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13. Abstract

This study aimed to conduct a needs assessment and performance evaluation of Traffic Incident Management (TIM) in Louisiana and identify areas for TIM improvement. The study also aimed to assess interoperability as a solution to communication gaps. The research team achieved this by performing evaluations and assessments of Louisiana's TIM and communications during traffic incident response.

The evaluation revealed several communication gaps and TIM needs. It was found that the Traffic Management Center (TMC) systems are not fully integrated with law enforcement Computer Aided Dispatch (CAD). As a result, TMCs sometimes rely on public CAD

information to detect incidents and update their incident response plans. It was also found that dispatchers are responsible to receive information from on-scene first responders and coordinate interagency communication. While this arrangement functions well for small incidents, it may lead to delays and the loss of critical information for larger events. Additionally, the evaluation suggested that there is no direct communication between the TMC and other on-field first responders. Given the crucial role that TMCs play in TIM, this could lead to problems. The TMC relies on Motorist Assistance Patrol (MAP), or the dispatchers who operate at Public Safety Answering Points (PSAPs), to obtain and pass information. This means that in locations where MAP does not operate, the TMC may have to rely on one or more dispatchers for information sharing. This may in turn lead to delays in receiving updates on incident response and the subsequent update of traveler information systems relied upon by the general public. Receiving and passing information through multiple dispatchers may result in information loss and delays in receiving accurate messages. Several of these identified gaps are due to regulations and institutional arrangements that prohibit TMC operators from directly speaking to on-scene first responders or accessing law enforcement systems.

The evaluation indicated that apart from improving the efficacy of TIM in Louisiana, web-based interoperable communication platforms could help address several of the identified communication gaps. For instance, closed talk groups could be used to mitigate concerns about sharing sensitive law enforcement information. Additionally, the sharing of data, text, and multimedia information could improve situational awareness, especially for large incidents. However, incorporating an interoperable communication platform will require interagency coordination and possible regulation changes.

Results from the study also suggested that Lousiana's TIM program needs reorganization and strengthening. Several important elements of TIM, such as TIM committees, standard operating procedures (SOPs), regular TIM meetings, and joint training exercises, are not standard in Louisiana. To have a fully functional TIM program that improves the safety and efficiency of the transportation system, efforts should be made to update the state's TIM program to include these missing elements.

Steps to consider when implementing an interoperable platform into Louisiana's TIM include: gaining leadership buy-in; engaging with stakeholders; clearly defining functional requirements; utilizing interagency agreements; leveraging current TIM systems for integration; and addressing cybersecurity. Other implementation considerations include: engaging with the legal department; creating a long-term operating budget; addressing compatibility issues; and designing intuitive systems. Additional lessons learned from the study were that only relevant features of the platforms should be used, the integration of such platforms enhances coordination, the long-term benefits of the platform exceed the costs of integration, and previous agency use experience is an advantage.

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The evaluation revealed several communication gaps and TIM needs. It was found that the Traffic Management Center (TMC) systems are not fully integrated with law enforcement Computer Aided Dispatch (CAD). As a result, TMCs sometimes rely on public CAD information to detect incidents and update their incident response plans. It was also found that dispatchers are responsible to receive information from on-scene first responders and coordinate interagency communication. While this arrangement functions well for small incidents, it may lead to delays and the loss of critical information for larger events. Additionally, the evaluation suggested that there is no direct communication between the TMC and other on-field first responders. Given the crucial role that TMCs play in TIM, this could lead to problems. The TMC relies on Motorist Assistance Patrol (MAP), or the dispatchers who operate at Public Safety Answering Points (PSAPs), to obtain and pass information. This means that in locations where MAP does not operate, the TMC may have to rely on one or more dispatchers for information sharing. This may in turn lead to delays in receiving updates on incident response and the subsequent update of traveler information systems relied upon by the general public. Receiving and passing information through multiple dispatchers may result in information loss and delays in receiving accurate messages. Several of these identified gaps are due to regulations and institutional arrangements that prohibit TMC operators from directly speaking to on-scene first responders or accessing law enforcement systems.

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Additionally, we would like to express our appreciation for the contribution of personnel from law enforcement, fire departments, emergency and medical services (EMS), state police, and Traffic Management Centers (TMCs) in Louisiana and across the nation who provided information for this report.

Implementation Statement

The recommendations in this report should assist in reorganizing and strengthening the Traffic Incident Management (TIM) program to provide more efficient incident response in Louisiana. The findings from this study also provide considerations to successfully integrate an interoperable communications platform into the state's TIM.

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Introduction

Implementing an efficient Traffic Incident Management (TIM) strategy will lead to several tangible benefits in Louisiana, including reduced congestion, reduced pollution, and improved transportation operations. Additionally, an effective TIM has been found to decrease first responder fatalities, the mortality of crash victims, and the risk of secondary crashes. These benefits have spurred federal and state governments to continuously find ways to improve TIM. Louisiana's vision of "Destination Zero Deaths" has become a top priority for the state and could be realized by improving the state's TIM.

TIM is a multiagency endeavor and relies on efficient interagency and intraagency communication. Communication is required to provide accurate and timely information to coordinate rapid responses for incidents. However, effective cross-agency communication is a challenge. These challenges are associated with incompatible technologies, scarce spectrum, poor planning, and lack of coordination and cooperation among agencies. Interoperable communications has been identified as a solution to interagency communication challenges during TIM. Such communications ensure that prompt, reliable and accurate information is provided to first responders on demand and in a timely manner. Interoperable communications also guarantee that a structured and consistent means of communication is maintained during incident response. Strides in technology mean that communications interoperability is being improved consistently through the seamless sharing of voice, video, and data using wireless communications and the internet. This has led many agencies to incorporate interoperable communication systems into their TIM.

The objectives of this study were to conduct a needs assessment and performance evaluation of the TIM system in Louisiana, identify areas for TIM improvement, and explore interoperablility as a solution to communication gaps. Additionally, the study aimed to provide recommendations for TIM improvement and strategies to advance interoperable communications for incident response.

To achieve these objectives, the research team first performed a literature review. Information was collected from various sources on incident response and TIM, including published reports, studies, and articles. Additional information for the study was obtained through observation and interviews. The benefits of TIM and interoperable communications, as well as its stakeholders and their roles, were discussed as a part of the literature review.

The next portion of the report discusses the methodology used for the study. This includes an explanation of completed tasks and identifies TIM best practices. Additionally, the primary elements of successful TIM programs are discussed and used as a baseline to compare Louisiana's TIM with others. Information for this section was obtained from national and state documents, as well as available national standards.

TIM in Louisiana is discussed next, with descriptions of operations, stakeholders, ITS resources, and performance measures. Special attention is given to communications during incident response in the state. The arrangements and flow of interagency communication among key stakeholders is assessed in this part of the report, as well as the state of communications interoperability and its use in incident response in Louisiana. Additionally, a performance evaluation was carried out using data obtained from Traffic Management Centers (TMCs) and the Regional Integrated Trasnportation Information System (RITIS). The evaluation was conducted to identify trends and issues in incident response for interstates and TMCs.

A needs analysis identified several communication and other TIM needs based on the previous review of best practices. Communication needs included the use of interoperable communications platforms, co-location of response agency dispatchers and personnel, and the need for full integration of TMC systems with law enforcement CAD. Other needs included the reorganization of the TIM program in Louisiana, multiagency SOPs, joint training, interagency agreements, and the sharing of performance measures with partner stakeholder agencies.

At this point, the features and characteristics of several interoperable communication platforms were assessed. This assessment was designed to evaluate how these platforms could enhance interoperable communications. The strengths and limitations of the platforms are identified and discussed in this section.

The next section features considerations and lessons learned from agencies who have integrated interoperable communications platforms into their TIM. This involved interviewing TIM managers and practitioners who have been involved in the integration and maintenance of interoperable communication platforms in their organizations. The key considerations and lessons learned by these agencies are documented in this section.

Finally, recommendations are made for the integration of an interoperable platform that allows the sharing of voice, text, data, pictures, and videos to enhance TIM. Other recommendations relate to improving TIM communications, reorganizing and strengthening TIM, integrating law enforcement CAD into TMC systems, increasing TMCs, increasing MAP coverage, and improving funding for TIM.

Literature Review

Traffic Incidents

Traffic incidents are one of the major causes of congestion in urban areas. The effects of congestion have risen steadily in recent decades due to population growth. These effects impact economic productivity and increase pollution [1]. Due to the relationship between traffic incidents and congestion, there have been continuous efforts to manage incidents by enacting efficient response strategies. A traffic incident is defined as "any non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand." Such events include traffic crashes, disabled vehicles, spilled cargo, highway maintenance and reconstruction projects, and special non-emergency events [2]. In addition to travel delays and pollution, the risks faced by response personnel serving the public at an incident scene are considered one of the most serious issues associated with highway incidents [3].

Secondary crashes are also a particularly concerning aspect of traffic incidents. The risk of secondary crashes increases more than six times after the occurrence of primary crashes [4]. Secondary crashes alone are estimated to account for 20% of all crashes and 18% of all fatalities on freeways [5]. The risk of secondary crashes is directly related to incident duration time. Longer incident duration leads to a higher probability of secondary crashes; each minute of additional incident duration increases the probability of a secondary crash by 1.2% [6].

Travel delays resulting from incidents are another concern of Traffic Incident Management (TIM), as they impact many people. These delays result in multiple negative impacts, including increased response time by police, fire, and emergency medical services. Moreover, delays also increase the cost of goods and services, increase fuel consumption, reduce air quality, and have other adverse environmental impacts. Additionally, traffic incidents increase vehicle maintenance costs, reduce quality of life, and escalate the negative image of public agencies involved in incident management activities [7] . According to the National Traffic Incident Management Coalition (NTIMC), non-recurring traffic incidents cause 25% of all traffic congestion in the United States [8]. During traffic congestion, each minute that an interstate lane remains blocked results in a four-minute travel delay [9].

Traffic Incident Management

Traffic incidents have significant economic, social, and environmental impacts. TIM has been found to effectively mitigate those effects by reducing detection and verification time, implementing the appropriate response, and investigating and safely clearing an incident while managing the affected traffic through and around the scene until full capacity is restored [10]. TIM is "a planned and coordinated process to detect, respond to, and remove traffic incidents and restore traffic capacity as safely and quickly as possible" [2].

Overview of TIM

U.S. DOT's National TIM Coalition (NTIMC) provides guidance and resources to improve TIM nationwide. According to the NTIMC, the TIM process includes four phases: detection, verification, response, and clearance [11] [12].

The first and most important step in the TIM process is the detection phase. Incident detection is the process by which an incident is initially identified by the agencies involved in incident management. Approaches used to detect traffic incidents include mobile telephone calls from motorists, CCTV cameras, automatic vehicle identification (AVI) combined with detection software, police patrols, aerial surveillance, and sensors installed on roads [13].

The second step in the TIM process is incident verification. The precise location and nature of the incident are determined during incident verification. Accurate and detailed information about the incident can ensure that the appropriate personnel and resources are dispatched to the scene. Approaches used to verify traffic incidents include field verification by on-site responders, CCTVs viewed by operators, and the combination of information from multiple cellular phone calls [14].

There are several challenges to effective incident detection and verification. One such challenge is inconsistent notification of incident responders [15]. When there is a lack of 24 hour operations or active involvement in TIM, the notification of incidents to support responders, such as transportation agencies, can be inconsistent. Typically, public safety agencies such as law enforcement, fire and rescue, and emergency medical services (EMS) are the first to be notified via 911 dispatch. Inaccurate incident reports are another issue that affects incident detection and verification. Motorists with cellular phones are frequently the first to detect and report incidents. Motorists may not provide accurate location information and may exaggerate the severity of the incident. Motorists may confuse directional information by using landmarks to describe the incident location rather than roadway identifiers. As a result, response resources that are unnecessary, inadequate, or insufficient may be dispatched to the incident scene [12]. Responders also face the challenge of dispatch overload in the detection and verification of incidents [3]. Typically, after a major incident, dispatchers receive multiple calls from motorists reporting the incident. Multiple calls can overwhelm dispatchers and divert their attention from other emergencies [12]. Another challenge is slow detection. Higher traffic volumes in urban areas and the prevalence of cellular telephone users in the traffic stream result in rapid and reliable incident detection. However, incidents may go undetected for some time in non-urban or remote areas where passing vehicles are less frequent [2]. Early detection aids in providing prompt medical attention and reducing secondary incidents.

The third step in the TIM process is incident response. Incident response is the activation of a planned strategy for the safe and rapid deployment of the appropriate personnel and resources to the incident scene [12]. Information management is important in incident response, as providing the right information to the responsible individual is critical to getting the right response. Accurate information about an incident, such as its location, traffic impacts, vehicle types involved, the presence of an injury or fatality, and other special conditions (e.g., the presence of hazardous material), is critical in determining the appropriate response [3]. An on-scene responder or a dispatcher at the communication or Traffic Management Center (TMC) typically determines the level of required response [14]. Some of the resources used in incident response are Computer-Aided Dispatch (CAD), towing and recovery vehicles, rescue unit and ambulances, major incident response teams, and HAZMAT response units [13].

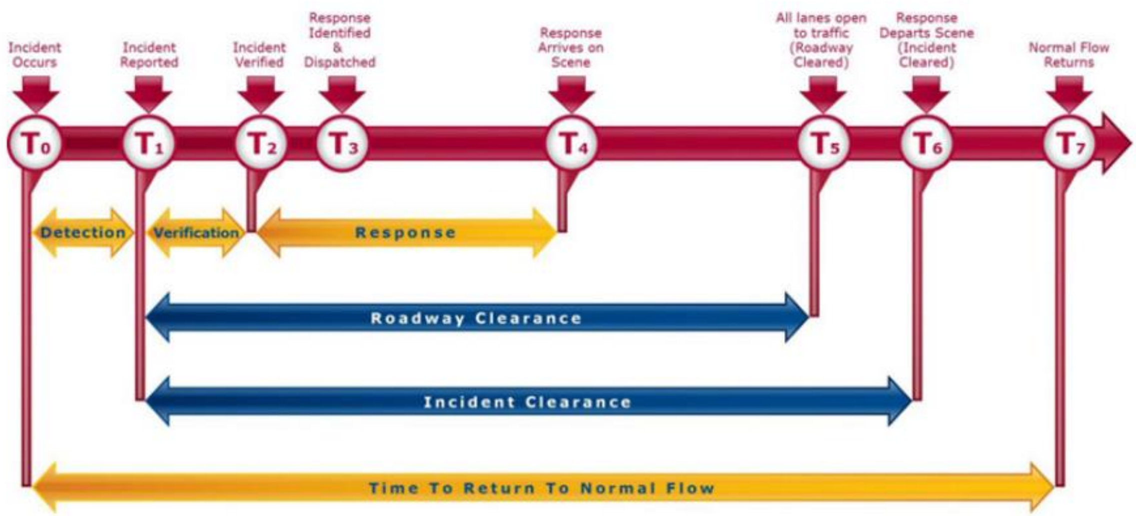
A common challenge related to incident response is achieving optimum response. Under-response and over-response are two such issues. Under-response occurs when insufficient or inappropriate resources are dispatched, resulting in delays and longer response times. Over-response, however, includes sending excessive resources, resulting in congestion and decreased efficiency. Both improving verification techniques and increasing responder awareness of each agency's needs and capabilities are required to achieve optimum response [12].

Another difficulty responders face in incident response is gaining access to the incident scene. The primary cause of the incident responder’s limited access is traffic congestion and roadway design [2]. Amber-colored flashing lights have little effect on traffic movement. Wide roadway shoulders were once used to facilitate emergency access, but they are now frequently used as general-purpose or special-use lanes in urban areas to relieve traffic congestion [12].

Incident clearance is the fourth and final step in the TIM process. It involves removing wreckage, debris, or any other element that disrupts normal traffic flow or forces lane closures and restoring roadway capacity to pre-incident levels [13].

The TIM timeline, shown in Figure 1, identifies the chronology of a traffic incident from the point at which an incident occurs to the point at which traffic conditions return to normal. Major milestones are T0 (i.e., the time an incident occurs) through T7 (i.e., the time traffic conditions return to normal). The goal of TIM is to shorten the duration between T0 and T6 [16] [17].

Figure 1. Timeline of traffic incident elements [18]



TIM Goals and Benefits

The primary goal of TIM is to reduce the impact of traffic incidents and the risk of secondary incidents by quickly clearing incidents. TIM has several objectives, which include reducing detection, verification, and response times, and ensuring proper and safe on-scene personnel and equipment management while keeping as many traffic lanes open as possible. In addition to reducing clearance time, it is also critical to provide timely and accurate information to the public so that they can make informed decisions, such as revising travel plans and taking alternate routes [19] [20].

The NTIMC created the National Unified Goal (NUG) for TIM, which includes [21] :

- Responder safety

- Safe, quick clearance
- Prompt, reliable, interoperable communications

To achieve these overarching goals, NTIMC identified and executed 18 strategies. The strategies are related to recommended practices for multidisciplinary TIM operations and communications, multidisciplinary TIM training, goals for performance and progress, and promotion of beneficial technologies. A discussion of several key elements is provided in the "TIM Strategic Program Elements" section of this report.

Benefits of TIM

When applied efficiently, TIM plays a significant role in economic growth and yields benefits to the transportation system. Traffic incidents have a significant impact on highways, as they result in loss of life, injuries, and property destruction. Traffic incidents also cause costly delays, air pollution, and fuel waste. TIM can be one of the most effective tools for mitigating incident impacts [22]. The benefits of TIM include:

Reduced Traffic Congestion. One key benefit of a TIM program is a reduction in traffic congestion by reducing incident clearance time. Traffic incidents cause 25% of all traffic congestion in the United States [8]. During traffic congestion, each minute that an interstate lane remains blocked results in a four-minute travel delay [9]. TIM has been found to be effective in reducing traffic in Virginia, Washington, and Texas [23] [24] [25]. For example, Maryland's Coordinated Highways Action Response Team (CHART), a comprehensive incident management program that includes motorist assistance patrols, successfully reduced the average incident duration by 23% in 2005 [26].

Economic Savings. TIM programs improve the economic savings of both national and regional economies by reducing travel delays, fuel consumption, emissions, and secondary accidents. TIM programs in Texas, Minnesota, and Maryland have been found to improve the economy by reducing travel delays [27] [28]. In 2005, the total direct benefits to highway users due to travel delay reductions alone from Maryland's CHART program was estimated to be $578 million [29].

Energy Conservation and Environmental Benefits. Shorter incident durations result in a reduction in fuel consumption, costs, and emissions, which leads to energy conservation and environmental benefits. South Carolina and Florida have found TIM effective in energy conservation [30] [31]. In 2005, the Road Ranger program in Florida was estimated to save 1.7 million gallons of fuel per month, worth $3.4 million [31].

Improved Safety and Public Health. Approximately 43,000 Americans die in traffic incidents annually. An effective TIM program improves roadway safety and reduces crashes. A 35% and 30% reduction in primary and secondary crashes, respectively, were estimated in a before-and-after analysis of the San Antonio TransGuide TIM System [32]. In 2005, the Maryland's CHART program resulted in an estimated 290 fewer secondary incidents [26]. In Atlanta, the time between verification and lane clearance was reduced from 6.25 hours to 1.5 hours after the implementation of a TIM program, resulting in a reduction of 2 million vehicle hours of delay annually [33].

Reduced Mortality. Faster detection and response to highway incidents can save lives. The probability of crash survival depends on the incident response time, including the time the victims receive medical attention on the scene and at the hospital. Arrival at the hospital within the "golden hour" after a crash is thought to be a strong predictor of patient outcomes for seriously injured patients [34].

Increased Responder Safety. Effective TIM implementation also improves responder safety. The safety of emergency responders, including safety service patrols (SSPs), fire, law enforcement, EMS, and others, is of serious concern. According to estimates from the Emergency Responder Safety Institute (ERSI), 155 emergency responders died between 2019 and 2021, with 27 already killed before the end of June 2022. Aside from Line of Duty Death crashes, several roadside emergency responders have been involved in struck-by or near-miss events while on duty [35] [36]. A 2001 report indicated that approximately 26 firefighters were struck and killed between 1990 and 1999 [37].

Increased Customer Satisfaction. TIM improves public satisfaction with government services. SSPs are quite popular among travelers. Tennessee reported that 99.9% of 1,572 feedback cards received about their HELP service patrol in 1995 were rated "excellent" [38]. SSPs in Florida, Texas, and Louisiana are also viewed favorably by the public.

TIM Strategic Program Elements

TIM Strategic program elements establish a structure for TIM activities and provide specific guidance on multiagency TIM teams. Pre-incident planning and training are important factors to consider in preparation for responding to traffic incidents. To safely and quickly clear an incident, it is necessary to apply the principles of effective incident management. To achieve effective incident response, all of the agencies involved in traffic incidents must operate within a common command system framework [39].

National Incident Management Systems (NIMS). The formalization of TIM program elements was established through NIMS. With the backing of a Presidential Directive, NIMS was formed in 2004 by the U.S. Department of Homeland Security (DHS) [40]. In March 2004, DHS issued the NIMS as a comprehensive framework for managing incidents applicable to all levels of jurisdictions [41]. NIMS provides a standardized approach across the nation, enabling efficient and effective collaboration among federal, state, tribal, and local governments. This collaboration is essential in preparing for, preventing, responding to, and recovering from domestic incidents, regardless of their scale, cause, or complexity [42].

NIMS frameworks align the TIM program into three broad categories that correspond to the NIMS concepts of preparedness, resource management, and communications and information management [2] [43] [44]:

- Strategic: Focused on planning, preparing, and performance measurement.
- Tactical: Focused on the effective execution of the plan and efficient utilization of available resources.
- Support: Involve the use of tools and technologies for the management and communication of information.

National Traffic Incident Management Coalition (NTIMC). The NTIMC was established in 2004 to create a forum for sharing information and coordinating TIM strategies between public safety and the transportation community at the national level [5] [45]. The primary aim of NTIMC is to enhance incident management policies, procedures, and practices through the creation of a multidisciplinary coalition at the national level. To achieve this aim, NTIMC formulated a National Unified Goal (NUG) [43] [46]. As noted previously, the three objectives of the NUG are responder safety, safe and rapid clearance, and prompt, reliable, interoperable communications. These objectives are achieved through 18 strategies [20] [21]. Key strategies include [21]:

- **Multidisciplinary Communications Practices and Procedures.** For effective and coordinated TIM, multidisciplinary communications practices and procedures are necessary. Such communications allow for effective coordination among multiple agencies involved in TIM, promote timely incident response, and ensure responder and public safety at the incident scene. Standardized multidisciplinary traffic incident communication practices and procedures should be developed and implemented by traffic incident responders.

- **Prompt, Reliable Responder Notification.** Prompt and reliable responder notification plays an important role in TIM. Rapid notification to incident responders can aid in the quick mobilization of responders and resources to incident scenes, which will result in a reduction in response time. Shorter response times lead to a reduction in congestion and secondary crashes.

- **Interoperable Voice and Data Networks.** Interoperable voice and data networks provide seamless communication across numerous agencies and responders from various jurisdictions, facilitating a rapid response to incidents. Stakeholders in TIM at the state, regional, and local levels should collaborate to develop interoperable voice and data networks.

- **Broadband Emergency Communications Systems.** Broadband emergency communications systems enable rapid and accurate information sharing. National Traffic Incident Management stakeholders should collaborate to reduce the barriers to the development and integration of both wired and wireless broadband emergency communications systems.

- **Prompt, Reliable Traveler Information Systems.** For efficient TIM, it is essential to have a prompt and reliable traveler information system. Such communication allows drivers to make informed decisions by providing them with real-time updates related to traffic incidents, roadway conditions, and alternative routes.

- **Partnerships with News Media and Information Providers.** Partnerships with news media and other information providers facilitate the rapid and extensive dissemination of incident information to the public, improving public safety and awareness.

TIM Stakeholders

TIM requires the coordination and collaboration of various stakeholders to effectively respond to and manage traffic incidents. This coordinated process involves a number of public and private sector stakeholders, including [20]:

- Law Enforcement

- Fire and Rescue

- Emergency Medical Services
- Public Safety Communications
- Transportation Agencies
- Safety Service Patrols
- Towing and Recovery
- Hazardous Materials Contractors
- Traffic Information Media

Law Enforcement. Law enforcement agencies are most often the first responders who arrive at incident scenes [2]. After assessing the incident scene, an officer may request additional resources such as fire, emergency medical service (EMS), towing and recovery, and others as needed [3]. The primary concern of law enforcement officers is to ensure quick clearance of the incident, thereby securing the safety of responders and motorists at the scene. Law enforcement officiers are usually the incident commander at scenes, directing response efforts. Furthermore, law enforcement officers are responsible for investigating incident scenes and collecting evidence [20].

Fire and Rescue. Fire and rescue services are delivered by county and municipal fire departments, as well as through mutual aid agreements with neighboring fire departments [47]. Typical duties of the fire department include protection of incident scenes, extinguishing fires, rescuing victims, and providing emergency medical care. Additionally, their duties include coordinating transportation for the injured and providing assistance in clearing the incident site [43].

Emergency Medical Services (EMS). EMS agencies are responsible for assessing, treating, and transporting crash victims [2]. In many areas, fire and rescue companies also handle EMS. Typical roles and responsibilities of EMS in traffic incidents include delivering advanced emergency medical care, determining destination and transportation requirements for the injured, and coordinating evacuation with fire, police, and ambulance or airlift. Additionally, EMS personnel serve as incident commanders for medical emergencies, determining the approximate cause of injuries for the trauma center and removing medical waste from the incident scene [47].

Public Safety Communications. Dispatchers from response agencies are usually the first to know an incident has occurred. Dispatchers are required to convey the necessary information to the right agencies and field personnel quickly, accurately, and completely to get the right personnel and equipment to the incident in a timely manner [20]. Dispatchers record information into a CAD system, if available, making the incident visible to other agencies. In some areas, dispatchers from different stakeholder agencies may be located in one joint center with call takers sending calls to the appropriate agency dispatch.

Transportation Agencies. Transportation agencies are typically responsible for restoring the flow of traffic as quickly and safely as possible following an incident [47]. The roles and responsibilities of transportation agencies include assisting in incident detection and verification, initiating traffic management strategies for incident-impacted facilities, protecting the incident scene, and initiating emergency medical assistance until help arrives. Transportation agencies also undertake traffic control, assisting motorists with disabled vehicles, providing motorist information, and providing special equipment for clearing incident scenes. Some transportation agencies fulfill their tasks using SSPs. Furthermore, transportation agencies determine incident clearance and roadway repair needs, establish and operate alternate routes, and coordinate clearance and repair resources [43].

Safety Service Patrols (SSPs). SSPs are responsible for keeping incident scenes safe, clearing incidents more quickly, and assisting police, fire, and EMS personnel at incident scenes [48]. Major roles and responsibilities include checking for injuries, identifying and calling for required Emergency Services, administering first aid until EMS arrives, relocating disabled vehicles to a safer location when possible, assisting with the exchange of information when appropriate, and returning traffic to its normal flow as safely and quickly as possible [49].

Towing and Recovery. The safe and effective removal of damaged or disabled vehicles, as well as debris from the accident scene, is the responsibility of towing and recovery service providers [3]. Their typical responsibilities include the recovery and removal of vehicles from the incident scene, protecting the victim’s vehicle and property, clearing roadside debris, and performing other services, such as traffic control, as directed or under contract [50].

Hazardous Materials Contractors. Hazardous materials contractors are hired by emergency or transportation authorities to clean up and dispose of toxic or hazardous materials involved in traffic incidents [47].

Traffic Information Media. The responsibilities of media related to incident management include reporting traffic incidents, providing information on alternative routes, broadcasting delay information, constantly updating incident status, and offering video or photography services [3] [47].

Coordinated, Interoperable Communications

Communication forms a critical part of TIM and includes the exchange of information both on- and off-scene, as well as within and between participating agencies [12]. Critical communication links include an agency's dispatch with responders in the field, between responders from different agencies in the field, and between dispatchers from different agencies. Clear, accurate communication and the timely sharing of information among responders aids in the allocation of adequate resources to incident scenes, resulting in rapid incident clearance.

Clear and effective communications are important for responders to work together seamlessly, regardless of their agency or jurisdiction. This can ensure that all responders work toward a common goal and that their efforts are not duplicated or wasted. Communication challenges, such as limited en-route and on-scene communication, inefficient communication (i.e., relaying messages through multiple dispatchers), and non-standardized communication protocols (including the use of codes), as well as equipment and system-related failures, can compromise response operations.

During incident response, it is important for dispatchers and responders to communicate within and across agencies, coordinate, and work well together. This is called interoperability. Interoperable communications are defined by the Aviation Safety Communiqué (SAFECOM) of the DHS as "the ability of public safety agencies to talk across disciplines and jurisdictions via radio communications systems, exchanging voice and/or data with one another on demand, in real-time, when needed, and as authorized" [51]. Interoperable communications can also be defined as the effective use of communications to enable agencies to work together toward common ends [52]. With interoperability, technical emergency communication systems should interface with national standards and permit data sharing throughout incident response among all key participants (e.g., police, fire, EMS, DOT, and other emergency responders).

As previously noted, the primary value of interoperability in TIM is that it provides an effective and seamless exchange of information among different response agencies. This means that important information known or collected by an agency during a response is immediately accessible to the other agencies involved. This improves on-scene operations and enhances coordination, resulting in better incident management [3]. Additionally, coordinated and interoperable communications improve situational awareness. Responders can gain a comprehensive understanding of incidents and their impact on traffic flow and safety by sharing information promptly and accurately, allowing them to make informed decisions and take appropriate actions. Interoperable communication also enables responders to share information about their resources and capabilities, which can ensure that resources are deployed efficiently [53].

Other benefits of interoperable communications, according to the FHWA and U.S. DOT, include an improvement in overall incident response, reduced clearance time, and reduced risk of secondary crashes [17] [30]. Furthermore, the increased awareness of incidents, including their location and severity, aids in the allocation of resources for optimum responses to incident scenes. Additionally, prompt incident information enables timely notifications on traveler information systems, alerting motorists to incidents or lane closures on their routes.

Challenges of Achieving Coordinated and Interoperable Communications

Achieving coordinated and interoperable communications among response agencies can be challenging. One of the primary challenges is the complexity of the incident response environment, which involves multiple agencies and responders that may use different communication systems and protocols [17] [54]. Different agencies may use different radio frequencies, technologies, and communication protocols, which can create barriers to effective communication and coordination [2]. Additionally, communication infrastructure may be damaged or overloaded during incidents, making establishing and maintaining communication difficult [55]. Another challenge is the need for training and standard operating procedures to ensure all stakeholders can use the communication systems effectively and understand the communication protocols [53].

FHWA, state DOTs, and the U.S. DOT have identified several challenges faced by TIM in achieving coordinated and interoperable communication among response agencies. One such challenge is inadequate planning during system development. Many jurisdictions upgrading their communication systems must consider that their choice may impact the ability to interoperate with other emergency response agencies [51]. Non-integrated proprietary systems are another issue in preventing interoperability. Many response agencies developed their communication system to fulfill their internal communication requirements and are not able to integrate them with the communication systems of other emergency response agencies [12].

Yet another challenge identified is funding constraints. The replacement of outdated emergency communication systems that do not support modern interoperability technologies is costly, and funding constraints for upgrades can be a major hurdle in achieving interoperability in communication [2] [51]. Response agencies also face the challenge of system incompatibility, which prevents interoperability in communication [3]. Communication barriers between different agencies and responders are the most common challenge. Effective communication requires a shared understanding of communication protocols and a willingness to collaborate across agencies and jurisdictions [12] [46].

Best Practices for Coordinated, Interoperable Communications

The SAFECOM program of DHS defines five critical elements of interoperability success: governance, standard operating procedures, technology, training and exercises, and usage [56]. The establishment of a strong governance structure is the first step in achieving real-time communication and information exchange [57]. A common governance structure improves communications, coordination, and cooperation across regions and disciplines, which are critical for achieving an acceptable level of communications interoperability [51]. Another factor found to be important is standard operating procedures (SOPs). Clear and effective SOPs are essential in the development and deployment of any interoperable communications solution [58].

Technology is also needed when it is crucial to integrate interoperable communication in TIM. Additional technology elements to consider when improving communications and interoperability include carrying out an inventory to identify user needs, evaluating the findings, and identifying vulnerable targets. Additionally, technology may aid in coordinating new partnerships to maximize existing infrastructure and resources while continuing planning efforts to ensure operability and system replacement [2] [56].

Effective training and exercise programs to practice communications interoperability are critical to ensure that technology works and responders can communicate effectively during emergencies [51]. Usage is another important factor for coordinated interoperable communications. Usage refers to the frequency of use of interoperable communications technologies. The development and interaction of the other four elements in the interoperability continuum area are necessary for this element to succeed [56].

Objective

This project's objective was to improve incident response through coordinated, interoperable communications in Louisiana. The specific project objectives were to:

1. Conduct an operational needs assessment and a performance evaluation of the TIM system in Louisiana.
2. Identify areas for TIM improvement and interoperability as a solution to communication gaps.
3. Provide recommendations for TIM improvement and strategies to advance interoperable communication for incident response.

Scope

This study focused on improving incident response through interoperable communications. An extensive assessment was carried out on Louisiana's TIM with a focus on interoperable communications; the scope of this evaluation was limited to TIM on Louisiana's interstates. Gaps were identified based on this assessment, and recommendations were made to improve TIM in the state through interoperable communications and other major measures.

Methodology

The focus of this research project was to conduct an operational needs assessment and performance evaluation of the TIM system in Louisiana, as well as identify areas for TIM improvement using interoperability as a solution to communication and TIM gaps. The research tasks to accomplish the project objectives are discussed below.

The first task performed was an extensive information review to better understand TIM in Louisiana and other jurisdictions. This included identifying stakeholders and understanding their role in TIM, as well as identifying TIM technical standards and available TIM practices and technology in Louisiana and the U.S. In addition to a review of available literature, this task was accomplished through an observation of TMC communication and operations, interviews with technical staff from various response agencies, and a review of technical documents.

The second task involved an evaluation of the TIM system in Louisiana. Information gathered from the preceding task was used to understand the current technological, functional, and operational needs of TIM in Louisiana. Other parts of the TIM system evaluated included the extent of automation in incident response, the extent of interoperability, and available operating procedures in relation to national standards. Barriers to interoperability, data collection, and measurement of TIM performance were analyzed within this task.

For the third task, a performance evaluation was conducted based on performance measures identified by TIM managers in Louisiana. This task was designed to identify gaps in performance for TMCs and interstates and make recommendations for improvement.

The project team next completed a needs analysis for TIM and incident response communication by TIM stakeholder agencies. Information for this task was primarily obtained through interviews with individuals with technical knowledge about TIM and communications during incident response. Information about the available communication devices, use of data in TIM, the extent of interoperability, communication needs, and operational challenges were obtained from the interviews.

Following the needs assessment, the project team identified current interoperable platforms. The features, use, and capabilities of several commercially available platforms were identified. Special focus was given to understanding the applicability and use of these interoperable platforms in traffic incident response and management. Additionally, insights into the extent of use and limitations of these interoperable platforms were derived from the available user manuals, case studies, publications, and other relevant documents.

