# NCDOT AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES A T S P M IMPLEMENTATION PLAN


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# I. Decision Process

## 1. Decision to Pursue ATSPM

Automated Traffic Signal Performance Measures (ATSPM) utilize high-resolution controller data to create detailed performance measure reports for signals and signal systems. These performance measures give traffic engineers a complete picture of signal system operations and allow for finely calibrated signal timing, real-time improvements, and enhanced system awareness.

NCDOT began assessing the need for ATSPM in 2018**.** The *NCDOT Guide on ATSPM* was completed in April 2019 and summarizes the costs, benefits, and operational requirements of ATSPM. Based on this information, program metrics were identified to evaluate the benefits of implementing ATPSM in North Carolina.

### Program Benefits Metrics

#### Signal Level

**METRIC** Implement more effective signal timing plans using high-resolution data.

MEASURE Signal timing improvements as measured by a reduction in congestion, minimized cycle failures and split failures, improved safety, improved progression, minimized delays, or reduced citizen complaints.

#### Project Level

**METRIC** Implement more effective project prioritization and resource allocation.

MEASURE Use performance data to more easily identify and re-optimize under-performing signals and signal systems.

MEASURE Use performance data to more easily identify and upgrade under-performing signals and signal systems.

MEASURE Use performance data to more easily identify and allocate maintenance for identified equipment failure.

#### Program Level

**METRIC** Use performance measures to assess the Return on Investment for statewide signal timing funds.

MEASURE Use data-driven decision making to optimize resources, resulting in a higher return on investment for funding of signal timing.

### Challenges

During the research process, the following challenges of implementing ATSPM were identified:

- Server requirements
- Personnel buy-in
- Utilizing data effectively
- Hardware/software upgrades (i.e. funding)

After evaluating the potential benefits and challenges of deploying ATSPM in North Carolina, NCDOT decided to develop an implementation plan for ATSPM with a long-term goal of upgrading all NCDOT signal systems to ATSPM. This document will lay out the necessary requirements and methods for implementing ATSPM.

## 2. ATSPM Software Decision Process

During the evaluation of ATSPM deployment, a variety of ATSPM software options were researched and evaluated. A software evaluation matrix was created to compare the costs and benefits of the software options and a webinar was held on March 20, 2019 with peer agencies currently utilizing the Open Source ATSPM Software developed by the Utah Department of Transportation.

### Software Evaluation Matrix

- Research was conducted on a range of ATSPM software options.
- Proprietary options evaluated were Centracs MOE, Centracs SPM, Trafficware, and Miovison. The Open Source ATSPM Software was also evaluated.
- ATSPM Software options were evaluated based on reports produced, operational objectives, lifecycle costs, software/hardware costs, implementation effort, and other user features.
- The software evaluation matrix is included in Appendix 1.

### Peer Agency Webinar (March 20, 2019)

- April Wire from Maricopa County, AZ and Justin Effinger from Lake County, IL presented on each of their agency's use of the Open Source ATSPM Software.
- Maricopa County evaluated several vendor solutions before choosing the Open Source ATSPM Software. While the vendor solutions output more polished graphs than the Open Source ATSPM Software, both proprietary and non-proprietary software options use the same data.
- Justin Effinger (Lake County) was able to configure the Open Source ATSPM Software by himself in a matter of weeks. The largest effort was configuring each traffic signal in the software (10-15 minutes each).
- Maricopa County hired a consultant to configure the Open Source ATSPM Software.
- Both agencies concluded that the vendor software is too expensive for the limited benefits it provides. In addition, there are hidden costs associated with the vendors.
- Additional features can be added to the Open Source ATSPM Software to tailor it to an agency's needs. Agencies using the Open Source Software share their customizations on GitHub for anyone to use and NCDOT also can contribute customizations developed during their implementation.
- A vendor software option also can be implemented in the future since it uses the same data as the Open Source ATSPM Software.

## Core Team Follow-Up Meeting (March 25, 2019)

- The team's main concern with the Open Source ATSPM Software was that a significant effort would be required to roll out the software. Justin Effinger addressed this concern in the webinar, indicating that a single person with sufficient experience could set up the software and configure the signals in a matter of weeks. Secondly, April Wire discussed her process of using outside resources for the configuration. Both referenced the effort needed for the set-up, but that it was manageable, and they were able to see results very quickly as they continued to integrate signals and systems.
- The team also considered the following factors:
  - The Open Source software offers significantly more reports (See the Operational Objectives chart in Appendix 1).
  - Multiple peer agencies already have large-scale implementations and can offer knowledge and experience as NCDOT begins to deploy.
  - Only the Open Source software offers the Link Pivot report, which reduces the need for traffic simulation to determine offsets.
  - NCDOT houses and controls all data.
  - The Open Source software is completely software, hardware, and vendor agnostic, thus future-proofing the ATSPM platform against changes in software and hardware contracts.
  - Centracs SPM was not chosen because it is limited to the Econolite hardware and software.
  - Miovision was not chosen due to its excessive costs.
- The team decided to move forward using the Open Source ATSPM Software.

# II. Hardware and Software Requirements

## 1. Baseline Conditions

Baseline conditions for signal system hardware and software were defined to establish the incremental costs and benefits of ATSPM. Not all signal systems currently meet the defined baseline conditions. A portion of the implementation plan will address the phased upgrade of systems to the baseline, regardless of the ATSPM solution that is identified for the corridor. For the purposes of this implementation plan, the baseline configuration for a signal system is defined with the following hardware and software.

