMAP).** NC's safety service patrol that supports safe, quick clearance of incidents and debris in coordination with law enforcement and other first responders. IMAP also proactively prevents incidents by assisting with the removal of disabled/abandoned vehicles and debris in the roadway.
- **Coordination with Emergency Responders.** On-scene coordination involves effective communication between all partners. This communication is built through relationships and learning about each other's roles through multi-discipline training, team meetings, after action review meetings.
- **Towing Program.** NCDOT implemented an incentivized program to safely and quickly clear incidents in partnership with towing and recovery professionals. Although currently focused on major work zones, there are plans to expand the program during adverse weather and in other critical areas across the state.

1.1.1 Incident Management Assistance Patrol (IMAP)

One of NCDOT's most visible and effective congestion management resources are IMAP Responders, which serve as a first line of support on NC freeways. Since the initial deployment, the IMAP program has evolved from aiding motorists with minor tasks such as tire changes and fuel assistance into a formalized program supporting first responders through responsibilities such as providing emergency traffic control (ETC), supporting on-scene management, and encouraging quick clearance. In 2010, the IMAP Program established standardized training to facilitate statewide consistency for incident response and emergency traffic control applications.

Although IMAP Responders are classified as transportation workers (TWs), their training and job responsibilities require a higher level of knowledge, skills, and abilities. In fact, NCDOT recently completed a reassessment of their Transportation Worker Program (2021), resulting in two classifications: TWII (Responder) and TWIV (Senior Responder). NCDOT will be working to revise the IMAP responder classification to emergency responder based on the nature of IMAP's job duties, working environment, and relationship to incident management.

IMAP's primary function is to help manage and expedite the safe clearance of crashes and other incidents along major corridors in the state. In an effort to minimize the potential personal injury and/or economic loss associated with disruptions to the regular flow of traffic, the North Carolina Legislature passed General Statute 20-161(f) authorizing the immediate removal of vehicles and/or property which

interfere with the regular flow of traffic or otherwise constitute a hazard on the State highway system, known as “Quick Clearance.”

To support this effort, NCDOT and NCSHP partnered to establish a memorandum of understanding (MOU) that provides guidance and outlines specific authority, responsibilities, and obligations to implement “Quick Clearance.” The MOU establishes blanket concurrence between NCDOT and NCSHP to allow IMAP to immediately move minor incidents such as abandoned or disabled vehicles and minor crashes out of the roadway before law enforcement arrives. When applying Quick Clearance strategies and in the absence of gross negligence, this “hold harmless provision” protects NCDOT, its delegates, and NCSHP from criminal and civil liability.

Clearing the roadway safely and quickly provides a tremendous benefit to motorists. A 10-minute reduction in clearance times was realized when IMAP responders deployed on I-95. A 10-minute reduction in clearance times was realized when IMAP Responders deployed on I-95. The reduction of congestion and improvements in safety by minimizing the likelihood of secondary crashes are additional benefits of quickly clearing the scene of an incident. IMAP also clears disabled motorists more efficiently from the roadway by changing flat tires, jump starting vehicles, providing small quantities of fuel, and many other safety-oriented tasks.

In 2021, IMAP assisted over 50,000 motorists. IMAP Responders patrol over 850 miles of freeways across the state. **Table 1** provides a breakdown of IMAP stops by month for 2021. Many of these stops require IMAP to install Emergency Traffic Control (ETC). While NCDOT is maximizing the current allocation of IMAP resources, an additional complement of responders is necessary to effectively provide the ideal level of service. The impact from a lack of IMAP resources is particularly noticed on some major roadways (e.g., I-485), during peak travel times, and during significant weather events such as hurricanes and winter weather.

Table 1. IMAP Stops by Month and Type in 2021

	Vehicle Removal	Vehicle Fire	Disabled Vehicle	Debris	Crash	Abandoned Vehicle	Grand Total
January	80	22	1,403	287	668	702	3,162
February	103	17	1,620	367	711	795	3,613
March	92	23	1,880	351	810	839	3,995
April	104	31	1,974	458	829	815	4,211
May	108	20	2,197	517	891	927	4,660
June	111	23	2,193	501	969	945	4,742
July	123	34	2,086	482	912	894	4,531
August	136	22	2,488	506	846	1,053	5,051
September	93	24	2,126	359	930	989	4,521
October	99	28	2,163	383	972	946	4,591
November	109	22	2,035	378	809	974	4,327
December	99	17	1,789	322	785	806	3,818
Grand Total	1,257	283	23,954	4,911	10,132	10,685	51,222

1.1.1.1 IMAP Structure

IMAP is currently deployed in 8 of the 14 Divisions in North Carolina. The staffing levels and responsibilities of each IMAP team may vary slightly and are influenced by the geographic features, division structure, and local needs of each Division. Despite these variations, the primary intent and responsibilities of each IMAP Responder should be consistent statewide.

Today, IMAP patrols over 850 centerline miles in those 8 Divisions. IMAP Routes are determined through an analysis of multiple data points including:

- Average of weekday traffic volumes,
- Frequency of crashes and incidents,
- Recurring congestion levels during the AM/PM peak hours, and
- Seasonal traffic patterns that generate peaks around weekends or significant events

An ideal IMAP route has a high frequency of crashes or congestion, is bookended with safe, designated turn-around points responders, and can be patrolled within a timeframe that aligns with the needs while minimizing responder patrol overlap.

Hours of operation and staffing levels for each shift are managed by the Division or Region, but there are typical approaches. Generally, the route is patrolled by one responder for one continuous shift. A standard shift may be extended beyond typical hours to accommodate:

- Responders remaining on scene until an incident has cleared and all responders have left the scene,
- Special events, weather events, or weekend hours,
- Construction activity, or
- Shifting to a different geographic location within the state to support the additional needs in that Division/Region (typically due to a weather event).

Staffing levels of IMAP in each region vary slightly and are influenced by geographical location and local input from the Division or Region. Routes are managed at the Division or Region level and are determined based on regional factors. Each Division or Region has at least one supervisor, larger, some Divisions or Regions have more due to the number of IMAP Responders or number of shifts. Each Division or Region has at least one supervisor; larger compliments may have more. The IMAP Supervisors report to an Incident Management Engineer (IME) or another position with similar responsibilities.

Rural areas typically have smaller IMAP fleets and cover fewer route miles whereas urban areas cover a higher quantity of route miles. Based on this logic, rural IMAP fleets should be 50/50 split of TWII and TWIVs. Urban areas should be 70/30 TWII to TWIVs split. The total number of responders for each Division depends on need, Division partnerships, and available positions.

Coordination between IMAP and the STOC/TMC operators is vital for IMAP Responders and Supervisors in terms of yearly performance evaluations. During the annual Valuing Individual Performance (VIP) process, IMAP Responders are evaluated on the timeliness of their response following notification, and timeliness of the overall incident clearance from the roadway. IMAP supervisors are evaluated on how well the Region performs in the two previously mentioned categories. After each incident, operators in

the STOC/TMC are required to document these times so this data can be provided in a report for use during the VIP cycles.

1.1.1.1.1 Areas of Patrol

Currently, IMAP patrols major areas within the Triangle, Triad, Metrolina, Mountain, and Coastal Regions, as well as along the I-95 corridor. **Figure 1** provides an overview of the IMAP route coverage in NC. Each Division and Region is responsible for managing their hours of operation and identifying additional resource needs. IMAP routes can be classified as patrolled routes or response routes. Patrolled routes are assigned a responder to patrol a specific location during a designated shift. Response routes are portions of major roadways where IMAP can respond to incidents outside their patrol routes based on responders' location, need, and availability. Response routes are not consistently patrolled by a designated IMAP responder. IMAP coverage can be modified in preparation or in response to major weather events to provide additional coverage for motorists in areas expected to be most impacted. When IMAP resources are repositioned, Statewide is more actively involved and supports the resource balancing by facilitating lodging, designating teams, and assigning patrol routes.

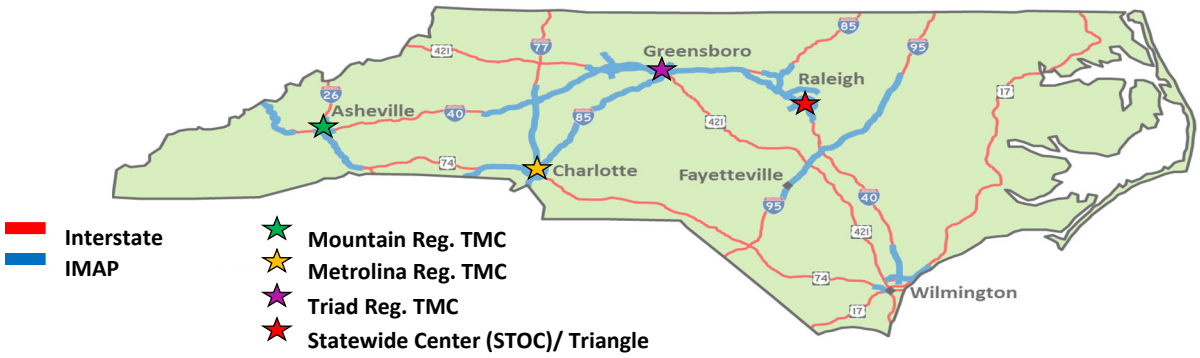

Figure 1. IMAP Routes and TMC locations

NCDOT has recently developed an IMAP Dashboard tool to provide planning-level deployment screening and benefit cost analysis support for the IMAP program. The analysis is based on specific data, like traffic volumes, crash data, IMAP events, and IMAP deployment costs. This tool is being integrated into effective data-driven decision-making processes for providing IMAP coverage across the state.