The project team next engaged with U.S. agencies that have successfully implemented interoperable communication platforms into their TIM systems. The goal of this task was to document the factors these agencies considered when planning and implementing interoperable communications. Institutional, financial, organizational, and technical challenges during the implementation of interoperable communications were identified within this task. In addition to identifying interoperable implementation challenges, the research team also sought to understand how agencies overcame those issues.

The final task of the research was making recommendations on improving TIM and implementing integrating interoperable communications in Louisiana's TIM based on the information gathered throughout the project. These recommendations were based on information obtained from the evaluation and needs analysis of TIM in Louisiana, available interoperable communications platforms, and lessons learned from other states in implementing interoperable communications.

TIM Best Practices

TIM best practices refer to programs, plans, practices, and resources that support TIM in fulfilling its goal of safe, quick clearance of traffic incident scenes. Through a search of the literature and publicly available documents, several best practices of TIM were identified. Though the basic functions of a TIM program have been defined by groups such as the NTIMC, there is no universal agreement regarding what constitutes a comprehensive TIM program. However, effective TIM programs in multiple jurisdictions have several common elements that are identified in this section. This task was performed to identify and summarize the basic features of TIM programs in different jurisdictions. These practices cover various aspects of TIM, including TIM setup and organization within states, operating procedures, communication during incident response, and current technology utilization. This task evaluated Louisiana's TIM against these programs and practices in order to identify gaps and areas for potential improvement.

TIM Communications

Communication is an essential part of TIM because it allows for an efficient response to traffic incidents by facilitating coordination and an effective allocation of resources. Additionally, communication helps notify and provide updates to the public, thus enabling the reduction of incident impacts, such as congestion and secondary crashes. There has been a recent focus on communications interoperability in providing prompt and reliable communications. Interoperable communications permit the real-time exchange of information and aid in the coordination of response agencies. This section discusses TIM communication, the integration of CAD into TMC systems, and the co-location of response agencies.

Communication and Interoperability

TIM communications refer to the exchange of information both on- and off-scene, as well as within and between participating agencies [12]. Timely and effective communication among agencies can facilitate faster incident detection, verification, response, site management, traffic management, incident clearance, and recovery. Communication strategies include common mutual-aid channels, alternative communication devices, standardized communication technology and protocol, interagency communication, interoperable communication, and traveler information systems [20].

Mutual-aid channels refer to emergency radio systems that allow all personnel at an incident scene to communicate on a common frequency [12]. Designated frequencies can be programmed into radios for all agencies. Alternative communication devices, such as cellular phones, are used as backup methods for communication if primary methods have been disabled or are not functioning properly [59]. Standardized communication technology and protocol is required for compatibility across various communication devices.

The use of interoperable communications in TIM leads to quick incident response by improving the exchange of information and response coordination. By leveraging wireless and broadband technology, interoperable communications are used to improve communication capabilities among response agencies. These technologies allow for communication to occur across jurisdictions and disciplines [60]. Interoperable communication systems permit different communication devices from multiple agencies to interact seamlessly. Across the U.S., several jurisdictions are leveraging wireless networks to connect disparate voice, data, and video systems across various agencies and disciplines [61]. This approach has been found to be affordable compared with the conversion of all agencies to a common radio platform [62]. The use of interoperable communication leads to quick incident response through coordinated and effective communication.

Integration of Law Enforcement CAD with TMCs

CAD systems are primarily used to catalog and coordinate activities by public agencies, such as law enforcement. Information sharing may be done by integrating CAD with operating systems at TMCs. Law enforcement receives many calls through their 911 centers, with CAD automatically initiating data collection for the reported incident. More than half of state DOTs across the U.S. have access to real-time public CAD data that range from manual incident notifications to fully integrated data exchanges. There are several levels of data sharing from law enforcement to state DOTs, including manual notification (i.e., incident information provided over the phone), view-only access (i.e., TMC operators viewing the CAD data feed), required data verification, and automated data transfer (i.e., CAD data being automatically transferred to TMC systems) [63]. Overall, the integration of CAD into TMC operating systems results in reduced coordination time and distraction for responders, reduced time to notify agencies, and an increase in responder safety during incident response. In addition to improving situational awareness, sharing this resource aids in updating traveler information systems as incident response progresses. The integration of CAD with TMC systems has been reported to result in a 34% and 38% reduction in incident clearance time in Maryland and Oregon, respectively [64].

Co-location of Response Agencies

Co-location refers to the placement of response agencies' teams and equipment at a shared location. Co-location facilitates real-time communication and data sharing among personnel from different agencies, thereby enhancing efficient decision-making and resource utilization [65]. Co-location provides opportunities for responders to communicate face-to-face while cooperatively managing incidents. By working together in a shared space, co-location also helps build positive relationships and trust among personnel from various agencies. This aids in decision-making, which is necessary to expedite the response to traffic incidents. Co-location is a strategy that has been adopted by agencies in Texas, Minnesota, Utah, and Washington, among many others.

TIM Organization

The key to an effective state TIM program is coordination among the various agencies that have a role to play. To this end, some states organize their TIM programs by assembling TIM committees across different jurisdictions. These jurisdictions may cover urbanized or regional areas. Formal TIM programs, interagency agreements, multiagency SOPs, and regular TIM meetings are all key aspects of effective TIM organization. The following section discusses several of these measures.

Formal TIM Program

A formal TIM program is important for improving efficiency in managing traffic incidents through coordinated efforts among the various agencies involved [65]. Key elements of a formal TIM program include legislative authorization, strategic goals, SOPs, dedicated staff, ongoing training, well-defined responsibilities, dedicated funding, and clear reporting channels [66]. Formal TIM programs are also characterized by structured multiagency collaboration, strategic planning, and the establishment of interagency agreements [59]. TIM programs also help organize TIM groups that may be regional into units that plan and respond to traffic incidents. Effective program coordination is achieved among agencies by clarifying roles, responsibilities, and policies, and is best achieved through multiagency strategic planning. A TIM program reinforces the goals and objectives of the personnel of participating agencies and provides opportunities for enhanced collaboration. Different jurisdictions across the U.S. have formal TIM programs, including Tennessee [67], Colorado [68], and Texas [69].

Interagency Agreements

Interagency agreements are formal agreements between response agencies that clearly define responder operations during incidents. These agreements are developed to facilitate efficient TIM operations by enabling cooperation among different response agencies [12]. The roles and responsibilities of different agencies regarding TIM are defined in the agreements. Additionally, interagency agreements are written to be clear to avoid misunderstandings, disagreements, delays, and inefficiencies in effectively resolving a traffic incident. These agreements include the sharing of data among agencies for timely incident response and the sharing of resources such as equipment and personnel to achieve an optimum response [12].

Multiagency Standard Operating Procedures (SOPs)

Multiagency SOPs are sets of guidelines and protocols designed for the coordinated response and management of traffic incidents involving multiple agencies [20]. Areas the SOPs address include the Incident Command System (ICS)/Unified Command, the roles and responsibilities of each participating agency, common terminologies, communication during incident response, and response procedures [65].

The number of on-scene agencies needed to manage an incident increases as the incident size and complexity increase. The ICS structure is required to efficiently coordinate between multiple responders from different agencies by clearly defining a command, improving interdisciplinary communication, and fully utilizing available resources [20]. SOPs also govern how agencies share information, implement TIM projects, and share resources.

Regional TIM Groups

Regional TIM groups, also called steering committees, enable TIM planning at regional levels. In addition to aiding in planning, regional TIM groups foster coordination among stakeholder agencies within the jurisdiction. The group may comprise law enforcement, fire, EMS, transportation agencies, and towing and recovery companies. TIM teams can provide incentives to build a coalition of key stakeholders to facilitate the implementation of effective TIM strategies regionally. Additionally, regional TIM teams foster the establishment of formal agreements, facilitate the identification of TIM champions in different agencies, and allow for the review of TIM regional programs. TIM groups can perform an oversight role to enforce the implementation of effective TIM strategies, such as the use of SOPs and regular TIM meetings.

TIM Meetings

Regular TIM meetings among stakeholder agencies are important for achieving established TIM goals and objectives by providing a forum to discuss challenges, response procedures, and resource needs for the successful execution of response plans [59]. TIM meetings aid in identifying areas for improvement and increase coordination among agencies by ensuring each agency knows its role and responsibility. Policy issues, roles and responsibilities, report reviews, and emerging trends can be discussed during TIM meetings. Additionally, the TIM meetings can promote regular joint training exercises and the development of working relationships to better understand each agency's roles and responsibilities. Furthermore, these meetings are important for improving the efficiency of incident response by facilitating post-incident debriefing, in which representatives of various agencies discuss what went well and what needs to be improved [12]. Regular TIM meetings also promote awareness among agencies about ongoing TIM-related activities and initiatives.

TIM Training

TIM training is a core of NTIMC NUG strategies. According to the National Highway Institute (NHI), TIM training provides first responders with an understanding of the requirements for safe, quick clearance of traffic incident scenes [70]. Additionally, training enforces the concept of prompt, reliable, and open communication, along with the safety of both motorists and responders. NHI instituted TIM responder training in 1998. This training is completed by hundreds of first responders each year, with the FHWA requiring states to provide reports of the number of personnel who have taken the training each year. Joint TIM training with stakeholder agencies also contributes to staff education and efficient operations, contributing to a safer environment for both working personnel and the public.

Response and Clearance Policies, Strategies, and Procedures

Several strategies, policies, and resources have been adopted to expedite scene clearance, improve safety, and maximize traffic flow around incident scenes. These processes are enhanced by utilizing a formal TIM structure, including the use of removal laws, SOPs, response plans, detection and verification strategies, TMCs, and SSPs. The following section discusses several strategies and resources adopted by different states for effective TIM response.

Laws and Regulations

Legislative measures, such as move-over or removal laws, are important for the safe and quick clearance of incidents. Moveover, laws enhance responder safety by requiring that drivers approaching an incident scene either change lanes when possible or reduce their speed [20]. This provides an additional buffer zone between responders and traffic. Some state laws require specific reductions. For example, Florida requires motorists to slow down by 20 mph on roadways where the speed limit is 25 mph or greater or slow down to 5 mph on roadways where the speed limit is lower than 25 mph [71]. Removal laws provide legal authority for incident responders to move vehicles or other obstructions from the traffic lane or shoulder if the vehicle is creating a hazard. The law enhances the safety of responders, reduces the risks of secondary incidents, and minimizes the disruption to traffic flow [59].

Traffic Management Centers (TMCs)

TMCs serve as the heart of effective TIM programs. TMCs are designed to monitor and manage traffic conditions within an area, and ITS tools are used to accomplish this task. In terms of TIM, TMCs serve as a critical source of information on incidents and provide ongoing updates on the incident response status to first responders. TMC operators detect, verify, and dispatch resources using a combination of ITS resources (e.g., CCTV, fiber optic cables, loop detectors) and advise motorists through DMS, HAR, social media, or the state 511 of current traffic conditions and alternative routes. Additionally, by utilizing these tools, TMCs improve access to incident scenes for first responders and enhance responder safety by being utilized for situational awareness. Importantly, these centers provide access to real-time data that enables decision-makers to take firm action to respond to incidents rapidly. TMCs also serve as repositories of data for analyzing performance metrics. Traffic management software captures data such as the arrival and departure times of first responders, incident location, incident severity, response duration, and agencies involved in response. Some TMCs, such as those in Florida, have also established center-to-center connections for interconnectivity [72]. To facilitate interagency communication, some TMCs are co-located with 911 operators from other agencies. Some centers have also developed real-time data-sharing capabilities, enabling videos and images to be transmitted to the device's first responders at the scene of an incident. TMCs in many jurisdictions are staffed on a 24 hour, 7 day per week basis with personnel primarily from transportation agencies but also from law enforcement and other emergency service agencies [2].

Safety Service Patrols (SSPs)

SSP programs support TIM goals by aiding in incident clearance, reducing traffic congestion by providing traffic control, and improving safety at incident scenes. In coordination with law enforcement and other first responders, SSP operators work to safely and quickly clear incidents and offer assistance to motorists. Critically, SSPs also detect and verify incidents. The locations and hours of SSP operations rely on traffic, operational and safety needs, time of day, and available resources. Most SSP programs are implemented within urban and surrounding areas. Operational coverage may include peak hours only, Monday through Friday for 16 hours a day, 24 hours per day and 7 days a week, or on call [73]. For example, Georgia DOT operates 24 hours per day and 7 days a week, while Florida DOT has a variable program across the state based on demand. SSPs programs have been instituted in over 40 states and are popular with the traveling public. These include Georgia (HERO), Florida (Road Ranger Service Patrol), and Tennessee (HELP), among many others.

Response Plans and Operating Procedures

TIM response plans and operating procedures generally aim to increase responder safety while decreasing response times to incidents. Standardizing plans and operating procedures present TIM teams with action plans and procedures. These may include incident management plans (e.g., alternative route plans, TMC operation guidelines, predefined contact lists of personnel and equipment resources, quick recovery teams, and equipment staging areas) [12]. An alternative route plan involves the establishment of predefined alternative routes after the identification of possible traffic disruptions. These could serve as routes for emergency vehicles or routes to mitigate traffic congestion during incident response. For example, Arizona's Statewide Incident Management Plan includes statewide alternate route plans and TMC TIM operations guidelines, which were developed in collaboration with legislative, transportation, law enforcement, and other response agencies [74]. A predefined contact list of personnel and equipment resources, including special equipment, that is contained within an incident management plan can mitigate the effects of a major incident by facilitating quick clearance of the roadway [59]. Such a list of contacts and resources also reduces issues with the indirect communication needed to request personnel and resources. Defined equipment staging areas along with pre-positioned and pre-stored materials close to locations that suffer from high incident rates is another strategy to reduce incident response time. These staging areas are defined in TIM response plans in states such as Tennessee and Wisconsin [12].

Major Incident Response Teams and Special Events Planning

Major incident response teams are highly specialized trained units comprised of personnel from various agencies, such as law enforcement, fire and rescue, and transportation authorities [20]. These teams complete special training and respond to major incidents together. They should be available 24 hours per day and 7 days per week [65]. Major Incident Response Teams improve the incident response through advanced preparedness. Response agencies also plan for special events, such as major sporting events, concerts, conventions, and weather-related events that impact local traffic [12]. TIM teams pre-plan for transportation management, medical response, and traffic incident response during these events.

The implementation of NIMS in March 2004 provides a formalized framework for the effective operation of major incident response teams. NIMS utilizes Incident Command System (ICS) principles, enabling responders from various agencies to work together during major incidents. This framework emphasizes incident management practices, standardized personnel training and certification, communications interoperability, and continuous performance evaluation to improve overall TIM operations [4]. Delaware, Pennsylvania, Wisconsin, Georgia, and Tennessee all have major incident response teams [75] [76] [77] [78].

Use of Advanced Technology

Integrating advanced technologies can improve TIM's efficiency in every aspect. The strategic use of these technologies can improve incident response by facilitating real-time monitoring of traffic conditions, quick detection and verification of an incident, and prompt and reliable notification of incident information to the incident responders and the public [20]. Some technologies include CCTVs, Automatic Vehicle Location (AVL), electronic loop detectors, DMS, CAD, broadband, traffic software, crash notification systems, traffic signal priority systems, and congestion detection systems.

CCTVs are used for the real-time monitoring of traffic conditions and verification of an incident. CCTV images of an incident help dispatchers mobilize the appropriate resources and personnel to the incident scene [65]. AVL and Geographic Information System (GIS) technologies track emergency vehicles in real-time and mobilize the nearest resources to the incident scene, reducing the overall response time. Electronic loop detectors are used for incident detection by monitoring traffic flow and vehicle speed. These detectors detect incidents by identifying changes in traffic flow patterns [12]. Broadband technology rapidly transfers data among responders, including transferring incident videos from CCTV, on-scene images, and audio. Broadband also aids in the rapid dissemination of incident-related information to the public. Additionally, Advanced Traffic Management Systems (ATMS), when integrated with other technologies, aids in the monitoring and management of traffic incidents. Traffic signal priority is also a strategy to reduce delays for emergency vehicles by prioritizing signals for them [65]. There is also current software that automatically notifies responders of incidents. The use of drones and cameras attached to patrol vehicles for incident response are other technologies gaining attention.

Performance Monitoring and TIM Self-Assessment

Information is collected to detect and verify incidents before a response begins. During the response, additional incident information is collected. This information from several incidents may be used for assessments of response, resources expenditures, and the overall TIM program. Additionally, the information may be shared with partner agencies to help them adequately provide effective traffic incident response. Importantly, regular information can help agencies perform self-assessments to continuously improve their TIM programs. The following section discusses performance monitoring and TIM self-assessment.

TIM Performance Measurement

According to the NTIMC NUG strategies, a systematic approach is needed to measure TIM performance [79]. The periodic assessment of TIM programs through performance measurement is such an approach and is used to evaluate the extent to which agencies are fulfilling their goals and responsibilities. The use of performance measurement also helps to continuously evaluate progress, identify limitations and areas for improvement, and justify TIM program continuation or expansion. Performance measures utilize specific metrics to evaluate the efficiency and effectiveness of a TIM program [65]. A scan of TIM programs across the U.S. indicates that incident clearance time, roadway clearance time, and number of secondary crashes are common performance metrics promoted by the FHWA and utilized by states [80]. The time taken to notify the public of an incident is also reported often. Incorporating such performance measures into long-range transportation plans can also help TIM programs receive funding.

The collected performance metrics should be shared with partner agencies, including law enforcement, to improve operational efficiency. This data sharing should include regular updates on performance metrics to enable a unified effort in achieving performance targets. Sharing data improves coordination and interagency integration and fosters success in improving overall TIM programs.

Self-Assessment

In 2002, the FHWA developed a method to measure TIM program performance and identify potential program gaps at the national level. This method, referred to as Traffic Incident Management Self-Assessment (TIMSA), is a self-assessment tool to periodically measure the achievements of TIM multiagency programs [2]. Through the TIMSA, progress can be assessed, and areas for improvement at both the state and local levels can be identified [3]. State and local TIM program managers are encouraged to utilize the TIMSA to evaluate their TIM programs and identify strengths and weaknesses. The assessment also helps the FHWA evaluate progress in TIM, as well as identify national TIM program initiatives [12]. Each year, the new assessment is compared against an established baseline from initial assessments in 2003 and 2004, as well as the previous year's evaluation. The FHWA conducts TIMSA annually and publishes the aggregated results from all urban areas in the annual TIMSA Analysis report.

Funding

Funding is required to maintain and sustain TIM programs at the state and local levels. The efficient management of TIM program resources not only involves the utilization of dedicated funds but also outreach to the decision-makers to ensure the effectiveness of TIM is recognized and prioritized within transportation budgets. The FHWA provides the largest funding for TIM under the Federal Aid program, in which funding is appropriated to various transportation categories (e.g., safety, congestion management, maintenance) [81]. This funding is distributed to states according to a predetermined funding formula. Individual states then decide how much funding should be dedicated to TIM. Other funding for transportation comes from local revenues, including fuel taxes, tolls, vehicle registration fees, and license plate fees, among others.

Given that there are several competing needs for limited funds from the FHWA and the state, it is important to dedicate funds specifically to TIM. Some agencies, such as the Illinois

Tollway and Washington State DOT, integrate TIM into maintenance or operations, so portions of funding for those activities can be dedicated to TIM [80]. Other states have special programs, such as the statewide Traffic Incident Management Enhancement (TIME) Program in Wisconsin, under which special funding is dedicated to support TIM operations [80]. The presence of a champion to extol the benefits of TIM and advocate for funding has been identified an effective approach to gain support for TIM programs [12].

TIM in Louisiana

TIM in Louisiana is discussed in this section based on information obtained from interviews with TIM personnel, a survey, and an observation of TIM operations. A list of the staff interviewed to better understand Louisiana's TIM can be found in Appendix A. Appendix B includes sample interview questions for the TMC and other TIM agencies, while Appendix C includes the survey questionnaire for TMC supervisors.

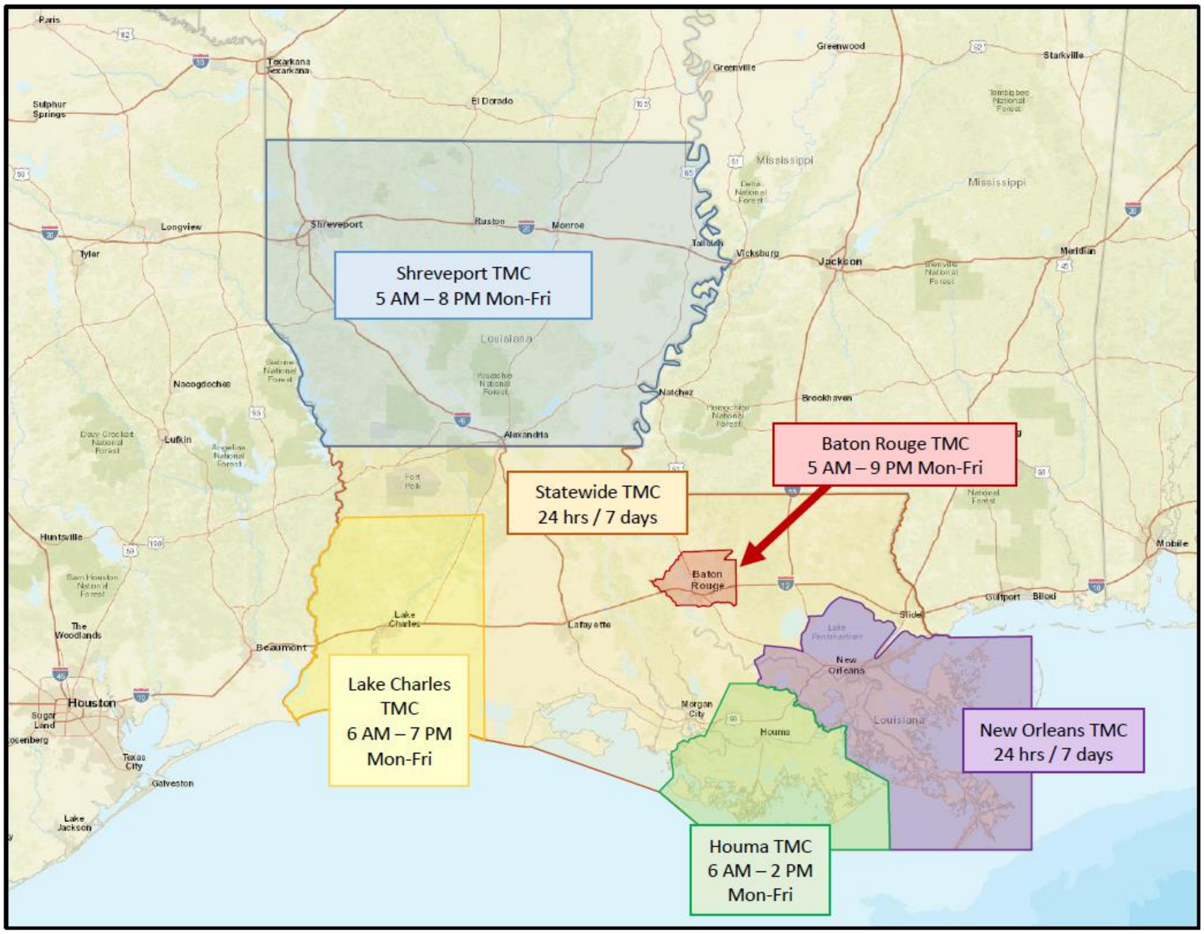
The Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) plays a significant role in emergency management in Louisiana. GOHSEP provides leadership and works with all emergency support and recovery agencies in the preparation, response, recovery, mitigation, and prevention of emergencies in the state. This is achieved by coordinating with parishes, municipalities, and state agencies to ensure adequate resources are provided to prevent or respond to emergencies. GOHSEP is guided by the principles of the National Response Framework (NRF) and draws its authority from the Louisiana Homeland Security and Emergency Assistance and Disaster Act. Emergency response, including TIM in Louisiana, follows the framework outlined by GOHSEP. The Louisiana Emergency Operations Plan (EOP) identifies state Emergency Support Functions (ESFs) to coordinate resources by area of function [82]. The EOP defines functional areas of disaster response and identifies the state agency responsible for that function. These functions relate to prevention, mitigation, preparedness, response, and recovery, encompassing all five phases of emergency management. The functions cover transportation, communications, firefighting, public works and engineering, emergency management, and search and rescue, among many others.

Louisiana's TIM goals are derived from the NUG, which seeks to ensure the safe and quick clearance of roadway incidents, prioritize responder safety, and encourage prompt and reliable interoperable communications [79]. In Louisiana, local authorities within a jurisdiction respond to traffic incidents. Local law enforcement, fire departments, EMS, and the highway authority form the core of the response team, which coordinates incident response. In larger urban areas of the state, TMCs and MAP usually contribute to the TIM effort. The response team is led by law enforcement, with fire, EMS, and other responders providing support to the effort.

The primary role of the TMC is to coordinate and monitor incident response. The TMC does not direct incident response operations but is a tool providing services to law enforcement and first responders in TIM. TMCs play an active role in detecting and verifying incidents, notifying other agencies, dispatching MAP personnel to the scene of the incident, and communicating with responders during incidents. TMCs also provide improved situational awareness during incident response by utilizing cameras installed along interstates to continuously monitor roadway conditions. There are currently six operational TMCs established across the state. These TMCs comprise a statewide center in Baton Rouge and five regional TMCs in Baton Rouge, New Orleans, Houma, Shreveport, and Lake Charles, as shown in Figure 2. These TMCs cover a combined length of 980 miles; Shreveport TMC covers the most interstate length (400 miles), while Houma TMC covers the least interstate length (38 miles). Other TMCs cover 210 miles (New Orleans), 79 miles (Lake Charles), 52 miles (Baton Rouge), and 201 miles (statewide) of interstate length. The statewide TMC can cover 946 miles if needed. The statewide and New Orleans TMCs operate 24 hours per day and 7 days per week, whereas the other TMCs have different operational hours. With access to cameras installed across the state, the statewide TMC takes over the functions of the regional TMCs when they are not operating. In instances where larger incidents are being managed, the statewide TMC assists regional TMCs by coordinating response efforts and aiding in the dispatch of additional resources. Figure 2 shows the location and operation times of the TMCs.

Apart from its role in TIM, TMCs also play a key role in disaster management. For example, the TMC aids DOTD's Emergency Management Operations during emergency evacuations by providing information related to route closures or road damage. This information is provided to the State Emergengy Operations Center, which subsequently informs Parish Operations Centers. MAP is Louisiana's SSP, providing motorist assistance and aiding TIM efforts during incident response. The TMC primarily communicates with MAP, providing directions and receiving status reports of the incident response. MAP is contacted directly by the TMC via radio and dispatched to the location of an incident using mile markers, intersections, and other geographic descriptions. MAP is typically the first to arrive at the scene of an incident, providing verification and requesting additional resources if needed. In case of a minor incident, such as a flat tire, the TMC will dispatch MAP to the incident scene without the need for police or other first responders. For major incidents, such as vehicle crashes, MAP personnel assist the first responders with lane closures, traffic control, and ensuring that the incident scene includes a secure corridor for first responders. MAP personnel also help in relocating crash vehicles to safer locations and provide first aid until the arrival of EMS so that other responders can focus on their core duties.

Figure 2. Operational areas of TMCs



Apart from incident response, MAP also assists motorists and improves traffic flow by providing free services (e.g., adding fuel, changing flat tires, performing jump starts) to stranded motorists in the Baton Rouge, New Orleans, Lake Charles, Shreveport-Bossier City, Alexandria, and Northshore areas, thereby reducing traffic congestion and improving safety on the state's highways. MAP is equipped with 66 trucks, two flatbed rollback wreckers, one long-term incident management trailer, and a 14-wheel lift wrecker [83].

Police departments respond to incidents when notified. Police are always present at scenes of crashes for safety, investigative, and insurance purposes. The police are usually the incident commanders and coordinate incident response. They direct other response agencies regarding medical assistance, traffic control, vehicle recoveries, requests for additional resources, and incident scene security. City police respond to traffic incidents occur along interstates within their respective jurisdictions. For example, within the City of Baton Rouge, the Baton Rouge

Police Department is responsible for TIM. This arrangement exists for towns outside incorporated areas where the Sheriff's Department or other law enforcement primarily responds to traffic incidents. On interstates outside incorporated areas, the State Police are responsible for TIM.

Apart from the TMC, MAP, and police, other stakeholders involved in Louisiana's TIM are fire, EMS, DOTD, private towing companies, and the coroner's office. Most parishes and municipalities deliver fire and medical services within their jurisdictions, as well as through mutual aid agreements with neighboring fire and EMS departments. The fire department's primary duties include securing incident scenes, extracting crash victims from vehicles, providing first aid, and extinguishing fires. EMS provides first aid, assessment, treatment, and transportation of crash victims to medical facilities.

DOTD oversees the TMCs and MAP for Louisiana's TIM program. The department provides the infrastructure, logistics, and personnel to successfully manage the TMCs and MAP. The department also receives notifications of incidents via email or phone calls, which are reported to MAP and the police for verification. DOTD's maintenance division is responsible for long-term lane closures and other tasks, including assessing and fixing road infrastructure damage. The department may also assist in the control of hazardous material spills by spreading sand over such materials.

The Emergency Operations Center (EOC) may be activated in emergencies to serve as a central operations center to acquire and coordinate resources during events such as natural disasters and severe weather events. The EOC is especially important in situations in which the resources required to respond to an incident exceed the capabilities of responding agencies.

MAP vehicles primarily tow immobilized vehicles off of the roadway to improve safety and traffic flow. These vehicles are towed to a safe location at the nearest exit. Vehicle owners may then engage private companies to tow the vehicles to a specified destination. Some vehicles, such as heavy vehicles, require specialized equipment. In such instances, towing companies with specialized equipment are called.

Key Performance Measures Used by Louisiana's TIM

Louisiana's TIM uses different performance measures to evaluate the performance of its operations. Key performance measures include MAP operator dispatch time, TMC event confirmation time, time to post messages to DMS, and notification time of TIM partners and agencies. Other measures considered are incident clearance and roadway clearance times, MAP on-scene time, and MAP roadway clearance time. Performance targets include event confirmation and dispatch times of less than a two minute monthly average. Additionally, the time to post messages to DMS and initiate a response plan is targeted at less than seven minutes based on a monthly average.

Other performance measures tracked are staff retention, adherence to TMC staffing minimums, TMC availability, and TMC operator complaints. Staff retention measures the total number of staff at the beginning of each month and is an indicator of staff turnover. TMC availability measures the number of working and non-working equipment at the TMCs. The TMC operator logs the number of complaints received and investigated for merit. These performance measures and metrics are shown in Table 1.

TIM Severity and Classifications

The severity of incidents is classified based on the number of blocked lanes. Incidents are classified as low, moderate, high, and closed. An incident that occurs on the shoulder or has been moved to the shoulder is classified as a low severity incident, which is common for stalled vehicles. In moderate severity incidents, one lane is blocked due to the incident. In situations where two or more lanes are closed, the incident is categorized as high severity. When all lanes are closed arising from an incident, the severity of that incident is classified as closed.

Table 1. Louisiana's TIM performance measures and targets

Performance Measure	Description	Performance Target
MAP Operator Dispatch Time After Detection	Measure the time it takes for a TMC Operator to dispatch MAP (T3) after an incident is verified (T1).	< 2 mins on a monthly average
TMC Event Confirmation	Measure the time it takes for TMC Operators to verify and respond to an incident through use of CCTV or detected by the TMC. Operators are expected to reject the alarm as invalid or acknowledge it and start the incident management process.	< 2 mins on a monthly average
Notify TIM Partners and Other Agencies	Measure the time taken for a TMC Operator to notify first responders and other TIM partners (911, police, fire, law enforcement, EMS, tow) after incident verification.	< 7 mins on a monthly average
DMS Preventative Messages	Count the number of preventative messages displayed on DMS as part of the safety and awareness campaigns.	2 campaigns on a monthly average, with the number of signs posted dependent on the number of DMS on the network
Incident Detection Sources	Measure the percentages of detection sources for ATMS incidents broken down by CCTV, MAP, and the like. Should also consider the analysis of the confidence in the detection source.	SSP and TMC: 85%.
Incident Detection (without CCTV available)	Measure time required for TMC Operators to verify and respond to an incident without the use of CCTV. Operators are expected to reject the alarm as invalid or acknowledge it and start the incident management process.	< 10 minutes on a monthly average

Performance Measure	Description	Performance Target
MAP On-Scene Time	Measure the time it takes MAP to arrive on-scene after being dispatched to an incident. Calculate the percent of time that time falls below a target threshold.	< 15 minutes
Roadway Clearance Time	Measure the total time between incident report (T1) and all travel lanes being opened (T5) for all incidents managed by ATMS. Break down by route, incident type, severity, day of week, and time of day. Incidents where no lanes were closed would not be included in this metric.	< 30 minutes
MAP Roadway Clearance Time	Measure the time between MAP arrival on scene (T4) and roadway clearance (T5).	< 15 minutes
Incident Clearance Time	Measure the total time between incident report (T1) and scene clearance (T6) for all incidents managed by ATMS . Break down by down by region, district, route, day of week, and time of day.	< 70 minutes
Roadway Clearance Time for Incident Type	Define type as disabled, congestion, debris, tunnel event, vehicle fire, and the like. Align data with the data iNet provides.	Not provided

TIM ITS Resources

The current ITS resources in Louisiana's TIM include CCTV cameras, DMS, Advanced ATMS software, and vehicle detectors located along the major roadways of Alexandria, Baton Rouge, Houma, Lafayette, Lake Charles, Monroe, New Orleans, Northshore, and Shreveport. There are 480 CCTV cameras, 110 DMS, and 11,501 vehicle detectors installed statewide.

Another TIM resource in Louisiana is 511la.org, which provides instant access to emergency information, safety information, and MAP services [84]. 511la.org includes both mobile and web-based applications and provides the public with real-time traveler information about crashes, congestion, warnings, lane closures, roadway event information, and videos from the CCTV cameras installed throughout the state. With a registered account, Louisiana's 511 also provides text messages or email notifications for daily commutes. Additionally, cameras can be saved onto a slideshow on the account, and residents can receive emergency notifications based on location.

At the TMCs, the ATMS performs several activities to log, manage, and store incidents. Importantly, the ATMS monitors and aids in incident response by utilizing ITS devices and traffic data throughout the state. The ATMS operates throughout the day year round and is integrated with over 450 CCTV cameras, more than 100 dynamic DMSs, and several vehicle detection devices connected via DOTD's fiber optic network and wireless and cellular technology. CCTV cameras integrated into the ATMS allow for the continuous monitoring of highways. These cameras are also integrated into the 511 system, which is open and accessible to the public. Notification of incidents can be done by utilizing cameras to observe locations with congestion. The cameras can also be used to verify incidents for onward communication to MAP units. It is DOTD policy not to keep video recordings of incidents, so video footage is only used for response purposes.

The ATMS is used by Louisiana's TMCs to manage and operate the highway transportation system. The TMCs currently use Parsons iNET™ ATMS integrated with ITS devices found in areas of TMC coverage. The ATMS comprises several modules, including a base, devices, ITS, and several external modules.