*Note: Econolite's Centracs is currently the central software but is subject to change.*

### a. Hardware

i. Central hardware is the Centracs server.
ii. Field hardware is the NCDOT standard 2070E controller.

### b. Software

i. Central software is Centracs. All new signal systems will have Centracs and existing systems are in the process of upgrading.
ii. Field software is either Oasis, ASC/3, or EOS.

### c. Communications

i. For systems on Centracs, Field-to-Central communications are cellular modems or ITS fiber.
ii. Signal-to-signal communications are either fiber optic cable or ethernet radios.

### d. NCDOT Standard Detection Scheme

The standard NCDOT detection scheme is deployed on a majority of NCDOT signal systems and will be considered the baseline detection configuration.

The standard cross-section assumption is:

- Major Street Approaches: Two through lanes with dedicated left turn and right turn lanes
- Minor Street Approaches: One through lane with dedicated left turn and right turn lanes

The standard detection is:

- Major Street: Lane-by-lane through lane advanced detection, left turn lane presence detection
- Minor Street: Lane-by-lane presence detection

**Figure 2** shows the NCDOT standard detection configuration and the available ATSPM reports based on that detection scheme. More robust detection schemes provide additional reports and those are detailed in Section V.

## 2. ATSPM Deployment Conditions

Additional technical requirements must be met to collect and process ATSPM data.

### a. ATSPM Software

The ATSPM software will be the Open Source ATSPM Software.

### b. High Resolution Controllers

High resolution controllers are required to support ATSPM data collection. 2070LX controllers are compatible with ATSPM.

### c. High Resolution Software

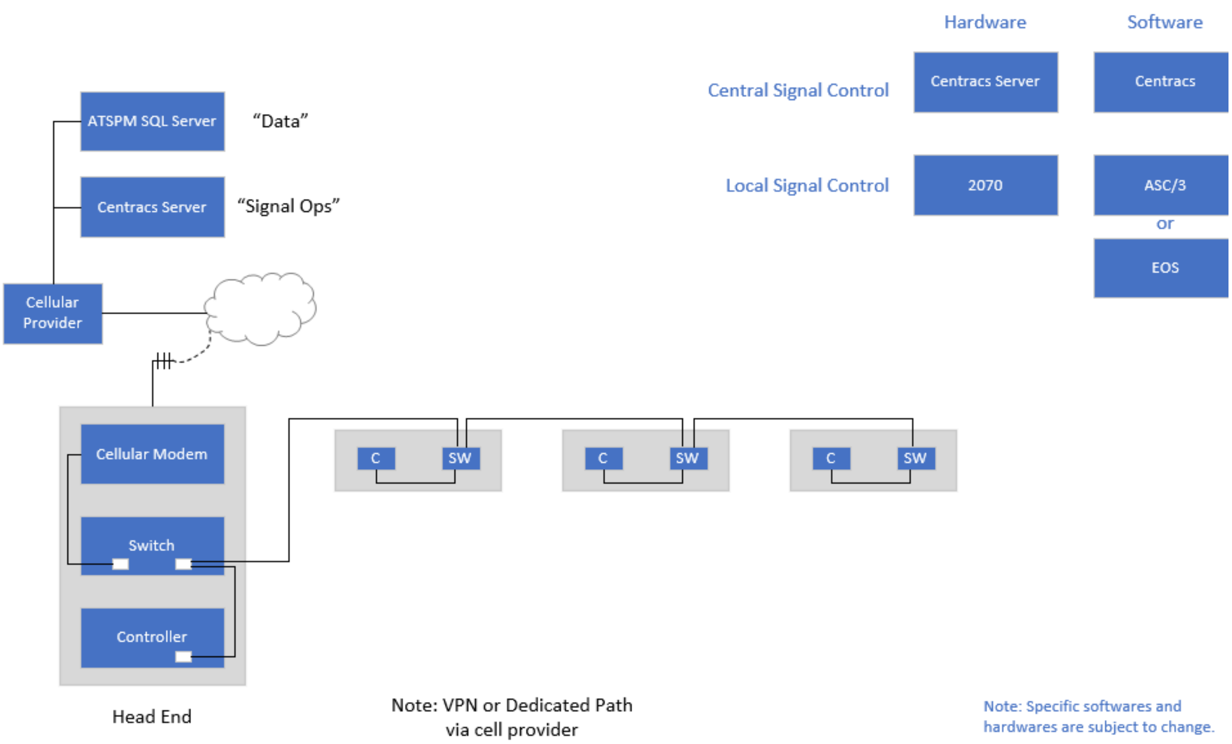
High resolution controller software is required to support ATSPM data collection. ASC/3 and EOS are compatible with ATSPM.

# III. System and Design Requirements for Open Source ATSPM Software

## 1. Network Configuration

The baseline conditions for the signal systems will include interconnect with the head end controller and communication to both the Centracs central server and the ATSPM central server. **Figure 1** shows the communication architecture for the baseline condition.

*Figure 1: ATSPM Network Configuration*




## 2. Server Needs

The ATSPM central server will require data storage that can accommodate continuous data collection from every intersection. The COST group initiated conversations in April 2019 with IT to discuss server requirements that can support the space needs estimated for ATSPM data. UDOT estimates approximately 19 MB of storage space for each signal controller per day. The volume of data collected at each intersection is directly related to the amount of detection deployed at an intersection so a conservative estimate of 20 MB/day was used to calculate data storage with an assumed length of storage time of 3 years. Based on these assumptions, the anticipated server needs were estimated to be:

- By end of 2019: 2TB (100 signals)
- By end of 2020: 10TB (500 signals)
- By end of 2021: 30TB (1,500 signals)

- By end of 2022: 80TB (4,000 signals)
- By end of 2023: 100TB (5,000 signals)

It is projected that 5,000 traffic signals statewide could potentially benefit from ATSPM implementation. Coordination with IT regarding additional technical requirements will continue as implementation moves forward.