The Dashboard combines data sources and algorithms into a GIS-based web portal that provides statistics and interactive visualizations. It includes benefit-cost algorithm calculations for existing and proposed routes considering congestion, safety, and environmental benefits. There are considerations of benefits from avoided crashes, debris events, and reductions in incident clearance times. Safety benefits consider reductions in secondary crashes, and crashes due to debris events; Environmental benefits encompass emissions reductions; and cost elements encompass the cost of IMAP responders and trucks, as well as administrative costs for overseeing the IMAP fleet.

1.1.1.1.2 Training and Certifications

The IMAP Training and Certification Program provides consistency in incident management training for IMAP employees across the state. This single curriculum provides training for all roles and responsibilities of the IMAP Responders and Supervisors. The curriculum model for IMAP Responders and Supervisors follows a **learn** (in a classroom), **observe** (at the Statewide Transportation Operations Center (STOC)), **practice** (at the TIM Training and Development track), and **demonstrate** (on the road) methodology.

NCDOT is expanding the training and certification program to include two additional courses that will support continuing education for IMAP staff:

- In-Service Training – modules that will be identified and conducted annually to refresh knowledge of critical areas of operation and provide updates to best practices in procedures or new safety information and protocols
- Rehire Process – specific training and assessments required when an IMAP Responder is rehired after leaving the position for a specified period

The IMAP Certification Program goals continue to focus on:

- Risk Mitigation
- Interoperability
- Stronger Partnerships
- Enhanced Abilities
- Safety
- Consistency
- Program Maturation

1.1.1.1.3 TIM Training and Development Track

NCDOT, in partnership with the NCSHP, constructed the Traffic Incident Management (TIM) Training and Development Track (shown in **Figure 2**) in Raleigh, NC to provide an optimal training environment for the IMAP program. In 2021, the TIM Training and Development Track was awarded the National Operations Center of Excellence (NOCoE) Transportation Systems Management and Operations (TSMO) award for Agency Improvement. The track is available for use by IMAP and NCSHP personnel to practice various incident management response maneuvers in a controlled environment. Through coordination with the NCSHP, the facility also supports the ability to host multi-agency TIM training exercises. The dedicated IMAP training facility provides an environment to safely conduct field training within a simulated real-world experience and was designed to meet the following three goals:

- Safe and controlled environment
- Sufficient size for full demonstrations
- Road geometrics simulating a real-world environment

Figure 2. TIM Training and Development Track

1.1.1.2 IMAP Relationship & Culture

Since being formalized in 1991, IMAP has gained a strong contingent of support among the first responder community. IMAP's extensive training reinforces the value to the safety of incident scenes through effective traffic management strategies.

While external partners continue to support and value IMAP's capabilities, IMAP continues to struggle to find its identity as a stand-alone responder unit within the Department and is often seen as a support unit for Division and Regional maintenance activities. IMAP's specialized technical training received is specific traffic management activities. Regions lean on Division staff to support resources needs and those individuals may not have attended any technical training related to incident response and traffic management. Use of the extended staff can create risks when those individuals do not have the established relationships with other responders or the full breadth of training.

1.1.1.3 IMAP Sponsorship

The NCDOT IMAP Sponsorship Program offers an opportunity to sponsor IMAP operations in return for vehicle and signage acknowledgements. The awarded sponsor/sponsorship will generate revenue payable to the Department in exchange for signs posted along IMAP routes acknowledging the sponsor, as well as branding on the IMAP vehicles and through other promotional materials. The current contract includes a Sponsorship Amount ($785,000/year) that is guaranteed revenue for the IMAP Program as outlined in the Sponsorship Agreement.

These funds help the program in many ways by supporting IMAP training costs, supplementing the TIM Training and Development Track construction and maintenance, and supporting regional budgets (e.g., purchasing IMAP vehicles).

1.1.1.4 Safety Service Patrol Industry Association (SSPIA) and SSP Pooled Fund Study

Safety Service Patrols (SSP) are currently operated in approximately 40 states, providing valuable first responder services on the nation's most traveled roadways. SSPs save lives and generate a positive rate of return on investment for DOTs and other agencies, making them one of the most important and popular services provided to the traveling public.

The NCDOT is a charter member of the Safety Service Patrol Industry Association (SSPIA), which was formed to help promote their safety, working conditions and public awareness. The SSPIA's Mission Statement: "To improve the standardization and professionalism of Safety Service Patrols' emergency traffic response operations across the Nation, and to promote a higher level of recognition of the vital role Safety Service Patrols play in keeping our roadways safe."

NCDOT partnered with other state agencies and FHWA to establish a SSP Pooled Fund Study (PFS). NCDOT has dedicated research funds to the PFS for the next 3 years and has committed to remain engaged as a participant during the execution of the research which will kick-off in Spring 2022. The objective of the SSP PFS is to support the development of recognized industry standards by establishing tools and technical reports that identify best practices and aligns those best practices to assist organizations in addressing issues that are common among agencies that manage and operate SSPs. The SSP PFS will provide an opportunity to facilitate information sharing and documentation of the successful practices of established SSP programs. The SSPIA will partner with the SSP PFS to establish a repository of information for all existing and future agency members of the SSPIA.

The primary objective of this PFS study will be to gain technical information related to SSP program management, standards associated with SSP response protocol and the implementation of traffic

control, and references and guidance related to staffing, training, and resource allocations within SSP programs.

1.1.1.5 IMAP Strategic Pilot or Funded Projects

The TSMO program has initiated pilot deployments with the use of Statewide Transportation Innovative Council (STIC) funding of emergency vehicle alerts and unmanned aerial system. These pilots are in partnership with IMAP to vet the applicability of innovative solutions and how they can better support some of the program's needs. During this deployment, the Program will be evaluating whether the solutions will further increase the program's overall efficiency and effectiveness.

Emergency Vehicle Alert (EVA)/Unmanned Aerial Systems (UAS): Both devices are being piloted within the NCDOT IMAP program. EVA devices are intended to increase compliance with the State's "Move Over" law G.S. 20-157 (f) by increasing motorist awareness of the presence of IMAP Responders on NC roadways. EVA devices increase awareness of active IMAP vehicles to the traveling public in real-time using GPS location and communication technology. The current responding vehicle's location information is collected and disseminated to DriveNC.gov and to third party navigation companies such as Waze. Additionally, any system ingesting the DriveNC.gov API will also receive this data set.

Tethered UAS (drones) are equipped with high resolution cameras and provide capability to capture and stream live video feeds to the STOC/TMCs. Those feeds can also be shared with partner agencies on-scene and at remote locations to further increase situational awareness. In some cases, IMAP routes cover portions of roadway with limited or no CCTV camera coverage. Increased awareness from the remote video from the tethered drones will improve the response by allowing agencies to dispatch appropriate resources, monitor queue lengths, and adapt traffic control in response to the evolving crash scene.

1.1.2 Coordination with Emergency Responders

NCDOT continues to build relationships with emergency responders across the state. These established relationships help coordinate strategies that prepare, mitigate, manage, and recover during incidents. The coordination between partners during an incident is fast paced, demanding, and has a level of uncertainty. By knowing the roles and responsibilities of those who are on-scene, responders can support a safe and successful management of the incident. Training, team meetings, after action reviews, and resource manuals support this coordination.

- Multi-Discipline Training. The TIM Training and Development Track was developed to include various road features from across the state that allows for realistic training. The multi-disciplinary training provides the opportunity to train fire, law enforcement, emergency medical services (EMS), IMAP, and towing companies on how best to clear and control the scene together. This training is done at a facility that provides a safe place to learn, practice, and show trainers they have grasp of the concepts before going into live traffic.
- Team Meetings. Team Meetings provide a forum for building relationships, sharing information, and ultimately improving TIM processes that are executed by response agencies in the field. They are a valuable coalition-building strategy to promote the "3 Cs" of TIM: Communication, Collaboration, and Coordination. Team Meetings should be managed by the local champion, typically an IME, Regional ITS Engineer, Safety Engineer, Division Traffic Engineer (DTE), County Maintenance Engineer (CME), or locally defined designee.
- After Action Reviews. Local designees help coordinate after-action reviews (AARs) to discuss and improve responses to major incidents in their Regions. AARs provide a forum for NCDOT, first

responders, and other partner agencies to review their response and effectiveness following a specific event.

- Incident Management (IM) Manual. The Incident Management (IM) Manual is intended to document key aspects of incident management, noting the ins-and-outs of how to do these defining fundamental processes. The IM Manual is a guide for those new to incident management and is designed for Incident Management Engineers (IME) or those directly involved with incident management. Ensuring statewide understanding and consistency of the TIM program is vital to efficient and effective incident management response across the state.

1.1.3 Towing Program

NCDOT Performance Based Tow Contracts are incentivized light-duty and heavy-duty wrecker operations that are designed to support safe, quick clearance practices. NCDOT executes contracts with prequalified private towing firms that include monthly service fees and opportunities for incentives and disincentives (refer to **Figure 3**). This provides towing services that are readily available to clear the roadway network of incidents. The contracts are primarily implemented in and around construction zones that are expected to have a significant impact to the roadway network.

