Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)

Advanced Connected Traffic Infrastructure and Operations Network (ACTION) Evaluation Report

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Notice

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EXECUTIVE SUMMARY

The Advanced Connected Traffic Infrastructure and Operations Network (ACTION) initiative was launched to improve transportation in Tuscaloosa and surrounding areas by using modern technology to make roads safer, traffic smoother, and information more accessible for travelers. Led by The University of Alabama and the Alabama Department of Transportation, the project focused on upgrading traffic signals, adding roadside sensors, and connecting these systems through a regional traffic management center. The project covered both freeway and city routes and was built with support from state and federal partners, including the U.S. DOT.

ACTION was designed as a collaborative solution that leverages ITS tools rather than traditional road expansion. Improvements focused on real-time traffic monitoring, faster response to incidents, and the delivery of useful travel information to the public. The initiative also targeted freight routes and manufacturing supply chains to keep goods moving efficiently. Throughout the project, the team worked with local governments, freight operators, and technology providers to identify challenges and deploy solutions that would serve all road users.

Improvements were evaluated across five key goal areas using a mix of real-world data, user feedback, and simulations. Results show that the project brought meaningful benefits to safety, traffic flow, environmental performance, freight movement, and traveler information.

Key Takeaways:

- ***Improved safety****:* New roadside cameras and sensors helped regional traffic center operators detect incidents earlier. Detection rates improved and events were confirmed and cleared faster. These enhancements contributed to better incident management and were accompanied by a decline in total reported events and crashes along the corridor.
- ***Reduced congestion and better mobility****:* Travel times became more reliable, especially in the westbound direction on I-20/59, where consistency (standard deviation) improved and small gains were seen in overall speed and flow.
- ***Environmental benefits****:* Despite more vehicles being on the road, better traffic signal control and fewer delays helped reduce fuel waste, with one corridor showing a modeled 3% drop in fuel costs during the study morning peak period.
- ***Support for freight and logistics****:* A key manufacturing partner reported fewer delays and more reliable delivery times, suggesting that enhanced monitoring and response through the deployment helped the just-in-time / just-in-sequence supply chain to reduce production downtimes.
- ***More informed travelers****:* Use of the state's traffic information app more than doubled in the region, showing strong demand for real-time updates. While connected vehicle apps saw limited growth, interest in travel information and tools showed sustained growth.

The ACTION initiative has established a strong foundation for modern traffic management that will continue to serve the region well into the future. By integrating advanced technologies and building partnerships across agencies, the project has helped shift the culture toward proactive, data-informed operations. These tools and practices now form part of the region’s long-term transportation strategy and offer a sustainable model for other communities looking to improve safety, mobility, and system performance.

INTRODUCTION

The Advanced Connected Transportation Infrastructure & Operations Network (ACTION) initiative is a collaborative effort aimed at deploying advanced technologies to enhance efficiency, capacity, and safety on freeways and arterials in and around Tuscaloosa, Alabama. This initiative was developed through a partnership involving the Alabama Department of Transportation (ALDOT), the Alabama Transportation Institute (ATI) at The University of Alabama (UA), the Tuscaloosa County Road Improvement Commission (TCRIC), the cities of Tuscaloosa and Northport, and other regional and industry stakeholders, including manufacturing and trucking sectors. Originally funded under the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant program, the Bipartisan Infrastructure Law (BIL) has since amended and renamed this program as the Advanced Transportation Technologies and Innovative Mobility Deployment Program. This Final Report provides a comprehensive overview of the ACTION initiative, covering its description, scope, timeline, goals, performance metrics, evaluation methods, results, lessons learned, recommendations, and conclusions. Submission of this report fulfills the deliverable requirement described in the Cooperative Agreement and collectively addresses the final report requirements for individual components of the initiative. The ACTION program demonstrates the potential of leveraging technology and multi-agency collaboration to transform transportation systems and address regional mobility, safety, and environmental challenges.

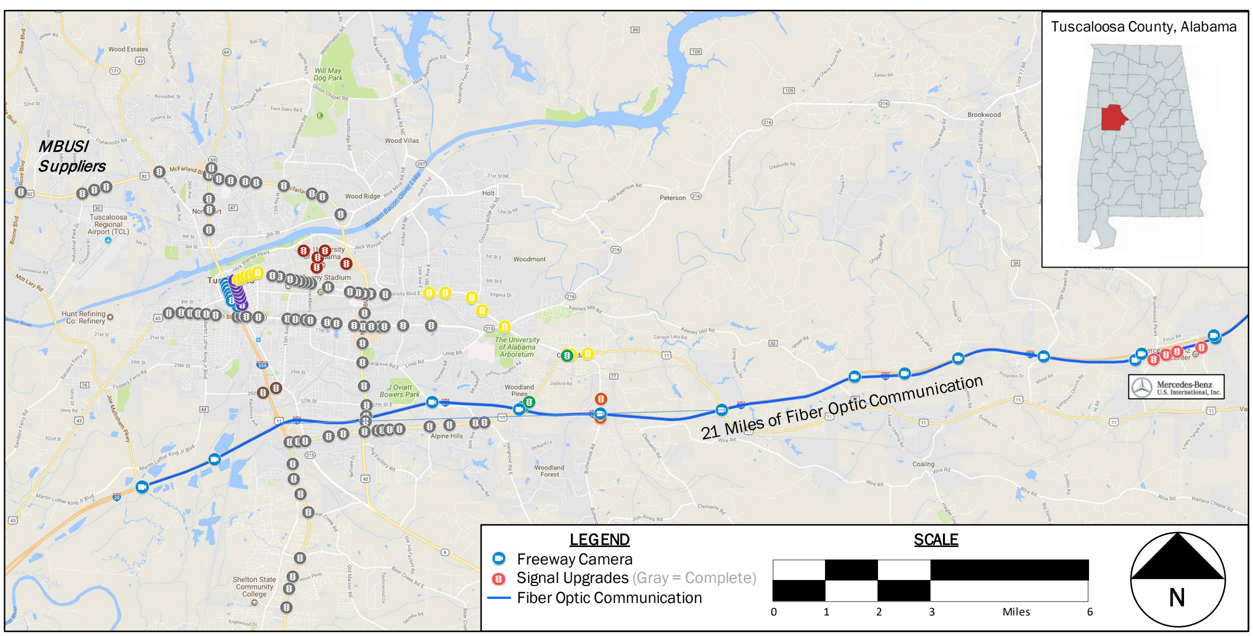


Figure 1. ACTION Deployment in Tuscaloosa County in West Central, Alabama

1. PROJECT SUMMARY

Description of the Project

The ACTION initiative is a comprehensive ITS deployment on freeways and arterials in and around Tuscaloosa, Alabama, with the primary goal of leveraging advanced technologies to enhance efficiency, capacity, and safety. Developed through a collaborative effort among ATI/UA, ALDOT, TCRIC, the cities of Tuscaloosa and Northport, and various regional industry stakeholders, including manufacturing and trucking partners, the initiative demonstrates the power of multi-agency collaboration to address critical transportation challenges.

Key components of the ACTION deployment include a network of sensors, cameras, communications technologies, and traffic signal systems. These technologies enable near real-time exchange of data among vehicles, infrastructure elements, and users. These capabilities allowed transportation agencies to implement adaptive operational strategies based on real-time demand and capacity, enabling motorists to proactively adjust their travel behaviors. The project's outcomes include reduced congestion, increased travel time reliability, improved safety, and environmental and other benefits for the region.

Upon completion, the ACTION deployment successfully upgraded 135 intersections in west-central Alabama with Advanced Traffic Signal Controllers (ATSCs), Connected and Automated Vehicle Infrastructure Systems (CAVIS), and other Intelligent Transportation Systems (ITS) components. Sensors installed throughout the network detect local roadway and traffic conditions, relaying this information to signal controllers and the Regional Traffic Management Center (regional TMC or RTMC). The RTMC is then able to share key information with drivers via cellular vehicle-to-network (CV2N) and cellular vehicle-to-everything (CV2X) radios deployed at key locations, as well as through cellular communications via the AlgoTraffic app. Additionally, RTMC staff actively monitored and updated dynamic digital message signs (DMSs) and mobile notifications, contributing to long-term planning for the region. The I-20/59 corridor between Tuscaloosa and the Mercedes-Benz plant in Vance has historically faced congestion and extended delays due to crashes and incident response, underscoring the need for real-time monitoring and coordinated operational strategies. These enhancements minimized travel delays for passenger and freight vehicles while improving mobility and accessibility, particularly for underserved communities in the region.

The vision of the ACTION initiative was to enhance mobility, accessibility, safety, and environmental quality across the project area while demonstrating how strategic technology deployments can reduce the need for traditional roadway expansions. By leveraging and enhancing existing infrastructure assets through CAVIS and ITS, the project achieved efficiency gains through expanded RTMC monitoring and response capability. The deployment of emerging technologies yielded tangible and intangible benefits, showcasing the value of technology-focused solutions over traditional infrastructure improvements. The goals and objectives of the ACTION initiative were developed in close collaboration with stakeholders and aligned with the objectives outlined in the ATCMTD program under the Bipartisan Infrastructure Law. These goals were operationalized through the performance metrics summarized in Table 1.

Project Scope

Over the years, ALDOT and UA have collaborated to develop the West Central RTMC, focusing initially on major arterials where fiber and communication infrastructure supported Intelligent Transportation System (ITS) technologies. This partnership identified a critical need to expand ITS technologies to the I-20/59 corridor between Tuscaloosa and Birmingham (a 21-mile stretch), leading to the development of the ACTION initiative. The ACTION project scope includes deploying cutting-edge CAVIS and ITS technologies, including fiber optic communications, traffic monitoring cameras, radar vehicle detection systems, advanced traffic signal controllers, and connected vehicle (CV) hardware. This approach emphasizes operational efficiency over road expansion, aiming to maximize the effectiveness of current infrastructure assets through technology. The deployment supports the goals of enhanced mobility, safety, and environmental sustainability, focusing on cost-effective, technology-based solutions. Due to escalating project costs from the award and through COVID, a few technologies were reduced or eliminated from the original scope, including the removal of experimental cable median crash sensors, removing the truck parking system, shifting to CV2X (and CV2N) connected radios rather than the deprecated DSRC technology, and reducing the length of the fiber and ITS deployment from 32 miles to 21 miles. The geographic scope for this project in Tuscaloosa County includes I-20/59 from milepost 68 to milepost 89 and key parallel corridors.