## 3. Utah Software Configuration

An experienced user can set-up the software and configure the traffic signals. The process is estimated to take a few weeks and is dependent on the number of intersections that will be initially configured. Once the initial software is installed and ready, each intersection will require approximately 10-15 minutes to configure.

Georgia Department of Transportation provides an ATSPM Software Installation Manual that guides the user through server requirements, installation procedures, and database configuration. In addition, UDOT provides manuals regarding the use of the website interface to access data (ATSPM Component Details) and the application of individual reports (ATSPM Reporting Details).

# IV. Corridor Prioritization Methodology

## 1. Implementation Tiers

ATSPM implementation can vary based on the needs of the corridor. Five implementation tiers were established to define potential levels of ATSPM implementation.

*Table 1: Implementation Matrix*

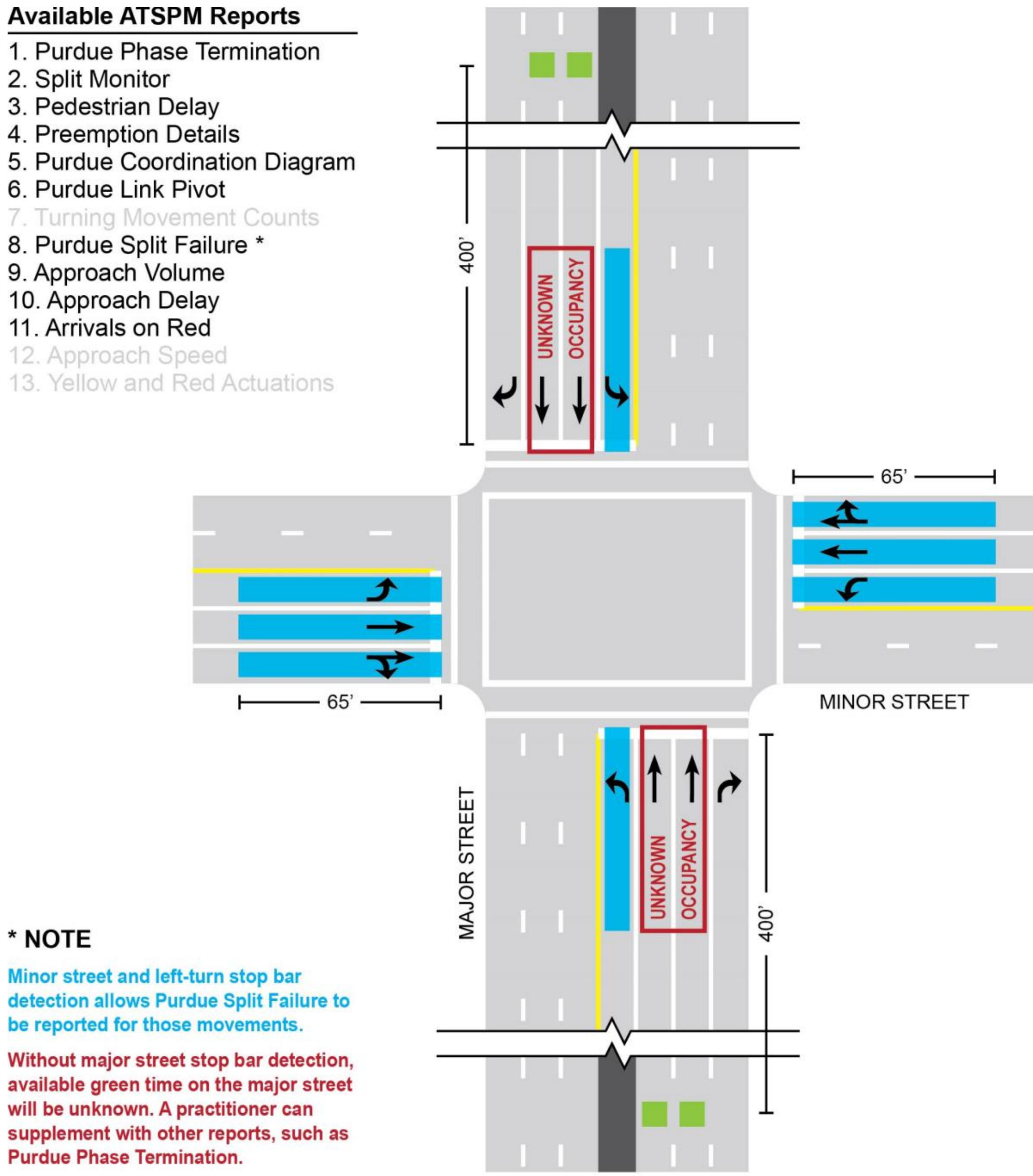
| | Tier V | Tier IV | Tier III | Tier II | Tier I |
|---|---|---|---|---|---|
| **Central Signal Control** | None | Yes | Yes | Yes | Yes |
| **Field Hardware** | No High-Resolution Data Controller Installed | No High-Resolution Data Controller Installed | High-Resolution Data Controller Installed (2070LX) | High-Resolution Data Controller Installed (2070LX) | High-Resolution Data Controller Installed (2070LX) |
| **ATSPM Software** | No configuration with ATSPM central software | No configuration with ATSPM central software | Configuration with ATSPM central software | Configuration with ATSPM central software | Configuration with ATSPM central software |
| **Detection** | No detection upgrades | No detection upgrades | No detection upgrades | Detection upgrades at critical approaches to critical intersections | Full detection upgrades on most or all approaches at the majority of intersections |
| **Result** | No ATSPM data available | No ATSPM data available | Some ATSPM data available | ATSPM data available at critical intersections. | ATSPM Data available on all approaches at all intersections |
| **Notes** | | Tier IV is considered the baseline. | Tier III is the lowest level of ATSPM implementation and generates some performance measures. | Tier II is the middle level ATSPM implementation and generates a moderate number of performance measures. | Tier I is the most complete ATSPM implementation and generates the most performance measures. |

