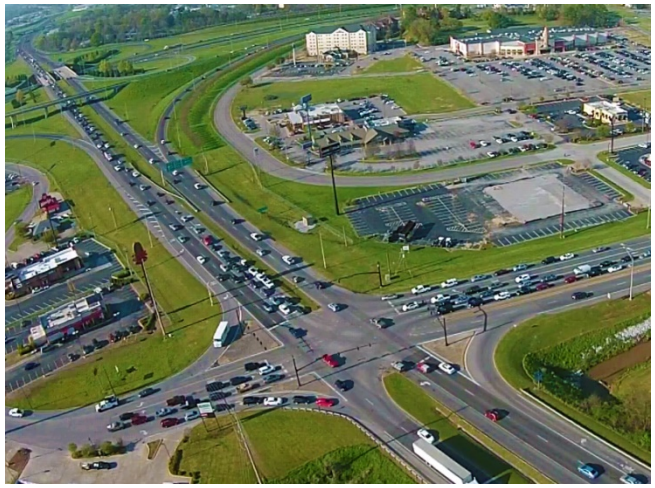

West Central Alabama **ACTION**

Advanced Connected Transportation Infrastructure & Operations Network

Project Name	Advanced Connected Transportation Infrastructure & Operations Network (ACTION)
Eligible Entity Applying to Receive Federal Funding	The University of Alabama
Total Project Cost	$16,280,764
ATCMTD Request	$7,333,458
Are matching funds restricted to a specific project component? If so, which one?	No

State(s) in which the project is located	Alabama
Is the project currently programmed in the: • **Transportation Improvement Program (TIP)** • **Statewide Transportation Improvement Program (STIP)** • **MPO Long Range Transportation Plan** • **State Long Range Transportation Plan**	Yes, the components contained within the ACTION initiative enhance projects identified in the TIP, STIP, regional MPO, and long range ITS roadmap for Alabama. The ACTION initiative unifies these efforts within the region and advances the deployment efforts to meet the needs of the rapidly growing area.

Technologies Proposed to be Deployed (briefly list)	DSRC radios, cellular communications, advanced data-logging traffic controllers, active signal control, wireless vehicle detection, traffic management centers, traveler information systems, smart work zones, digital PTZ cameras, end-user mobile apps

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INTRODUCTION

This proposal is to deploy an **Advanced Connected Transportation Infrastructure & Operations Network (ACTION)** in and around Tuscaloosa, Alabama. The initiative's core theme is ***Efficiency, Capacity, and Safety Through Technology***. ACTION will streamline traffic to improve mobility on the region's road network during normal operations and situations when roadway capacity or traffic demands adversely affect traffic operations (*e.g.*, special events that generate significantly higher traffic volumes, events that reduce roadway capacity, inclement weather, and other emergency or disaster situations). ACTION will incorporate next-generation sensor and traffic control systems and communication platforms combined with mobility tools for passenger and freight vehicles. This will substantially enhance safety, mitigate congestion, and improve travel time reliability in the region, all of which are critical for the economic vitality of the region and interstate commerce. Companies that rely on just-in-time (JIT) or just-in-sequence (JIS) manufacturing are particularly impacted (*1 minute delay = $10,000 for Mercedes Benz U.S. International, MBUSI*). A multi-agency partnership will work collaboratively on the ACTION initiative. The partnership includes the Alabama Transportation Institute (ATI) at the University of Alabama (UA), the Alabama Department of Transportation (ALDOT), the Tuscaloosa County Road Improvement Commission (TCRIC), and other local and regional stakeholders from industry including manufacturing, and trucking.

Key components of ACTION include a network of sensors and cameras, communications technologies, and traffic signal systems as well as mobile apps to facilitate near real-time exchange of data between vehicles, network elements, and users. Facets of ACTION include user functionality embedded in existing mobility apps, responsive traffic signals, and smart work-zones. These will enable agencies to implement operational strategies based on real-time demand and capacity, allowing motorists to respond proactively to such changes. These capabilities will result in improved safety, reduced congestion, increased travel time reliability, and yield significant economic and environmental benefits.

ACTION will upgrade 135 intersections West Central Alabama by implementing emerging connected and automated vehicle infrastructure systems (CAVIS) technologies and Intelligent Transportation Systems (ITS). Sensors will detect local traffic conditions and relay information to signal controllers and the regional traffic management center (RTMC), which will implement adjustments to traffic control strategies across the system. This information will be shared with drivers over a network of 175 Dedicated Short-Range Communications (DSRC) radios and/or cellular communications through the AlgoTraffic app. RTMC staff will monitor and update dynamic digital message signs (DMSs), mobile application routing and notifications, and enhance longer-term planning for the region. This will minimize the effect of travel delays for both passenger and freight vehicles by improving accessibility and mobility for underserved communities in the region.

ACTION Initiative with ATCMTD Funding will Deploy:

- *Advanced Traffic Signal Controllers (**135**)*
- *Dedicated Short-Range Communication Radios (**175**)*
- *Network Pan-Tilt-Zoom Cameras (**90**)*
- *Mobile Application Platform (>**50,000 Users**)*
- *V2I, V2V, and V2P based Traffic Communications*
- *System-Wide Management & Optimization Algorithms*
- *Model Multi-Agency Collaborative Partnership*

Projects meant to improve transportation efficiency and capacity can have adverse consequences on travel times, congestion, safety of motorists and pedestrians, and fuel consumption during construction. The ACTION initiative will monitor and facilitate improved traffic movement for vehicular and pedestrian traffic in already congested urban areas to help ease the impact of road construction projects. ACTION will be integrated with four key planned projects across the region to magnify their benefits, optimize the long-term efficiency of the construction enhancements, and minimize construction impacts.

ACTION will result in the implementation of advanced CAVIS/ITS and transportation management technologies such as those listed in Table 1. Engineers and system operators will be able to quickly and accurately monitor, assess, and respond to changing traffic conditions. Initial efforts by UA on an ongoing project sponsored by ALDOT in Tuscaloosa have already shown improvements of up to 17% in vehicles arriving on green. The next step is to scale this up to a regional deployment to enhance planned infrastructure improvements by jurisdictional agencies. This multi-agency cooperative effort will increase the impacts of existing and planned large-scale transportation projects across a critical area of this state, with recurring benefits over the next decade.

The ACTION initiative has enabling agreements in place between UA, ALDOT, and other agencies to develop and deploy CAVIS/ITS technologies (Appendix 2). Further, there is strong commitment and support from leaders and stakeholders across the state. Volume 2 of this application documents this with more than a dozen letters of support from elected officials at the federal, state, and local levels, the director and regional engineer of ALDOT, city and county agencies, and key industry partners.

The ACTION initiative will deploy a model CAVIS/ITS using advanced technology and communication to improve safety, efficiency, system performance, equity, and return on investment. ACTION will provide an enhanced transportation system that effectively addresses the needs of the rapidly growing area. By making our roadway system smarter, not just larger, ACTION will provide a value model by which other agencies can enhance and improve their networks by better leveraging the existing infrastructure assets through the deployment of context-appropriate technologies, tools, and management systems.

Table 1: Connected, Automated Vehicle and Infrastructure Systems (CAVIS) applications examples

Safety	**Environment**	**Mobility**
Red Light Violation Warning	Eco-Traffic Signal Timing and Priority	Advanced Traveler Information System
Spot Weather Impact Warning	Eco-Traveler Information	Signal Priority (transit, freight)
Reduced Speed/Work Zone Warning	Low Emissions Zone Management	Mobile Accessible Pedestrian Signal System
Pedestrian in Signalized Crosswalk	Eco-Routing (light vehicle, transit, freight)	Emergency Vehicle Preemption
Agency Data	**Road Weather**	Queue Warning
Probe-based Traffic Monitoring	Motorist Advisories and Warnings	Freight-Specific Dynamic Travel
Work Zone Traveler Information	Weather Response Traffic Information	Emergency Communications and Evacuations

Adapted from https://www.its.dot.gov/pilots/cv_pilot_apps.htm

VISION, OBJECTIVES, AND GOALS

The ACTION initiative will integrate existing infrastructure assets in the region and further enhance their effectiveness through CAVIS and ITS components. The deployment of hard and soft technologies will result in verifiable results that will enhance safety, accessibility, and mobility across the project area. ACTION will serve as a model and will showcase how strategic technology deployments can, in many cases, forestall the need to expand roadways by more efficiently leveraging the existing assets and context-appropriate technology-based solutions. This initiative will yield numerous tangible and intangible benefits across the region that will provide a substantial return on investment and reduce the total lifecycle cost of ownership.

The vision and objectives of the ACTION initiative focus on deploying technologies, improving safety and system reliability, enhancing mobility, increasing fuel efficiency, providing economic benefits, and showcasing a multi-organizational partnership to leverage resources to improve existing infrastructure. The vision, objectives, and performance goals for the project are summarized in the adjacent panels and center around safety, travel time reliability, connected infrastructure, and associated benefits from these system enhancements.

The ACTION initiative's advisory board will guide the project efforts. The coordinating committee and project team will evaluate performance metrics over the project lifecycle, document progress towards the stated goals, and implement adjustments and changes needed to the project plan to enhance ACTION's effectiveness. Close attention to the performance metrics and progress will ensure significant multiplier effects from technology-focused ATCMTD investments beyond traditional road infrastructure improvements in the region.

VISION AND OBJECTIVES

1) **Deploy** technologies that leverage emerging tools and innovative system integration strategies to create a safer and more efficient and equitable transportation network.
2) **Improve** system reliability and performance by using advanced data integration and analytics.
3) **Enhance** mobility within the region to improve access to education, employment, and healthcare, especially for underserved communities.
4) **Increase** system-level fuel economy and mitigate adverse environmental effects.
5) **Provide** economic benefits to the region by improving system throughput and reducing delays.
6) **Create and showcase** an exemplary multi-jurisdictional CAVIS and ITS deployment initiative.

PERFORMANCE GOALS

1) **Improve** safety by reducing the number of secondary crashes by 20% in the region.
2) **Increase** travel time reliability by 25%.
3) **Connect** at least 50% of the motorists in the region with AlgoTraffic and V2X information.
4) **Achieve** systems-level fuel economy gains of 20%, and derive accompanying emissions reductions.
5) **Reduce** industry downtime for JIT and JIS manufacturing by 5%.
6) **Integrate** connected intersection infrastructure to 50% of intersections in the project area.

STAKEHOLDERS

The University of Alabama

Founded in 1831, UA is the oldest and largest public university in Alabama. The UA campus in Tuscaloosa has a student enrollment of over 37,000 and more than 1,800 staff. Its annual economic impact exceeds $2.6 billion. Transportation and Cyber/Information Systems are two of the four focal areas identified by UA in its 2016 Strategic Plan.

Alabama Transportation Institute

ATI is at the core of all transportation-centric research at UA. ATI coordinates transportation efforts across centers, labs, faculty, and researchers and provides centralized resources for research development and deployment initiatives as well as educational and outreach programs.

Center for Advanced Public Safety

The Center for Advanced Public Safety (CAPS) focuses on Reseach Development & Deployment (RD&D) efforts. CAPS, with about 75 IT related professionals on staff, has developed numerous software tools such as AlgoTraffic, Critical Analysis Reporting Environment (CARE), and law enforcement citation/ crash reporting systems for national and state level deployment. Software created by CAPS for FMCSA is used in all 50 states, and other software is used by 20,000+ law enforcement officers.

Alabama Department of Transportation

The Alabama Department of Transportation (ALDOT) is tasked with maintaining over 213,000 lane-miles of roads in Alabama. Their mission is to provide a safe, efficient, environmentally sound intermodal transportation system for all users, especially the taxpayers of Alabama. The West Central Region (WCR) of ALDOT covers a 13-county area that extends from the Mississippi border to Birmingham.

Tuscaloosa County Road Improvement Commission

The Tuscaloosa County Road Improvement Commission (TCRIC) provides oversight for the prioritization and financing of public road and bridge construction and maintenance projects financed by local tax proceeds. The Commission is composed of the following members (see letters of support in Volume 2):

- Tuscaloosa County Probate Judge Hardy McCollum, Chairperson
- Tuscaloosa Mayor Walt Maddox, Vice-Chairperson
- Northport Mayor Donna Aaron
- State Senator Gerald Allen
- State Representative Chris England
- Mr. Jim Page, CEO of the West Alabama Chamber of Commerce
- Mr. Dara Longgrear, Executive Director of the Tuscaloosa County Industrial Development Authority

Tuscaloosa Department of Transportation

The Tuscaloosa Department of Transportation (TDOT) oversees the installation, maintenance, and monitoring of traffic signals and fiber optic communication in the Tuscaloosa region. Many of their 190 signals are along key corridors that affect traffic within, through, and around the region.

Mercedes-Benz U.S. International

MBUSI is located in Tuscaloosa County, Alabama. It accounts for more than 24,500 jobs - both at the plant in Vance (approx. 3,600) and through their suppliers across the region. MBUSI has an annual economic impact of more than $1.5 billion. MBUSI is also the state's largest exporter, with more than $1 billion in exports each year to over 130 countries. In 2016, MBUSI produced more than 300,000 vehicles.

GEOGRAPHIC AREA: WEST CENTRAL ALABAMA

The ACTION initiative directly addresses the needs of West Central Alabama. This includes the Tuscaloosa-Northport metropolitan area, which is the regional nexus for other very rural areas often referred to as the Black Belt region. The Tuscaloosa metropolitan area has a population of approximately 230,000 and it is located about 60 miles from Birmingham.

West Central Alabama has many underserved communities that depend on reliable transportation networks to access jobs, schools, health care, and other services. The cities of Tuscaloosa and Northport serve as gateways for commuters from much of the outlying area heading to employment centers. The area is home to large manufacturing plants, including MBUSI and BF Goodrich Tires; UA; and Stillman College and Shelton College. Tuscaloosa is also home to many federal, state, and local government agencies that employ approximately 25% of the area's population.

Tuscaloosa has grown over 10% in the last 5 years, so local traffic has become an issue for people and goods traveling through the area. Between Northport and Tuscaloosa, there are four river crossings, including a privately operated toll bridge. Drivers need to know the best route to take within the area. This is complicated with heavy local traffic, especially to UA. Once through the city, traffic converges at I-20/59 to head to Birmingham. Adding lanes to the freeway has increased capacity, but crashes and congestion often prompt traffic to use US-11 as an alternate route. This is an example of where technology-based solutions can assist commuters to efficiently navigate to jobs at MBUSI in Vance or further on to Birmingham. Figure 1 illustrates these effects overlaid on a map of the region.

Interstate 20/59 traverses the region connecting Meridian, MS, to Tuscaloosa and on to Birmingham. I-20, stretching from western Texas to eastern South Carolina, runs concurrently through the region (from Meridian, MS, to Birmingham) with I-59, which connects southern Louisiana to the Georgia-Tennessee state line. Trucks account for 40% of the traffic volume on I-20/59 in this region. This reflects the critical role of the network for freight, commerce, and economic productivity.