Project Timeline

The project schedule included a phased approach. The first three quarters focused on planning and development; then the focus turned to the design and letting process (including a redesign and rebid); after that, two years of construction and deployment on the freeway and arterials followed, along with two years of data collection and preparation of the final report. The final year of the construction project involved evaluation and a burn-in period. Key milestones included design completion, project letting, construction completion, evaluation periods, and the final report preparation with the following timeframes:

- Planning and Development – 2019 Q3 to 2020 Q1
- Design and Letting – 2020 Q2 to 2021 Q1
- Construction and Deployment – 2021 Q2 to 2023 Q3
- Data Collection – 2023 Q1 to 2024 Q4
- Final Report – 2025 Q1 to 2025 Q2

2. PERFORMANCE METRICS, EVALUATION METHODS, AND DATA SOURCES

The ACTION project aligns closely with several primary goals outlined in Section 13006 of the Infrastructure Investment and Jobs Act (IIJA), aiming to create a safer, more efficient, and accessible transportation network. Key goals include improving safety by enhancing incident detection and response times, reducing congestion and improving mobility through more reliable travel times, and minimizing environmental impacts by reducing fuel consumption and emissions. The project also seeks to optimize overall system performance by integrating real-time data exchange among vehicles as well as infrastructure to support multimodal travel. This system will also provide the public with up-to-date travel information through widely available mobile applications and roadside units.

Table 1. Evaluation Goals, Objectives, and Evaluation Questions

Goal Area	Objectives	Action	Evaluation Questions
I. Improve safety	A. Reduce traffic related fatalities B. Reduce traffic related injuries C. Reduce traffic crashes	Deploy sensor systems, communications, analytical tools to detect crashes.	1. How has the deployed technology changed the ways that RTMC operators detect crashes and incidents? 2. How much quicker is our RTMC able to detect and respond to crashes and incidents?
II. Reduced congestion and/or improved mobility	A. Reduce traffic congestion by increasing travel time reliability B. Reduce travel delay by improving system resilience C. Improve travel time, speeds or travel reliability	Use sensors to measure speed and volume to develop alerts for conditions. Develop models based on sensor data to better understand system issues. Use probe data and CV data to characterize network performance / improvements.	3. How much has the standard deviation of travel times changed? 4. How have travel times and travel speeds changed?
III. Reduce environmental impact	A. Reduce transportation-related emissions by increasing system level fuel economy	Model and identify hot spots for high fuel consumption	5. How much have drivers saved on fuel costs?
IV. Improved system performance	A. Reduce downtime of just-in-time and just-in-sequence (JIT/JIS) networks.	Work with JIT/JIS partners to reduce downtime for manufacturing	6. How has reliability for freight / supply chains improved?
V. Effectiveness of providing integrated real-time transportation information to the public to make informed travel decisions	A. Understand how drivers use and interact with traveler information systems, CAV apps, and how these solutions can be easily deployed with near-term technologies.	Deploy DSRC, C-V2N, and C-V2X hardware to create and showcase the first multi-jurisdictional connected vehicle-to-infrastructure (V2I) deployment initiative in Alabama. Incorporate the TravelSafely app into AlgoTraffic. Monitor users and usage of traveler information systems and CAV apps.	7. How many drivers are using connected traveler information and CAV apps, and how can these solutions be easily deployed with near-term technologies (particular CAV hardware and solutions)?

To address the goal of improved safety, the evaluation sought to understand how the deployment transformed RTMC operations. The hypothesis was that RTMC operators would use cameras and sensors to detect crashes and incidents more effectively than relying on external reports, thereby improving incident management and reducing crash severity. Metrics such as the number of crashes and incidents logged by the RTMC and detection and response times for crashes were used to evaluate these changes. Faster detection and response times were hypothesized to reduce the frequency and severity of crashes (e.g. reduced secondary crashes, rubbernecking, etc.), providing safer outcomes for road users.

For reduced congestion and improved mobility, the evaluation focused on travel times and their reliability. The team hypothesized that the standard deviation of travel times would improve, and that average travel times and speeds would increase with better Transportation Systems Management and Operations (TSMO). Metrics such as the standard deviation of travel times, average travel times, and speeds were used to assess whether the deployment reduced congestion and improved mobility, thus aligning with the project's objectives to create a more efficient transportation network.

The project's focus on reducing environmental impacts was evaluated using modeled fuel consumption based on real data. The hypothesis was that improved traffic operations would lead to fuel savings for drivers, as smoother traffic flow reduces fuel consumption and emissions. Using advanced microsimulations, before-and-after data was analyzed to quantify these changes and assess the environmental benefits of the deployment.

To evaluate improved system performance, the initiative examined metrics such as downtime for just-in-time (JIT) and just-in-sequence (JIS) freight networks, as well as travel times and route reliability for freight. The team hypothesized that reliability in freight and supply chain operations would improve due to reduced delays and more predictable routes. These metrics provided insights into the deployment's impact on economic performance and the resilience of freight operations in the region.

Finally, for enhanced access to real-time information, the evaluation measured the adoption of connected traveler information applications and connected and automated (CAV) technologies. The hypothesis was that as CAV technology continues to evolve, drivers would increasingly use traveler information systems to make informed travel decisions. Metrics such as app download rates, usage statistics, and the number of vehicles utilizing CAV features were used to evaluate these changes. The integration of real-time information is aimed at empowering drivers and enhancing system-wide accessibility and efficiency.

The quantitative performance measures summarized in Table 3 were used to assess whether the technologies met their intended goals. These measures align with the project's scope and objectives, with specific methods designed to evaluate key metrics. The data collection focused on detection and response times from the RTMC, crash frequencies and severities, app downloads, travel times, and connected vehicle operating characteristics. Additional metrics included modeled fuel consumption and economic performance indicators, such as downtime for regional freight operations. Data was gathered from various sources, including RTMC logs, Critical Analysis and Reporting Environment (CARE) crash reports, Bluetooth and probe vehicle data, microsimulations, app analytics, and freight partner interviews. The data collection process spanned before and after the deployment to establish baseline conditions and track changes. Limitations and constraints, such as data availability and sampling coverage, were documented to ensure transparency in the evaluation process. This methodology provided a comprehensive framework for assessing the deployment's impact on safety, mobility, environmental outcomes, and system performance.

Table 2: Performance Metrics

Goal Area	Performance Measure	Data Method	Data Source	Data Collection Time Period	Sample Size
Improve Safety	Number of crashes and incidents logged by the RTMC	Incident logs	RTMC incident reports	Before: January 1, 2023 to December 31, 2023 After: January 1, 2024 to December 31, 2024	Before (2023): 1,449 incidents After (2024): 1,328 incidents
	Detection and response times from the RTMC				
Reduced Congestion and/or Improved Mobility	Standard deviation of travel times	Travel time data	Crowdsourced Probe Data (Travel Time)	Before: January 1, 2023 to December 31, 2023 After: January 1, 2024 to December 31, 2024	Before (2023): 57,864 travel times After (2024): 68,386 travel times
	Travel times improvement	Travel time data	Crowdsourced Probe Data (Travel Time)		
Reduced Environmental Impact	Percent reduction in fuel consumption	Microsimulation	Microsimulation Results and Crowdsourced Probe Data	Before: January 1, 2023 to December 31, 2023 After: January 1, 2024 to December 31, 2024	Before (2023): 249 days of travel time data After (2024): 249 days of travel time data
Improved System Performance	Downtime at MBUSI and freight delivery times (Averitt)	Interviews and route times	Interview response from key manufacturing partner	Before: January 1, 2023 to December 31, 2023 After: January 1, 2024 to December 31, 2024	One interview
Integrated Real-Time Information	Number of connected vehicle app downloads	App analytics	App user, web users, and CV messages	Algo: 2023-2025 TravelSafely: 2019-2025	Algo: 2 years of usage data TravelSafely: 6 years of usage data

3. EVALUATION RESULTS

Improve Safety

In a before-and-after analysis (2023 vs. 2024), safety through event management is analyzed below for both (1) how the deployed technology changed the ways that RTMC operators detect crashes and incidents and (2) how much quicker the RTMC is able to detect and respond to crashes and incidents. The calendar years 2023 and 2024 were selected to provide equal-duration windows under consistent seasonal and operational conditions, with 2024 representing the first full year of sustained, corridor-wide system operation. In 2023, a total of 1,449 traffic events (including both crashes and non-crash incidents) were recorded, compared to 1,328 events in 2024. This represents a decrease of approximately 8.4% in the number of events recorded in 2024. While this reduction is noteworthy, it could be influenced by several factors, including potential improvements resulting from the ACTION project deployment. The project deployed cameras, sensors, and Dynamic Message Signs (DMS), which provide real-time data to both the RTMC and drivers. These systems allow the RTMC to make more informed decisions, and drivers receive timely updates via DMS and the traveler information AlgoTraffic app, enabling them to adjust their behavior proactively. In addition, external (possibly confounding) variables such as traffic patterns, infrastructure modifications, or other differences unrelated to the project may have also contributed to changes between the before period (2023) and after period (2024). Despite these factors, the reduction in recorded events suggests that the project may have played a role in reducing events. Careful consideration of these elements is necessary when interpreting the data, especially with regression-to-mean principles. However, the observed decrease provides a promising indication of the project's potential positive impact, forming a solid basis for year-over-year performance comparison.