a. Central Signal Control: The signals are connected to the central control software for signal systems. Currently, the software is Centracs. The baseline for ATSPM includes Centracs, so Tier IV represents the baseline conditions for the purposes of this implementation plan. Signal systems in Tier V are not on Centracs and are not currently planned to be upgraded. Should funding become available to upgrade these systems to Centracs, they should be reevaluated to assess the implementation tier based on the needs of the corridor.

b. Field Hardware: High resolution controllers are necessary for high resolution data to be collected and pushed to the ATSPM server.

c. ATSPM Software: Indicates whether a signal system is configured with the ATSPM software, which is anticipated to be the Open Source ATSPM Software. Only Tiers I, II, and III will be configured with the ATSPM software and have ATSPM reports available.
d. Detection: The detection configuration determines the level of information collected for a corridor and the number and types reports available. Tier III assumes the standard NCDOT detection configuration. Tier II includes detection upgrades as necessary at critical intersections. Tier I includes upgrading to the full detection scheme at all intersections on the corridor. **Figure 2** and **Figure 3** depict the detection configuration for Tier III and Tier I, respectively.

*Figure 2: NCDOT Standard Detection Configuration*

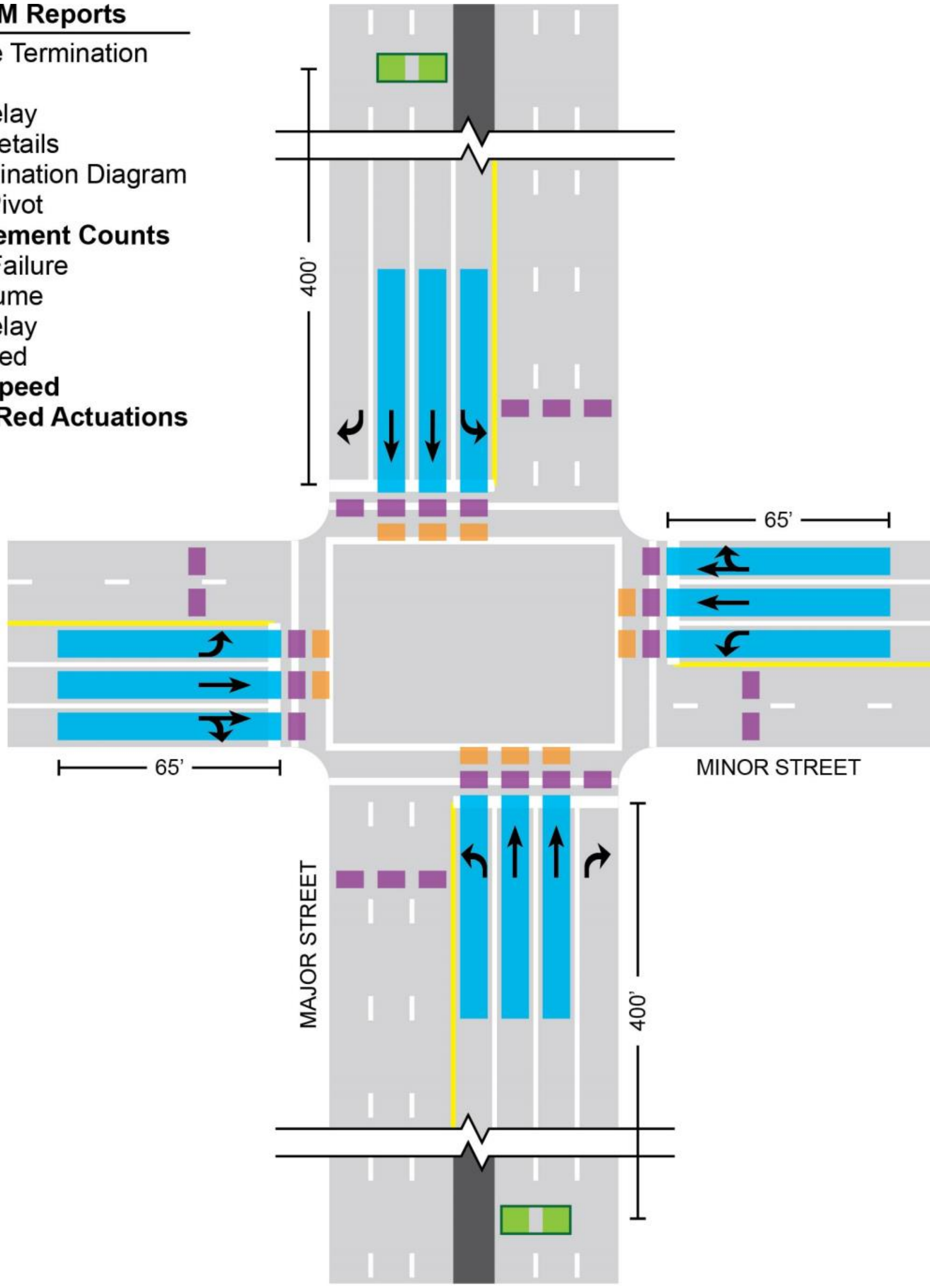



| Legend | Detection Requirements | Recommendations/Notes |
|---|---|---|
| Presence | Lane-by-Lane or Lane Group | Lane-by-Lane will provide more accurate occupancies. |
| Advanced Count | Lane-by-Lane or Lane Group | Lane-by-Lane will provide more accurate activations. |
| Advanced Speed | Wavetronix Radar Only | |
| Stop Bar Count | Lane-by-Lane | |
| Yellow & Red Actuation | Lane-by-Lane or Lane Group | Lane-by-lane will provide more accurate activations. Speed filter recommended for <15mph. |

*Figure 3: Tier I Full Detection*

**Available ATSPM Reports**

1. Purdue Phase Termination
2. Split Monitor
3. Pedestrian Delay
4. Preemption Details
5. Purdue Coordination Diagram
6. Purdue Link Pivot
7. **Turning Movement Counts**
8. Purdue Split Failure
9. Approach Volume
10. Approach Delay
11. Arrivals on Red
12. **Approach Speed**
13. **Yellow and Red Actuations**

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| Stop Bar Count | Lane-by-Lane | |
| Yellow & Red Actuation | Lane-by-Lane or Lane Group | Lane-by-lane will provide more accurate activations. Speed filter recommended for <15mph. |

## 2. Implementation Tool for Divisions

A spreadsheet tool was created to identify an initial recommendation for the implementation tier for each signal system (See Appendix 2). The tool is designed to allow Division Traffic Engineers to qualitatively evaluate the signal systems in their Division. The tool assesses which ATSPM implementation tier a signal system warrants based on the current signal system configuration and the current corridor performance. The tool identifies the Current Tier and proposes a Goal Tier based on that assessment. Additionally, it will serve as an inventory of signal systems for all Divisions. The questions included in the tool are:

Background Information

- Length of Corridor (miles)
- Number of Signals
- Annual VMT (millions)
- Is this system CMAQ eligible?

Current Signal System Configuration

- Controller
- Communications