Incident logs are created in ATMS once an incident has been verified. The logs include notification, verification, and response times. Additionally, Incident Response Plans (IRPs) are created with traveler information, among other notifications and alerts, and are posted to Twitter/X automatically from the ATMS using the Advanced Traveler Information System (ATIS) function. The ATMS is able to display traveler information on DMS across the highway network. The ATMS can also customize multiple DMSs at the same time. Additionally, the ATMS serves as a data repository. However, its use for this purpose is challenged due to the storage capacity required to accommodate data, given its integration with crowdsourced and probe data.

Communications Interoperability in Louisiana

Louisiana has an emergency response communication system that enables seamless interoperability among first responders. This system comprises technical equipment and infrastructure, a governance structure, and interagency procedures for seamless communication. The Statewide Interoperable Executive Committee (SIEC) is the governing body that oversees interoperable emergency communications in Louisiana. The SIEC comprises representatives from all nine GOHSEP regions in Louisiana, five representatives from state agencies, and six representatives from local public safety agencies. The SIEC administers the state's communication network and addresses interoperability challenges in Louisiana [85]. The SIEC also facilitates new technology assessments and knowledge transfer, conducts cyclical gap analysis of the state's wireless network, and evaluates potential uses of LTE capabilities by state and local partners.

Louisiana relies on the Louisiana Wireless Information Network (LWIN) as the foundation for statewide interoperable communications among first responders. LWIN is an internet protocol (IP) network-based and trunked radio system that operates primarily in the 700 MHz and 800 MHz bands and can share voice and data. LWIN enables all public safety agencies to operate on a common communication platform. Also, LWIN supports user agency-defined talk groups, interoperable parish and regional talk groups, and statewide interoperability talk groups. In addition to this system, Louisiana has implemented cross-spectrum interoperability, allowing integration with existing legacy communication systems and non-LWIN systems by utilizing shared radios and other communication infrastructure [85].

Currently, LWIN supports 137 tower sites that provide reliable communications to over 98,000 users from 576 different agencies. LWIN supports 256 parish, 36 regional, and 14 dedicated statewide interoperability channels and talk groups, as well as 16 dedicated interstate mutual aid channels [85]. Additionally, LWIN is Project 25 (P25) compliant. P25 defines standards for a digital wireless radio communications system to be used by first responders. P25 consists of eight interfaces that allow the products of one manufacturer to interoperate with the products of other manufacturers by defining the signaling and messages that cross the interface [86]. This implies that an agency with P25 portable radios from one vendor, mobile radios from another, and base stations from other vendors would all be interoperated under P25 standards. LWIN cannot share pictures and videos. Participating agencies do not pay any fees to use LWIN but are required to have LWIN-compatible equipment. Agencies must meet specific qualifications to be authorized to access the LWIN.

In addition to LWIN, in 2017 Louisiana signed up for a specialized wireless broadband network for first responders known as First Responder Network Authority (FirstNet). This nationwide interoperable public safety broadband network allows first responders to leverage public safety broadband services to improve emergency response. While LWIN focuses on radio communication using dedicated frequencies, FirstNet addresses the need for seamless, dedicated data sharing, including high-speed video, location, document sharing, and applications during an emergency or disaster [87]. This capability may be used to improve interoperability by leveraging FirstNet's ability to share data. FirstNet operates using the dedicated band 14 spectrum, enabling coverage in all U.S. states, territories, and Washington, D.C.

The U.S. DOT is promoting a new 911 system known as the Next Generation 911 (NG911) system [88]. NG911 is a digital, internet protocol (IP)-based system that will replace the traditional 911 infrastructure [89]. NG911 significantly improves interoperability and data exchange among agencies by enabling the public to send videos, images, and texts to 911 centers, also referred to as Public Safety Answering Points (PSAPs). NG911 permits telecommunicators to share data with first responders and PSAPs.

One of the key features of NG911 is its ability to provide dispatchers with highly accurate caller locations even if callers are unaware of their exact location. It also enables responders to view a three-dimensional map showing the caller's exact location [90]. All of the data received from an NG911 call can be immediately transferred to first responders. Furthermore, NG911 improves the safety and situational awareness of first responders by providing them with real-time videos and images of incidents so that they can assess the severity of the incident and dispatch the required resources to the scene [91]. In NG911, all calls are answered even when there is a call overload, power outage, or natural disaster.

Interoperability is required for large events such as sporting events, whether planned or unplanned. Interoperable channels for a specific incident are important because regular communication channels become overburdened, and additional incidents cannot be reported. Apart from financial and technical challenges, there will be many legal obstacles to achieving that level of interoperability.

In case of a major incident, such as a hazardous spill or multi-crash event, a unified command is formed with representatives from each agency. One agency is considered the lead; this is typically whoever has jurisdiction over that incident. This unified command coordinates with other agencies to respond to incidents by collecting and disseminating information to all relevant parties. Once the lead agency determines the need to open an interoperable channel, they instruct all personnel involved to switch to that channel. Agencies involved in that emergency are required to switch to those designated channels. Although there is no limit on the number of people using the same channel, only one person can speak at a time. Additionally, those monitoring the interoperable channel for emergencies must monitor their regular communication channel. Radios can scan both interoperable and regular communication channels, allowing responders to listen to communication on both channels. However, if one wants to speak to any channel, they can switch to that channel. If one is listening to an interoperable channel and getting a call from the regular channel, one can switch to that channel and speak.

Louisiana's TIM Communications

Over the past several years, Louisiana has recognized that the advancement of internet protocol (IP)-based technologies provides opportunities to improve communications interoperability in the state. Therefore, the state is using this new technology to improve emergency response by enhancing governance, technology, and financing for communications interoperability [85]. In 2019, CISA provided 25 performance markers for states and territories to establish an initial picture of interoperability within their jurisdiction by assessing progress against those markers. These performance markers cover governance, technology, data, and cybersecurity, among many others. Louisiana completed the CISA assessment in August 2023, publishing the results in Louisiana's Statewide Communication Interoperability Plan [85]. The performance markers were rated as initial, defined, and optimized, correlating to early, intermediate and advanced stages of interoperability.

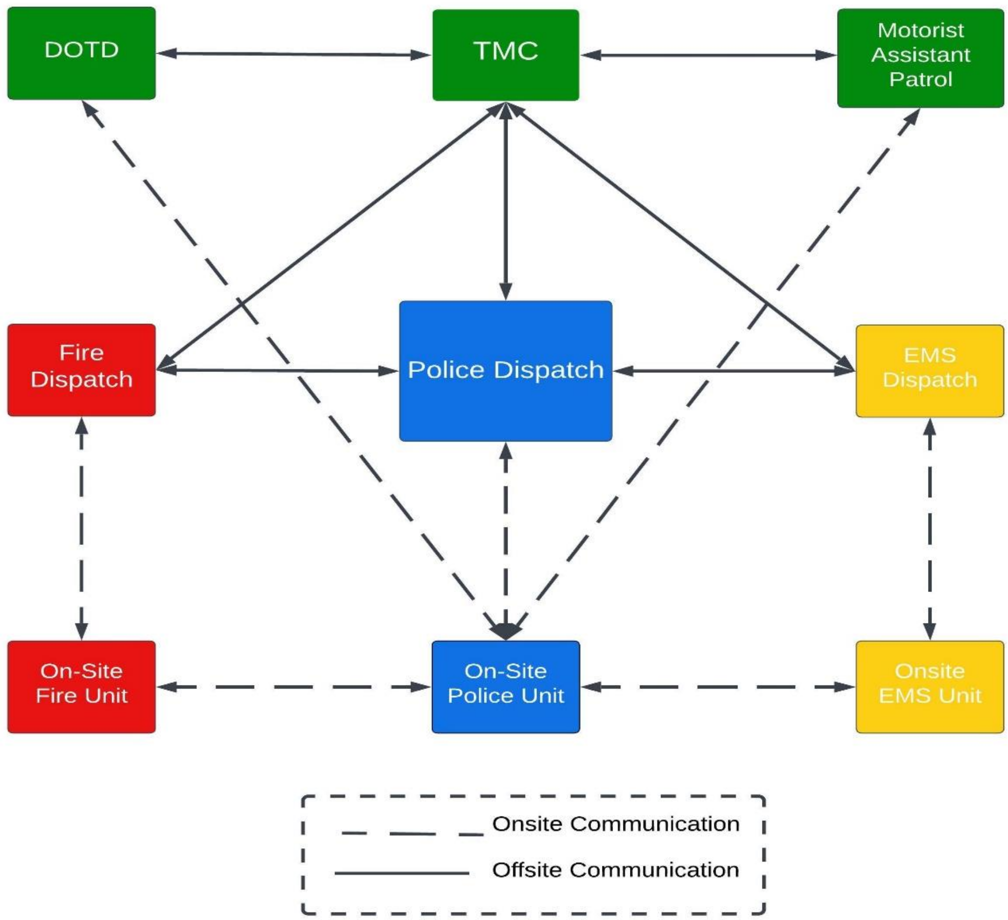
The following section details several important performance markers summarized from the assessment. In terms of implementing interagency communications policies, procedures and guidelines, Louisiana is assessed at an intermediate level where SOPs are established and used within the state. For radio programming, the state was assessed at an intermediate level, with between 50 and 75% of radios for first responders being programmed for interoperable communications. The state also provided an assessment for data interoperability, which relates to the ability of agencies to exchange data on demand using systems such CAD to CAD, chat, GIS, and Web EOC. The state was again rated intermediate, with limited data and information-sharing capability. Louisiana was assessed at an intermediate level with respect to incorporating emergency communications objectives into exercises, having a database listing trained communication unit personnel, and establishing capabilities to enable state-to-state emergency communications.

The state was assessed at an advanced level of performance in terms of updating tactical interoperable communications plans and field operation guides within the last two years. The same performance level was assessed for the sustenance of interoperability and risk identification for emergency communication systems. However, the assessment indicated an early rating for NG911 implementation in the state.

Communications for Incident Response

Figure 3 shows typical communications during incident response in Louisiana based on discussions with TIM stakeholders. When a 911 call is made to a PSAP about an incident, a dispatcher answers the call and sends information about the incident to first responders. The majority of calls regarding incident notification go to the police dispatch. The nearest police unit to the incident scene is dispatched to verify the incident with an event created in a police CAD detailing all relevant incident information. The TMC informs police dispatch if they are the first to detect an incident through its systems or via notifications from the public.

Figure 3. Communication among agencies during incident response



Incident information is also shared with the nearest MAP units, after which they are dispatched by the TMC. An event is created on ATMS and updated with the verification information provided by the MAP unit. MAP personnel sometimes communicate with the TMC using smartphones to share pictures and videos of the incident. An incident response plan (IRP) is also created and updated throughout the incident duration with information provided by MAP. Based on the incident verification, the incident commander may request additional resources. If the incident commander is a law enforcement officer, this request is routed through police dispatch, who communicates with the dispatcher of the requested agency. The agency then dispatches its responders and resources to the scene of the incident based on the information received. As shown in Figure 3, interagency communication for incident notification and detection usually occurs through dispatch. At the incident scene, face-to-face communication is the primary means of information exchange. The incident command directs the response, with on-scene responders updating their respective dispatch about the response as needed. This is the typical day-to-day communication during incident response.

It should be noted that one of the objectives of the NUG is prompt, reliable, interoperable communications. In some instances, information sharing through multiple dispatches, as shown in Figure 3, may lead to a loss in the details of the message being shared. Additionally, the use of multiple dispatchers may result in the delay of critical information being received for decisions to be made. For small incidents involving only a few agencies, the TIM communication setup shown in Figure 3 may work effectively. However, delays and loss of information could occur for large incidents involving multiple agencies. Although interoperable communication channels are used during response to large incidents, the reliance on multiple dispatchers could still result in delays and loss of information. Direct communication between supervisors with less reliance on dispatchers may enhance communication, especially for large incidents.

The TMC relies primarily on MAP to provide the incident response information used to update the traveling public about the conditions of roadways through traveler information systems, including DMS and social media. Communication between the TMC and on-scene responders from other agencies rarely occurs, as shown in Figure 3. This is because there is no policy that allows TMC personnel to directly speak to law enforcement or provide directives to first responders. TMC radio communication with first responders is limited due to the need to change frequencies. Also, regulations prohibit non-authorized personnel from listening to radio traffic where information about police operations and personally identifiable information may be shared. These restrictions mean that in areas where MAP does not operate, the TMC must rely on the dispatchers of other on-scene responders to update their IRP and traveler information systems. This sometimes creates delays, as the TMC operator has to call the dispatcher of the partner response agency with personnel on the scene. Some law enforcement officers interviewed indicated that they rarely speak directly to the TMC, though they suggested such direct communication may improve incident response. They also noted that speaking to the TMC involved calling a landline to overcome the absence of direct radio communication with the TMC. Operators at the TMC also indicated that given the responsibility of MAP during incident response, communication about the progress of the incident response is sometimes delayed when MAP personnel are involved in undertaking other critical duties. Again, such situations could result in delays in updating traveler information systems, leading to the public relying on outdated information to make decisions regarding travel. For co-located partner agencies, this type of delay is less significant, as the

TMC operator may have faster access to the information being shared. Law enforcement also has no radio communications with MAP. All radio communications with MAP are through the TMC, which may also rely on dispatchers from partner response agencies for information about the incident, especially when there is no CCTV coverage.

The communications arrangement shown in Figure 3 may be improved by providing direct radio communication between the TMC and law enforcement. Concerns about sharing sensitive security information with MAP operators may be overcome by developing and implementing communication protocols. The use of a commercial interoperable platform also provides opportunities to seamlessly set up talk groups involving only relevant personnel. The security of information could be controlled by sharing only non-sensitive communication resources, since each response agency has control over its resources shared on the platform. For example, a law enforcement officer may decide not to share communication with their dispatch on the platform. The talk group may also be set up in such a way that only vetted responders are allowed access to communications on the platform. These talk groups may then be activated only when needed. However, such an arrangement would require changes to protocols, regulations, and executive action.

Operational Assessment of Louisiana's TIM

This section discusses the operational assessment of Louisiana's TIM. Data for this assessment was obtained from managers at the DOTD ITS Office and the Regional Integrated Transportation Information System (RITIS). The assessment was conducted to identify issues in TIM performance that may be improved. The assessment was only performed for some interstates and all TMCs in Louisiana. The interstates considered were I-10, I-110, I-12, I-20, I-210, I-220, I-310, I-49, I-510, I-55, and I-610.

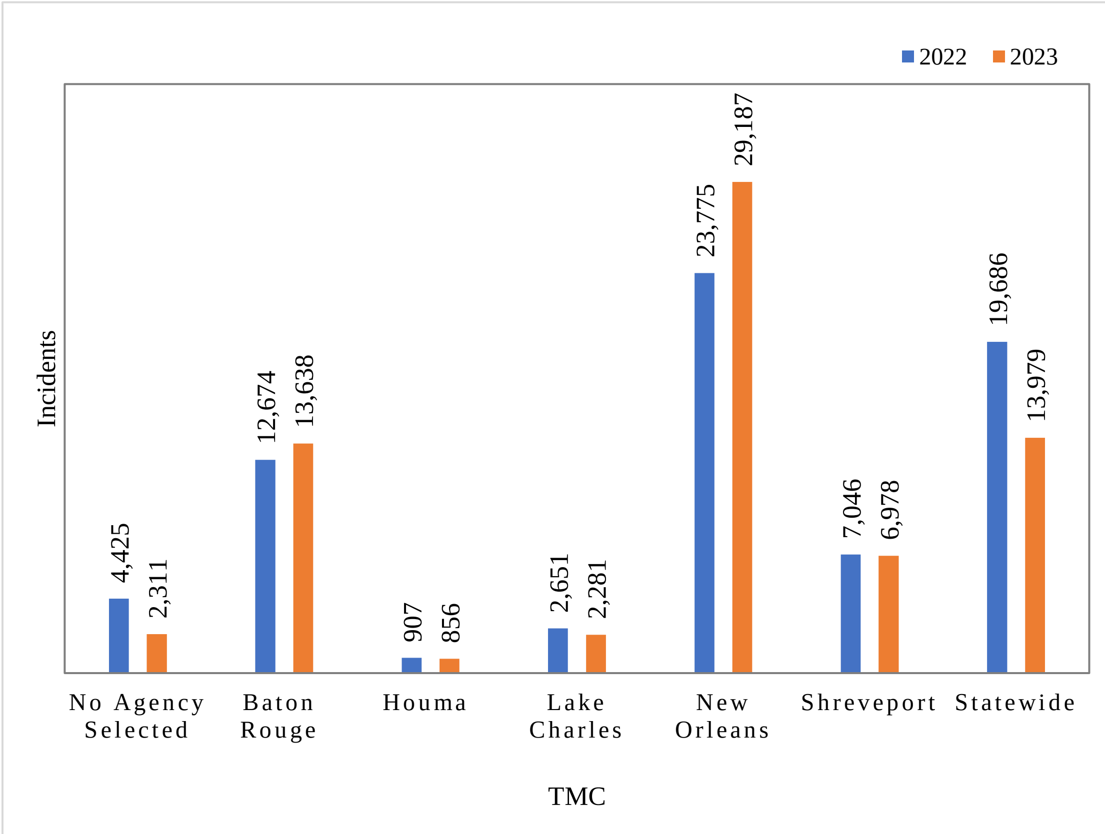
Two years of data (2022 and 2023) were used for the analysis. The TMC recorded a total of 71,164 incidents in 2022. This comprised 13,720 crashes, 10,265 lane-blocking incidents, 1,000 road closure incidents, and 174 planned events. In 2023, a total of 69,230 incidents were recorded, including 12,817 crashes, 10,040 lane-blocking events, 1,020 road closure incidents, and 69 planned events. The data from RITIS showed a total of 197,132 and 163,036 incidents occurred, respectively, on the interstates under consideration. This discrepancy in the number of incidents recorded by the TMC and RITIS is attributed to the fact that the RITIS database contains both ATMS and 511 incident data, while the TMC database is only comprised of ATMS data.

The assessment of Louisiana's TIM was based on dispatch time, incident response time, road clearance time (RCT), and incident clearance time (ICT). These assessments were done for interstates and TMCs. Dispatch time, incident response time, RCT, and ICT, along with their targets, were defined in Table 2.

Total Number of Incidents Responded to by TMCs

Figure 4 shows the total number of incidents sorted by TMC. As seen in the figure, the New Orleans TMC responded to the most incidents, followed by the statewide and Baton Rouge TMCs. The Houma TMC responded to the least incidents in both 2022 and 2023.

Figure 4. Total number of incidents per TMC



Confirmation, Dispatch, and Response Times for TMCs

Table 2 shows the average annual confirmation, dispatch, and response times by TMCs. The table shows that confirmation time was less than two minutes for almost all TMCs in both 2022 and 2023. However, the Houma TMC had the highest confirmation times at 16.6 minutes in 2022 and 7.7 minutes in 2023. Most TMCs had average dispatch times of less than five minutes for both years, though TMCs in Baton Rouge and Shreveport, along with the statewide TMC, recorded higher times in one or the other year. The statewide TMC had the highest dispatch time of 7.8 minutes in 2022, but reduced it to 4.3 minutes in 2023. All TMCs had annual averages of less than five minutes in both years, with the Houma TMC having the highest response time at four minutes in 2023.

Table 2. TMC confirmation, dispatch, and response times

TMC	Confirmation Time (Minutes)		Dispatch Time (Minutes)		Response Time (Minutes)	
	2022	2023	2022	2023	2022	2023
No Agency Selected	1.6	0.5	4.5	11.6	1.3	1.8
Baton Rouge TMC	0.6	0.1	4.5	8.0	2.0	2.4
Houma TMC	16.6	7.7			1.5	4.0
Lake Charles TMC	0.3	1.1	4.6	2.2	1.1	2.2
New Orleans TMC	0.7	0.9	2.8	1.3	1.3	2.0
Shreveport TMC	0.3	0.4	5.7	2.9	0.8	1.2
Statewide TMC	0.9	0.4	7.8	4.3	1.9	2.6

ICT and RCT by TMC

The average ICT and RCT for each TMC are shown in Figures 5 and 6, respectively. For ICT, Houma had the highest average for both 2022 and 2023, though it responds to the fewest number of incidents. Though the New Orleans TMC responded to the most incidents in 2022 and 2023, it had the lowest ICT in 2022 and the second-lowest ICT in 2023. The statewide TMC had the second-highest ICT for both years, corresponding to the second-highest number of incidents responded to in both years.

From Figure 6, it can be seen that the average RCTs are again highest for the Houma TMC for both years. For 2022, the Shreveport TMC has the second-highest average RCT, while the Lake Charles TMC has the lowest average RCT. Though it has the second-highest average RCT, the Shreveport TMC responded to fewer incidents compared to the New Orleans, statewide, and Baton Rouge TMCs, which all performed better in terms of RCT. It should be noted that apart from the number of incidents, other factors, such as the number of personnel, equipment, and law enforcement, among others, may impact ICT and RCT. For instance, the relatively poor performance of the Houma TMC for ICT and RCT in comparison to other TMCs has been attributed to the absence of MAP in the area. Additionally, the TMC is operated by only one person, which leads to the observed performance.

Figure 5. ICT by TMC

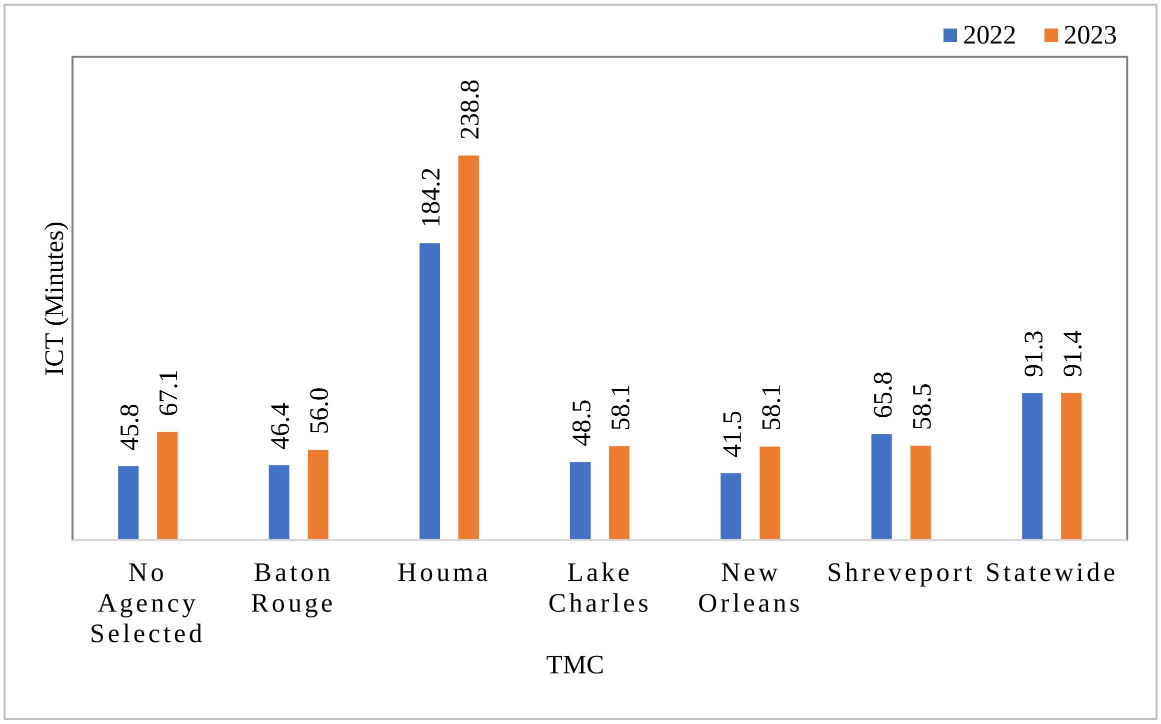
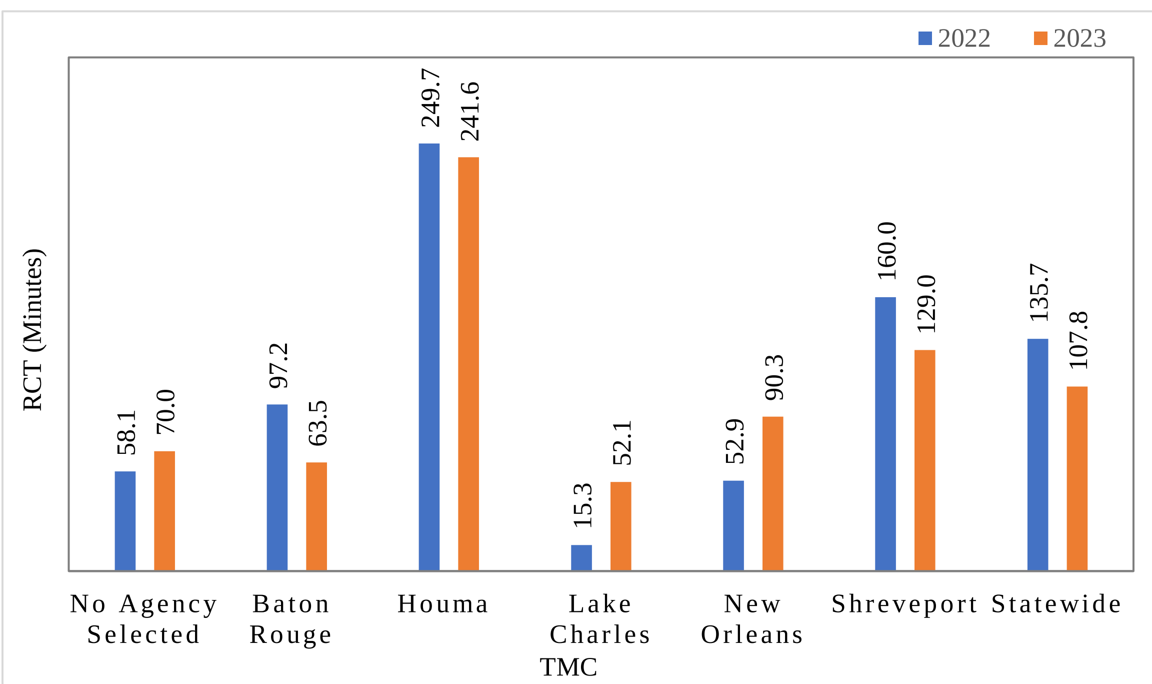


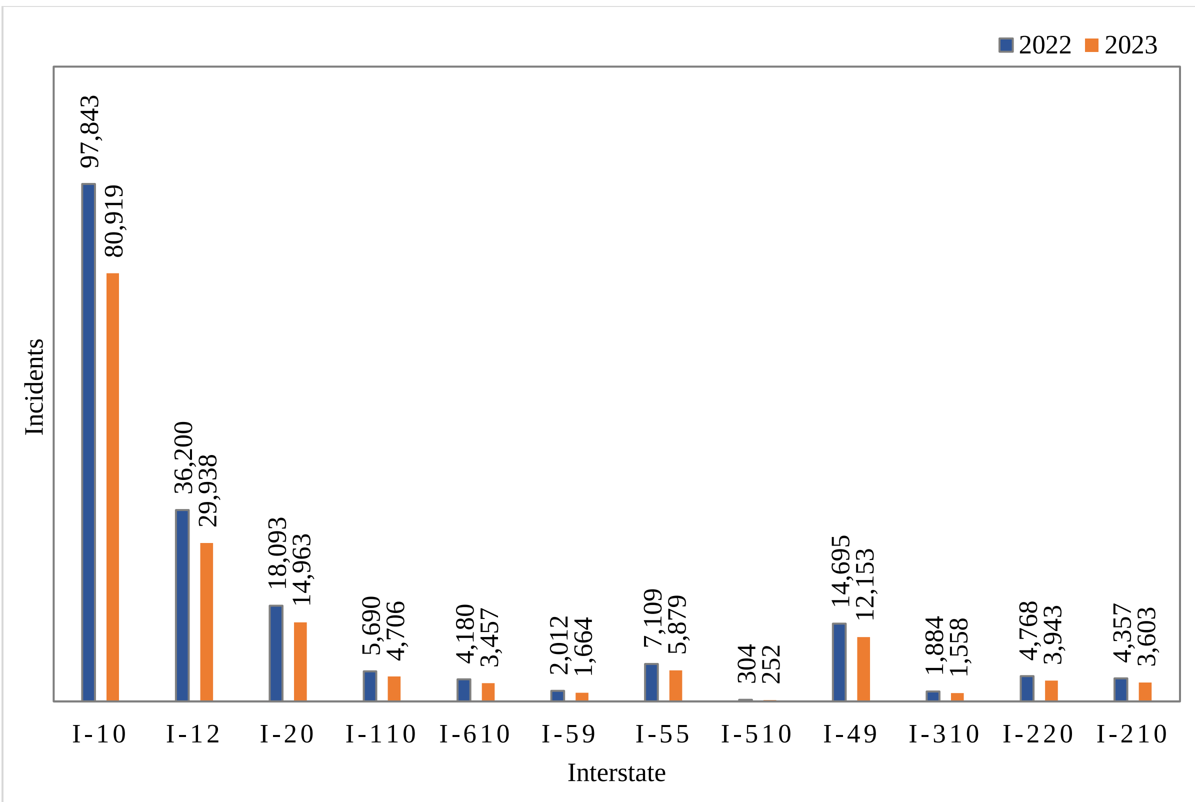
Figure 6. RCT by TMC



Total Number of Incidents by Interstate

The total number of incidents per TMC is shown in Figure 7. It can be seen that I-10, I-12, and I-20 recorded the highest number of incidents. This is expected because these interstates are lengthy and carry a substantial amount of traffic. The chart also shows that more incidents were recorded for all highways in 2022 than in 2023, in contrast to the mixed observations made for the TMCs.

Figure 7. Total number of incidents by interstate

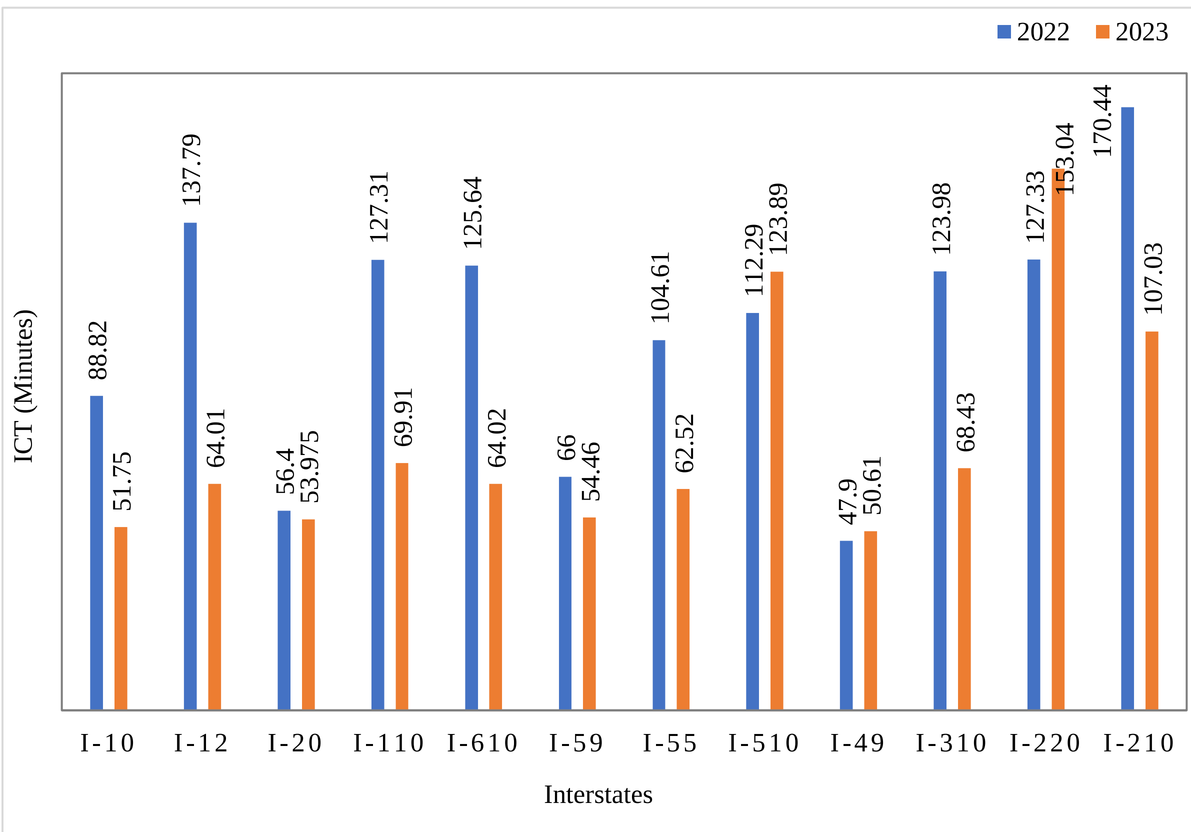


ICT and RCT by Interstate

For the estimation of the ICT and RCT from the RITIS data, a cutoff of 1,500 minutes was used to lessen the impact of outliers. This represented the 99th percentile of the data. Figures 8 and 9 show the average ICT and RCT on Louisiana's interstates. It should be noted that the TMC generally excludes stalled vehicle incidents on shoulders that last several hours in their analysis. This is because it sometimes take several days to move the vehicle. Though the vehicle no longer impacts traffic operations, an incident log created for the event is not closed until the vehicle is moved off of the shoulder. As a result, a duration of several days may be recorded for these shoulder incidents. However, the RITIS data did not provide enough information to identify and remove incidents related to stalled vehicles on road shoulders. Therefore, some of these incidents may still remain in the data. However, excluding incidents lasting more than 1,700 minutes as outliers may mitigate the effect of these incidents.

