Road Ranger Programs for Arterials

BDV31-977-142

Final Report

Prepared for

FDOT

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November 2021

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METRIC CONVERSION CHART

U.S. UNITS TO METRIC (SI) UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
in	Inches	25.4	millimeters	Mm
ft	Feet	0.305	meters	M
yd	Yards	0.914	meters	M
mi	Miles	1.61	kilometers	Km

METRIC (SI) UNITS
TO U.S. UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
mm	millimeters	0.039	inches	In
m	Meters	3.28	feet	Ft
m	Meters	1.09	yards	Yd
km	kilometers	0.621	miles	Mi

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. Final Report	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Road Ranger Programs for Arterials		5. Report Date November 2021 6. Performing Organization Code UF	
7. Author(s) Sivaramakrishnan Srinivasan, Ilir Bejleri, Siddhartha Gulhare, and In Je Lee		8. Performing Organization Report No.	
9. Performing Organization Name and Address University of Florida Transportation Institute, University of Florida, 512 Weil Hall PO BOX 116580, Gainesville, FL 32611.		10. Work Unit No. (TRAIS) 11. Contract or Grant No. BDV31-977-142	
12. Sponsoring Organization Name and Address The Florida Department of Transportation Research Center 605 Suwannee Street, MS 30 Tallahassee, FL 32399		13. Type of Report and Period Covered Draft Final Report (2021) 14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract The intent of this project was to examine the spatiotemporal profile of incidents and suggest an initial plan for service patrol deployment for the arterials in Orlando. The study area was defined by the following boundaries: SR-434 in the north, US-17-92, I-4, US-441 in the east, SR-482 (Sand Lake Rd) in the south; and Kirkman Rd, John Young Pkwy and US-441 in the west. Based on a spatiotemporal analysis of crash frequencies and clearance times, the southern part of the study area was identified as the primary candidate for the service patrol program. Numerical simulations to evaluate performance of staged and centrally dispatched service program with one vehicle were undertaken. The results indicated the service vehicle could respond to over 70% of the crashes on an average and that the average clearance time per crash would be around 30-40 minutes. Overall, the service patrol program could result in a reduction of 36 to 45 minutes of clearance time on average per crash. The service vehicle would be occupied for about 3-4 hours/day/shift. It is anticipated that a staged and centrally dispatched service patrol program will be deployed as a pilot in the southern part of the study area. Patrolling-based operations may also be tested for a couple of weeks during the pilot implementation to see if there are any unanticipated benefits. The data collected from the deployment will be used to re-evaluate the program (approximately 18 months after deployment) to make suitable modifications and to make recommendations for the best approaches for deploying service patrols in other arterials in the state of Florida.			
17. Key Words Safety patrol, arterials, crash clearance times		18. Distribution Statement No restrictions.	
19. Security Classification (of this report) Unclassified.	20. Security Classification. (of this page) Unclassified.	21. No. of Pages 60	22. Price

ACKNOWLEDGEMENTS

This research was sponsored and funded by the Florida Department of Transportation Research Office. We are extremely thankful to Jeremy Dilmore, Sheryl Bradley, and Ryan Casburn for their support throughout the project.

EXECUTIVE SUMMARY

The Central Florida region has a robust service patrol program for incident management on freeways but not for the major arterials. The intent of this project was to examine the spatiotemporal profile of incidents and suggest an initial plan for service patrol deployment for the arterials in Orlando.

The study area was defined by the following boundaries: SR-434 in the north, US-17-92, I-4, US-441 in the east, SR-482 (Sand Lake Rd) in the south, and Kirkman Rd, John Young Pkwy and U-441 in the west. Historical crash data from January 1, 2018, through December 31, 2020, were used for analysis. Only crashes that happened between 6 AM and 10 PM on weekdays were considered for analysis. Given that service patrol deployments typically begin with weekday daytime services, it was deemed appropriate to exclude the nighttime and weekend crashes and incidents. Further, crashes and incidents that happened along I-4, the turnpike, and several local freeways managed by the Central Florida Expressway were excluded because the Road Ranger program currently serves all these freeways.

Based on a spatiotemporal analysis of crash frequencies and clearance times, the southern part of the study area was identified as the primary candidate for the service patrol program. Numerical simulations to evaluate performance of staged and centrally dispatched service program with one vehicle were undertaken. The results indicated the service vehicle could respond to over 70% of the crashes on an average and that the average clearance time per crash would be around 30-40 minutes. Overall, the service patrol program could result in a reduction of 36 minutes to 45 minutes of clearance time on average. The service vehicle would be occupied for about 3-4 hours/day/shift.

As a single service vehicle operating from a staged location while occupied for 50% or less of its service duration per shift can still service over 70% of all crashes and contribute to significant reduction in clearance times, it is deemed that additional service vehicles are perhaps not necessary.

It is anticipated that a staged and centrally dispatched service patrol program will be deployed as a pilot in the southern part of the study area. Patrolling-based operations may also be tested for a couple of weeks during the pilot implementation to see if there are any unanticipated benefits. The data collected from the deployment will be used to re-evaluate the program (approximately 18 months after deployment) to make suitable modifications and to make recommendations for the best approaches for deploying service patrols in other arterials in the state of Florida.

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ACRONYMS

CRS	Coordinate Reference System
FLHSMV	Florida Department of Highway Safety and Motor Vehicles
FDOT	Florida Department of Transportation
FHP	Florida Highway Patrol
OPD	Orlando Police Department
PDO	Property Damage Only
SCSO	Seminole County Sheriff's Office
SIRV	Severe Incident Response Vehicle

CHAPTER 1 BACKGROUND AND OBJECTIVES

It is well established that large-scale incidents along arterials can block lanes, which can have significant impact on overall travel time reliability of the region and sometimes can also lead to secondary crashes. The availability of a service patrol program can assist the law enforcement at the incident location with many critical tasks such as moving the disabled vehicles off the road, clear debris, and management of traffic. Expedition in incident clearance can reduce delays, minimize the likelihood of secondary crashes, and improve travel time reliability.

A vast majority of the literature on the use of service patrols for traffic incident management is in the context of freeways. The state of Florida has a robust freeway service patrol program called the “Road Rangers”, which has been operational for several years. More recently (Srinivasan et al., 2016) Florida Department of Transportation (FDOT) and the University of Florida also developed a data-driven approach for prioritizing future deployments and extensions (either spatially or temporally) of the service patrol program for other freeways in the state. The same final report also provides a detailed review of the literature in the context of freeway deployments, and these are not discussed in this report.

The search for research studies on the use of service patrols in the context of *arterials* was performed in Google Scholar. Additionally, the Traffic Incident Management Knowledgebase, maintained by FHWA Traffic Incident & Events Management (TI&EM) Knowledge Management System, was searched to find relevant studies. The final subset of articles can be broadly classified into three categories: (1) evaluation studies, (2) simulation studies, and (3) studies to improve the existing strategies.

These studies evaluated the traffic incident management programs based on performance indicators such as reduction in delay and benefit-cost ratio. Ryan et al. (2009) evaluated arterial service patrol program (named I-64 Traffic Response) that monitored the major adjacent arterials when I-64 was closed for reconstruction. It was estimated that the benefit-cost ratio was 8.3:1, reduction in secondary crashes per year was 183, and the annual reduction is congestion cost was $1,034,000. It is useful to note here that the arterials to be covered by the service patrol program were known *apriori* because these were the routes the traffic was redirected to because of the freeway reconstruction.

There is a number of studies which involve traffic simulations to evaluate the impacts of various traffic incident management scenario involving real-time traveler information systems, route guidance system, and signal coordination to redirect traffic. For example, Lin (2002) evaluated the impact of Advanced Traveler Information Systems and Advanced Traffic Management Systems on incident management. SYNCHRO was used to develop optimal signal timings on alternative routes and later Sim-Traffic traffic simulation was used to evaluate the alternatives. Other similar studies involving traffic simulations are Dia and Cottman (2006), Cazares (2017), Vichiensan et al. (2011), Bhide (2005), Gondwe and Dia (2005), Gondwe (2008) and Kim et al. (2015). However, none of these simulation studies considered the effects of a service patrol program on evaluating the impacts.

Other studies have contributed to developing incident management strategy with emphasis on developing better coordination among various actors involved.

Raub and Schofer (1997) conducted the Arterial Incident Management study (AIMS) for Illinois Department of Transportation to determine the typical procedure used for traffic incident management on arterials, to define improved strategies and avenues to implement them. Several approaches were used including analysis on data reported by police and fire agencies debriefings, videorecording of incidents and incident management simulation workshop involving various agencies such as police, fire, medical, public works, insurance, and media. The study found that a successful incident management program focuses on broad and integrated responses which include victims, personal and material hazards, and traffic operations.

Steenbruggen et al. (2014) offered an overview of principles and practices of incident managements in the Dutch context. They also presented an advance information system as a new direction for a better coordinated interaction of many public and private actors to improve the fast clearance of the incident scene.

Shlayan et al. (2012) proposed a formal language theory, widely used in software and hardware systems, to model, analyze and implement the traffic incident management procedure. The proposed theory allows rigorous debugging on current and future scenarios covering all possibilities for inefficiencies for which solutions can be found. The proposed methodology was implemented to a case study in the Las Vegas area. Other studies which contributed to improvement or coordination among various actors in traffic management strategy are Abou-Beih et al., (2010) and Deeter (1993).

It does not appear that any of these studies included service patrols as an additional entity for handling incident management. In summary, the documented literature on the design and deployment of service patrols for arterial incident management appears scarce.

However, FDOT District Four has a Severe Incident Response Vehicle (SIRV) on arterial patrol in Broward County to provide a coordinated response to clearing incidents along the arterial system[1]. SIRV operates one dedicated truck in the arterial roadways (Figure 1) between 6 a.m. and 7 p.m. Monday through Friday. An implementation plan is underway to extend SIRV services to Palm Beach County, and to increase SIRV's patrol hours and response fleet to two dedicated trucks patrolling from 6 a.m. to 10 p.m. in Broward County. The locations and phases for deployment were based on the available ITS devices used to monitor traffic conditions along the arterials by dedicated AMP Operators.

[1] This section is based on information provided during a meeting on June 8 2021 and email correspondence with District 4

Figure 1 Location of arterial patrols in Broward County

SIRV is designed to mitigate the delays caused by severe traffic incidents on interstates by providing a safer work zone for emergency responders. SIRV measures their success by documenting reductions in the length of time individual lanes are blocked (Lane Blockage Time Savings), the length of time other responders is required to remain on scene (Agency Time Savings) and the duration of the event as a whole Incident Time Savings. SIRV responds to a variety of lane blocking events in the arterial roadways. Most of the events are crashes, but others involve Police Activities, Disabled Vehicles and any other events as requested. Most of the crashes SIRV responded to occurred at intersections. The SIRV vehicles can either be dispatched to a "serious event" location based on video data reviewed at the TMC or the driver can come up on a disabled vehicle while patrolling (even in this case, the driver reports the event to the TMC).

In 2020, SIRV responded to 378 lane blocking events in the arterial roadways in Broward County, with an average response time of 11 minutes, 9 seconds. Due to actions such as removing vehicles and debris from the roadway, mitigating oil & fuel spills, and making repairs to asphalt, SIRV was able to reduce the duration of the event on 143 events, with an average reduction of 12 minutes per event. SIRV's time savings in minutes in the arterials by category break down as follows:

- Incident Duration 3,775 minutes
- Individual Lane Duration 5,005 minutes
- Agency Time Savings 2,339 minutes

In Summary, the Central Florida region has a robust service patrol program for incident management on freeways but not for the major arterials. The intent of this project was to examine the spatiotemporal profile of incidents and suggest an initial plan for service patrol deployment for the arterials in Orlando. The analysis was based on available data, contextual knowledge and opportunities and constraints imposed by network and land use condition. The data collected from the deployment were used to re-evaluate the program (approximately 18 months after deployment) to make suitable modifications and to make recommendations for the best approaches for deploying service patrols in other arterials in the state of Florida.

CHAPTER 2 ANALYSIS OF DATA ON DISABLED VEHICLES

The data on disabled vehicles were obtained from two agencies: Orlando Police Department (OPD) (Orange County) and Seminole County Sheriff's Office (SCSO) (Seminole County). Data from each agency had a different set of fields. A standardized set of fields common to both locations was first generated (Figure 2). The agency name field was added to this standardized set. The OPD data had several fields describing the time of the incident, while the Seminole data had only one. Therefore, a single time field was retained using the "create Date/Time" field from OPD. The location fields were common to both agencies. The OPD data identified the primary unit responding to the incident and whether or no additional units were also involved. In the case of Seminole data, a single field called units listed all the attending units. The first unit listed under units in the Seminole data was extracted as the primary unit, and if there were additional entries in this field, the "additional units" field was set to true.

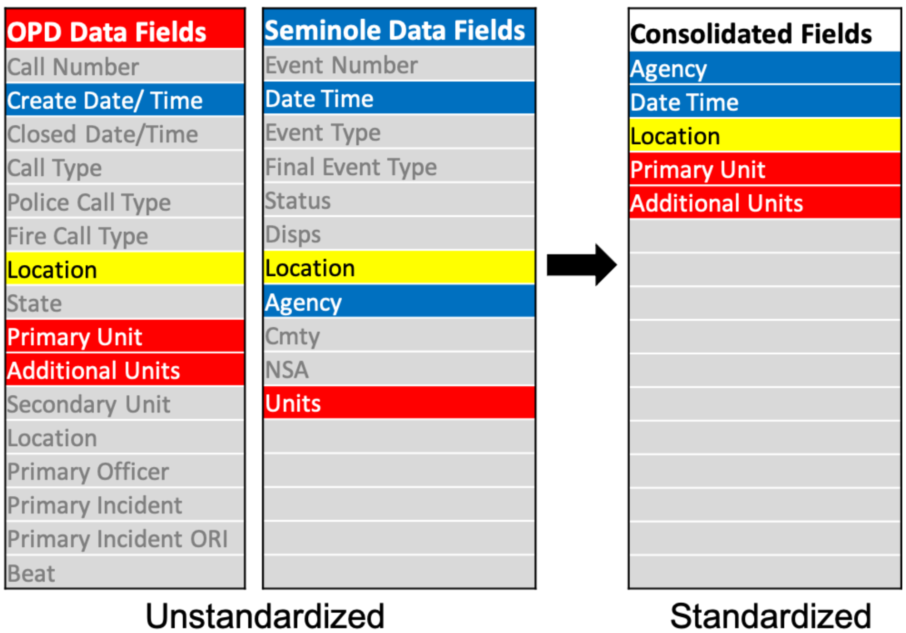

Figure 2 Standardized fields

Geocoding is a process of transforming a description of a location into geographic features with attributes. The disabled vehicle data have a "Location" field, but the address information presented one of three types: (1) a street address (yellow in Figure 3), (2) intersection (pink in Figure 3), or (3) latitude and longitude (green in Figure 3). The addresses in the figure are geocoded using the Geocode Addresses tool in ArcGIS pro. However, not all addresses matched with locator addresses; the unmatched addresses were reviewed individually. The Locate tool in ArcGIS was used to find unmatched locations on the map, and the Pick Address from Map tool was used to match the address (Figure 4).

C	D	E	F	G
Location	Primary Unit	Additional Units	Date_Time	Agency
VINELAND RD / S KIRKMAN RD, Orlando	E14A	False	12/27/2020 19:14	OPD
N JOHN YOUNG PKWY / W COLONIAL DR, Orlando	C53	False	12/27/2020 15:54	OPD
LAT: 28.4860; LON: -81.4403, Orlando	549	False	12/26/2020 6:18	OPD
4529 N PINE HILLS RD, Orlando	B47	False	12/24/2020 10:28	OPD

Figure 3 Screenshot illustration 1

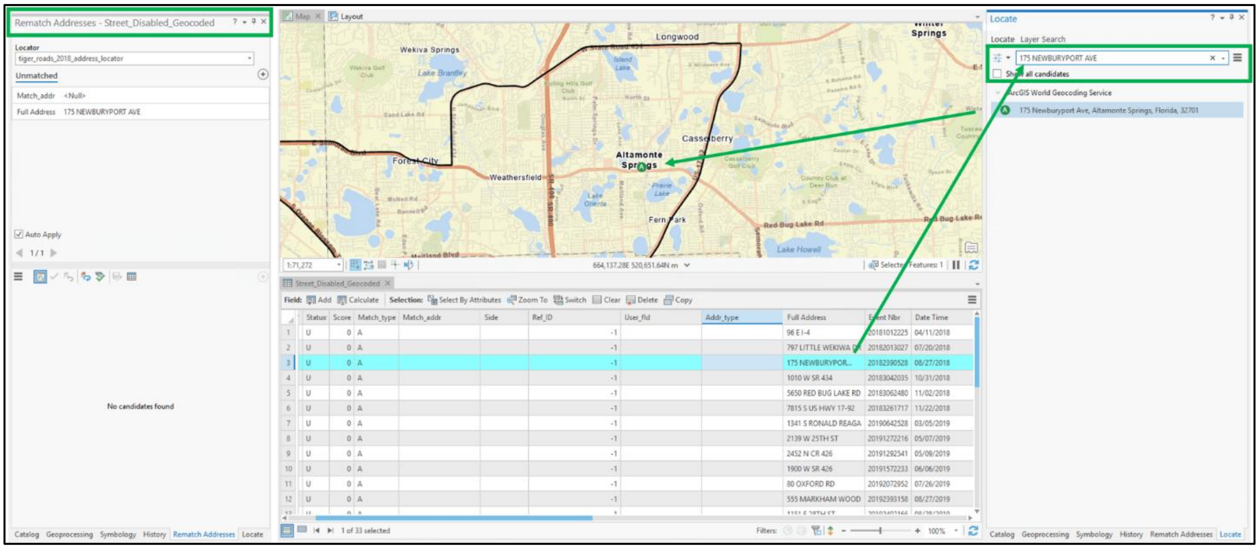

Figure 4 Screenshot illustration 2

The disabled-vehicle data from OPD have 387 records from August 2019 to April 2021. SCSO's data have 548 records with a time range of January 2018 to December 2020 (Table 1). Although the desired time frame for analysis is January 2018 – December 2020; the data prior to August 2019 could not be obtained from OPD because of changes in software used.

Table 1 Disabled vehicles by years

Agency	Year	Counts	Percent
OPD	2019 (Aug-Dec)	84	22%
	2020	228	59%
	2021 (Jan-Apr)	75	19%
Total		387	100%
SES	2018	182	33%
	2019	212	39%
	2020	154	28%
Total		548	100%

The temporal distribution of disabled vehicles (all the 935 records) is shown in Figure 5. The initial arterial service patrol program will be deployed only during the daytime (6 AM – 10 PM) on weekdays. Therefore, data for weekends and the nighttime period of 10 PM – 6 AM will be excluded from further analysis.

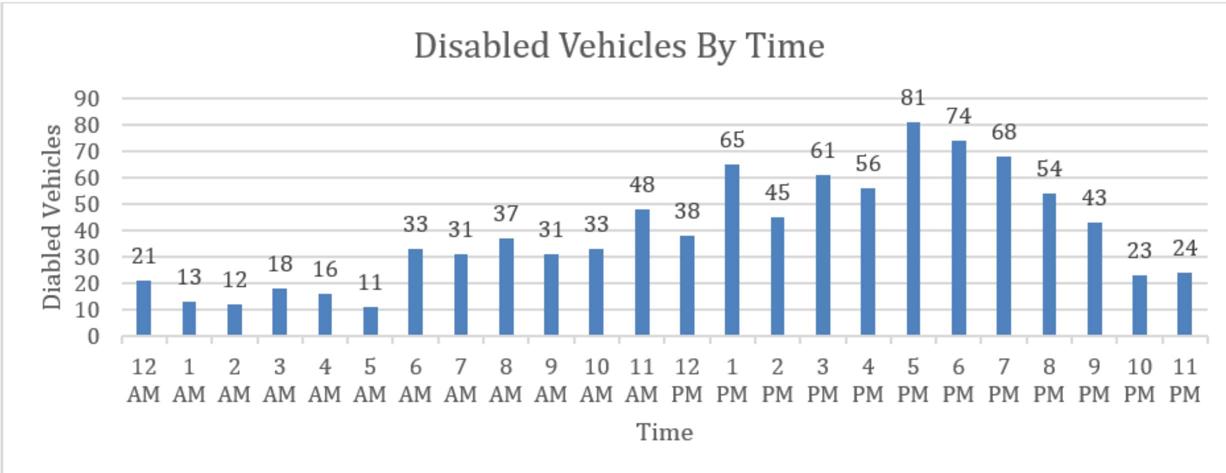

Figure 5 Disabled vehicles distribution over 24 hours

The study area of interest is shown in Figure 6, with a bold black line as the boundary. Data obtained from OPD and SCSO represent geographic areas corresponding to the respective jurisdictions of these agencies and therefore also include areas outside the study area. The data outside the study area are therefore removed. There are roads within the study area where Road Rangers services are provided: Interstate 4, SR-408, and SR-414, and Florida's turnpike. Data from these roads within the study area are also excluded.