- Is this system currently using Centracs?
- Is the system planned to be upgraded to Centracs in the next 5 years?
- Does this signal system have high resolution data controllers?

Current Corridor Performance

- Is this corridor over capacity?
- Does this corridor have atypical travel patterns (i.e. not AM/PM commuter travel)?
- Are additional performance measures needed to understand the corridor (beyond travel time runs)?
- Does this corridor have an unusually high number of maintenance calls?
- Does this corridor receive an unusually high number of complaints from the public?
- Does this corridor have safety issues? (Combined Safety Score > 80)
- Is this corridor retimed frequently? (on average, every 3 years)
- Is the corridor more than 60 minutes from the central maintenance facility?

Future Corridor Conditions

- Is the corridor anticipated to change rapidly in the future? (i.e. development, new connections, TIP Projects)

Based on answers to these questions, the tool assigns a Current Tier and a Goal Tier to the signal system. The rules for assigning the Current Tier and Goal Tier are described below. In addition, the tool confirms configuration and performance data that can be used in the project prioritization process.

Current Tier

- Tier IV: The system is currently using Centracs OR is planned to be upgraded to Centracs.

- Tier V: The system does not have Centracs AND is not planned to be upgraded to Centracs.

Goal Tier

The goal tier is calculated on the number of "yes" answers to questions in Current Corridor Performance and Future Corridor Conditions.

- Tier I: Answer "yes" to 8 or more questions.
- Tier II: Answer "yes" to 6 or more questions.
- Tier III: Answer "yes" to 4 or more questions.
- Tier IV: Answer "yes" to 2 or more questions.
- Tier V: Answer "yes" to 1 or fewer questions.

*Note: A "yes" answer to "Is the corridor more than 60 minutes from the central maintenance facility" only counts towards the total if "yes" is answered for either "Does this corridor have an unusually high number of maintenance calls" OR "Does this corridor receive an unusually high number of complaints from the public."*

# V. Costs and Benefits

## 1. ATSPM Costs

### a. Software

The Open Source ATSPM Software has no costs associated with procuring (downloading), installing, or configuring for use. NCDOT expects to utilize internal resources for software installation and configuration.

### b. Field Hardware

The following costs are associated with upgrading controllers:

- 2070 LX Controller: $2,500 each ($1,500 under state contract)

The most common communication architecture for closed systems uses either fiber or 900 MHz radios to connect individual signals back to the head end. A 4G cellular modem at the head end then can communicate to any central servers. The bandwidth of the 4G cellular modem is sufficient for daily data transfers to the central servers. NCDOT is planning to test a corridor to evaluate the reliability of the 900 MHz radios to transmit the high resolution data from the individual intersections to the head end. If necessary, radios may require an upgrade to 2.4 GHz or 5.8 GHz to provide reliability in data collection.

- 2.4 GHz of 5.8 GHz radio upgrades: $2,500 each (1 per signalized intersection)

### c. Detection

Implementation Tiers I and II require detection upgrades from the NCDOT standard detection configuration. **Figure 3** shows a Tier I detection configuration. Unit costs for detection upgrades are listed below.