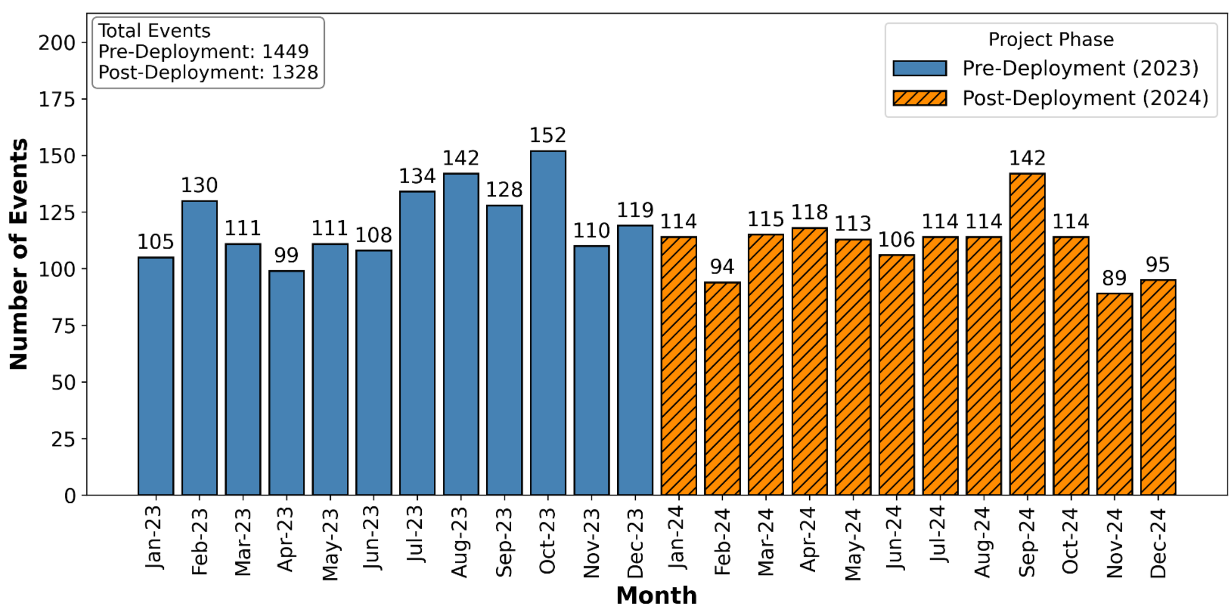


Figure 2. Monthly Event Totals along I-20/59 ACTION Corridor

RTMC Detection of Crashes and Incidents

Starting with evaluation question #1 (Table 1), the TMC Operators and Alabama Service Assistance Patrol (ASAP) Operators together account for the majority of event detections in both years. Figure 4 compares how traffic events were detected before and after the deployment of the ACTION project. TMC Operators continued to be the leading source of event detection, identifying 38.9% of events in the pre-deployment period (2023) and 40.1% of events post-deployment period (2024). This marks a modest increase in their share of total detections, indicating a strengthened role of the RTMC's camera-based monitoring deployment. ASAP Operators were the second-largest source, identifying 37.2% of events pre-deployment and 36.3% of events post-deployment. Police/911 calls accounted for the identification of 17.5% of events during the pre-deployment period and 20.6% of the events in the post-deployment period. This rise may indicate that emergency calls continued to be a valuable and responsive detection source even as other systems improved. Other sources such as DOT staff or other miscellaneous incident identification methods saw decreases in the share of detections.

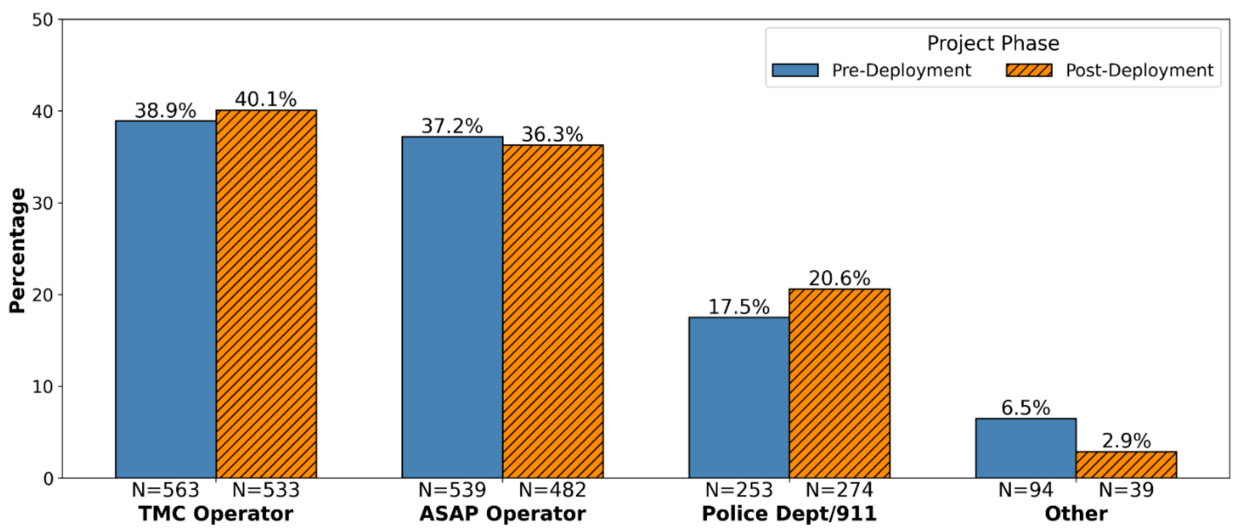


Figure 3. Comparison of total number of events and rate by detection method pre & post deployment

It is also informative to see what kinds of events each detection method tends to catch, as this can reveal the impact of camera and sensor monitoring (which is largely done by TMC operators) on different event types (crashes vs. non-crash incidents). Figure 5 shows that events detected by TMC staff (using cameras) were predominantly traffic incidents (non-crash), such as disabled vehicles, minor obstructions, and similar issues. In 2023, about 63% of TMC-detected events were classified as incidents, and about 37% were crashes. In 2024, this skew toward incidents increased, with about 68% of TMC-detected events being incidents and about 32% being crashes. The freeway service patrol (ASAP Operator) detections were overwhelmingly 95% incidents rather than crashes. These patrol operators mainly find stalled vehicles, debris, etc., often before they escalate to larger congestion and even crash conditions. Events first reported via 911 calls or police dispatch were more likely to be crashes and more severe incidents. In 2024, about 50% of 911-detected events were crashes (up from 48% in 2023).

The breakdown overall shows that TMC operators and patrols excel at catching the less severe, routine incidents (and some smaller crashes), often before they become bigger problems. This suggests that TMC operators were especially effective at spotting minor events that drivers might not always report, which could be attributed to the new cameras and sensors enabling earlier detection. Meanwhile, crashes continued to be reported through 911 operators at similar or slightly higher rates. This division of labor is consistent with a modest increase in the share of minor incidents detected by TMC operators. While this overall change is small, monthly trends in Figure 6 show consistently higher incident detection shares in 2024, suggesting a recurring pattern. This may reflect increased visibility through expanded monitoring infrastructure and supports the plausibility of an operational effect aligned with the project's intent.

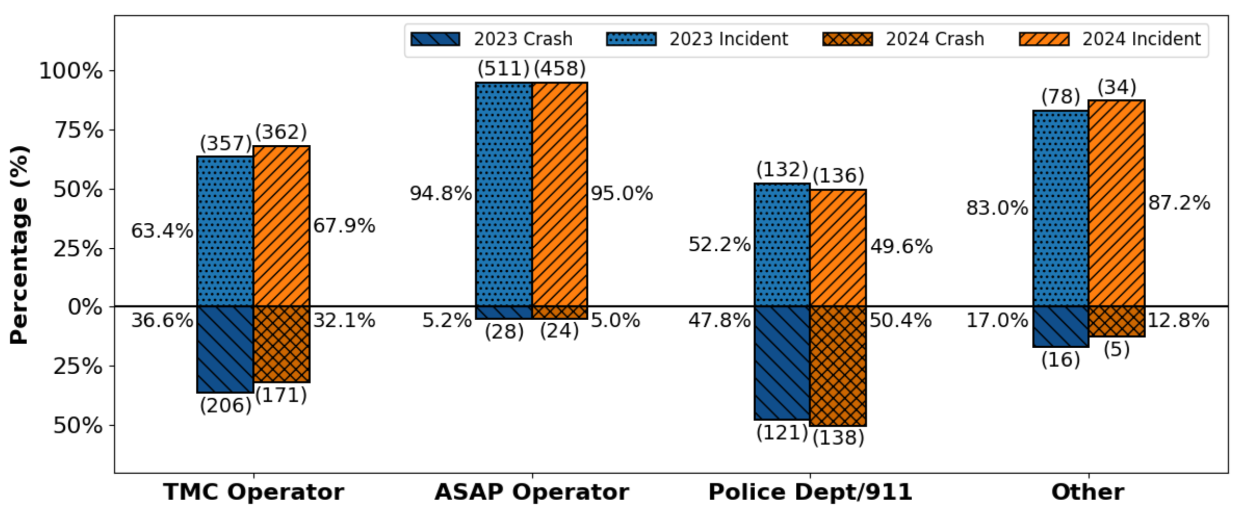


Figure 4. Comparison of Crashes and Incidents by Detection Method Pre & Post deployment