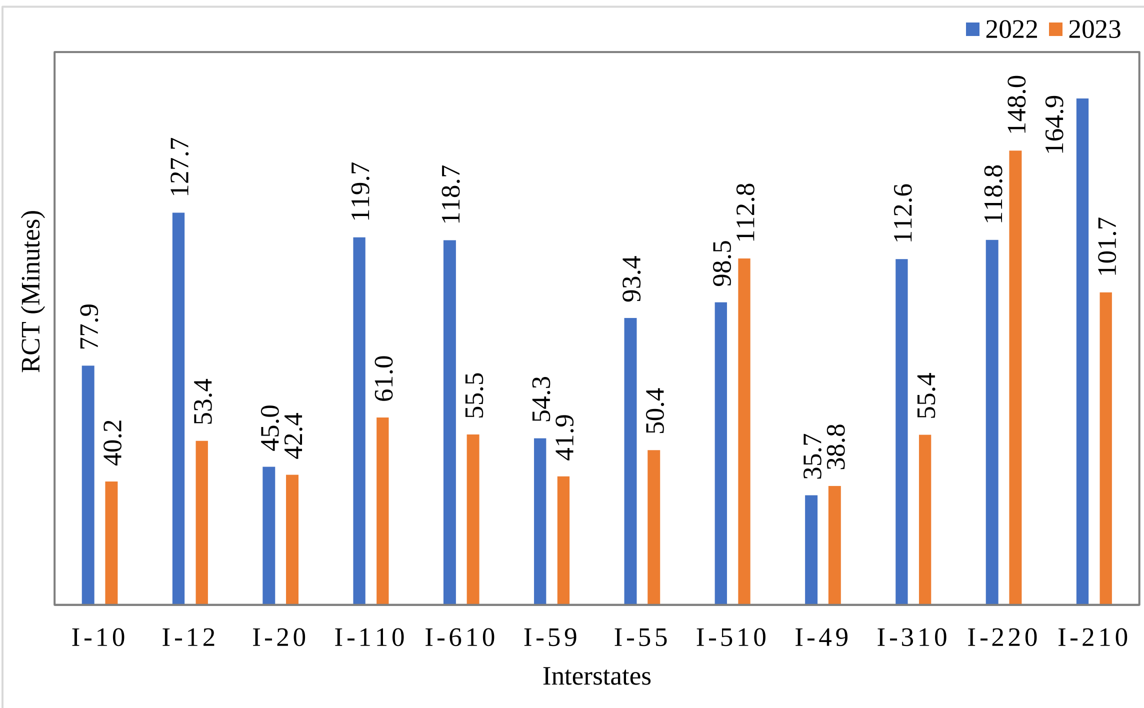
In terms of ICT, I-210 had the highest ICT of 170.4 minutes in 2022 compared to I-10 and I-12, which had ICTs of about 88.2 and 137.8 minutes, respectively. It may be observed from Figure 7 that I-210 was among the interstates that recorded the least number of crashes in 2022. In 2023, I-220 had the highest ICT of 153 minutes, which was higher than those of I-10 (51.8 minutes), I-12 (64 minutes), and I-110 (69.9 minutes).

Figure 8. ICT by interstate



In terms of RCT, I-210 had the highest time of 164.9 minutes in 2022, while I-220 recorded the next highest RCT of 148 minutes, as seen in Figure 9. The RCTs for these two interstates were higher than what was observed for I-110, I-12, and I-110 in both years. These observations are attributed to the higher number of truck crashes recorded on these roadways. ICT and RCT are usually higher for truck crashes compared with other vehicle crashes. These findings may indicate a need to increase resources on I-210 and I-220 to reduce their ICTs and RCTs.

Figure 9. RCT by interstate



Figures 10 and 11 show the ICT and RCT aggregated by month for interstates. From Figure 10, it can be seen that the ICT was less than the performance target of 70 minutes, apart from July 2022, when ICT exceeded 300 minutes. A similar observation was made for the 2022 RCT, where the average RCT in July also exceeded 300 minutes. The values of ICT and RCT observed for July 2022 were exceedingly high compared to other months. This warranted a closer inspection of the data, which revealed that there was an unusually high number of incidents (>3,500) in which the ICT and RCT exceeded 1,000 minutes. By comparison, in June 2022 only 235 and 245 incidents were observed to have ICT and RCT greater than 1,000 minutes, respectively. No such anomaly observed in 2023 for ICT and RCT. It is not immediately apparent what led to so many incidents being recorded in 2022. Plots of ICT for individual interstates by month in Appendices E and F reveal a similar pattern for most interstates, with July 2022 having high values in comparison to other months. Generally, ICT and RCT values were observed to be higher in 2022 than in 2023.

Figure 10. ICT aggregated for interstates by month

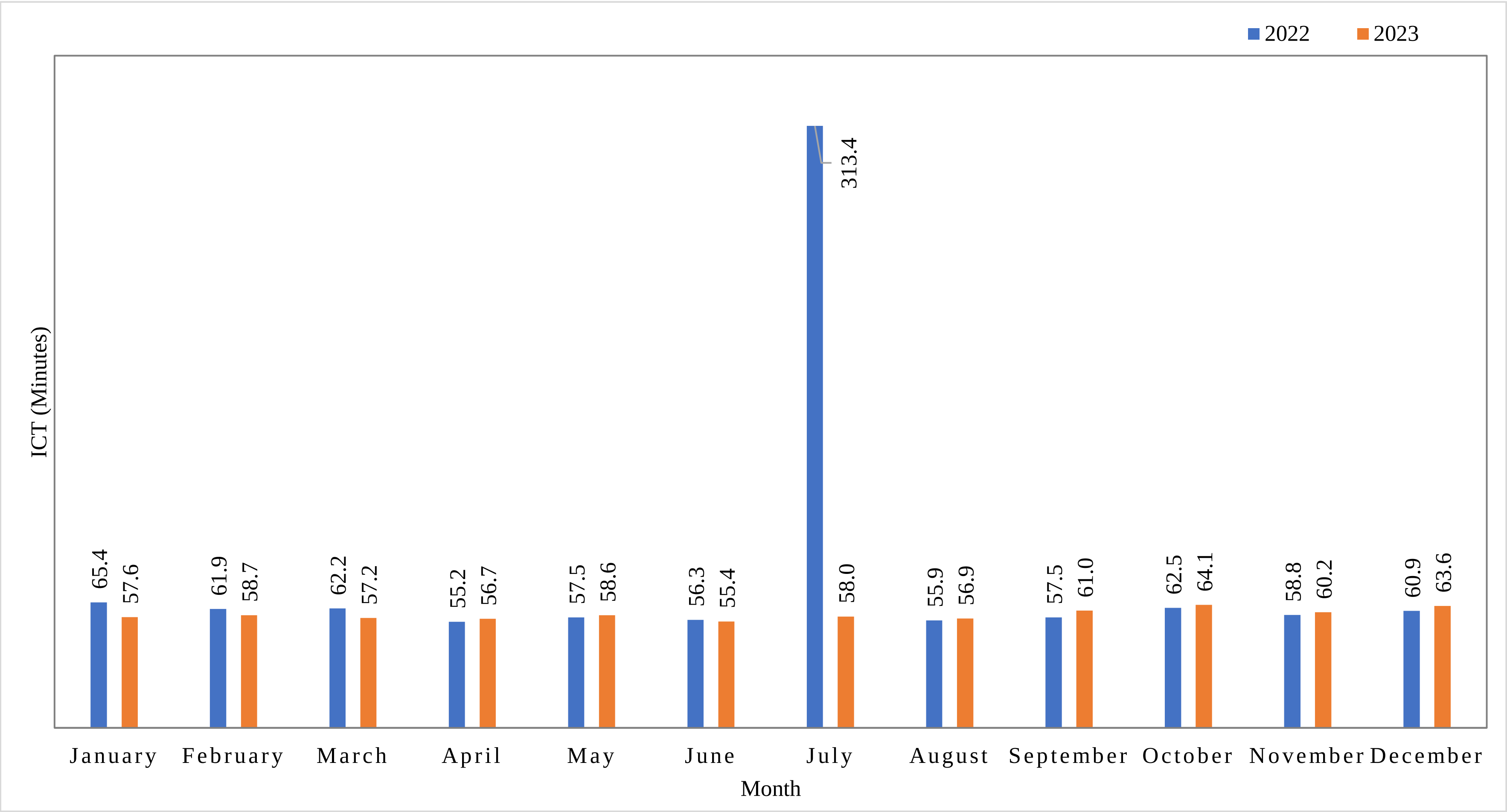
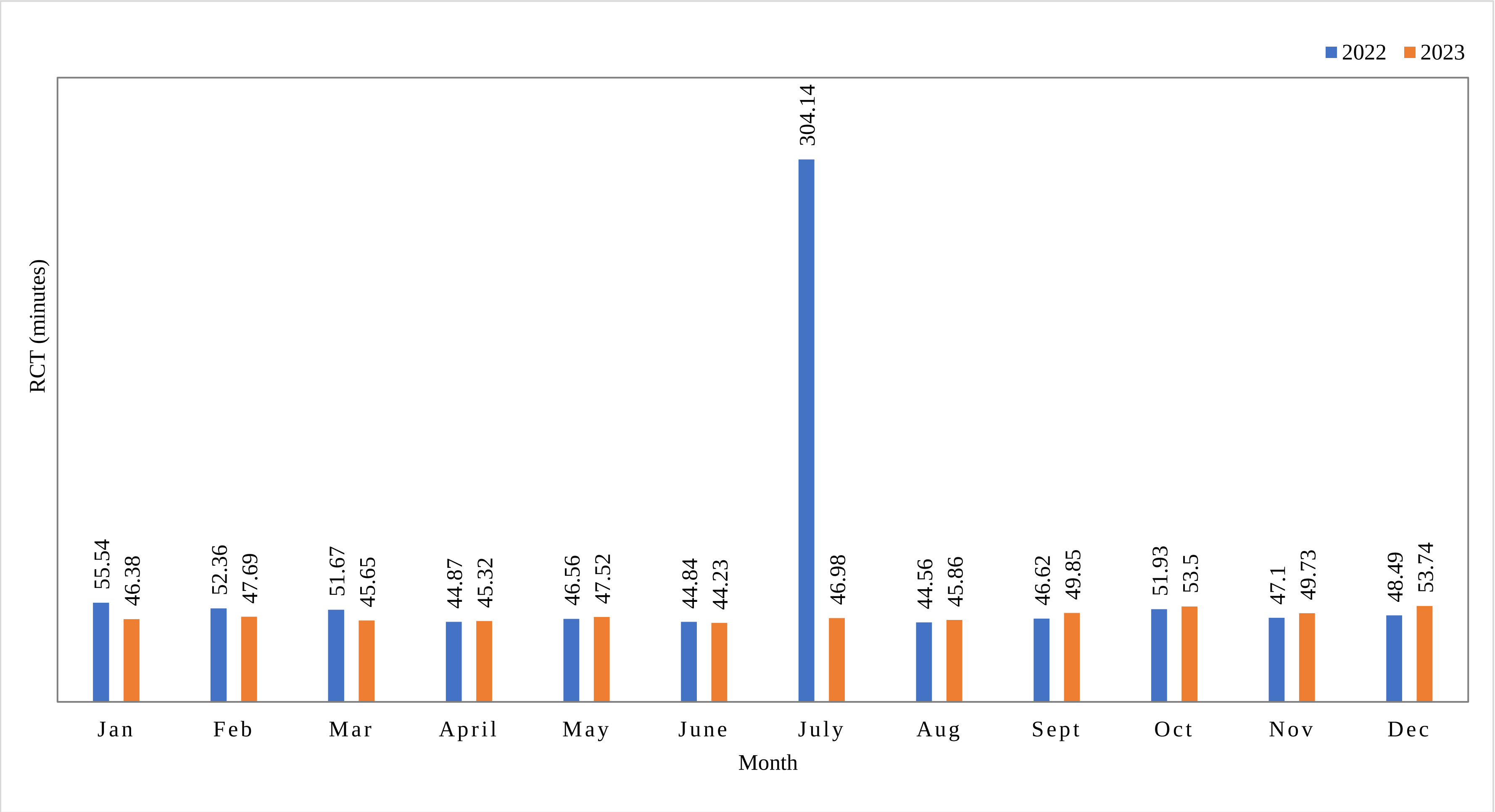


Figure 11. RCT aggregated for interstates by month



Needs Assessment

The needs assessment was conducted by collecting information from personnel directly involved in TIM from stakeholder response agencies. The research team relied heavily on interviews but also utilized questionnaires and surveys. This task was performed alongside the collection of information to better understand TIM in Louisiana. The assessment also compared TIM best practices in the published reports and literature with Louisiana's TIM to identify gaps. These gaps were discussed with stakeholder representatives to determine if they would benefit TIM in Louisiana. The research team also attempted to understand the difficulties in implementing some of the practices identified. The needs assessment is presented in the following section, categorized by general TIM needs and needs specific to TIM communication.

Louisiana TIM Communication Needs

TIM communication in Louisiana relies predominantly on LWIN for interoperable communications. The system is robust and well integrated with existing legacy communication systems by utilizing radios and other communication infrastructure. An assessment of Louisiana's TIM communication revealed the following needs:

Co-location of Response Agencies

Among other benefits, the colocation of dispatch and personnel of response agencies enables faster sharing of information. Apart from the Baton Rouge regional TMC, which is co-located with EMS, the fire department, and the Baton Rouge Police, no other TMC in the state is co-located. This is attributed to the lack of available space and inadequate funding to acquire it. Funding for co-location is a shared task requiring all partner agencies to contribute. Convincing all agencies to prioritize co-location is at times challenging due to competing needs.

Integration of Law Enforcement CAD with TMC Software

Law enforcement CAD-TMC integration is vital to TIM and is standard in many jurisdictions across the U.S. Law enforcement receives many calls about incidents that are not immediately reported to the TMC. This means the TMC is sometimes minutes behind in the notification of incidents. Access to CAD permits TIM data to be automatically shared with integrated TMC operating systems, thereby reducing the need for TMC operators to manually search navigation maps to detect incidents and enter incident information. Currently, law enforcement CAD is not integrated with TMC operating systems in Louisiana. This lack of integration has been attributed to security concerns involving the exposure of personally identifiable information in most CAD systems. The result is that TMC operators must manually enter information on their TIM systems. Additionally, incident information available to law enforcement may not be transmitted in a timely manner to the TMC, meaning updates to the traveler information system are delayed. The TMC can see raw data and unconfirmed information on incidents reported to the East Baton Rouge Parish 911, Lafayette Parish 911, and Caddo Parish 911 CAD systems on web pages available to the public. The information on these pages serves as a guide to possible traffic-related incidents being investigated but are monitored by the TMCs to obtain actionable information. These incidents may have been reported or classified incorrectly, hampering the TMC response. Also, confirmation of the incidents reported on the pages may occur long after the incident is cleared. CAD resources can be fully integrated with TMC operating systems while removing sensitive personal and security information. This has been achieved in Illinois, Washington, Texas and Utah, among other states, where the use of a filter system ensures that data transferred to the TMC includes no sensitive information [92].

Use of Interoperable Communications Platforms

The utilization of internet protocol (IP)-based technology in public safety provides opportunities to increase the amount of information first responders can receive. Public safety agencies across the U.S. are taking advantage of this advancement in technology to improve interoperable communications. As noted previously, Louisiana manages an interoperable communication system. Discussions with managers, personnel, and operators in TIM across multiple agencies indicated that Louisiana's communication system is robust and fit for this purpose. The state's wireless communication network, LWIN, provides a trunked radio system available to all first responders. The network is optimized for legacy radio systems and permits the formation of talk groups on dedicated channels when needed. This means that response agencies can establish command systems that utilize LWIN's interoperable capabilities during large-scale events. However, the system is not utilized to share multimedia information, and all information exchange is accomplished only via voice across two-way radios. Though responders know the dedicated interoperable channels, they must be notified manually to tune their radios to the frequency.

Most TIM personnel were not fully informed about interoperable communication platforms that allow different devices to operate on a single platform where voice, text, video, and pictures can be shared during incident response. These platforms are discussed in the next section. When the capabilities of the interoperable platforms were explained, managers who spoke with the research team indicated several benefits of using these platforms, especially in responding to large incidents requiring multiple agencies and resources. However, they noted that the reliability of these platforms may pose a challenge in extreme events, as they depend on internet services. Internet access is often one of the first services lost during severe storms or hurricanes, which may render these platforms useless in some events. Additionally, there were concerns that sharing videos and pictures would distract responders from their primary duties, which are to safely secure the incident scene and rapidly clear the roadway. They worry that these distractions may increase response time and create unsafe conditions at incident scenes. The need for additional training to use platforms, cybersecurity, data privacy, and confidentiality was also noted.

The U.S. DOT-supported NG911 initiative, when fully established, will provide another avenue for enhanced interoperability, especially in rural areas of the state. As stated previously, NG911 is a secure IP-based communication system that integrates multimedia data as well as voice and text. NG911 has similar features to third-party interoperable platforms and is being developed to replace the traditional 911 PSAPs, which have been used over the last four decades [88].

Louisiana General TIM Needs

Reorganization of TIM Program

Several critical elements that form a formal TIM program were absent in Louisiana. For example, responders interviewed for this study across various TIM stakeholder agencies could not identify an SOP used in their operations. They were also unable to identify any interagency agreements between their agency and others. It was also found that there are no TIM committees locally or regionally, and no regular TIM meetings are being held. Some responders interviewed were unsure of the roles played by other agencies. Given that a formal TIM program serves as the basis to organize incident response in a jurisdiction, it is important they are established at the local and regional levels. Benefits of a formal TIM program include improvement of multiagency collaboration, clarification of roles, and definition of agency and personnel roles and responsibilities. TIM programs also lead to the establishment of SOPs, interagency agreements, TIM meetings and training exercises, and incident response plans.

The task of strengthening and reorganizing Louisiana's TIM program is underway. This effort is proposed to be led by a steering committee that draws members from several Louisiana institutions, including DOTD, State Police, Sheriff's Association, Fireman's Association, towing and recovery, and more. Recommendations will also be made to form Regional TIM teams in all urban centers in Louisiana, including Baton Rouge, New Orleans, and Northshore, among others. Regional TIM teams can be formed to integrate and collaborate with existing Regional Safety Coalitions to improve TIM in their areas of concern.

Regular Interagency TIM Meetings

As noted previously, evaluation results suggested that regular interagency TIM meetings are not occurring locally or regionally. Currently, Safety Coalition meetings are held regularly across different parts of the state. However, TIM issues are often not discussed at these meetings. Given that TIM falls under the Infrastructure and Operations emphasis area of Louisiana's Strategic Highway Safety Plan, discussing TIM issues during the coalition meetings is appropriate. This strategy leverages existing institutional programs to plan and organize TIM locally, regionally and statewide.

Multiagency Standard Operating Procedures

As part of the evaluation of TIM in Louisiana, it was found that no common multiagency SOP is available to state agencies. Additionally, most agencies involved in TIM did not have an agency SOP. The operator of the state's TMC has developed an SOP, but this is only used by their operators. As noted previously, SOPs emphasize an incident command system, define the roles and responsibilities of agencies, ensure common terminology, and define communication flow and channels for incident response. For example, it was found that codes used to refer to incident types differed for the East Baton Rouge Police and West Baton Rouge Sheriff's Department. It was also found that some personnel across different agencies lack an understanding of the incident command structure. NIMS recommends plain language and common terminology across response agencies to enhance communication. However, the institution of changes required for improved communication and understanding of the incident command structure may encounter obstacles in the form of agency attitudes. There are plans for a multiagency SOP to be developed for use by all agencies involved in TIM in Louisiana in the short term. In this SOP, the dynamic nature of the incident command structure during incident response will be reinforced. Additionally, standardized communication terminology, response protocols, agency responsibilities, and other pertinent issues will be discussed in the SOP. The development of the SOP should address a fundamental strategy of the NUG requiring the implementation of standardized multi-disciplinary traffic incident communication practices and procedures.

TIM Training and Regular Joint Exercises

Louisiana takes part in training programs mandated by the FHWA. Personnel from law enforcement, fire, towing and recovery, EMS, transportation and public works, and other disciplines take part in TIM training. Louisiana has achieved 83.4% of its TIM training goal as of December 2023. Louisiana ranked second among all states that had trained their personnel in TIM. Discussion with the Louisiana TIM Training Coordinator indicated that personnel from fire departments are not currently mandated by Louisiana law to take part in TIM training as police officers are under RS 32:152. A mandate to include fire in TIM training will ensure that uniform TIM procedures are followed during TIM response, since fire personnel have some enforcement powers.

It is important to pair TIM training with regular joint training exercises for partner stakeholder agencies. Discussions with personnel from several TIM agencies indicated that joint training exercises have not occurred in the past. These joint exercises improve coordination and enforce the principles of unified incident command. Also, TIM managers indicated that some law enforcement personnel are unfamiliar with TMCs and the role they play in TIM. Given the importance of TMCs in incident response, this situation must be remedied to better help TMCs perform their roles. Joint training exercises will lead to a better understanding of all agencies involved in TIM and how they are valuable resources during incident response.

Effective Detection and Verification Systems and Strategies

Incident detection and verification systems are effective in most parts of Louisiana. With CCTV cameras, 911 calls, police CADs, and navigation apps, incidents are easily detected on interstates. Roving MAP units and police patrols deployed on the state's interstates are effective and have the advantage of being in proximity to incidents for verification purposes, especially under congested conditions. However, an increase in CCTV camera coverage on interstates is needed to increase coverage and mitigate issues in rapidly verifying incidents. Additionally, the use of technology could enhance the rapid notification of incidents. Commercially available traffic management software has automatic incident detection capabilities. DOTD should add this capability to the next ATMS update. These technologies are faster and more efficient compared with the current practice of scanning navigation apps or listening to police radio for incident detection. The use of combined electronic loop detectors and CCTV cameras has been found to be effective and should be studied by Louisiana's TIM agencies [12].

Enhanced Use of ATMS

Several ATMS modules are currently active and available across Louisiana's TMCs. These include map, security, and administration (SAS), automated incident detection, dynamic message signs (DMS), CCTV, ramp metering systems, and SSP. Other available modules are vehicle detection, automated vehicle location, event management, decision support systems, travel times, data archival and reporting, and center-to-center. Maximum utilization of the ATMS modules will lead to decreased reliance on manual methods and an improvement in incident detection, verification, and response. However, the research team observed that many of these modules are not being used by the operators at the TMCs visited. This is attributed to the high turnover of TMC personnel and the time needed to train new employees. DOTD managers of the TMCs indicated that incorporating the active traffic management module featuring active queue warning and adaptive ramp metering modes will enhance the ATMS. Additionally, leveraging artificial intelligence, such as video analytics, in future upgrades of ATMS will be beneficial.

Increase in TMC and MAP Coverage

Given the critical role played by the TMCs and MAP, it is crucial to increase their coverage. Apart from the six operational TMCs, there are plans to develop others in Monroe, Alexandria, and Northshore. These new TMCs are needed to complement the existing operational TMCs. Additionally, MAP has proven popular with the public in Louisiana, given its role in TIM and its assistance to motorists. MAP operates on interstates in all major urban areas of Louisiana. TIM managers in Louisiana have plans to extend the MAP program to some other areas in Louisiana in the future. The TMCs and MAP program has proven to be instrumental in Louisiana's TIM. There is a universal agreement among partner agencies that the TMCs and MAP are invaluable tools that provide vital support during incident response. Therefore, these programs must be prioritized for funding to sustain and expand them. Also, the state's TMCs are not connected to one another at the moment. This implies that there is no data sharing among them. For large-scale events, there is significant benefit in sharing information between TMCs. This situation should be remedied to maximize the effectiveness of the TMCs.

Increase in CCTV Coverage

CCTV cameras are an important component of current TIM programs across the U.S. In Louisiana, CCTVs provide a valuable means to detect and verify incidents. Most CCTV cameras have been replaced recently with new cameras that allow turning with an increased zoom capability. Additionally, up to half of the available cameras can be enhanced to incorporate smart video analytic capability. However, there are large sections of interstate that have no camera coverage. Funding is needed to purchase more CCTV cameras to cover the most incident-prone locations on the interstate.

Incorporation of New Technology

The proliferation of AI presents opportunities to incorporate technologies that enhance automation in TIM. For example, given that the critical task of incident notification is not automated, commercial video analytical software could be integrated with TMC operating systems to scan roadways and alert operators when an incident occurs. The use of advanced warning technologies could lead to a reduction in secondary crashes, while emergency vehicle preemption systems could help responders get to incident scenes more rapidly. Additionally, unmanned aerial systems could be utilized as tools to support TIM response in areas without CCTV camera coverage. NG911 systems have also been identified as a technology to improve incident notification and management.

Data Collection, Performance Measurement, and Information Sharing

Traffic incident data is collected through incident logs recorded by ATMS. The data is used for analytics and reporting (e.g., after-action and senior management reports) and is shared with other DOTD sections, other departments and agencies, and the public upon request. Performance metrics, including operator dispatch time, event confirmation, and time to update the IRP, are estimated from the incident data. The key performance measure, the number of secondary crashes recommended by the FHWA, is not being collected. This has been attributed to ambiguity in defining a secondary crash.

During the evaluation, it was found that though personnel from partner TIM agencies know the importance of TIM data in measuring performance, they are mostly unaware of their localized TIM performance metrics. The summarized performance data is not shared with partner agencies locally. Personnel from partner agencies were mostly aware of the need to respond rapidly and clear incidents. However, specific performance metrics were not being tracked within their jurisdictions. The implementation of a strengthened TIM program, along with the formation of regional interagency TIM teams, would aid in the use of common TIM performance measures across the state. This is important to create awareness of TIM performance regionally and to develop a unified approach to improve identified shortfalls. Data-sharing agreements between regional TIM stakeholder agencies should be promoted, with the data forming the basis of the TIM programs' development.

Additionally, TIM managers identified the following measures to improve data collection:

- Increased automation to minimize manual data entry
- Improved interagency and interstate data sharing
- Development of a national standard by the FHWA to eliminate long processes in procuring new traffic management software
- Institution of laws for ATMS data to have immunity from liability so that more data can be stored with no concern for subpoenas

Funding

Most of the TIM supervisors and managers who spoke to the research team expressed an urgent need for more funding to support and expand TIM in the state. There is no central state funding for Louisiana’s TIM. Instead, funding comes from stakeholders indirectly as they fund their individual operations. For DOTD, TMC, and MAP, funding is derived from the operations budget of the ITS section. MAP funding is split equally between DOTD and Municipal Planning Organizations (MPOs) that have MAP within their jurisdiction.

According to DOTD, the key needs that require funding include new TMCs, expansion of the MAP program, contributions to rent of space for co-location purposes, and deployment of new ITS devices. According to TIM managers at DOTD, locations being considered for co-location of stakeholder agencies are constrained by space and staffed with outdated equipment. Currently, plans to co-locate TMC staff with 911 dispatchers from other agencies at Lake Charles and Mandeville are facing challenges due to funding. Expanding the MAP program to new MPOs also requires funding to purchase vehicles and equipment and employ new staff. Given that MAP has expanded its services to construction projects, current MAP resources are being strained. Additionally, maintaining a TIM program involves investing in the upgrade of ITS devices. However, the costs required to purchase, install, and maintain these devices continue to increase due to inflation and the general cost of new technologies. Discussion with TIM managers at DOTD suggests that these challenges have led to a shortfall in funding for TIM with no significant budget increase over the last couple of decades. To improve TIM in Louisiana, additional funding is required for DOTD, since the department is responsible for the TMCs and MAP, which are critical elements of the state's TIM program.

Interoperable Communication Platforms

This section discusses several interoperable communication platforms that are currently being used or can be modified for TIM. The key features of the platforms are identified and discussed in relation to how they can contribute to improving incident response. Additionally, the limitations of these platforms as they apply to TIM have been identified. The interoperable communication platforms analyzed are RIMIS, Mutualink, TIMS2GO, Omnigo, and Active911. At the end of the section, a summarized overview of each platform is provided.

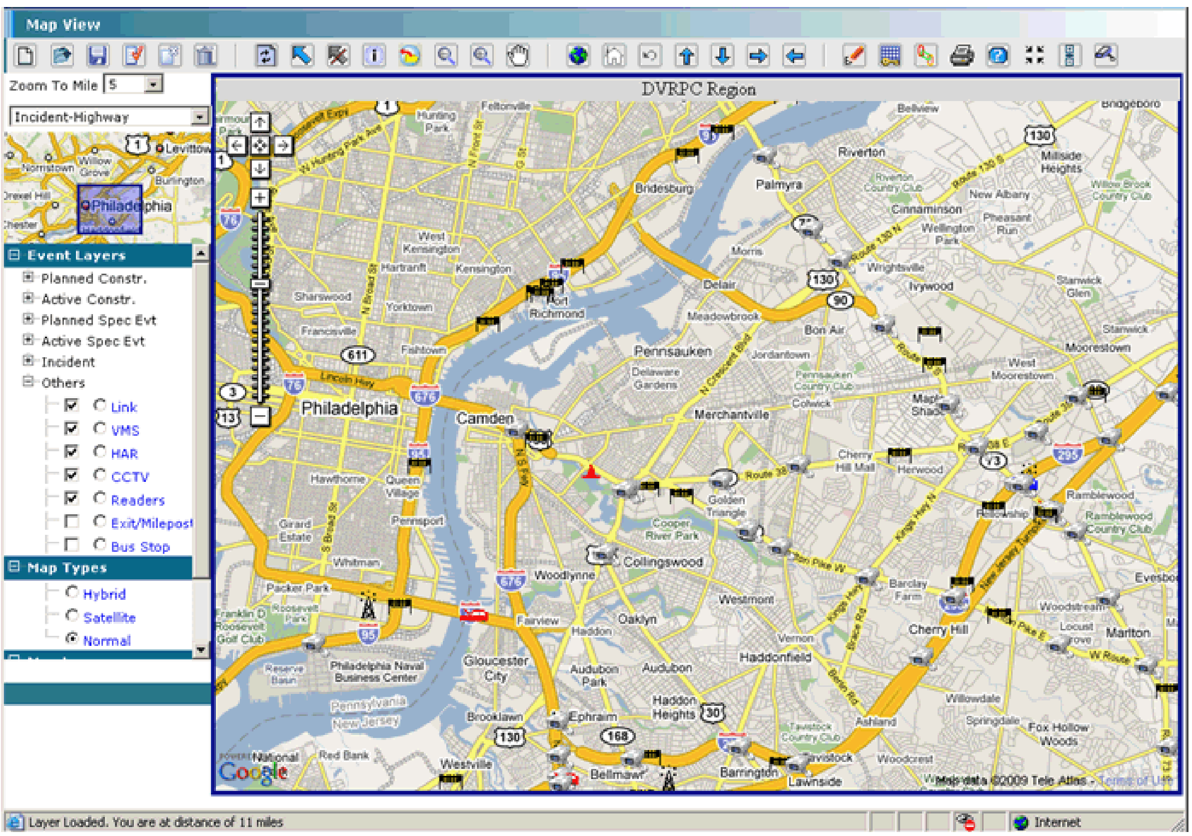
Regional Integrated Multimodal Information Sharing (RIMIS) Project

RIMIS is a web-based platform developed for agencies in the Delaware Valley Regional Planning Commission (DVRPC) for interagency coordination. The DVRPC spans four U.S. states: southeastern Pennsylvania, southern New Jersey, northern Delaware, and the Eastern Shore of Maryland. RIMIS enables the sharing of traffic-related information among highway operation centers, transit control centers, and 911 call centers. These centers can view transportation systems via detailed databases, maps with situational information, and real-time traffic videos [93]. RIMIS was built in-house to enable agencies to share timely and accurate information about traffic incidents. It aims to improve the interpretation of transportation information by using standard formats [94].

RIMIS consists of several databases that list ongoing and planned activities. The software enables data entry for highway incidents, transit incidents, and other planned events. The events map, which shows all events in the region, is used by most RIMIS users to monitor transportation systems. As shown in Figure 12, different icons represent different event categories, such as cones for maintenance construction activities or vehicles for highway incidents. Detailed information on the event is provided by clicking an icon. The map can also show CCTV cameras, variable message signs (VMS), and traffic flow detectors. The operator can examine real-time video, live dynamic message sign content, and traffic flow information by selecting one of the components [93].

There are other key features of RIMIS, including the use of standard messaging formats to improve the quality and completeness of communication. It also providers operators with access to incident videos and informs emergency responders and other agencies about the best routes to reach the incident scene [94]. Additionally, RIMIS provides immediate access to available background data, which consumes a significant amount of time if such data is unavailable. Another feature of RIMIS is its ability to verify message notifications of incidents and real-time situational information, which eliminates the need for time-consuming follow-up communications, especially when rapid action is required. Moreover, it includes user filtering and control of the communications system interface, which reduces the load of unnecessary or unwanted transmissions and enables agencies to use their own criteria for internal notifications and processes [95].

Figure 12. Event map for RIMIS [93]



RIMIS is designed to manage and share various types of information among regional transportation stakeholders, enabling the seamless exchange of information. These include incident notifications as soon as they are detected or reported, including information about the severity of the incident and its expected duration. It also includes sharing incident response decisions and activities. Additionally, RIMIS handles information about special events and management plans, real-time traffic, and transit updates. It also provides information about traffic management resources such as VMS and the status of current notifications and warnings. Furthermore, it manages information about construction and maintenance activities that affect lane closures on expressways, detour routes, and bus routes in an efficient manner [94].

Another key feature of RIMIS is electronic message management. It provides templates with pull-down menus to simplify message composition. These templates include information such as incident types, expected durations, incident location, necessary resources, and time of day. Broadcast messages, alerts, and notifications can be sent manually or automatically [94]. The RIMIS platform also includes scenario-based message templates such as accidents, road construction, and weather conditions. Additionally, RIMIS permits operators to view the status of the transportation network display. This map-based regional transportation network display with spatial analysis tools automatically displays incident types and locations, including special events, vehicle breakdowns, accidents, major incidents, and weather conditions. The map-based display also provides traffic flow information and monitors network ITS device status, including VMS and Highway Advisory Radio (HAR) messages, as well as providing information on transit vehicle location, route schedules, and delays. Other features include incident tracking and data archiving. RIMIS can zoom in on incidents and track response progress. The platform serves as a vital record of all exchanged messages and data transfer. This feature allows users to use the system and respond to future transportation scenarios more effectively [93].

Although RIMIS provides various functionalities, it does have several limitations. One such limitation is its inability to share incident-related videos. Another is that it has no multimedia or data sharing groups for the public, operators in the centers, and first responders in the incident scenes. Additionally, users can only access the RIMIS platform through a website, as it has no mobile application. This limits the ability of on-scene supervisors and responders to gain holistic awareness of the situation. RIMIS is also location-specific, developed to fit the needs of the DVRPC. This means it cannot be utilized readily by other jurisdictions without undergoing substantial modification.