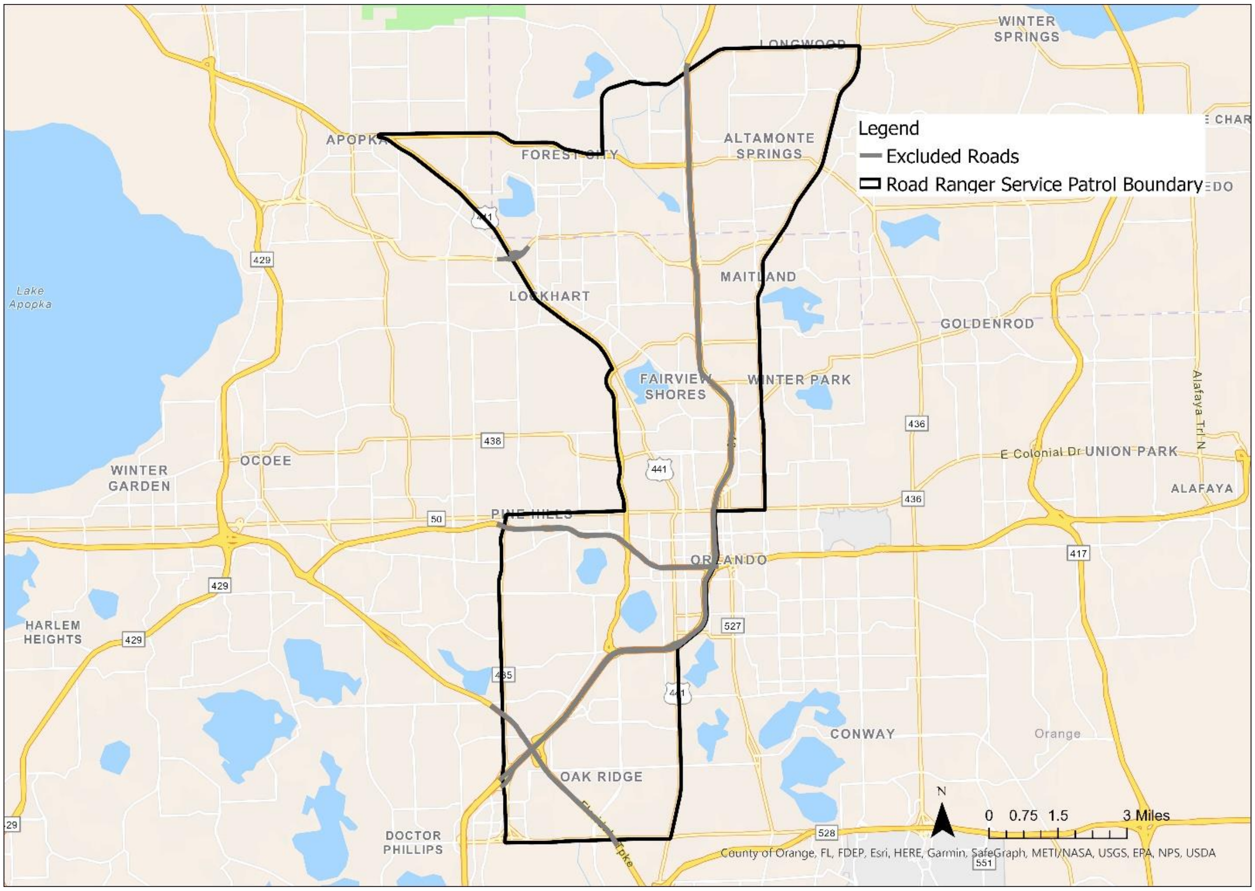

Figure 6 Study area

Upon applying the spatial and temporal filters, only 130 of the 935 (13.9%) total disabled vehicle incidents were found to be within the study area and during weekday daytime hours. The primary reason for the substantial reduction in the number of incidents (from 935 to 130) was that a vast majority of the incidents were outside the study boundary (See blue dots in Figure 7 and Figure 8). Among the incidents that were within the study boundary, a good proportion was on roads already covered by the Road Ranger (See red dots Figure 7 and Figure 8).

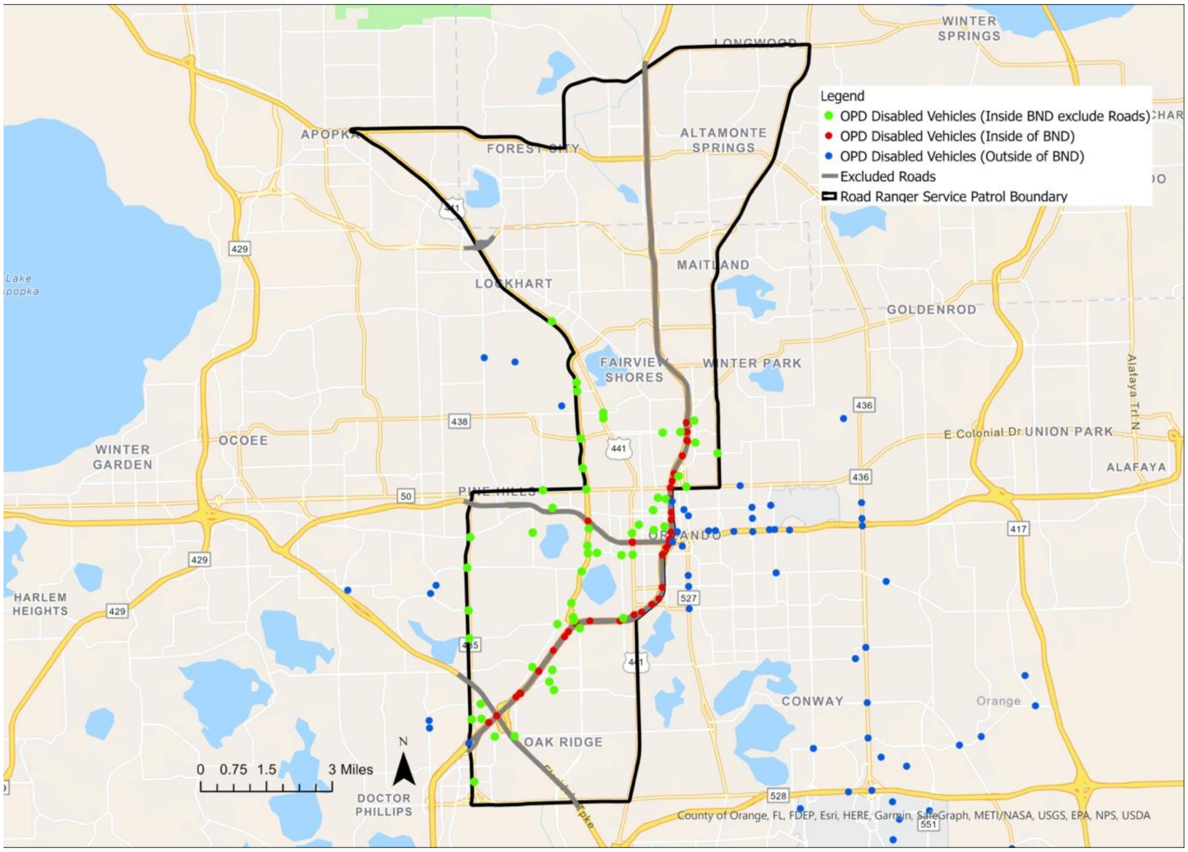

Figure 7 Disabled vehicles by OPD agency

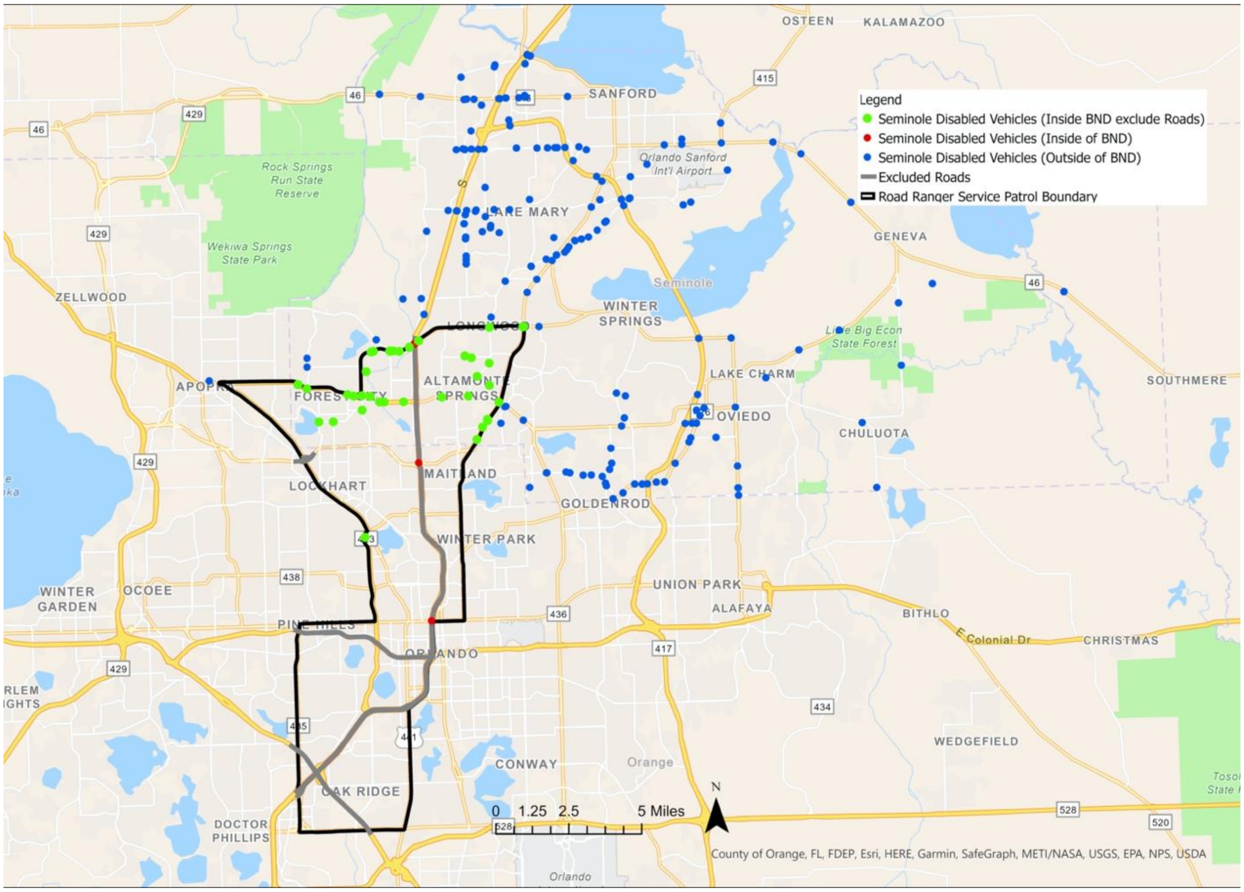

Figure 8 Disabled vehicles by Seminole County agency

The spatial distribution of these 130 incidents is presented in Figure 9, and the temporal distribution of these incidents is presented in Figure 10. Given the small overall sample of such incidents, further spatial/temporal analyses were not undertaken.

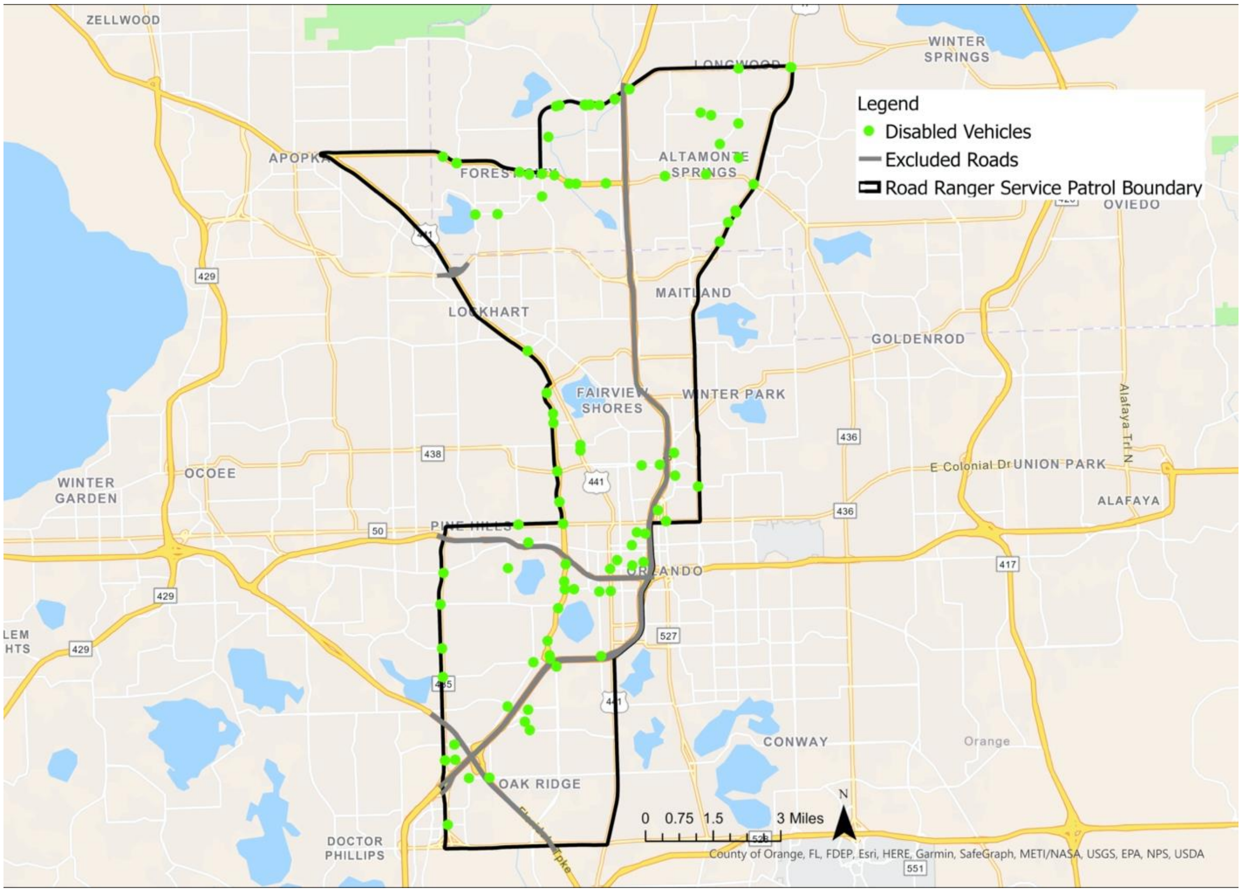

Figure 9 Location of disabled vehicles within the study area

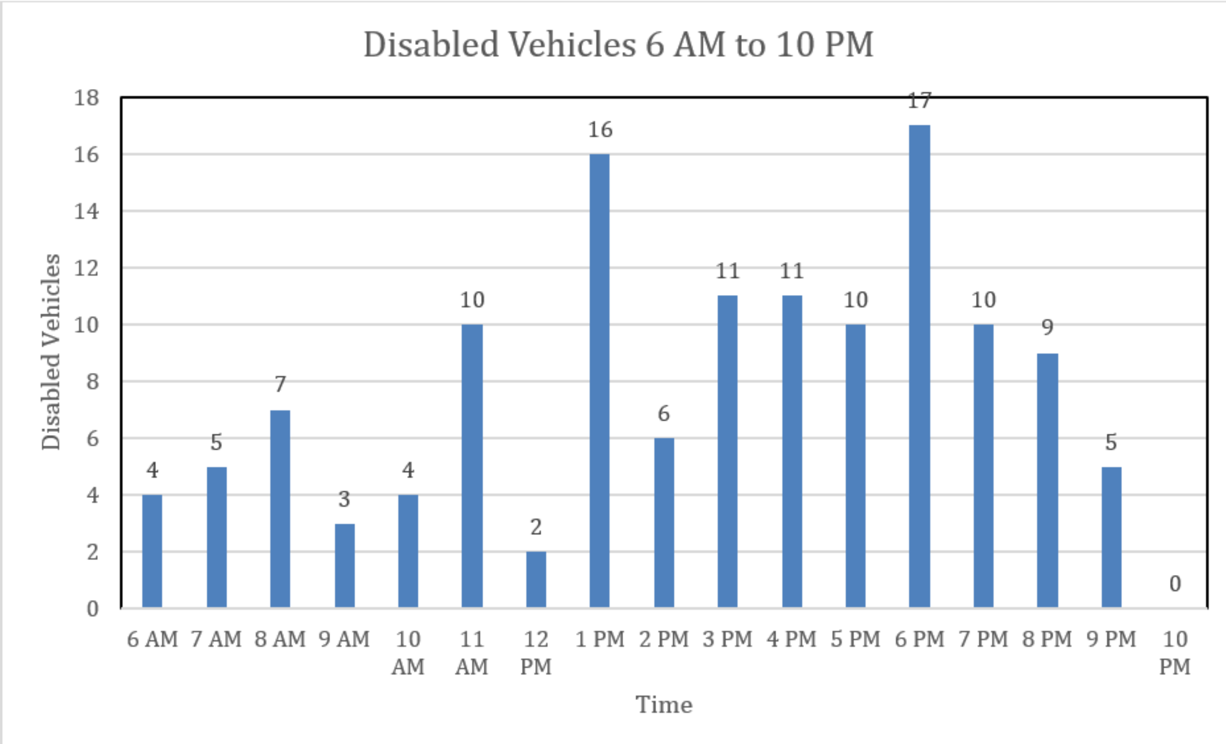

Figure 10 Disabled vehicles distribution 6 AM to 10 PM

Overall, the analysis of the disabled vehicle data suggests a limited potential of an arterial service patrol to address such incidents in the area. Only 130 such incidents were identified over a three-year period. However, it should be noted that data could not be obtained from all police departments serving the region. Of the two agencies that provided data, the time periods of data availability were different.

However, a vast majority of the disabled vehicles attended to by the OPD and SCSO agencies were located outside the desired study area. Therefore, the analysis suggests there are other locations in the vicinity of the current study area which can benefit from a service that can help with disabled vehicle.

CHAPTER 3 ANALYSIS OF CRASH DATA

The study area lies in Orange and Seminole counties in Florida and is defined by the following boundaries: SR-434 in the north, US 17-92, I-4, US-441 in the east and SR-482/Sand Lake in the south, and Kirkman Rd, John Young Pkwy and US 441 in the west. Figure 11 shows the study area. The background map was extracted from Open Street Map data. While the road network was extracted from HERE data. The roads were colored based on the functional classes as mentioned in HERE data, also shown in Figure 11. The roads with functional class value more than 3 were categorized as minor roads while others with class 3 or less were categorized as major roads (please see Table 2 for details).

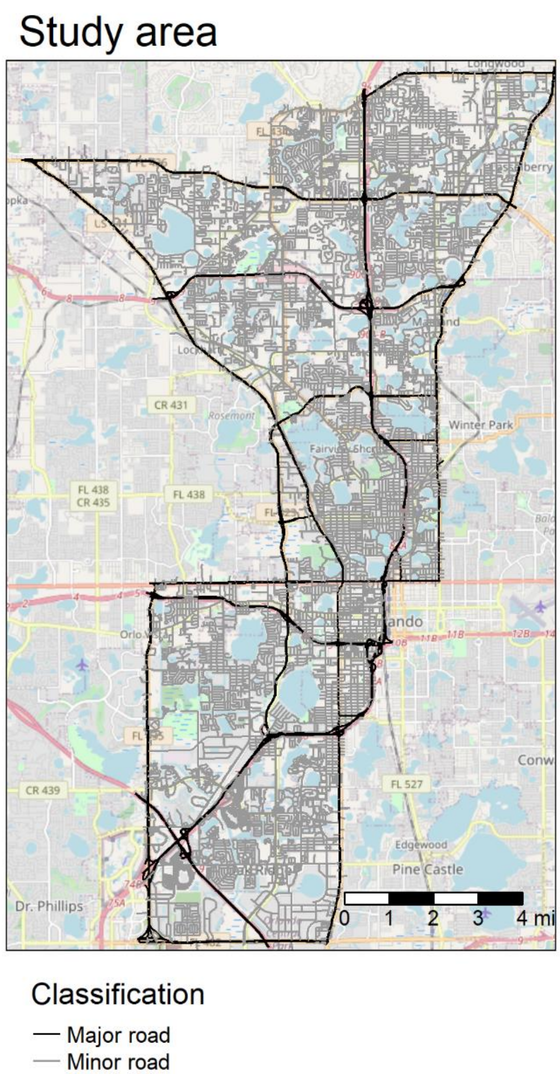

Figure 11 Study area

Table 2 Functional class of roads

Functional class	Definition
1	a road with high volume, maximum speed traffic
2	a road with high volume, high speed traffic
3	a road with high volume traffic
4	a road with high volume traffic at moderate speeds between neighborhoods
5	a road whose volume and traffic flow are below the level of any other functional class

Historical crash data from January 1, 2018, through December 31, 2020, were used for analysis. Given the major construction that happened along the I-4 corridor in recent years, it was deemed that data prior to 2018 will not be reflective of the current conditions. Within the 3-year period, only crashes that happened between 6 AM and 10 PM on weekdays were considered for analysis. Given that service patrol deployments typically begin with weekday daytime services, it was deemed appropriate to exclude the nighttime and weekend crashes and incidents. Further, crashes and incidents that happened along I-4, the turnpike, and several local freeways managed by the Central Florida Expressway were excluded because the Road Ranger program currently serves all these freeways. There were 26,861 weekday daytime crashes reported in the study area during this period.

Because the primary intent of this effort was to determine locations that can benefit from an arterial service patrol, the clearance times associated with crashes were of primary interest. Locations that experience crashes requiring larger clearance times can benefit from the additional assistance provided by the service patrol vehicles leading to potentially reduced clearance times and improved travel time reliability.

The data contain the following information about the clearance of crash sites: time of crash, time of notification (to respective agency), time of dispatch (of emergency vehicles), time of arrival (of emergency vehicles), and time of clearance (of crash site). Each crash incident should report these events in the correct sequence. Those crash incidents found not to have reported these events in the correct sequence were removed and not considered for further analysis. Further, all crash incidents for which the difference between the time of clearance and time of notification was over eight hours were also removed. Overall, 831 observations were discarded, and therefore, the final crash data consist of 26,030 crash incidents.

Figure 12 shows the distribution of clearance time of all the crashes. The distribution is skewed towards the left, and the mean and median clearance times are 1.28 hours, and 1 hour respectively.

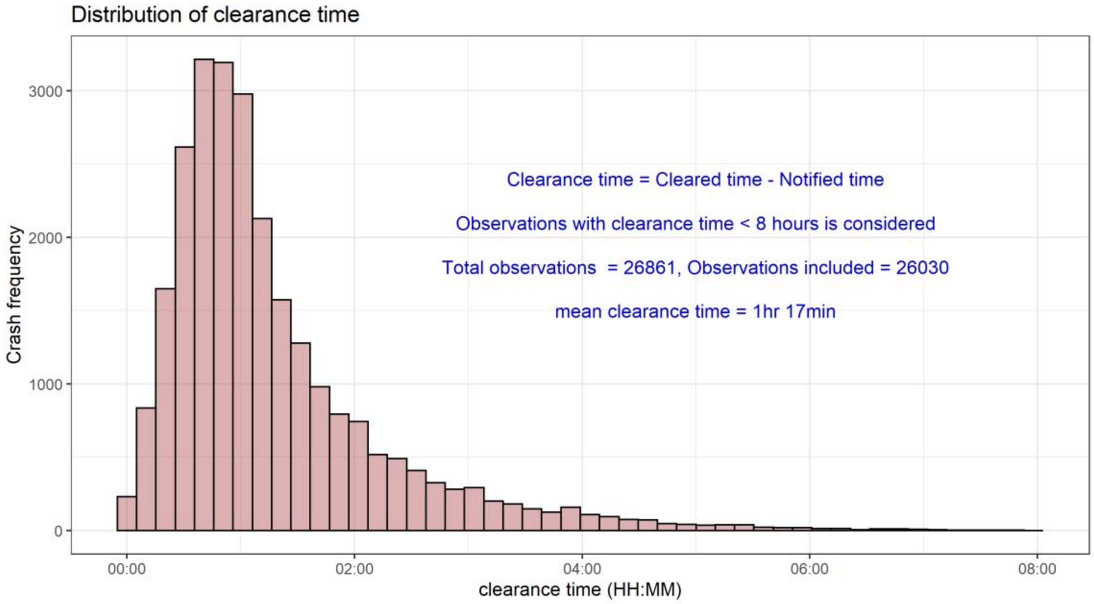

Figure 12 Distribution of clearance time of crashes

Figure 13 shows the distribution of time duration between successive events of the overall incident clearance process. The average duration between crash and notification is 4 minutes and this was a reason why the notified time was taken as the starting time in the computation of the total clearance time shown in the previous figure. The average time between notification and dispatch was 20 minutes, the average time between dispatch and arrival was 14 minutes and the average time between arrival and clearance was 42 minutes.