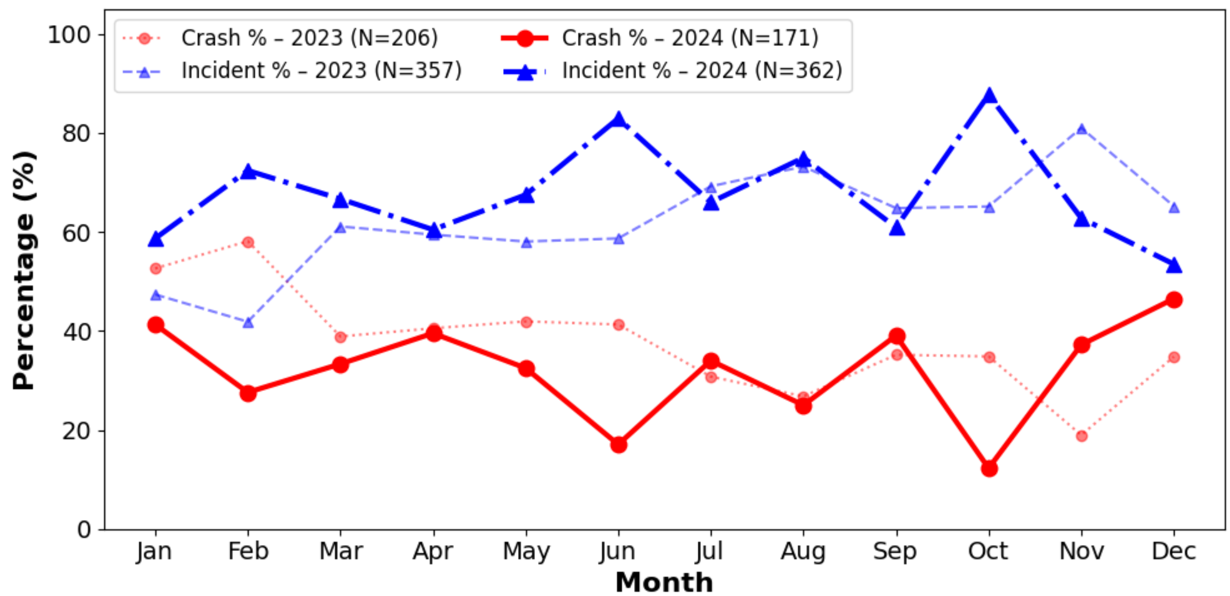


Figure 5. Trend in Monthly Crash and Incident Detection by TMC Operators

RTMC Detection and Response Times

For evaluation question #2, RTMC incident logs were used to calculate key performance metrics, including time to verification, time to dispatch, time to responder arrival, and time to clearance. The dataset was cleaned and filtered using inter quartile range (IQR)-based outlier removal to ensure consistent interpretation across detection methods (TMC, ASAP Operator, Police/911, other) and data retention rates were comparable (e.g., Time to Clearance: 87.8% pre vs. 88.0% post), confirming that cleaning did not disproportionately affect one phase.

- **Time to Verification**: The time from when an event is created in the system to when it is officially verified by TMC staff. This reflects how quickly an incident is confirmed (often via camera or responder eyes on scene).
- **Time to Dispatch**: The time from when an event is created to dispatching response units. Short dispatch times mean TMC operators quickly notify responders (police, ambulance, service patrol) after confirming an incident.
- **Time to Responder Arrival**: The time from when an event is created to the first responder (of any agency) arriving on-scene. This indicates how quickly police/fire/EMS or service patrol reach the incident after being dispatched.
- **Time to Clearance**: The total time from event creation to all lanes being re-opened and normal traffic flow restored. This is a holistic measure of how long an incident disrupts traffic, encompassing detection, response, and clearance.

Post-deployment, Figure 7 shows that TMC-initiated incident verification times remained steady, changing only slightly from 0.97 to 0.90 minutes, reflecting consistently fast confirmation through internal systems. Motorist Call detections (categorized as "Other") showed notable improvements, with verification times dropping from 1.00 to 0.60 minutes and dispatch times improving from 2.09 to 1.59 minutes, indicating faster system support for public-reported events. Response times for Motorist Call incidents remained relatively stable, and clearance times dropped significantly from 32.35 to 21.18 minutes, suggesting consistent coordination and faster resolution. Notably, TMC-handled events also saw a substantial improvement in clearance time, decreasing from 55.08 to 41.52 minutes. ASAP Operator clearance durations increased (perhaps due to an earlier time on scene, and thus a longer total event or clearance time), while Police/911 events showed a modest reduction. Another exogenous factor which may confound some of these results is that the crash severities decreased from 2023 to 2024. While a decrease in crash severity is likely not due to the ACTION deployment, this decrease could influence the change in clearance times. The crash data is included for documentation and discussed in the next section.

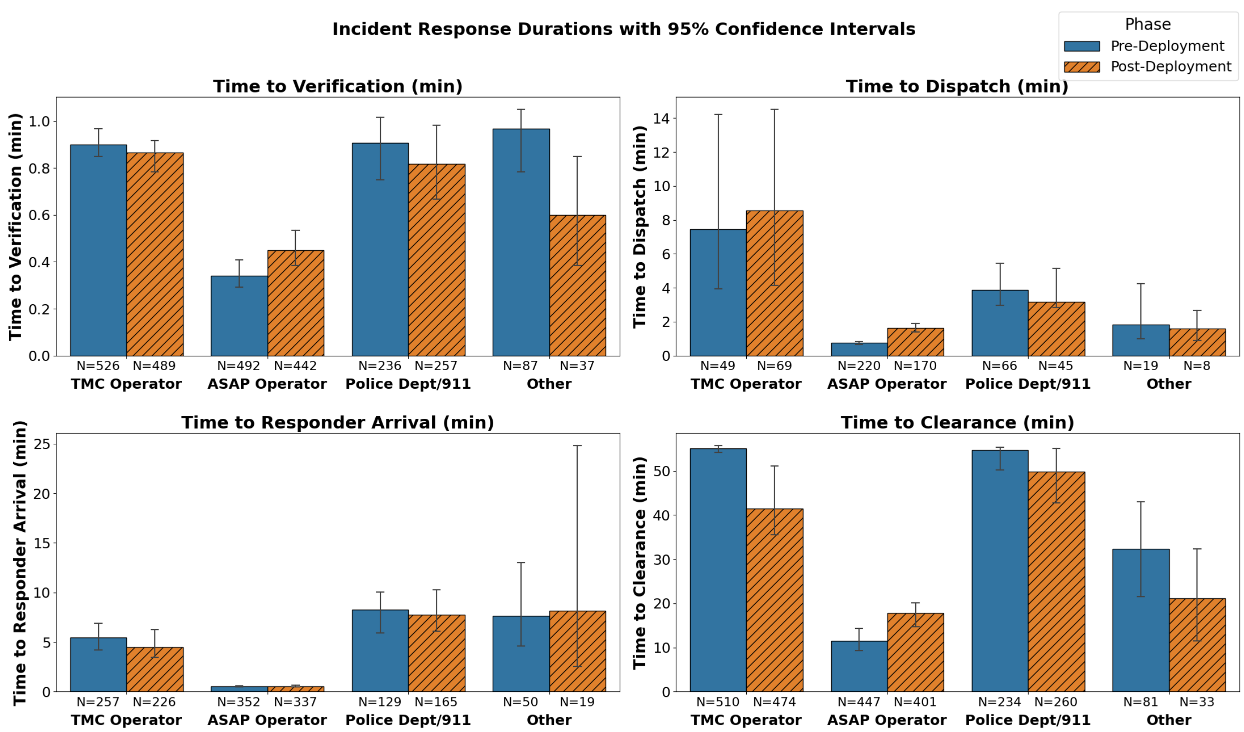


Figure 6. Median Response metrics Pre & Post Project deployment

CARE Crash Data

In addition to the improvements in incident detection and response times noted earlier, the deployment of the ACTION system may have assisted with safety improvements through better incident and crash management (e.g. reducing secondary crashes due to prolonged queuing) along the I-20/59 corridor (Table 3). A detailed crash severity analysis based on crash records obtained from CARE crash data revealed that total crashes declined by 6.9%, from 466 in 2023 to 434 in 2024, which is in line with the 8.9% drop observed in ALGO event data. Traffic-related fatalities dropped by 80% (from five to one), and suspected serious injuries decreased by 35.7%, providing compelling evidence of enhanced roadway safety post-deployment. Reductions were also observed in non-incapacitating injuries and possible injuries, suggesting that not only were fewer crashes occurring, but that those that did occur were generally less severe. Again, these changes in crash severity are not directly attributed to the ACTION deployment, as they may be influenced by various external factors. These safety improvements tend to support the observed operational enhancements, such as shorter clearance times and reduced dependence on motorist-reported incidents.

Table 3. Crash counts by severity by year

Crash Severity Category	**2023**	**2024**
Fatal Injury	5	1
Non-Incapacitating Injury	48	39
Possible Injury	18	14
Property Damage Only	381	371
Suspected Serious Injury	14	9
Total Crashes	**466**	**434**

Reduced congestion and/or improved mobility

With additional cameras and monitoring by the RTMC, the hypothesis is that travel time variability should be reduced along the project corridor through earlier detection of incidents, faster response and clearance times, and improved traveler information through the statewide traveler information app (Algo Traffic) and DMS. The standard deviation of travel time was initially analyzed to evaluate the variability of travel conditions before and after the project implementation. The key I-20/59 freeway and freight route (MP 68-89) between Tuscaloosa, Alabama, and the Mercedes-Benz plant in Vance, Alabama, was the focus of the analysis. To evaluate the effectiveness of the deployment and the impact on travel time fluctuations, a before-and-after study was conducted using one year of 15-minute interval travel time and variability data from 2023 (before) and 2024 (after) for both eastbound (EB) and westbound (WB) directions. Two core evaluation questions were addressed: (Q3) whether the variability in travel times changed following deployment and (Q4) whether overall travel times improved.