Table 4 Heavy Duty Performance Measures, Requirements, and Compensation

HEAVY DUTY		Response Time (minutes)		Immediate Removal Times (minutes)				Disincentive
Incident Classification		20 or less	>20	Incentive Threshold	Incentive Amount	Maximum Immediate Removal Time	Maximum Removal Time	*Applies when Response Times, Removal Times, and Immediate Removal Times are not met.*
Category	Type							
Minor	Hazard	Req	Infraction	NA	NA	NA	60 (CFS)	Infraction
	Crash	Req		NA	NA	NA	60 (NTP)	Infraction
Inter.	Hazard	Req		NA	NA	45 (CFS)	NA	Infraction
	Crash	Req		<30 min.	$2500	60 (NTP)	NA	$250 per 15m and Infraction
Major	Hazard	Req		NA	NA	60 (CFS)	NA	Infraction
	Crash	Req		<75 min.	$5000	120 (NTP)	NA	$250 per 15m and Infraction
Notes	CFS – (Call for Service) Hazards will not need a NTP so Immediate Removal Time begins at initial CFS) NTP – Notice to Proceed Hazard Type – Vehicles that are not involved in crash but are disabled, in a hazardous location, improperly parked or abandoned. Hazard Type also includes debris or lost cargo. Hazard Type Incidents are ineligible for incentives.							

Table 5 Maximum Removal and Intermediate Removal Times for Heavy Duty Incidents

Heavy Duty Incident Type	Removal Time
Minor – Crash	within 60 minutes of receiving Notice to Proceed
Minor – Hazard	within 60 minutes of receiving the Call for Service
Intermediate – Crash	within 60 minutes of receiving Notice to Proceed
Intermediate – Hazard	within 45 minutes of receiving the Call for Service
Major - Crash	within 120 minutes of receiving Notice to Proceed
Major – Hazard	within 60 minutes of receiving the Call for Service

Figure 3. Project Special Provision for Towing Contracts

Towing contracts are funded directly through NCDOT construction projects for which they are targeted. By having a contract with one responsible tower, NCDOT can dispatch towers as soon as an incident has been detected. In traditional law enforcement rotation wrecker systems, standard procedure is to dispatch the tower after law enforcement personnel arrives on scene and verifies the need for a tow. The time savings between dispatching a tower upon first learning of an incident as opposed to waiting until after law enforcement confirms the need for a tow can be significant. The sooner a tower is notified, the quicker they can respond and help mitigate the impact an incident will have on the motoring public.

The most significant benefit of the towing contracts to the public is a reduction in incident clearance times which results in less time and fuel expenses realized when not sitting idle in traffic. Clearing incidents more quickly reduces the likelihood of a secondary incident. NCDOT's law enforcement and first responder partners greatly value the benefits of tow contracts as they lessen the on-scene time commitment and exposure to the hazards of traffic.

NCDOT has a goal to expand the program beyond construction projects to address critical corridors to facilitate the safest and most efficient clearance of large-scale incidents, using performance-based

contracting. One example is NCDOT developing protocols for emergency tow contract to support similar efforts during adverse weather. This would extend the limits incentivized towers can respond and allow other areas to coordinate resources where no towing contract currently exists. These tools will help NCDOT to quickly respond and clear vehicles and mitigate the risks of vehicles on the shoulder or blocking lanes.

1.2 Traffic Management Centers (TMC)

An effective traffic operations program provides value to the department and the public by addressing recurring and non-recurring congestion, improving safety, and optimizing capacity. In keeping with NCDOT's mission for an integrated transportation system for improved safety and mobility for travelers, a regional approach to transportation operations is recommended. The diverse Regions in NC warrant the need for local TMCs that can more easily and efficiently respond to local needs. The Regional TMCs can establish local experience and relationships that allow the Department to more quickly detect and respond to incidents and manage events.

The STOC is the hub for coordination between Regions, Divisions, other states, partner agencies, and first responders and focus on statewide impacts, while allowing TMCs to focus locally on traffic management. STOC provides a consistent one point-of-contact for NCDOT that all emergency responders can use and receive a consistent response regardless of staff changes within NCDOT. STOC/TMCs coordinate with other agencies with an interest in the safe and efficient operation of interstates, arterials, and local roads. The structure of the Regional TMCs allows the TMCs to address traffic management related to congestion, planned and unplanned events, and work zones. The STOC/TMCs also provide oversight of evacuation demands in response to large weather events.

1.2.1 TMC Structure

NCDOT currently maintains one statewide and 4 Regional TMCs that are each staffed by a team of operators responsible for monitoring traffic conditions and detecting incidents; initiating and coordinating response efforts (including IMAP dispatch); and providing traveler information to motorists (refer to **Table 2**). The STOC is the only center in NC that operates 24x7x365. STOC is responsible for coordinating events that affect multiple Regions or multiple states. ITS and other tools are essential to the day-to-day function of each of these centers. Together all TMCs support consistent and redundant operations and TIM responsibilities across the state.

Table 2. Current TMC Structure

TMC	TMC Location	Operational Hours	# of Shifts	Coverage Area
STOC Triangle TMC NCTA	Raleigh	*24/7 x 365*	3	Division 5, Triangle Expressway, I-95, additional counties outside other rural Regions not supported by a Regional TMC
*Metrolina TMC** NCTA	Charlotte	*Monday-Friday 5:30am-9pm*	2	Division 10 & 12, Monroe Expressway. Boundaries align with travel and commute patterns aligning with their urban centers
Triad TMC	Greensboro	*Monday-Friday 5:30am-9:30pm*	2	Division 7 &9. Boundaries align with travel and commute patterns aligning with their urban centers
Mountain TMC	Asheville	*Monday-Friday 6am-10pm*	2	Division 13 & 14. Western portion of NC, west of Old Fort

**I-77 Mobility Partners manage operations mile marker 11 - 37*

1.2.1.1 NC Turnpike (NCTA) TMC Support

NCTA's TMC responsibilities are provided by STOC and Metrolina Regional (MRTMC) operators from 6AM to 10:30PM, Monday-Friday. These operators provide support functions that include, but are not limited to:

- Monitoring incidents and travel conditions on tolled roadways,
- Advising NCTA operators of incidents/requests affecting tolled roadways, and
- Coordinating with NCTA operators in response to incidents affecting tolled roadways.

Outside of NCTA's operating hours (i.e., 3rd Shift, M-F, and weekends), the STOC is primarily responsible for maintaining NCTA functions that include, but are not limited to:

- Traffic and incident management for the Triangle Expressway,
- Monitoring NCTA ITS devices and toll equipment and reporting malfunctions,
- Responding to Reverse Vehicle Notifications (RVN), and
- Documenting activity and sending Shift Summaries to NCTA TMC personnel.

1.2.1.2 Regional TMC Importance

A large portion of the urban highways managed in NC traverse the metropolitan "crescent" which starts in the Metrolina area, heading northeast through the Triad region, and ending in the Triangle. Beyond this crescent, NC has the western and eastern areas of the state that include several medium-sized cities and unique geographical features. Current technology could allow the entire transportation system to be managed from a single location; however, the benefits of the local presence at the regional level includes stronger relationships with TIM partners such as IMAP and first responders and a better understanding of the local infrastructure. These relationships are foundational to achieving successful results in traffic operations.

Furthermore, a Regional TMC approach provides a closer view of each region's opportunities for growth and impact. The collection of TMCs will support a comprehensive statewide view of the program's potential. This closer look provides the capacity to perform assessments on local routes, local partnerships, and local challenges and prioritize areas of focus relative to the potential impact.

STOC and. Regional TMC: TMC functions are also closely coordinated between statewide and regional roles. Statewide staff manage responsibilities within the STOC, while Regional TMC functions are managed locally at the regional level with close collaboration with the STOC. In fact, the STOC assumes current operations from the Regions after standard hours of operation. Each TMC and the STOC perform day-to-day traffic management functions related to both recurring and nonrecurring congestion. These daily responsibilities and the application of SOPs prepares the TMCs and the STOC for handling major incidents when they occur. An overview of the STOC/TMC responsibilities includes:

- Actively monitor and support the delivery of congestion and incident management strategies
- Work to detect, confirm, and coordinate with first responders during major incidents
- Provide surge capacity support and coordination for emergency operations and adverse weather
- Dispatch IMAP units across the state
- Deliver real-time information to the public through Dynamic Message Signs (DMS) and Traveler Incident Management System (TIMS)
- Conduct daily checks of ITS devices

1.2.2 TMC Tools

With over 80,000 miles of roadway to manage in NC and 285,074 crashes reported in 2019 and 247,214 crashes reported in 2020, the TMCs use a host of tools to monitor, support, and provide public information for congestion, crashes, special events, work zones, weather events, and more. Those tools include:

Surveillance Tools for Situational Awareness

- Permanent and portable closed-circuit television (CCTV) cameras
- Vehicle Probe Speed Data
- NCSHP and other Law Enforcement Computer Aided Dispatch (CAD) Feed
- Probe Speed Data Maps
- VIPER Radio
- WAZE, Google Maps, etc.
- Media
- Direct contact (e.g., email or phone call) from other stakeholders (Police Department, Sheriff's Office, County Emergency Management, NCDOT Maintenance, Resident Engineers or Construction Contractors, etc.)