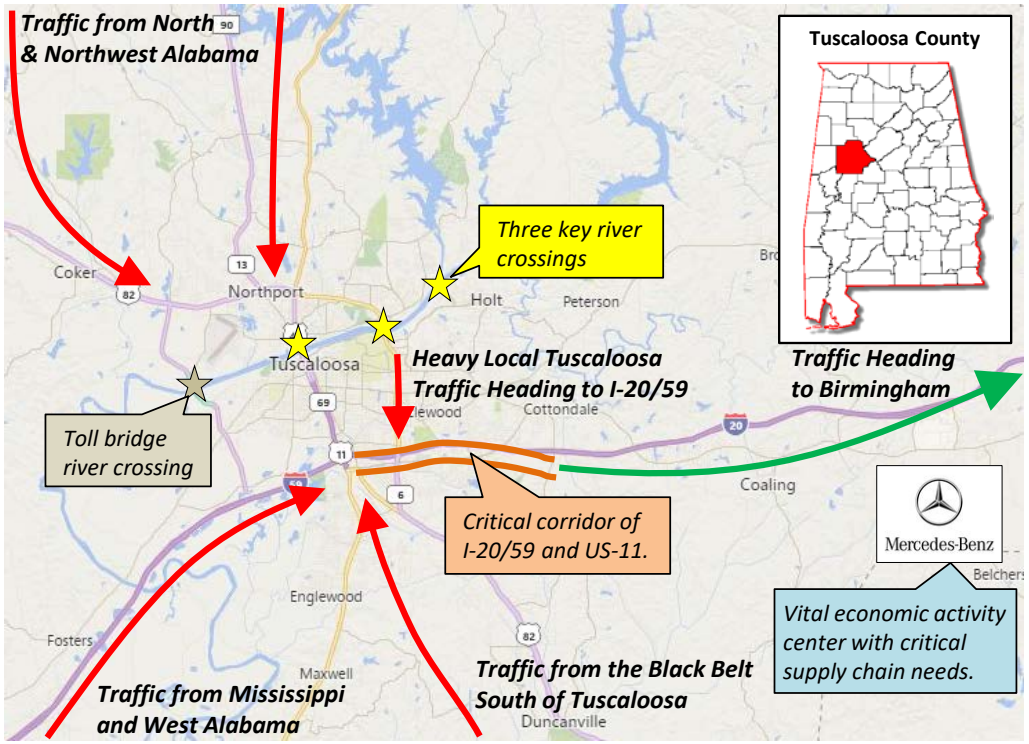


Figure 1: Regional map with major traffic flows and other highlights

REAL WORLD ISSUES

ACTION's main themes of *Efficiency, Capacity, and Safety* are vitally important to effectively and equitably serve the freight and passenger mobility needs of the Tuscaloosa region. These are closely interrelated, especially during times of traffic congestion (*e.g.*, reduction in road capacity or spikes in demand due to construction, weather, crashes, or special events). While there have been several transportation projects in the area (*e.g.*, expansion of I-20/59), much of the work has focused on rebuilding efforts to recover from the EF-4 tornado that struck the region in April 2011. The rapid growth in the region (Tuscaloosa is the fastest growing city in Alabama) warrants even greater emphasis on improving the road network's *Efficiency, Capacity, and Safety*. In addition to enhancing capacity, there is a pressing need to adopt CAVIS, ITS, and other advanced technology solutions.

How Will ACTION Help?

The ACTION initiative will significantly increase the benefits and the magnitude of investment impacts beyond those derived from traditional roadway projects that often have limited technology-oriented resources. ACTION will accomplish this through innovative strategies that include CAVIS and ITS solutions and a multi-organizational partnership. It will upgrade existing traffic control systems, deploy state-of-the-art sensors and cameras, and incorporate emerging communications technologies combined with smart-phone apps and other enabling tools for an integrated regional transportation management approach. This will substantially enhance safety, mitigate congestion, improve travel time reliability, improve fuel efficiency, and reduce adverse environmental impacts for both passenger and freight communities. The target deployment locations were chosen to address the needs of proximate underserved communities. These technology-focused investments will have a 10- to 20-fold multiplier effect on the accrued benefits.

Figure 2: Example of safety management in work zones.

With the heavy proportion of trucks on the road network within, through, and around Tuscaloosa, crashes involving commercial vehicles (CMVs) have been, and remain, a particular concern and issue. Between January 1, 2013, and June 1, 2015, there were 471 crashes involving a CMV on I-20/59 within the Tuscaloosa region. CMV crashes are both a safety concern and a mobility concern as freeway shutdowns from CMV crashes can have tremendous impacts on vehicle delays. Once a shutdown occurs, long queues can form and produce ripe conditions for secondary crashes. In a preliminary study, 50% of fatal CMV crashes and 40% of incapacitating CMV crashes were rear end collisions where CMVs approaching at high speed have are involved in crashes with slower moving traffic. Often, this scenario is at the back end of a queue. ALDOT has aggressively employed traditional options, as illustrated in Figure 2, to help keep speeds down and respond to incidents, but technology such as CAVIS applications offers tremendous potential to supplement these methods with advanced information and warning.

Issue: Safety and Crashes

Crashes are always a major concern for transportation agencies and road users. A NHTSA study of connected vehicle technologies has shown that they have the potential to eliminate up to 80% of non-impaired crashes. We believe that the ACTION project will be essential to realizing these benefits from technology in West Central Alabama.

CAPS manages the citation, crash, driver and vehicle licensing databases for Alabama. The 2015 crash data were used as one way to prioritize areas of higher need for Traveler Information and Incident Management strategies. Urban Tuscaloosa had a total of 5,306 recorded crashes; rural Tuscaloosa had 1,865; and Northport had 1,206. About 51% of the crashes in urban Tuscaloosa are intersection-related, while this category only accounted for 10% of crashes in rural Tuscaloosa. In Northport, 34% of all crashes are intersection-related.

Looking at the most recent data for the Tuscaloosa region, pedestrian-involved fatal vehicle crashes increased by 220% and are 2.4 times the national average. ACTION will include vehicle-to-pedestrian (V2P) components specifically targeted towards pedestrian safety to address the growing issues in the region.

In addition to general crash and pedestrian safety data, specific crash data were obtained from ALDOT using CARE for urban and rural routes in the study area for the past five years. These data were analyzed to determine locations for incident hot spots as shown in Figure 3. The locations for incident hot spots were chosen based on one or more of the following:

- A high number of crashes near a location;
- A high ratio of crash rate (based on ADT, VMT); and/or
- A high proportion of severe crashes based on exposure.

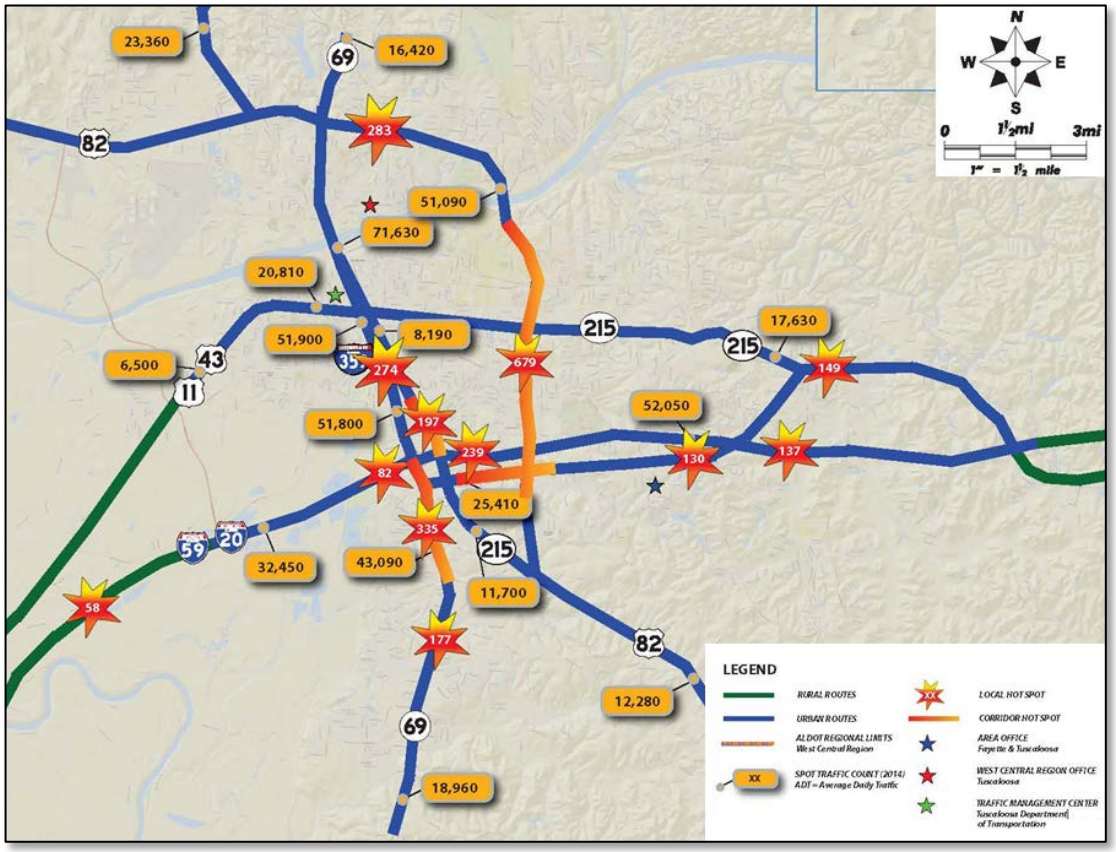
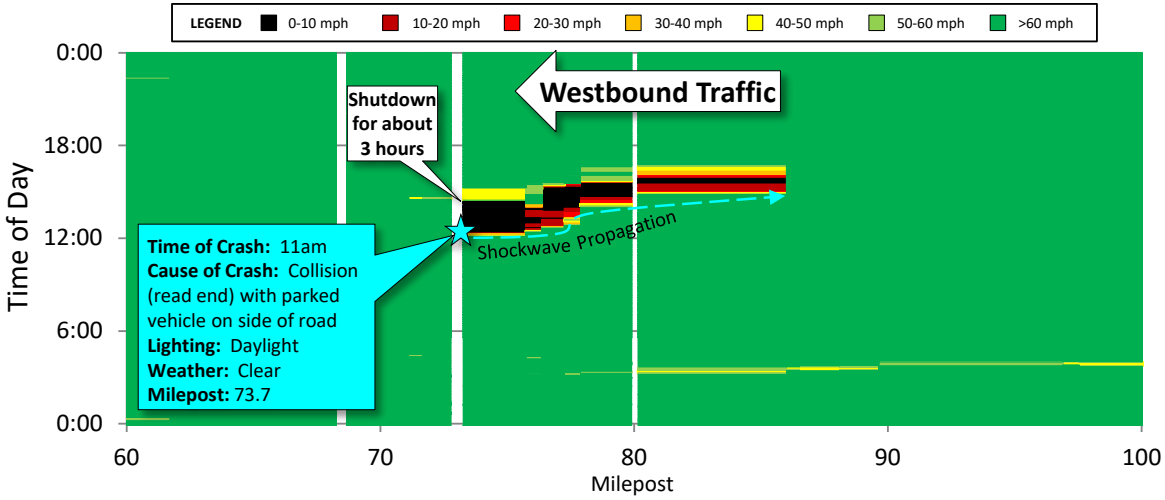


Figure 3: Hot spots for traffic and crashes around the Tuscaloosa region.

Issue: Traffic Incident Management

As previously noted, crashes have been a concern on the freeways in the region, and will continue to be an issue with the upcoming construction projects. These crashes are often severe and have a tremendous impact on operations. ALDOT measures speeds to monitor and quantify crash congestion, with both speed and congestion leading to further safety concerns. Two fatal CMV crashes from 2014 demonstrate the impact on freeway congestion. Higher severity crashes (such as fatal crashes) have an extreme impact on mobility. Figure 4a shows the effect on speeds resulting from congestion due to a westbound fatal crash where a truck rear-ended a vehicle on the side of the road. The crash at 11 am shut down the freeway for 3 hours, with shockwave or queuing effects observed over 10 miles upstream. Figure 4b shows an eastbound fatal crash where a CMV struck a guardrail and caught on fire. The eastbound segment of the freeway was shut down for about 5 hours. The data and information behind these figures can be used to quantify the impact from each crash. ACTION will be the platform to capture, analyze, visualize, and relay such data to users and operators.



a) Westbound fatal injury crash congestion

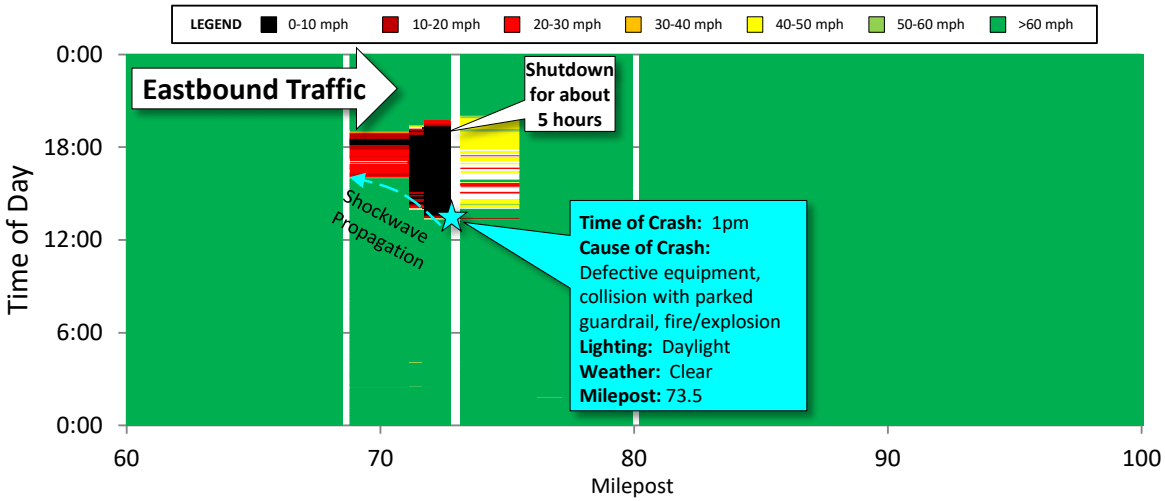


Figure 4: Example of congestion and queuing impacts from two separate fatal crashes

Issue: Special Event Traffic

Special events, such as major athletic events, are important to many people and businesses in the community. The UA football games are a major traffic generator, bringing in more than 100,000 fans for each home football game. This traffic has such an impact that the state has reconfigured certain highway interchanges to accommodate it. Data need to be collected and processed for decision-makers to understand the performance of the transportation system. In fall 2014, Alabama began using commercial probe data to characterize each of the home football games in Tuscaloosa. Figure 5 shows a capture from video playback of the congestion. Each segment of I-20/59 between exits was colored based on 1-minute speeds (https://youtu.be/wxK8k2DLn88). The red shows heavy congestion leading up to the 11:00 am kickoff.

The objective of this portion of ACTION will be to generalize these techniques to develop standard reporting procedures for agencies to use when hosting diverse special events such as NASCAR, PGA, and perhaps even inauguration events, to characterize when segments of the transportation network return to normal. By providing system performance feedback, the special event traffic management workforce can establish better traffic management strategies to utilize existing capacity. This information can also be communicated to fans and other road users about alternate routes or transportation modes (such as carpooling, buses, and other ways to get to the event). This analysis will be used for each game to help understand the effects of weather, traveler origins, time-of-day, score, and other factors that contribute to congestion. Local arterials and regional freeways will be monitored, using real-time connected-vehicle data and signal data, to identify congested locations where alternative routes or other traffic management strategies may need to be employed.

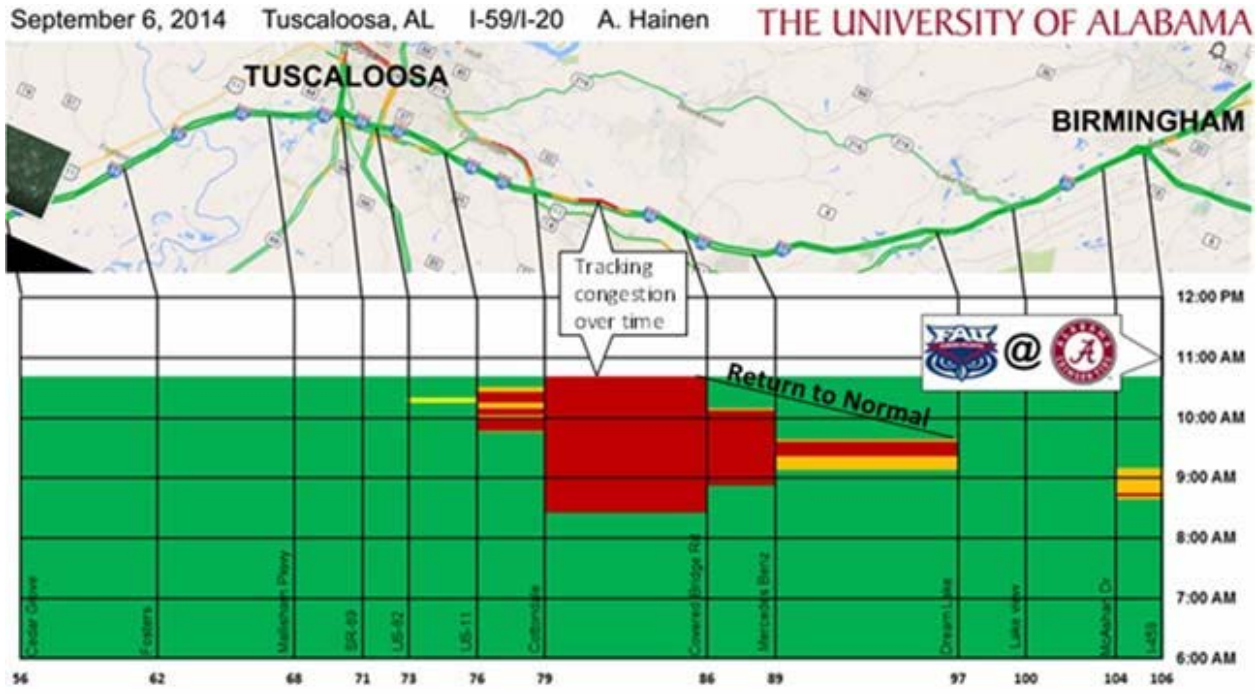


Figure 5: Example of congestion induced by special event traffic

Issue: Construction Projects

A number of significant infrastructure projects are scheduled in the ACTION region over the next two to three years, totaling over $150 million in investments (as summarized in Table 2). They aim to improve road network capacity for the region. Integrating the ACTION initiative's technology into these planned deployments will further enhance the new capacity.