Mutualink

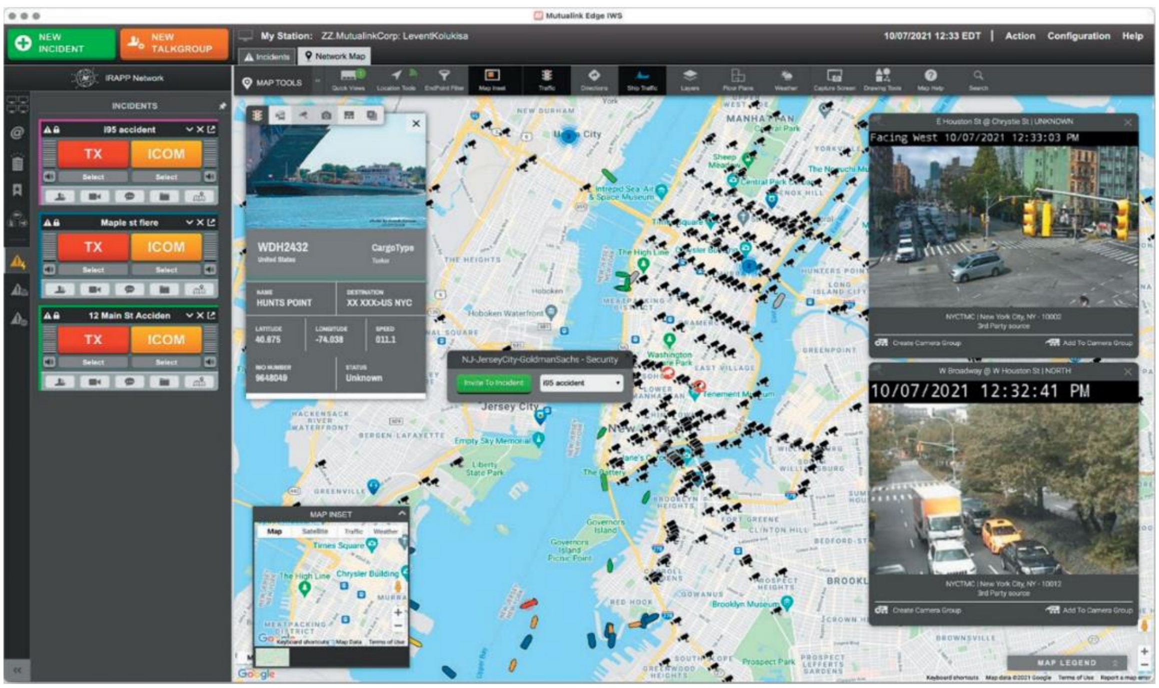
Mutualink is a cross-agency interoperable platform that enables communication and data sharing across multiple agencies involved in TIM. Agencies coordinate and share communication resources on the platform while maintaining full sovereignty over their resources. Mutualink is a secure system that ensures all participating agencies are mutually authenticated, with all media fully encrypted [95]. The platform bridges voice, picture, video, data, and text solutions to enable instant communications among agencies. Mutualink provides complete multimedia communication capabilities, including voice communication through radios, phones, intercoms, user devices, and PTT (push-to-talk) systems, along with video sharing through cameras, video management systems, cellular phones, and webcams. Additionally, Mutualink supports text messaging, chat rooms, the sharing of files, location, and GIS data, and the sharing of generalized device data and information [96]. Figure 13 shows the Mutualink interface.

Once an incident occurs, the platform operator coordinating incident response creates an incident ticket and invites pre-configured personnel from partner response agencies to the platform. A talk group involving all needed personnel is formed, with members joining and leaving the group as desired. Invited responders receive a notification and join the platform. Communication on the platform can be carried out using different technologies, including push-to-talk, Long Term Evolution (LTE), wi-fi, and wired communication. Other technologies used are conventional Land Mobile Radio (LMR), Public Switched Telephone Networks (PSTN), voice-over LTE, PA systems, and others that permit the transmission and receipt of audio. With the architecture of Mutualink, cross-agency responders with different communication devices across various networks are able to communicate, coordinate, and respond to incidents on the platform at the same time. The system provides immediate access to shared real-time information to all responders simultaneously. This ability obviates the need to purchase new equipment, since responders can access information with their current devices on the Mutualink platform [97]. Responders may exit the platform at any time or may stay on passively to receive incident updates while performing other tasks [98].

Another unique feature of Mutualink is its ability to share multimedia on the platform. This feature not only allows the sharing of voice communication in virtual talk groups but also facilitates the sharing of multimedia and data among its users. This feature allows the sharing of videos, pictures, files, maps, and geospatial data, as well as the use of text messaging. The sharing of location data is especially important, as responders on the platform can immediately determine an incident location to initiate a response. Overall, the ability to share multimedia allows responders to have access to real-time information, which enables the dissemination of more comprehensive information and improved situational awareness, all resulting in the more rapid clearing of incidents.

A coordinated response is continuously monitored on the Mutualink platform through the sharing of videos, texts, and voice calls heard by all responders. The incident ticket is updated and visible to all responders currently logged onto the platform with a multimedia enabled device. Once the incident response has ended, a record of the incident timeline is saved and stored. However, other data shared on Mutualink, such as videos and pictures, are not saved. The Mutualink interface is shown in Figure 13.

Figure 13. Interface of Mutualink [97]



Mutualink is a commercial interoperable platform and requires agencies to purchase a license. These license costs may be prohibitive in agencies where there are a large number of responders. Some agencies have overcome this issue by purchasing licenses only for supervisors, who then relay instructions to on-field responders. Using the platform in such a way limits the core strength of Mutualink: its ability to share information (e.g., videos, pictures, texts, and files) with many responders in a short time. Additionally, Mutualink is not readily integrated with the existing ITS infrastructure an agency may have.

TIMS2GO

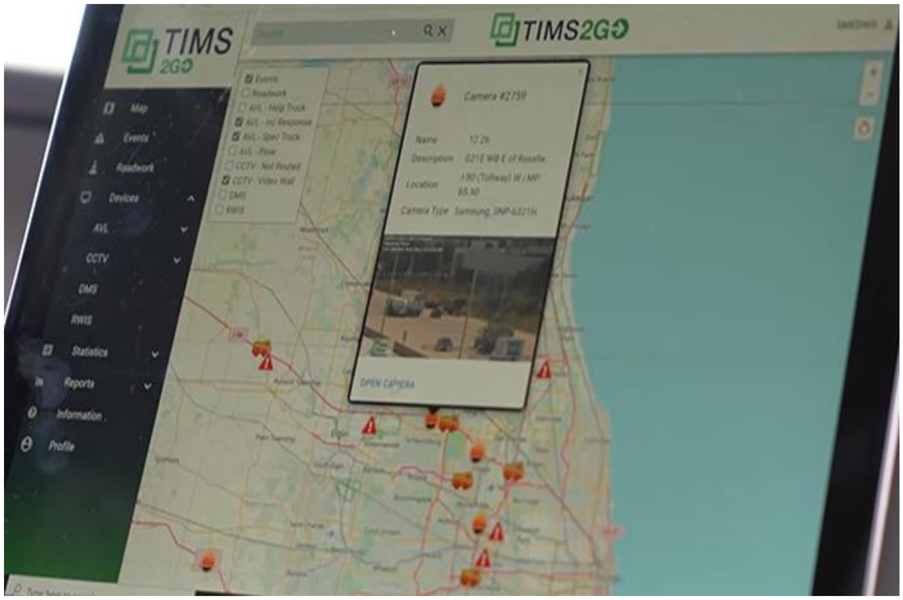
The Illinois Tollway's Traffic Operations Center (TOC) developed the TIMS2GO Mobile Incident Response Tool, which is a mobile-friendly web application. TIMS2GO helps traffic and incident managers gather real-time incident information and direct resources to respond to incidents from anywhere using any smartphone, tablet, or laptop on any browser [99]. The application was developed by Atlas® through its wholly owned subsidiary, Transmart®.

The Illinois Tollway system contains nearly 2,200 ITS devices to cover its five highways across 294 miles in Northern Illinois; these include 1,340 CCTV cameras, 417 vehicle detection systems, 51 dynamic message signs, and 21 roadway weather information systems [100]. On average, the Illinois Tollway is used by approximately 1.6 million drivers each day, and 650 incidents are reported daily.

The TIMS2GO mobile app has been fully operational since 2020, providing instant access to live-streaming video, incident details, and response status updates. Traffic managers efficiently share real-time information with the Illinois State Police, which is responsible for patrolling the Illinois Tollway system, as well as other emergency responders and roadway maintenance personnel [100]. Figure 14 shows the interface of TIMS2GO.

TIMS2GO provides instant, real-time communications to all responders. This enables the Tollway operators to respond to traffic incidents in a timely fashion. TIMS2GO allows emergency responders to take the required actions to reduce the risk of secondary crashes, congestion, and travel delays [101]. The app has been fully integrated with CAD, CCTV cameras, DMSs, and Waze, as well as off-the-shelf solutions such as video streaming platforms to simplify its operations. Responders are dispatched through the app, while an events screen provides details of the incident. Responders can also see details of incident-related DMSs and continuous updates of the incident response.

Figure 14. Interface of TIMS2GO [102]



Staff can check the surrounding area of an incident by zooming in on the installed CCTV. If managers notice additional hazards, they can inform responders ahead of time. Instant information also shows managers which response vehicles have arrived and what progress has been made. As new details become known, that information can be immediately added to the app [102]. Additionally, the responders can monitor the responses at the incident scene without leaving their vehicles, which reduces the risk of injury. Also, the use of the TIMS2GO app reduces the need for telephone conversations between TOC and incident responders, resulting in a more rapid response [101].

Although TIMS2GO provides various functionalities, it also has several limitations. Unlike Mutualink, the available documentation reviewed does not indicate any file-sharing capabilities. Additionally, the platform does not allow different agencies to share their communication resources (e.g., radios, phones, multimedia, text) on the platform. It should also be noted that while TIMS2GO was developed specifically for the Illinois Tollway, it provides a helpful framework that can be utilized by different states across the U.S.

Omnigo

Omnigo is a mobile application and web-based interoperable communication platform that allows the sharing of incident videos, audio, photos, and documents among response agencies involved in incident management [103]. Omnigo is primarily a tool for law enforcement to respond to incidents. The Hazelwood Police Department in Missouri has reported that the use of Omnigo has resulted in a reduction of response time by 50 to 80% [104].

The Omnigo platform has several modules, including CAD, command and planning, records management, evidence management, investigative case management, and asset management. The Omnigo CAD module ensures that responders are dispatched rapidly to locations where they are needed. The module allows responders to receive real-time access to CAD information, search CAD information, and see live and historical CAD event data and activity logs [105]. Additionally, this feature allows the dispatchers to efficiently gather and rapidly transfer the necessary information to the relevant departments, including the nature and location of the incident and how many responders are needed.

Omnigo CAD shares a central database with other Omnigo applications, making all data elements immediately available. CAD can be easily extended to exchange information with federal, state, regional, and third-party systems, including E911 and Automatic Location (AVL). Omnigo CAD has knowledge of responder duty status, vehicle type, and current location. At the time of dispatch, the system automatically recommends responders with the most appropriate training and units best equipped to respond [106].

The command and planning module enables the mobilization and tracking of resources through a central command system. Along with the CAD module, the planning module improves interoperability by enhancing the reporting and tracking of incidents. Additionally, responders with different communication devices can access, monitor, and update information instantaneously from anywhere, which results in more rapid response times. This module also ensures that incident response expectations are met by providing responders with access to detailed response checklists via a mobile device [107]. Responders can also execute and manage response plans by using the central command board map that delivers real-time, location-based information such as deployed resources, surrounding traffic conditions, an active log, and streaming CCTV cameras [108]. However, Omnigo does not permit the sharing of communication resources by different agencies on the platform. This means data from partnering response agencies, including images and video, cannot be shared in real time with all responders. Instead, Omnigo functions as a central command tool to send information and directions to responders.

The third Omnigo module pertinent to TIM is known as investigation case management. This module accelerates the progress of incident investigations by organizing, developing, and managing all cases from a central point of command. Omnigo has a customizable dashboard, and notifications draw immediate attention to any changes or updates to the investigation. This feature easily records and documents interactions with people involved or related to the investigation, including phone calls, emails, and walk-ins [109]. The use of this module could enhance crash investigations at the scene of incidents by allowing data to be collected faster than it is using other methods.

Despite the TIM-related utility of several modules, Omnigo does not have a route planning feature and does not provide multi-channel communications. Additionally, Omnigo has been developed primarily for law enforcement agencies, though it has some applications that are beneficial to TIM efforts.

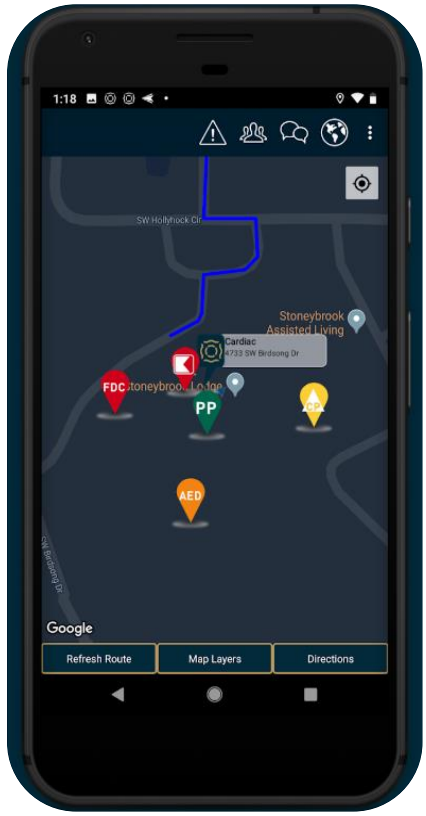
Active911

Active911 is a mobile application and web-based communication platform designed to improve incident response through interoperable and coordinated communications among response agencies. Active911 allows the sharing of text, voice, documents, images, and email. Once an incident occurs, the information from the 911 call is forwarded to Active911 servers. Active911 then sends an alert with CAD information, along with a map and GPS coordinates, to each response agency involved [110].

One of the key features of Active911 is its ability to send instant alerts to responders [111]. Active911, which integrates with the local dispatch system, notifies first responders instantly through mobile devices. These alerts provide important information, such as the incident type and location on a map. Figure 15 shows the Active911 app interface on a mobile phone.

Another unique feature of Active911 is its ability to provide real-time updates [110]. This feature allows users to see who is responding to calls and track their locations on a map. Additionally, Active911 provides accurate mapping and routing, which provides responders with step-by-step directions to the incident location with exact distances [112]. Active911 also features resource labeling on its map. Users can add map markers to identify key locations and attach documents to these markers.

Figure 15. Active 911 mobile app



Active911 is designed to exchange incident-related data among response agencies to improve incident response. The platform supports various file formats, such as PDF, PNG, and JPEG. Data that can be exchanged on Active911 include maps, pre-plans, and alerts. Additionally, to improve coordination and communication during incident response, Active911 allows responders to indicate whether or not they are on shift, which aids in efficient coordination [110]. This communication platform also includes group chat, allowing seamless communication among response agencies. Responders can see others’ responses to an alert [112]. The app also allows users to organize their agencies by different groups, improving the overall coordination by aligning agencies based on incident needs.

ActiveComms, another key feature of Active911, permits users to respond to an alert within the ActiveAlert app [113]. This ability is also extended to allow responders to listen and respond to radio channels using this application on their phones using cellular connectivity [111].

Although Active911 offers various features, it also has several limitations. Unlike Mutualink and Omnigo, the reviewed documents do not indicate any video-sharing capabilities. Additionally, the platform does not have the capacity for detailed customization, such as scenario-based message templates, or integrated incident tracking systems, such as those found in TIMS2GO.

Other Platforms

Other interoperable platforms that may be used for TIM include Alert Media and Crisis Go. These platforms were not reviewed extensively due to limited information regarding their features. These public safety platforms are web-based interoperable communication platforms with mobile applications. Response agencies can communicate and coordinate incident response through text messages, emails, voice messages, and conference calls. Alert Media makes it possible for users to create chat groups and invite relevant personnel to share information related to incidents, while Crisis Go permits the integration of existing ITS infrastructure onto the platform. The two platforms have modules to enhance interoperability and the sharing of information to responders.

Table 3 summarizes the key features of interoperable and interagency communications offered by RIMIS, Mutualink, TIMS2GO, and Omnigo for incident management. Additional features and limitations of the interoperable platforms are included in Appendix D.

Table 3. Summary of interoperable communication platforms

	RIMIS	TIMS2GO	Mutualink	Omnigo	Active911
Application Type					
Web-Based	✓	✓	✓	✓	✓
Mobile-Application		✓	✓	✓	✓
Data/Information Sharing					
Data Sharing Groups			✓		✓
Multimedia		✓	✓	✓	✓
Map/Location		✓	✓	✓	✓
Integration to Resources					
Existing ITS Infrastructure	✓	✓		✓	
Existing Communication Network/Devices			✓		✓
Communications					
Chat/Data Groups			✓		✓
Voice		✓	✓	✓	✓
Text			✓		✓
Multi-channel			✓		✓
Data Management/Security					
Data Security		✓	✓	✓	✓
File Editing				✓	
File Tracking				✓	
Licensing Requirement			✓	✓	✓
Response Monitoring					
Emergency Route Optimization	✓				✓
Response Logs		✓	✓	✓	✓
Lane closures/Traffic Condition Notification	✓	✓		✓	✓

Considerations and Lessons Learned from Integrating Interoperable Communication Platforms into TIM

Integrating an interoperable communications platform into an agency's TIM is a challenge on many levels. Transportation agencies that attempt to integrate interoperable platforms into their TIM operations are confronted by institutional, technical, financial, and other obstacles. The research team consulted with three agencies that had successfully integrated interoperable platforms into their TIM operations to document factors to consider and lessons learned from their experience.

Managers and TIM practitioners from the Illinois Tollway, Florida DOT, and the City Government of Columbia, South Carolina, operating TIMS2GO, Mutualink, and Active911, respectively, were interviewed. A sample of the interview questions can be found in Appendix A. The considerations and lessons learned are discussed in the following two sections.

Gain Leadership Buy-In

Support from agency leadership is crucial for the successful integration of an interoperable communications platform into TIM. Leadership support ensures that resources are dedicated to the implementation and sustainability of the integrated platform [76]. In addition to leadership buy-in, support from the agencies participating in TIM is equally necessary. Leadership buy-in may be gained by highlighting the added benefits that will be obtained by integrating the interoperable platform into TIM. Efforts to gain leadership buy-in from various TIM agencies are bolstered by forming a task force to advocate for the platform.

Engage with Stakeholders, Including Actual Users

TIM stakeholders should be engaged when considering the integration of interoperable platforms into the current system. This step aids leaders in defining functional requirements, data sharing, and funding needs, among other items. It is also important to include actual users, such as TMC supervisors and operators, rather than executives only.

Clearly Define Functional Requirements

The functional requirements of the interoperable platform should be clearly defined. The requirements should be specific and fit multiagency expectations and use-purpose. Requirements from actual users should be incorporated to ensure the product is used effectively after integration with TIM systems. Where appropriate, interoperability standards should be included in defining functional requirements.

Utilize Interagency Agreements

Interagency agreements are recommended as a part of integrating an interoperable platform into an agency's system. It is important that agencies commit to writing agreements that reinforce elements critical to program sustainability. Interagency agreements highlight the responsibilities of all agencies and encourage collaboration. Also, the agreements may specify guidelines, support, and performance, as well as the share of funding required by each agency. These agreements may include MOUs, Memoranda of Agreement, and SOPs.

Engage with Legal Departments Early in the Process

Agencies wishing to introduce an interoperable platform that integrates with other agencies' communication resources must involve their legal department in the early stages of the process. Issues related to nondisclosure agreements, privacy policies, and sensitive information should be reviewed by the legal department of each participating agency. Policies regarding the storage, distribution, archival, and ownership of data must be discussed as well.

Create a Long-Term Operating Budget

The costs of purchasing, installing, operating, and maintaining an interoperable platform, as well as the cost of training personnel, should be addressed early and in-depth. According to the Law Enforcement Guide for Interagency Interoperable Communications Projects, funding for interoperable communications should be sustainable and come from recurring revenues readily available and distributable across all system costs [48]. The funding should come with few, if any, legal or stakeholder challenges. Capital costs for the platform installation may be substantial, but its operating costs may be minimal over its lifespan. These costs are usually offset by the benefits in the long term. Funding may come from highway revenues, departmental budgets, or grants.

Address Compatibility Issues

System compatibility presents challenges that must be overcome before integrating with an interoperable communications platform. TMC and law enforcement systems such as ATMS and CAD may be incompatible with interoperable platforms, leading to difficulties in integration and utilizing relevant platform tools. Compatibility challenges should be discussed with other TIM agencies and platform vendors before a decision is made to purchase any platform. Discussions with agency technical teams may also be beneficial in identifying and advising on any insurmountable compatibility issues.

Design an Interoperable Platform that is Intuitive and Simple to Operate

The interoperable platform should be intuitive and simple, not requiring complicated navigation or the opening of multiple pages. Complex designs may compromise safety and lead to the rejection of the platform by actual users despite a substantial investment made by agency leaders.

Leverage Current TIM Systems for Integration

Building an interoperable communications platform on existing systems, such as the ATMS, offers several advantages. These include a lower learning curve for operators and reduced installation and equipment costs. Operators will be encouraged to learn and utilize new systems for TIM.

Address System Security

The security of the system is a shared responsibility of the agencies that use the interoperable platform and should be discussed from the outset. The security of individual agency cyber resources shared with multiple agencies could be ensured by providing access only to relevant systems. Additionally, agencies could restrict or prevent information from being extracted from their system. Instead, the interoperable platform could only provide a way to disseminate information to other agency systems without allowing access to the agency's internal system. It is important, however, that the implementation of security considerations not result in a cumbersome system that discourages widespread use. For example, the use of one password by each operator for all integrated systems on the interoperable platform results in a better user experience rather than requiring different passwords for different systems. It is also important that only authorized users have access to the interoperable platform, where regular security scans are conducted. The need for security should be emphasized to all operators from participating agencies utilizing the interoperable platform. A proactive approach to handling security issues should be adopted, and security breaches should be immediately communicated to all participating agencies.

Lessons Learned

The managers and practitioners interviewed regarding the integration of interoperable communication platforms into their TIM shared several lessons they learned during the integration and use of these platforms.

Select Only Features That Have Value to the Agency's TIM

Commercially available interoperable communication platforms have many features that may not be applicable to an agency's TIM. TIM managers should ensure that only features that enhance TIM operations are purchased. Purchasing complete suites with broad functionality is unproductive and expensive, as some of the features may be utilized minimally or not at all.

Integration of Interoperable Communications Platform Enhances Coordination

One TIM practitioner indicated that integrating an interoperable platform into their TIM enhanced cooperation. This coordination was improved due to agencies working together to integrate into the interoperable platform so that most of their needs are met. This enhanced coordination resulted in several agencies actively investigating areas to reduce their TIM timelines.

Previous User Experience with Interoperable Platforms is an Advantage

Several of the TIM practitioners interviewed noted that previous agency experience with an interoperable communications platform makes integration into TIM easier. For example, several law enforcement agencies in Florida utilized Mutualink for public safety purposes years before stakeholders started discussing its integration with TIM. With their previous experience with the platform, the law enforcement agencies communicated the advantages of Mutualink. This paved the way for other TIM agencies to join the platform.

Interoperable Communication Platforms Do Not Hinder the Work of Responders

Interoperable communication platforms do not hinder the work first responders, but rather are tools that improve incident response if used properly. The TIM managers interviewed agreed that the use of the communication platforms did not distract first responders from their duties, nor did they compromise safety. They attributed this to the design of the platforms, in which information is presented in such a way that first responders only need a short time to look at their devices to understand the information being presented to them.

Treat Interoperable Communication Platforms as Secondary Support Systems

The interoperable platforms provide support and enhance TIM operations but are not a replacement for traditional TIM systems. Maintaining and strengthening existing TIM systems and procedures is required to efficiently integrate and utilize these platforms. For example, strong and defined communication protocols are needed to fully utilize and gain the benefits of interoperable communication platforms.

Benefits of Well-Integrated Interoperable Communication Platforms Outweigh Costs

The TIM practitioners interviewed suggested that the integration of interoperable platforms resulted in substantial benefits compared with its costs. These benefits were realized from improved situational awareness, reduced TIM timelines, and enhanced interagency cooperation. None of the managers and practitioners interviewed directly measured performance improvement due to the integration of the interoperable platform into their TIM systems and operations, but they anecdotally linked TIM improvement to the new communications technology.

Conclusions

The primary aim of this study was to improve incident response through coordinated, interoperable communications in Louisiana. This was achieved by conducting an operational needs assessment and performance evaluation in Louisiana, identifying areas of needed TIM improvement and proposing interoperability as a solution to communication gaps. Recommendations are provided for TIM improvement, including the advancement of interoperable communication for incident response based on the results of the assessment.

To fulfill the objectives of the project, the research team conducted an information review regarding TIM goals and benefits, strategic program elements, and stakeholder responsibilities in incident response. The importance of coordinated interoperable communications in TIM was also examined. This review identified challenges associated with achieving coordinated interoperable communications. These included technical, institutional, and communication challenges.

Next, TIM best practices were reviewed. This task was performed to identify the best TIM practices to be used as a benchmark for evaluating Louisiana's TIM program. TIM best practices refer to programs, plans, and resources utilized in TIM to fulfill its goal of safe, quick clearance of incident scenes. Best practices were identified broadly under TIM communications, TIM organization, response and clearance policies, performance monitoring, and TIM funding. These practices were identified and discussed by relying on relevant published reports and documentation from the federal government, states, and other agencies involved in TIM.

TIM practice in Louisiana was assessed next. Stakeholders, resources, areas of operation, performance measures, and communications interoperability, including communication among agencies during incident response, were discussed. Additionally, a needs assessment was conducted using the findings from the identification of best practices. This assessment was conducted through interviews and a survey of first responders.

Several interoperable communication platforms were evaluated in terms of their features and limitations. The platforms evaluated were RIMIS, Mutualink, TIMS2GO, Omnigo, and Active911. All of these platforms are web-based and have features that may enhance communications during TIM. Most of the platforms can be viewed and used on mobile phones, tablets, and laptops, and some can be configured to work with existing radios used traditionally in TIM. Integration with GIS maps, automatic notifications, and the ability to share data seamlessly across multiple agencies are all strengths of these interoperable communication platforms.

TIM managers and supervisors from various jurisdictions discussed considerations and lessons learned from integrating interoperable communication platforms into TIM. These managers and supervisors from Illinois, South Carolina, and Florida have integrated TIMS2GO, Active911 and Mutualink, respectively, into their TIM.

Major conclusions drawn from this project include:

- Louisiana has communications interoperability, which is primarily used in large events such as hurricane response. Interoperable communications in the state are primarily executed through voice via trunked-radio systems. While the state's communications interoperable system functions well as a reliable means of communication during incidents, it lacks several critical features. Features available in commercially web-based platforms could be used to improve interoperable communication. The use of these interoperable platforms allows response agencies to share communication resources only when needed and desired without foregoing the ownership of these resources. For example, the use of chat groups on the platforms permits the sharing of relevant information to vetted people only without sharing dispatch communication. Additionally, there is no need to overhaul the communications infrastructure or make large equipment purchases to use these web-based platforms.
- A review of TIM communication in the state during incident response indicated that interagency communication primarily occurs through dispatchers. While this is convenient and reduces the risks of sensitive information being shared, it predisposes TIM information sharing during incident response to delays and loss of information, especially during large events. In critical incidents where information is needed quickly to make decisions, the use of interoperable platforms could enable supervisors to speak directly to one another, leading to faster information sharing. Additionally, the absence of direct communication between law enforcement and the TMC, especially in areas where MAP does not operate, could lead to delays in updating information systems needed by the public to make travel decisions.

- Interoperable communication platforms could enhance Louisiana's TIM and address the communication gaps identified, especially in large incidents. The use of chat groups in which supervisors may communicate directly with one another without relying on multiple dispatchers could be beneficial for prompt and accurate information sharing. Additionally, the ability to use different communication devices on these platforms would allow multimedia information that enhances situational awareness to be shared, possibly contributing to better decisions on incident response.
- TMCs are not fully integrated with law enforcement CAD. Instead, TMCs rely on the public web pages of CAD shared by different parishes. This information, while important, is mostly unconfirmed and is not integrated seamlessly with TMC software. Additionally, this requires TMC operators to manually enter information about incidents into the ATMS. The lack of law enforcement CAD-TMC integration has been attributed to regulations limiting the sharing of sensitive information to unauthorized personnel. Reports from other states have indicated that law enforcement CAD-TMC integration is beneficial to TIM in reducing response times. Other states have overcome this issue by using filtering systems to avoid sharing sensitive information with TMC personnel.
- Most TMCs are not co-located with other response agencies. Only the Baton Rouge TMC is co-located with dispatchers from police and EMS. There are efforts to remedy this situation; currently, officials are attempting to find a shared space for the TMC and other response agencies in Lake Charles. However, funding to achieve co-location remains a challenge.
- Louisiana's TIM program needs to be reorganized and strengthened. A TIM program forms the bedrock of any incident response organization in a jurisdiction. The implementation of an efficient and strong TIM program is integral to solving many issues related to the efficient operation of TIM in the state. This is because a successful and efficient TIM generally requires a formal TIM program, including interagency coordination, incident response plans, regular TIM meetings, TIM training, SOPs, and joint training, among other items. Forming and strengthening formal TIM programs statewide, regionally, and locally is the first step to enhance TIM.
- Neither regular TIM meetings nor joint training exercises are held currently in Louisiana. This often leads to personnel from stakeholder agencies being unfamiliar with other response agencies in TIM. For example, not all law enforcement officers who work in TIM are aware of the function of TMCs. Additionally, the lack of regular TIM meetings means that TIM planning is inefficient at most local levels.

- Several TIM performance measures and metrics have been identified and are being collected, but these metrics are currently not shared with other response agencies. This is a recent effort by TIM managers in the tate, who have identified these performance measures to collect as they evaluate TIM. Sharing performance metrics will be most useful only if TIM is organized into regional and local groups.

- There is a shortfall in TIM funding. Without adequate investment, progress and improvement in TIM in the state will not occur. Budgetary constraints have hampered the expansion of MAP and TMC coverage, space rentals for co-location, and the purchase of additional ITS devices, including CCTV cameras. Additionally, incorporating the next generation of TIM technologies will not be achieved without significant budgetary increases. Discussions with TIM managers indicated that the DOTD budget for TIM has not seen a significant increase over the last two decades despite the steep rise in the price of goods and services.

- There are institutional, legal, and operational obstacles that must be overcome to improve TIM. For example, the lack of CAD integration with the TMC, attributed to security and privacy concerns, can be solved institutionally by political leadership. Additionally, changes in communication protocol to allow more information sharing between the TMC and other response agencies, as well as laws to indemnify ATMS data from liability, cannot be achieved by TIM supervisors and managers alone but instead requires effort from institutional leadership as well.

- Considerations to prepare for the integration of interoperable platforms include gaining leadership buy-in, engaging with stakeholders, including actual users, clearly defining functional requirements, engaging with the legal department, and creating long-term budgets. Other considerations include selecting an intuitive and simple platform and addressing compatibility issues across agencies.

- The TIM managers interviewed indicated that the benefits of integrating their respective interoperable communications platforms outweighed the costs in terms of improving incident response and enhancing interagency coordination. They also suggested that the previous experience of one or more agencies with these platforms made it easier to convince other agencies to be part of the integration. The managers also emphasized that the interoperable communication platforms should be treated as secondary support systems.

Recommendations

This section outlines recommendations for advancing TIM in Louisiana to fulfill its part in the goal for Destination Zero Deaths.

- Web-based interoperable communication platforms that permit the sharing of voice, text, data and multimedia information should be integrated into Louisiana's interoperable communication system. This will enhance Louisiana's TIM coordination and response, especially for large events involving multiple response agencies. The advantage of these web-based systems is that they readily integrate with the communication infrastructure of partner agencies without requiring an overhaul of operational communication systems. The expansion of the federally supported FirstNet also provides opportunities to enhance interoperability using many features available on commercial systems while also being assured of system security.
- When considering the purchase of a commercial web-based interoperable platform, it is important to select only features that are deemed important by TIM managers and operators. The purchase of too many features may overwhelm users and lead to an underutilization of other important features.
- Efforts should be made to fully integrate law enforcement CAD into TMC systems. This integration would automate several aspects of incident response for the TMCs. Such an undertaking is challenging, requiring new protocols and legislation, but it has been successfully achieved in other states. This need should be brought to the attention of state executives who may have the power to influence legislation.
- Louisiana's TIM should be reorganized and strengthened. This reorganization should focus on forming TIM committees at the local and regional levels. The statewide TIM steering committee should then coordinate the development of standardized TIM program elements such as SOPs, communication protocols, interagency agreements, and joint training exercises. Additionally, current traffic safety coalition meetings in regions across the state can serve as platforms to start or revive regular TIM meetings.
- A common hallmark of many successful TIM programs is the presence of as many champions as possible. TIM champions should have a sustained personal interest in the program's success.

- TMC and MAP coverage should not only be preserved but also extended to more urbanized areas in Louisiana. Because the majority of TIM stakeholders in the state acknowledge that TMCs and MAP are valuable TIM resources, these programs should be expanded.
- Legislative support should be secured for several of the proposed TIM improvements. These include issues such as increased TIM funding, the integration of law enforcement CAD into TMC systems, and indemnifying the ATMS from liability so that more TIM data can be stored.
- Efforts to revive the use of performance measures to track TIM performance in the state should be encouraged. These performance measures should also be shared with TIM partner agencies so that progress on a successful TIM program will be a shared responsibility.
- A mechanism should be established for reviewing and updating TIM policies regularly to incorporate technological advances and current best practices. This will ensure that the TIM program remains adaptive and effective.
- The federal government is promoting several next generation TIM technologies, including advance warning systems, NG911, UAVs, and emergency vehicle lighting, among others. The state should embrace these technologies and incorporate them as they become available.
- A well-functioning and successful TIM program relies heavily on sustained funding. Given that the DOTD budget for TIM has not substantially increased in recent years, it is crucial to explore dedicated sources of funding, including federal resources.