Traveler Information Tools

- Permanent DMS and portable changeable message sign (CMS)
- Traveler Information Management System (TIMS) and DriveNC.gov
- WAZE, Google Maps, Bing Maps

1.2.3 TMC Strategic Pilot or Funded Projects

The TSMO program has initiated some focused projects to support innovation and to address some identified gaps. This includes a project that is intended to further increase the program's overall efficiency and effectiveness and a pilot deployment to vet the applicability of specific solutions.

Advanced Transportation Management System (ATMS): NCDOT is currently in the process of procuring a statewide ATMS software. ATMS software provides a consolidated interface for agencies to operate, monitor, and manage ITS devices to support the real-time management of roadways. NC is one of the only states in the US that does not have a statewide ATMS software platform in place. ATMS software provides benefits such as:

- More efficient control of ITS devices,
- Interoperability and redundancy between facilities,
- Coordinated incident management response plans,
- Support emergency management and special events management,
- More consistent statewide traveler information,
- Improved collaboration through customized notifications,
- Well supported performance-based decisions through consistent reports,
- Consistent incident management activities via ATMS operational checklists, procedures, and response plans, and
- System expandability and interoperability for future transportation management solutions and partners

1.3 ITS Operations

NCDOT has invested millions of dollars over the past several decades in ITS infrastructure across the state. These investments have had an enormous, positive impact on transportation operations through several performance metrics including reduced congestion, reduced travel times, reduced crashes and resulting fatalities, and enhanced emergency management collaboration. Most recently, NCDOT was awarded a grant to install a significant amount of broadband communications that will double the fiber network footprint in the state as well as manage the maintenance of that fiber and ITS devices directly connected to it. At the same time the existing field equipment is aging at a rate that is outpacing the resource capabilities to maintain and replace.

1.3.1 ITS Field Devices

Most of the ITS infrastructure has been constructed as a partnership between TSMO Unit and the Divisions as part of Transportation Improvement Program (TIP) capital projects. The TIP program enabled the Department to effectively build out the statewide ITS infrastructure, one capital project at a time, over 20+ years. NC now has hundreds of miles of fiber optic cable, a private cellular communication network, and thousands of ITS devices used to gather data, disseminate traveler information, provide situational awareness, enable incident detection, and enhance emergency management.

NCDOT currently has CCTV cameras (permanent and portable), permanent DMS, portable CMS, road weather information system (RWIS), and detectors. Although some detection equipment remains, NCDOT has been supplementing speed and other data by procuring probe data from third party providers for the past ten years. **Table 3** summarizes the current inventory of permanent DMS and CCTV cameras, which are the primary devices supporting TIM activities.

Table 3. Summary of Devices

Device Type	Number	Expected Lifecycle	Percentage of Uptime	Usage of Each Device	Who uses
DMS	334	20	79%	Inform motorists of incidents, work zones, amber/missing person alerts, weather impacts to roads	View: Public, Media Control: NCDOT
CCTV Cameras	793	10	50%	Incident detection/verification, public view/media on DriveNC.gov	View: Public, Media Control: Public Agencies, NCDOT

The quantity of these devices continues to climb as NC expands the footprint and communications infrastructure. Since 2018, NCDOT has installed nearly 200 additional CCTV cameras and over 60 DMS. NCDOT is not keeping up with the maintenance needs of the devices and that challenge increases as the program expands. The Statewide Device Resiliency Contract is focused on addressing some of those pressures, but a sustained funding source will be needed for that program to address the uptime challenge represented in **Table 3**.

The permanent devices are tested daily (M-F), and an email is provided to the Divisions with the status of each device. The device uptime data is uploaded monthly to NCDOT's Performance Management Dashboard (PMD).

1.3.2 Broadband Project on I-95, US 70, and US 74

NCDOT is using an innovative procurement approach and has defined the following objectives for the Broadband Project to maximize value to the citizens and motorists of NC.

- Creating a fiber backbone for NCDOT's current and future technology needs
- Expanding the State's fiber network for universal access, including rural areas, schools, police, emergency response, and economic development
- Unlocking commercialization opportunities from excess capacity to share with the private sector

A key component of the Project's second objective aims to leverage "transportation infrastructure to support education and economic development in NC's rural communities." The grant also stated that the installation of fiber optic cabling along the corridor would significantly augment the state's broadband network access to rural Regions. This would provide significant societal benefits to these outlying rural Regions and in areas with pockets of disadvantaged communities."

As a result of the Project, NCDOT will be doubling the State's fiber network footprint for universal access by providing the private sector with the opportunity to commercialize fiber assets in rural communities. The installation of fiber for State use will allow NCDOT to partner with State Agencies such as the North Carolina Department of Information Technology (NCDIT) and support the effort to provide fiber access to rural communities where the commercialization potential for the private sector is not feasible.

NCDOT has embarked a new strategy for managing the broadband infrastructure across NC. This includes the use of an Operations, Maintenance, and Commercialization (OMC) contract for the broadband plant currently under construction. The OMC contractor is responsible for the operation and maintenance of Department's fiber infrastructure defined in their contract and the installation of any additional infrastructure necessary for commercialization purposes to support the offset of the Project costs and generate additional revenue. Key responsibilities include the following:

- Operations and Maintenance ("O&M") Services – necessary to provide operations, maintenance, repairing and corrective maintenance for fiber optic cable and related infrastructure in accordance with the applicable performance standards and requirements. O&M services are required for both the Department's assets and the commercialization assets. O&M of the commercialization assets shall be paid for by the contractor.
- Commercialization Services – necessary to commercialize the broadband and related services (i.e., Cellular Connected Vehicle Sites, towers, etc.) to offset the Department's Project costs and generate revenue for the Department. Commercialization Services include all necessary infrastructure investment, design, and construction/installation required.

TSMO will be managing the performance-based OMC contract which is the first of its kind in the state. This has necessitated the need for a more mature asset management and contract management strategy.

1.4 Traveler Information

Traveler information includes tactics that collect and disseminate information that notifies the public about disruptions to their trip. Traveler information can have a direct impact on safety for everyone on the roadway network, while also increasing the customer service experience and the credibility of the NCDOT due to the value it adds for the users of the transportation system.

Traveler information provides data relative to both planned and unplanned incidents and supports pre-trip and en-route routing decisions. It provides the traveler with knowledge regarding potential impacts to their day-to-day travel experience or vital information related to an emergency event. It also provides information regarding emergency notifications for Amber / Blue / Silver alerts and even safety messages focused on protecting the motorists. DMS are used to share this traveler information messages pertinent to the drivers on that corridor.

TIMS has been the cornerstone of NC's traveler information program since 1999 (refer to **Figure 4**). It is a distributed system that collects data from over 1,000 NCDOT employees that serve as the input users of the system and manage real time local data related to conditions of the roadways. The public facing portion of TIMS was rebranded in 2017 as DriveNC.gov but is still supported by data from internal interface to the TIMS database.

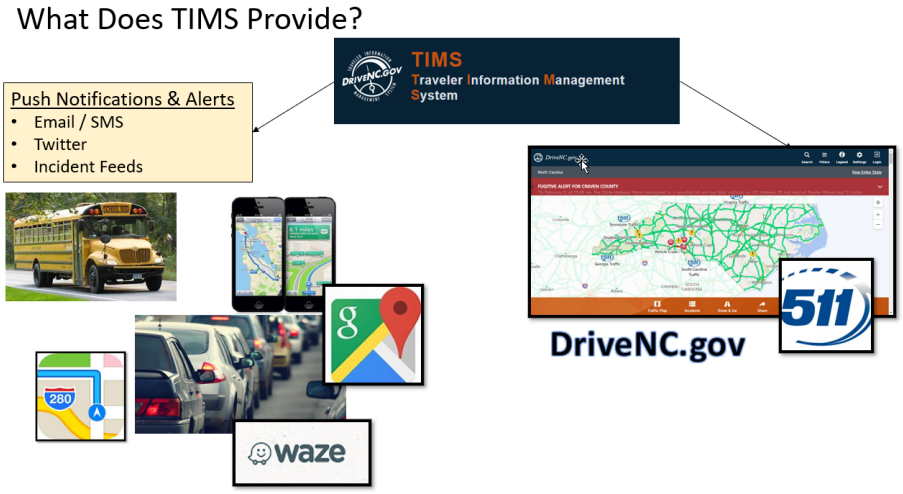

Figure 4. Traveler Information Program

In addition, NCDOT partners with third party data providers (e.g., HERE, Inrix) and navigation companies (e.g., Google, Waze) to achieve a broader set of real time data and situational awareness of the roadway network conditions. The industry is evolving, and the way traveler information is being collected, processed, and provided to the users is being continually refined. These partnerships and focus on next generation technologies support the NCDOT's ability to deliver on that customer service objective and improve safety for the public. Some recent initiatives to expand the program include:

- **I-40 Work Zone Traveler Information**: Replacing a bridge on I-40 in the mountains of NC forced NCDOT to close the interstate for several months. The challenge was that traffic queues were beginning to lengthen, and trucks were tempted to use truck-prohibited exits in advance of the work zone. Using multiple communication means, NCDOT urged trucks to use a more effective detour 50 miles before the work zone. This included DMS, Drivewyze, and coordination with Navigation providers. The effort was a success and queues were less than expected.
- **Drivewyze**: In 2021, Drivewyze customers in NC on I-95 and parts of I-40 and I-77 began receiving congestion and slow down alerts on their Electronic Logging Devices. 87,000 of these INRIX powered alerts have gone out to trucks in NC.