ACTION will result in a long-term capacity handling and optimization mechanism for the deployment area rather than just meeting the near-term needs. While many of these projects are focused on the region, some, such as the I-20/59 project, have national implications by enhancing the aggregate capacity on that key interstate thoroughfare.

Table 2: Tuscaloosa Region Transportation Projects

Project Name	Description	Cost
I-20/59 Add Lanes	Following previous add-lanes work on I-20/59 east of Tuscaloosa, this project will increase capacity by adding lanes to 3.21 miles on I-20/59 through Tuscaloosa. This will be a 2- to 3-year project which, when completed, will increase safety and mobility for all road users.	$70M
SR-69 Overpass	The purpose of this project is to relieve congestion at the intersection of SR-69 and US-11, close to I-20/59. The project will consist of additional lanes, additional turn lanes, a grade separation bound by retaining walls on SR-69, access changes on SR-69 and US-11, bicycle and pedestrian improvements including a shared-use path, installation of ITS technologies, and improvements at adjacent intersections, including signal optimization, to assist the overall function of the US-11 and SR-69 intersection. The project will take 2 to 3 years to complete.	$57M
Lurleen B. Wallace Upgrades	The two parallel one-way corridors of Lurleen B. Wallace Boulevard traverse downtown Tuscaloosa and handle over 70,000 vehicles per day. This project will consist of rebuilding Lurleen B. Wallace with sufficient and more uniform pavement buildup, eliminating on-street parking to create left turn lanes and right turn lanes, pedestrian improvements and shared use path, and intersection / signal improvements. This project will take 2 years to complete.	$17M
US-82 Interchange Modifications at University Boulevard	The purpose of this project is to improve traffic operations and efficiency at the existing interchange, thereby allowing the interchange to better serve the existing and future traffic demand. This project will consist of additional lanes on US-82 from 13th Street to Campus Drive and on Dr. Edward Hillard Drive, from Paul Bryant Drive to University Boulevard. It will widen road segments along the US-82/University Boulevard interchange ramps and along University Boulevard to allow for additional lanes/turn lanes/auxiliary lanes. It will include intersection improvements at Paul Bryant Drive and University Boulevard, and other improvements such as pedestrian facilities, weaving elimination, and signal upgrades. This project will take 3 years to complete.	$6M
	Total Infrastructure Investment	**$150M**

TRANSPORTATION SYSTEM AND SERVICES TO BE INCLUDED

ACTION will leverage proven and emerging ITS technologies to streamline traffic flow in the deployment region, optimize feedback to users, and collect, analyze, and synthesize data for system-wide analysis and enhancement. We will upgrade existing infrastructure elements with components necessary to realize the potential as a "smart" system.

ACTION will include 135 intersections in total with upgraded traffic signal control and a system of 175 DSRC radios to create one of the largest connected vehicle deployments in the nation. ACTION will be able to provide dynamic signal timings across the region by upgrading the signal controllers, many of which are 30+ years old. This will improve aggregate system flow and provide greater travel time reliability. We will couple active signal control with in-road wireless vehicle detection modules to provide a feedback mechanism for signal controllers to track intersection approach volumes and queue lengths.

A hybrid DSRC radio and cellular ecosystem will facilitate the transfer of information to both a new class of connected vehicles (using DSRC) as well as to legacy vehicles and pedestrians (using cellular). Traveler information such as road travel times, signal phasing and time (SPaT), lane closures, crashes, construction zone information, etc. will be available from both DSRC and cellular transmissions to an enhanced version of the AlgoTraffic mobile app platform. The mechanisms for implementing this system are described in greater detail in the deployment plan.

ALDOT and UA have an agreement to collocate and operate a regional traffic management center (RTMC) to coordinate traffic activities across the ALDOT's West Central Region (WCR) – to unify varied services and systems. This RTMC will be operational by July 2017. With direct access to the aforementioned technologies, the RTMC will have the ability to control and manage signal timings, deploy assets, identify alternate routes, and communicate with the DMSs and mobile users to relay relevant travel information in a timely manner. This will also help to improve travel time reliability and safety.

In addition to a data-centric view, the RTMC will also have digital pan-tilt-zoom (PTZ) cameras that will provide an "eyes on the scene" perspective. PTZ cameras are key to helping stranded motorists, evaluating crash scenes, and examining traffic flow patterns. The digital PTZ feeds can also be fed to computer-learning algorithms to determine auto and CMV patterns and provide predictive traffic flow models.

The ACTION initiative seeks to transform this critical transportation corridor in West Central Alabama through this unified approach of technology-enabled services. We will integrate ACTION components into existing or planned infrastructure elements to derive improvements and capabilities that capacity-enhancement alone cannot provide.

ACTION SYSTEM & SERVICES

- Advanced data-logging traffic controllers, active signal control
- DSRC & cellular infrastructure-to-vehicle communication
- Traveler information systems
- End-user mobile apps
- Dynamic routing based on real-time traffic patterns
- Smart work zones
- Traffic management center & digital PTZ camera feeds
- Wireless vehicle detection

DEPLOYMENT PLAN

The ACTION initiative will deploy hardware and technologies to produce new data streams that can be integrated into widely-distributed apps. Signal systems, controllers, detection/sensor upgrades, and communication improvements will be deployed through the tasks defined in ACTION. We will increase *Efficiency, Capacity, and Safety Through Technology* by enhancing current and planned projects.

As the area's freeway add-lanes project start in the fall of 2017, there will be greater dependence on traffic data by both traffic operators and end-users for day-to-day decision-making. To prepare for times when traffic uses surface streets more heavily (*e.g.*, rerouting), our deployment will begin with upgrades to the signal system. This will include advanced traffic controllers (ATC) with data-logging capabilities, upgraded detection (which will help to collect data for further analysis), and communication upgrades within the signal controller cabinets. Since each of these intersections will be connected to the RTMC, networked PTZ cameras will be used for observation and surveillance of traffic. Cameras will also be installed at key locations along the freeway, as noted in ALDOT WCR's Transportation Systems Management and Operation (TSMO) plan. ALDOT will handle fiber optic additions to their network for the back-haul of video and data to the RTMC.

To successfully continue the deployment beyond the initial hardware installation and fully utilize new capabilities, the UA team will immediately begin to enhance the existing AlgoTraffic app, collect data, store data, develop algorithms, and streamline existing platforms for system operators and end-users. This will assist other efforts by ALDOT in their TSMO plan execution with efforts such as smart-work zones, special event management, and other previously identified approaches.

The ACTION initiative will also collaborate with TCRIC projects and programming. Many of their projects have only nominal funding for ITS components, especially in the form of traffic signal installations and improvements. ACTION will greatly enhance these large investment infrastructure projects.

ACTION will leverage approximately $7.3 million in ATCMTD funds coupled with $8.9 million in matching funds to accomplish the initiatives described in this application. This deployment will expand on the $150 million investments in heavy infrastructure projects planned in the area (Table 2). ACTION will benefit from signal system upgrades, sensor systems, communication connectivity, RTMC operations, and other aspects of those projects. Table 3 lists the principal ACTION deployment groups and sources of funding for each group from the sponsors: ATCMTD, ALDOT, TCRIC and UA.

Table 3: ACTION Funding Summary

Deployment Funding Overview				
Category	ATCMTD	ALDOT	TCRIC	UA
Signals	$1,350,000	$210,000	$2,000,000	
DSRC	$465,000			
Digital Message Signs		$800,000		
Fiber		$1,161,000		
Data Integration	$930,051			
Algorithms & Analytics	$1,591,000			
Connected Vehicle App	$1,395,076			
Deployment Evaluation	$922,332			
RTMC Operations		$2,634,000		$500,000
Cameras	$680,000	$1,640,000		
TOTAL	**$7,333,458**	$6,445,000	$2,000,000	$500,000
CASH MATCH		**$8,945,000**		
PROJECT TOTAL	**$16,278,458**			

High Level Description of Deployment Plan

The ACTION initiative builds on a TSMO master plan (Figure 6) that ALDOT adopted in January 2017 for its systems approach to implement ITS in the West Central Region. A Regional Systems Engineering Analysis report for the TSMO plan identifies the needs, user groups, projects, and operational roles early in the process to define requirements prior to specific and detailed design. This, in turn, lays the framework for implementation, system performance metrics, day-to-day operations, and life-cycle maintenance. ACTION takes the high-level components identified in the ALDOT Statewide ITS Architecture and further develops these to assure compliance with National Standards and the State and National ITS Architectures. The ACTION initiative will follow and further the TSMO master plan to achieve successful deployment of system components. A selection of the key components is shown in Figure 7, including signal upgrades, Bluetooth detection systems, closed circuit cameras, DMSs, fiber optic communication, and other hardware. The ACTION initiative includes parts of these aforementioned items, along with other components (*e.g.*, DSRC radios) and enhancements for the integration of the various data streams and sources.

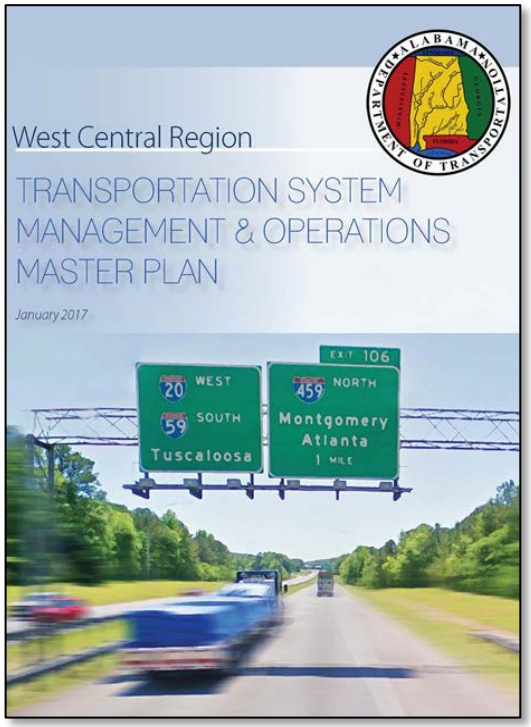


Figure 6: TSMO Master Plan

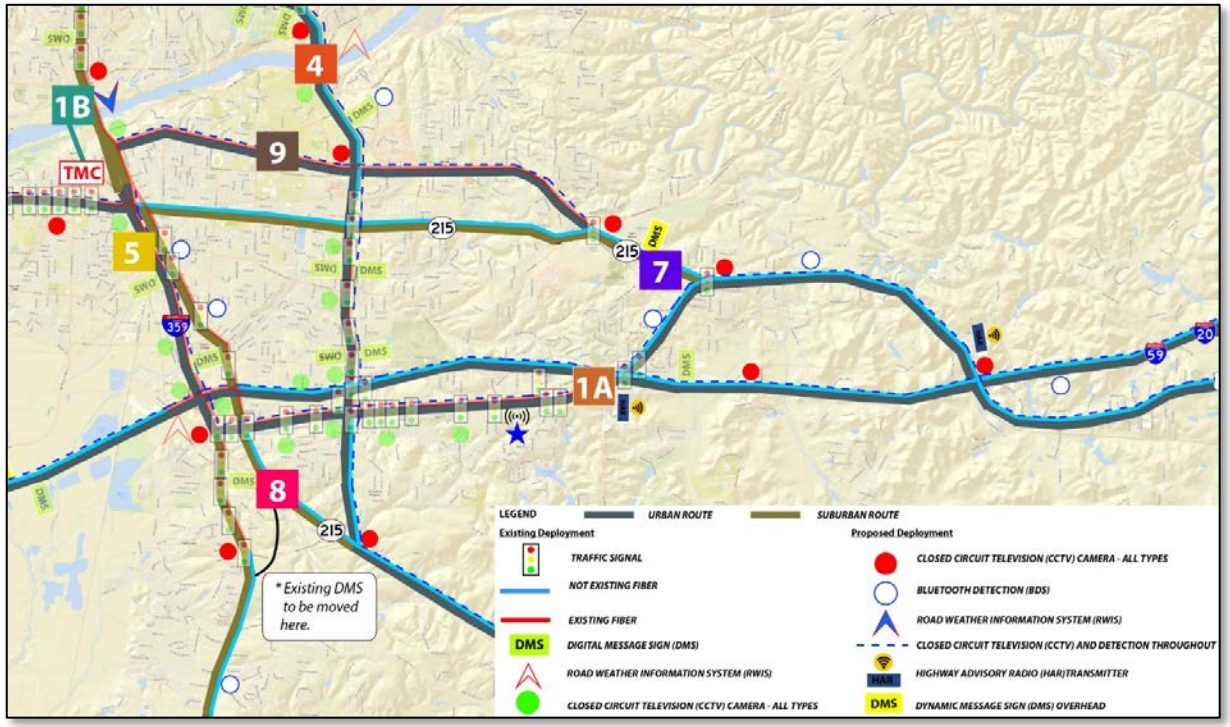


Figure 7: ACTION Deployment Map

Traffic Signal Upgrades

We have identified nearly 50 traffic signals for upgrades through the ACTION initiative (candidate locations are listed in Appendix 3). These signalized intersections will enhance *Efficiency, Capacity, and Safety* by augmenting the 85 intersections that are being upgraded by ALDOT. ACTION will focus upgrades on a number of major routes to further extend the coverage of connected infrastructure and DSRC especially to improve accessibility and mobility for outlying communities around Tuscaloosa. The hardware upgrades will include modern data-logging ATCs, accurate point detection sensors (capable of providing fine-grained detection information for individual vehicles), fiber switches for communication, and PTZ cameras for traffic observation. Figures 8 and 9 show UA and ALDOT personnel working jointly on field installations / operations.

Capabilities of ATCs will enable the use of modern communications and newer algorithms for tactical control and operations. Alabama and many other states have effectively used wireless magnetometers for point detection. While each type of detection has its own advantages and disadvantages, the wireless magnetometers are excellent for providing crisp and snappy detection capable of observing each vehicle. These data will be collected and used for analyses and optimization algorithms.

Fiber optic communication networks will be used to transmit data from the traffic controllers to the RTMC. This requires appropriate network switches in the cabinets which will be used to provide within-cabinet communication between the traffic signal controller, DSRC radio, and other IP-based devices. The switches will have the necessary optics to send the data over the fiber network to the RTMC and data storage servers.

Figure 8: UA deploying new cabinet control hardware

Figure 9: UA and ALDOT personnel deploying advanced detection for performance monitoring

Dedicated Short-Range Communications

In the transportation realm, technologies are rapidly changing how vehicles, roads, and other users and elements of infrastructure interact. The emergence of DSRC equipment and protocols have provided a new way for vehicles to directly interact and communicate with one another. ACTION will use DSRC radios to improve the *Efficiency, Capacity, and Safety* of the intersections and vehicles in the region by providing real-time communication capabilities between the vehicles and infrastructure (V2I). and vehicles and vehicles (V2V).

DSRC equipped vehicles and infrastructure elements (see Figures 10 and 11) will facilitate an entirely new communication platform for the facilitation of transportation-specific data. This communication uses a protected 75MHz spectrum of the 5.9GHz wireless band. It allows for very low latency communications within the range of about 100 meters to permit vehicles to share pertinent speed, location, acceleration, road, and other information directly and securely. Also, vehicles and infrastructure elements can communicate with each other, and information can be disseminated to enhance driver awareness. Some examples of DSRC applications include cooperative adaptive cruise control, forward collision warning, and intersection timing and status.