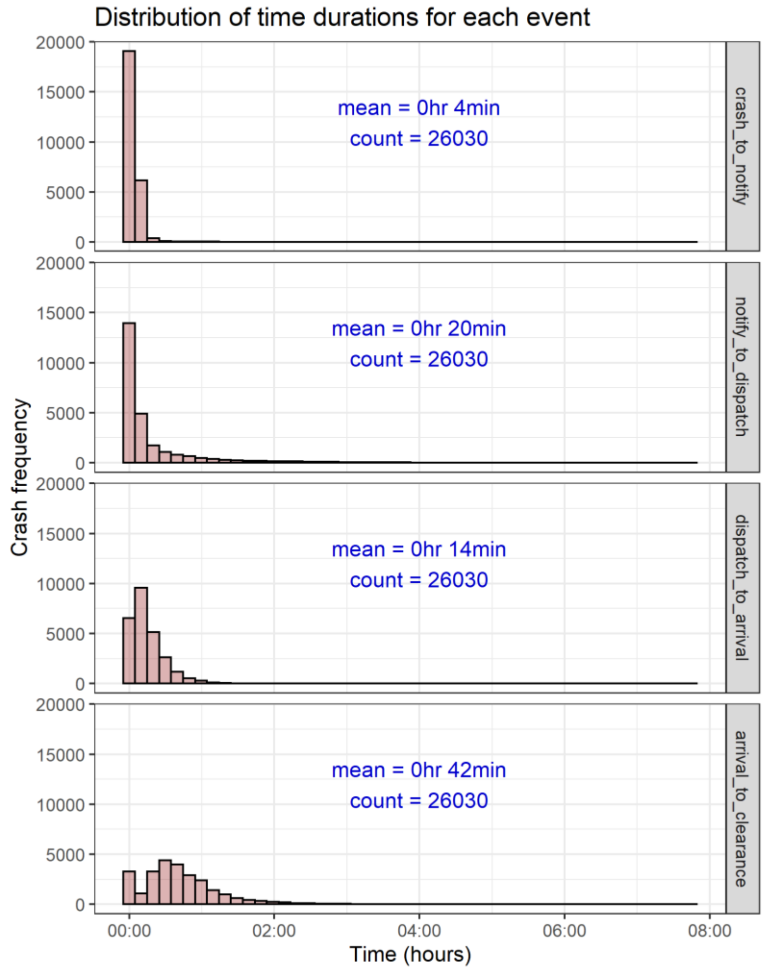

Figure 13 Distribution between durations of consecutive events

The next several figures present the distribution of total clearance times by various crash characteristics. Figure 14 presents the clearance time by the highest level of injury severity (Fatal, incapacitating injury, non-incapacitating injury, possible injury, and property damage only). The results show that the clearance times are, on an average, higher when the highest level of severity of the crash are higher. Figure 15 presents the clearance time by number of vehicles involved in the crash and Figure 16 present the clearance times by the number of persons injured in the crash.

These figures highlight that the clearance times are greater when more vehicles are involved in the crash or more people are injured in the crash. Overall figures 14, 15, and 16 demonstrate the correlation between clearance times and overall severity of the crash. It is logical that such high severity / high clearance time crashes should be prioritized to receive assistance from the service patrol. It is also useful to acknowledge that, for higher severity crashes, it would be necessary for other emergency providers (police, EMS, fire, etc.) to be present and lead the clearance efforts and the role of the service patrol may be limited to maintenance of traffic, debris removal, and secondary assistance. On the other hand, service patrol vehicles may be able to play a bigger role in clearing out less-severe crashes (moving the vehicles away from obstructing the roadway to completely clearing out the scene). This differential role of the service patrol vehicles must be recognized when responding to incidents of varying severity.

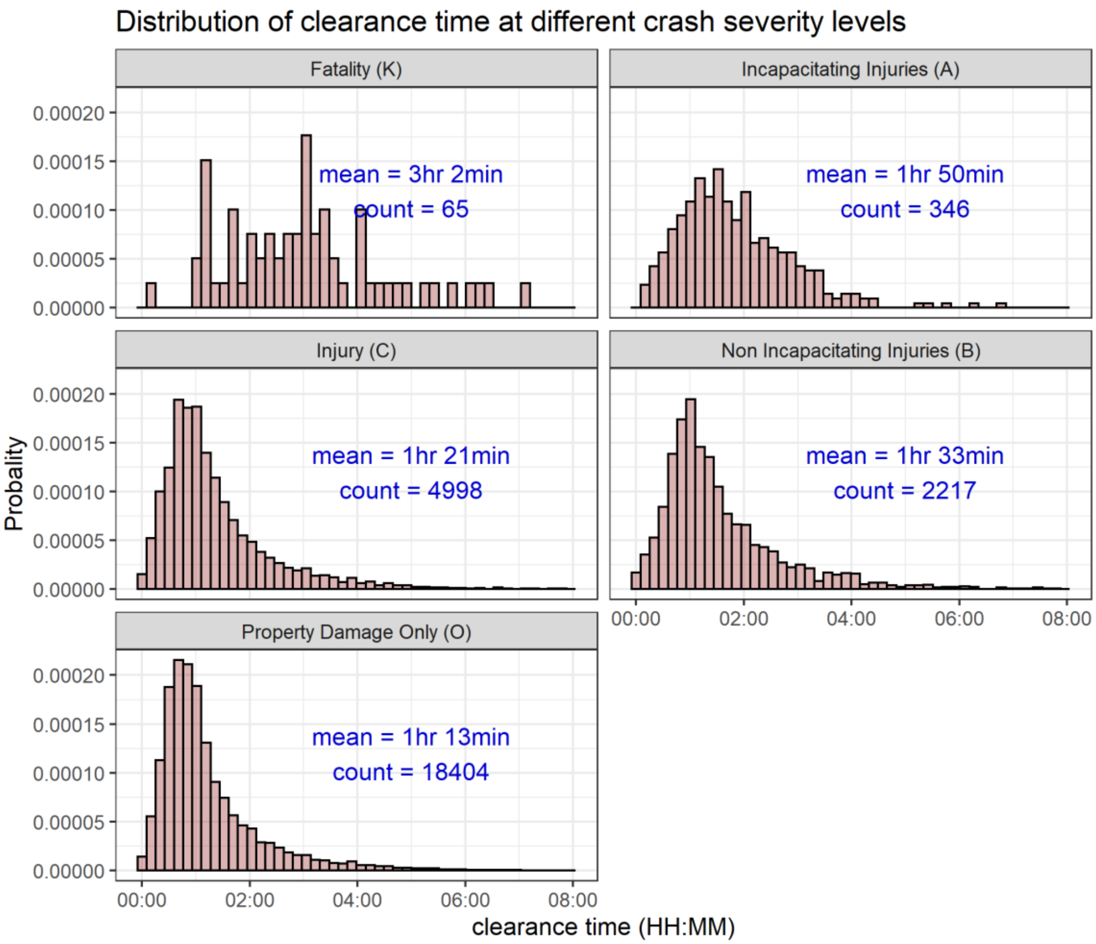

Figure 14 Distribution of clearance time at different crash severity levels

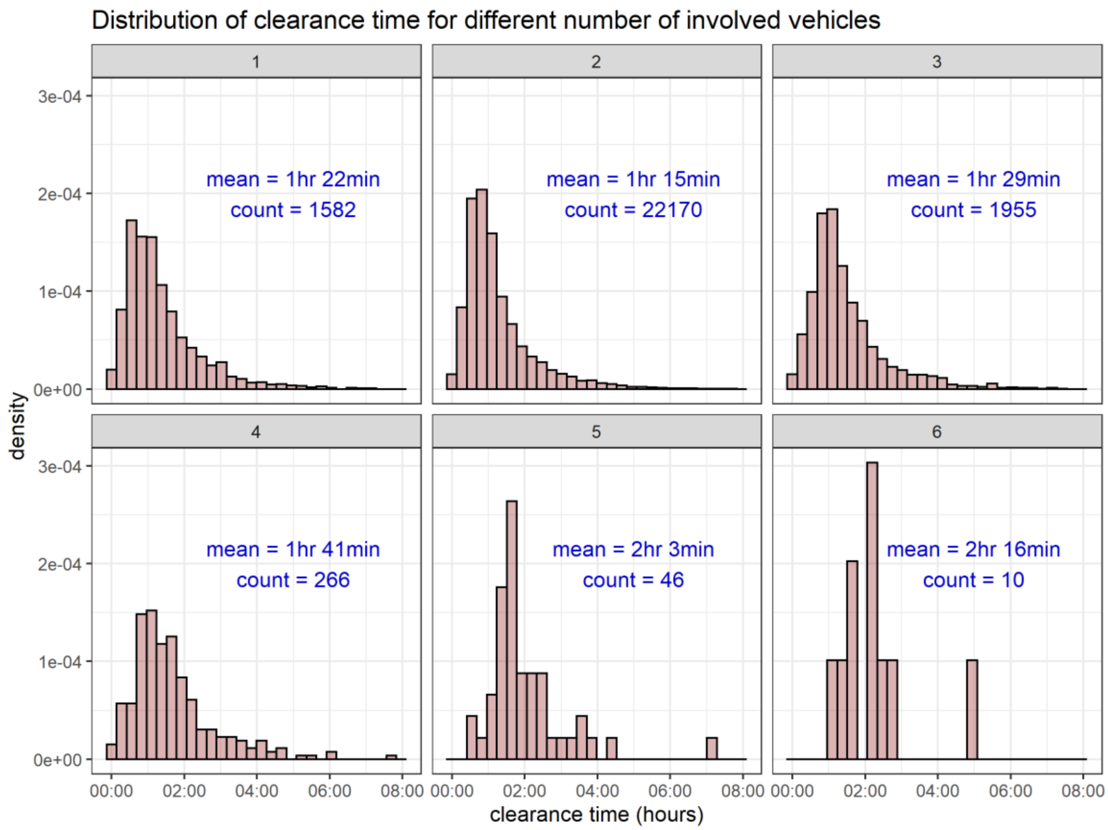

Figure 15 Distribution of clearance time for different number of involved vehicles

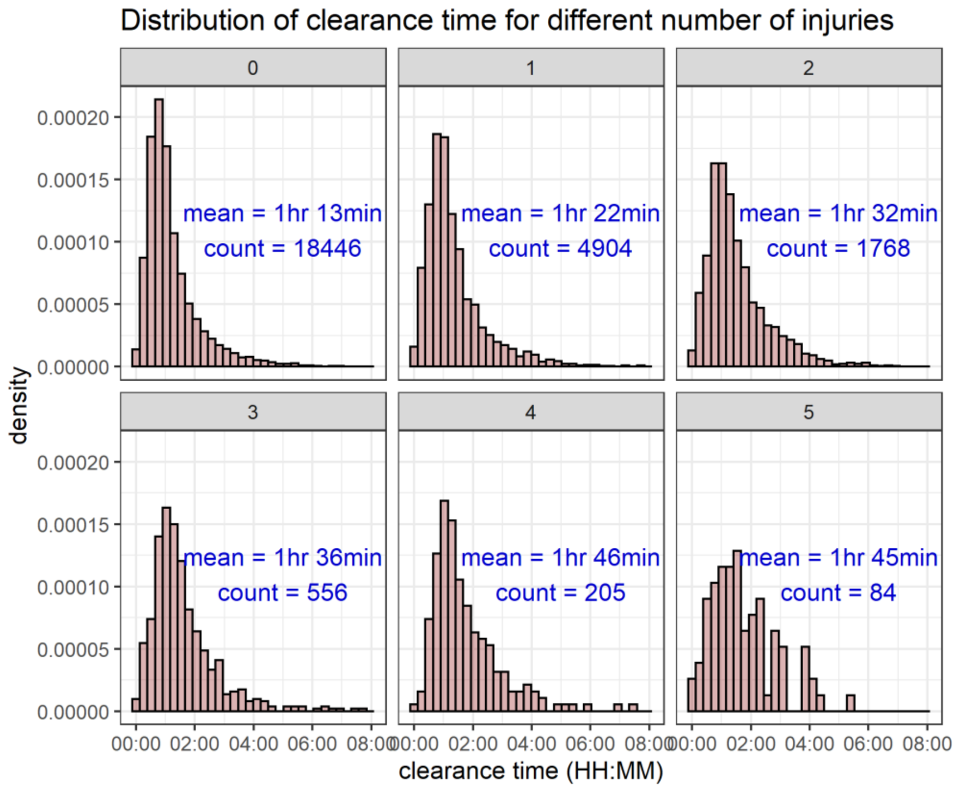

Figure 16 Distribution of clearance time for different number of injuries

The next several figures present the distribution of clearance time by temporal characteristics of the crash. Figure 17 shows that the clearance times are not very different across the five weekdays.

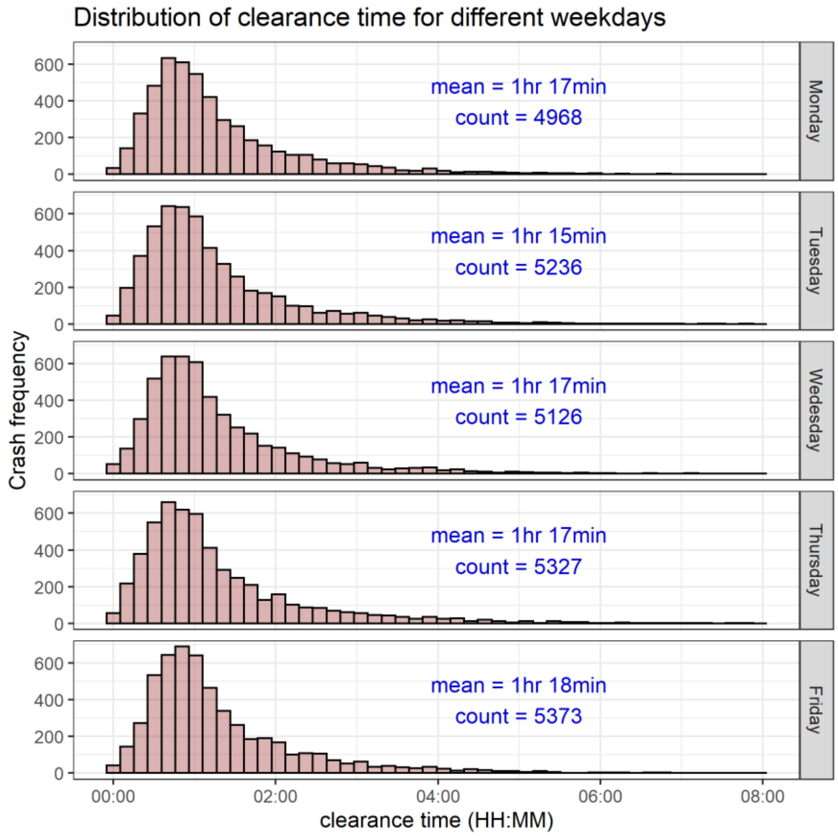

Figure 17 Distribution of clearance time for different weekdays

The time of day was split into two periods of eight hours each (6 AM to 2 PM and 2 PM to 10 PM), corresponding to the typical shifts of the service patrol. Figure 18 shows the distribution of clearance time for two different shifts. The afternoon shift was found to have slightly more crashes and a slightly longer clearance time (1 hr 21 min versus 1 hr 12 min) than the morning shift.

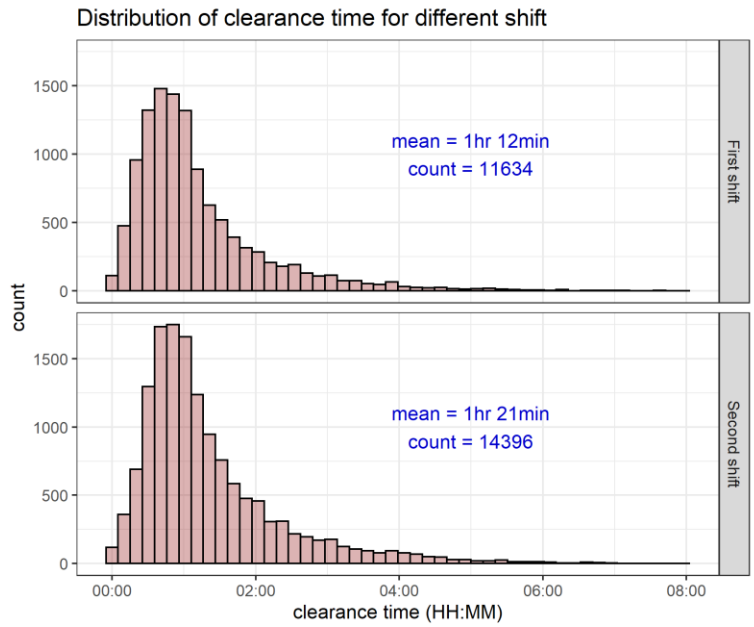

Figure 18 Distribution of clearance time for different shifts

Figure 19 shows the distribution of clearance time at different weather conditions. About 80% of all incidents are under clear weather conditions. Further, the average clearance times are also quite similar under the different weather conditions.

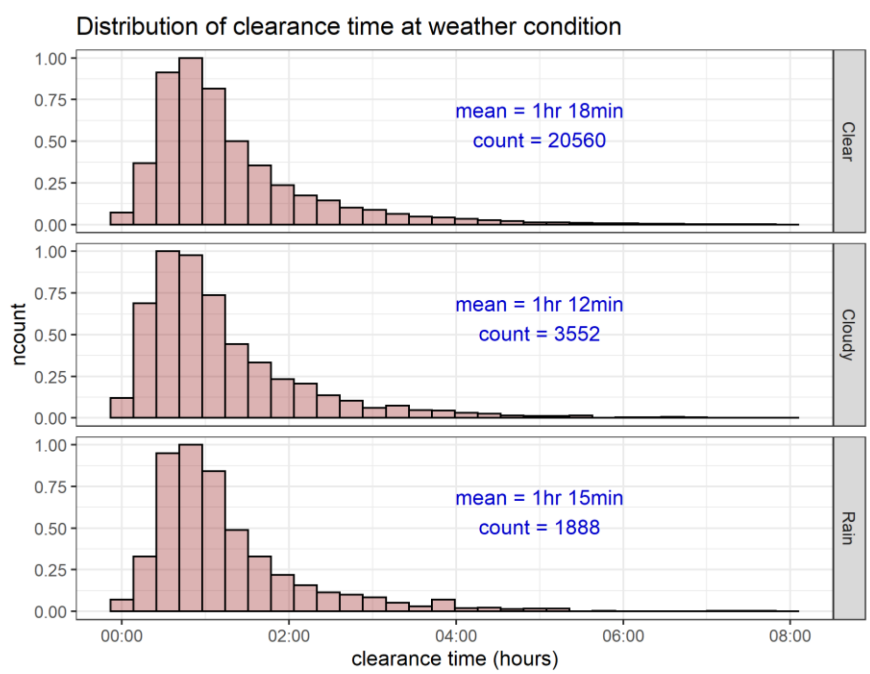

Figure 19 Distribution of clearance time at different weather conditions

Figure 20 and Figure 21 shows the distribution of time duration between successive events of the overall incident clearance process at different weather conditions. The time taken for each event was found to be similar under different weather conditions. The arrival to clearance time is same under Clear and Rain weather conditions, while it is slightly less for Cloudy condition.

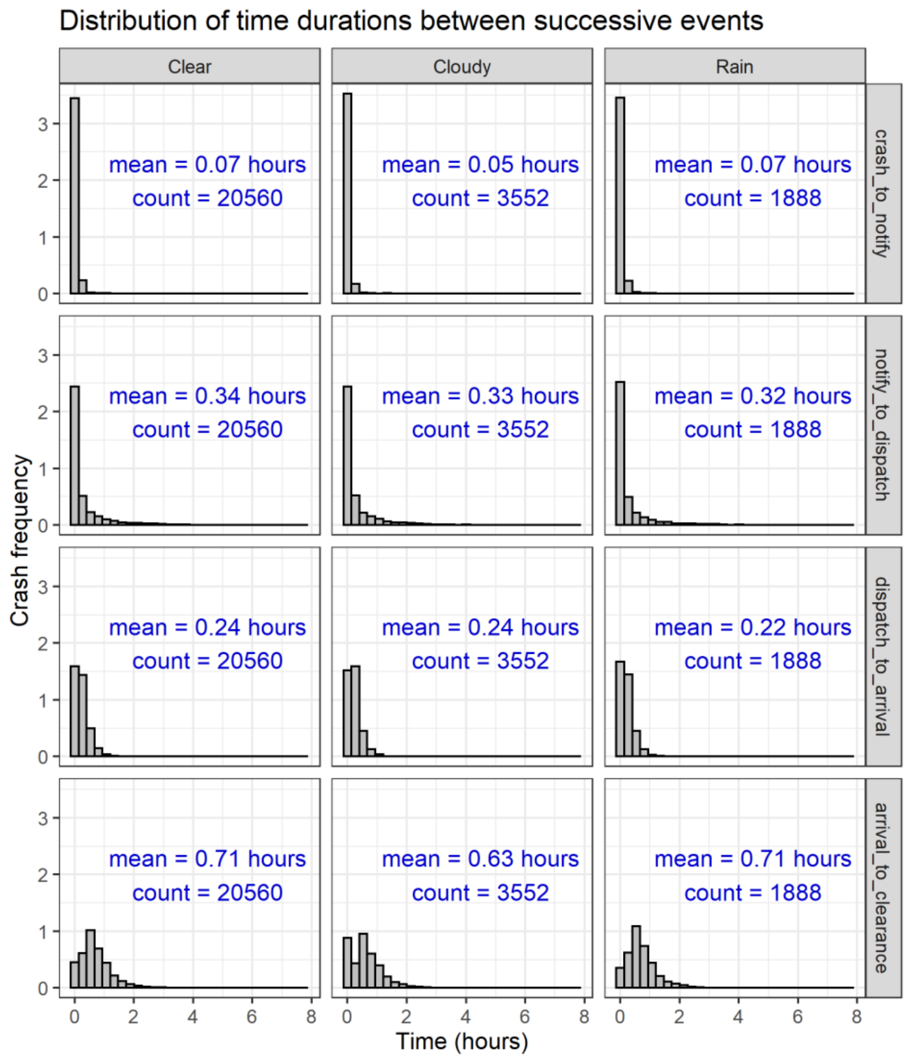

Figure 20 Distribution of durations between consecutive events at different weather conditions

Figure 21 shows the distribution of clearance times between crashes happening within city limits and those happening outside the city limits (the determination was made by the police officer responding to the crash and recorded in the crash report). The differences are very striking. The average clearance time for within city crashes is about 0 hr 59 min, while those for outside the city limits are 2 hr 2 min.