- **one.network**: Despite not getting a USDOT WZDx grant, NC became the first state in the US to publish a statewide WZDx feed in 2022. The NCDOT partnership with one.network made this happen at no cost to NC.
- **Streetlight Home State Analysis for Work Zone Traveler Information**: NCDOT used Streetlight to evaluate home states of travelers through 2 major work zones to decide which traveler information resources and strategies to use to minimize impacts of these work zones.
- **TIMS Upgrades**. Upgrades are planned to further evolve the data integration and accuracy of the traveler information data.
  - Automated Road Closure Report (RCR)
  - Integrated Corridor Management (ICM) tracking
  - Emergency Vehicle Alert (EVA) integration
  - Snow and Ice mapping on DriveNC.gov

1.4.1 Traveler Information Strategic Pilot or Funded Projects

The TSMO program initiated a pilot deployment to vet the applicability of the Drivewyze solution to better support some of the program needs.

Drivewyze: Drivewyze is an ITS service that provides bypass to commercial vehicles as they approach participating state highway weigh stations. Any participating vehicles' safety record, credentials, and weight are automatically verified and if they comply with the state's screening rules for automatic bypass, they are authorized to bypass the weigh station versus pulling in for a manual inspection. This helps to minimize the time and fuel a commercial vehicle spends while waiting at the weigh stations. It also helps to lower the congestion at the weigh station allowing more commercial vehicle to bypass the station as opposed to queueing as they wait for inspection. The Drivewyze bypass will work in any lane, so drivers are able to bypass avoiding the chance of crossing lanes and causing an accident.

NC has 16 sites across the state located in specific location along I-40 (Asheville/Statesville), I-26 (Hendersonville), I-77 (Mt. Airy), I-85 (Charlotte and Hillsborough), and I-95 (Lumberton area). The Drivewyze application provides notification to the driver of upcoming sites to avoid violations and minimizing accidental avoidance.

1.4.2 511 and Customer Service Center

In 2016 NCDOT moved its traveler information phone line, 511, from an automated voice response system to the NC Correctional Institute for Women (NCCIW) in Raleigh. NC Department of Commerce had created the call center at the prison to answer Travel & Tourism related calls. The call center is open Monday – Friday from 8 am to 8 pm and 8 am to 5 pm on Saturday and Sunday, with expanded operating hours during travel emergencies like hurricanes and snowstorms. NCCIW operators have answered over 200,000 511 calls and callers frequently comment on their helpfulness and courteousness.

In 2019 NCDOT added Customer Service to NCCIW Call Center's responsibility, and they routinely answer nearly 100 calls per day pertaining to maintenance, traffic, and other DOT related citizen needs. A strong partnership with the Department of Commerce and support from the Department of Corrections has made this a very successful program at a low cost to NCDOT.

1.5 Signal Systems Timing and Operations

Signalized arterial routes play a significant role in the performance of this comprehensive transportation network. Some of these arterial networks are managed through centralized signal systems that span signalized intersections on multiple corridors, but an even greater number is managed by interconnected coordinated signal systems located on a single corridor. In 2020, NCDOT was awarded the NOCoE TSMO award for Agency Improvement for modernizing and centralizing much of the traffic signal systems in smaller, rural area across the state.

Studies have shown that improving traffic signal coordination plans is one of the most cost-effective uses of transportation funds, with a consistent benefit-cost ratio of 40:1. Efficiently coordinating a set of traffic signals within a system with well-designed coordination plans can reduce travel time delays, crashes, fuel consumption, and emissions. Signal system timing work is focused on two high-level goals:

- Balancing and minimizing congestion
- Promoting smooth flow along a corridor

NCDOT has developed a process that is streamlining the signal system timing and operations program to accomplish the following objectives:

- Design appropriately to the prevailing conditions
- Provide versatile solutions that can accommodate a range of conditions
- Prioritize competing objectives for the corridor

NCDOT outlines their signal timing philosophy through an iterative process as presented in **Figure 5.** This is focused on achieving the vision for coordinated signal systems: ***To minimize stops and delays, within the context of safe operation.***

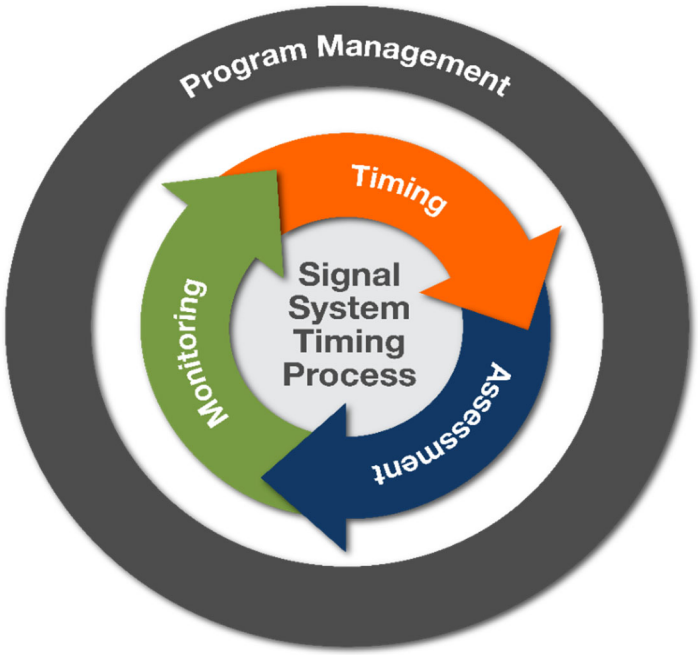

Figure 5. Signal System Timing Process

1.6 Emergency Weather Traffic Operations

Emergency Weather Traffic Operations response & resiliency includes NCDOT's preparedness for impacts from significant weather or unplanned events. This includes activities that should occur prior to, during, or after the event. As part of the response, NCDOT partners with other transportation agencies, emergency management, NCSHP, local law enforcement, and others that can provide real time data related to impacts or resources during different phases of the event.

Planning and event agnostic activities include a mock exercise for winter weather and hurricanes, and these are conducted in advance of each relative season and among stakeholders. Additionally, after-action reviews (AARs) are conducted following an event to review the response and capture what went well, what was challenging, and ways to improve the response during future events.

Collaboration across the multiple agencies and the state allow for more effective resource balancing, improved communication relative to situational awareness and real time needs, and more efficient routing of emergency personnel and supplies based on the impacts to the roadway network. Each core focus area plays a critical role during the emergency response. Typical daily activities are magnified and

sometimes refocused to best support the overall event management. In response to local needs and resources availability, IMAP Responders can be redistributed to support both evacuation and reentry activities around a hurricane. TMC resources are also increased based on the anticipated impact of an event to address the surge of requests and incidents. Partnerships with the National Guard at pre-identified hot spots, provide equipment that can address choke points for traffic when freight vehicles are unable to make steeper inclines due to icy conditions.

The Division of Aviation works closely with the STOC to help provide better situational awareness of the affected areas via fixed-wing or rotary-wing assets, or with UAS teams. The Hydraulics Unit and TSMO section coordinate on vulnerable infrastructure and share findings on flooded portions of the network via Hydraulics' and EM's developed tools like Bridge Watch and Flood Inundation Mapping and Alert Network – Transportation (FIMAN-T). The Work Zone Traffic Control section provides plans for adding capacity along the evacuation routes using strategies like late-lane merges and hard-should running. TSMO is also prepared to provide detailed emergency routing instructions to responders and EM services post event to allow them to return to affected areas along viable routes.

NCDOT was awarded the NOCoE TSMO for Major Incident or Special Event and the Overall Award in 2019 for NCDOT's preparation and response during Hurricane Florence. The award highlights the TSMO's coordination and collaboration between all partners, including law enforcement, IMAP, local communities, and other states.

1.7 Active Work Zone Management

Work Zone Management includes strategies for mitigating the impacts of construction projects and are focused on minimizing traffic delays, maintaining motorist and worker safety, efficiency of the construction activity, and maintaining access for businesses and residents within the vicinity of the project. NCDOT has employed a few tactics including integrated corridor management (ICM), the HAWKS program, and work zone planning activities focused on integrating existing systems into the overall traffic management plan.

ICM is an approach to TIM that efficiently synchronizes multiple response measures to quickly reopen travel lanes and dynamically manage traffic demand. NCDOT is currently using ICM to achieve measurable benefits including **Increased Mobility**, **Improved Safety**, and **Fewer Costly Disruptions to Construction**. ICM applications are scalable and NCDOT can refine which of the individual components below are included based on the expected traffic impacts of each project.

- Coordinated Response Plans = Faster, synchronized response
- Tow Contracts = Faster incident clearance and decreased congestion
- Increased IMAP Presence = Faster incident clearance and improved responder safety
- Trailblazers = Additional improvements to alternate route performance
- Signal Timing Action Sets = Increased mobility along alternate routes
- Smart Work Zones = Improved mobility through work zone
- DMS/CMS Scenarios = Faster, higher-quality travel information
- HAWKS = Increased work zone safety

ICMs have been implemented across the state, specifically along I-95, I-40, I-85, and I-26. I-85 is currently the only deployment unrelated to a construction project. While there has been valuable return along I-85 with ICM activations, those ICMs associated with construction projects have seen additional benefits to the construction project as well. Specifically, the I-26 ICM helped to decrease the

construction costs by allowing traffic to use the pre-planned detour routes bridge demolition. It also the overall construction of the project by reducing traffic during critical construction activity and mitigating congestion, which permitted resources to access the work zone more efficiently.