- Loops: $1,500 each
- Radar: $5,000 each
- Cameras: $10,000 per intersection

In **Table 2,** the first two columns show the detection deployment costs at a new intersection for a Tier III (Standard Configuration) and Tier I (Full Deployment). The third column shows the cost to upgrade from a Tier III to a Tier I. There are two options for a Tier I implementation: loop-based and camera-based. **Figure 2** and **Figure 3** show the loop configuration requirements regardless of the technology selected. The camera-based option will require radar and advance loops to capture advanced speed and advanced count.

Tier II implementation costs fall between Tier I and Tier III and depend on the level of detection needed for each intersection.

*Table 2: Detection Costs*

| | Tier III (Standard Configuration) | | Tier I (Full Deployment) | | | | Upgrade from Tier III to Tier I | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Loop-Based | | Loop-Based | | Camera-Based | | Loop-Based | | Camera-Based | |
| | Count | Cost | Count | Cost | Count | Cost | Count | Cost | Count | Cost |
| Loops | 12 | $18,000 | 50* | $75,000 | 4 | $6,000 | 38* | $57,000 | - | - |
| Cameras | - | - | - | - | - | $10,000 | - | - | - | $10,000 |
| Radar | - | - | 2 | $10,000 | 2 | $10,000 | 2 | $10,000 | 2 | $10,000 |
| | | $18,000 | | $85,000 | | $26,000 | | $67,000 | | $20,000 |

**NCDOT utilizes 332/336 signal cabinets which only have 28 inputs. Additional detector racks can't be added to the cabinet due to space constraints. Therefore, a loop-based Tier I deployment is not feasible.*

For a camera-based Tier I deployment, four loops (two for each major approach) are required for advanced detection beyond the reach of the camera. In addition, one radar is necessary for each major approach for advanced speed detection. These needs may vary depending on the camera vendor.

There are multiple camera-based detection systems already in use by municipalities in North Carolina. The City of Greensboro is using GridSmart, which costs approximately $10,000 per intersection and does not have a subscription fee. A single fish-eye camera can capture stop bar and advance detection for most intersections on 35 mph roadways and they offer a supplemental traditional camera for advance loops where needed. The City of Wilmington is utilizing ITS Plus, which costs approximately $9,000 per intersection, has no subscription fees, and utilizes one camera per approach.

Camera-based detection systems have advantages over loop-based systems. Camera maintenance is less invasive than loops, camera technology is more flexible to adapt to new software improvements, detection zones can easily be modified for changes in intersection geometry, and cameras can also provide additional video surveillance of an intersection (bandwidth must be taken into consideration for streaming video).

## 2. ATSPM Benefits

There are a variety of benefits associated with implementing ATSPM, including maintenance efficiencies, timing optimization, and safety. The benefits of ATSPM vary based on the number of performance reports available, which in turn is based on the level of detection. More robust detection schemes associated with higher implementation tiers will provide greater operational benefits.

### a. Data and Reports

Different sets of reports are available based on the detection configuration. **Figure 2** shows the reports available for the NCDOT standard detection configuration (Tier III) and **Figure 3** shows the reports available a full detection configuration (Tier I).

b. Maintenance

ATSPM maintenance benefits include:

- Time savings for maintenance technicians through remote verification of issues
- Maintenance priorities based on performance
- More timely identification of potential technical issues

c. Signal Timing Optimization

ATSPM will completely overhaul the signal retiming and optimization process. Rather than a 3-5 year retiming cycle, signal systems can be identified for retiming and optimization based on performance data. Signal timing optimization benefits include:

- Proactive and automated notification of declining operational performance
- Ability to quickly and easily identify and address declining operational performance
- Reduced time spent traveling to and from the field
- Reduced time spent diagnosing and correcting operational deficiencies
- Ability to quickly and easily give a snapshot report of signal and system performance
- Ability to assess and implement incremental signal adjustments to address citizen complaints
- Prioritize signal retiming projects based on most urgent needs
- Eliminate the need for travel time runs
- Eliminate the need for manually-collected turning movement counts (Tier I only)

d. Safety

ATSPM safety benefits include:

- More granular data regarding red light running (Tier I only)
- Support timing plan adjustments based on red light running data
- Indirect benefit of fewer crashes due to less corridor congestion

# VI. Short Term Implementation Plan

## 1. CMAQ Corridors

The Congestion Mitigation and Air Quality (CMAQ) Program provides funding to support surface transportation projects and other related efforts that contribute to air quality improvements and provide congestion relief in areas that fail to meet the National Ambient Air Quality Standards.

There are currently 21 counties in North Carolina classified as non-attainment counties and are therefore eligible for CMAQ funding (See Appendix 3). NCDOT currently has approximately $1.8 million in CMAQ funds to begin ATSPM implementation. The signal systems in this initial implementation must be in non-attainment counties and should include a variety of implementation tiers, corridor locations, and corridor characteristics. These implementations will provide additional insight into how North Carolina can benefit from ATSPM data and further guide long term implementation decisions.

## 2. Initial Implementation Cost/Benefit

CMAQ funding will be utilized to implement ATSPM on several initial corridors throughout the state. In order to justify funding for additional ATSPM implementations, the costs and benefits of each of these CMAQ corridor implementations should be tracked. In addition to tracking the total project cost, suggested benefits metrics are listed below.

- Reduced congestion
- Minimized cycle failure
- Improved progression
- Minimized delay
- Reduced maintenance visits
- Fewer citizen complaints
- Utilizing performance alarms to quickly address issues
- Reduced time needed to fix timing problems

# VII. Long Term Implementation Plan

## 1. Applying Implementation Tiers and Priority List

The Implementation Tool assigns a Current Tier and a Goal Tier for signal systems but does not assign priority. A signal system with Goal Tier I does not always imply the highest project benefits or the highest priority for implementation.