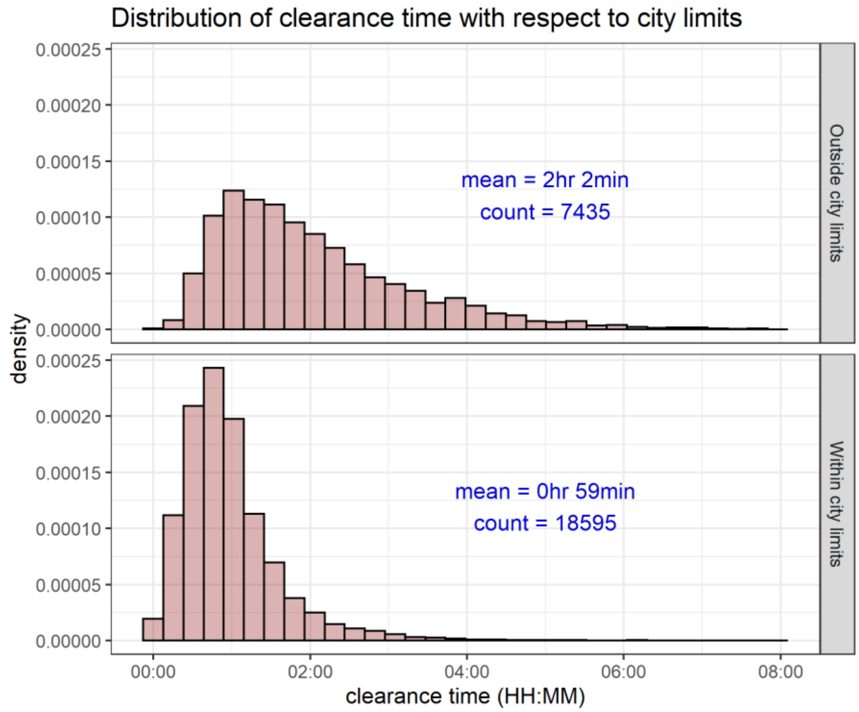

Figure 21 Distribution of clearance time with respect to city limits

Figure 22 shows the distribution of the components of the clearance time separated by within city and outside city crashes. Table 3 presents average values if the clearance times by injury severity level and by location (within city versus outside city). There are significant differences in each component of the clearance time. The overall average time between notification to dispatch is about 0.17 hours within the city but 0.77 hours outside the city (Table 3). This difference is largely for Property Damage Only (PDO) crashes (

Table 3); in the case of fatal crashes, the difference between within city and outside city is only 0.1 versus 0.24 hours. Within the city, the help is provided by the police department (Orlando Police Department, OPD, being the primary agency in our study region; See Table 4), and they can respond quickly. Outside of the city limits, assistance is provided by Florida Highway Patrol (FHP; see Table 4). Given the limited availability of FHP officers and their focus on highways over arterials, arterial crashes outside city limits take longer to clear. Even PDO crashes take a long time to clear because of the significant delay in FHP officers responding to the incident. The time between dispatch and arrival is also higher for outside city crashes as the FHP officers may have to travel from a farther location to arrive on the scene. The arrival to clearance time is also higher for out of city crashes. Overall, this analysis does suggest that arterials that are out of city limits may benefit from a service patrol program as the service can provide quicker assistance to these crashes (especially PDO crashes).

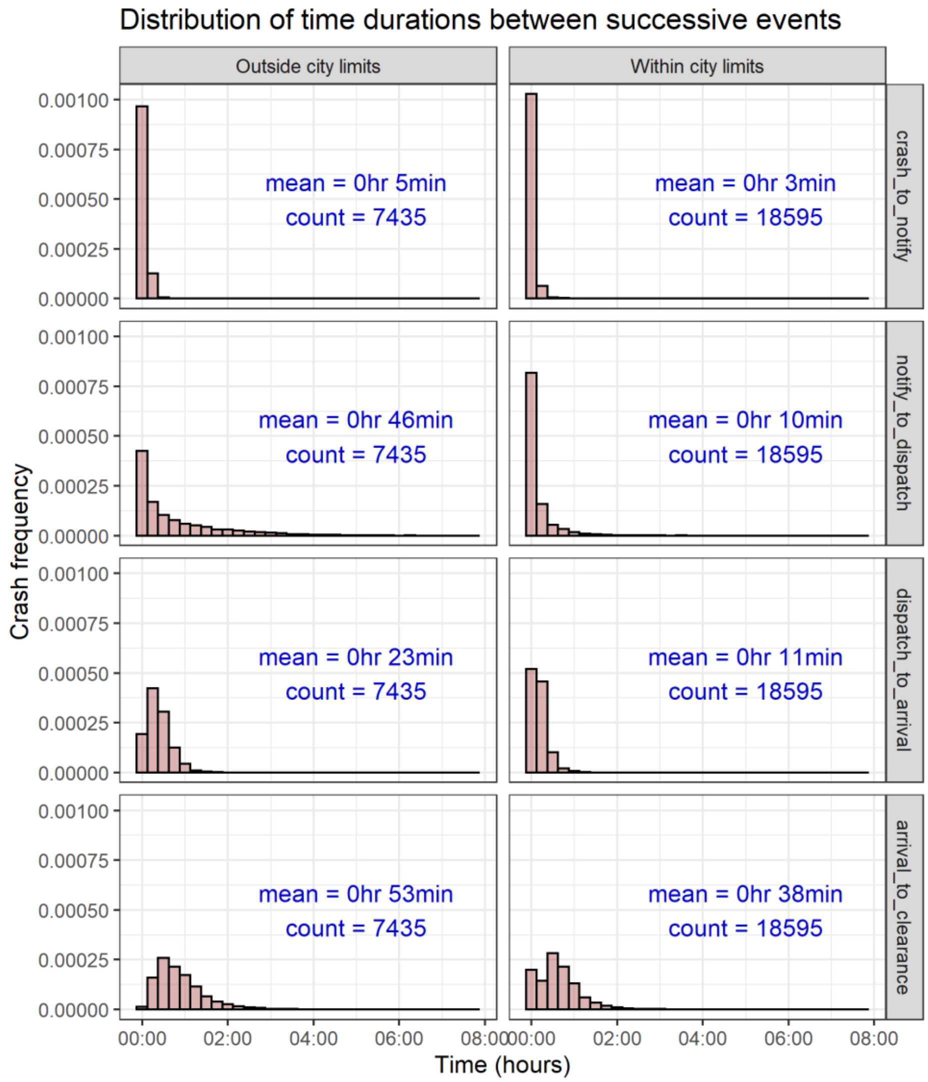

Figure 22 Distribution of durations between consecutive events with respect to city limits

Table 3 Mean duration and crash frequency for various event for different severity levels and city limits

Events	City Limits	Fatality (K)	Incapacitating Injuries (A)	Injury (C)	Non-Incapacitating Injuries (B)	Property Damage Only (O)
Crash to Notification	Outside city limits	0.14 hours 40 crashes	0.07 hours 183 crashes	0.1 hours 1403 crashes	0.1 hours 811 crashes	0.08 hours 4998 crashes
	Within city limits	0.05 hours 25 crashes	0.03 hours 163 crashes	0.04 hours 3595 crashes	0.04 hours 1406 crashes	0.06 hours 13406 crashes
Notification to Dispatch	Outside city limits	0.24 hours 40 crashes	0.51 hours 183 crashes	0.78 hours 1403 crashes	0.77 hours 811 crashes	0.77 hours 4998 crashes
	Within city limits	0.1 hours 25 crashes	0.09 hours 163 crashes	0.15 hours 3595 crashes	0.1 hours 1406 crashes	0.18 hours 13406 crashes
Dispatch to Arrival	Outside city limits	0.27 hours 40 crashes	0.39 hours 183 crashes	0.38 hours 1403 crashes	0.41 hours 811 crashes	0.38 hours 4998 crashes
	Within city limits	0.09 hours 25 crashes	0.15 hours 163 crashes	0.17 hours 3595 crashes	0.15 hours 1406 crashes	0.19 hours 13406 crashes
Arrival to Clearance	Outside city limits	2.5 hours 40 crashes	1.3 hours 183 crashes	1.01 hours 1403 crashes	1.09 hours 811 crashes	0.8 hours 4998 crashes
	Within city limits	2.9 hours 25 crashes	1.18 hours 163 crashes	0.71 hours 3595 crashes	0.89 hours 1406 crashes	0.57 hours 13406 crashes

Table 4 Crash reported by various reporting agencies

Reporting Agency	Within city limits	Outside city limits
Altamonte Springs Police Department	2961	-
Apopka Police Department	549	-
Broward County Sheriff's Office	9	-
Casselberry Police Department	451	-
Eatonville Police Department	172	-
Edgewood Police Department	2	-
Florida Highway Patrol	996	6485
Hollywood Police Department	1	-
Longwood Police Department	1196	-
Maitland Police Department	1232	-
Miramar Police Department	3	-
Oakland Police Department	7	-
Orlando Police Department	9732	-
Oviedo Police Department	1	-
Palm Beach County Sheriff's Office	-	1
Seminole County Sheriff's Office	227	949
University of Central Florida Police Department	1	-
Winter Park Police Department	1055	-

The crash data contain the location of each crash. The geographic coordinate reference system (CRS), which contained latitudes and longitudes of crashes, was first converted into the projected coordinate reference system, Florida GDL Albers (EPSG code 3087). The road network within the study area was extracted from HERE data and was also projected to Florida GDL Albers CRS.

The spatial distribution of crashes was studied by creating a grid over the study area and then aggregating the crash-related information (crash frequency and clearance time) at each cell. It is important to select the appropriate cell size for analysis. For this purpose, different cell sizes were tested. The crash frequency and average clearance time for each cell were calculated for each size. At smaller cell sizes, there were very few crashes per cell. Larger cells could potentially include crashes from adjoining streets. A cell size of 600 feet (square) was chosen for the final analysis. At this size, there was an adequate number of crashes per cell, and the patterns also seemed to mirror the underlying road network.

The total crash frequency and the average clearance time were calculated for all cells. The data were aggregated into quartiles for better visualization. The analysis was performed using all the data and separately for each shift (morning shift = 6 AM–2 PM and evening shift is 2 PM–10 PM).

Figure 23 presents the spatial distribution of the frequency of crashes for the entire period (left figure) and for each of the two shifts (two right figures). All the major arterial roadways of the region show up in the highest quartile. This is as expected because these roads also have the highest traffic volumes.

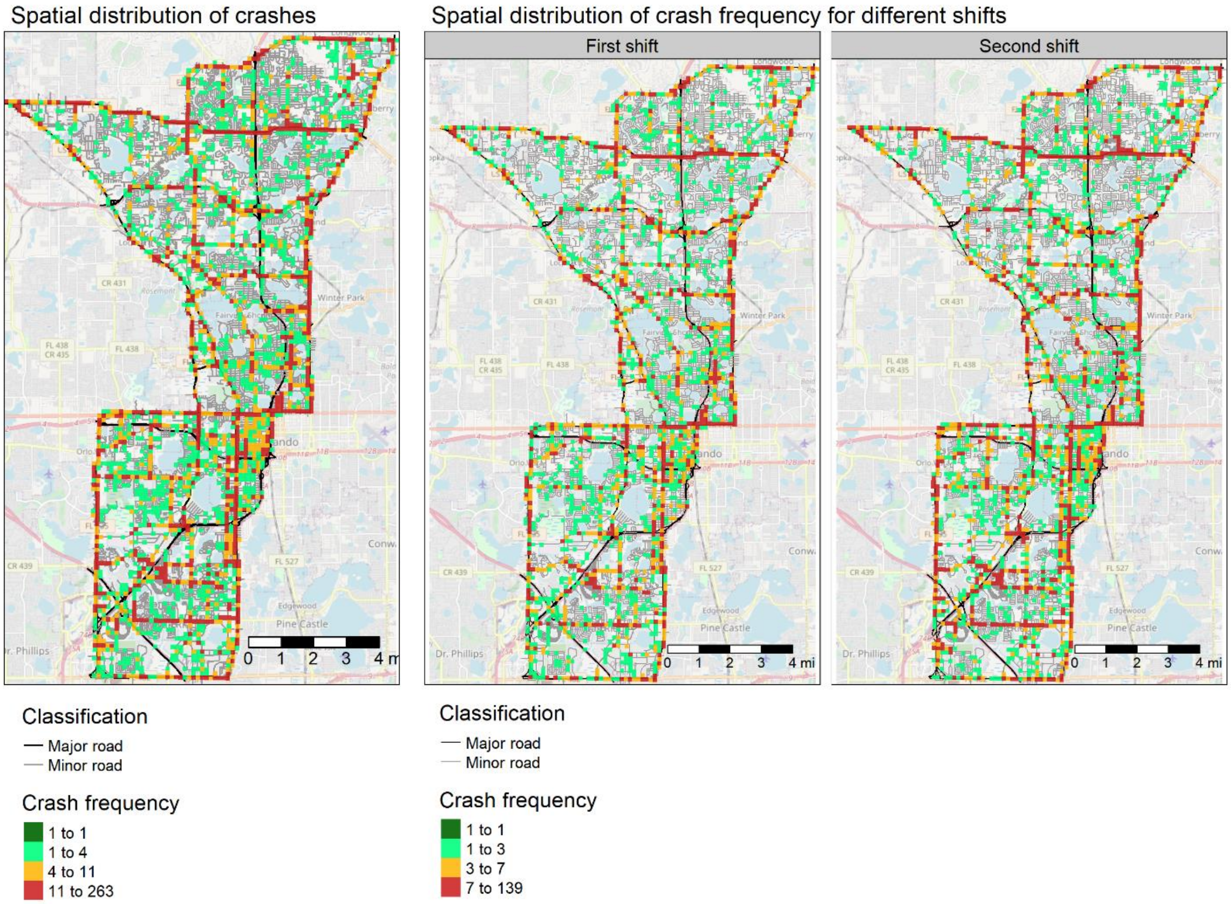

Figure 23 Spatial distribution of crashes. Left figure shows the distribution for the whole study duration (6 AM–10 PM). The other two figures show the distribution for first shift (6 AM–2 PM) and second shift (2 PM–10 PM)

Figure 24 presents the spatial distribution of the average clearance times for the entire period (left figure) and for each of the two shifts (two right figures). The locations belonging to the top quartile are clustered into three main groups. These locations also generally correspond to the places that are “out of city limits” per the crash reports.

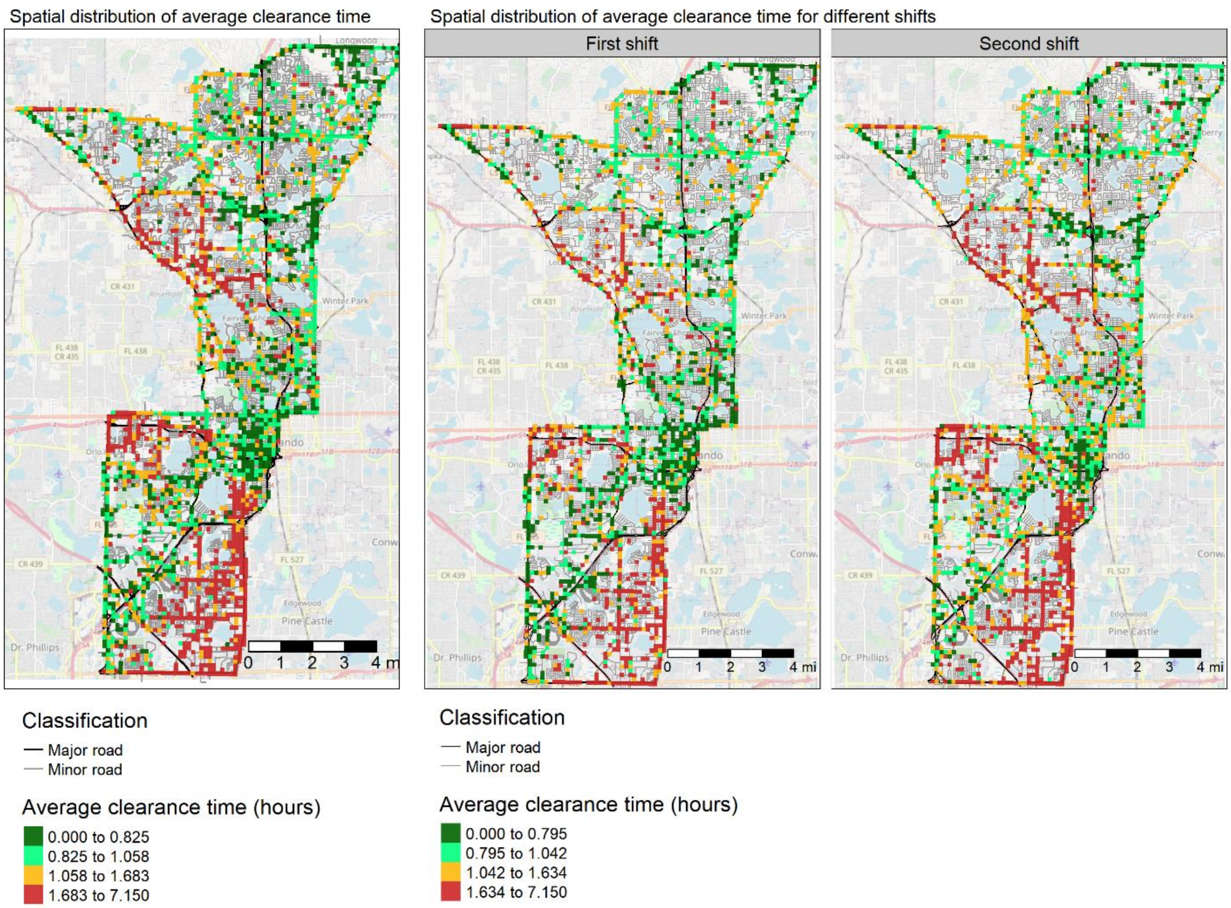

Figure 24 Spatial distribution of average clearance time of crashes. Left figure shows the distribution for the whole study duration (6 AM–10 PM). The other two figures show the distribution for first shift (6 AM–2 PM) and second shift (2 PM–10 PM)

Figure 25 presents the priority locations for the arterial service patrol would be those places that have many high-clearance times (over 1.6 hours) crashes. Therefore, Figure 25 presents the spatial distribution of high-clearance time crashes (top quartile) based on the frequencies. The red squares represent the locations which are in the top quartile (over 7 crashes per cell) in terms of crash frequencies. There are three main clusters with all three clusters more pronounced for the second shift than the first.

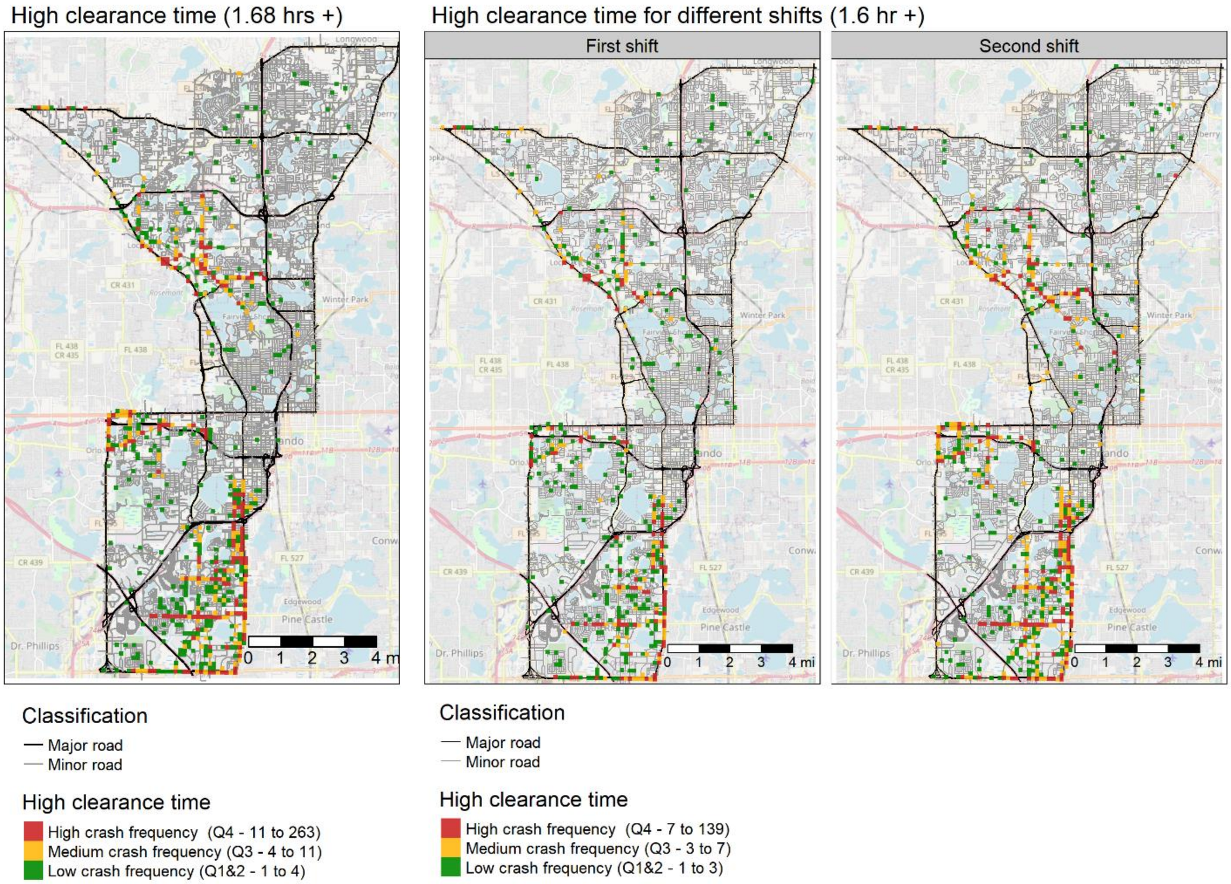

Figure 25 Spatial distribution of crashes with high clearance time (Q4). Left figure shows the distribution for the whole study duration (6 AM–10 PM). The other two figures show the distribution for first shift (6 AM–2 PM) and second shift (2 PM–10 PM)

Figure 26 presents the spatial distribution of medium-clearance time crashes (second and third quartiles; 0.8 – 1.6 hours) based on the frequencies. The red squares represent the locations which are in the top quartile in terms of crash frequencies (over 7 crashes per cell).