Standard Deviation of Travel Times

For evaluation question #3, changes in the variability of travel times were analyzed using measures of standard deviation within each 15-minute period and statistical variance across all 15-minute intervals. Since the data was not normally distributed, non-parametric methods were used appropriately. In the eastbound (EB) direction (shown in Figure 7), the Welch's t-test for changes in mean standard deviation yielded a t-statistic of –0.9048 with a p-value of 0.3656, indicating no statistically significant change. In contrast, the westbound (WB) direction in Figure 8 showed a substantial improvement, with a Welch's t-statistic of 11.333 and a p-value of <0.0001, indicating a statistically significant reduction in mean standard deviation. Further, the Mann–Whitney U test supported these findings, with a p-value of 0.000084 for EB and <0.0001 for WB, confirming significant distributional differences in standard deviations between years. The Kolmogorov–Smirnov (KS) test reinforced this interpretation, producing KS statistics of 0.0317 (EB) and 0.0536 (WB), both with p-values of <0.0001. To evaluate variability across all time intervals, an F-test was conducted. Results showed a statistically significant difference in variance for both directions: EB had an F-statistic of 1.1178 with a p-value < 0.0001, and WB had an F-statistic of 1.0419 with a p-value of 0.00027. Together, these results indicate that the WB direction saw a meaningful and statistically significant improvement in travel time consistency, while the EB direction did not exhibit such gains.

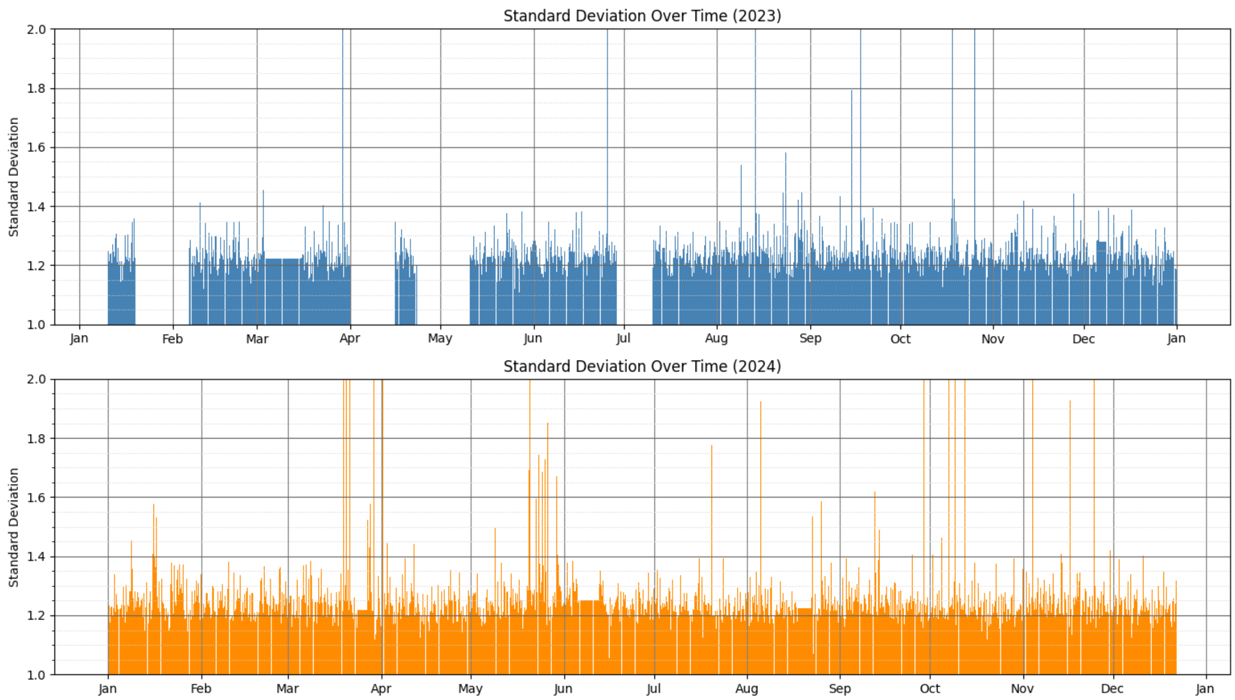


Figure 7. Eastbound I-20/59 travel time standard deviations (MP 68-89)

Figure 8. Westbound I-20/59 travel time standard deviations (MP 89-68)

Change in Travel Time

For evaluation question #4, changes in average travel times were examined using both distributional and mean-based tests. As with the variability analysis, the travel time data was determined to be non-normally distributed using the Anderson–Darling test. In the EB direction, the average travel time slightly increased from 17.0548 ± 0.7378 minutes in 2023 to 17.0759 ± 0.6978 minutes in 2024 (negligible from a practical standpoint). In contrast, the WB direction showed a reduction from 20.8084 ± 0.7008 minutes in 2023 to 20.7487 ± 0.6866 minutes in 2024 (again, fairly negligible). The Kolmogorov–Smirnov test showed statistically significant differences in the distributions for both directions (KS statistics of 0.035 for EB and 0.058 for WB, with p-values of <0.0001). The Mann–Whitney U test also revealed significant differences: $U = 463{,}713{,}512$ (EB) and $U = 525{,}889{,}888$ (WB), both with p-values < 0.0001. While the one-tailed t-test suggested no significant change in the EB direction ($t = -3.637$, $p < 0.0001$, but with a negative mean difference), the WB direction demonstrated a statistically significant improvement ($t = 10.7733$, $p < 0.0001$). The average difference in travel times was –0.0212 minutes for EB (95% CI: [–0.0326, –0.0098]) and +0.0597 minutes for WB (95% CI: [0.0488, 0.0705]). These results indicate that while the eastbound direction experienced a slight and statistically significant increase in travel time, the westbound corridor benefited from a meaningful and significant decrease, suggesting that the ITS deployments had a more pronounced positive effect in that direction.

Figure 9. Eastbound I-20/59 travel times (MP 68-89)

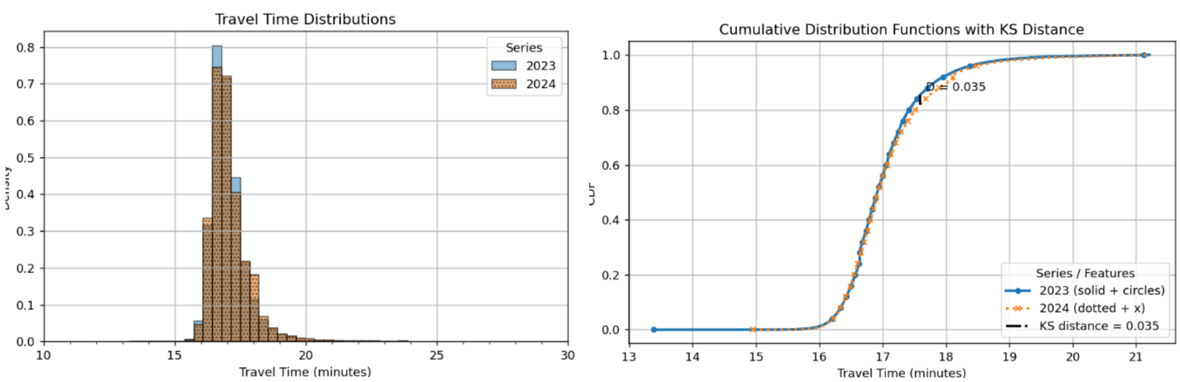


Figure 10. Eastbound I-20/59 travel time distributions and testing (MP 68-89)

Figure 11. Westbound I-20/59 travel times (MP 89-68)

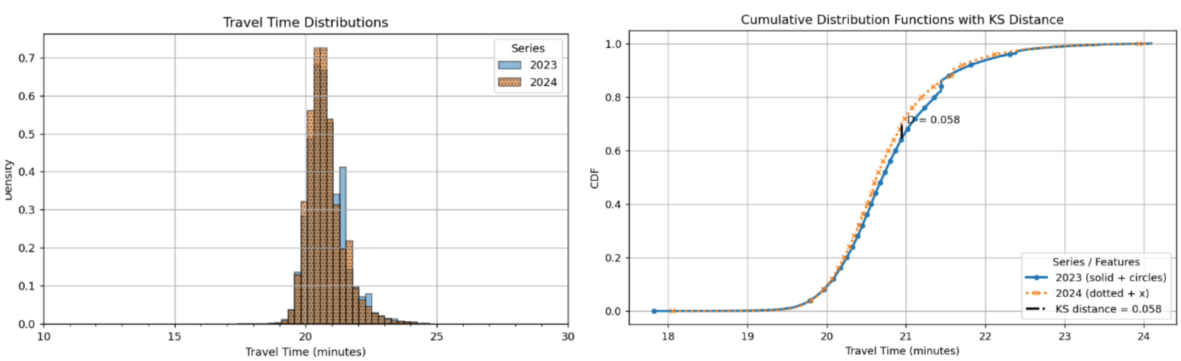


Figure 12. Westbound I-20/59 travel time distributions and testing (MP 89-68)

Reduce Environmental Impact

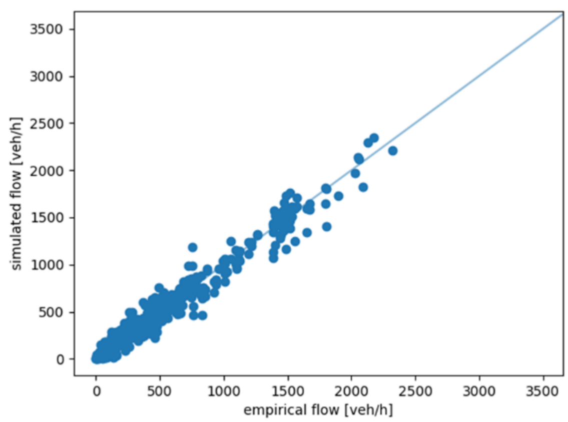
The system-wide impact of the transportation system upgrades are also evaluated with a focus on environmental impact for evaluation question #5. While total fuel consumption and emissions are most strongly a factor of total volume in the network, the deployment of signal controller upgrades, incident response improvements, and overall corridor control optimization can have positive impacts despite increased total volume. To facilitate the evaluation of fuel consumption (and correlated emissions), two methods are applied: 1) traffic microsimulation calibrated to 2023 data provides full system analysis as baseline for on-going evaluation, and 2) a sample case study investigating travel time, speed, and wasted fuel costs along a critical corridor in the region comparing 2023 to 2024.