HAWKS (Helping All Work Zones Keep Safe) is a joint program between the NCDOT and NCSHP to staff and compensate troopers for additional patrol shifts on high priority work zones. The NCSHP troopers are used primarily for speed enforcement in critical areas to provide an additional measure of safety for on-site construction workers and the public. The HAWKS program also stages SHP so they can respond to incidents within the work zone more rapidly and support a faster incident clearance from the roadway. The patrols are assigned on a volunteer basis based on the staffing levels of the troop. The DOT has a fiscal year (July 1st to June 30th) budget of $1.6 million. Once the annual state budget is finalized each year, the standing MOU is updated to include the most current Master Trooper hourly overtime rate and mileage reimbursement amount. Projects are selected based on criteria including crash history, historical speed, congestion data, and facility related to speeding. The HAWKS program began in 2009 and has been deployed on hundreds of projects over the years. As the master trooper rates have increased over the years, the amount budgeted for HAWKS has not increased, resulting in less shifts (nearly 4000 shifts / year in 2010 to less than 2000 shifts / year in 2021).

As part of the overall planning for operations focus, NCDOT is striving to integrate operations discussions earlier in the project development. This allows partners to identify existing ITS or other tools that could be leveraged during the construction project. It also integrates operations into the overall conversation and traffic management plan development. Aligning operational strategies with construction phasing provides a more effective strategy to mitigating the impacts of the construction project on the mobility and safety of the corridor.

1.8 Mobility Performance Measures

TSMO uses a variety of data sources in day-to-day operations and to drive decisions for the future. Data utilized by NCDOT includes probe speed data, crowdsourcing, and TEAAS Crash Data. Probe speed data has a variety of uses as seen in the graphic below. Probe speed data is pushed to the Traffic Viewer, which allows operators to view the current congestion on NC roads. NCDOT has been using probe speed data since 2008 and currently has access to data covering almost 20,000 centerline miles of roadway. This data is purchased by NCDOT and available for free to any public agency in NC. The previous data was purchased through the I-95 Corridor Coalition – Vehicle Probe Project. Beginning in the Fall of 2021, this is now procured through the Eastern Transportation Coalition – Traffic Data Marketplace and includes speed, travel time, volumes, and freight data.

The probe data is supporting multiple traveler information initiatives. NCDOT is integrating real time HERE probe speed data to feed travel times to the DMS. Analysis tools allows allow NCDOT to study after incident congestion scans to confirm the true impacts of the incident.

Probe data is also pushed to multiple external tools, (e.g., Regional Integrated Transportation Information System (RITIS), ClearGuide). NCDOT uses RITIS and ClearGuide to analyze real-time and historical speeds, travel times, and congestion data. An application programming interface (API) of the probe data supports the calculation and values used when developing travel time messages on DMS signs. **Figure 6** highlights the tools used for performance measures and how they feed data to each.

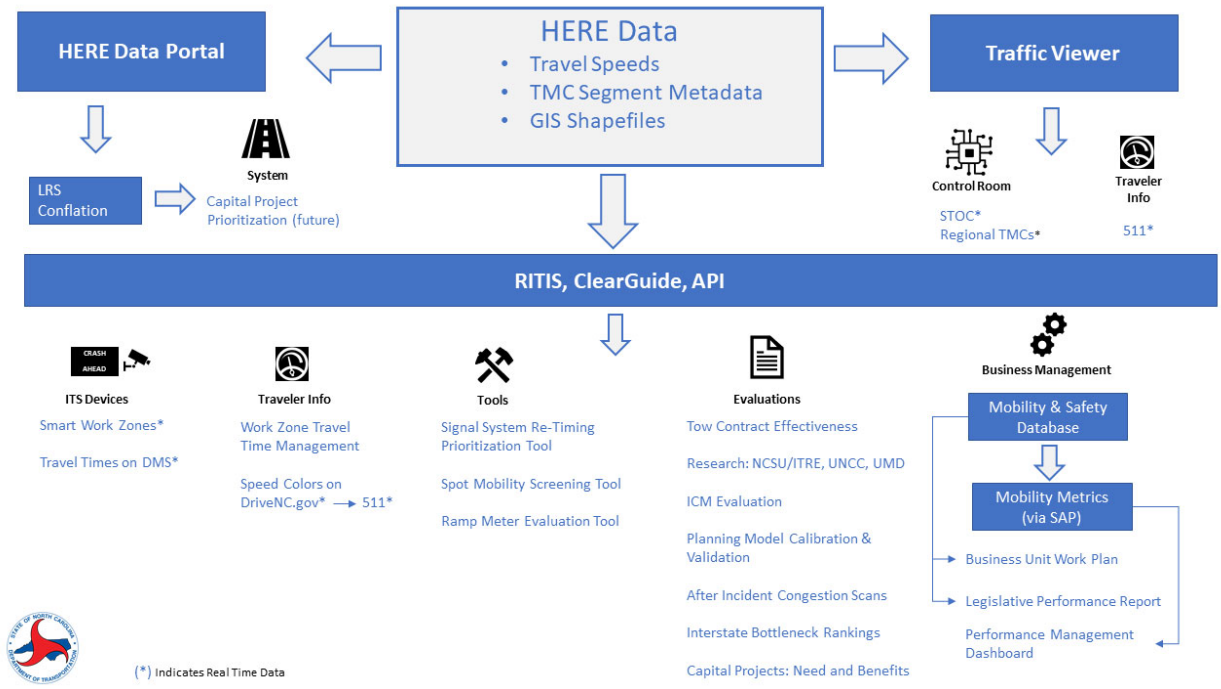

Figure 6. Performance Data Tools

NCDOT uses these data sources to generate recurring reports (monthly or quarterly) on key TMC service measures and performance indicators, such as incident clearance time (ICT). The data sources include HERE, WAZE, TEAAS crash data, TMC operator log data, and TIMS data.

NCDOT tracks six core goals in the public performance dashboard. One of the six goals is to improve reliability and connectivity of the transportation system by clearing crashes from the roadways within 90 minutes. This data is pulled directly from TIMS. NCDOT's internal performance management dashboard tracks mobility metrics provided by the TSMO group including Interstate Travel Time Index, Urban Peak Hour Average Speed, Crash Cleared in 90 minutes, Percentage of Congested Miles, and Device Uptime.

Figure 7 is example (Q2 2020) from the TSMO tracking report that highlights several of the key performance indicators. The example includes data associated with all captured information for a 3-month duration based on incident clearance duration and number of crashes, uptime of ITS devices, and users utilizing the traveler information services.

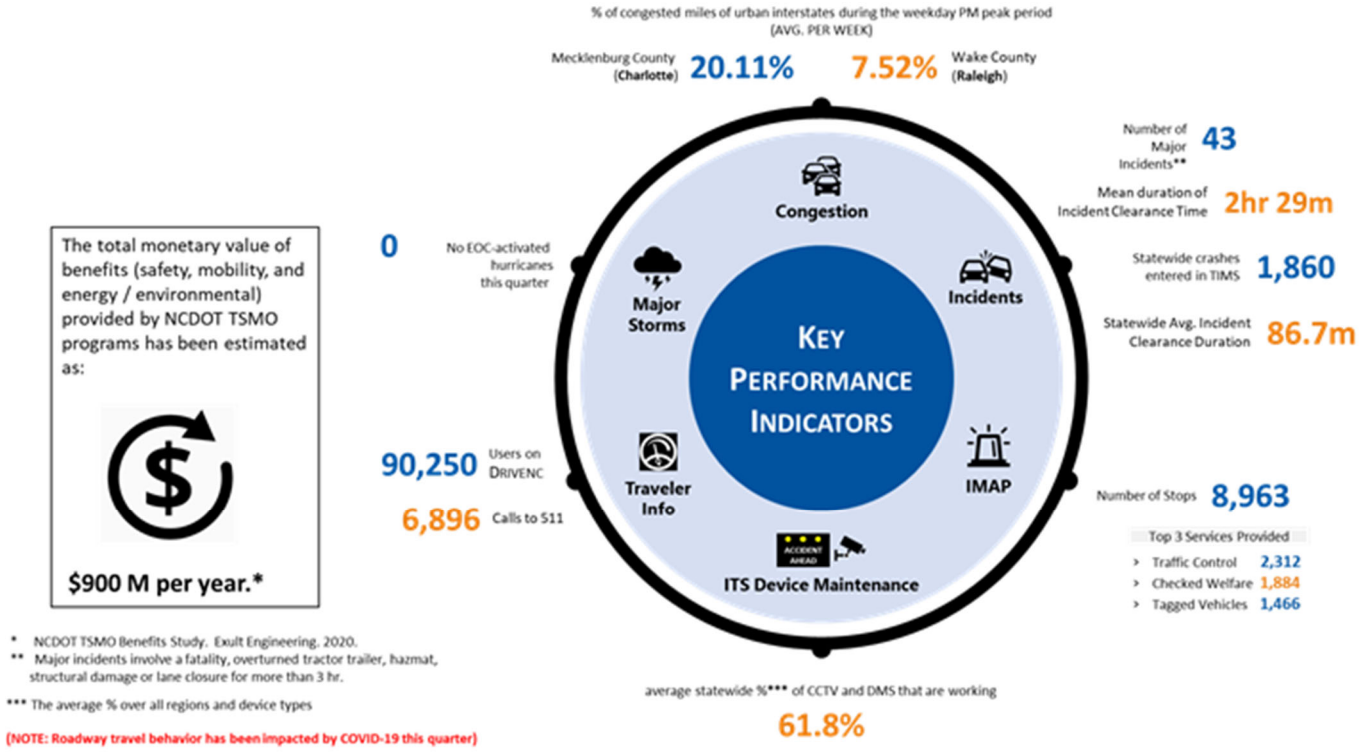

Figure 7. TSMO Program Key Performance Indicators

NCDOT is focused on making data-driven decisions. IMAP patrol routes and patrolling schedules are performed based on NCDOT's version of Incident Factor method and was implemented into the IMAP Dashboard Tool. Regional and statewide incident management program operations are directed by key performance indicator (KPI) reporting, and TMC staffing levels/TMC schedules are adjusted in response to activity levels and performance goals. NCDOT is constantly assessing how available data can applied to making better and more informed decisions.