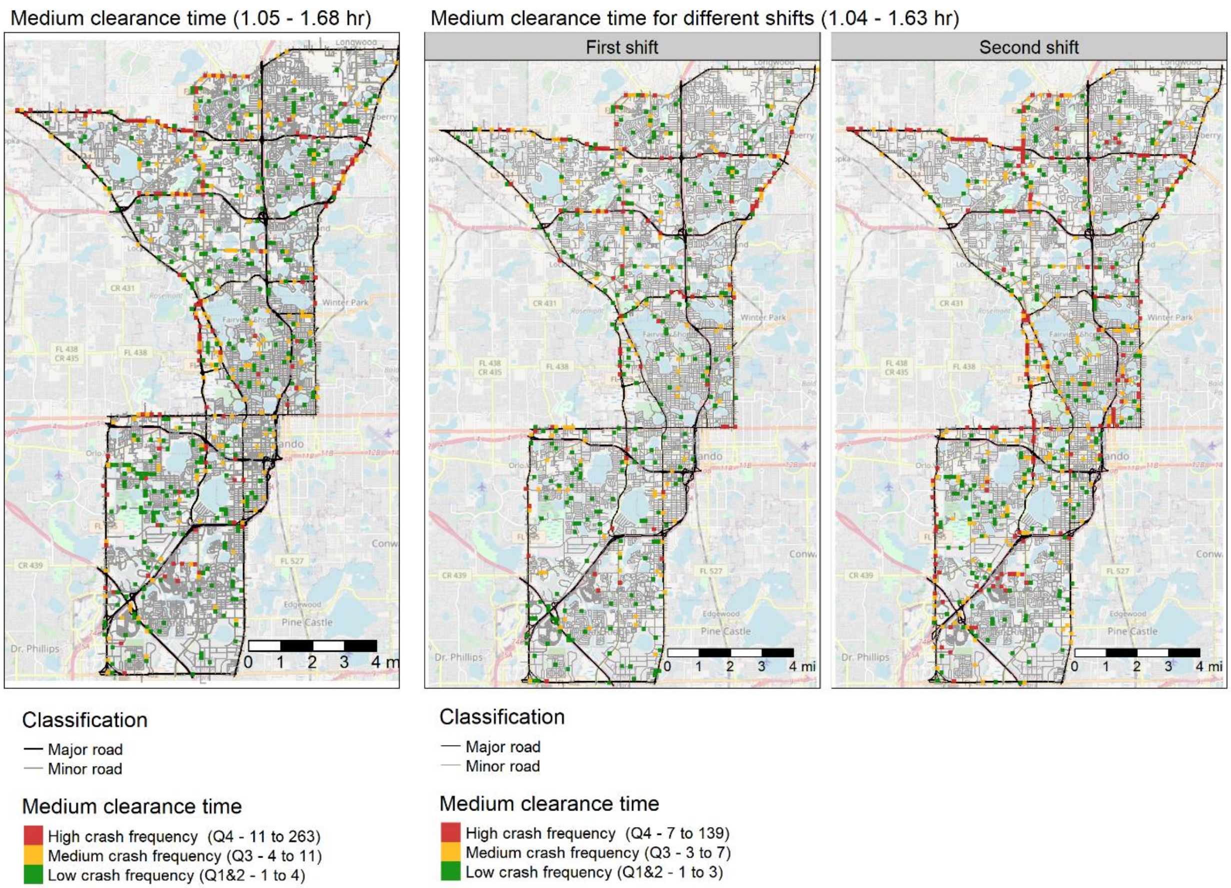

Figure 26 Spatial distribution of crashes with medium clearance time (Q3). Left figure shows the distribution for the whole study duration (6 AM–10 PM). The other two figures show the distribution for first shift (6 AM–2 PM) and second shift (2 PM–10 PM)

Figure 27 presents the spatial distribution of low-clearance time crashes (fourth quartile; less than 0.8 hours) based on the frequencies. These cells are largely concentrated near the downtown of the region. While some of these locations can also have a high frequency of crashes, the clearance times are generally lower. These locations, therefore, would have the lowest priority for an arterial service patrol (when compared to the other parts of the region discussed in the previous figures).

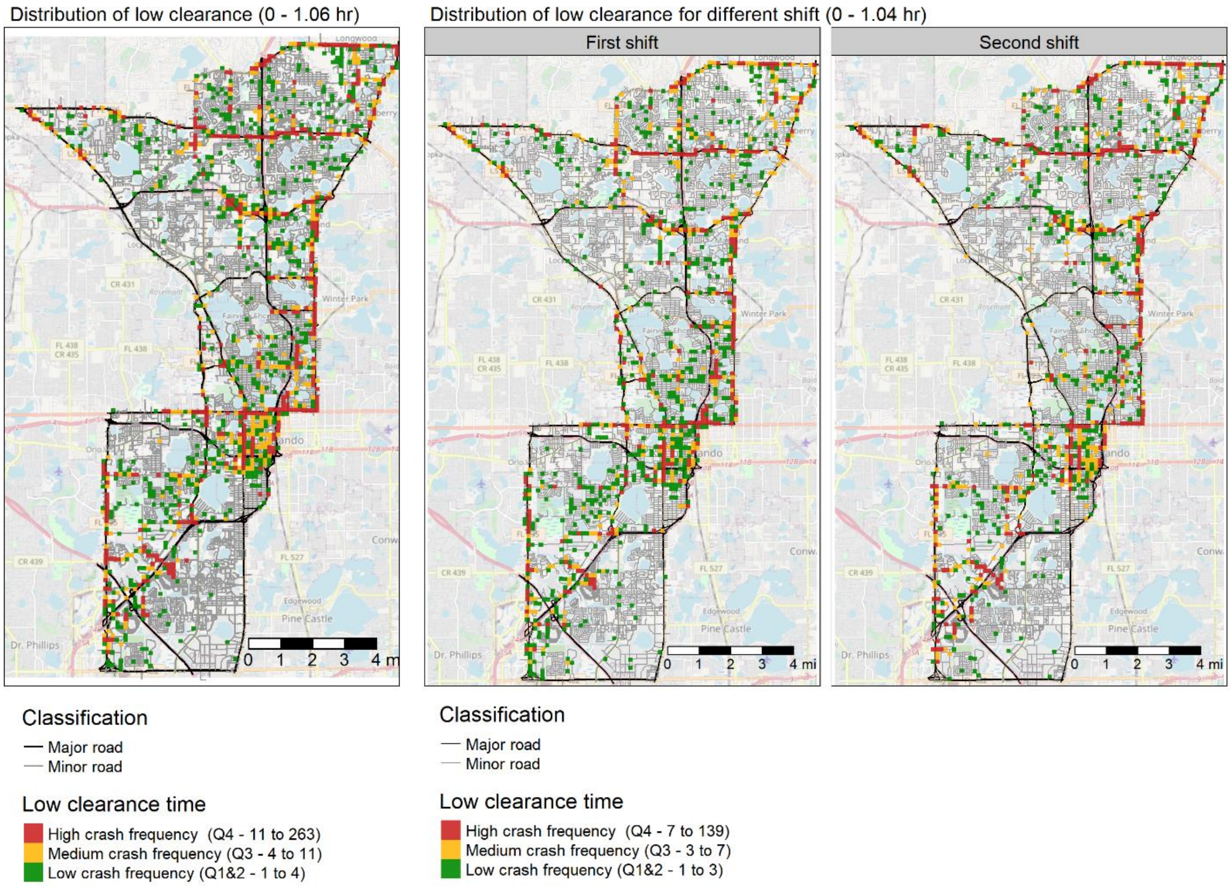

Figure 27 Spatial distribution of crashes with low clearance time (Q1 & Q2). Left figure shows the distribution for the whole study duration (6 AM–10 PM). The other two figures show the distribution for first shift (6 AM–2 PM) and second shift (2 PM–10 PM)

Figures 28, 29, and 30 presents zoomed-in versions of the three major clusters identified in the analysis of high-clearance time crashes (Figure 25).

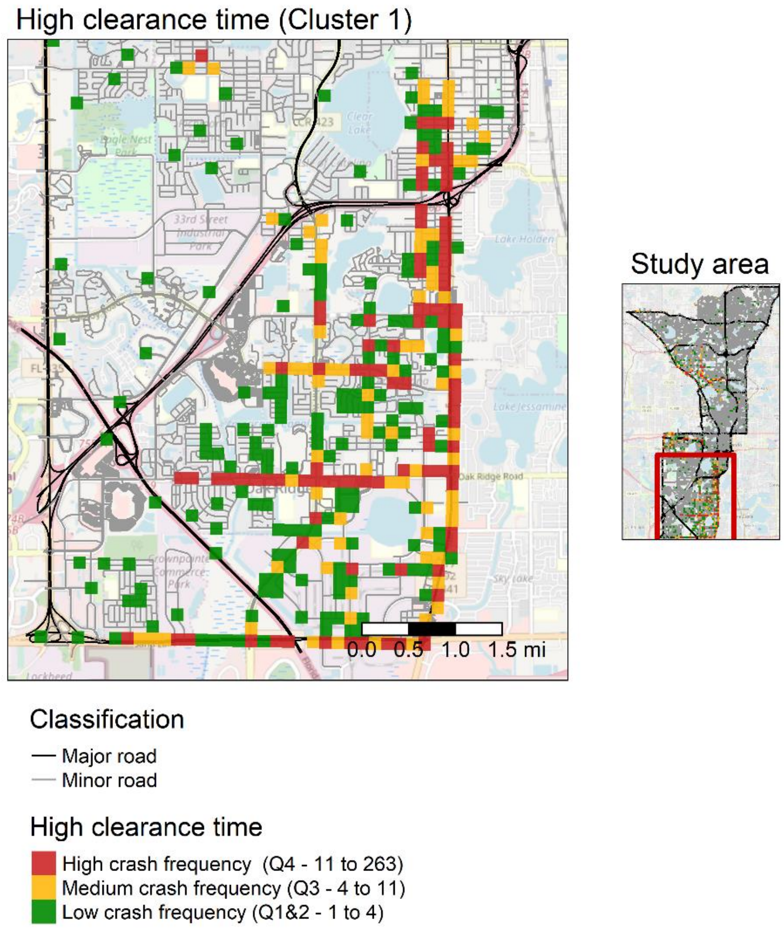

Figure 28 Cluster 1 of crashes with high clearance time (Q4)

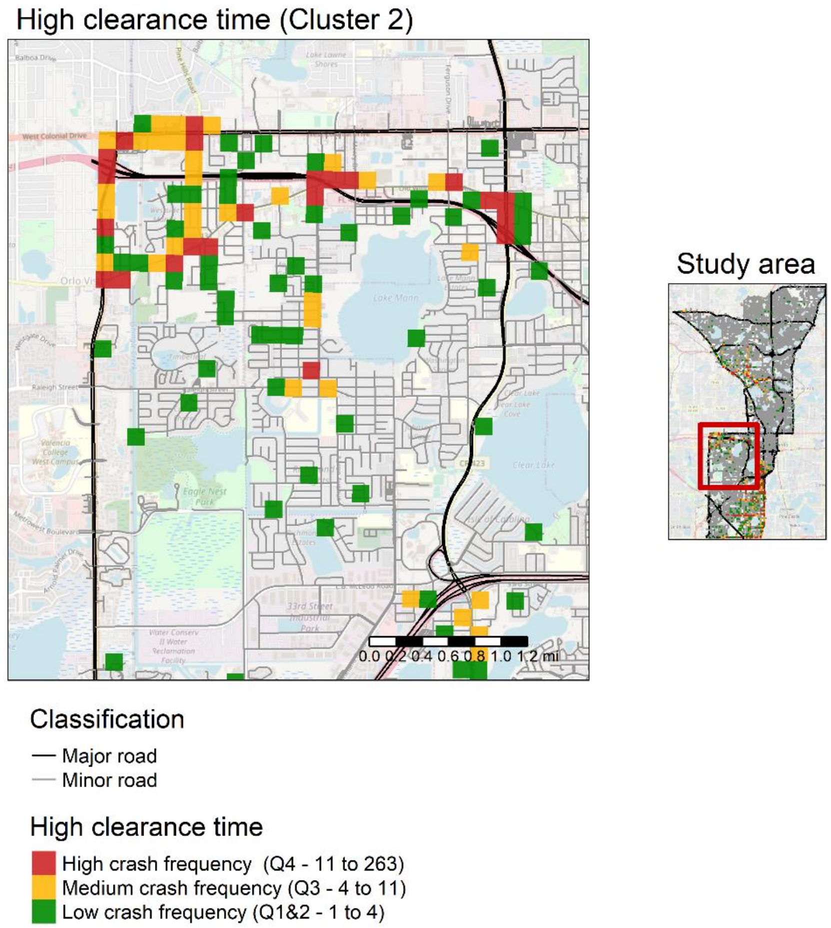

Figure 29 Cluster 2 of crashes with high clearance time (Q4)

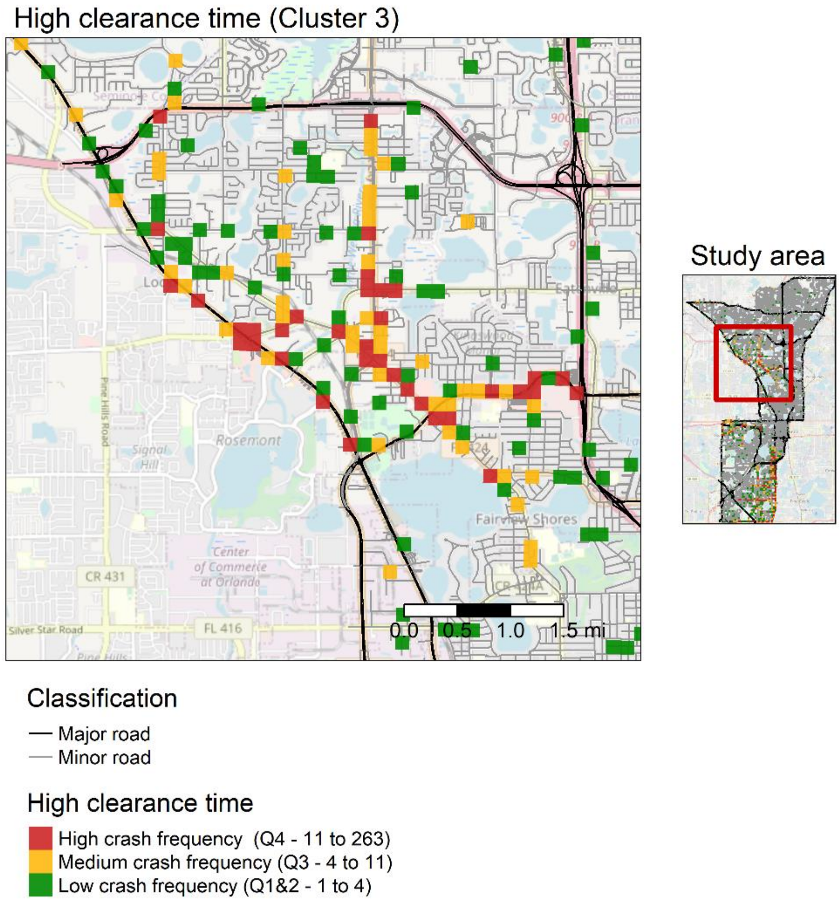

Figure 30 Cluster 3 of crashes with high clearance time (Q4)

CHAPTER 4 PERFORMANCE EVALUATION OF THE PROPSED SERVICE PATROL

The objective of the Arterial Service Patrol program is to provide a dedicated service to quickly clear the site after a crash to allow smoother functioning of the arterial network. A fleet of Arterial Service Patrol (ASP) vehicles in the study area would be able to respond and clear the crash site much faster than an existing response mechanism. There are many possible strategies to deploy the ASP vehicles, for example, the vehicles can continuously patrol along predefined routes, or they can wait idle at predefined staging locations (such as public parking lots or fire stations). In case a vehicle is staged at a location, it is important to identify the optimal staging location from where it can respond to the crashes. Some of these questions can either be answered after testing various strategies after field deployment or can be answered through numerical simulations before deployment.

A methodology to perform numerical simulation to evaluate performance of the Arterial Service Patrol is presented in this chapter. Such an exercise has many advantages: (1) It can be used for feasibility assessment of proposed service by quantifying the expected performance; (2) It can also be used to identify optimal staging locations for the vehicles; and (3) The results obtained from simulations can also be used as a basis or best guess for initial field deployment.

The crash response procedure is an ordered sequence of many steps: (1) Notification of crash; (2) Dispatch of vehicle; (3) Arrival at the crash site; and (4) Site-clearance. The crash data contained the timestamp (date and time) of completion of each event involved in the crash response procedure: Figure 31 shows a schematic diagram of current timeline (no service patrol) and expected “compressed” timeline (after deployment) of events involved in a crash response.

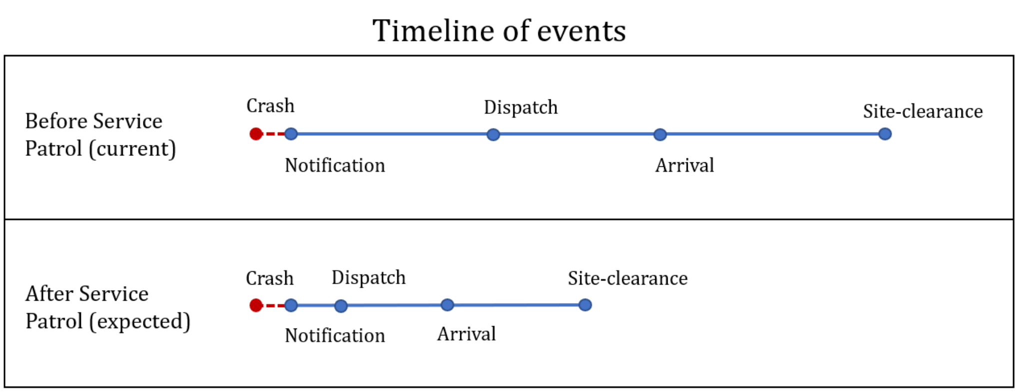

Figure 31 Timeline of crash response procedure. Before and after (expected) Service Patrol

The notification time is when the dispatch center(s) is notified of the crash. Currently, the time between a crash and its notification is 4 minutes on an average (for the southern part of the study area under consideration, average obtained based on 8454 crashes in this area between January 2018 and December 2020). After that, a vehicle is dispatched to the crash site, and the corresponding time is reported as dispatch time. The time between notification and dispatch is about 33 minutes for the area under consideration. The large delay is because the area is primarily served by Florida Highway Patrol currently and their primary jurisdiction is the freeways. With the availability of a dedicated service patrol service, this time can be expected to decrease substantially. The time at which the vehicle arrived at the crash site is reported as the arrival time. The average time between dispatch and arrival is about 18 minutes. With a service patrol, this can also be decreased by optimally locating the vehicle within the area. The time at which the site is cleared (one or more of vehicles moved, debris removed, lanes opened as appropriate) is reported as the site-clearance time. The time between arrival and site clearance is currently 43 minutes. The availability of additional help from the service patrol can reduce this time as well. The total clearance time (we used the term ‘clearance time’ in the rest of the report) is defined as the time taken to clear the site after the responder has been notified i.e., the time difference between the site-clearance time and the notification time. The proposed Arterial Service Patrol is expected to reduce the time taken in each event thereby significantly reducing the clearance time of crashes.

It is important to estimate the new (expected) timeline of events to evaluate the benefits of the proposed Arterial Service Patrol and to create a baseline for field deployment. Table 5 presents the assumptions made to estimate times with the service patrol program (A single service vehicle operating from a staged location is assumed here; the issue of a patrolling vehicle is discussed later).

Table 5 Assumption regarding calculation of clearance time

Event	**Methodology/Assumption to estimate time requirement**
Notification	Same as before
Dispatch	Random value between 0 to 3 minutes
Arrival	Estimated travel time from Open-Source Route Machine (OSRM) / Google
Clearance	50% of reported value
Return	Estimated travel time from Open-Source Route Machine (OSRM) / Google

The response agency is usually notified of crashes by victims/passers-by and so it was assumed that time required for notification (crash to notification) would remain same and unchanged.

A dedicated Arterial Service Patrol vehicle can be dispatched immediately if available. FDOT suggests that the vehicle should be dispatched within three minutes of notification. Therefore, randomly generated values between zero and three minutes are used for dispatch times.

Once the vehicle is dispatched, it is important to estimate a reasonable travel time to arrive at the crash site. The Open-Source Routing Machine (Huber and Rust, 2016) database was used to estimate the travel times between the staging location and crash sites. Open-Source Routing Machine (OSRM) data does not take account of time of day (congestion) to estimate travel times, so we calibrated the OSRM generated travel times using time dependent travel times generated using Google Maps Distance Matrix API. The Google Maps Distance Matrix API has limited free access, so it was only used to calibrate the OSRM travel times[2]. The detailed travel time calibration procedure is presented in Appendix A.

The site-clearance time is assumed to reduce by 50% once we have a dedicated and trained team for site-clearance. 15% of the crashes in the data reported zero minutes for site-clearance. There can be many possible explanations, including that the crash was minor, and vehicles had already left the crash site. We used a conservative site clearance value of five minutes for such crashes.

The travel times from the crash site to the staging location were also determined using the same procedures as in the case of travel time from staging location to the crash site.
As already indicated, the focus is on a scenario in which a single service vehicle is responding from a staged location. The vehicle returns to the staging location once it clears the crash site. If there are other crashes notified while the vehicle is responding to a crash, then it would serve those crashes based on a simple rule of tolerance time. The tolerance time is the difference between notification time of the next crash and the return time from the current crash response. Tolerance times of zero minutes and thirty minutes were examined.

When the tolerance time is zero minutes, the Arterial Service Patrol vehicle responds only to crashes which are notified when the vehicle is at the staging location (or already retuned from the previous crash response). On the other side, when the tolerance time is thirty minutes, the Arterial Service Patrol vehicle responds to crashes which are notified when the vehicle is at the staging location or notified less than thirty minutes before returning from the previous crash response).

Figure 32 and Table 6 illustrates these two tolerance-threshold scenarios with an example. The service patrol vehicle responded to the first crash and returned to the staging location at 3:16 PM. The notification about the second crash arrived at 3:22 PM. As the service vehicle is back at the staging location, the vehicle is available to respond to this crash for both zero- and thirty- minute threshold response policies. The vehicle arrives back at the staging location at 4:15 PM after servicing this crash. The notification about the third crash arrives at 4:11 PM, prior to the vehicle arriving back at the staging location. Under the zero-minute threshold scenario, this third crash would not be serviced by the vehicle; rather it is left to FHP or other agencies to handle it. However, under the 30-minue threshold scenario, this third crash would be serviced by the vehicle (if the crash was notified after 3:45 PM it would have been serviced under the 30-minute threshold).