The traffic microsimulation was performed with the open-source Simulation of Urban MObility (SUMO) software. After extracting the regional road network from Open Street Maps (OSM), substantial effort was made to clean and validate the road network, including manual inspection and correction of nearly 100 signalized intersections to ensure the lane and signal controller configurations were accurate. Using a combination of the most recent regional origin-destination data, 2023 average annual daily traffic (AADT) data (including truck percentages), and localized signal detector count logs, the team then completed a full-scale calibration of the model. These 2023 results are presented as a documented baseline for ongoing evaluation and are not by themselves evidence of environmental benefits. Future recalibration with 2024 AADT data will allow for direct quantitative comparison. An image of the resulting network is shown in Figure 14. The calibration focused on minimizing GEH across both passenger and truck traffic when comparing simulation and real-world AADT data.

Figure 13. Full network used for traffic microsimulation using SUMO software.

This GEH term is widely used in traffic engineering to assess modeling of volume flows[1]. The value is calculated at each location where data is available as shown in equation below, where M is the modeled flow and C is the real-world flow. Generally, a value less than 5 is acceptable at any given location, and achieving this at 85% or more of the locations in the model should be the target. In the final model, the GEH value for the 85% quantile was 4.5 for passenger vehicles and 2.8 for trucks, indicating an acceptable match. The results in Figure 15 show a more detailed comparison between simulation (vertical axis) and real-world (horizontal axis) counts at each of the AADT sampling locations around the region considered. It is clear that for both passenger vehicles (left) and trucks (right), the model captures the wide range of volumes around the network quite well.

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$



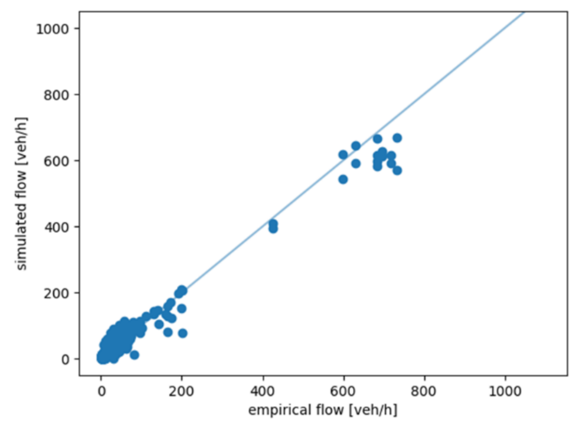


Figure 14. Detailed analysis of results for passenger vehicles (left) and trucks (right) showing simulated flow vs. real-world data at every location considered in calibration.

The following figures provide a qualitative impression of the microsimulation model outputs. Figure 16 and Figure 17 show the full network and a zoomed view of the fuel consumption results, clearly capturing the hotspots in major intersections and along high-volume corridors. Unfortunately, the 2024 AADT data is not available until late 2025, so recalibration and direct quantitative comparison is not yet possible. The team plans to continually update and utilize this model to support future decision-making processes in the region.

[1] GEH is pseudo-statistical test that allows for combined assessment of model accuracy across a range of real-world traffic volumes from mainlines and side streets (often orders of magnitude different) with a single parameter. Due to its non-linear formulation a large absolute deviation (M-C) for high flows will be mitigated by the divisor (M+C) in a way that a more simple percent variation metric would not allow.

Historically, the major corridors around the deployment region saw a 2-3% increase in volume, and it is expected that the same will be true from 2023 to 2024. Thus, while the AADT data is not available to do the full-scale analysis, travel time, average speed, and wasted fuel costs from ALDOT's ClearGuide system are available and able to provide some insight into the environmental and fuel consumption effects at both a system and individual driver's perspective.

Specifically, analysis is completed for vehicles along a 9.5-mile segment of US-82 traversing the majority of the Northport and Tuscaloosa region (as shown in Figure 18), with the average travel speed, travel time, and wasted fuel costs (shown in Figure 19) across the full year for 2023 and 2024.

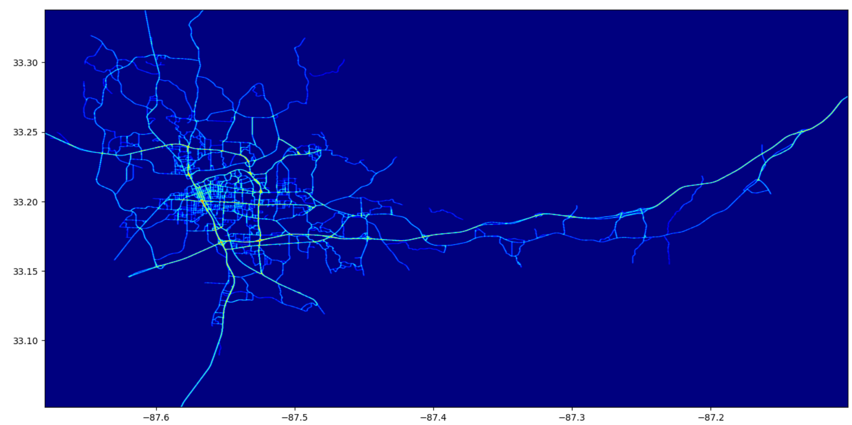


Figure 15. Full network fuel consumption heat map.

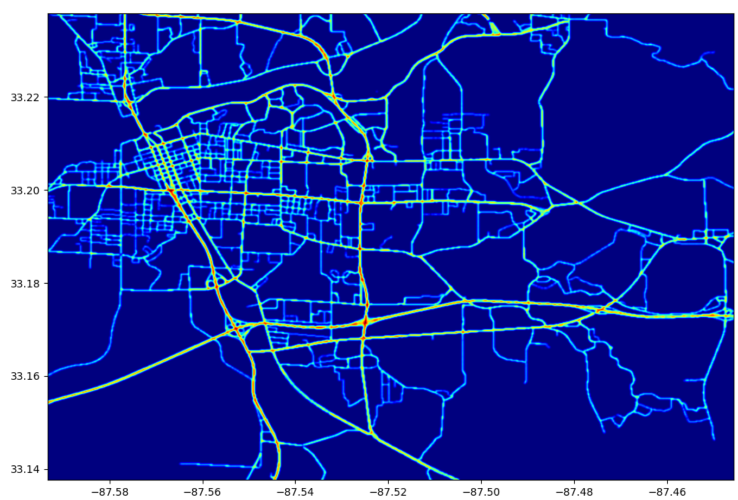


Figure 16. Zoomed view of fuel consumption heat map showing clear hotspots at major intersections and high volume corridors.

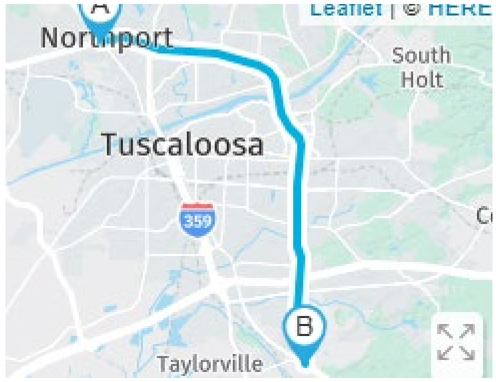


Figure 17. Route used for travel time, speed, and wasted fuel cost evaluation.

The results show interesting trends both within the year and between years. For travel times and average speed, the effects of Spring break in mid-March and the return of students in August are seen as steep changes in all data. The period between Spring break and August shows a continual decline in travel time of approximately 30 seconds and an increase in travel speed of 1-2 miles per hour (MPH). While the data provider obscures the calculation of wasted fuel cost and traffic volume, the relative trends are matched with speed/time as expected. Because the data provider obscures both the traffic volume and the calculation of wasted fuel cost, a per-vehicle normalization is not possible with the available data. Therefore, the results presented here should be interpreted at the system level, not as per-vehicle impacts.

The results from 2023 to 2024 (for the 0600-1000 morning peak period for one direction on this one corridor) show an improvement in both speed, time, and wasted fuel costs from January to August. After the Fall school term starts for both local schools and the university, there is a marked decrease in performance. This can be attributed to a number of factors, though not conclusively. For instance, the university had a record enrollment (up 1,000 from 2023 to approximately 41,000), the city population increased by an estimated 500 (to 113,700), and the county population also increased by an estimated 1,000 (to 238,000). Additionally, major construction along the US-82 route north of the Black Warrior River was under way, reducing available lanes and speeds. The localized effect of the additional 1,500-2000 potential drivers in the area around the US-82 route and the construction likely combined to cause this increase in travel time, wasted fuel costs, and reduced speeds.

In total, comparing the cumulative wasted fuel costs from 2023 to 2024 shows a reduction of just under $4,000 (about 3%) for this one direction in the AM peak period on this corridor. Considering both directions, all times of day, and additional deployment corridors could yield a much greater system-level benefit. It should be noted that while reductions in wasted fuel represent reductions in delay-induced emissions, total emissions across the network may still have increased due to overall traffic growth. Once AADT data for 2024 are available, these preliminary conclusions can be more rigorously tested, the microsimulation model updated, and system-wide impacts more fully assessed.