1.9 Planning for Operations

NCDOT is making a concerted effort to break down silos of communication and coordination across all phases of project development. This has been supported in part with the Integrated Project Delivery (IPD) focus within the Department, but additional education and partnership is needed. From the program's perspective, the concept of Planning for Operations, as defined by FHWA, is the next goal for the evolution of programmatic planning. This approach integrates coordination efforts between operations, planning, and design to ensure NCDOT is effectively employing strategies that align with the objectives of safety and mobility.

TSMO is reflected in all 5 stages of the Project Delivery Network (PDN), from Stage 1 Project Initiation through Stage 5, Construction. TSMO has documented several processes associated with planning like:

- Operational Risk Assessments
- Standard D/B Scopes
- Standard Tow Contract language
- ITS Siting Guidance
- Integrated Corridor Management process guide

- Prequalification codes for TSMO planning and design
- Incident Management Plan guidance
- Signal System Timing Philosophy

Prior to the PDN, TSMO strategies were often incorporated late into project delivery requiring quick turnarounds on the design and implementation. ICM designs, tow contracts, and arterial signal upgrades are significant efforts associated with significant projects, which require time to develop and put into place. There is still a fair amount of organizational change required to make TSMO planning more incorporated into the norms.

2 Program Resources

The continuity and impact of the TSMO Program is dependent on two primary categories of resources: funding and staff. The growth of the program is often supported through designated capital funding sources, but the ongoing operations costs require a focus on sustained funding sources to prevent potential disruptions to the services provided. Staff support of the program is dependent on all facets of staff including hiring, on-boarding, technical training, retention, and continuous knowledge transfer as turnover occurs. Focused effort is required to maintain an alignment between the objectives the program and an appropriate allocation of resources to support those objectives.

2.1 Program Costs

Currently, funding for the TSMO Program is primarily through the NCDOT's General Maintenance Reserve (GMR) funds. Prior to 2016, the TSMO Program was funded through 80% federal funding in the State Transportation Improvement Plan (STIP) Project R--4049. R-4049 was a recurring federally supported funding source for traffic operations activities. GMR funds also finance the maintenance activities across the state – this creates strain as both programs are competing for allocations from the same underfunded funding source. In total, these funds are used to support:

- Device maintenance and life cycle replacement
- IMAP operations and resources (trucks, personnel)
- STOC/TMC staff contract
- IMAP training and TIM staff contract
- Traveler Information, ITS Operations, and Planning for Operations Programs

Other funding sources that support the TSMO program include:

- IMAP Sponsorship - $785,000/year (4-years)
- Highway Safety Improvement Program (HSIP) - $1.5M/year

Table 4 identifies the FY2022 dedicated funding sources and the corresponding dollar allocation to the program.

Table 4. FY2022 Funding Sources

Funding Source	Amount Allocated to TSMO Program
General Maintenance Reserve (GMR) Funds	$14.5M
IMAP Sponsorship	$0.8M
Statewide Transportation Improvement Plan (STIP)	$1.6M
Highway Safety Improvement Program (HSIP)	$1.5M
TOTAL	**$18.4M**

The Program obtains additional funds from other sources, but typically those amounts small, the timeframes are finite, or designated for a specific purpose:

There are some STIP projects that are supported by the TSMO Program until the project is complete, such as incentivized towing contracts or IMAP patrol in the work zone. However, if there is a continued need after the construction a new funding source must be identified. STIP projects are supported by statewide transportation plans and influenced by regional transportation planning organizations (RTPO) (e.g., metropolitan planning organization (MPO), rural planning organization (RPO), and transit agencies). STIP projects are focused on capital costs of projects and the funding only covers the planning and construction costs of a project. Funding is not identified for operations and maintenance of the assets constructed. Moreover, any resources funded for the duration of the construction period, lose that funding sources once the construction is complete.

NCDOT applies for Congestion Mitigation and Air Quality (CMAQ) grant funding, but the amount awarded will fluctuate based on the application and those funds are connected directly to the identified effort defined within the grant application. The CMAQ program awards annually and is not systemic. Over recent years, the Program has been awarded amounts ranging from $2.5M to $5.7M for several different projects. Some of the projects include the design and construction of the TIM Training and Development Track, design and deployment of technology for an ICM along I-85, an ATSPM pilot implementation, and one-year of ITS device operations.

In 2018, NCDOT was awarded an Infrastructure For Rebuilding America (INFRA) grant. INFRA grants provide financial assistance to national and regionally significant highway/ freight projects that align with the Fixing America's Surface Transportation Act (FAST Act) program goals. NCDOT's INFRA grant includes funding to expand the fiber network across the state and to establish a contract for device resiliency through a first-ever operations contract in NC. NCDOT is hoping this contract will be the basis for additional, similar contracts in the future. The NCDOT had to designate a dedicated funding source of $3.5M for the first five (5) years until revenue generation starts to support the OMC Contract.

NCDOT has used multiple Statewide Transportation Innovative Council (STIC) grants to fund other investments in the program. In 2021, NCDOT was awarded $50,000 to pilot the EVA/UAS devices mentioned earlier in the report. NCDOT will apply to other grants for additional support to fund various aspects of the program. These grants are not considered part of the sustained program funding source as they typically are focused on a specific project, often require monetary matches of state funds, and are not recurring.

Although the TSMO Program provides services that are not in the forefront, those services do impact motorists on the roadway and the partners who rely on the information made available. Like any complex system, the Program requires dedicated focus to ensure its effectiveness. Gaps or lack of dedicated resources to support that system will impact the ability to provide these core areas that are solely focused on the safety of the drivers and NCDOT's responding partners.

The range of possible funding sources remains inadequate to the size and demands of the program. This lack of a consistent funding stream impacts staffing levels, health of the ITS operations infrastructure, and processes that stretch the lifecycle of the equipment and tools in place. Subsequently, the inability to properly manage the staffing and equipment resources limits the program's ability to recognize the full return on investment from the capital expenditures.

2.2 Staffing

NCDOT supports the TSMO Program through a combination of statewide, regional, and contract staff. NCDOT is developing opportunities to better enhance the program at the statewide and regional levels through incorporating emerging technologies, benefit assessments of innovative applications and processes, and expanding training opportunities that continue to build and retain technical expertise. The STOC and Regional TMCs will continue to have a significant role in managing incidents across the state, and it is of upmost importance to maintain a consistent approach and philosophy across all the core areas.

Statewide Staff. The program is supported by Statewide personnel who coordinate resource balancing and planning efforts. Statewide staff focus on consistency across Divisions and regional boundaries. Statewide staff oversee the daily operations within the Statewide Transportation Operations Center (STOC) and focus on statewide consistency at the division and regional boundaries. They assist with daily operations at the regional level – especially in more rural areas that do not have a dedicated TMC. Lastly, Statewide staff lead collaborative efforts with neighboring states and other state level agencies.

The following NCDOT staff positions are dedicated to the TSMO Program.

- State Traffic Systems Operations Engineer
- State Traffic Operations Engineer
- Traveler Information Engineer
- ITS Operations Engineer
- Senior Traffic Operations Engineer
- Traffic Operations Information Engineer
- Traffic Operations Engineer
- State Signal Systems Engineer
- Senior Systems Engineer (2)
- Project Engineer (3)

Division / Regional Staff. The regional staff is managed at the Division level. Each Division is responsible for some functions within each of the core focus areas.

The TIM responsibilities within the Regions are focused on managing incidents in collaboration with their Regional TMC and the IMAP teams. Based on local knowledge, they also provide recommendations in support of interregional and statewide decisions. Most importantly, the Division staff members are tasked with developing and fostering relationships with regional and local stakeholders. Additionally, responsibilities vary between rural and urban Divisions which creates imbalances in staffing levels across the state.

Rural: ITS and Signal System Timing functions are handled by 1-2 positions that are also responsible for other traffic engineering functions (signing, pavement marking, signals). Without a team of dedicated staff, it is challenging to focus on TSMO Program activities.