Figure 10: DSRC Roadside Unit

The American Association of State Highway and Transportation Officials (AASHTO) has issued a challenge for each state to deploy 20 DSRC radios by the year 2020. To enhance the impacts and reach of a $3.2 million ALDOT sponsored project, in 2017 UA invested $465,000 to deploy DSRC radios at 85 connected intersections in Tuscaloosa. The UA/ALDOT team is working with operators of motor vehicle fleets to install DSRC equipment to establish a test group on the road network.

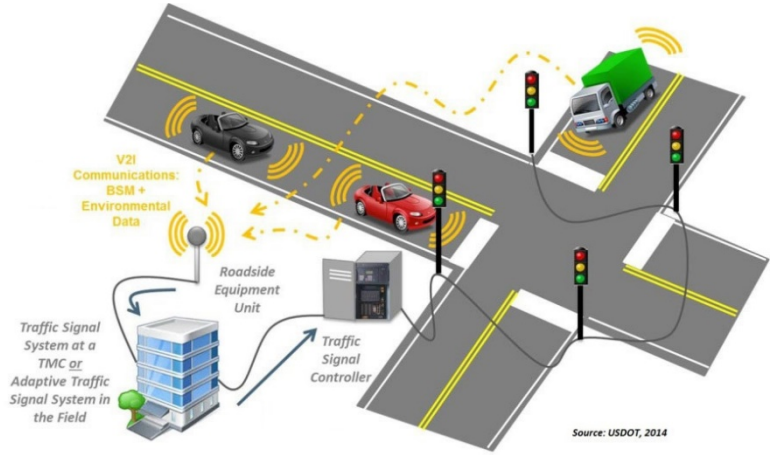


Figure 11: V2X Schematic Architecture

One challenge with the DSRC platform is that while it can easily be deployed (especially at intersections where power is readily available), network coverage and capability is limited by the low percentage of vehicles currently on the road with these on-board-units (OBUs) or other means of communications. It is widely believed that, most if not all, vehicles will be equipped in the future with 5.9GHz capable OBUs. In the meantime, UA researchers plan to develop and deploy a cellular-based application which can be used on any smart phone. This will allow practices and processes to be developed and widely shared before the full deployment and utilization of the 5.9GHz DSRC platform. However, the apps will be platform- and device-neutral, and able to work seamlessly on the new platform.

Data Integration

The significant volumes of data generated from the ACTION initiative will be used to optimize system performance with a focus on *Efficiency, Capacity, and Safety*. We will develop and integrate algorithms to improve signal timings based on volume, speed, and other factors, and pedestrian flow considerations.

ALDOT has initiated efforts to upgrade traffic signals with ATCs capable of collecting high-resolution event-based data. Since these modern controllers are part of connected infrastructure, they enable data to be collected and stored using traditional communication networks. These data record each vehicle detection, pedestrian actuation, signal phase change, and many other key events that occur at the intersection. The data are stored in a disaggregate fashion to the nearest tenth of a second. A typical intersection will usually generate about 100K-250K records per day. Engineers can observe current performance, identify issues or concerns, and simulate changes which can then be evaluated once deployed in the field.

ALDOT has nearly completed installing ATCs at about 85 signalized intersections in the Tuscaloosa and Northport area. Some of the data have been stored for a year, which provides engineers and operators with seasonal insights, including capturing special-event traffic. Quantifying the proportion of vehicles arriving during the green interval is an example metric of how the data are used. We can expect typical intersection improvements of 10-20% by improving and maximizing this metric.

UA researchers have developed a web interface that provides graphical assessment tools which help engineers and system operators easily use data from the ATCs. These tools have been developed into the Signal Performance Metrics site, an FHWA Every Day Counts Round 4 Innovation as shown in Figure 12.

The image in the bottom of Figure 12 is known as a Coordination Diagram, which can be used to graphically characterize arrival information.

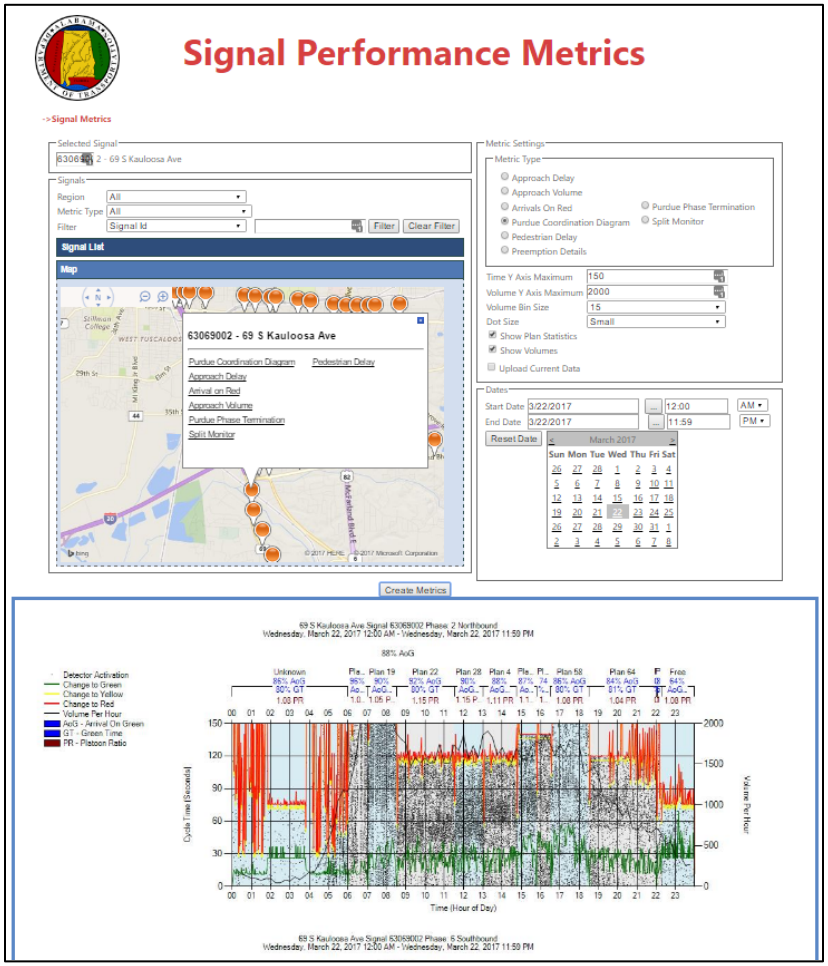


Figure 12: Traffic Signal Performance Measurement

Optimization Algorithms and Long-Term Monitoring

The rapidly increasing access to traffic, roadway, signal control, weather, and other data from multiple sources generates millions of disaggregated records. To take advantage of these data, we need to identify, evaluate, and select the relevant data streams in order to develop appropriate management and optimization algorithms and tools. Traditional objectives such as minimizing delay, maximizing percent arrivals on green, and other desirable performance measures show great benefit and may be used. But newer objectives such as minimizing red light violations, maximizing the collective fuel economy, and other broader objectives based on newer data streams will add value and improve the overall system from new perspectives.

ACTION will integrate optimization algorithms and long-term monitoring into connected components to enhance their awareness of the overall ecosystem and to optimize the effectiveness of the hardware and system performance. The continuous feedback loops of data processed from back-end systems will result in overall improvements of *Efficiency, Capacity, and Safety* across the region.

Safety algorithms with the CAVIS data will be developed and deployed to further reduce the number of crashes and their outcomes such as fatalities, injuries, and economic losses. Speed, acceleration, and other spatial-temporal data can be used to reduce the number of crashes at the back-of-queues (which are particularly prone to be severe or fatal crashes). Further, social media and other direct feedback through the AlgoTraffic app will be valuable to address user and provider concerns. This will allow a larger number of users to help locate and describe issues that can directly assist agencies to improve both the actual and perceived traffic system performance.

As we make changes and improvements, monitoring relevant data over time is also important. Figure 13 shows one way to track performance over time by considering a specific time of day and the day of the week. These types of dashboards and data presentation can help decision-makers quickly assess complex problems and evaluate and quantify improvements.

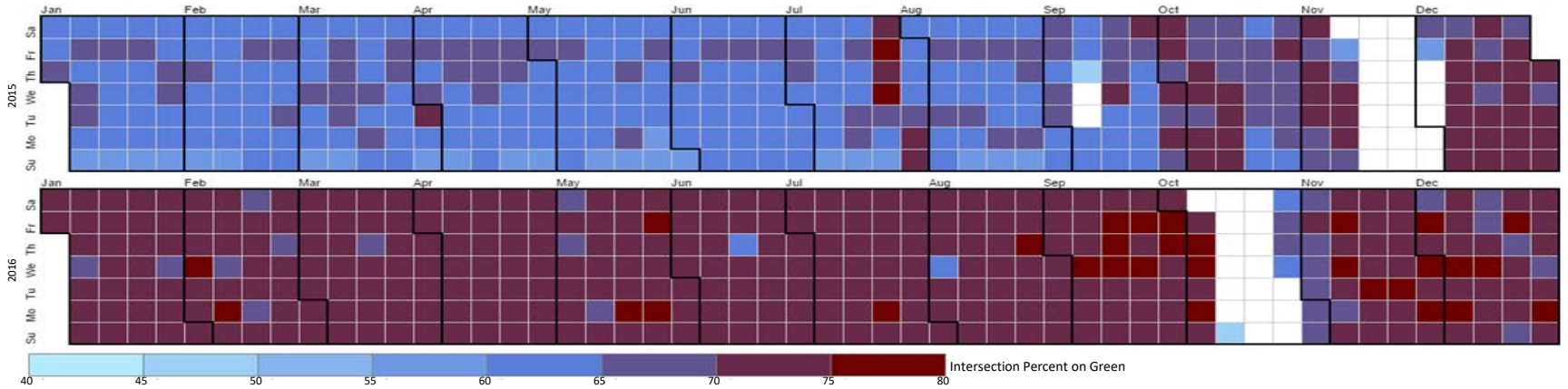


Figure 13: Long-term Monitoring & Visualization of System Performance Over 2 Years. Adapted from UA SensMetrics Project.

Connected Vehicle App

Alabama has focused much of the state's 511 system towards a mobile smart phone application, AlgoTraffic. This is based on the ubiquity of mobile devices, which in turn helps to address the limited extent of DSRC-enabled vehicles. Native Apple iOS and Android applications are part of the AlgoTraffic umbrella as is a responsive HTML5 website. CAPS developed and maintains AlgoTraffic, which provides a unified architecture to disseminate all traffic-related information is across the state. By using GPS tied into their mobile apps, users can receive traffic flow and Amber alerts for their area, and get push updates when approaching construction zones. Other data feeds are also available, such as traffic cameras, accidents/incidents, weather information, and special events.

Since its launch in late 2016, the AlgoTraffic application has been installed on 10,000+ mobile devices and the website has received hundreds of thousands of visitors. The platform has proven to be especially useful during extreme weather events where traffic flow patterns are significantly altered, and the AlgoTraffic system has provided a real-time decision support system to meet those needs. Data from the emerging CAVIS/ITS environment offer tremendous potential for AlgoTraffic ACTION will help realize some of this potential.

It may be several years before in-vehicle DSRC units are in the majority of vehicles on our roadways. In the meantime, Alabama intends to leverage its AlgoTraffic platform to perform a subset of DSRC OBU functionality on a mobile device. This mobile-OBU, or mOBU for short, will expand AlgoTraffic to include functionalities that are suitable for mobile devices. This will reduce driver distraction by linking the functionality of the mOBU to the vehicle in a GPS-like use model.

The AlgoTraffic mOBU functionality is a first of its kind. It will enable faster adoption of DSRC-like functionality by leveraging existing user devices. However, we recognize and we will address a number of privacy and safety concerns within the mOBU application. We will follow the IEEE 1609 WAVE (Wireless Access in Vehiculawer Environments) protocol that DSRC units use. We will incorporate these into the mOBU application to ensure adherence to security protocols/standards and protect rights of anonymity.

ALGOTRAFFIC PLATFORM

The following are the set of data/applications that Alabama will extend to AlgoTraffic through the ACTION initiative:

1) *Vehicle (V2V and V2X) collision warning (medium range)*
2) *Pedestrian Alert and Awareness and Crosswalk presence*
3) *Weather: are the roads safe for travel?*
4) *Signal Phase and Timing (SPaT) messages*
5) *Signal Priority and Preemption*
6) *Work zone safety (worker presence, speed advisory)*
7) *Dangerous curve warning*

The ability to add DSRC-like functionality will increase user adoption of the technology and improve aggregate roadway safety and capacity due to the feedback provided by the users. Active participation by the users can also crowdsource roadway issues to the RTMC, shortening the response cycle for dealing with objects on the roadway, stalled vehicles, potholes, and other system issues. Future mobile app versions can also seek to provide incentives beyond just information feedback to the users (*e.g.*, license point reductions, insurance discounts, etc.).

The new set of application functionality will extend well beyond the capabilities offered by traditional DMSs. Real-time in-vehicle feedback will help bridge the gap for legacy vehicles as DSRC adoption emerges. The mOBU solution provides a cost-effective mobile DSRC-like solution that will help introduce the public to the benefits that a connected vehicle-to-infrastructure system can offer.

Efforts to increase adoption of the mobile app will focus on existing communication channels for vehicle registrants in the area. We will work with existing partnerships with county license commissioners to publicize the availability of the app, which can be pushed out annually with registration renewal reminders. In the digital realm, mass notification and promotion of the app can be done through existing social media and website notices. If app adoption and usage does not meet expectations, a broader media and broadcast campaign will be implemented that integrates billboards, print media, and other outreach efforts at large community events (*e.g.*, sports).

In order to keep driver safety in mind, we will optimize the application for in-motion usage. Driver notifications will primarily be audible cues and can override streaming audio on the host device to provide users with safety-critical messages in a timely manner. Also, application interactive functionality can be reduced or limited while in motion, similar to navigation apps such as Waze.

AlgoTraffic will integrate existing drivers into the ACTION initiative, will provide them with increased *Safety* and roadway *Efficiency* information, and will increase the overall network *Capacity* by providing real-time network usage data back to signal controllers and traffic engineers.

MOBILE APPLICATION VISION

- **Centralized platform** for all traffic mobility and safety related information.
- **Alternative to DSRC** while the DSRC technology emerges.
- **Driver safety** enhancement by focusing the mobile device on a safety application rather than regular phone in-car use.
- **Build upon** the existing successful platform that is already deployed to 10,000+ users.
- **Leverage** existing technologies to provide a real-time on-demand set of information that any traveler can access.

Joint ALDOT/UA Regional Traffic Management Center

The Tuscaloosa metropolitan area is the gateway for passenger and freight vehicles through western Alabama. The region is rapidly outgrowing its roadway infrastructure. To meet the growing transportation needs for this area, regional partners have engaged in expanding existing infrastructure and optimizing the system through centralized transportation coordination. In May 2017, ALDOT and UA signed an agreement to collocate personnel and jointly operate a RTMC. This RTMC (see Figure 14) will serve as a focal point for all transportation-centric data in the region.

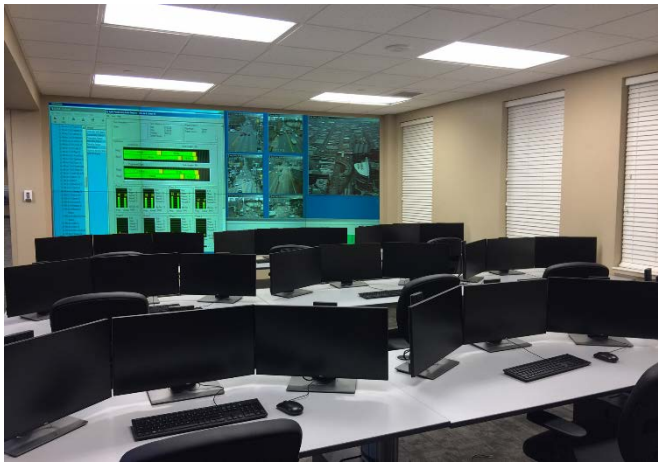
We will monitor roadway and travel conditions using a variety of detection systems, including Radar and Bluetooth Detection Systems, Roadway Weather Information Systems (RWIS), and Internet Protocol (IP) Cameras. We will disseminate the aggregated information and travel guidance to motorists using DMS and Travel Time Signs, Highway Advisory Radio (HAR) messages, Video Kiosks at Rest Areas and Welcome Centers, websites, mobile devices, 511 and media partners. AlgoTraffic will provide data into and out of the RTMC and other TMCs across Alabama.