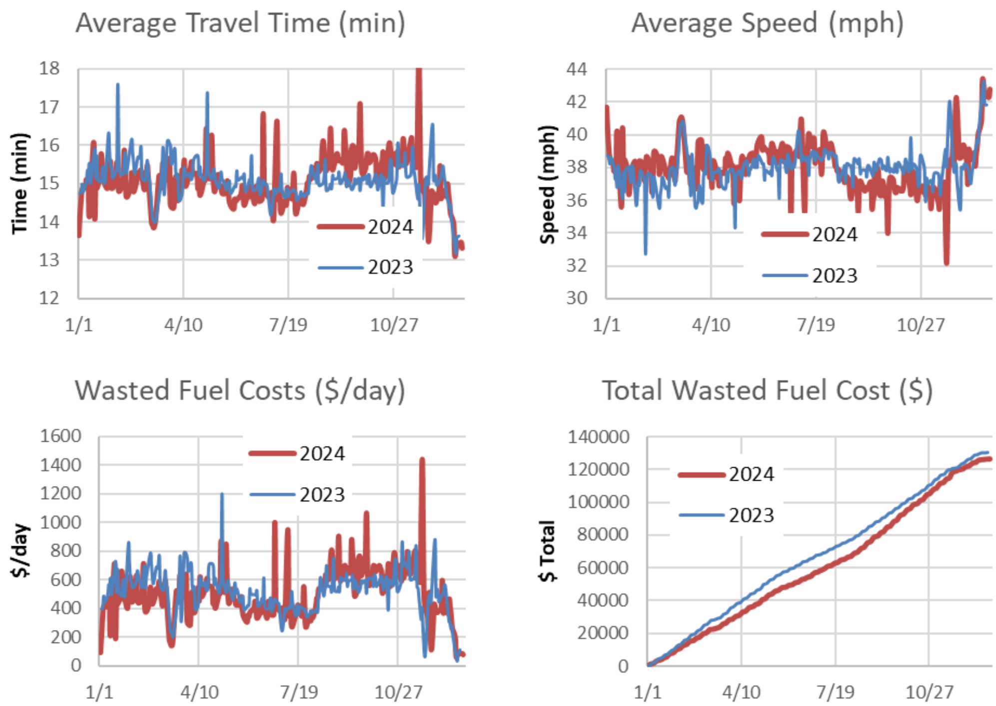


Figure 18. Comparison of travel time, speed, and wasted fuel costs along US-82 from 2023 to 2024

Improved System Performance

With regard to evaluation question #6, the ACTION project was designed to improve reliability across the entire regional transportation system, with a particular emphasis on supporting critical freight and supply chain operations. West central Alabama is home to a number of major manufacturing and logistics operations, including Mercedes Benz U.S. International (MBUSI), ZF Lemforder, and numerous tiered suppliers that depend on consistent, predictable travel times to support JIT/JIS delivery models. These operations form the economic backbone of the region, and their performance is directly tied to the efficiency of the road network. Unplanned disruptions whether from crashes, weather, construction, or special events can have outsized impacts. For example, MBUSI estimates that a single minute of delay can cost upwards of $10,000 in lost productivity, underscoring the high economic sensitivity to travel time reliability. These reliability gains benefit not only MBUSI but also a wide array of manufacturers, logistics companies, and service providers operating throughout the region.

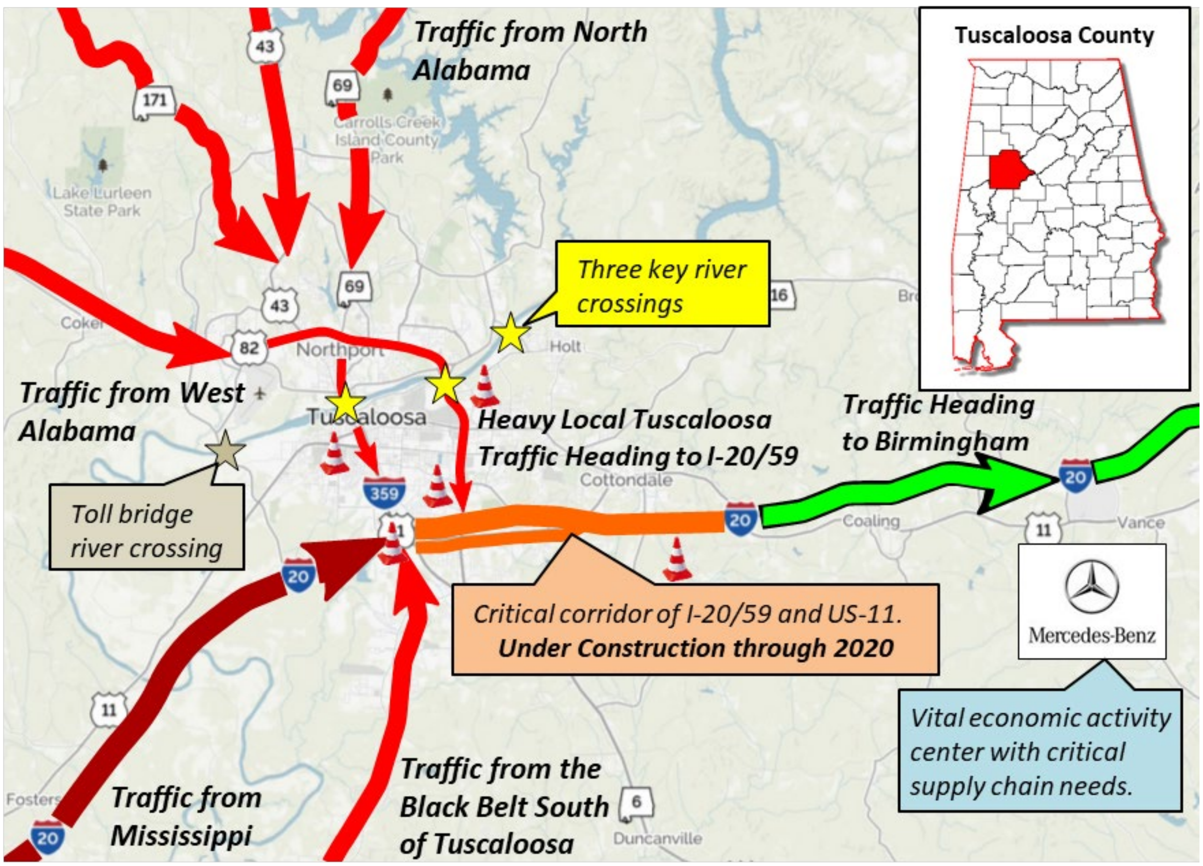


Figure 19. ACTION impact of just-in-time / just-in-sequence operations

To support the evaluation of freight reliability impacts, the team conducted a structured interview with representatives from MBUSI, one of the region's key just-in-time (JIT) and just-in-sequence (JIS) manufacturing stakeholders who oversees and monitors more than 50 suppliers and their transportation logistics in the area. While the ability to measure this goal was limited to only a single interview with the MBUSI team, the broad representation of supplier performance and reliability was robust. The discussion covered operational metrics, disruption impacts, data availability, routing practices, and feedback on system performance post-deployment. MBUSI shared that they actively monitor performance using several logistics-based indicators, including unused truck rates, dwell times, and trailer utilization, all of which are crucial for maintaining production continuity.

The interview highlighted the sensitivity of manufacturing operations to traffic disruptions, particularly on high-volume corridors like I-20/59. MBUSI noted that even brief delays can have cascading effects on supply chains, with local deliveries often more vulnerable due to narrower time windows. Importantly, MBUSI confirmed the use of route trackers and contingency plans to mitigate risks, and they described how real-world incidents have led to downtime and operational adjustments. Since the deployment of ACTION infrastructure, MBUSI and their logistics supply chain partners have observed improved operations for their just-in-time / just-in-sequence operations, with fewer instances of production shutdowns due to shipping delays.

MBUSI also expressed interest in future transportation improvements, particularly tools that could proactively alert carriers to real-time conditions affecting specific routes. Their willingness to engage in future data-sharing efforts reflects a broader recognition of the value of coordinated infrastructure, data, and logistics strategies. This collaboration serves as an important example of how ACTION benefits extend beyond individual firms to the entire regional freight and supply chain ecosystem.

Effectiveness of providing integrated real-time transportation information to the public to make informed travel decisions

This section of the ACTION evaluation focuses on how drivers are engaging with connected traveler information systems and CAV applications. The ACTION project deployed SPaT broadcasting, red-light warnings, and vulnerable road user notifications. As hypothesized in the evaluation plan, while CAV technologies are still emerging and may face adoption challenges due to hardware and integration barriers, travelers are showing greater interest in systems that provide accessible and timely travel information. To explore this, the team examined user engagement with two key platforms implemented in the ACTION region: (1) the Algo traffic information platform and (2) the TravelSafely CAV app. These systems offer complementary approaches to improving mobility and safety. Algo provides pre-trip and en-route traffic updates through both mobile and web-based interfaces, while TravelSafely focuses on direct safety messaging using CV2N and CV2X communication, especially around intersections and along signalized corridors.

Algo Traveler Information System Users Analysis (App and Website)

Since early 2023, the Algo Traveler Information System (both the smartphone app and website) experienced slow and steady growth with moderate advertising through DMS, weather platforms, and other small outreach efforts. Weather events in January 2024 and January 2025 saw drastic spikes in usage (Figure 21) along with some sustained increase in usage. The information being shared by the RTMC is relevant and valuable to drivers, and this seems to be the way that most drivers are getting travel information. Cameras from the ACTION project are also shared on these platforms, wherein drivers can get live video of actual traffic and weather conditions.