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[2] An alternate option is to use microscopic traffic simulation which can explicitly account for delays in determination of travel times. However, these simulations would require us to simulate the entire transportation network (in and around the study area) and that would require high resolution spatial and temporal traffic data such as speed, volume, density, signal timings, driving characteristics, etc. and detailed information of road geometry such as presence of shoulder, etc. It is impossible to gather all these data to calibrate and simulate the traffic to evaluate service patrol strategies.

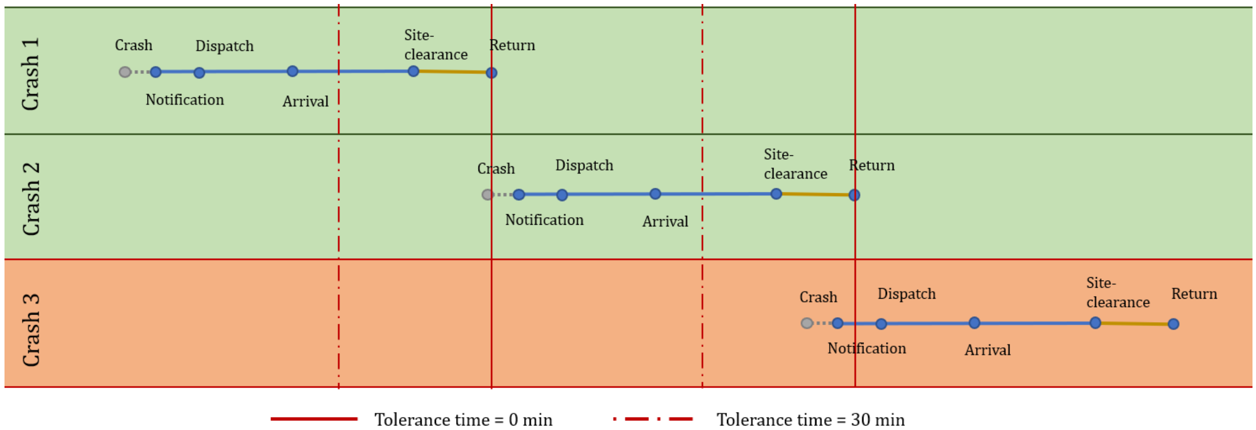

Figure 32 Illustration of Arterial Service Patrol Operation (Vehicle returns to staging location after clearing crash site

Table 6 Illustration of timeline of Arterial Service Patrol Crash response

# Crash	Notification	Dispatch	Arrival	Site-Clearance	Return	Clearance time
Crash 1	2:39:00 PM	2:40:07 PM	2:52:13 PM	3:04:43 PM	3:16:41 PM	25 min 43 sec
Crash 2	3:22:00 PM	3:23:27 PM	3:34:19 PM	4:04:19 PM	4:15:12 PM	42 min 20 sec
Crash 3	4:11:00 PM	-	-	-	-	-

All the analyses are presented in the context of southern part of the study are representing "high-clearance time cluster 1" (Figure 28, Chapter 3). However, the patrol service will potentially respond to all crashes within this area (Figure 33). In the crash response simulations, four staging locations were considered (Figure 33). For each location both 0-minute and 30-minute tolerance thresholds were examined. In a first set of simulations, all the 8454 crashes that happened over the 3-year period, were assumed to be potential events to which the service patrol must respond. In a second set of simulations, a random subset of 80% of all (8454) crashes were assumed as the crash "demand". As the crash rates have not rebounded to the pre-COVID levels (See Appendix B), this second scenario could be closer to what might be expected during the pilot deployment anticipated in early 2022. The Arterial Service Patrol program is assumed to operate in two shifts: First Shift from 6 AM to 2 PM and Second Shift from 2 PM to 10 PM. All results are reported separately for each of the shifts.

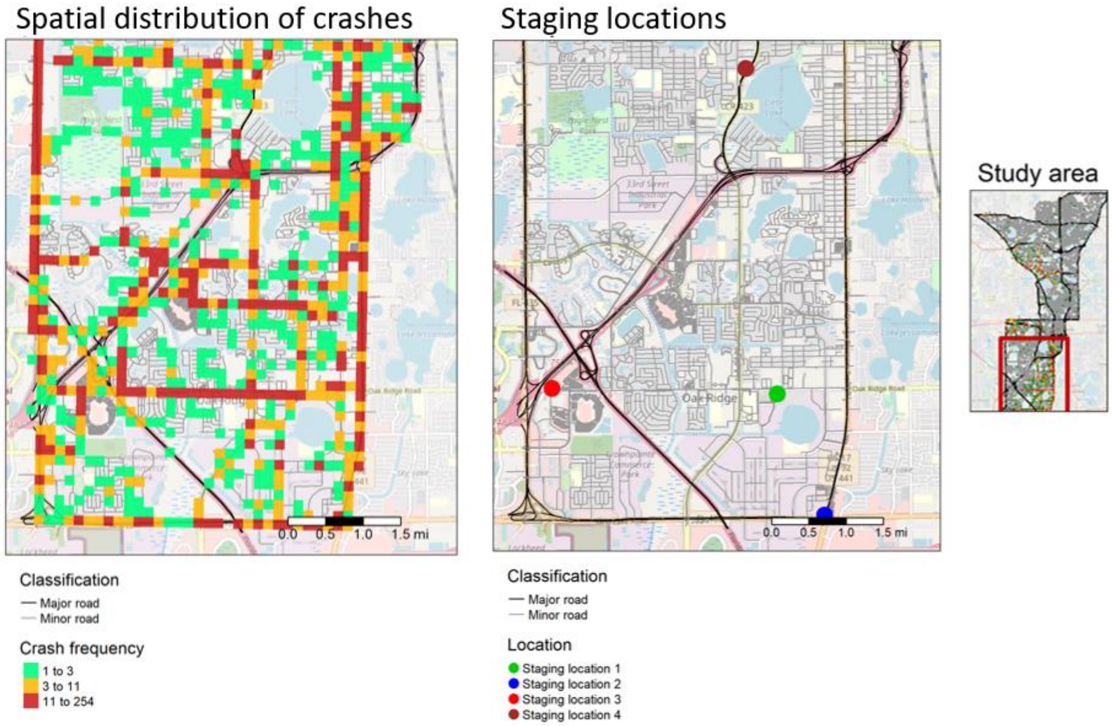

Figure 33 Various potential staging locations and the spatial distribution of crashes

Table 7 and Table 8 shows the simulated crash response during the first shift on January 10, 2018, with zero minutes and thirty minutes of tolerance time respectively (vehicle staged at location 1 in Figure 33). Seven crashes were reported in that shift. With a 0-minute tolerance policy, the service patrol would have responded to three of the seven crashes (crash response rate of 3/7). With a 30-minute tolerance policy, the vehicle would have responded to four of the seven crashes (crash response rate of 4/7). The overall fourth crash which was reported at about 7:45 AM was serviced in the 30-minute tolerance scenario as the vehicle has returned to the staging area at about 8:15 AM after serving the first crash. On comparing the simulated and observed clearance times for the crashes that the vehicle was able to respond to (last two columns of the table), the positive benefit of the service patrol in reducing the clearance times is evident. Finally, Table 7 and Table 8 also highlight the differences in the extent to which the service vehicle is engaged/occupied during the day. This can be determined by summing up the difference between the return and dispatch times for each event.

Table 7 Simulated crash response in the first shift of Jan 10, 2018, with zero minutes of tolerance time

Notification	Dispatch	Arrival	Site-clearance	Return	Simulated clearance time	Reported Clearance time
6:59:00 AM	7:01:50 AM	7:15:35 AM	8:03:05 AM	8:16:20 AM	1 hr 4 min 6 sec	2 hr 1 min
7:35:00 AM	-	-	-	-	-	1 hr 3 min
7:36:00 AM	-	-	-	-	-	26 min
7:46:00 AM	-	-	-	-	-	3 hr 8 min
8:57:00 AM	8:57:21 AM	9:12:48 AM	9:35:48 AM	9:49:44 AM	38 min 48 sec	53 min
9:24:00 AM	-	-	-	-	-	11 min
10:19:00 AM	10:19:18 AM	10:31:08 AM	10:36:08 AM	10:47:59 AM	17 min 9 sec	31 min

Table 8 Simulated crash response on first shift of Jan 10, 2018, with thirty minutes of tolerance time

Notification	Dispatch	Arrival	Site-clearance	Return	Simulated clearance time	Reported Clearance time
6:59:00 AM	7:00:45 AM	7:14:31 AM	8:02:01 AM	8:15:15 AM	1 hr 3 min 1 sec	2 hr 1 min
7:35:00 AM	-	-	-	-	-	1 hr 3 min
7:36:00 AM	-	-	-	-	-	26 min
7:46:00 AM	8:15:37 AM	8:23:29 AM	9:00:29 AM	9:09:15 AM	1 hr 14 min 30 sec	3 hr 8 min
8:57:00 AM	9:10:36 AM	9:26:03 AM	9:49:03 AM	10:02:59 AM	52 min 3 sec	53 min
9:24:00 AM	-	-	-	-	-	11 min
10:19:00 AM	10:21:00 AM	10:32:50 AM	10:37:50 AM	10:49:41 AM	18 min 51 sec	31 min

Based on the previous discussed, three performance measures are calculated for the simulations: (1) Simulated clearance time (simulated time between notification and site clearance), (2) Crash response rate (proportion of crashes the single service vehicle was able to respond to), and (3) Occupancy of patrolling vehicle (duration for which the vehicle is actively engaged in serving a crash).

The distribution of crashes per shift is shown in Figure 34. On an average, there were 10.8 crashes per day in the cluster with a significant variance. Therefore, all the three performance measures will vary from day to day (and for each shift). Therefore, all the performance measures were calculated for each day and each shift for the three-year period and then suitably summarized for further discussion.

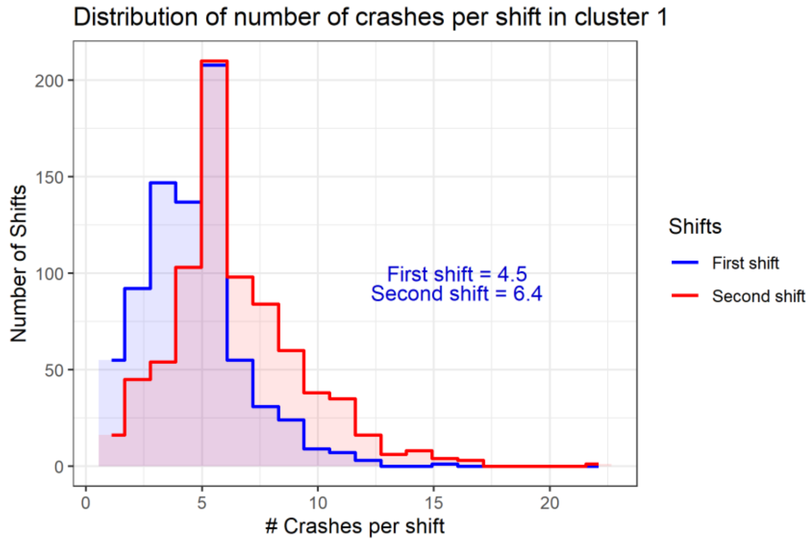

Figure 34 The distribution of crashes per day in cluster one

Figure 35 presents the simulated clearance times by shift (blue and orange graphs), for each of zero- and thirty- minute tolerances (two columns) and for vehicle staged at each of the four locations (the four rows). Figure 36 presents the same information for the reduced crash demand scenario (80% of all crashes). Across both figures 35 and 36, the average simulated daily clearance times per crash ranges from 33 – 40 minutes (clearance time averaged over all crashes / day by shift). The reduced crash demand did not significantly impact the average clearance times. The values are slightly higher for the second shift than the first and for the thirty-minute tolerance scenario compared to the zero-tolerance scenario. Location 1 has the lowest average clearance times among the four staging locations considered. However, the differences in average simulated clearance times by demand levels, shift, tolerance, and staging locations all appear to be very minimal.

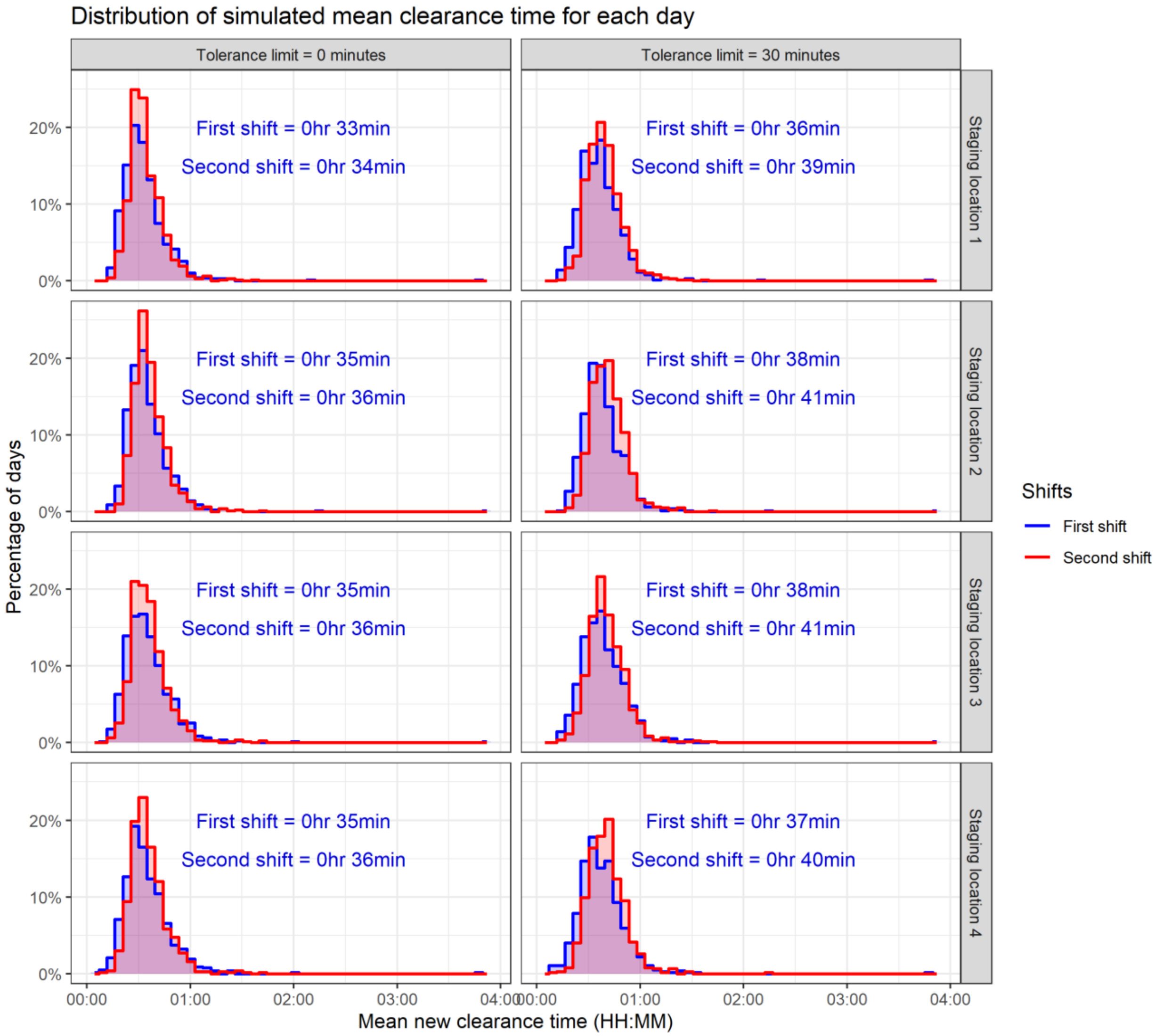

Figure 35 The distribution of simulated clearance time for both shifts of the day for different staging locations (Simulation Scenario 1)

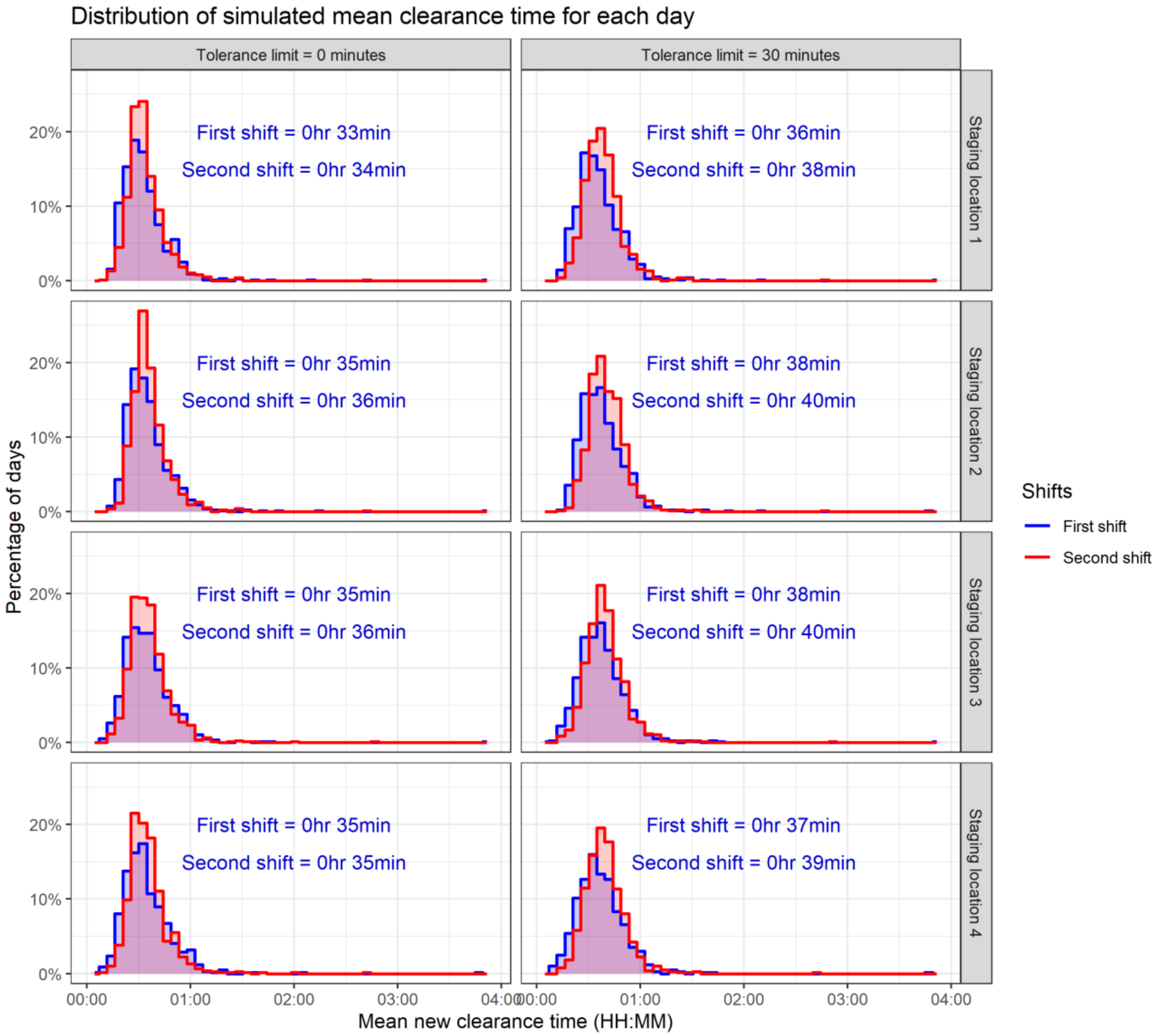

Figure 36 The distribution of simulated clearance time for both shifts of the day for different staging locations (Simulation Scenario 2)

Figure 37 show the distribution of percentage of crash responded on each day. As in the case of the previous two figures, the graphs are stratified by shift, tolerance, and staging location. Figure 38 presents the same information for the reduced crash demand scenario (80% of all crashes).

The results in Figure 37 show that, with a tolerance thirty minutes, the service patrol vehicle was able to respond to 83% to 86% of crashes in the first shift, while it was able to respond to 74% to 77% in the second shift. The crash frequency is lower in the first shift compared to the second shift and therefore, the vehicle was able to respond to a greater number of crashes in the first shift. The figure also indicates that, from staging location 1, on 60% of the days, the vehicle was able to respond to all crashes in the first shift. While it was able to respond to all crashes in the second shift on 38% of the days. When tolerance limit was zero minutes, the mean percentage of crashes responded on each shift reduced by almost 15%.

On comparing the results from Figure 37 with corresponding results in Figure 38, we find that the % crashes responded increased. A lower overall crash demand in the second case implies that there would be a lesser chance of a crash happening when the patrol vehicle is servicing a different crash. Therefore, the increase in the proportion of crashes responded to is as expected.

These results also indicate that a single service vehicle would generally be adequate to handle a substantial proportion of the crashes in the study area interest.