To prioritize the signal systems for implementation, the Implementation Tier will be cross-referenced with the signal retiming prioritization process. The retiming process considers the overall corridor performance of each signal system. Maximum ATSPM value would come from a system high on the retiming priority list with a low implementation cost, which can be estimated based on the implementation tier. For example, a system with Current Tier V and Goal Tier I would have a higher implementation cost than a system with Current Tier IV and Goal Tier II.

This prioritization process can be used to allocate funding as it becomes available.

### 2. Funding Sources

There are a variety of funding sources that can be utilized for ATSPM implementation. See Appendix 4 for details on the following long-term funding opportunities:

- Congestion Mitigation and Air Quality Improvement Program (CMAQ)
- SPOT Mobility
- SPOT Safety (Highway Safety Improvement Program)
- State Transportation Improvement Program

## VIII. Moving Forward

### 1. Next Steps

As of completion of this document, these are the next steps required to move ATSPM Implementation forward:

- Identify CMAQ Corridors
    - Based on Division responses to the Implementation Tool, corridors with a variety of Goal Tiers, locations, and current conditions should be chosen.
- Define Before/After Study of CMAQ Corridors
    - In order to measure the effectiveness of implementing varying levels of ATSPM on different types of corridors, a before/after study should be devised. For example, ATSPM could be installed on a corridor to gather existing conditions data for a period of time before any timing changes are made.
    - This information will be useful in applying for further ATSPM funds and to fine-tune the level of implementation necessary for different corridor types.
- Guiding Divisions Forward
    - After completing the ATSPM tool, Divisions can begin identifying corridors for ATSPM upgrade as funds become available. For example, Divisions should incorporate ATSPM implementation into TIP scopes for other projects.

### 2. Operational Considerations

The scope of this document is the implementation of ATSPM and does not cover best practices for utilizing ATSPM in operations. During the research process, the following topics were identified as best practices for and challenges to successful ATSPM implementation.

- Incorporating ATSPM into the signal retiming process
- Roles and responsibilities for use
- Alarm parameters and response
- Asset management of closed loop systems
    - Quickly identify and repair malfunctioning loops and track maintenance
- Management of ATSPM data, including public access and archived data retention schedule

The Signal Timing Philosophy Manual should be updated to address these topics, along with other operational procedures for the effective utilization of ATSPM.

# Appendix

## 1. Software Evaluation Matrix

| | Evaluation Point | Centracs MOE | Trafficware | Open Source | Centracs SPM | Miovision |
|---|---|---|---|---|---|---|
| Costs | Software installation cost (per 25 intersections) | $ - | $ 8,000 | $ - | $ 22,000 | $ 36,000 |
| | Hardware cost (assume existing controllers are Econolite Oasis or ASC/3 2070) | $ - | $ - | $ - | $ - | $ 100,000 |
| | Annual subscription cost (per 25 intersections) | | $ 8,000 | $ - | $ 11,000 | $ 30,000 |
| | Life Cycle Cost (over 10 years) | $ - | $ 88,000 | $ - | $ 132,000 | $ 436,000 |
| | Controller upgrades required (assume existing controllers are Econolite Oasis or ASC/3 2070) | None | Upgrade to Trafficware Linux-based controller | Upgrade to any Linux-based controller | Upgrade to Econolite Linux-based controller | Upgrade to any Linux-based controller or install SmartLink widget |
| Features | Level of implementation effort | Low | Medium | High | Low | Medium |
| | Ability to process data from different vendors | Econolite only | Trafficware only | Yes | Econolite only | Yes |
| | Location of data storage | On-site | | On-site | | |
| | Dashboard metrics for multiple intersections | Not available | Not available | KHA custom dashboard available | Available | Available |
| | ATSPM summary tables | Not available | Not available | Available | Available | Available |
| | How to identify problems? | Scheduled reports identify possible maintenance concerns but not performance concerns | Click each intersection and generate each report | KHA dashboard shows changes in performance over time | Dashboard provides list of signals with possible performance concerns | Dashboard shows changes in performance over time |
| | Level of effort needed to identify problems | Medium | High | Medium | Low | Low |
| | Highlight hot spots | Not available | Not available | Not available | Available | Available |
| | Customization of queries by time frame | Available in 24-hour periods | Can customize one time frame at a time | Can customize one time frame at a time | Able to compare metrics between two date ranges | Able to query multiple days and intersections on single chart |
| | Customization of alerts (ease, versatility) | Not available for ATSPM | No alerting capabilities | Configurable daily email alerts | Available | Available |

## 2. Implementation Tier Tool

A screenshot of the implementation spreadsheet is included. The spreadsheet itself is attached.