Acronyms, Abbreviations, and Symbols

Term	Description
AASHTO	American Association of State Highway and Transportation Officials
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management Systems
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
CAD	Computer-Aided Dispatch
CCTV	Closed-Circuit Television
CHART	Coordinated Highways Action Response Team
CISA	Cybersecurity and Infrastructure Security Agency
DHS	Department of Homeland Security
DMS	Dynamic Message Sign
DOTD	Louisiana Department of Transportation and Development
DVRPC	Delaware Valley Regional Planning Commission
EMD	Emergency Management Department
EMS	Emergency Medical Service
EOC	Emergency Operations Center
ERSI	Emergency Responder Safety Institute
FHWA	Federal Highway Administration
FirstNet	First Responder Network Authority
GIS	Geographic Information System
GOHSEP	Governor’s Office of Homeland Security and Emergency Preparedness
HAR	Highway Advisory Radio
ICS	Incident Command System

Term	Description
ICT	Incident Clearance Time
IP	Internet Protocol
IRP	Incident Response Plan
ITS	Intelligent Transportation System
LMR	Land Mobile Radio
LODD	Line of Duty Death
LTE	Long Term Evolution
LTRC	Louisiana Transportation Research Center
LWIN	Louisiana Wireless Information Network
MAP	Motorist Assistant Patrol
MOU	Memorandum of Understanding
MPO	Municipal Planning Organizations
NG911	Next Generation 911
NHI	National Highway Institute
NHTSA	National Highway Traffic Safety Administration
NIMS	National Incident Management System
NTIMC	National Traffic Incident Management Coalition
NUG	National Unified Goal
NRF	National Response Framework
PSAP	Public Safety Answering Point
PSTN	Public Switched Telephone Networks
PTT	Push-to-Talk
RCT	Road Clearance Time
RFID	Radio Frequency Identification
RIMIS	Regional Integrated Multimodal Information Sharing
SAFECOM	Aviation Safety Communiqué

Term	Description
SAS	Security and Administration
SIEC	Statewide Interoperable Executive Committee
SOP	Standard Operating Procedure
SSP	Safety Service Patrols
TIM	Traffic Incident Management
TIMSA	Traffic Incident Management Self-Assessment
TIME	Traffic Incident Management Enhancement
TOC	Traffic Operations Center
USDOT	United States Department of Transportation
VMS	Variable Message Signs

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Appendix

Appendix A: List of Resource Personnel

1. Lucy Kimbeng
   ITS Supervisor
   Louisiana DOTD
   Baton Rouge, LA
2. Rosalinda Deville
   ITS Systems Integration Manager
   Louisiana DOTD
   Baton Rouge, LA
3. Ryan Reviere
   Traffic Incident Management Engineer
   Louisiana DOTD
   Baton Rouge, LA
4. Robert Mills
   Traffic Incident Management and Training Coordinator
   Consultant, Louisiana DOTD ITS Group
   Serco
   Baton Rouge, LA
5. Kaisey Seegmiller
   Statewide Baton Rouge TMC Supervisor
   Serco
   Baton Rouge, LA
6. Jennifer Tircuit
   Statewide Baton Rouge TMC Supervisor
   Serco
   Baton Rouge, LA
7. MaryAnn Nickles
   Quality Assurance/Quality Control and Media Liaison
   Consultant, Louisiana DOTD ITS Group

Serco
Baton Rouge, LA

8. Gordon McConnell
   Project Manager, Louisiana DOTD Statewide TMC
   Serco
   Baton Rouge, LA

9. Richard Ardis
   MAP Regional Supervisor
   Serco
   Baton Rouge, LA

10. Brad Waldrep
    Chief of Operations, West Baton Rouge Parish Fire
    Port Allen, LA

11. Lt. Ken Albarez
    Traffic Division, West Baton Rouge Parish Sheriff's Office
    Port Allen, LA

12. Stephen Phillippe
    Kenner Emergency Management
    Kenner, LA

13. Keesler Ely
    Livingston Parish Fire Protection, District 4
    Livingston, LA

14. Cpt. Jack Varnado
    Livingston Parish Sheriff's Office
    Livingston, LA

15. Lt. Jessie Shelton
    Louisiana State Police, Troop A
    Baton Rouge, LA

16. Tom Harris
    Baton Rouge EMS
    Baton Rouge, LA

17. Sheryl Bradley
    ICM Consultant
    Consultant, FDOT District 5 Traffic Operations
    AECOM
18. Bini William
    Director of Engineering and Design Services, Parson
    Consultant, Illinois Tollway
    Schaumburg, IL
19. Elyse Morgan
    Traffic Operations Center Manager, Illinois Tollway
20. Marcas Houtchings
    Communication Officer, City Government
    Columbia, SC
21. Rick Bauer
    Business Development Manager
    Intelligent Transportation Systems, Inc.
    Baton Rouge, LA

Appendix B: Sample Interview Questions for TMCs and Other TIM Agencies

Goals, Objectives, Incident Detection and Verification

- What are the stated goals and objectives of TIM in your agency?
- How does the TIM program prioritize its goals and objectives?
- What is your agency's role in TIM?
- What types of incidents have you experienced most frequently in your area?
- How do you evaluate the effectiveness of your incident documentation and data analysis processes?
- How do you categorize incidents and track them in your incident management system, and what data do you collect about each incident?
- For a large incident, such as a crash involving several vehicles, please discuss the incident response process.
- How does the TMC verify the location of an incident, and what tools and techniques are used to identify the exact location?
- How does the TMCs verify the severity of an incident, and what factors are considered in determining the severity level?
- How do the TMCs work to improve incident detection and verification processes over time, and what types of evaluation and feedback are used to inform these improvements?

Incident Response

- What types of data are collected and analyzed to support incident response?
- Which agencies are involved in incident response?
- Do you have a TIM standard operating procedure?
- What emerging technologies would be of use in supporting incident response?
- Please discuss the role of ATMS in incident detection, verification, and clearance.
- What are the limitations and challenges of using ATMS in incident response?

- What protocols do you have in place to escalate an incident response, and how do you determine when to escalate to a higher level of response?
- How do you ensure that your response efforts are proportional to the severity and impact of the incident?
- What types of ongoing maintenance and support are required to keep technology systems functioning optimally, and how is this managed?

Communications

- Please discuss the communication flow from incident detection to clearance.
- What measures are in place to ensure clear and effective communication during incidents?
- What communication devices are used during incident response?
- Please describe your agency's communication with other TIM agencies during incident response.
- What restrictions do you have regarding communications with the TMC?
- What are the roles of dispatch within your agency regarding TIM communication?
- What are the communication problems you face during traffic incident response?
- What other communication equipment would enhance your communications during incident response?
- Why is your agency's CAD not integrated with the TMC systems?
- What are the concerns you have about integrating CAD with the TMC?
- What aspects of TIM communication would you like to see improved?
- What is the standard operating procedure for communication between the TMCs and responding personnel?
- To what extent does TMCs have a system in place to notify relevant on-scene responders and healthcare facilities, and filter incidents to avoid unnecessary calls?

TMC Operation

- What are the key components of Louisiana TMC operations?
- How does TMC Dashboard operate?
- What are the standard operating procedures for operating Louisiana's TIM systems?

Data Sources

- What are the primary data sources used by the TMCs for incident response?
- What technologies are used to transmit data to the TMCs during an incident?
- How do Louisiana TMCs verify the accuracy and reliability of incoming data from different sources?

Data Collection

- What are the key parameters that need to be collected during data collection and why?
- What data collection methodologies are used during major events, such as natural disasters, in TIM?
- What techniques are used to ensure that data is collected in real-time in Louisiana TIM?
- What is the role of different stakeholders in data collection in Louisiana TIM?
- How do the TMCs collaborate with incident responders during collection and sharing of data?
- How are emerging technologies incorporated into data collection in Louisiana TIM?
- What is the level of privacy protection for collected data in Louisiana TIM?
- Is there any software application developed for smartphones by Louisiana TMCs for data collection related to incidents? Are there any plans to incorporate such a system?

Data Management

- What kind of data do TMCs store?
- How do Louisiana TMCs manage data?
- How do you store data?

- How do you ensure the security and reliability of your data storage?
- Have you faced any challenges while storing data, and how did you overcome them?
- How do you decide which data storage method is best for a particular type of data?
- What data management protocols are in place to ensure data is managed efficiently in Louisiana TMCs?
- Is data generated by Louisiana TMCs used other than in TMC operations? Is it accessible to other departments or groups to be used for public safety?
- Do they need to sign a Memorandum of Understanding for sharing of information?

Data Sharing

- What tools and technologies are used to facilitate data sharing at the Louisiana TMCs?
- What data sharing policies are in place at the TMCs?
- What are your TIM data needs?
- How do TMCs ensure the accuracy of shared data?
- What data sharing agreements exist between the TMCs and other agencies?
- How are Louisiana TMCs working to improve data sharing with other transportation agencies and stakeholders?

TIM Performance Measures

- Have the current Louisiana TMCs established methods to collect and analyze the data necessary to measure performance?
- Has the TIM program of Louisiana achieved TMC-CAD integration so that incident data and video information is transferred between agencies and applications? If not, when they are planning to integrate it?
- How interoperable is the TIM response in Louisiana?
- What interoperability standards and protocols are in place to facilitate communication and data sharing between different systems and agencies?

- What barriers have you identified to interoperability, and what steps have you taken to address these barriers?
- Do you have shared TIM performance measures with other agencies?
- Can you provide an example of a recent incident where interoperability was a challenge, and how it was addressed?

Emerging Technologies

- Which type of Intelligent Transportation Systems do Louisiana TMCs use to handle incident management?
- Which software do TMCs' staff think can give more efficiency, but are not currently installed in their system?
- What are some of the most significant challenges or limitations that the TMC faces when it comes to utilizing technology in its operations?
- How does the TMC evaluate and prioritize new technology systems and tools to determine whether they are a good fit for the organization's needs?
- Can you describe some of the key standards and protocols that the TMC follows when managing incidents?

Incident Management

- What are the components of incident management strategies at TMCs?
- Can you describe the scorecards and dashboards used by the TMC for external and internal reporting, including what types of data are tracked and how the data is presented?
- How are the scorecards and dashboards shared with internal stakeholders, such as TMC staff and management?
- How are the scorecards and dashboards shared with external stakeholders, such as other agencies and the public?
- How do you ensure that the scorecards and dashboards remain relevant and useful over time?
- Can you provide any examples of how the scorecards and dashboards have helped the TMC identify and address areas for improvement?

Other

- How do TMCs respond to unplanned special events, such as university football games, national security special events, shows, etc.? Which special equipment did they use in these cases?
- Do you attend regular TIM meetings?
- Are you involved in joint TIM training exercises?
- What other equipment would enhance your TIM operations?

Appendix C: Survey of Traffic Management Center Supervisors

Consent and Information Form

Title of the Study: Improved Incident Response through Coordinated, Interoperable Communications - 23-5SS

Traffic incidents on U.S. highways require a coordinated and efficient response to reduce exposing travelers' and responders' lives to risk and to lower delays. Congestion resulting from incidents can lead to secondary crashes, further increasing safety risks and economic costs. Interagency communication, exchange of information, and data sharing are key to achieving a rapid and efficient response to highway incidents. The Louisiana Department of Transportation and Development (DOTD), in an effort to improve incident response through coordinated interoperable communications in Louisiana - has commissioned this study.

As part of the study, a survey questionnaire has been developed to gather information on communication and operations of Traffic Management Centers (TMCs) in Louisiana as a means to conduct an evaluation of TIM in the state. Specifically, the questionnaire seeks to:

- Solicit information on interagency communication during incident response
- Understand TMC communication, use of technology, and data utilization
- Identify needs and areas of TIM improvement

If you agree to participate, you will be asked to complete a questionnaire consisting of (1) incident detection, verification, and response, (2) interagency communications, (3) data sharing and collection, (4) technological needs, and (5) performance monitoring. The survey will take 10-15 minutes to complete. Your responses will be collected and analyzed for the purpose of the study. Please complete and return this survey by August 20, 2024.

All comments and questions may be addressed to:
Milhan Moomen, Ph.D.
Research Assistant Professor/ITS & Traffic Research Manager
4101 Gourrier Avenue
Baton Rouge, LA 70808
(225) 767-9161
Milhan.Moomen@la.gov

Name:

Email:

Position at TMC:

(Contact information is only being collected in the event that there is a need to follow up with some additional questions)

1. Please indicate where your TMC is located in Louisiana.
   - Baton Rouge (Regional TMC)
   - Baton Rouge (Statewide TMC)
   - New Orleans
   - Shreveport
   - Houma
   - Lake Charles

2. How many years have you worked in a TMC?
   - Less than 1 year
   - 1-3 years
   - 4-7 years
   - More than 7 years

3. Approximately how many miles of highways are within the responsibility of your TMC? ____________
4. How many shifts do you run? _____
5. What is the staffing number per shift? ______
6. What is the number of supervisors per shift? _____
7. How many operators are in a shift? _____

Incident Detection, Verification and Response

8. How would you rate the promptness/fastness of incident notification by your TMC systems after an incident has occurred? (please select one)

    — Very quick notification

    — Quick notification

    — Neither quick nor slow notification

    — Slow notification

    — Very slow notification

9. What are the most common challenges that your TMC faces during incident response? (please select two)

    — Difficulty locating the site of the incident

    — Coordination among response agencies

    — Difficulty routing responders to the site of incident

    — Unreliable communications

    — Dispatcher overload

    — Slow detection and response

10. What are the common challenges to effective scene management and traffic control? (please select all that apply)

    — Confusion over authority/roles

    — Poor accessibility of incident location

    — Difficult on-scene maneuverability

    — Responder safety

    — Excessive delay

— Dispatcher overload

— Other (please specify) ____

11. According to your judgment, how would you describe the degree of automation of your system for incident response? (*note: automatic detection, location, and notification of incidents are examples of automated processes*) (please select one)

— Fully manual

— Partially automated

— Mostly automated

— Fully automated

12. Which of the following do you have as part of your incident response? (please select all that apply)

— Response vehicle parking plans

— Alternative route plans

— End-of-queue warning systems

— On-scene emergency lighting procedures

— Traffic management plans

— Personnel/equipment resource lists

— Equipment staging areas/pre-positioned equipment

13. Does your TMC have access to shared law enforced computer aided dispatch (CAD) data? (*note: CAD systems are used by dispatchers and 911 operators to prioritize and record incidents, dispatch responders, report incidents, show vehicle status, and manage information data*)

— Yes

— No

14. How would you rate the impact of integrating police computer aided dispatch (CAD) into TMC operations? (*note: CAD systems are used by dispatchers and 911 operators to prioritize and record incidents, dispatch responders, report incidents, show vehicle status, and manage information*) (please select one)

— Integrating police CAD into the TMC will hinder TIM operations

— Integrating police CAD into the TMC will improve TIM operations

— Integrating police CAD into the TMC will neither improve nor hinder TIM operations

Communication

15. Which procedures are commonly used for communicating with the public during major incidents in your jurisdiction? (please select all that apply)

— Issuing press releases

— Posting updates on social media platforms

— Broadcasting emergency alerts through radio and TV stations

— Deploying dynamic message signs (DMS) on roadways

— Other (please specify) ____

16. Which of the following communication challenges have you encountered the most in your TMC? (please select all that apply)

— Inadequate staffing for managing communication operations

— Difficulty in relaying critical information to emergency responders

— Technical issues with communication equipment

— Radio blackouts

— Other (Please Specify) ____

17. Which of the following most common technological barriers in communication does your TMC face? (please select all that apply)

— Inability to communicate across a common platform

— Communications equipment not available in emergency response vehicles

— Communications mechanisms not available during non-office hours

— Insufficient redundancy for some communications systems, making them vulnerable to loss of functionality

— Insufficient training, coordination, and planning between agencies to establish usage parameters

— Other (Please Specify) ____

18. Apart from MAP, which other first responder agency do you communicate most with during incident response? (please select one)

— Law enforcement

— Fire

— Emergency medical services (EMS)

— Towing and recovery

19. What is the level of TMC communication with law enforcement during incident response? (please select one)

— Frequent communication

— Occasional communication

— Rare communication

— No communication

20. In your opinion, would more communication with law enforcement during incident response improve Traffic Incident Management (TIM) in your jurisdiction? (please select one)

— More communication with law enforcement will NOT improve TIM

— More communication with law enforcement will neither improve nor worsen TIM

— More communication with law enforcement will improve TIM

21. How would you rate the level of communication and collaboration between your TMC and the other response agencies, using a rating of 5 for very good communication/collaboration and 1 for least communication/collaboration.

— Law enforcement (Rating ___)

— Fire (Rating ___)

— Emergency medical services (EMS) (Rating ___)

— Department of Transportation (Rating ___)

— Towing and recovery (Rating ___)

22. In your jurisdiction, do you have standardized communication terminology/protocol common to the TMC and other responding agencies (e.g., law enforcement, fire department, emergency medical services)? (please select one)

— Yes

— No

23. How often do you use alternative communication devices (e.g., cell phones, tablets, laptops) to communicate/exchange information with MAP and other first responders? (please select one)

— Frequently

— Occasionally

— Rarely

— Never

24. Communications interoperability refers to the ability to communicate and share information instantly whenever needed. Enhanced communications interoperability allows for communication across multiple networks and devices (e.g., radio, cell phones, tablets, laptops), as well as the sharing of information (e.g., text, pictures, video, data).

    From your point of view, to what extent will enhanced interoperability improve TIM operations for your TMC? (please select one)

— Somewhat detrimental to TIM operations

— Very detrimental to TIM operations

— Neutral

— Helpful to TIM

— Very helpful to TIM

25. Please state how enhanced interoperability may improve or hinder TIM during incident response (please attach an additional sheet to answer question if needed).

____

____

____

26. What concerns you the most about integrating enhanced interoperability (e.g., use of cell phones, tablets, laptops to access and share information) into your current incident response operations? (please select three)
    - Increased response time
    - Responder safety due to first responder distraction
    - Need for additional training to use devices and technology
    - Cost of integrating enhanced interoperability
    - Cybersecurity, data privacy and confidentiality issues
27. Which of the following communication strategies have been most effectively used in improving incident response in your juridiction? (please select all that apply)
    - Use of social media for incident reporting and public communication
    - Use of dynamic message signs (DMS)
    - Implementation of interoperable communication systems among agencies
    - Deployment of mobile data terminals in emergency vehicles to access critical information in real-time
28. How would you rate your level of satisfaction with the current communication system for incident response? (please select one)
    - Very Dissatisfied
    - Somewhat Dissatisfied
    - Neutral
    - Somewhat Satisfied
    - Very Satisfied

29. What aspects of your TMCs communication system would you like to see improved? (please attach an additional sheet to answer question if needed).

____

____

____

30. Does your TMC collaborate with news media and information service providers for the dissemination of traffic-related information to the public? (please select one)

— Yes, always

— Yes, often

— Rarely

— No, never

TIM Performance Measures and Assessment

31. How frequently does the TMC agency meet its performance measure targets? (please select one)

— Always meets targets

— Frequently meets targets

— Occasionally meets targets

— Rarely or never meets targets

— The TMC has no performance targets

32. What percentage of incident responses meet the TMC performance measure targets? (please select one)

— Over 75%

— Between 50-75%

— Between 25-50%

— Less than 25%

— The TMC has no response targets

33. Which of the following methods does your TMC use to review progress towards achieving its targets? (please select one)

— Conducting surveys to gather data on performance metrics

— Holding regular meetings with stakeholders to discuss progress

— Implementing software systems to track and analyze data

— Other (please specify) ____

34. How often does your TMC evaluate its progress toward achieving performance targets? (please select one)

— Monthly

— Quarterly

— Biannually

— Annually

35. Please select the strategies in staff development that are being used at your TMC (please select all that apply)

— Periodic staff meetings to encourage open communication

— Sharing of relevant performance data, including operational performance data and public feedback

— Debriefings with TMC staff and TMC process reviews after major incidents

— Updating TMC staff with important initiatives or activities at the department level

— Seeking opportunities for the TMC to be represented in broader organizational meetings

36. How often do you produce performance measure reports from your TMC? (please select one)

— Every week

— Every month

— Every quarter

— Every six months

— Once a year

— As needed

— Currently do not have a reporting procedure

Other Questions

37. Which of the following emerging technology does your TMC currently use? (please select all that apply)

— Communication over broadband wireless

— Unmanned Aerial Systems

— Advanced Video Analytics

— Other (please specify)____

38. How frequently does your TMC upgrade its equipment?

— Every year

— Every two years

— Every three years

— Every five years

— More than five years

39. Does your TMC have a policy to conduct debriefing meetings if an incident clearance substantially takes longer than the expected clearance time?

— Yes, debriefing meetings are always held for incidents exceeding standard clearance time

— Debriefing meetings are sometimes held for such incidents

— No, there is no policy to hold debriefing meetings

— Other (please specify) ____

40. What improvements would you suggest for your TMC? (please attach an additional sheet to answer question if needed)

____

____

____

41. What suggestions do you have on improving TIM in your juridiction? (please attach an additional sheet to answer question if needed)

Appendix D: Features and Limitations for Several Interoperable Communications Platforms

RIMIS	
Limitations	**Features**
• No mobile application. • Inability to share incident-related videos. • The documentation reviewed did not show whether different agencies have the capability to share their communication resources on the platform. • No multimedia/data sharing groups for the public, operators in the centers, and first responders at incident scenes. • Geographic-specific and developed to fit the needs of the DVRPC. This prevents other jurisdictions from using it without significant modification.	• Web-based platform. • The event map in RIMIS is used to monitor the transportation systems; it displays all events in the region. • Operator can examine real-time videos, live dynamic message sign messages, and traffic flow information. • Use of standard messaging formats. • Provide information on the best routes to reach the incident scene. • Provide information about construction and maintenance activities that affect lane closures. • Capable of Incident tracking and data archiving.
Mutualink	
Limitations	**Features**
• Mutualink is a commercial interoperable platform and requires agencies to purchase licenses. • Mutualink is not readily integrated with the existing ITS	• Mobile app and web-based platform. • Multimedia sharing groups. • Mutualink allows the sharing of videos, pictures, files, location, geospatial data, and the use of text messaging.

infrastructure the agency may have.	• Responders can communicate with their existing communication devices on this platform without the need to buy new devices. • Users can join multiple talk groups at a time and can have updates on multiple incidents. • Users can join from multiple devices simultaneously. • Operators can invite relevant personnel onto the platform. The responder receives a notification and can share videos, text, and other multimedia files with other responders.
TIMS2GO	
Limitations	**Features**
• Documentation reviewed did not indicate any file-sharing capabilities. • The documentation did not show whether different agencies have the capability to share their communication resources on the platform. • Inability to provide responders with the information about the best route to reach the incident scene. • TIMS2GO was developed specifically for the Illinois Tollway, but it provides a good	• Mobile app and web-based platform. • Users can get access to live-streaming video, incident details, and response status updates. • The app has been fully integrated with CCTV cameras and DMSs. • Responders can be dispatched through the app while an events screen provides details of the incident. • Staff can check the surrounding area of the incidents by zooming in on the already installed CCTV. • Responders can monitor the responses at the incident scene without leaving their vehicles, which reduces the risk of injury.

framework that can be utilized by different states.	
Omnigo	
Limitations	**Features**
• Inability to provide responders with the information about the best route to reach the incident scene. • Documentation reviewed did not show any text messaging capabilities. • Omnigo has been developed primarily for Law enforcement agencies, but it has a lot of applications that can be beneficial to TIM. • Responders on the Omnigo platform coordinating incident response cannot invite relevant personnel onto the platform as they can on the mutualink.	• Mobile app and web-based platform. • Allows the sharing of incident videos, audio, photos, and documents among response agencies. • Different responders with different communication devices can access, monitor, and update information instantaneously. • The central command board map of Omnigo provides real-time, location-based information such as deployed resources, surrounding traffic conditions, an active log, and streaming CCTV cameras. • Omnigo evidence management feature helps agencies to organize, store, and share a wide variety of data on a centralized, integrated system. • Omnigo permits responders to write notes on the stored/shared data, which can be helpful for other responders during incident response. • Omnigo CAD shares a central database with other Omnigo applications, making all data elements immediately available. • Omnigo has a customizable dashboard, and notifications draw immediate attention to any changes or updates to the investigation of an incident.

	• Responders can make sensitive folders confidential, ensuring that only a few people have access. • The platform shows which documents have been opened or edited and by which responders.
Active911	
Limitations	**Features**
• Reviewed documents did not indicate any video-sharing capabilities • Difficult to integrate with existing ITS infrastructure. • This platform only offers cloud-based storage and lacks local storage options • Required agencies to purchase licences. • This platform does not have the capability of detailed customization like scenario-based message templates.	• Mobile app and web-based platform • This platform provides real-time alerts with CAD details, incident type, and location. • Allows sharing of various file formats (PDF, PNG, JPEG) for maps, pre-plans, and alerts. • Active911 includes an availability settings feature for responders to indicate their status, which helps in multiagency coordination. • This platform includes a feature of group chat, allowing seamless communication among response agencies. • Active911 allows responders to label resources on maps, enabling users to identify key locations and attach documents. • Compatible with multiple devices, including smartphones, tablets, and computers