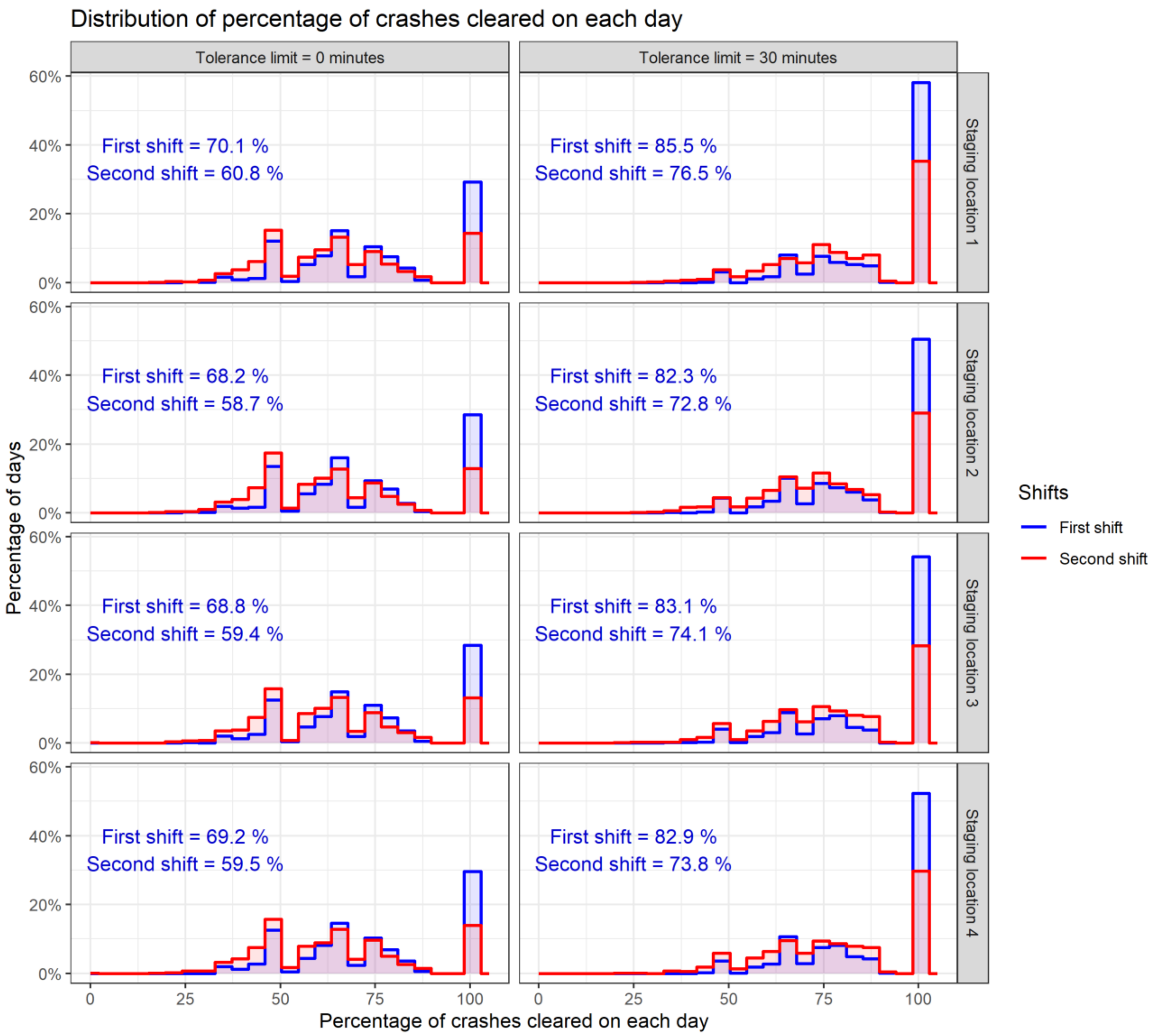

Figure 37 The distribution of percentage of crashes responded in each shift for different staging locations (Simulation Scenario 1)

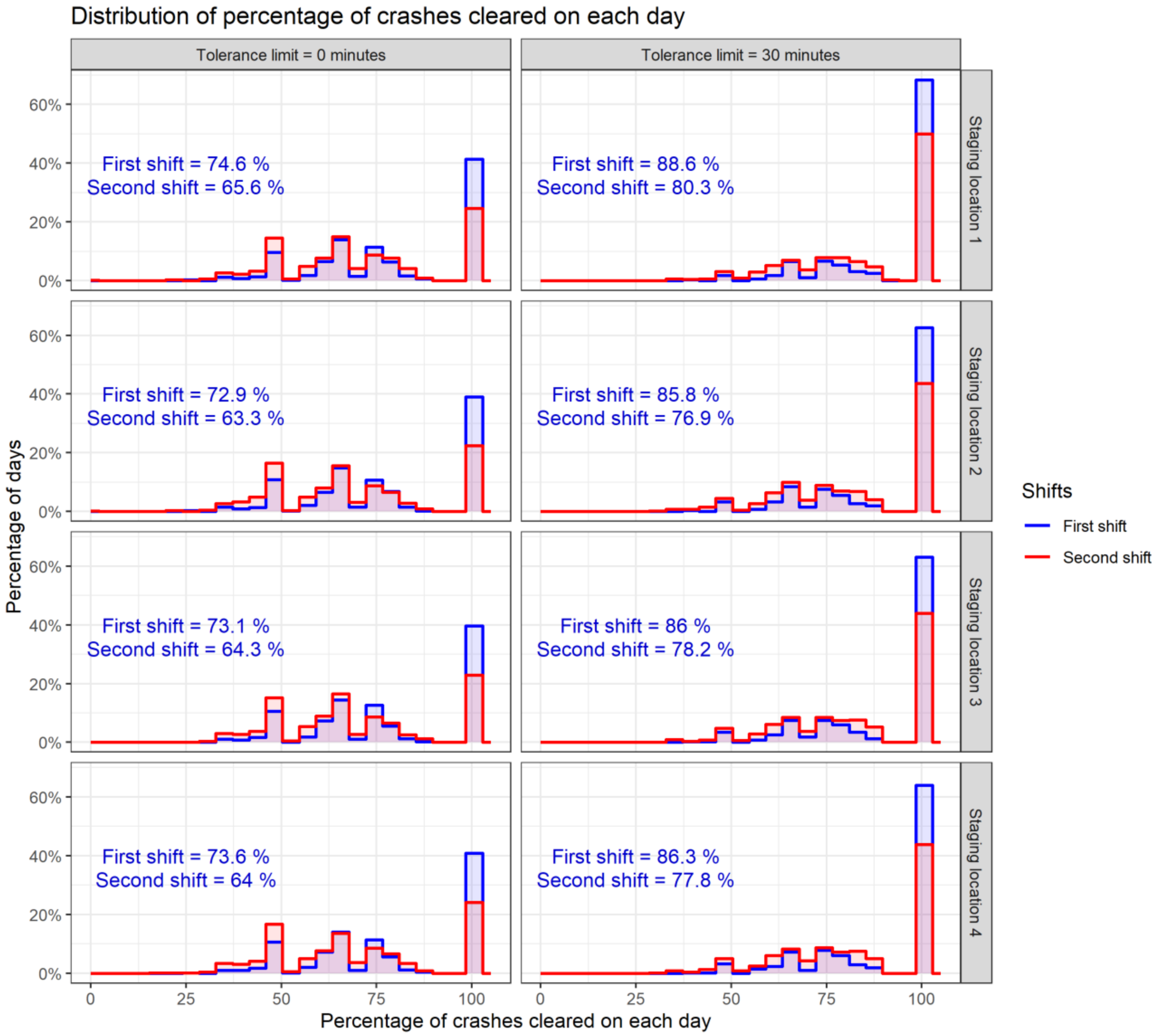

Figure 38 The distribution of percentage of crashes responded in each shift for different staging locations (Simulation Scenario 2)

The observed average crash clearance time over a three-year period (for 8454 crashes) was 1 hr 30 min for Shift 1 and 1 hr 37 min for Shift 2.

Based on the proportion of crashes the service vehicle responded to and the simulated clearance times in such cases, it is possible to calculate the total *reduction* in crash clearance time. While the clearance times are simulated for the crashes that the vehicle responds to, the clearance times for the other crashes are simply assumed to be what was reported in the data. Table 9 and Table 10 present the new clearance time for the different scenarios. Comparing the estimates from the tale with the observed clearance times, the reduction in clearance time would range between 36 minutes to 45 minutes for different scenarios and shifts.

Table 9 Mean reduced clearance time of the responded for simulation scenario 1

	First Shift		Second Shift	
Staging Location	Tolerance 0 min	Tolerance 30 min	Tolerance 0 min	Tolerance 30 min
1	0 hr 51 min	0 hr 45 min	0 hr 59 min	0 hr 54 min
2	0 hr 54 min	0 hr 49 min	1 hr 02 min	0 hr 58 min
3	0 hr 54 min	0 hr 49 min	1 hr 02 min	0 hr 57 min
4	0 hr 53 min	0 hr 48 min	1 hr 01 min	0 hr 56 min

Table 10 Mean reduced clearance time of the responded for simulation scenario 2

	First Shift		Second Shift	
Staging Location	Tolerance 0 min	Tolerance 30 min	Tolerance 0 min	Tolerance 30 min
1	0 hr 49 min	0 hr 43 min	0 hr 57 min	0 hr 51 min
2	0 hr 52 min	0 hr 47 min	1 hr 00 min	0 hr 54 min
3	0 hr 51 min	0 hr 46 min	0 hr 58 min	0 hr 53 min
4	0 hr 51 min	0 hr 45 min	0 hr 57 min	0 hr 53 min

Figure 38 show the distribution of serve vehicle occupancy (duration for which the service vehicle is actively engaged in assisting crashes). The vehicle is defined to be “occupied” from the time of departure at the staging location to the time of arrival back at the staging location after servicing the crash. As in the case of the previous two figures, the graphs are stratified by shift, tolerance, and staging location. Figure 39 presents the same information for the reduced crash demand scenario (80% of all crashes).

The average occupancy ranges from 2-4 hours per shift of 8 hours. The occupancy is higher for the second shift consistent with the increase in number of crashes in the afternoon. The occupancy is higher when a tolerance of 30 minutes was used. This is also reasonable as the service vehicle responds to more crashes with a greater tolerance threshold. Finally, the average occupancy also drops significantly in the reduced crash demand scenarios.

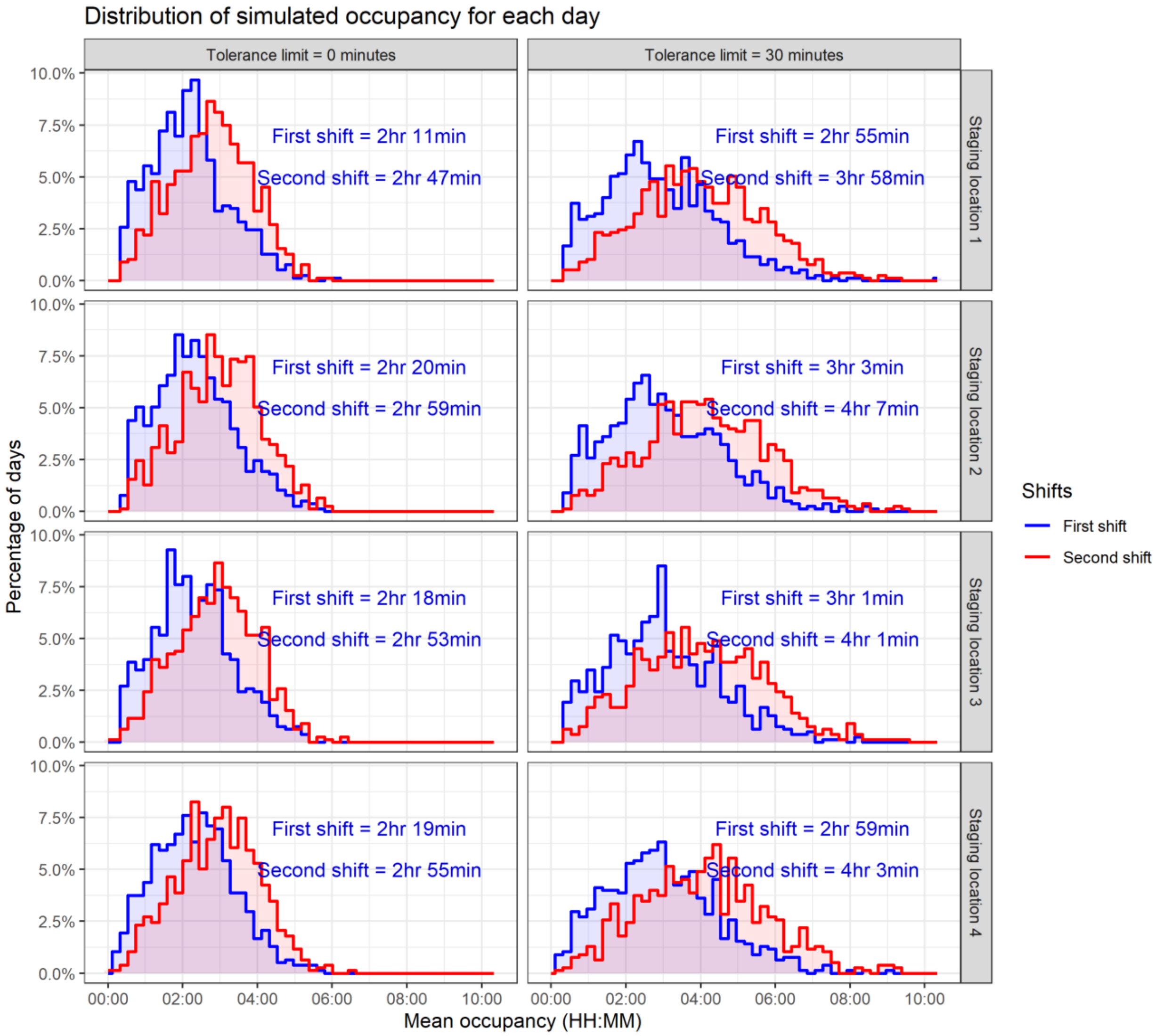

Figure 39 Distribution of simulated occupancy for different shift for different staging locations (Simulation Scenario 1)

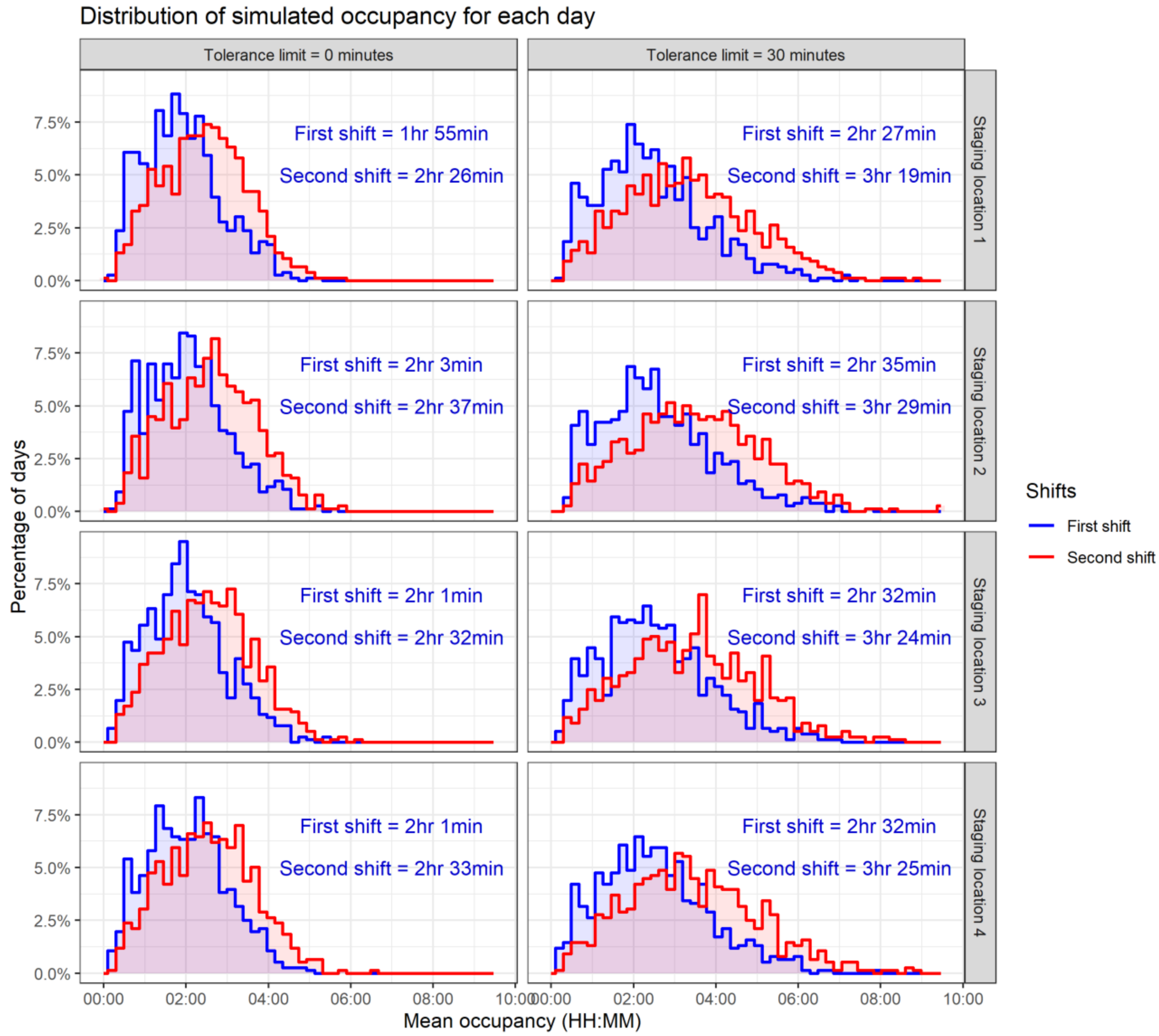

Figure 40 Distribution of simulated occupancy for different shift for different staging locations (Simulation Scenario 2)

Overall, these results highlight that a single service vehicle operating from a staged location while occupied for 50% or less of its service duration per shift can still service over 70% of all crashes and contribute to significant reduction in clearance times.

Additionally, Figure 41 and Figure 42 shows the distribution of occupancy of service patrol vehicle with time of the day for different staging locations and for different tolerance limit for each simulation scenario. It can be noted that from the figures that occupancies for both scenarios are similar. The estimated occupancy for tolerance time of 30 minutes is higher than for tolerance time of 0 minutes as it can be deployed for site clearance for crashes which occurred within 30 minutes prior to return to the staging location.

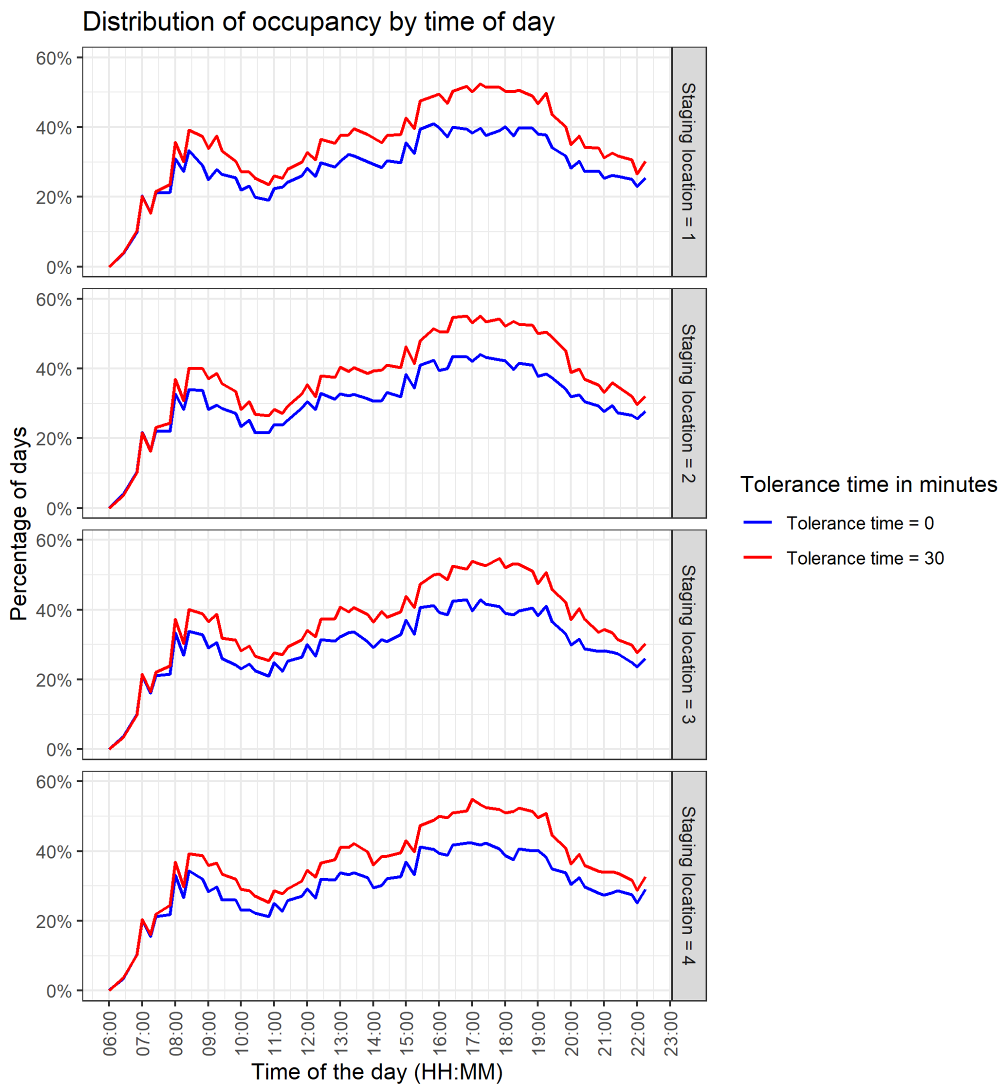

Figure 41 Distribution of occupancy by time of the day for different staging locations and for different tolerance times (Simulation scenario 1)

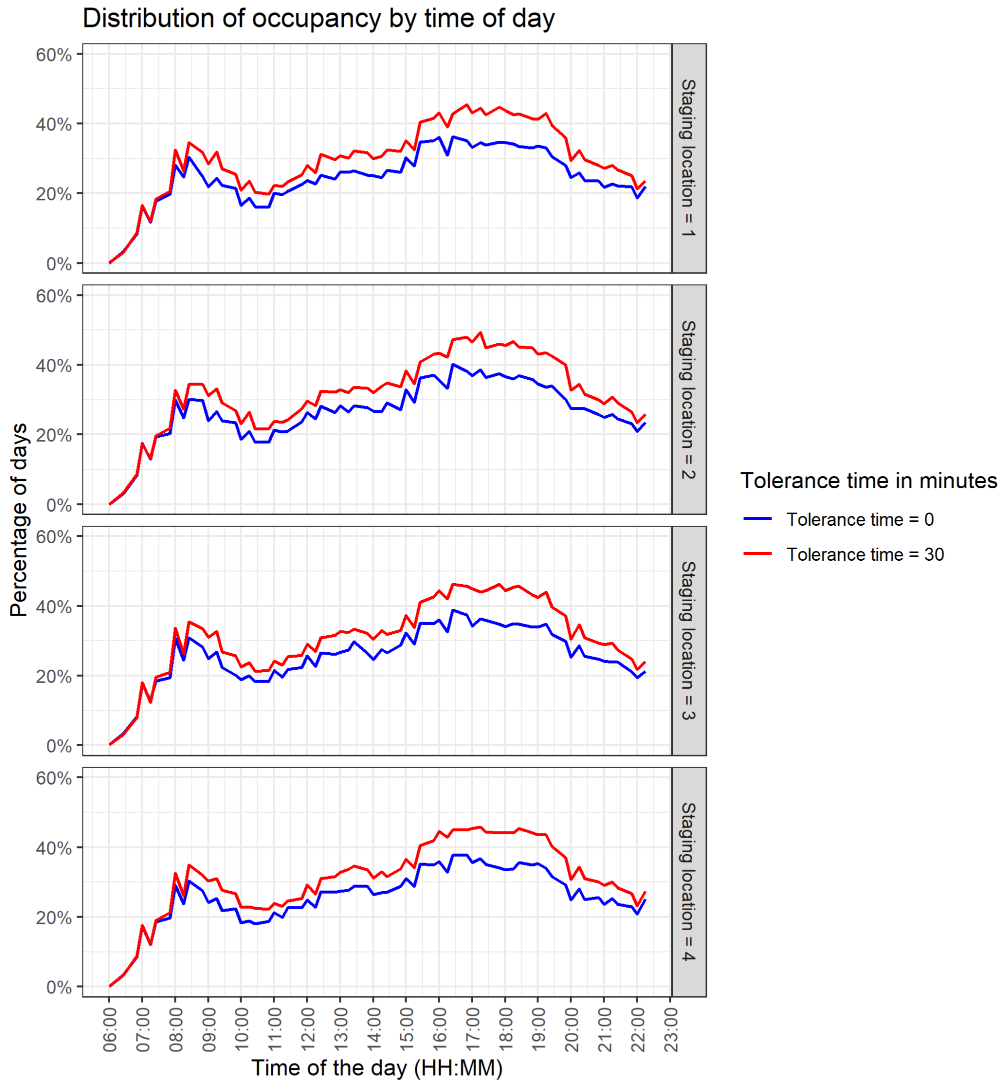

Figure 42 Distribution of occupancy by time of the day for different staging locations and for different tolerance times (Simulation scenario 2)

The natural extension of the proposed conservative simulation is to allow vehicle to respond to the next crash by directly traveling from one crash site to the next crash site without having to return to the staging location (the vehicle would still return to the staging location if a crash was not reported within the tolerance duration of time of clearing the previous crash). This scenario was not simulated but it is reasonable to believe that such a strategy could further reduce clearance times but perhaps not significantly (the benefit is primarily the time savings from not having to go via the staged location to the next crash site and only for successive pairs of crashes which happen in temporal proximity.)