Operators at RTMC will be able to effectively monitor roadway conditions, detect and respond to incidents, and inform motorists of prevailing travel conditions. A key aspect to how the RTMC handles large-scale traffic volumes and infrastructure issues will be integrating potential detour routes into freeway management strategies (where alternate routes exist and contain adequate monitoring infrastructure).

A central theme of this RTMC will be to "work smarter, not harder." This theme will be implemented through the integration of ITS and CAVIS technologies across the region to fully realize the potential of the area's infrastructure. The RTMC will optimize traffic flow at a regional level, while keeping in mind the state and national implications of the traffic flow patterns.

As part of Alabama's broader ITS initiatives, this RTMC will be linked to other TMCs within the state. TMCs in Birmingham, Montgomery, and Mobile will all use the same management platform that will facilitate collaboration between the regions and also serve as a disaster recovery mechanism and failover function for each area. ACTION will leverage this RTMC to coordinate the regional efforts with the goals of improving *Efficiency, Capacity, and Safety.*

JOINT ALDOT - UA RTMC



The West Alabama Regional Traffic Management Center will serve as the focal point of all road transport and mobility activities in the region.

Figure 14: Image of New Regional Traffic Management Center

Schedule

The 3-year long ACTION initiative includes traffic signal upgrades, developing on-road user applications for information distribution, and generating system-level management algorithms that will enhance the *Efficiency, Capacity, and Safety* of the Tuscaloosa region traffic system. Key tasks of the ACTION initiative include Traffic Signal Hardware Upgrades Deployment, Connected Vehicle App Development, Data Integration and Management Algorithm Development, and RTMC Integration. Figure 15 summarizes the proposed project schedule . The schedule also includes projects programmed by ALDOT and TCRIC as matching efforts. The task summaries follow.

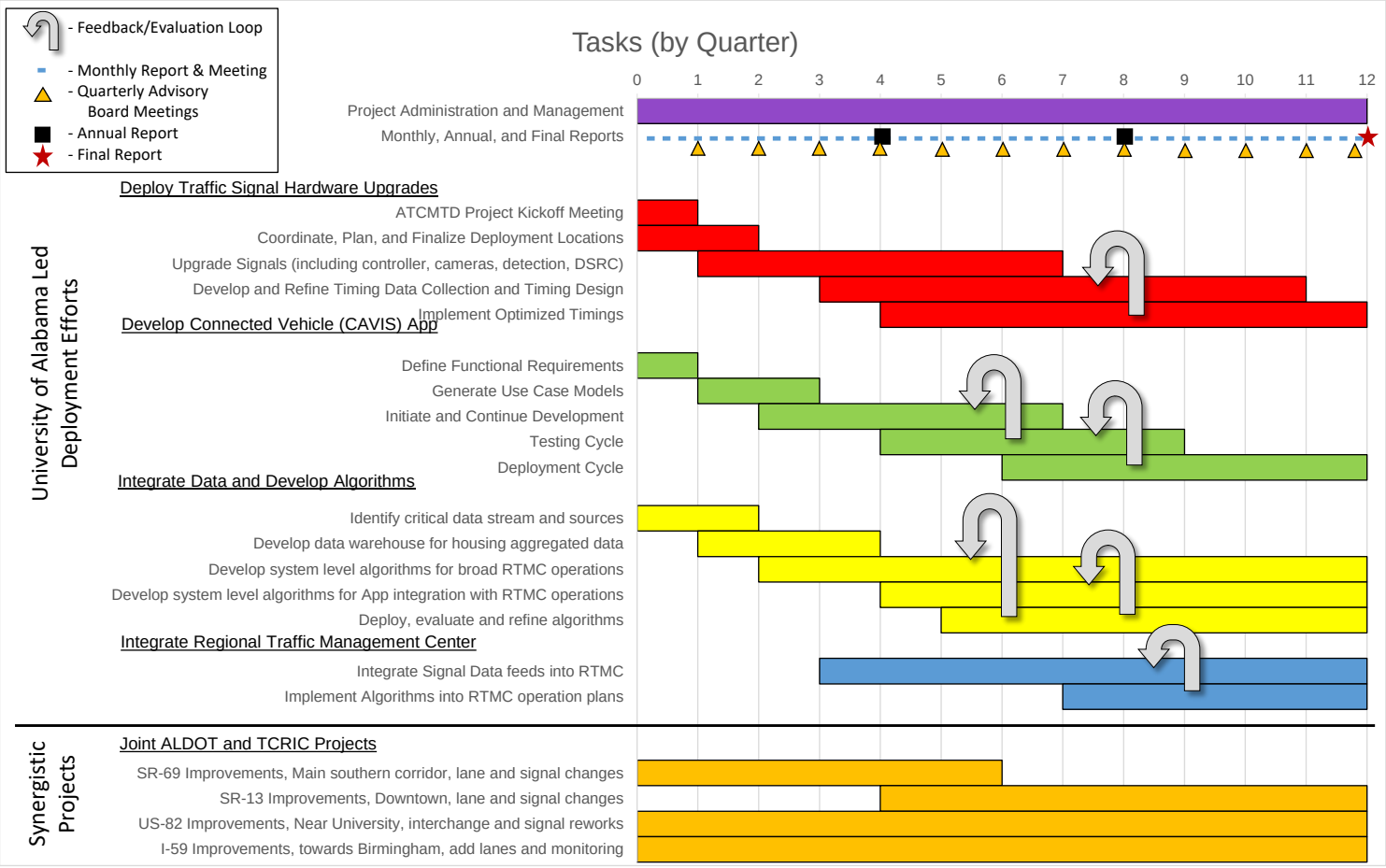


Figure 15: Overview of ACTION Project Schedule

Key Task Summaries

Deploy Traffic Signal Hardware Upgrades: We will work with ALDOT and TCRIC to select the specific hardware deployment locations. A set of candidate locations (included in Appendix 3) is based on traffic accident/fatality hotspots in the Tuscaloosa region. We will upgrade the selected sites with controllers utilizing advanced detection, cameras, and DSRC radios. Synergistic ALDOT and TCRIC projects will handle any fiber or cellular connections required to link this equipment with the RTMC. After commissioning the new equipment, initial data collected will provide baseline data for system-wide control algorithm development. Additionally, preliminary localized timing plans will be deployed based on these data.

Develop Connected Vehicle App: We will develop additional functionality for the AlgoTraffic app to incorporate the ability for the RTMC to communicate with drivers in the region. The first step for this is to identify requirements for communications to RTMC and user displays, followed by the generation of possible use cases to define specific functional needs of the app. These will be used to develop the app, followed by testing and deployment cycles to ensure expected operation and successful real-world usage.

Data Integration and Management Algorithm Development: While the signal upgrades and timing changes will create significant benefit to the regional transportation system, we expect the major enhancements to the *Efficiency, Capacity, and Safety* of the system will be achieved by leveraging technologies with smart operational algorithms. To develop these algorithms, the data streams and sources will be identified and curated for uniform storage in a data warehouse in the RTMC. The broad operation of the RTMC will be governed with coordinated system-wide signal timing plans that address dynamic traffic demands and patterns throughout the day and during special events. Next, we will integrate communications with users of the AlgoTraffic app. Beyond safety notifications, this will include routing information based on knowledge of RTMC operational plans (current and future), allowing optimization beyond that in a typical navigation app. Finally, we will deploy, evaluate, and refine the algorithms.

Regional Traffic Management Center Integration: The RTMC operations will be the backbone of the overall ACTION system. The data feeds from sensors such as the deployed cameras, traffic detection and data logging systems, and DSRC radios will be integrated with the RTMC system. These data are critical for the management algorithms. Mechanisms for implementing the operational decisions suggested by the algorithms will be developed prior to deployment and testing.

Joint ALDOT and TCRIC Projects: ACTION will build upon and enhance a number of projects programmed by ALDOT and TCRIC to improve traffic flow in the region. They include major projects for lane expansion, interchange improvements, signal changes, and remote monitoring. These improvements target the main southern corridor, downtown Tuscaloosa, an interchange near the busiest intersection in the area, and on the freeway US-11 corridor towards Birmingham. Federal funds from the ACTION initiative will enhance these projects, as well as other planned TSMO deployments by ALDOT in the region.

Evaluation: A key task included in each major activity will be the evaluation of performance relative to the target goals. The evaluation and feedback process is critical for overall commitment to success and it is built into the project schedule as shown in Figure 14. Specific evaluation metrics and methods are provided for safety, mobility, and environment in the "Quantifiable System Improvements" section.

CHALLENGES

It will be challenging to integrate information from traffic controllers, on-board units and AlgoTraffic apps within the overarching traffic management system and then implement routing suggestions, signal timing plans, and other actions. The success of this approach will serve as a template for future deployments in this region as well as by other organizations.

The following are key challenges for the ACTION initiative.

Regulatory and Legislative

- Effective data sharing, distribution, and systems-level management require negotiations and willingness to compromise by the stakeholders. We have addressed key aspects in this regard through existing and recently executed agreements that include UA, ALDOT, the cities of Northport and Tuscaloosa (the first pages of these agreements are included in the Appendix 2). As noted in the letters of support, we also have commitments from other leaders and stakeholders to cooperate and collaborate on the initiative.
- The enactment and adoption of regulatory and legislative requirements by federal agencies and industry coalitions/trade groups will affect the degree to which potential benefits are realized. For example, this includes standards in new vehicles such as OBUs with appropriate technology (*e.g.*, DSRC and 5G), or policies that limit the ability of vehicles without such capabilities to operate on some or all of the public road networks. Our mOBU approach mitigates this concern.

Institutional and Societal

- The degree of success of the AlgoTraffic app and the safety and mobility advantages it offers depend on the extent of its adoption by motorists. Attracting *en-masse* participation requires effectively communicating the benefits offered by the app. We will leverage our strengths in social-media marketing, and partnerships with print and broadcast media organizations and the Office of the License Commissioner (motor-vehicle registrations) to address this challenge.
- The AlgoTraffic app usage requires an appropriate Human-Machine-Interface so that in-vehicle displays and information would harmonize with the information supplied by the app. This includes alert sounds, text notifications, and verbal communications related to imminent safety and traffic situations. We will develop an appropriate override/interface with the in-vehicle audio system to ensure that the driver receives important information originating from the app.
- Users will have privacy concerns related to using the AlgoTraffic app and other CAVIS/ITS technologies. We will incorporate appropriate mechanisms to address the same.
- We will use standard industry practices and legal guidance to establish ownership of data generated from the ACTION initiative to facilitate inter-jurisdictional collaborations.

Other Obstacles

- Access to existing power and communications for DSRC deployments may be difficult in remote and underdeveloped regions. This is addressed in the budget and deployment plan.
- We need to ensure conformity and compliance with IEEE, NIST, SAE, ITE, NTCIP, etc. when designing and deploying traffic signal controllers, communication infrastructure, and the AlgoTraffic app. Our strategy to build on ALDOT WCR's TSMO plan and our experience working on similar efforts will greatly help in addressing this need. We will seek guidance from professional societies and industry organizations as needs arise. We will document these lessons to help with knowledge transfer beyond the ACTION initiative.

QUANTIFIABLE SYSTEM IMPROVEMENTS

Safety

The primary goal of the ACTION initiative is to enhance overall safety. From 2015 to 2016, Alabama experienced a dramatic 26% increase in vehicle crash fatalities. A number of factors contributed to that increase and a multi-pronged approach is key to reversing that trend.

Appendix 3 includes a heat map of traffic crashes including injuries, fatalities, and commercial vehicles. The targeted deployment locations for the ACTION initiative will complement the existing ALDOT TSMO plans and will directly address problem locations in the Tuscaloosa region.

The ACTION initiative will provide a direct means of reducing secondary crashes via targeted alerts to drivers on a route with an active crash scene. Using this data, we project a 20% reduction in secondary crashes, and a reduction of 10% in fatalities and 15% in injuries per year. In turn, this will have a substantial impact by reducing delays and associated adverse impacts on economic productivity (*e.g.*, JIT and JIS manufacturing at MBUSI, ZF Lemforder, etc.).

Pedestrian Safety

Pedestrian safety is a major issue in Tuscaloosa because of the over 40,000 students at the University of Alabama and two community colleges in the region. From 2015 to 2016, pedestrian-involved fatal vehicle crashes increased by 220% in the Tuscaloosa region and are 2.4 times the national average (Figure 16). There is a need to implement data-enabled safety countermeasures to address both vehicle and pedestrian safety. This is to reverse the increase in pedestrian-involved injuries and fatalities resulting from vehicle crashes. We will leverage data from the ACTION system and elsewhere, and we will use the AlgoTraffic app to provide real-time V2P alerts to motorists and pedestrians. The alerts will be bout potential safety hazards and risks in their proximity with a focus on locations with high pedestrian - traffic interaction.

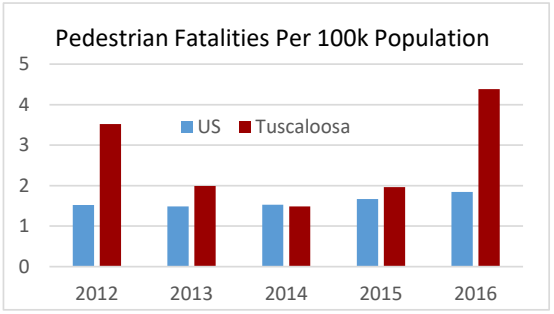


Figure 16: Annual Pedestrian Fatalities in Tuscaloosa and US.

The AlgoTraffic app is also valuable to mobility-impaired pedestrians. Similar to in-vehicle DSRC functionality, the app can serve pedestrians and interact with the signal infrastructure to increase awareness of their presence and improve their mobility within the network. The app can transmit automated pedestrian detection and actuation to help increase system awareness of pedestrian flow patterns and *vice-versa*. The walk phase duration for pedestrians could be dynamically adjusted so as to improve overall safety and increase system efficiency.

Evaluation Strategy

We will quantify and evaluate impacts over the duration of the project. These will be based on key metrics related to crashes, crash types, and their outcomes based on severity, characteristics such as road user type, location and facility type, and effectiveness of the AlgoTraffic app. Much of these data will be from CAPS who manages CARE (the main repository in the state for traffic enforcement and safety, and driver and motor vehicle registration data). We estimate that we can achieve improvements of more than 10% in the key safety metrics.

Mobility

ACTION will improve mobility within the region by optimizing intersection performance along interconnected corridors. We will achieve this by using an algorithm known as link-pivot. We will attain desired vehicle-platooning by adjusting the "offsets" or relative start times of the mainline coordinated traffic movements. We will collect and store data to enable engineers to simulate adjustments offline, consider the improvement, and then remotely make the offset changes in each controller. Offset adjustments at any intersection will affect both the traffic leaving that intersection (and how those vehicles arrive at the next intersection) and traffic arriving from other intersections. We will make improvements to the number of vehicles arriving on green at intersections using the automated traffic signal performance measures data obtained from advanced networked controllers, algorithms, and data storage devices.

Figure 17 shows the link specific improvements made on a 2.5-mile-long corridor on the major southern route into Tuscaloosa in the first phase of an ALDOT sponsored project conducted by UA in early 2017. For example, consider the first link at the northern end of the corridor: the northbound movement had a 35% increase in percent arriving on green and the southbound direction saw a reduction by 12% of the percent arriving on green, and the overall improvement on the link was 10%. These results reflect the deliberate prioritization of the peak directional traffic (northbound).

ACTION will integrate the network-connected data-logging traffic signals from across the Tuscaloosa region into the RTMC. This will allow these timing offset optimizations to be continually evaluated and optimized. Extending the corridor-level optimization to a system-wide optimization will enable traffic signal and suggested routing (conveyed to drivers via the AlgoTraffic app) changes based on time of day, accidents, construction or special events. We will deploy demand and supply responsive system-wide settings to maximize mobility provided by the system.

Evaluation Strategy

The primary metrics to evaluate the effectiveness of the mobility improvements include travel time, travel time reliability, percent arrival on green, and intersection delay. Specifically, we will document improvements of these metrics along routes from the surrounding region into employment and education centers.