Appendix E: ICT by Month for Individual Interstates

Figure 16. ICT by month for I-10

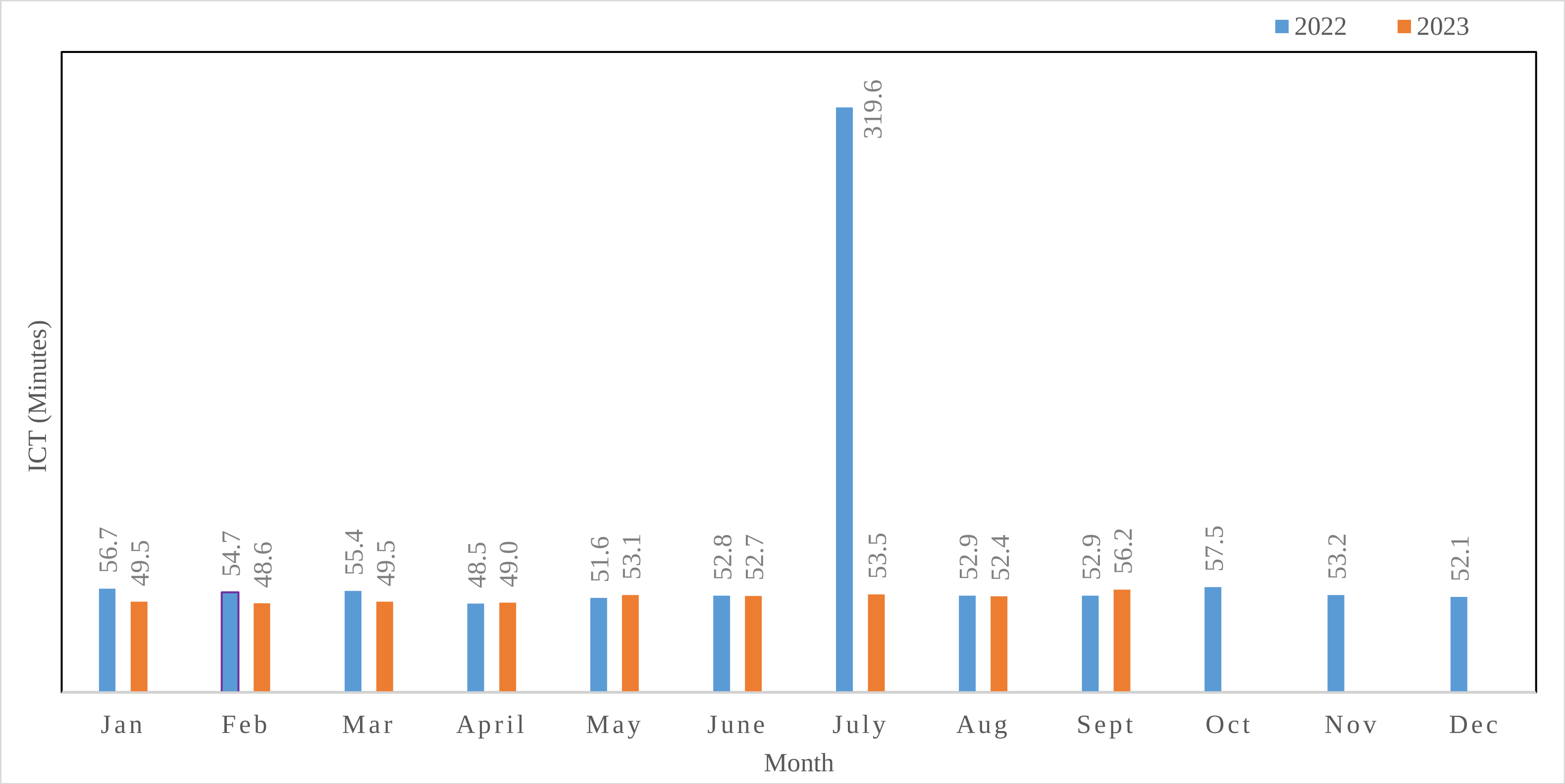


Figure 17. ICT by month for I-110

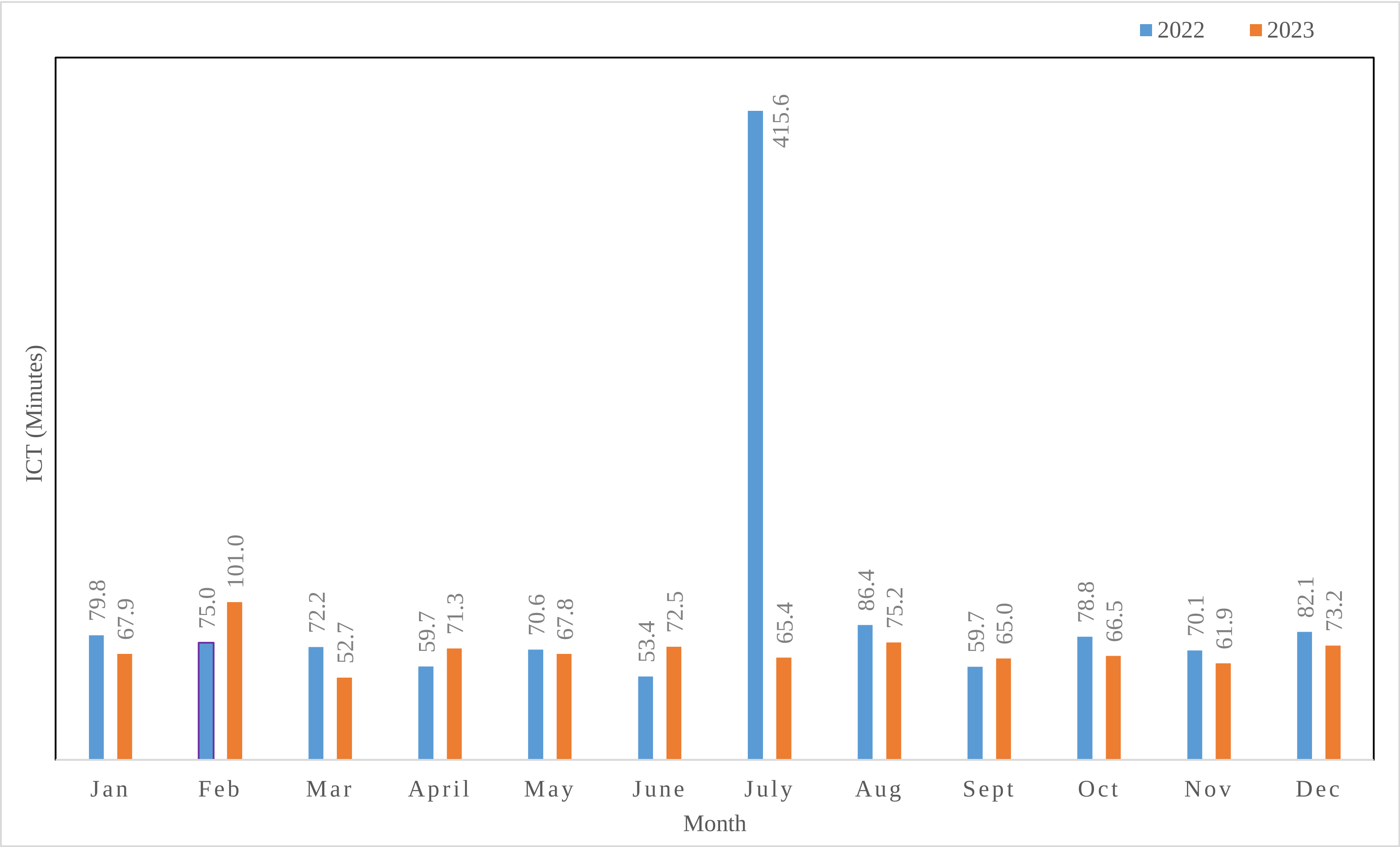


Figure 18. ICT by month for I-12

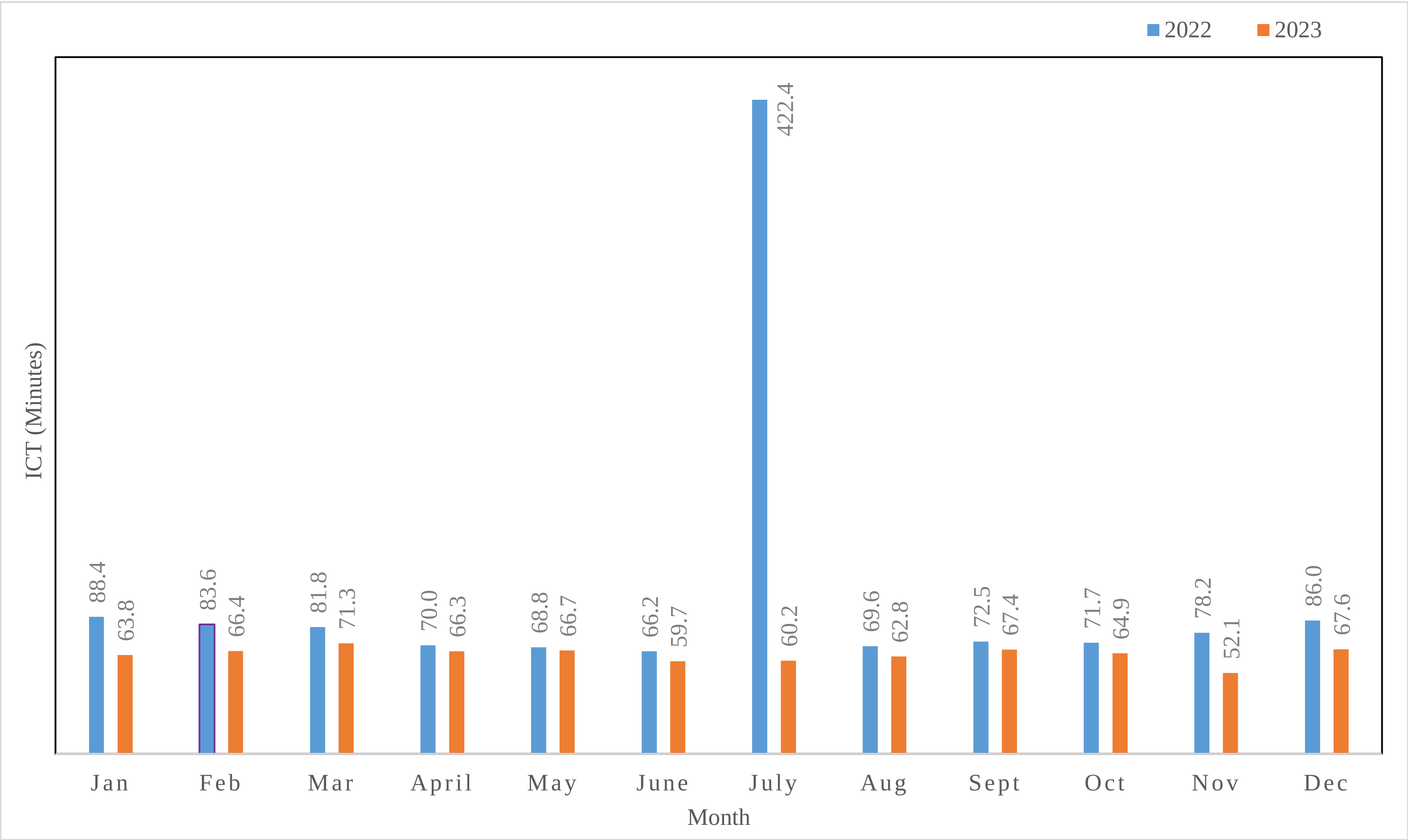


Figure 19. ICT by month for I-610

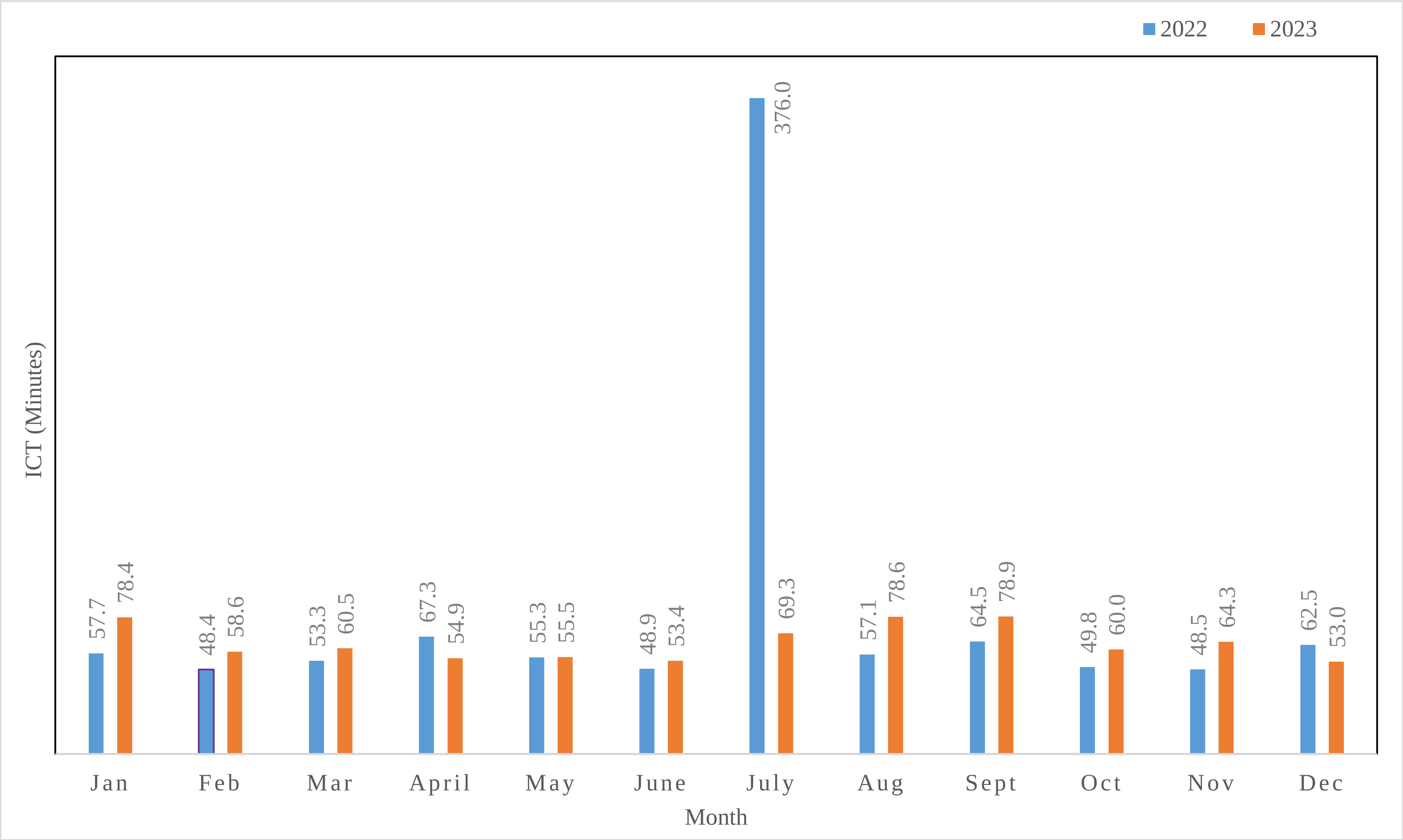


Figure 20. ICT by month for I-59

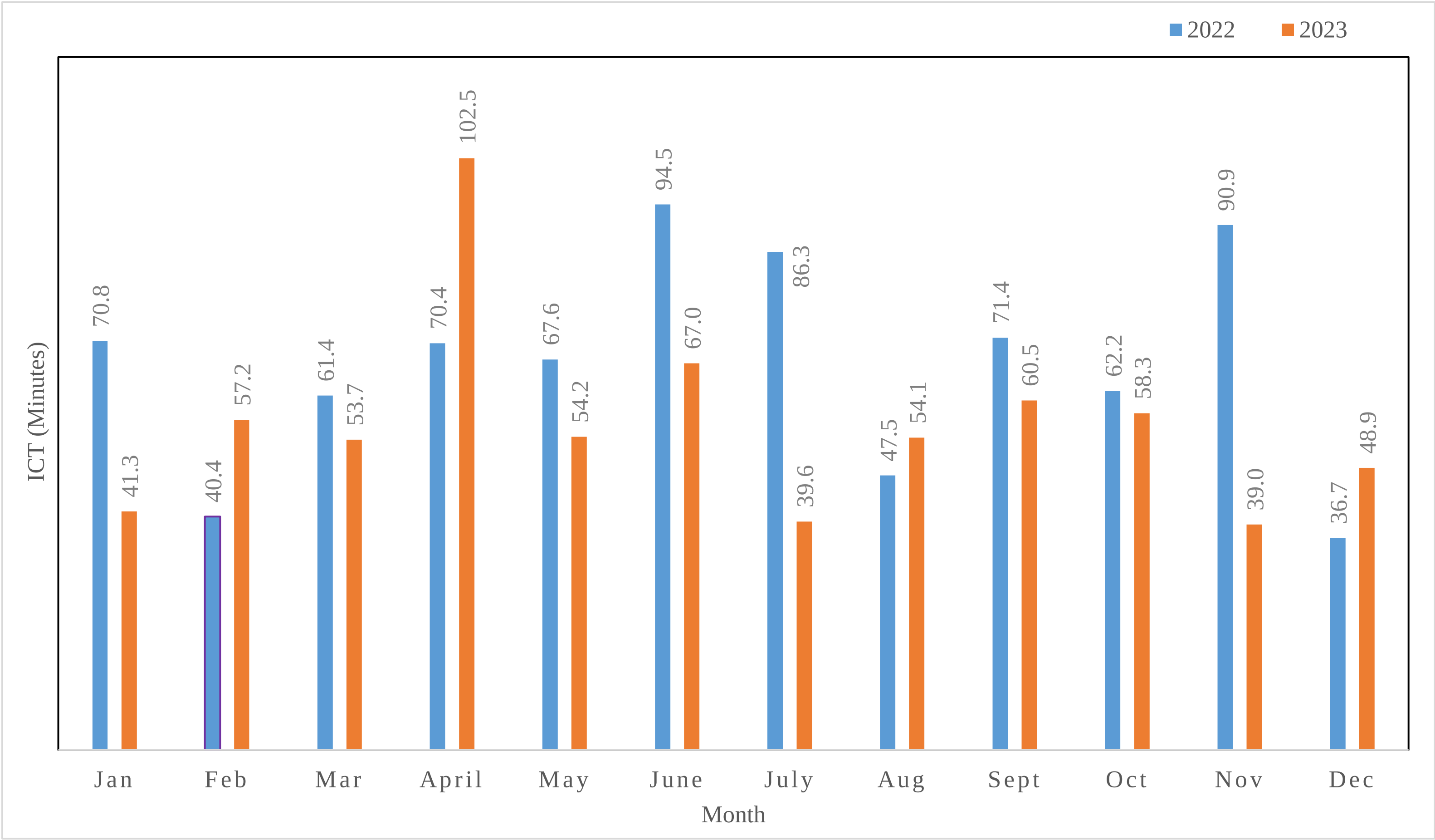


Figure 21. ICT by month for I-55

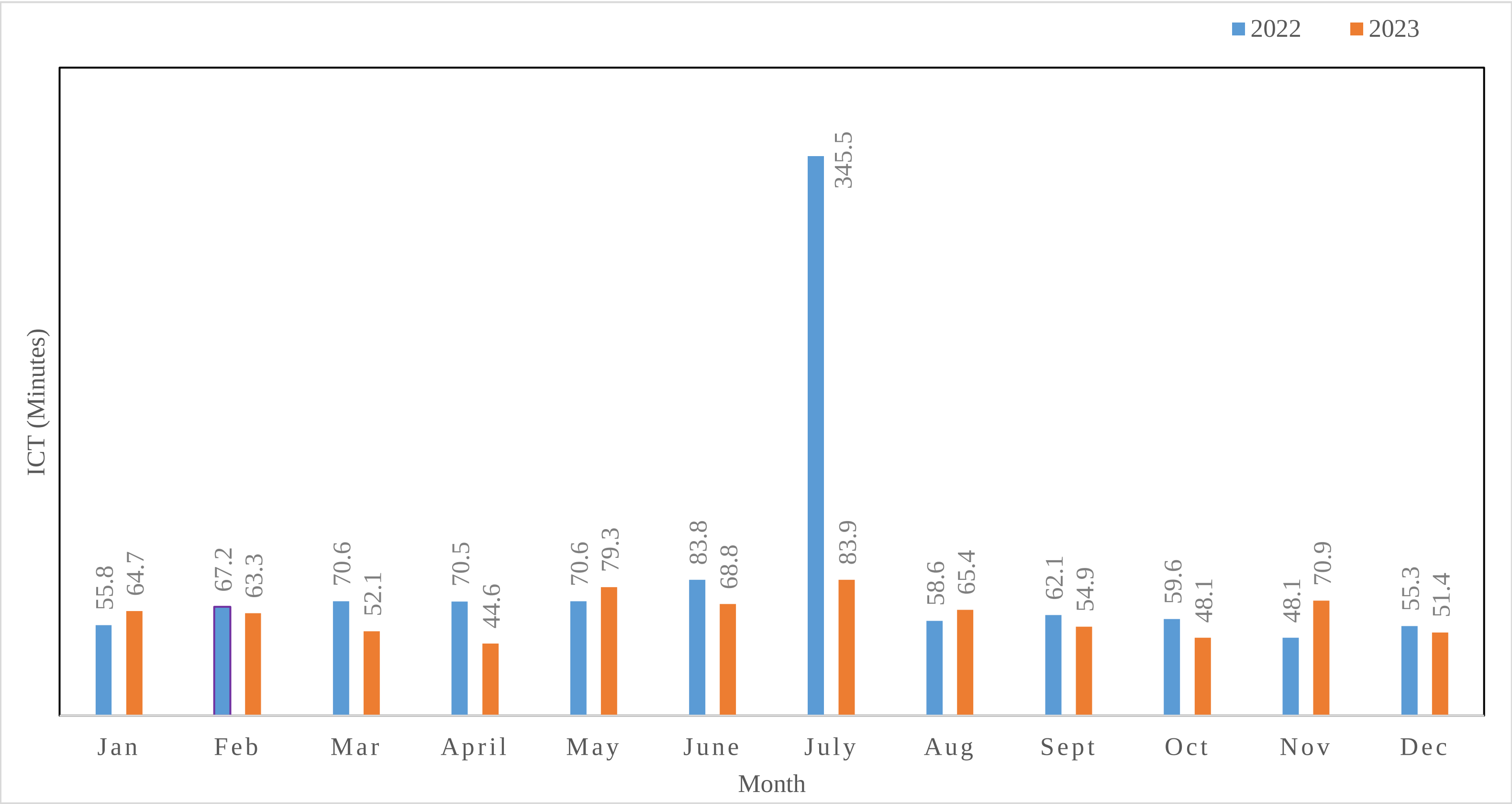


Figure 22. ICT by month for I-49

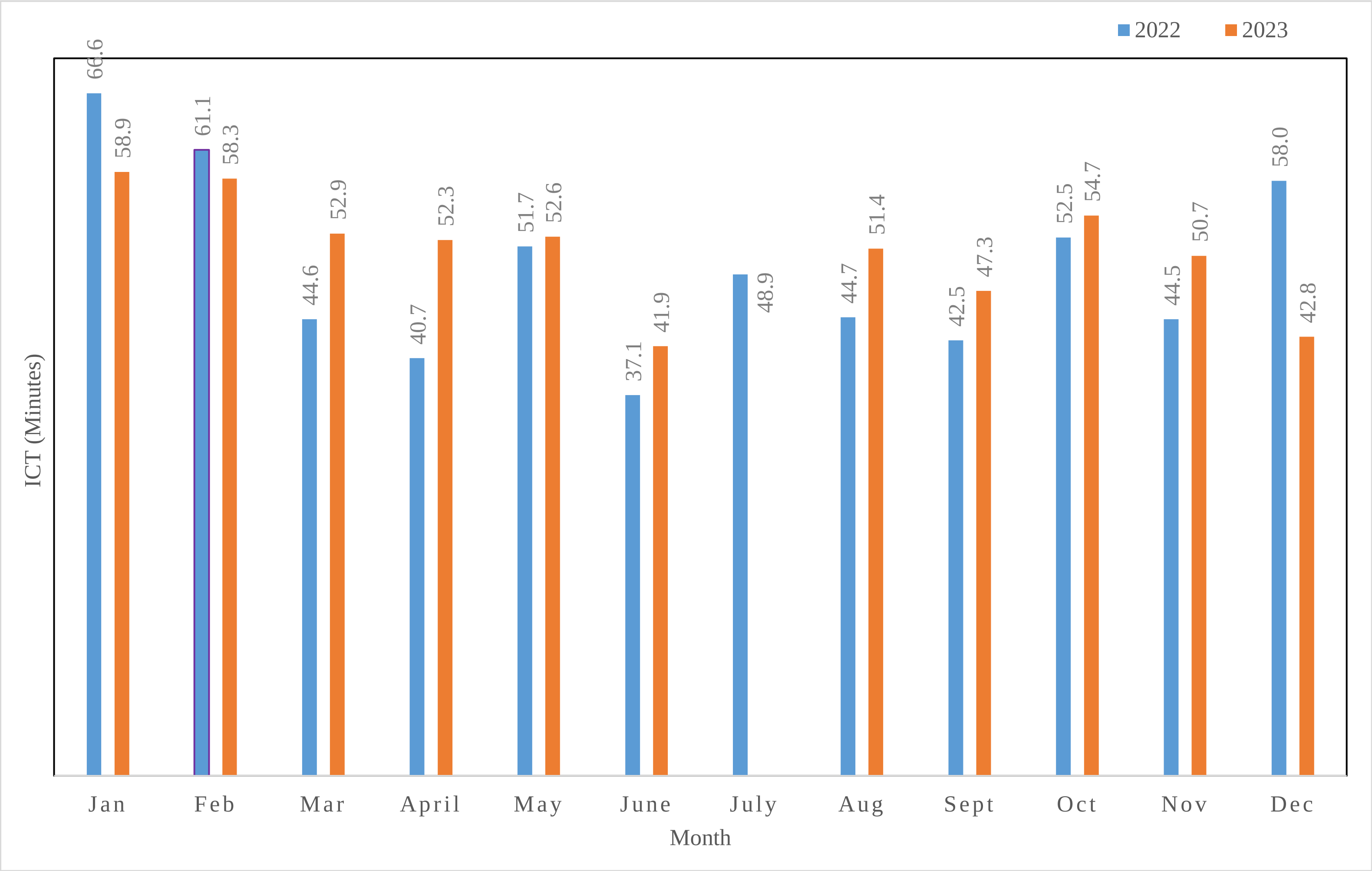


Figure 23. ICT by month for I-310

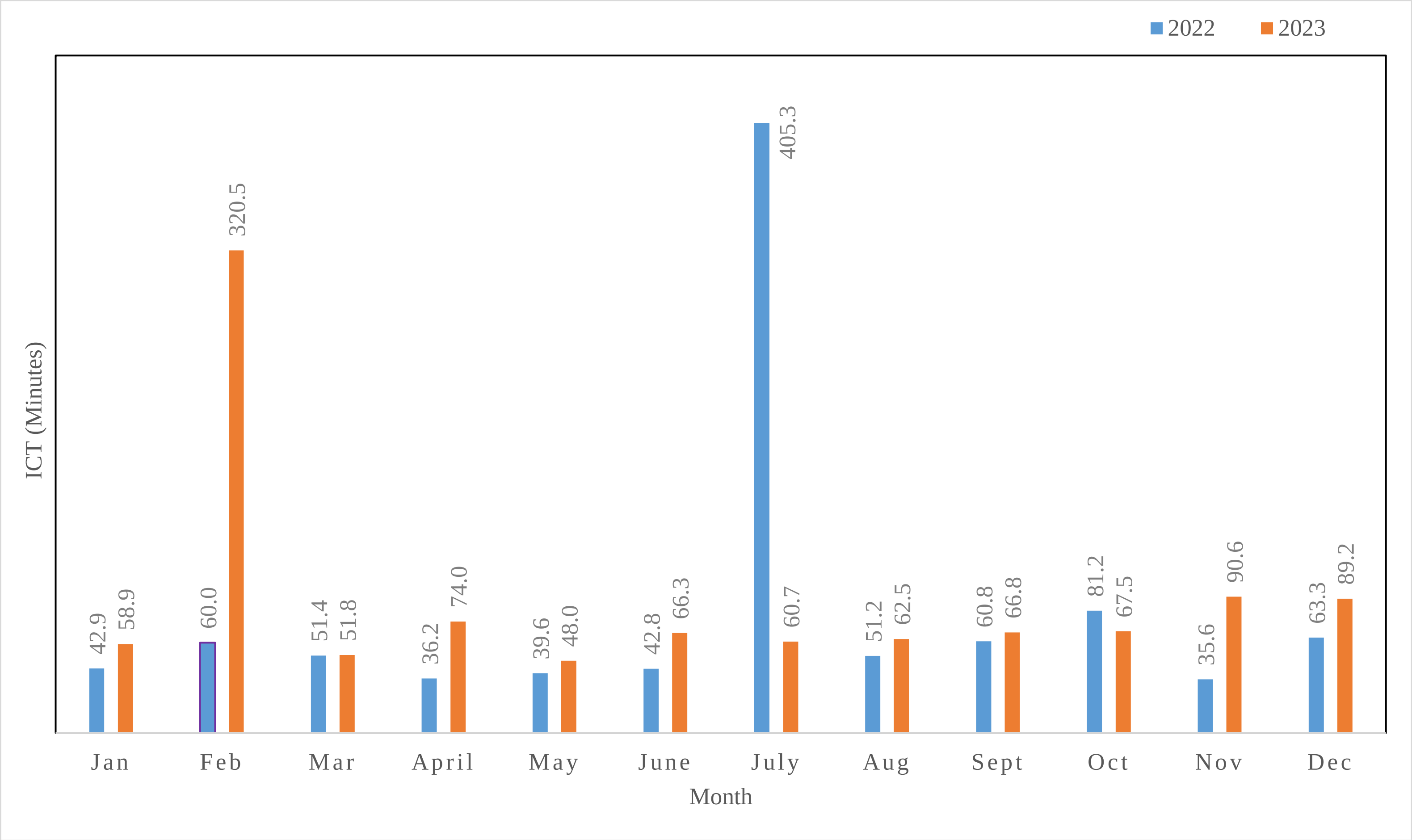


Figure 24. ICT by month for I-210

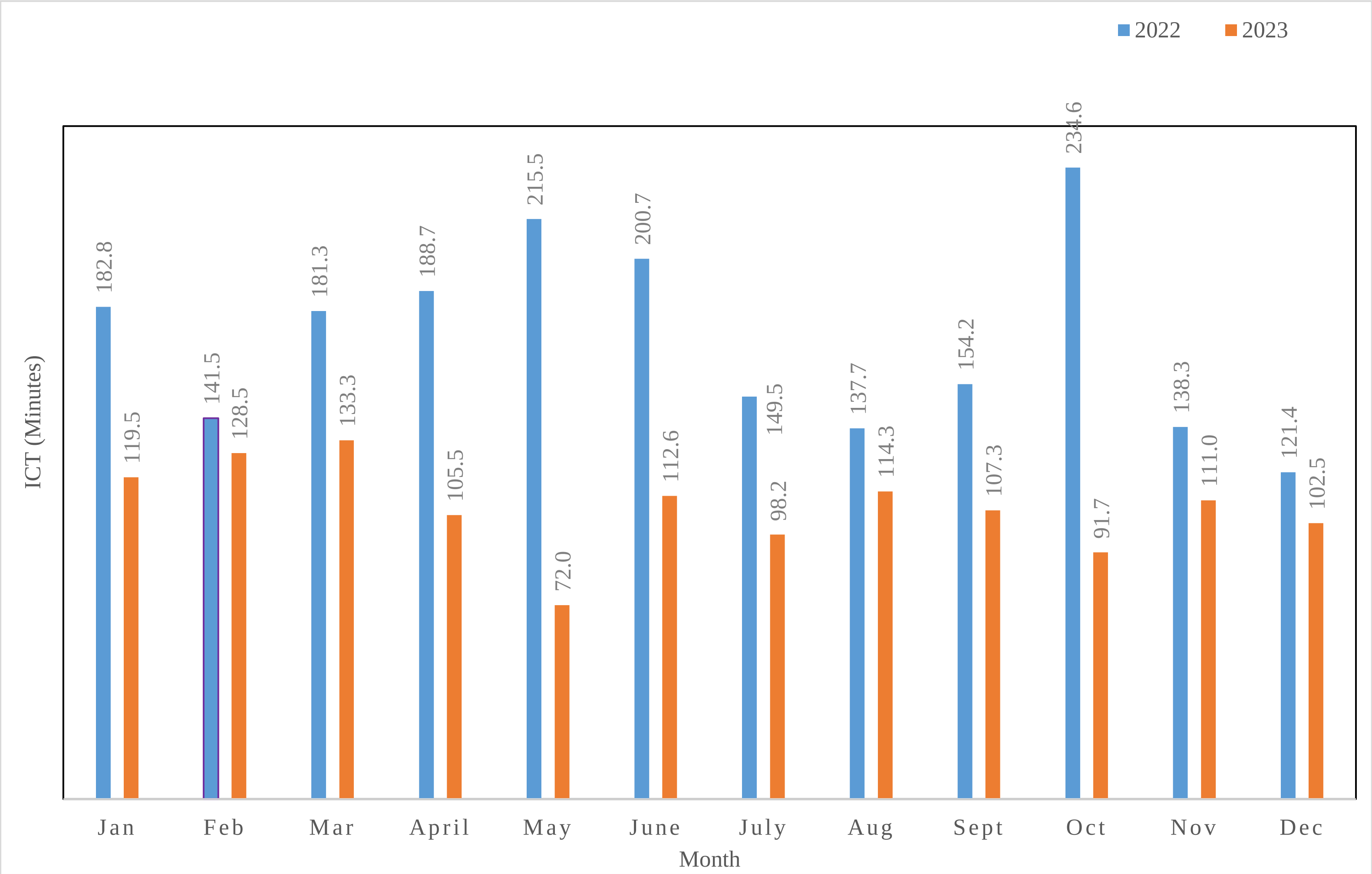


Figure 25. ICT by month for I-220

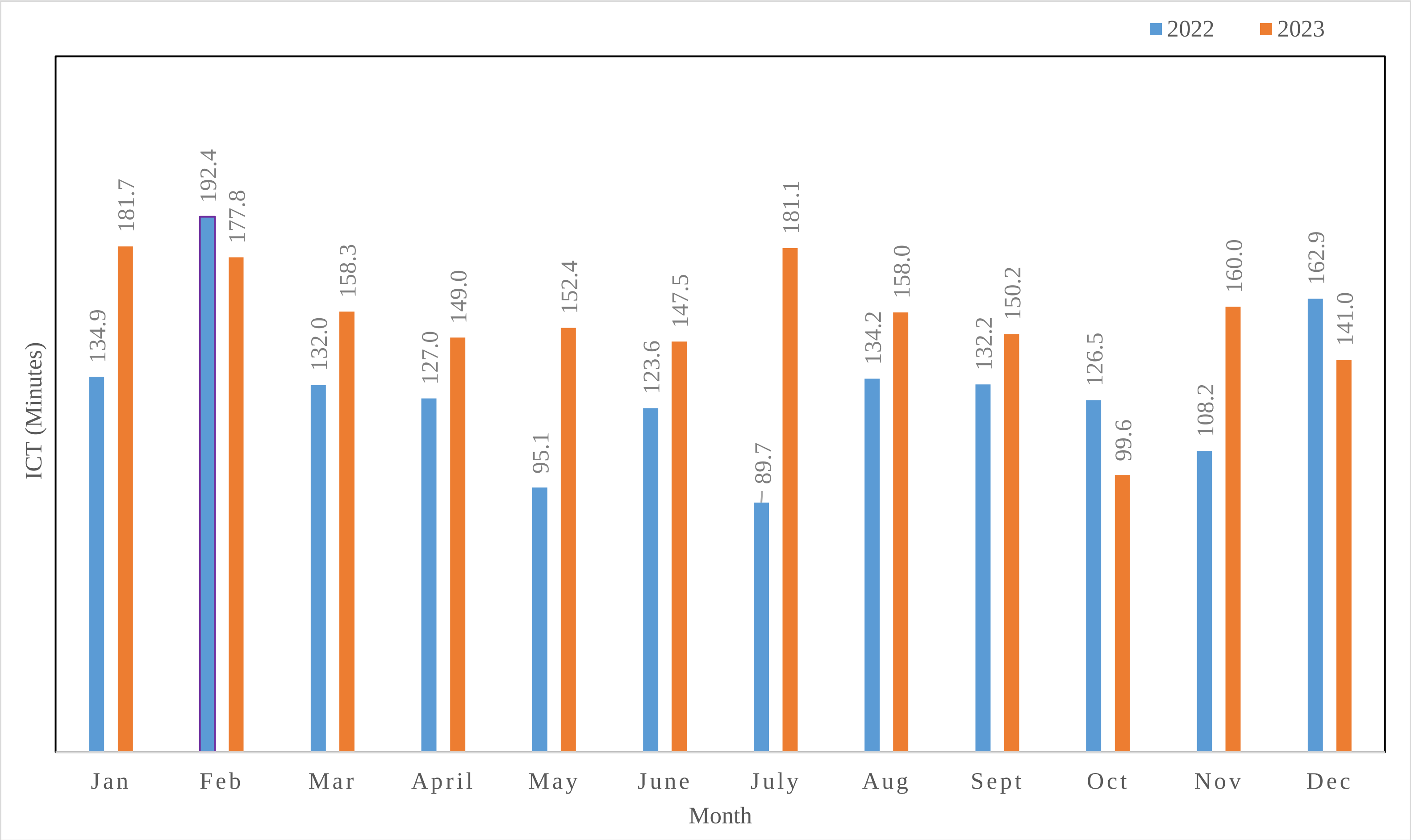


Figure 26. ICT by month for I-20

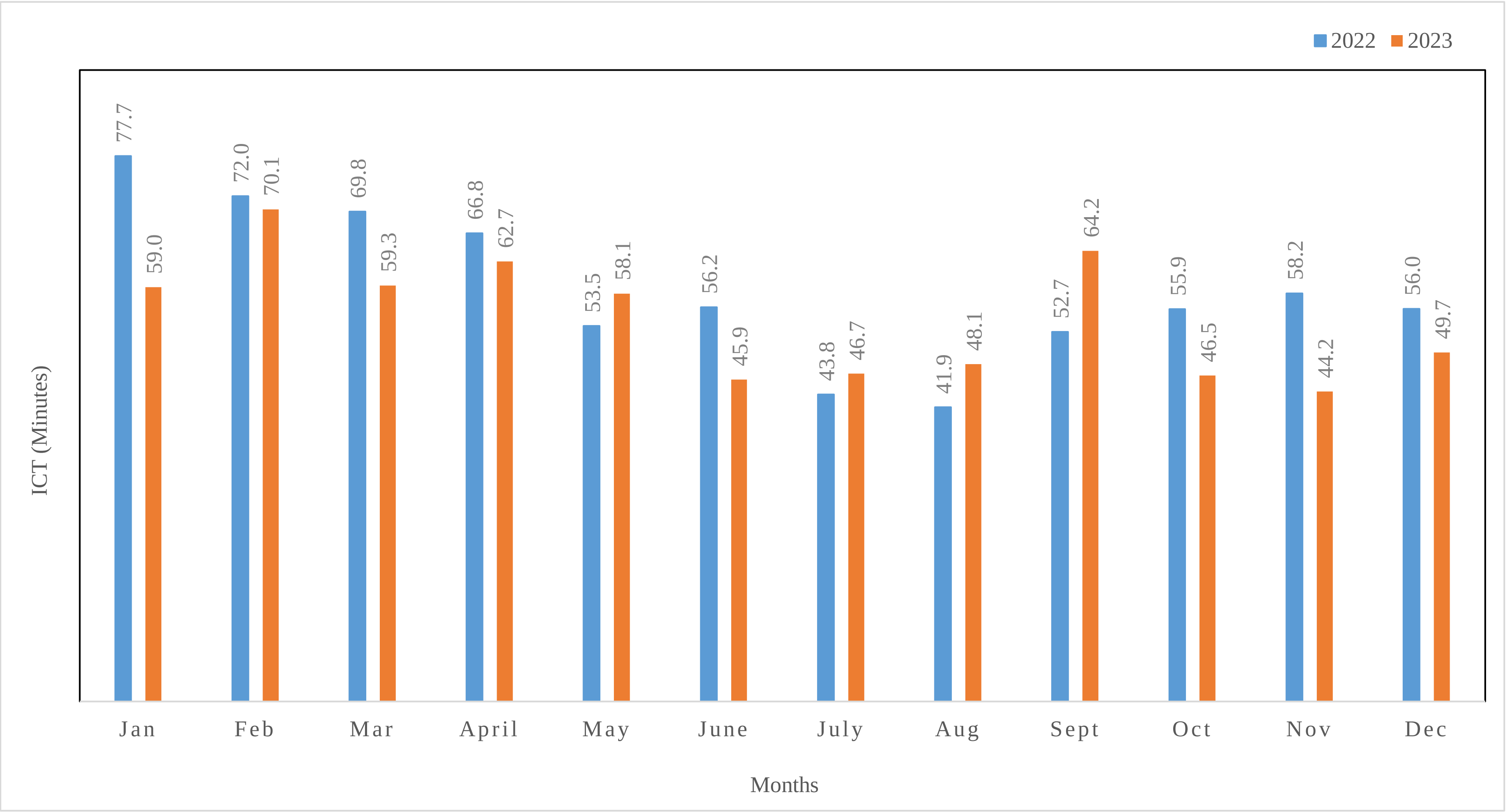
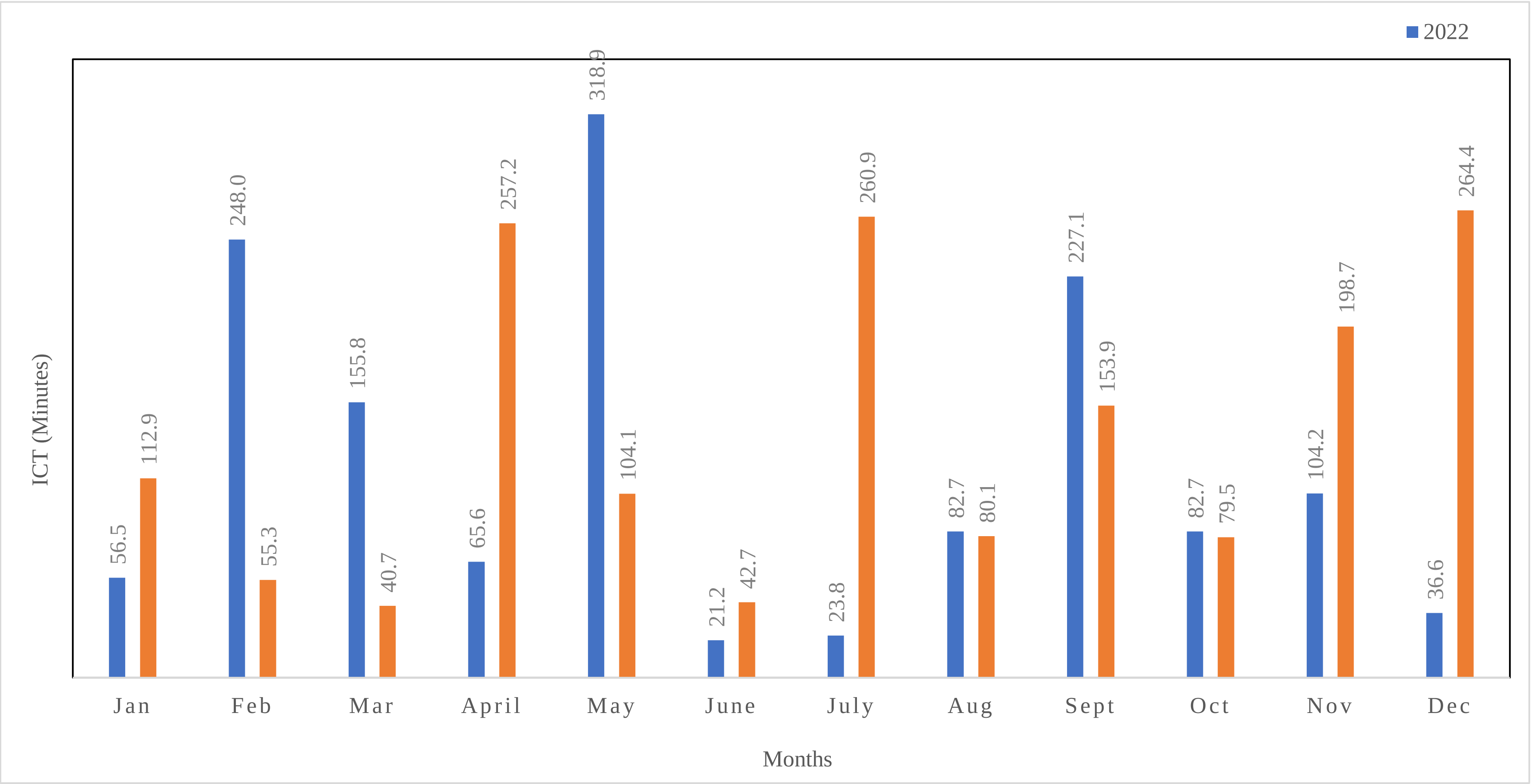