The service vehicle can also continuously patrol the area instead of remaining at a fixed staging location unless summoned. Simulating such strategies would require the determination of the location of the service vehicle when notified of the crash and this can be analytically complicated. The simulation analysis already indicates that the staged vehicles can reach the crash locations quickly. It does not appear that patrolling could further decrease these response times significantly.

The Road Ranger service vehicles on freeways in Florida do patrol their beats instead of responding from a staged location. Such a strategy may not be automatically desirable for arterials. The service area for freeway patrols is linear and the beats can cover the entire service area. In the case of arterials, the service area is a network grid and therefore the beat cannot provide a complete coverage. In the case of the “cluster 1” area of interest, there were 10 or more roads which had a significant number of crashes (See Figure 28). The service vehicles on freeways address several problems such as roadway debris and stranded motorists (overheated vehicle, out of fuel, tire replacement, etc.). These are not always reported to a central dispatch location (as crashes are); rather, the service vehicle is more likely to “happen upon” such instances during patrolling (a staged operating procedure with a central dispatch will not be ideal to address problems). However, roadway debris and stranded motorists are not significant problems in the case of arterials.

Given the above discussions and the estimated performance of the staged operations, it does appear that a patrolling operation may not be necessary in the context of the arterials. Further given that service vehicles are estimated to be occupied for less than 50% of the shift duration in the staged operation, a patrolling operation may result in increased fuel consumption and emissions. It may still be desirable to test out the patrolling operations for a couple of weeks during the pilot implementation to see if there are any unanticipated benefits. A hybrid approach could also be explored. In this approach, a service vehicle does a morning patrol before rush hour, an evening patrol during the rush hour, and a patrol during an active Integrated Corridor Management System (ICMS) diversion to find any unreported issues but have the majority of the shift time be spent at a staged location.

CHAPTER 5 SUMMARY AND CONCLUSIONS

It is well established that large-scale incidents along arterials can block lanes, which can have significant impact on overall travel time reliability of the region and sometimes can also lead to secondary crashes. The availability of a service patrol program can assist the law enforcement at the incident location with many critical tasks such as moving the disabled vehicles off the road, clear debris, and management of traffic. Expedition in incident clearance can reduce delays, minimize the likelihood of secondary crashes, and improve travel time reliability. A vast majority of the literature on the use of service patrols for traffic incident management is in the context of freeways. The state of Florida has a robust freeway service patrol program called the "Road Rangers," which has been operational for several years. The Central Florida region also has a robust service patrol program for incident management on freeways but not for the major arterials. The intent of this project was to examine the spatiotemporal profile of incidents and suggest an initial plan for service patrol deployment for the arterials in Orlando.

The study area was defined by the following boundaries: SR-434 in the north, US 17-92, I-4, US-441 in the east, SR-482 (Sand Lake Rd) in the south, and Kirkman Rd, John Young Pkwy and US-441 in the west. Historical crash data from January 1, 2018, through December 31, 2020, were used for analysis. Given the major construction that happened along the I-4 corridor in recent years, it was deemed that data prior to 2018 would not be reflective of the current conditions. Within the 3-year period, only crashes that happened between 6 AM and 10 PM on weekdays were considered for analysis. Given that service patrol deployments typically begin with weekday daytime services, it was deemed appropriate to exclude the nighttime and weekend crashes and incidents. Further, crashes and incidents that happened along I-4, the turnpike, and several local freeways managed by the Central Florida Expressway were excluded as the Road Ranger program currently serves all these freeways. There were 26,861 weekday daytime crashes reported in the study area during this period.

As the primary intent of this effort was to determine locations that can benefit from an arterial service patrol, the clearance times associated with crashes were of primary interest. Locations that experience crashes requiring larger clearance times can benefit from the additional assistance provided by the service patrol vehicles leading to potentially reduced clearance times and improved travel time reliability. Based on a spatiotemporal analysis of crash frequencies and clearance times, the southern part of the study area was identified as the primary candidate for the service patrol program.

Numerical simulations to evaluate performance of staged and centrally dispatched service program with one vehicle were undertaken. The results indicated that the service vehicle could respond to over 70% of the crashes on an average and that the average clearance time per crash would be around 30-40 minutes. Overall, the service patrol program could result in a reduction of 40 minutes in clearance time per crash. The service vehicle would be occupied for about 3-4 hours/day/shift.

As a single service vehicle operating from a staged location while occupied for 50% or less of its service duration per shift can still service over 70% of all crashes and contribute to significant reduction in clearance times, it is deemed that additional service vehicles are perhaps not necessary.

The service vehicle can also continuously patrol the area instead of remaining at a fixed staging location unless summoned. The Road Ranger service vehicles on freeways in Florida do patrol their beats instead of responding from a staged location. Such a strategy may not be automatically desirable for arterials. The service area for freeway patrols is linear and the beats can cover the entire service area. In the case of the materials, the service area is a network grid and therefore the beat cannot provide a complete coverage. The service vehicles on freeways address several problems such as roadway debris and stranded motorists (overheated vehicle, out of fuel, tire replacement, etc.). These are not always reported to a central dispatch location (as crashes are); rather, the service vehicle is more likely to "happen upon" such instances during patrolling (a staged operating procedure with a central dispatch will not be ideal to address problems). However, roadway debris and stranded motorists are not significant problems in the case of arterials. Therefore, it does appear that a patrolling operation may not be necessary in the context of the arterials. Further given that service vehicles are estimated to be occupied for less than 50% of the shift duration in the staged operation, a patrolling operation may result in increased fuel consumption and emissions.

It is anticipated that a staged / centrally dispatched service patrol program will be deployed as a pilot in the southern part of the study area. A patrolling-based operations may also be tested for a couple of weeks during the pilot implementation to see if there are any unanticipated benefits. The data collected from the deployment will be used to re-evaluate the program (approximately 18 months after deployment) to make suitable modifications and to make recommendations for the best approaches for deploying service patrols in other arterials in the state of Florida.

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APPENDIX A

Google Maps Distance Matrix API has limited free access while OSRM API has unlimited free access. So, we compared the travel times obtained from Google API and OSRM API. We randomly selected 2000 crashes from the crash dataset. Since, Google Maps Distance Matrix API does not allow estimation of travel time in past, so we changed the year of notification of each crash to 2022. The day of crashes changed when we changed the year, so we selected all the crashes which hypothetically occur on weekdays. There were 1215 crashes. We used four potential staging locations and calculated to-and-from travel times to the crash site using Google Maps Distance Matrix API. We used the notification time as depart time from staging location to the crash site and added half an hour (average clearance time was close to half an hour) to notification time to get the departure time from crash site to the staging location. The API allows three traffic model options: optimistic, best guess and pessimistic. We set the traffic model to "best guess". We estimated travel time for total 9720 trips (1215 crashes * 2 trips per crash * 4 locations). We estimated the travel times for the same trips using OSRM API which allowed us to compare the travel times from the two sources. Figure 43 show the distribution of travel times from the two sources. The travel times obtained from Google API was higher than travel times obtained from OSRM API by an average factor of 1.28. Later, we calculated the mean correction factors for each hour of the day which ranged between 1.26 and 1.32 and used them for calibrating the OSRM travel times in the simulation

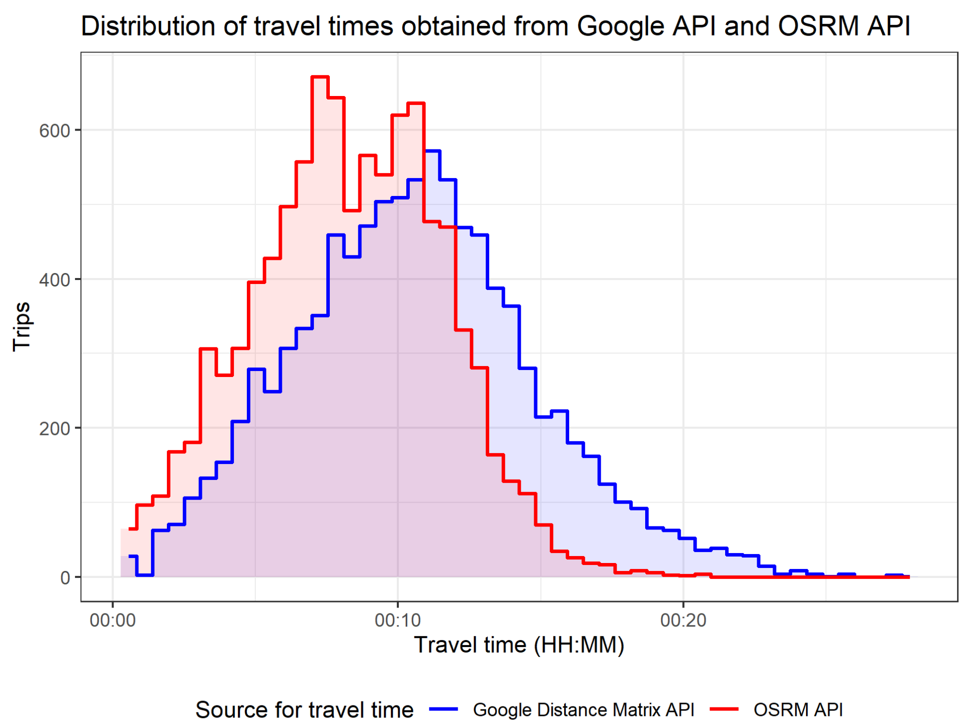

Figure 43 Comparison of OSRM and Google Travel Times

APPENDIX B

In order to examine impact of COVID on crash trends, the data used in the main analysis were supplemented with data from January – June 2021. These data were classified into the "pre-COVID" period (January 2018 – February 2020) and "post COVID" (March 2020 – June 2021). Table 11 also shows the crash counts for the two periods.

Table 11 Crash counts

Data Size	Study Area	Cluster 1 Boundary
Pre-COVID (2018 Jan - 2020 Feb)	21,243	6,877
Post-COVID (2020 Mar - 2021 Jun)	9,698	2,957
Total	30,941	9,834

The monthly crash trends in the overall study area and within the Cluster 1 of interest are presented in Figures 44 and 45. These graphs indicate that the crash rates have not yet rebounded to pre-covid levels as of June 2021.

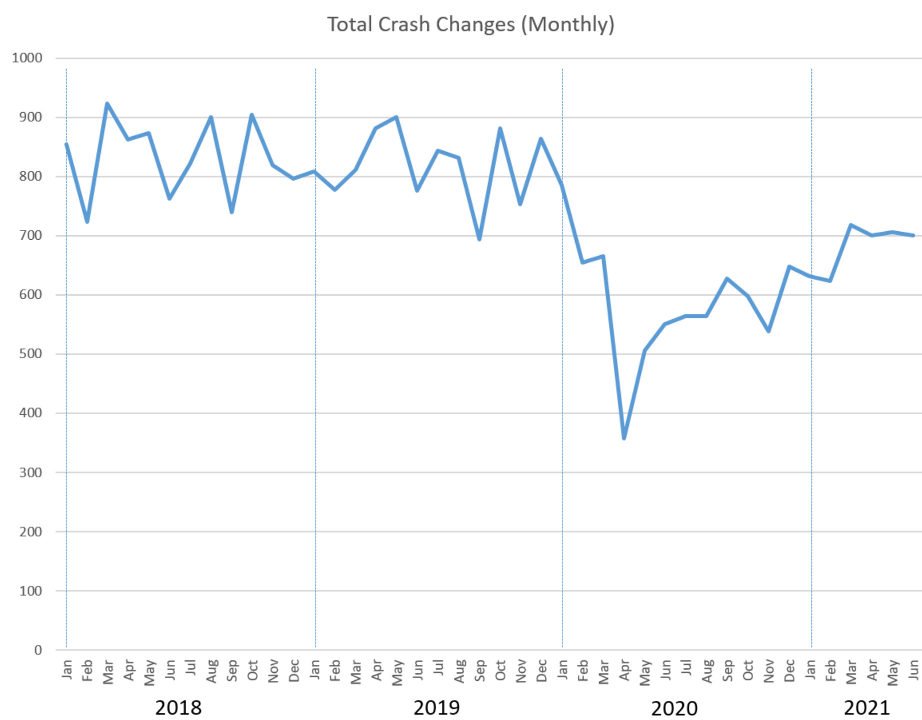

Figure 44 Total crash numbers 2018 to 2021 (Jun)

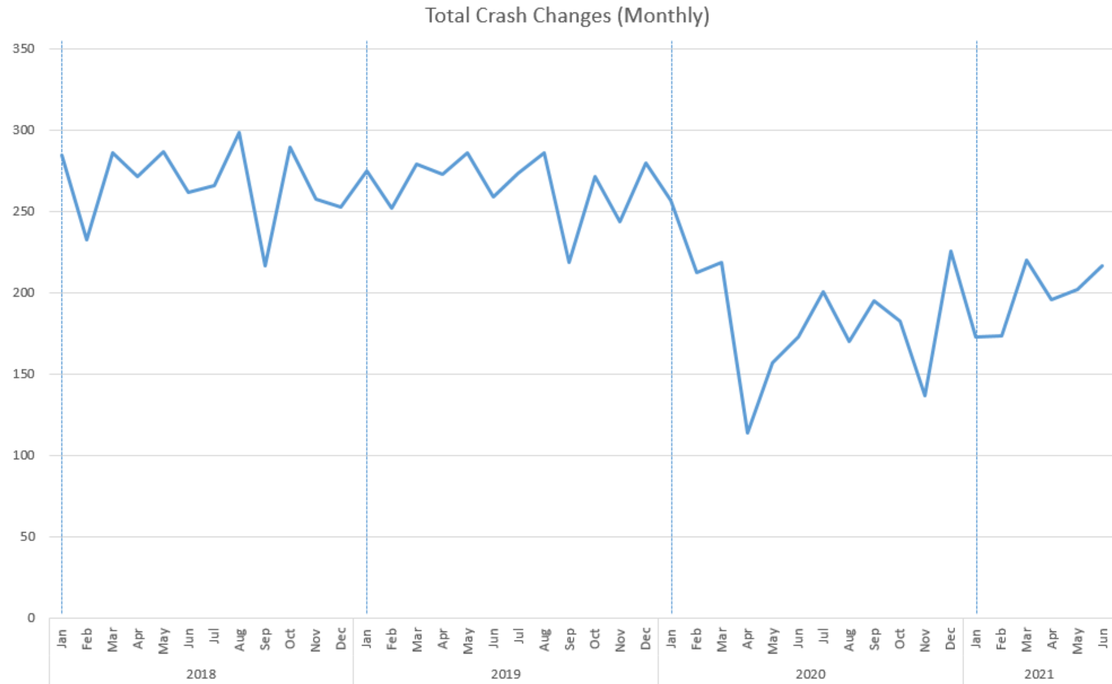

Figure 45 Total crashes in cluster 1 2018 to 2021 (Jun)

Figure 46 and Figure 47 compares the components of clearance times during the pre and post COVID periods. Figure 46 is for the entire study area while Figure 47 is specifically for crashes in the cluster 1 area. Even though the number of crashes has decreased, these figures indicate that the average clearance times have not changed significantly. In fact, none of the components of the clearance times have changed substantially.

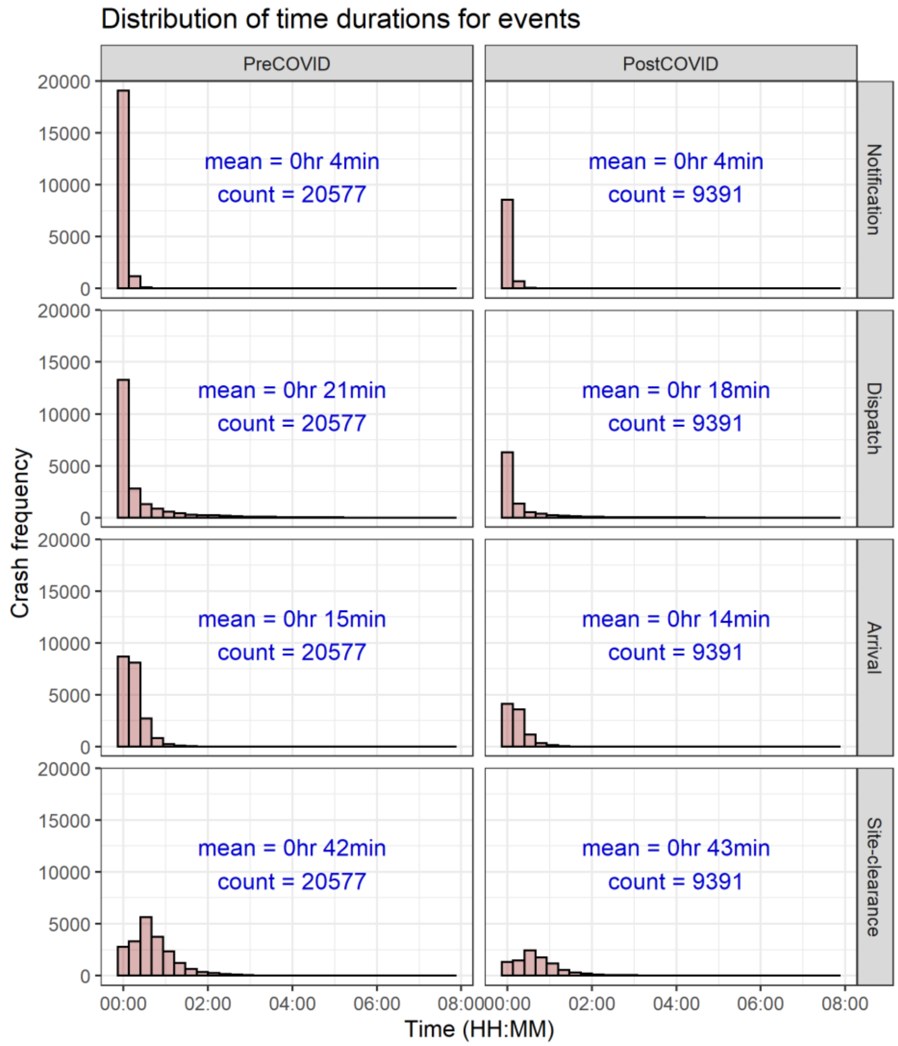

Figure 46 Distribution of durations between consecutive events before and after COVID for entire study area

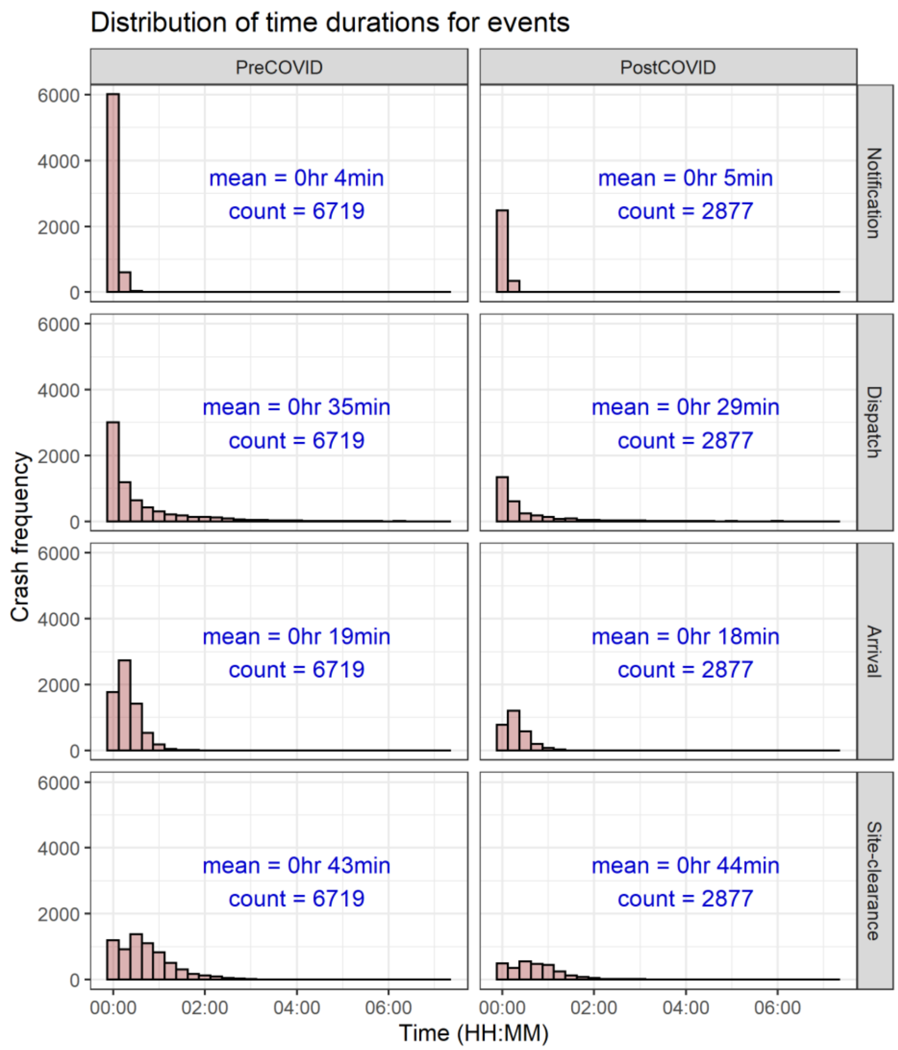

Figure 47 Distribution of durations between consecutive events before and after COVID for cluster 1