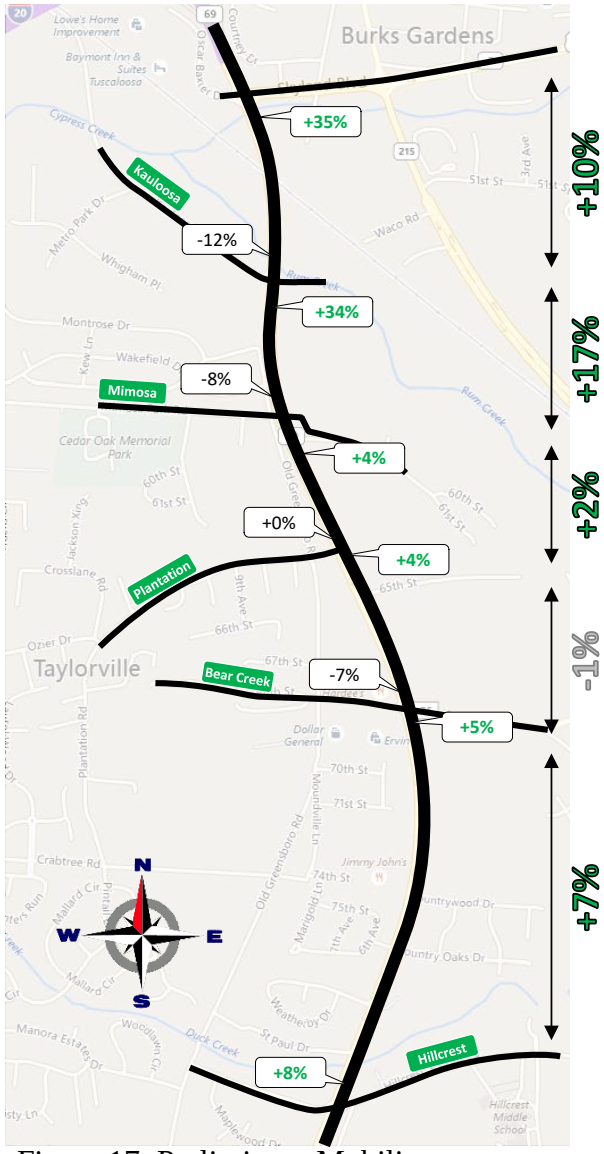


Figure 17: Preliminary Mobility Improvements on SR-69 South

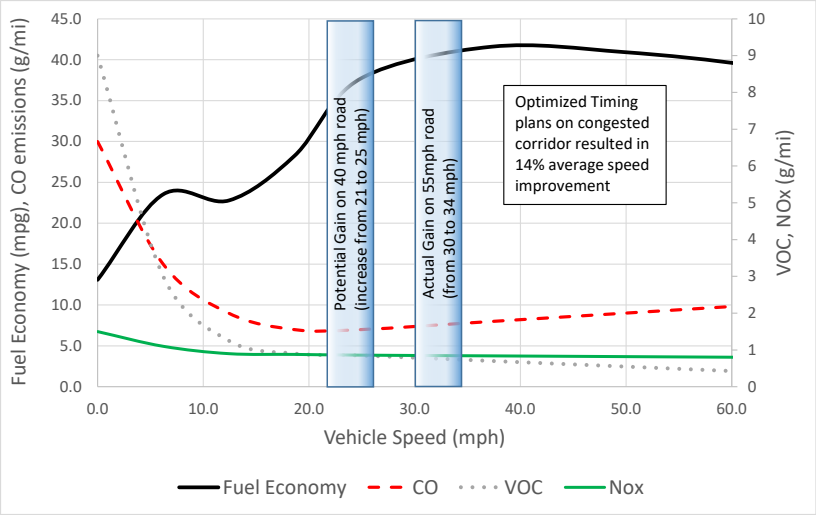
Environmental

The ACTION initiative will increase, during congested periods, average travel speeds and reduce travel time, both of which directly reduce the amount of fuel consumed and vehicular emissions. Figure 18 illustrates the effect of vehicle speed on fuel economy and harmful emissions for a typical modern compact sedan. Under congested travel conditions, the observed speeds are approximately half the posted limit, where fuel economy and emissions are significantly sub-optimal. By improving average travel speeds, through signal operations and coordination, we will reduce fuel consumption and emissions.

The following is an example of potential gains along the testbed in Tuscaloosa as described in the "Mobility" section. That effort to optimize timing plans increased the average speed during the peak period from 30 to 34 mph (speed limit of 55 mph), resulting in a 1 mpg improvement based on Figure 17. Extending the same relative improvement to a 40 mph route will yield a fuel economy increase of 5 mpg. These results suggest a 2%-12% reduction in fuel consumption based on efficiency improvements alone. For roads with lower average speeds the potential improvement is even higher.

The optimized traffic signal timings also reduced the average travel time by 12% through the same corridor. Combining time savings and efficiency gains, we estimate that the traffic optimization approach will reduce average fuel consumption by 15-25% during peak periods if the improvements can be extended across the Tuscaloosa traffic network. This equates to approximately 12 fewer full tanks of gas per year for a two-car family or a savings of more than $350 per year in fuel costs.

Considering the effect of increased travel time reliability and decreased travel times on the various regulated emissions, a 20% reduction in fuel consumption will result in reduced carbon



Fuel Economy Data: www.ecomobile.gouv.qc.ca/en/bases/motive_force.php
Emissions Data: www.fhwa.dot.gov/environMent/air_quality/conformity/research/mpe_benefits/mpe02.cfm

Figure 18: Compact Sedan Fuel Economy and Emissions versus Speed

monoxide, unburned hydrocarbons, and oxides of nitrogen into the atmosphere. While the apparent emissions at average travel speeds (>20 mph) are low, the stop-and-go nature of driving during congested conditions results in vehicles operating at low speeds where harmful emissions are elevated. The reduced emissions and associated improvement in air quality will positively impact the entire region.

Evaluation Strategy

We will monitor vehicle speeds system wide using data from tools such as the AlgoTraffic app or DSRC-equipped vehicles. Environmental impacts, fuel consumption and emissions, will be modeled using traffic simulation software (*e.g.*, VISSIM).

PARTNERSHIP PLAN

The ACTION initiative builds on excellent working relationships among academia, government, and industry partners who share a common vision and mission. As shown in Figure 19, we have mapped these partners into a model described in Etzkowitz's 2010 book *The Triple Helix: University-Industry-Government Innovation in Action.*

Figure 19: Triple-Helix of Partnerships

We will be deliberate to nurture new collaborations and partnerships. We will use informal and formal communications strategies, including quarterly meetings with partners.

Organizations

The following are key stakeholders and partner organizations of the ACTION initiative: ALDOT, TCRIC, Cities of Northport and Tuscaloosa, Tuscaloosa County, MBUSI, Averitt Express, and ZF Lemforder. Gresham Smith and Partners, a consulting firm, will also participate through their contract with ALDOT on the RTMC. We also will work with other established partners, such as those in transportation systems, communication and information technology, law enforcement, motor vehicle license commissioners, and print and broadcast media, to advance our goals and objectives and extend the impacts of the initiative.

ADVISORY BOARD

An advisory board will provide strategic guidance to the ACTION team to help achieve the projects goals and objectives. We have commitments from each of the core organizational partners to serve on the board. The group will meet quarterly to evaluate the performance metrics, goals, and impacts associated with ACTION, and to review upcoming activities. It will serve as the project governance committee.

A coordinating committee will address tactical matters and provide oversight for this multi-partner effort. It will include representatives from jurisdictional agencies, industry groups. ATI and CAPS. This group will meet on a monthly basis to review activities, accomplishments, and plans. This will help address the second objective of cultivating a deeper sense of interagency cooperation and support for programmatic elements of the ACTION initiative. Combined, the advisory board and the coordinating committee will ensure that key stakeholders in the region are represented appropriately. Figure 20 illustrates ACTION's overall organizational and operating structure.

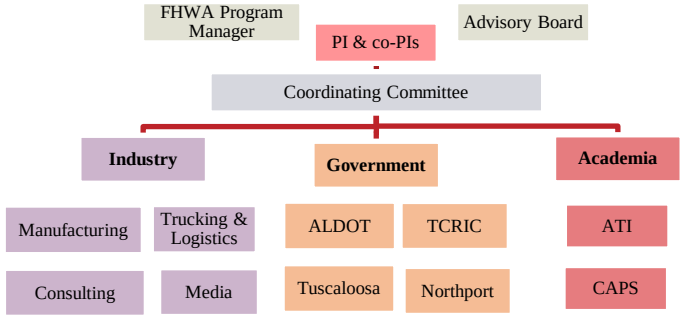


Figure 20: ACTION Organizational & Operating Structure

EXISTING TECHNOLOGY INVESTMENTS LEVERAGED AND SYNERGIES WITH DOT ITS

The EDC program is a joint effort by FHWA and AASHTO to *identify and rapidly deploy proven but underutilized innovations to shorten the project delivery process by enhancing roadway safety, reducing congestion, and improving environmental sustainability*. Currently, the fourth round of this program for 2017-2018 identifies a number of innovations used in the ACTION initiative, including the following:

- Automated Traffic Signal Performance Measures (ATSPMs)
- Community Connections
- Data-Driven Safety Analysis (DDSA)
- Safe Transportation for Every Pedestrian (STEP)
- Using Data to Improve Traffic Incident Management

The aforementioned items will be directly addressed by ACTION's theme of improving *Efficiency, Capacity, and Safety Through Technology*. We will build on the success of ATSPMs that have been widely used around the Tuscaloosa region. ACTION's efficiency and capacity improvement strategies help foster Community Connections by improving connectivity between disadvantaged populations and essential services. DDSA is an integral part of ACTION, and already a primary mission of UA's transportation research and outreach activities, especially through CAPS. We will use a novel approach based on cellular communications to integrate pedestrians into the CAVIS/ITS arena. We will use data from the ACTION initiative to improve, monitor, and handle Traffic Incident Management during normal and other-than-normal operating scenarios.

Supporting State Infrastructure Investments

Funding from the ATCMTD for the ACTION initiative will tremendously boost the benefits of large roadway infrastructure projects in the Tuscaloosa region. It will augment $150 million in investments from ALDOT and TCRIC in road projects by adding CAVIS/ITS technology-based tools and strategies. These investments include $8.9 million for basic ITS components and upgrades. However, they do not include funding for CAVIS or advanced ITS technology deployments which would further increase the benefit realized from the core infrastructure investments. Figure 21 illustrates the impact of strategic additional funding of the ATCMTD. USDOT funds for ACTION will greatly multiply the return on investment, generating benefits, which would otherwise be unrealized.

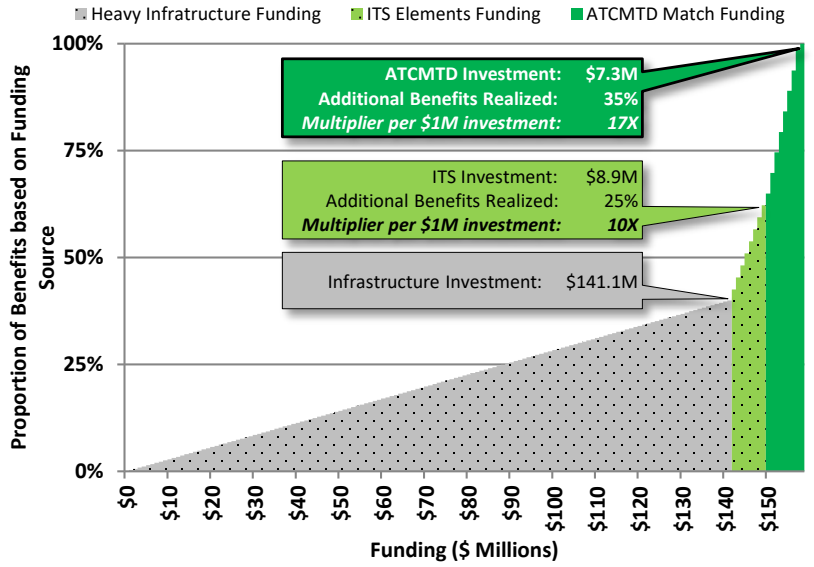
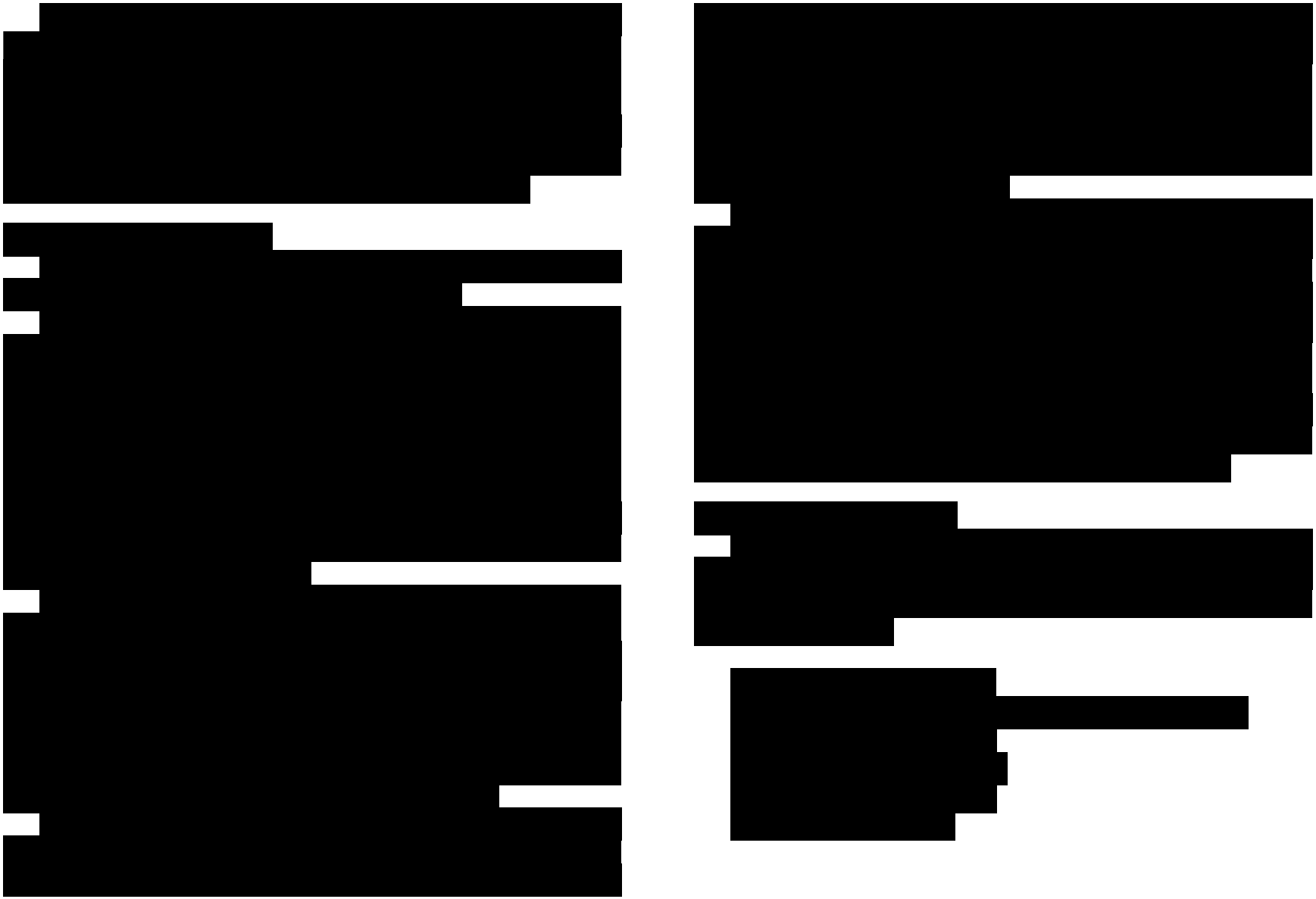
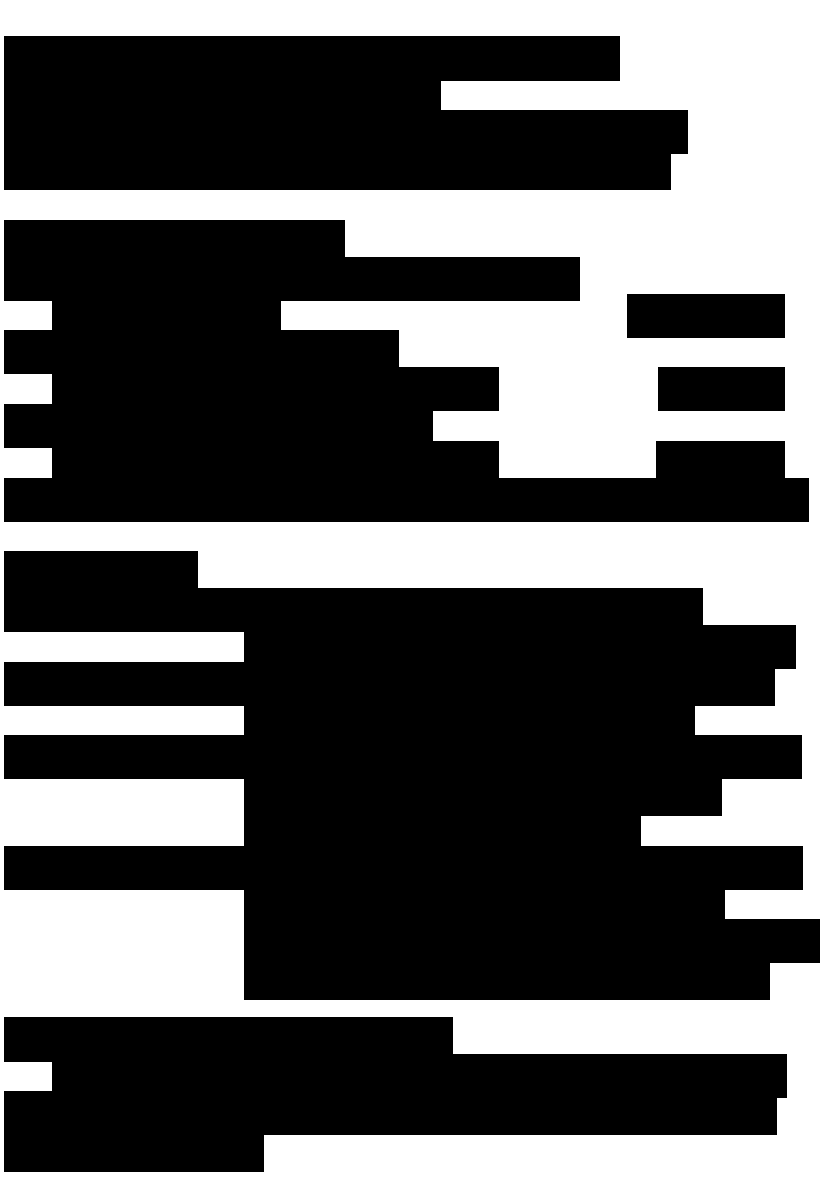
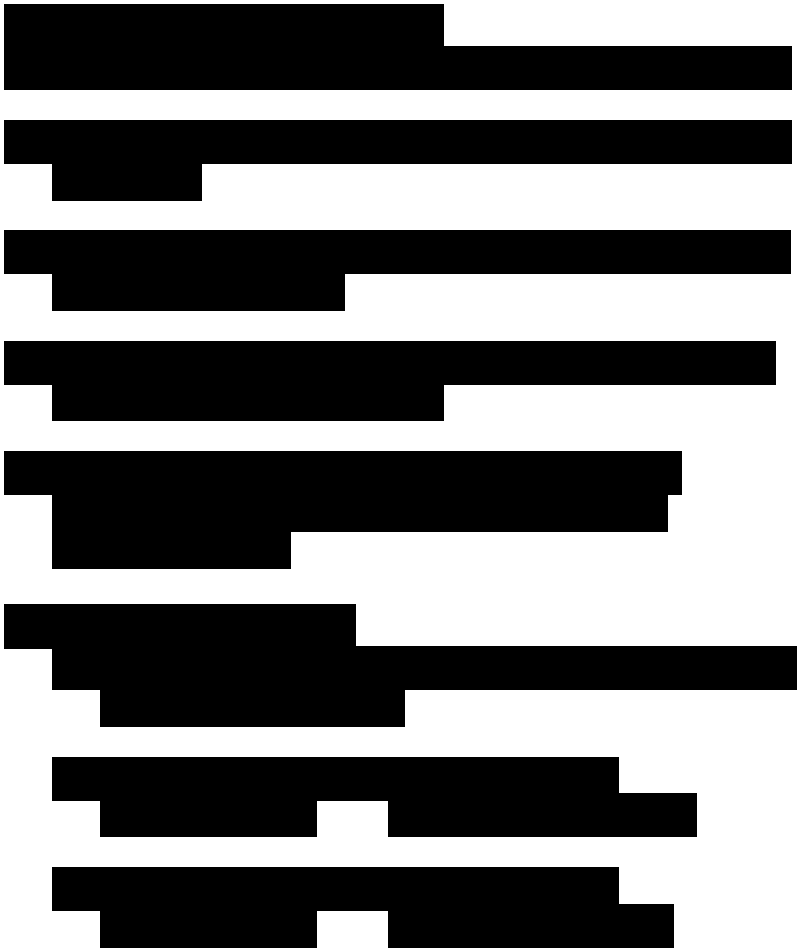