Urban: These Regions often include an organizational separate from the Traffic Engineer to form dedicated positions that focus on the ITS and TIM functions. Urban Regions have not staffed their TSMO Program groups consistently. **Figure 8** provides an overview of the functions that are managed at the division/regional level. Secondly, it presents the ideal staffing structure to support these functions for an urban division or region.

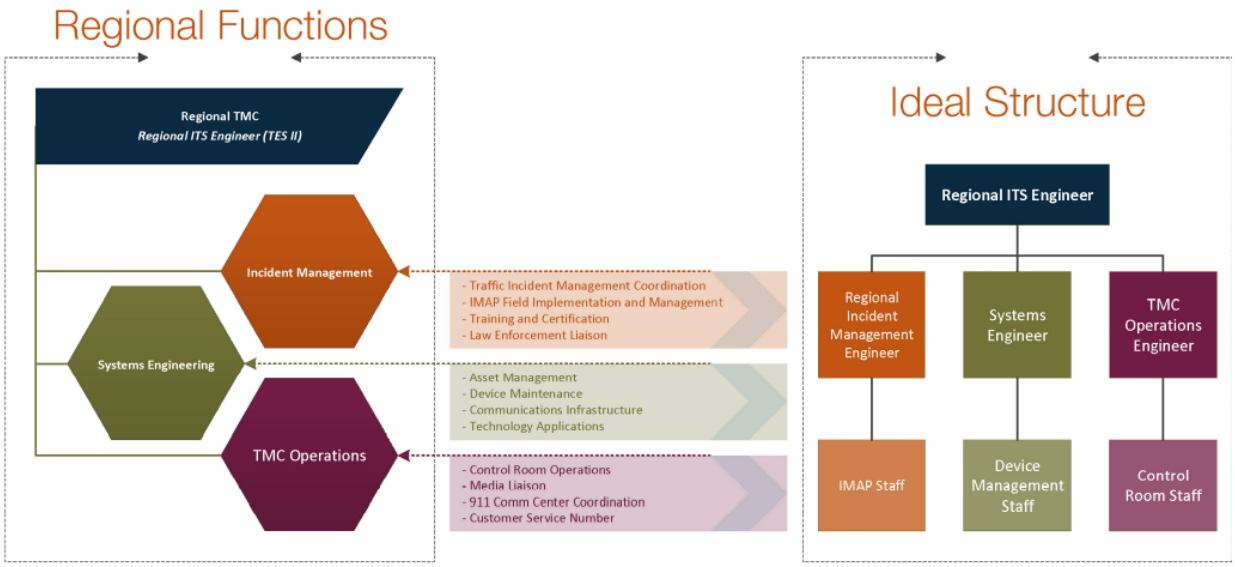

Figure 8. Regional Functions and Ideal Staffing Structure

The staffing structures within existing TMCs have been developed over time based on available resources and positions within each region. Notably, business processes also have played a role in how some Regions have established their organizational structure. Some Regions have used one position to accomplish multiple roles and the corresponding functions. In some Regions, individual positions are responsible for multiple functions while others may use a mix of internal or contract positions to help accomplish the functions.

Based on available positions, competing commitments, and other local circumstances, staffing levels and resource commitments vary between the regions. This creates an inconsistency in the position levels, individual positions, and capacity that each region can provide to TIM. The inconsistency exists between all regions, not just between urban versus rural staffing levels.

- All Regions with an existing TMC, currently staff a Regional ITS (RITS) Engineer.
- Only one of the Regions with an existing TMC staff a TMC Operations Engineer.
- Some Regions and Divisions will staff a Regional Incident Management Engineer, whereas some are achieving these responsibilities through other individuals that provide a portion of their time to TIM. More importantly, some Divisions have eliminated this position, which places additional pressure on that staff to keep pace with those responsibilities.
- Systems Engineers are present in one of the Regions and support the ITS operations responsibilities with the field devices.

TIM coordinators are also regional resources but are managed at the statewide level. They support the Divisions and Regions to promote consistency in the TIM Program across the state. The roles include a Statewide Coordinator and multiple regional coordinators to provide more localized support. The Statewide Coordinator fosters statewide relationships among sister emergency services like the State Highway Patrol (SHP), Fire and Rescue, and the Towing industry. Regional coordinators support the Divisions and Regions by cultivating these relationships at the local level and are managed by the statewide coordinator. However, there is not a TIM Coordinator in every region of the state.

The TIM Coordinators also support TIM tasks such as tow contract administration, emergency responder training, and relationship development within the NCDOT and emergency responder community. TIM coordinators can support both AARs and Team Meetings by educating and recruiting regional stakeholders, facilitating the meeting, developing agendas and topics, and coordinating materials in advance of the meeting. Currently, there is one Statewide TIM Coordinator and two Regional TIM Coordinators supporting the state.

Extension of Staff. NCDOT has had to rely heavily on staffing contracts to supplement the resources available to support the program. TSMO has employed this innovative approach of embedded staff that is committed to the program. Some TMC functions, the TIM program management, and even traffic engineering support staff are also provided through these types of contracts. While NC currently contracts the program management for TIM, other states have gone so far as to outsource their safety service patrol staff.

Existing extension of staff contracts include support for

- Traffic Operations Management
- TIM Program Management
- Broadband Operations and Maintenance
- Device Operations

3 Program Gap Considerations

NCDOT is continuously balancing the demands for funding across all the programs managed by the Department. To appropriately plan and budget for these funds, it is important to include factors that can increase the funding needs such as device maintenance, costs of new technologies, and ongoing operations. **Table 5** presents identified gaps for each of the core focus areas within the TSMO Program.

Table 5. Summary of the Program Gaps by Core Focus Area

TIM

- Resources to support TIM functions across all levels of the TIM Program
- Resources to adequately cover existing patrol and response routes
- Overuse of temporary staff that are limited work 11 months, with one month spent in training-
- Equipment replacement beyond life (average truck age is 6 years)
- Reclassification of responder positions through attrition, resulting in an arduous process
- Filling vacant positions is challenging
- Funding, staff, and equipment resources to extended coverage to response or new routes, extend coverage hours, or surge staffing for emergency activations or special events is limited
- Geographic gaps in IMAP coverage on interstates and freeways across the state
- Funded primarily through State Funds even though Federally supported
- Overnight responders are more isolated from support
- Designation of IMAP Responders to First Responders would afford responders advantages of safety and priority
- Upgrades to IMAP trucks to provide additional capabilities and safety enhancements
- Depth in the IMAP Trainers capabilities to conduct IMAP training
- Incorporate multi-discipline training, continuing education, and supervisor certification
- Capacity to upgrade VIPER Technology and channel templates
- Emergency traffic control training for Emergency Responders, maintenance, and traffic services
- Statewide approach to heavy towing and emergency activations
- Mechanism to stage equipment to be ready during adverse weather events
- Limited resources and funding to provide services in all locations that can benefit

TMC

- Advance Transportation Management System (ATMS) for freeway operations
- Availability of devices in the field to support situational awareness or traffic management
- Funded mostly by State Funds even though Federally supported
- Eastern Regional TMC to handle regional response using local knowledge and relationships Limitations on space within the TMC to accommodate program growth
- Higher demand on complex skillset for operators will require higher pay scales
- Alignment of number, role, and classification of positions between Regions
- Continuity of Operations between STOC and Regional TMCs
- Redundancy and capacity in staff to support knowledge transfer and continuity
- Permanent buildings for the Regional TMCs
- Tools to support a more proactive approach to incidents versus reactionary and potentially delayed responses

ITS Operations

- Broken, inoperable and outdated devices, uptime that continues to trend down.
- No plan for O&M and life cycle replacement of existing or new devices
- Lack of connectivity and redundancy within the NCDOT fiber network
- Reliance on the DIT Network without Service Level Agreements
- Long procurement processes hinder ability to purchase new technology
- Funded primarily through State Funds even though Federally supported
- Depth of specialized skill sets in ITS Operations
- Keeping up with technology advances
- Skillsets of networking, troubleshooting, and systems engineering lost through attrition
- No Asset Management system
- Broadband hastened need to develop asset management tools (still under development and reliance on DIT to provide tools due to procurement rules)
- Standardized asset documentation/management for operations and maintenance
- Staff resources to support ITS Operation functions

Traveler Information

- Awareness or accounting of all activities on the transportation network in the event management system (TIMS) and DriveNC.gov
- Standard approach to balance resources based on the large number of miles managed and the quantity of events being managed
- Documentation to mitigate knowledge transfer
- Process to prepare for infrastructure needs for big data and analysis
- Funded primarily by State Funds even though Federally supported

Signal Systems Timing and Operations

- Reliant on manual travel time runs for corridor performance
- Limited experience or knowledge with new data capabilities (CV, probe, etc.)
- Advance the Signal Performance Measure implementation plan
- Active traffic management of arterials
- Vacancies in critical positions and gaps in technical knowledge
- Specialized skill set that is hard to recruit
- Antiquated equipment limits capabilities

Emergency Weather Traffic Operations

- Staff specialized in data analytics and response plan development
- Devices deployed in strategic location for situational awareness (devices along evacuation routes)
- Devices operational when needed for emergencies
- Upgraded VIPER Technology and channel templates to ensure viable communication options
- Resources for IMAP resources to surge staffing for emergency activations or special events
- Lack of traffic volume data during evacuations

Active Work Zone Management

- Sufficient proactive response planning
- Staff resources to support ICM development, tow contract management, and planning