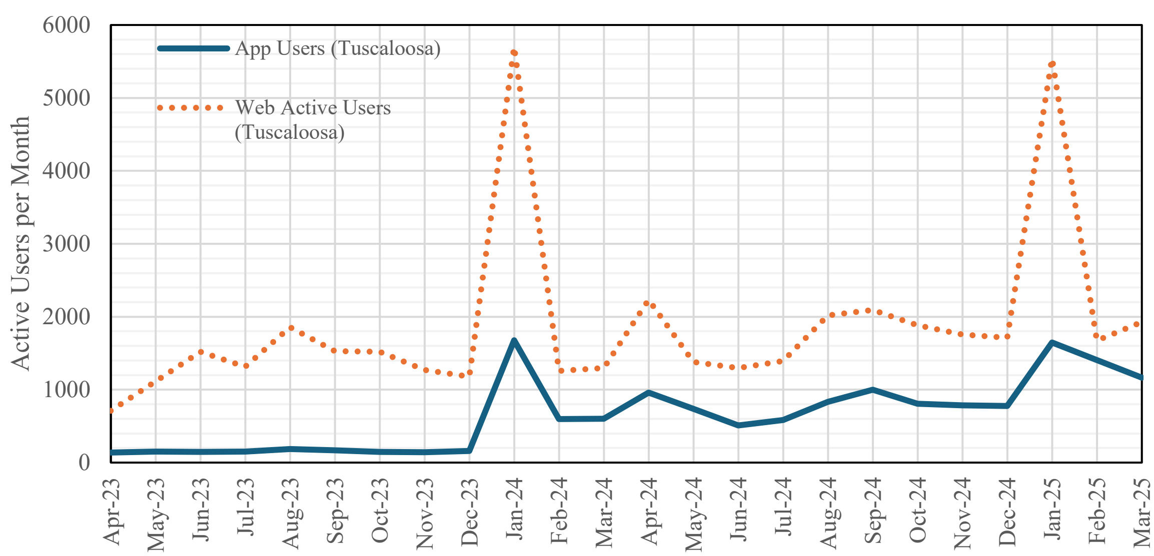


Figure 20. Algo app and web users by month for Tuscaloosa

Furthermore, Table 4 shows that the growth in Tuscaloosa is outpacing the rest of the state. For example, the app usage from 2023 to 2024 increased by 163% for Tuscaloosa compared to 110%

for the rest of the state. Also, while the web usage dropped by 18% for 2024 compared to 2023 for the state, Tuscaloosa web use increased by 23%. Clearly, the ACTION project in Tuscaloosa is providing valuable information that drivers want.

Table 4. Algo Users comparing 2023 and 2024

	2023	2024	Increase
App Users (Total)	14848	31151	110%
App Active Users (Tuscaloosa)	**356**	**934**	**163%**
App Users (New)	6224	6858	10%
App Sessions	62520	124015	98%
App iOS	7382	23073	213%
App Android	7466	8078	8%
Web Active Users (Total)	93049	76398	-18%
Web Active Users (Tuscaloosa)	**1689**	**2076**	**23%**
Web Users (New)	90469	71385	-21%
Web Sessions	136197	129480	-5%
Web Average Session Duration	00:02:45	00:04:07	50%
Web Sessions per user	1.46	1.75	20%

TravelSafely App Usage Analysis (CV2N and CV2X)

TravelSafely is a free app (iOS & Android) from Applied Information that integrates smartphones with connected vehicle information, notifications, and applications. UA and ALDOT have primarily used these applications for signal phase and timing (SPaT) information around Tuscaloosa County. While this started out as a free smartphone app approach, Applied Information has since integrated into OEM infotainment systems in some vehicles. The hypothesis is that, with increased integrations, some of the additional freeway alert information from the RTMC could be shared with all TravelSafely endpoints. While no direct advertising was done, there have been engineering-focused stories and social media posts regarding some of the technology. However, usefulness and streamlining integration continues to be a challenge with adoption.

The cumulative usage chart compiles all app interaction events (sessions/messages) from the start of the app's availability through April 2025. Beginning at zero in early 2019, the cumulative interactions climbed to about 100+ by early 2020, then continued upward each year. By the end of 2024, the TravelSafely app had facilitated approximately 349 total usage events in Tuscaloosa County. Each step up in the line corresponds to periods where users were actively using the app, and the fact that the line keeps rising confirms that the app continued to see usage over multiple years. In general, while the numbers are certainly lower than the Algo Usage, perhaps requiring drivers to manually open a TravelSafely app for real time information remains a challenge of adoption which should hopefully be addressed by further OEM infotainment integration.

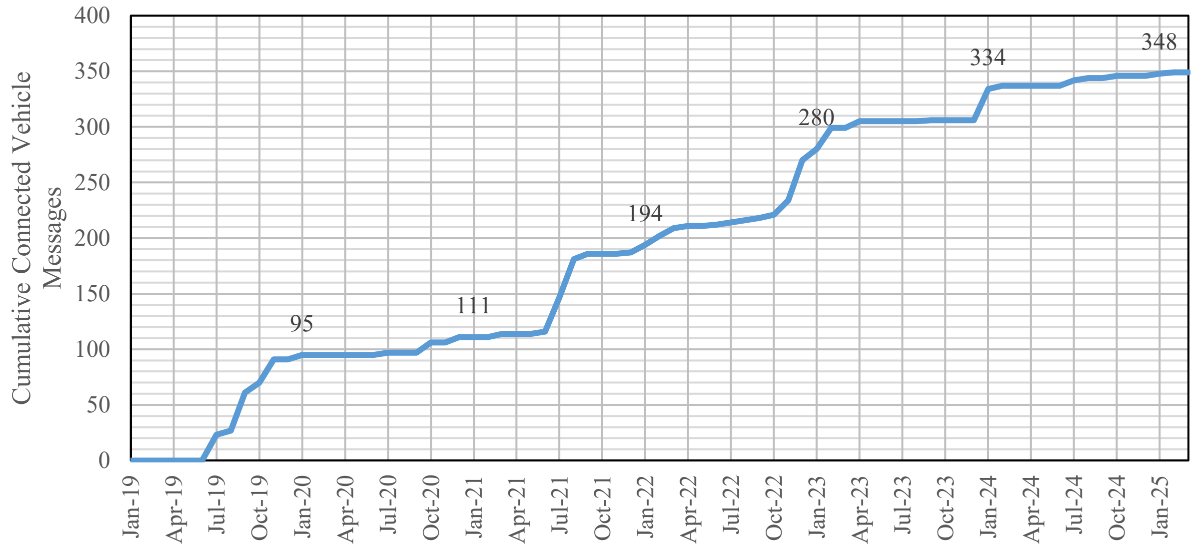


Figure 21. Travel Safely Connected Vehicle Messages Broadcast

4. LESSONS LEARNED, RECOMMENDATIONS, AND CONCLUSIONS

Key Takeaways

The University of Alabama and ALDOT successfully implemented the ACTION initiative through sustained collaboration, iterative design, and strong stakeholder engagement. Although the project experienced delays due to COVID-19 and supply chain disruptions, the team identified adaptive alternatives and completed a comprehensive deployment of intelligent transportation system (ITS) components. This included upgrades at 135 intersections and the integration of multiple connected vehicle (CV) technologies. The project remained consistent with its original goals and showed the value of using technology to improve transportation outcomes in the region, as summarized in the following:

1. The deployment of the ACTION system contributed to an 8.4% reduction in total traffic events from 2023 to 2024 and helped shift early detection of minor incidents to RTMC operators using new camera and sensor technologies. This led to faster verification and clearance times for both TMC-detected and motorist-reported events, indicating improved responsiveness and overall incident management.
2. For the I-20/59 corridor between milepost 68 and 89, the travel times for both eastbound and westbound travel times achieved small but significant improvements through better management and small improvements in travel reliability for one direction (and no change in the other direction).
3. A regional traffic microsimulation and corridor-level case study suggest that signal and incident management upgrades contributed to modest environmental benefits in 2024, including a 3% reduction in wasted fuel costs during the morning peak along a key corridor, despite increased traffic volume. Broader system-wide analysis will be conducted with forthcoming 2024 traffic volume data to expand these findings.

4. The key manufacturing and logistics partner reported in an interview that they experienced improved operations for their just-in-time / just-in-sequence operations, with fewer instances of production shutdowns due to shipping delays.
5. The demand for traveler information drastically increased through traditional traveler information apps and with better data from the RTMC, but connected vehicle application / hardware usage remained limited and steady without OEM infotainment integration.

The use of fiber-optic communications, increased monitoring by the TMC, and traveler information systems helped reduce travel delays, improve safety, and strengthen system resilience. Benefits have been captured in travel time reliability, environmental improvements, support for just-in-time freight operations, and increased demand for and usage of traveler information. From a qualitative perspective for a benefit-cost consideration, the cost of the hardware and construction has been shown to reduce delays, which could be multiplied by the volume of travelers impacted and the value of time. Careful monitoring of volumes (especially during incidents) should be collected for such an analysis in the future.

Project Lessons Learned

- **Flexibility:** Changes in technology, vendor issues, and budget limitations required scope adjustments. A flexible planning process allowed the team to adapt and continue progress despite these challenges.
- **Data integration planning:** Establishing baseline data and collecting consistent “before” and “after” measurements across platforms such as HERE, Algo, TravelSafely, and CARE proved more difficult than expected. Ensuring coordination and alignment among data sources took significant time and effort.
- **Strong partnerships:** The success of the project was built on collaboration among agencies, freight stakeholders, and technology providers. Early and regular engagement helped with smoother implementation and broader support.

Recommendations for Future Deployers

1. **Select technologies that allow for future upgrades:** The team will use modular tools such as CV2X radios and modern signal controllers that can grow with evolving systems.
2. **Include a thorough testing phase before full deployment:** Pre-deployment testing helped identify and resolve integration issues early in the process.
3. **Establish data collection procedures from the start:** Early planning for data pipelines and coordination across platforms will support performance monitoring and evaluation.
4. **Work closely with local agencies and freight operators:** Freight reliability is a major factor in regional economic performance. Engaging stakeholders early and often helps target the improvements that matter most.
5. **Align deployment with evaluation needs:** Clearly defined performance measures and consistent data collection support accountability and continuous improvement.