| **About:** This is a tool to classify signal systems into ATSPM implementation tiers based on certain hardware, software, and performance characteristics. See the definition of each implementation tier on the next tab. **Instructions**: Enter "yes" or "no" for each question for each signal system. If a pre-populated value is incorrect, please correct the value and highlight the cell so the database can be updated. | MA# 11016, NC 51 (Pineville- Mathews Rd) - SR 4982 (Polk St), Division 10, Mecklenburg, Pineville | MA# 11017, SR 1430 (Kannapolis Pkwy) North, Division 10, Cabarrus, Kannapolis | MA# 11018, SR 2697 (W Catawba Ave) DDI, Division 10, Mecklenburg, Cornelius | MA# 11019, NC 218 (Fairview Rd), Division 10, Mecklenburg, Mint Hill |
|---|---|---|---|---|
| **Background Information** | | | | |
| Length of Corridor (miles)* | 11.37 | 5.18 | 4.4 | 2.7 |
| Number of Signals* | 16 | 8 | 7 | 2 |
| Annual VMT (Millions)* | 44.51 | 33.27 | 21.05 | 5.43 |
| Is this system CMAQ eligible?* | yes | | | |
| **Current Signal System Conditions** | | | | |
| Controller* | 2070 | 2070 | 2070 | 2070 |
| Communications* | Wireless | Wireless | Wireless | Wireless |
| Is this system currently using Centracs? | yes | yes | yes | yes |
| Is the system planned to be upgraded to Centracs in the next 5 years? | yes | yes | yes | yes |
| Does this signal system have high resolution controllers? | no | no | no | no |
| **Current Corridor Conditions** | | | | |
| Is this corridor over capacity? | yes | yes | yes | no |
| Does this corridor have atypical travel patterns (i.e. not AM/PM commuter travel)? | yes | yes | yes | yes |
| Are additional peformance measures needed to understand the corridor (beyond travel time runs)? | yes | no | yes | yes |
| Does this corridor have an unusually high number of maintenance calls? | no | no | yes | no |
| Does this corridor recive an unusually high number of complaints from the public? | yes | no | yes | no |
| Does this corridor have safety issues? (Combined Safety Score > 80)* | yes | no | no | no |
| Is this corridor retimed frequently? (on average, every 3 years) | no | no | yes | no |
| **Future Corridor Conditions** | | | | |
| Is the corridor anticipated to change rapidly in the future? (i.e. development, new connections, TIP Projects) | yes | yes | yes | no |
| | | | | |
| Current Tier | Tier IV | Tier IV | Tier IV | Tier IV |
| Goal Tier | Tier II | Tier III | Tier I | Tier IV |

| | Summary |
|---|---|
| **Tier I** | 2 |
| **Tier II** | 10 |
| **Tier III** | 11 |
| **Tier IV** | 40 |
| **Tier V** | 1 |

## 3. CMAQ Eligible Counties

The following counties were in non-attainment as of 2011 and are eligible for CMAQ funding.

- Cabarrus
- Catawba
- Chatham*
- Davidson
- Davie
- Durham
- Edgecombe
- Forsyth
- Franklin
- Gaston
- Granville
- Guilford
- Haywood*
- Iredell*
- Johnston
- Lincoln
- Mecklenburg
- Nash
- Orange
- Person
- Rowan
- Swain*
- Union
- Wake

*Counties are only partially designated non-attainment. CMAQ projects within these counties must be within the non-attainment portion.

## 4. Funding Sources Matrix

### Appendix 4: Long Term Funding Sources

| Funding Documentation | | | | | |
|---|---|---|---|---|---|
| **Name of Funds** | **Web Resource** | **Funding Agency** | **Timeframe** | **Size of Project/Award** | **Notes** |
| Congestion Mitigation and Air Quality Improvement Program (CMAQ) | https://www.fhwa.dot.gov/fastact/factsheets/cmaqfs.cfm | USDOT FHWA | Awarded yearly; apply in February | Varies. Total available: $2.449B | Funds may be used for a transportation project or program that is likely to contribute to the attainment or maintenance of a national ambient air quality standard, with a high level of effectiveness in reducing air pollution, and that is included in the metropolitan planning organization's (MPO's) current transportation plan and transportation improvement program (TIP) or the current state transportation improvement program (STIP) in areas without an MPO. Infrastructure projects seeking funds through the statewide process must be a minimum of $500,000 in total costs. Non-infrastructure projects do not have a minimum required amount. |
| SPOT Safety | https://connect.ncdot.gov/resources/safety/Pages/NC-Highway-Safety-Program-and-Projects.aspx | NCDOT | Yearly | $400,000/project; $9 million total/year | The Spot Safety Program is used to develop smaller improvement projects to address safety, potential safety, and operational issues. The program is funded with state funds and currently receives approximately $9 million per state fiscal year. Other monetary sources (such as Small Construction or Contingency funds) can assist in funding Spot Safety projects, however, the maximum allowable contribution of Spot Safety funds per project is $400,000. A Safety Oversight Committee (SOC) reviews and recommends Spot Safety projects to the Board of Transportation (BOT) for approval and funding. Criteria used by the SOC to select projects for recommendation to the BOT include, but are not limited to, the frequency of correctable crashes, severity of crashes, delay, congestion, number of signal warrants met, effect on pedestrians and schools, division and region priorities, and public interest. |
| SPOT Mobility | NCDOT | Mobility and Safety | | $40M | This is a fund managed by the State Traffic Engineer, Kevin Lacy, and administers funds for smaller mobility focused projects. |
| State Transportation Improvement Program (STIP) | https://www.ncdot.gov/initiatives-policies/Transportation/stip/Pages/default.aspx | NCDOT | Updated every two years. New cycle begins in July-Sept 2019 | Amount varies. Funding breakdown: 40% State Mobility, 30% Regional Impact, 30% Division Needs | Through the process, called Prioritization, potential transportation improvement projects are submitted to NCDOT to be scored and ranked through the Strategic Mobility Formula at the statewide, regional and division levels, based on approved criteria such as safety, congestion, benefit-cost and local priorities. These scores and other factors are used to determine whether a project receives funding. Project prioritization occurs every two years. The current round of Prioritization is referred to as P5.0, because it is the fifth iteration of this process. |