Figure 27. ICT by month for I-510



Apendix F: RCT by Month for Individual Interstates

Figure 28. RCT by month for I-10

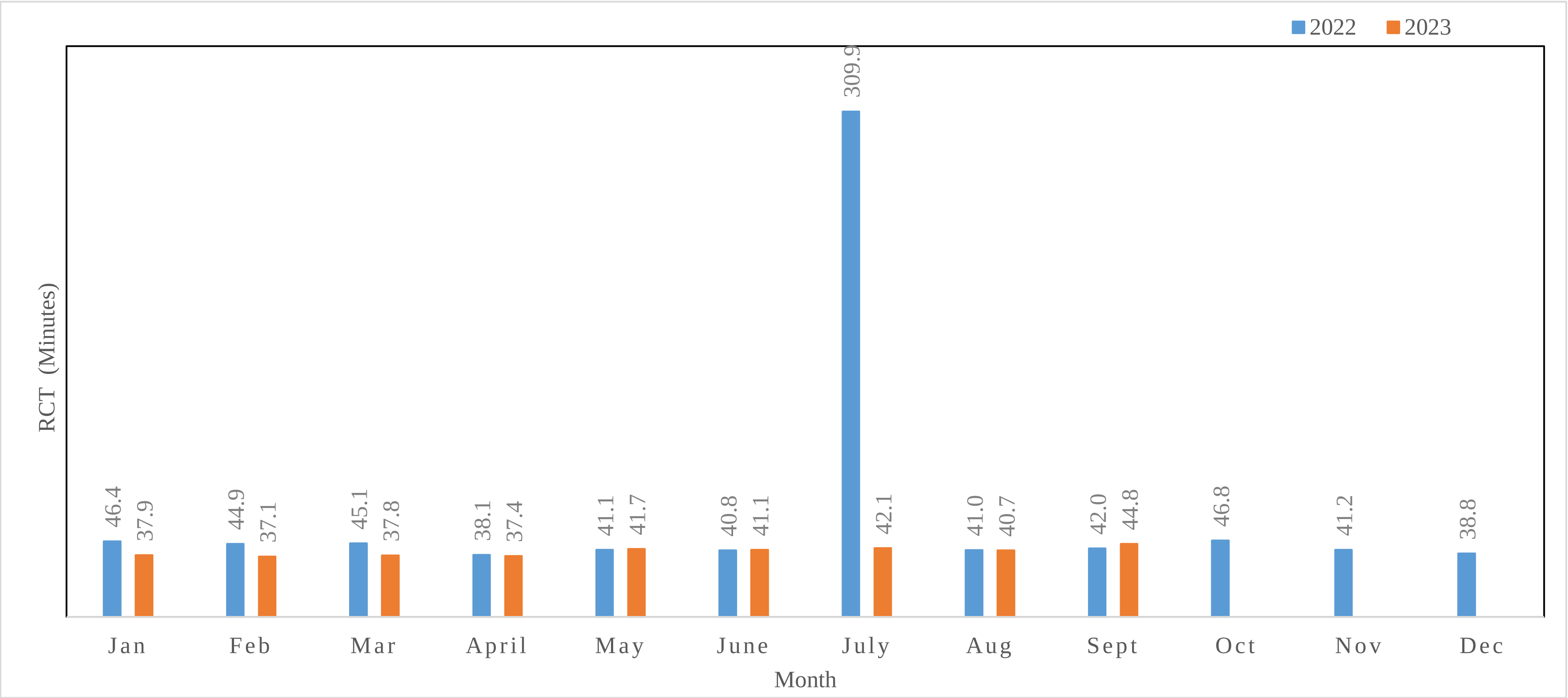


Figure 29. RCT by month for I-110

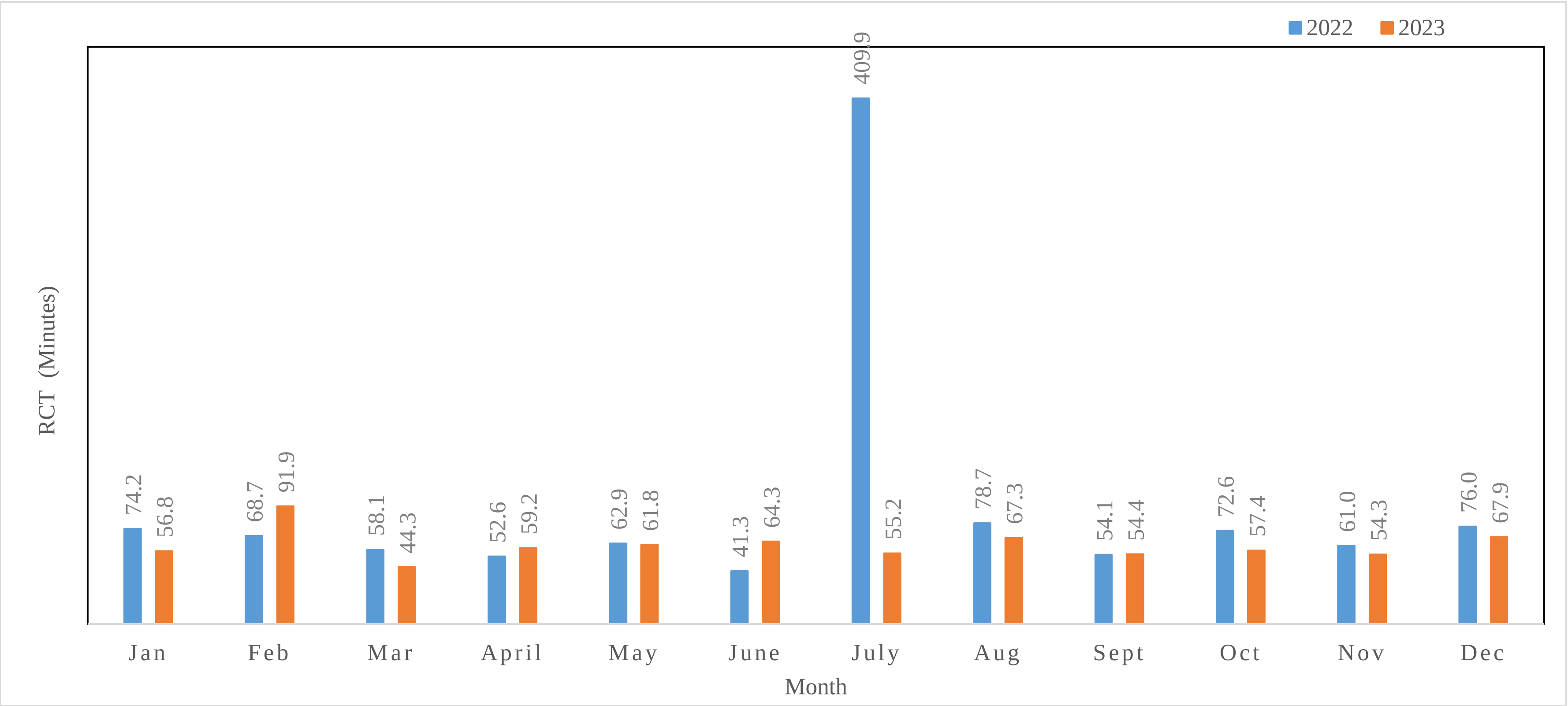


Figure 30. RCT by month for I-12

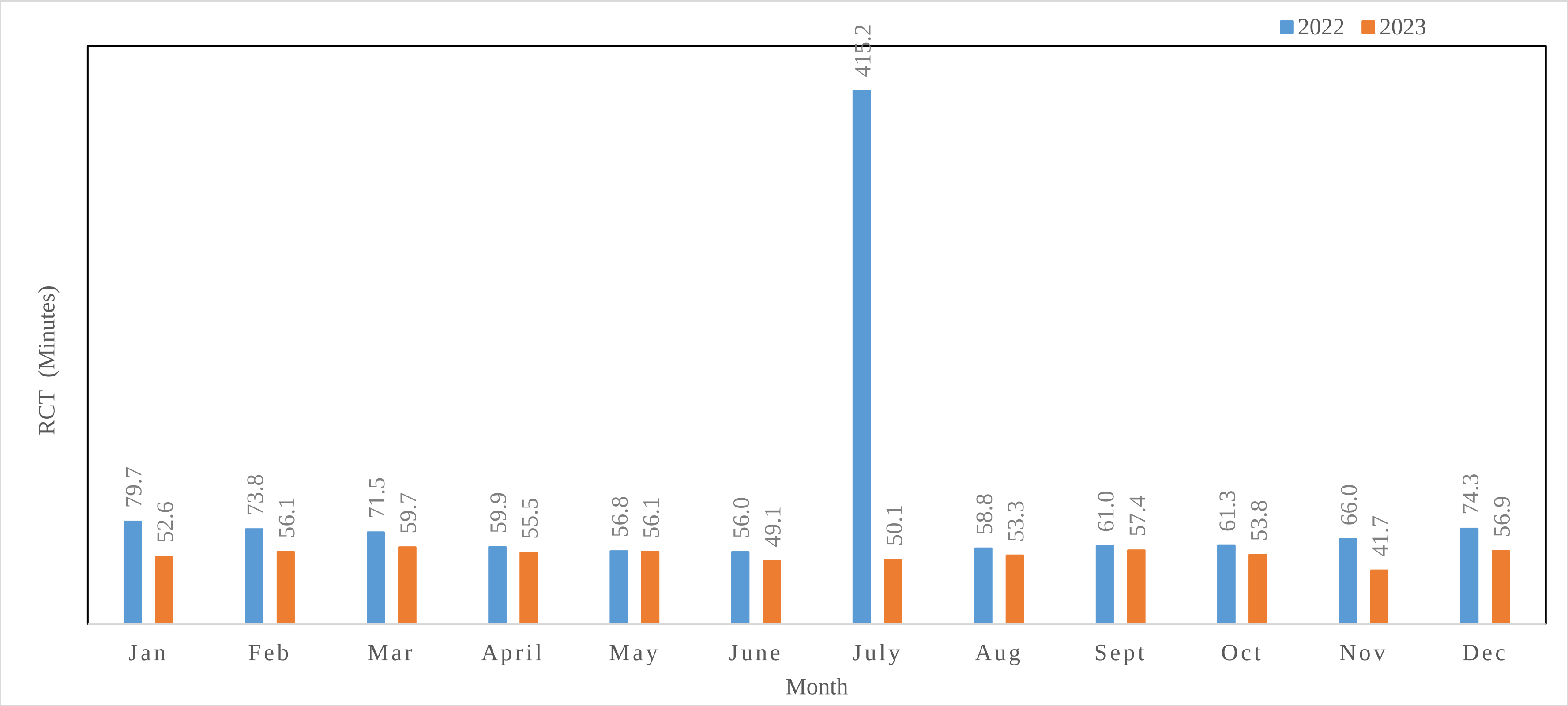


Figure 31. RCT by month for I-610

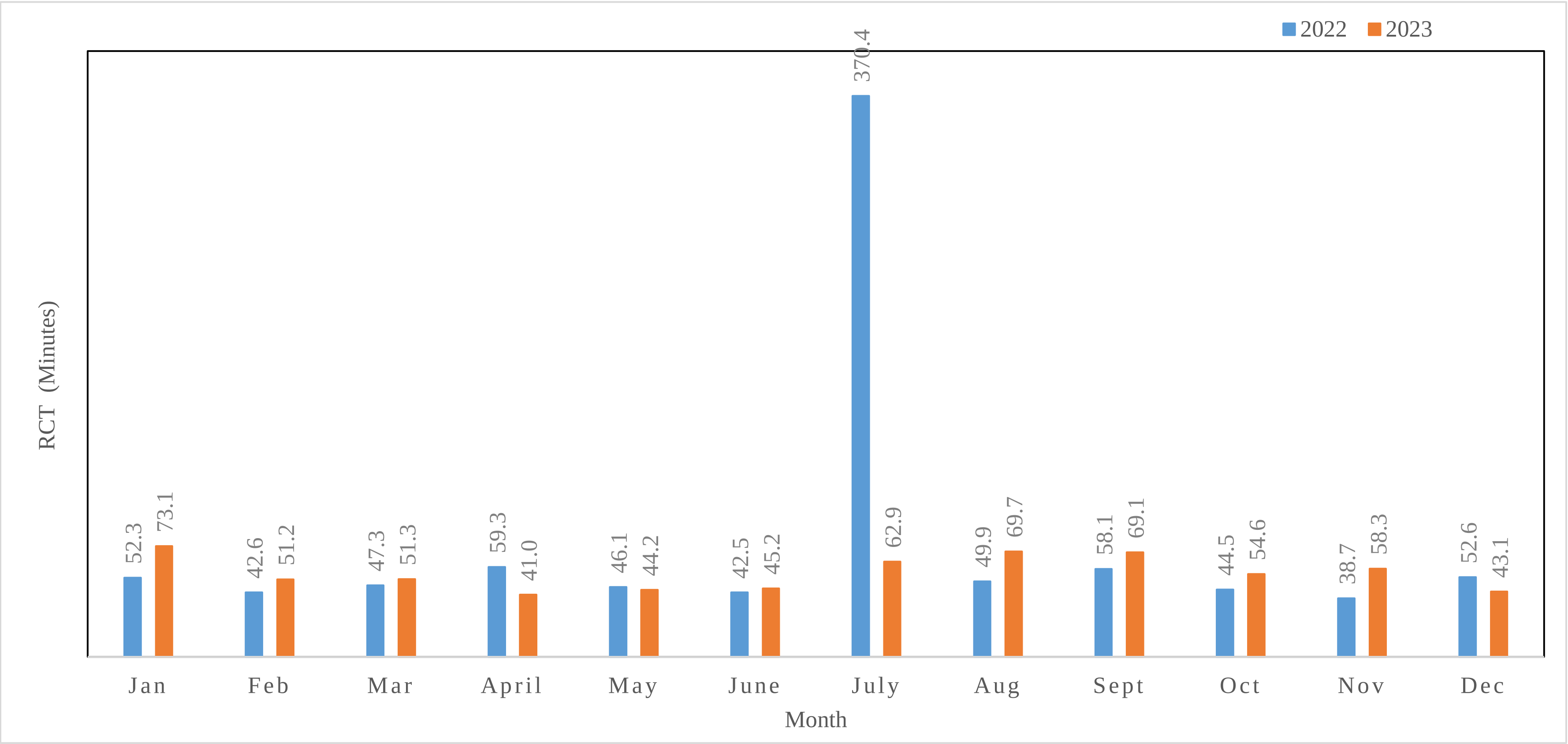


Figure 32. RCT by month for I-55

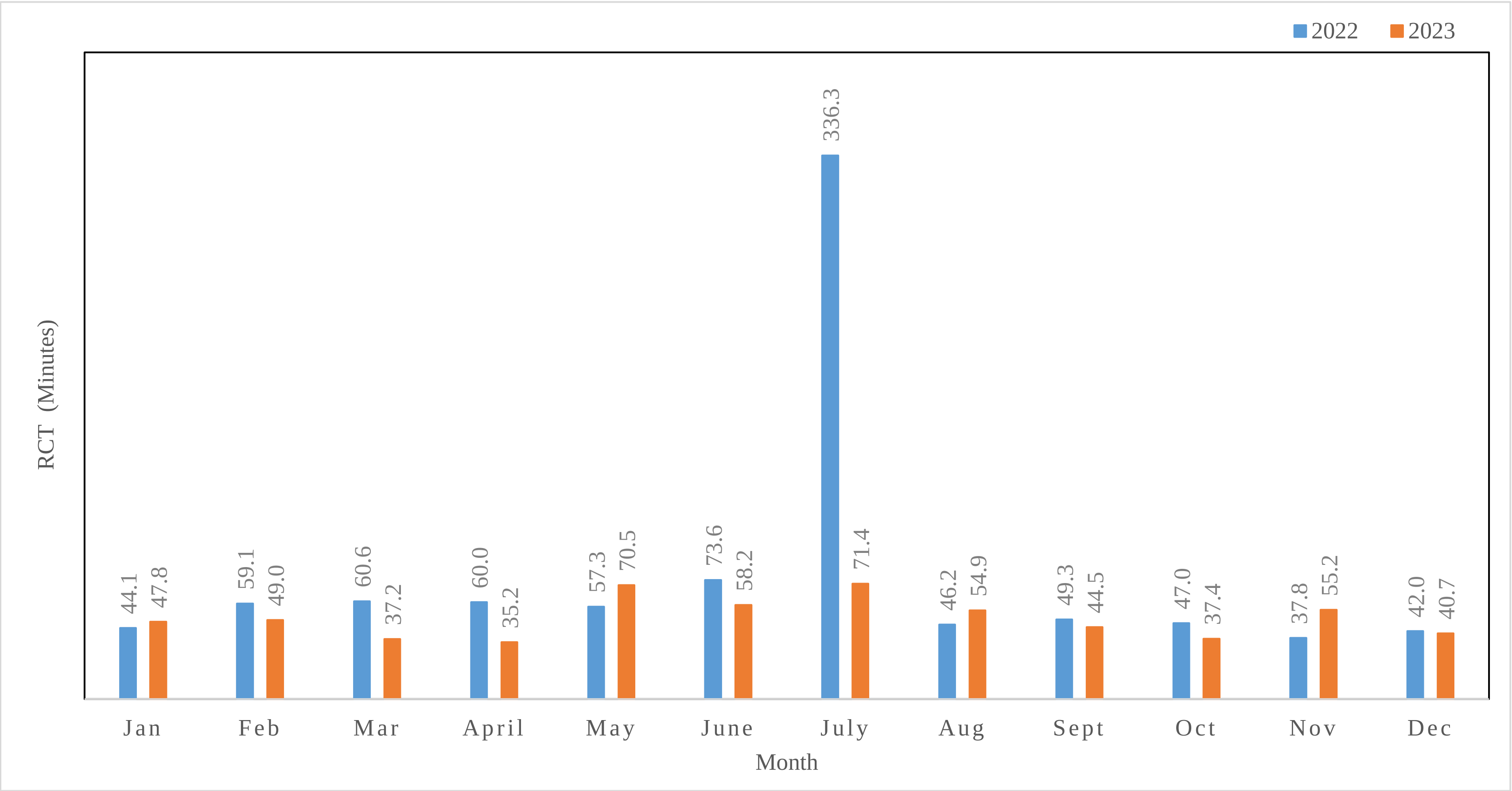


Figure 33. RCT by month for I-49

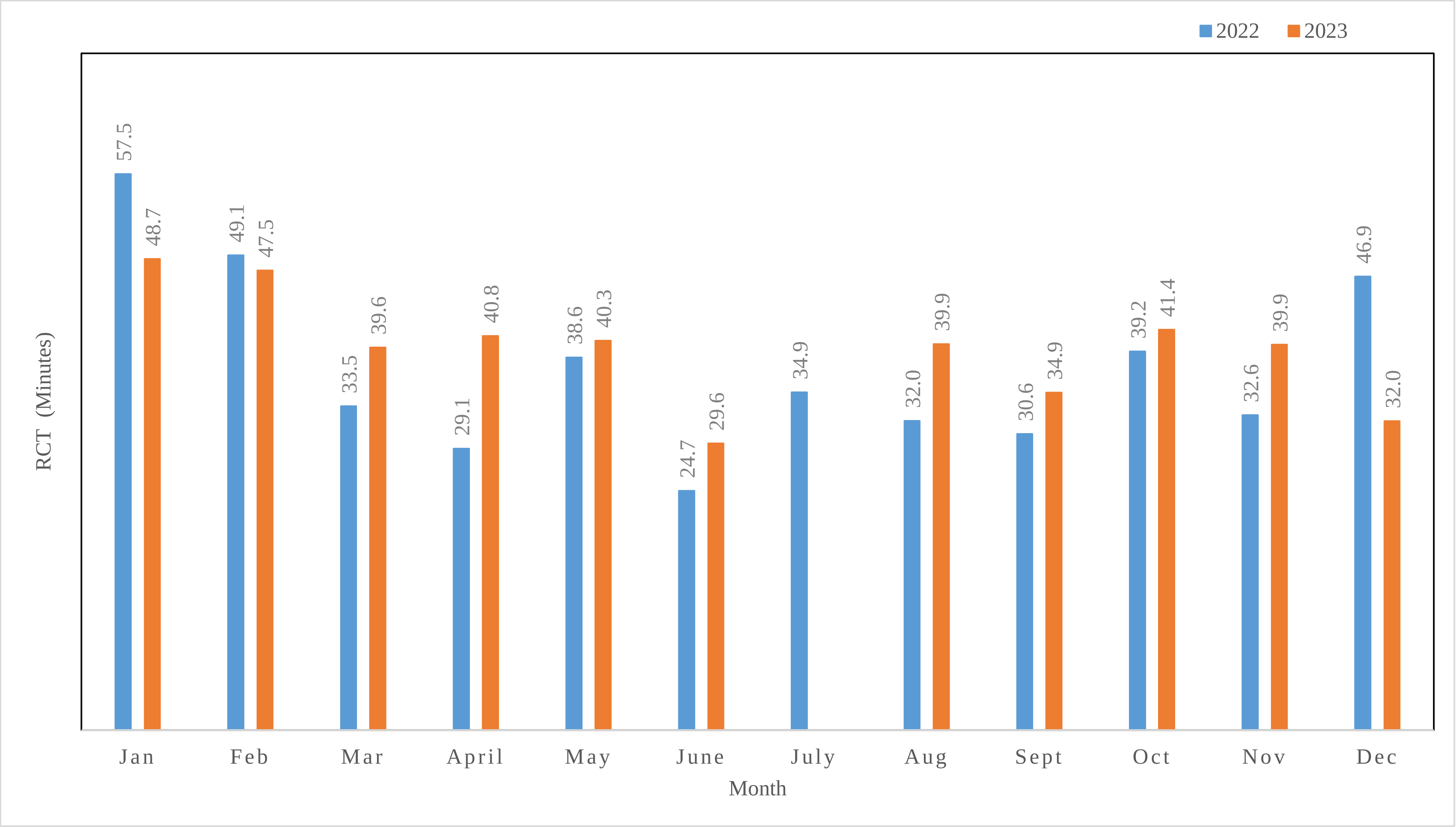


Figure 34. RCT by month for I-310

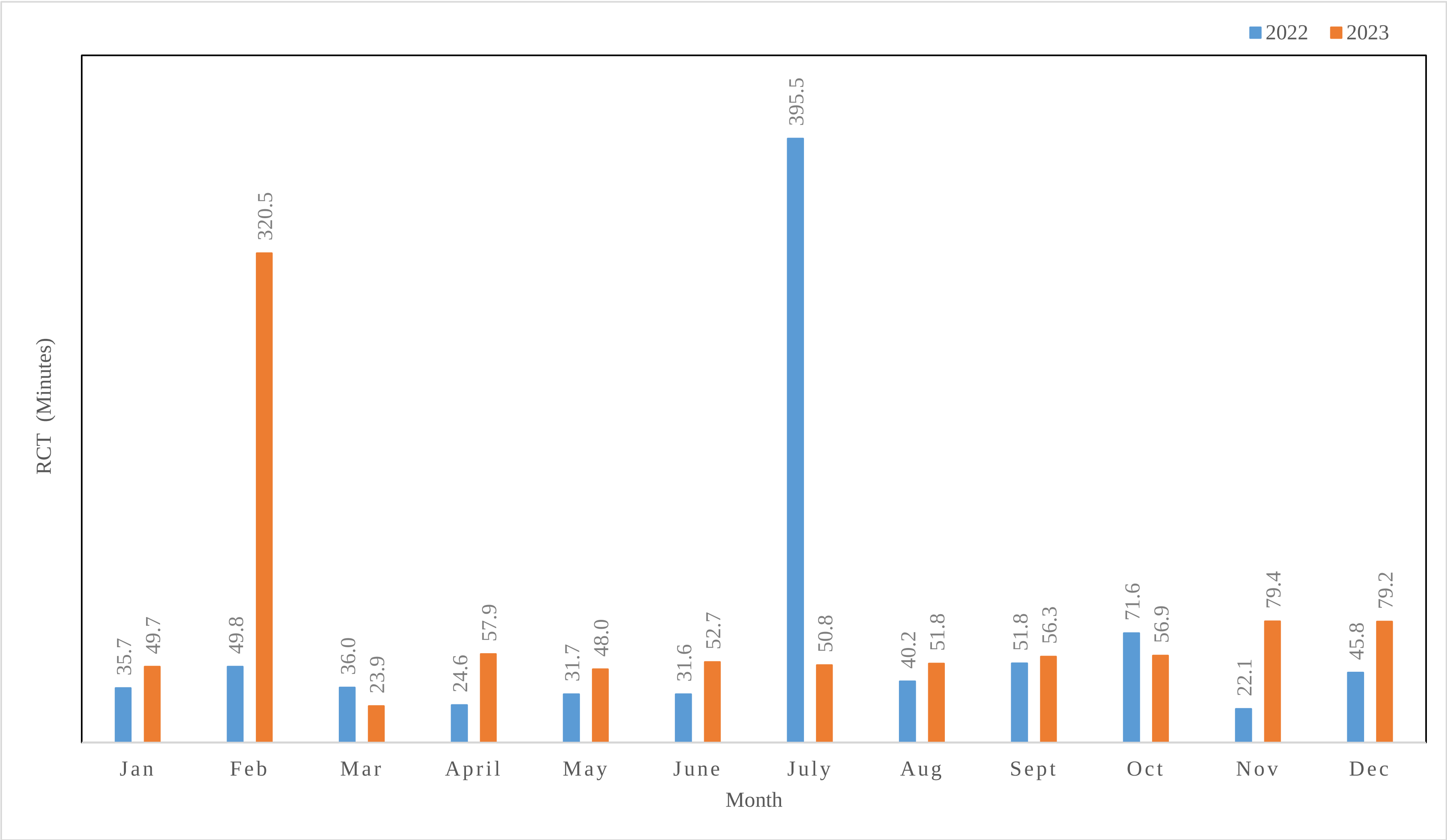


Figure 35. RCT by month for I-210

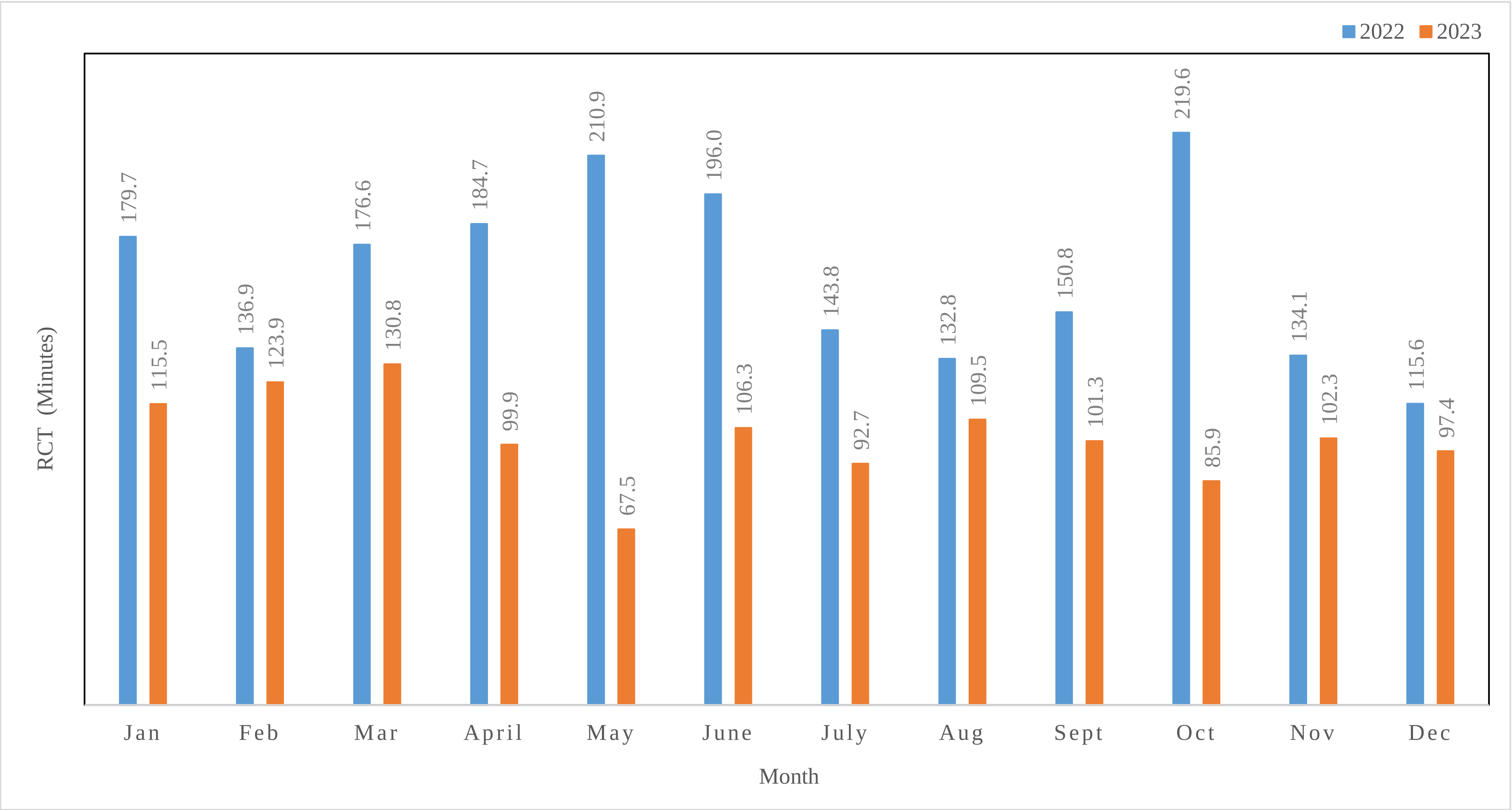


Figure 36. RCT by month for I-220

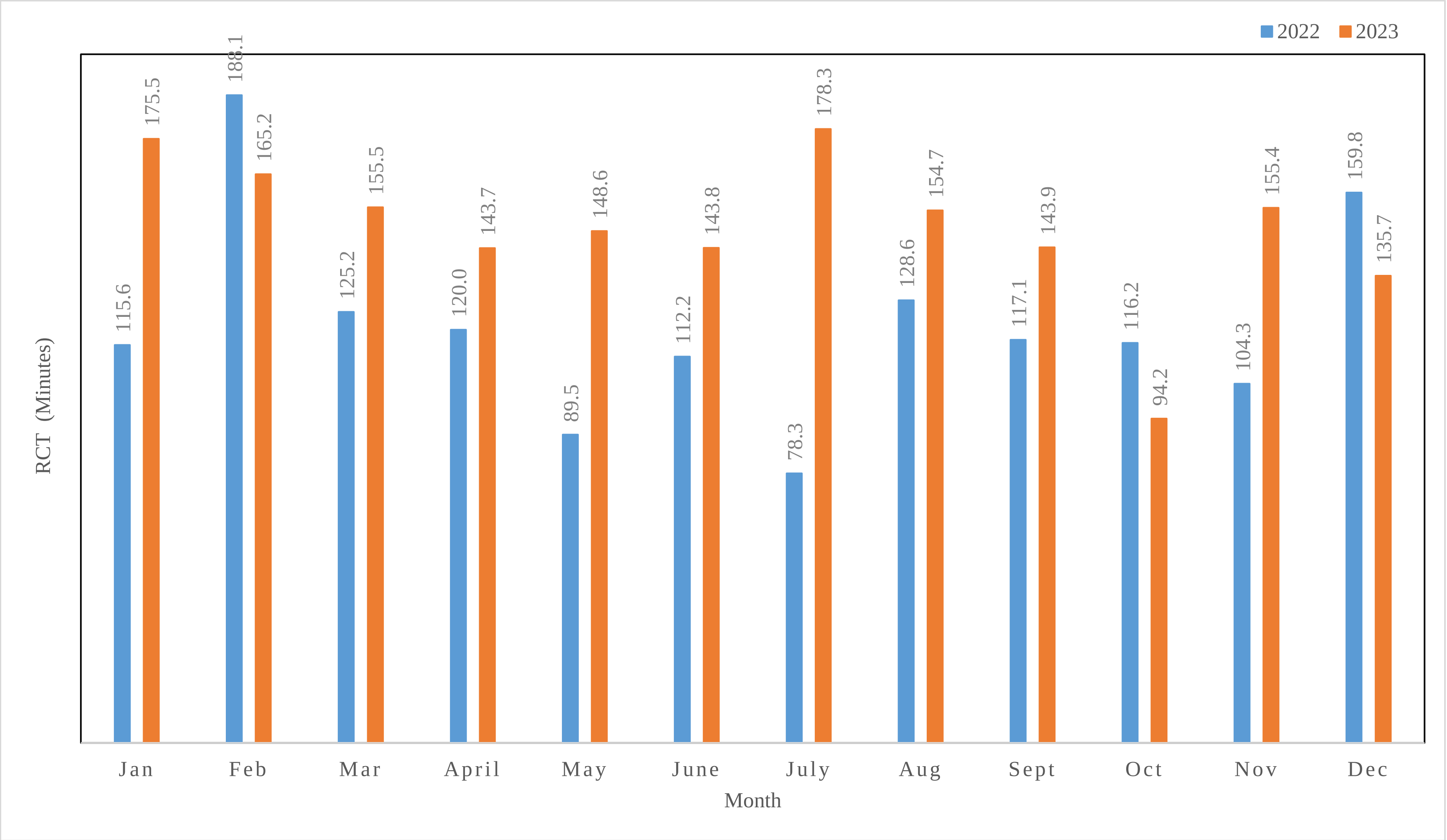


Figure 37. RCT by month for I-20

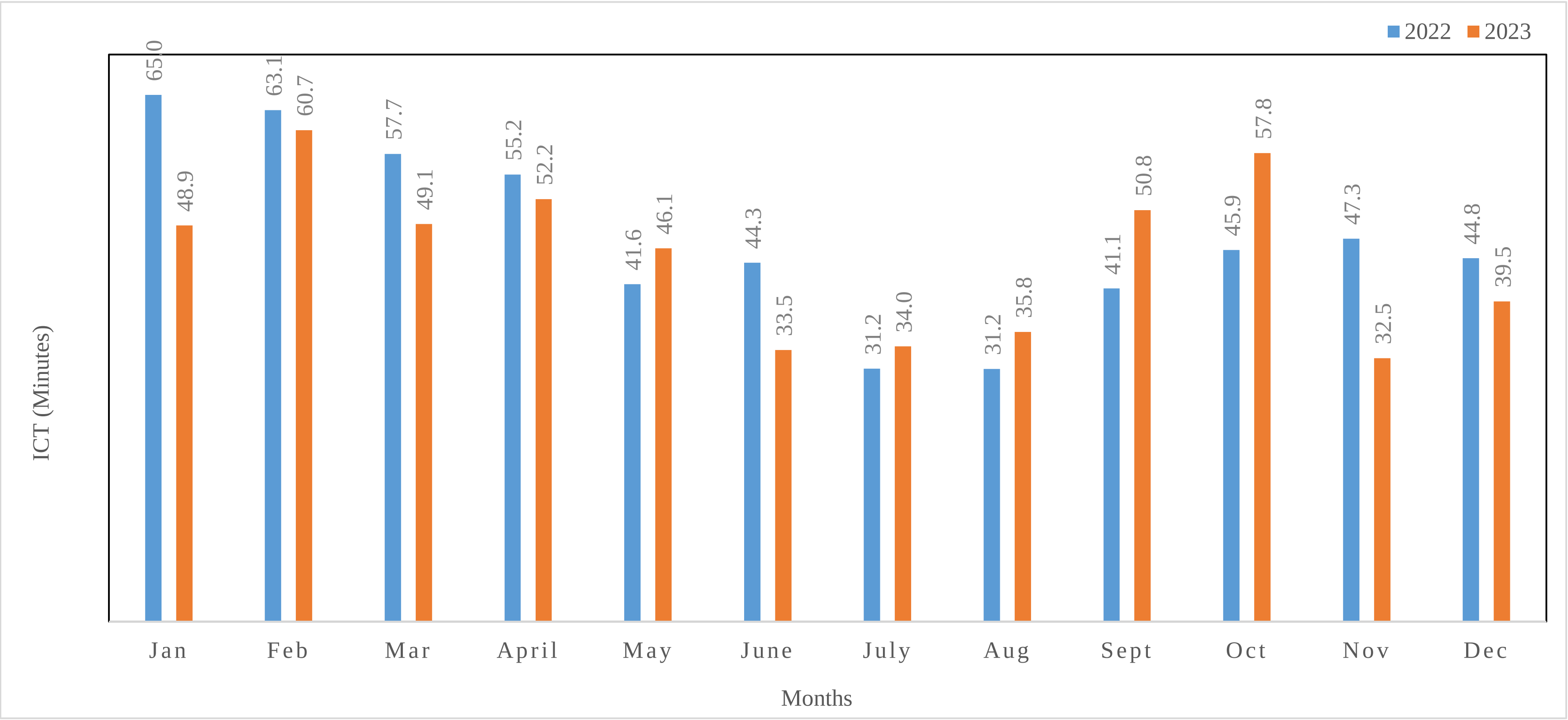


Figure 38. RCT by month for I-510