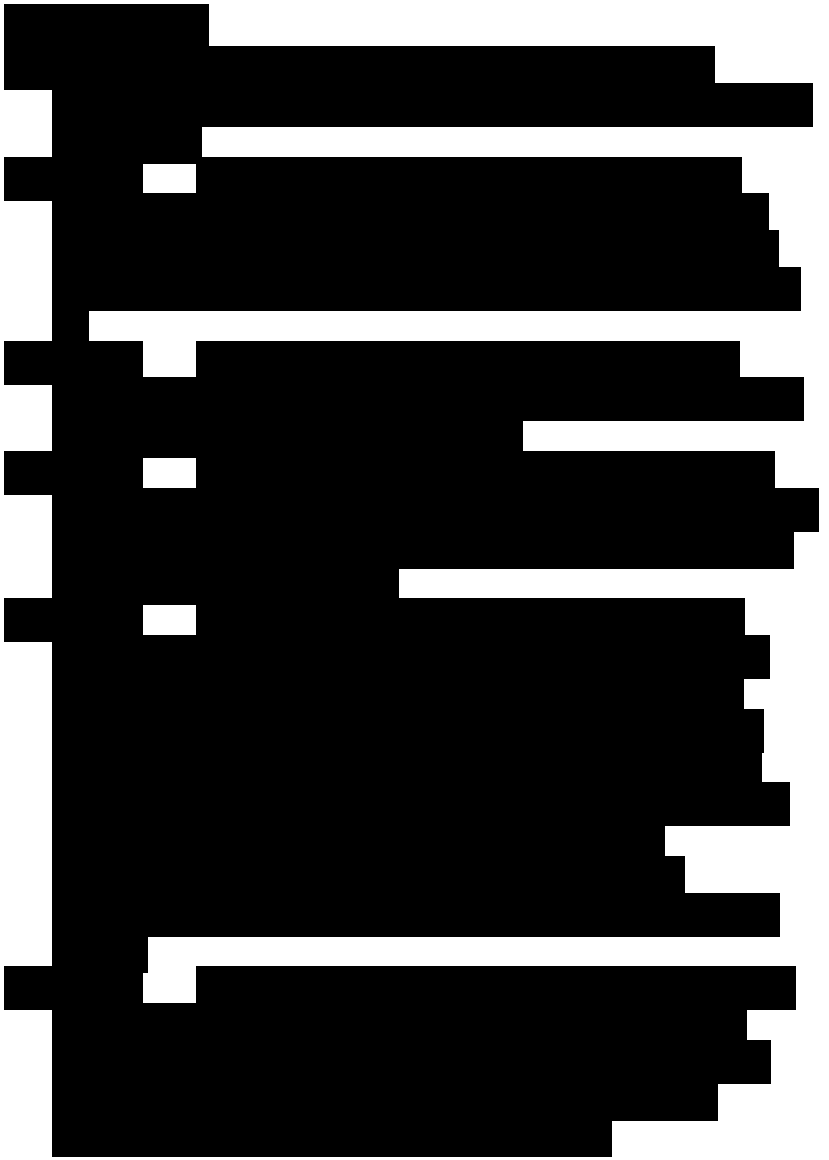
Figure 21: Increased Impact of ITS and ATCMTD

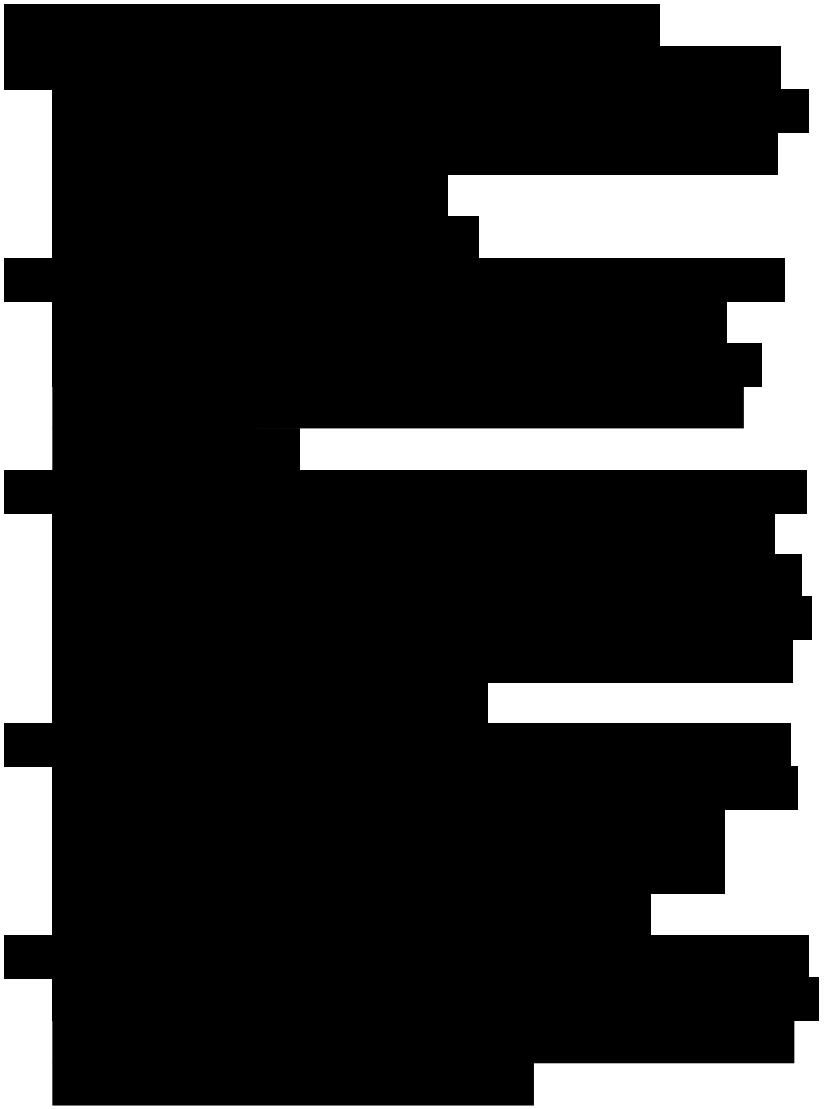
STAFFING PLAN

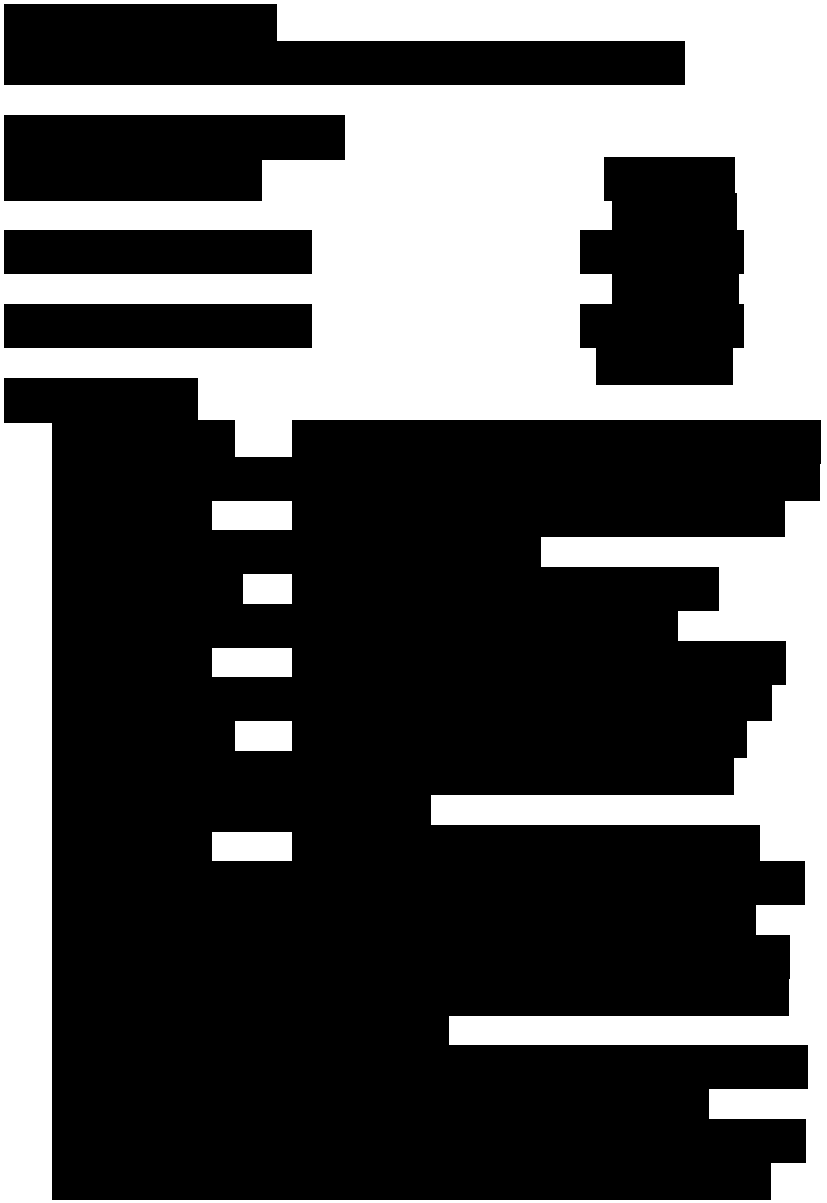


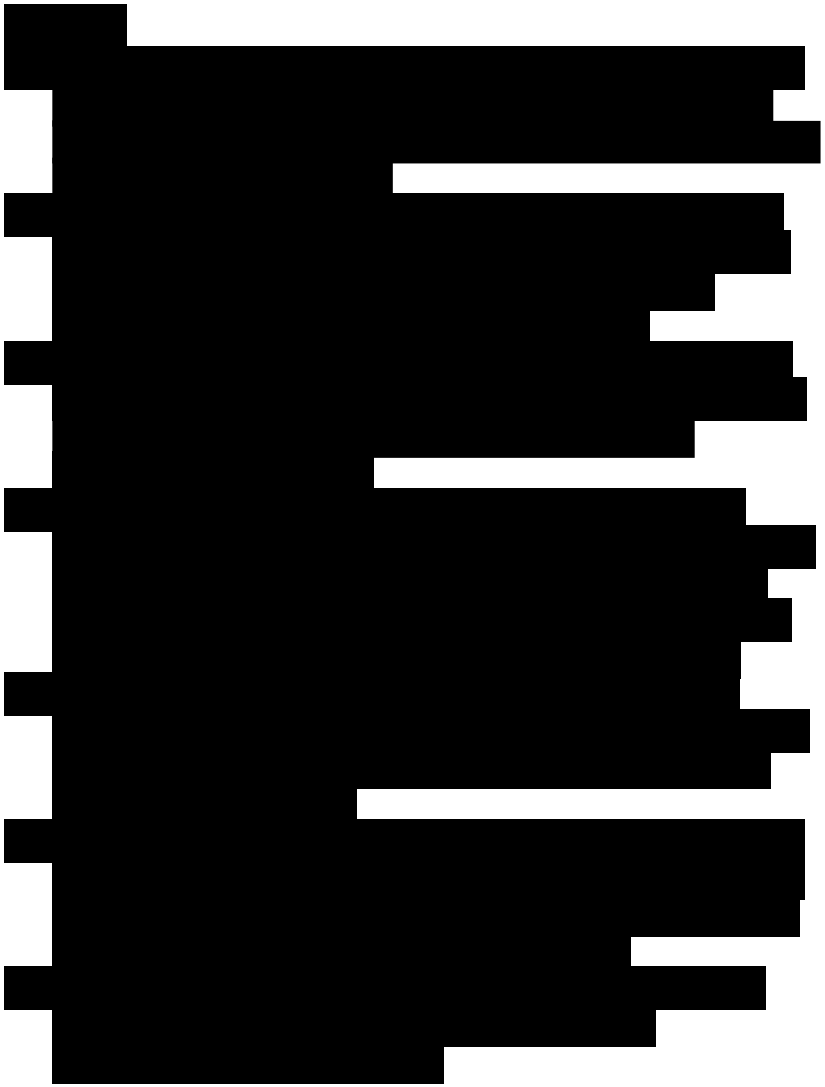




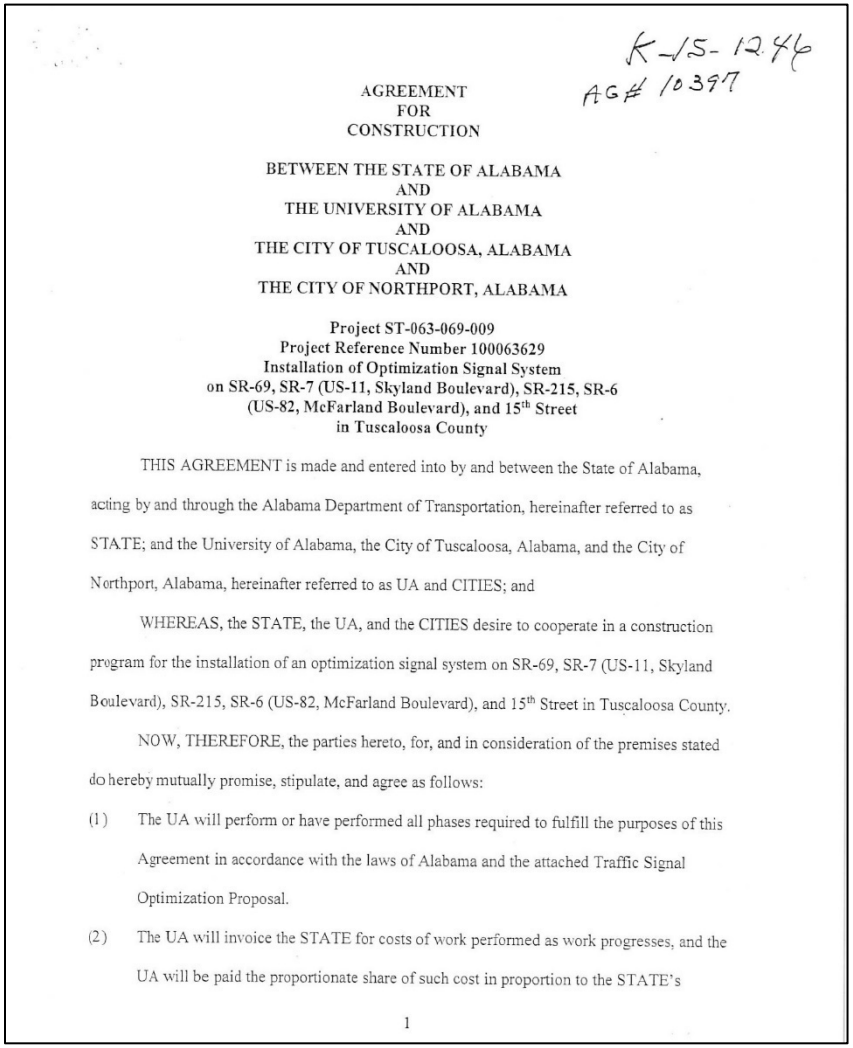








APPENDIX 2 – FIRST PAGE OF UA/ALDOT SIGNAL DEPLOYMENT & TMC AGREEMENTS



K-15-1246
AG# 10397

AGREEMENT
FOR
CONSTRUCTION

BETWEEN THE STATE OF ALABAMA
AND
THE UNIVERSITY OF ALABAMA
AND
THE CITY OF TUSCALOOSA, ALABAMA
AND
THE CITY OF NORTHPORT, ALABAMA

Project ST-063-069-009
Project Reference Number 100063629
Installation of Optimization Signal System
on SR-69, SR-7 (US-11, Skyland Boulevard), SR-215, SR-6
(US-82, McFarland Boulevard), and 15th Street
in Tuscaloosa County

THIS AGREEMENT is made and entered into by and between the State of Alabama, acting by and through the Alabama Department of Transportation, hereinafter referred to as STATE; and the University of Alabama, the City of Tuscaloosa, Alabama, and the City of Northport, Alabama, hereinafter referred to as UA and CITIES; and

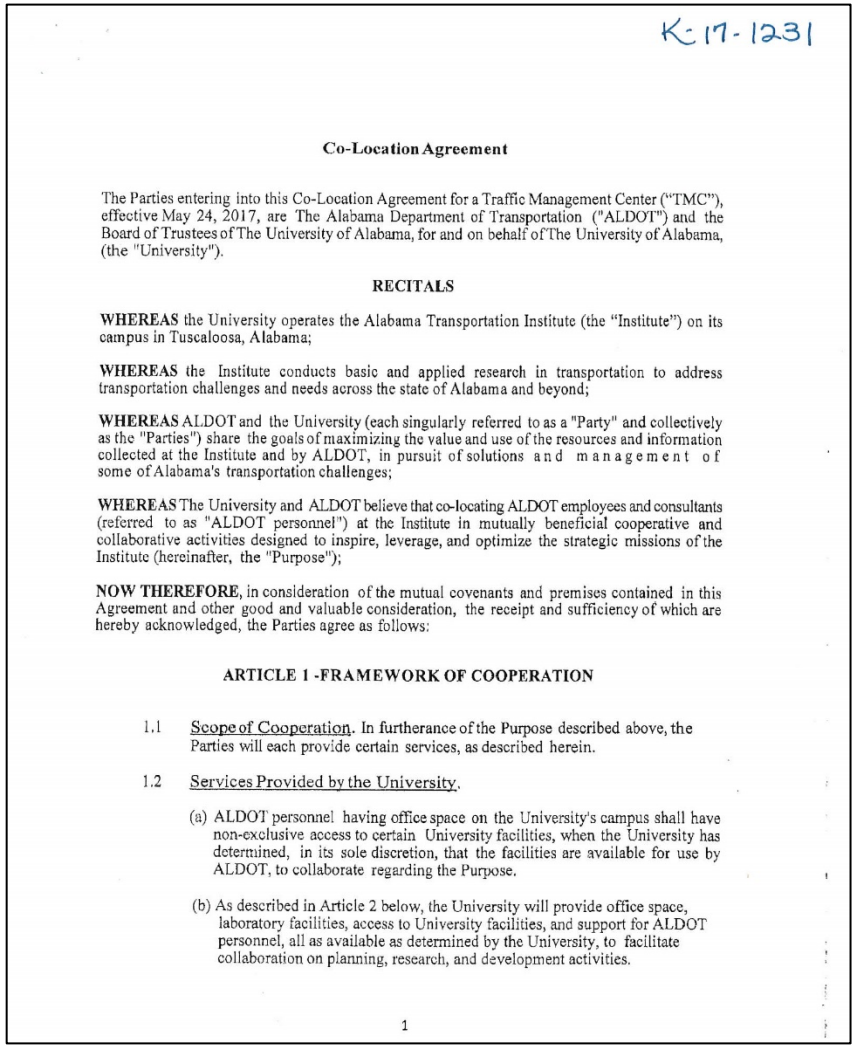
WHEREAS, the STATE, the UA, and the CITIES desire to cooperate in a construction program for the installation of an optimization signal system on SR-69, SR-7 (US-11, Skyland Boulevard), SR-215, SR-6 (US-82, McFarland Boulevard), and 15th Street in Tuscaloosa County.

NOW, THEREFORE, the parties hereto, for, and in consideration of the premises stated do hereby mutually promise, stipulate, and agree as follows:

(1) The UA will perform or have performed all phases required to fulfill the purposes of this Agreement in accordance with the laws of Alabama and the attached Traffic Signal Optimization Proposal.

(2) The UA will invoice the STATE for costs of work performed as work progresses, and the UA will be paid the proportionate share of such cost in proportion to the STATE's

1



K-17-1231

Co-Location Agreement

The Parties entering into this Co-Location Agreement for a Traffic Management Center ("TMC"), effective May 24, 2017, are The Alabama Department of Transportation ("ALDOT") and the Board of Trustees of The University of Alabama, for and on behalf of The University of Alabama, (the "University").

RECITALS

WHEREAS the University operates the Alabama Transportation Institute (the "Institute") on its campus in Tuscaloosa, Alabama;

WHEREAS the Institute conducts basic and applied research in transportation to address transportation challenges and needs across the state of Alabama and beyond;

WHEREAS ALDOT and the University (each singularly referred to as a "Party" and collectively as the "Parties") share the goals of maximizing the value and use of the resources and information collected at the Institute and by ALDOT, in pursuit of solutions and management of some of Alabama's transportation challenges;

WHEREAS The University and ALDOT believe that co-locating ALDOT employees and consultants (referred to as "ALDOT personnel") at the Institute in mutually beneficial cooperative and collaborative activities designed to inspire, leverage, and optimize the strategic missions of the Institute (hereinafter, the "Purpose");

NOW THEREFORE, in consideration of the mutual covenants and premises contained in this Agreement and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the Parties agree as follows:

ARTICLE 1 -FRAMEWORK OF COOPERATION

1.1 Scope of Cooperation. In furtherance of the Purpose described above, the Parties will each provide certain services, as described herein.

1.2 Services Provided by the University.

(a) ALDOT personnel having office space on the University's campus shall have non-exclusive access to certain University facilities, when the University has determined, in its sole discretion, that the facilities are available for use by ALDOT, to collaborate regarding the Purpose.

(b) As described in Article 2 below, the University will provide office space, laboratory facilities, access to University facilities, and support for ALDOT personnel, all as available as determined by the University, to facilitate collaboration on planning, research, and development activities.

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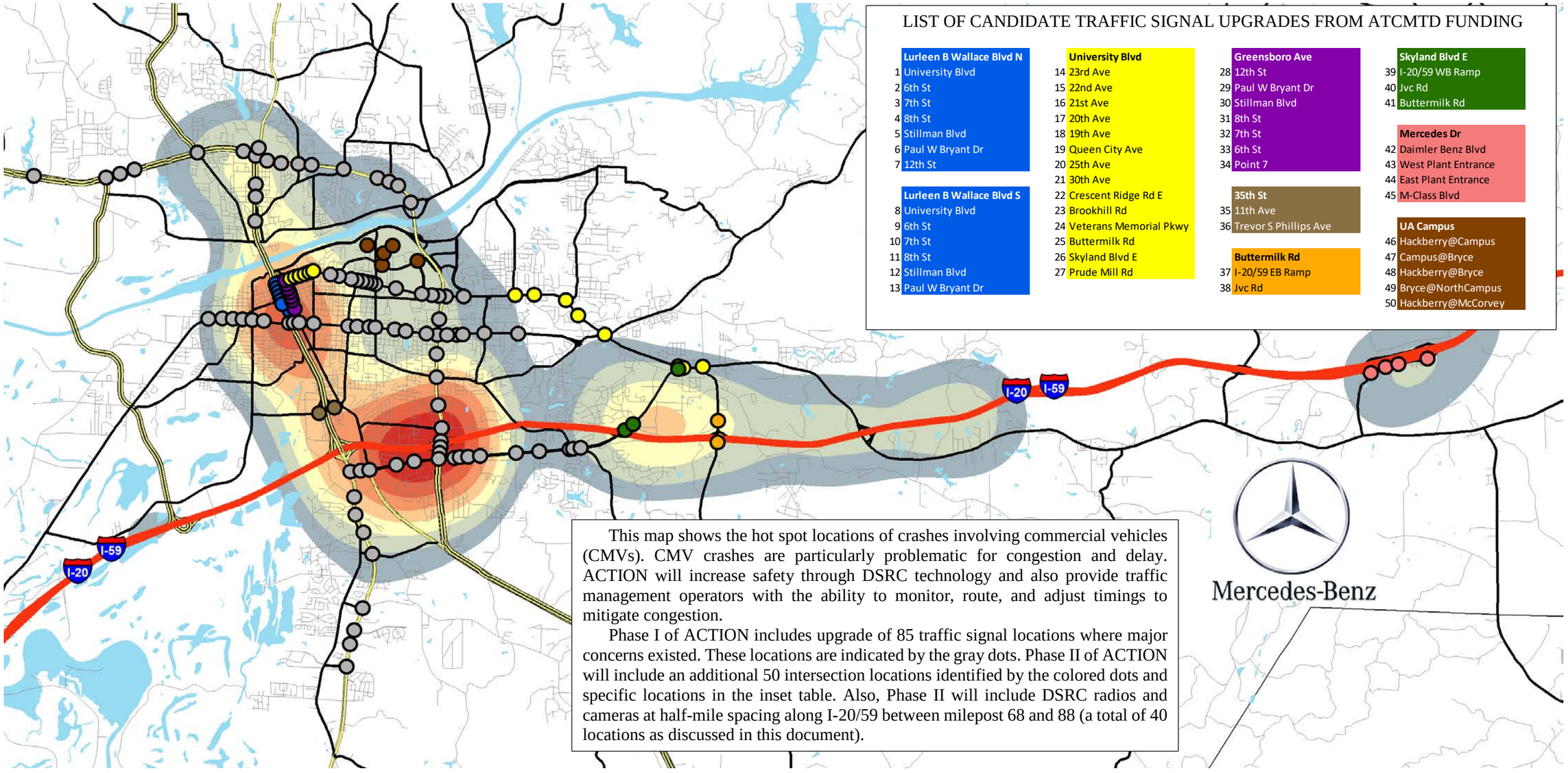
APPENDIX 3 – EXISTING & PROPOSED DEPLOYMENT LOCATIONS OVERLAID ON 2016 CMV INJURY & FATALITY HOTSPOTS



LIST OF CANDIDATE TRAFFIC SIGNAL UPGRADES FROM ATCMTD FUNDING

	Lurleen B Wallace Blvd N		University Blvd		Greensboro Ave		Skyland Blvd E
1	University Blvd	14	23rd Ave	28	12th St	39	I-20/59 WB Ramp
2	6th St	15	22nd Ave	29	Paul W Bryant Dr	40	Jvc Rd
3	7th St	16	21st Ave	30	Stillman Blvd	41	Buttermilk Rd
4	8th St	17	20th Ave	31	8th St		
5	Stillman Blvd	18	19th Ave	32	7th St		**Mercedes Dr**
6	Paul W Bryant Dr	19	Queen City Ave	33	6th St	42	Daimler Benz Blvd
7	12th St	20	25th Ave	34	Point 7	43	West Plant Entrance
		21	30th Ave			44	East Plant Entrance
	Lurleen B Wallace Blvd S	22	Crescent Ridge Rd E		**35th St**	45	M-Class Blvd
8	University Blvd	23	Brookhill Rd	35	11th Ave		
9	6th St	24	Veterans Memorial Pkwy	36	Trevor S Phillips Ave		**UA Campus**
10	7th St	25	Buttermilk Rd			46	Hackberry@Campus
11	8th St	26	Skyland Blvd E		**Buttermilk Rd**	47	Campus@Bryce
12	Stillman Blvd	27	Prude Mill Rd	37	I-20/59 EB Ramp	48	Hackberry@Bryce
13	Paul W Bryant Dr			38	Jvc Rd	49	Bryce@NorthCampus
						50	Hackberry@McCorvey

This map shows the hot spot locations of crashes involving commercial vehicles (CMVs). CMV crashes are particularly problematic for congestion and delay. ACTION will increase safety through DSRC technology and also provide traffic management operators with the ability to monitor, route, and adjust timings to mitigate congestion.

Phase I of ACTION includes upgrade of 85 traffic signal locations where major concerns existed. These locations are indicated by the gray dots. Phase II of ACTION will include an additional 50 intersection locations identified by the colored dots and specific locations in the inset table. Also, Phase II will include DSRC radios and cameras at half-mile spacing along I-20/59 between milepost 68 and 88 (a total of 40 locations as discussed in this document).