Port Recovery through Traffic Operations in the Aftermath of an Oil Spill Incident

Florida Atlantic University

Project Work

MD Sultan Ali

April 2018

ABSTRACT

Transportation systems and their components play a substantial role in the U.S. and the world economy. This research study serves as a guide to increase further research or perhaps to continue improving the traffic system in this growing economy. The setting for this research study is an oil spill incident on the Mississippi River near the Port of New Orleans (NOLA). Due to several oil spills in the past, port efficiency is stunted due to delays in the movement of cargo on the roads. The objective of this research study is to develop a quick and efficient solution by using the microscopic simulation platform VISSIM to New Orleans Port operations from being shut down due to an oil spill scenario. The benefits were quantified based on total travel time and total delay along the study corridor. Next, literature on past port oil spills and contingency plans due to oil spills were further researched, as a part of the study to serve as a guide to design the near-perfect plan for execution. The present challenges with the port operations could be alleviated through signal retiming during an oil spill incident. The after study results show the heavy vehicles reduce the delay time. In addition, it also reduce heavy vehicles travel time, provides better heavy vehicles efficiency, and increase overall road network efficiency.

KEYWORDS

Oil Spill, Heavy Vehicle Traffic, Signal Retiming, Microscopic Simulation, Travel & Delay Time

BACKGROUND

Ports are best known for intermodal activity, connecting rail lines, truck lines, barge lines, cruise lines, and ocean carriers. In terms of resilience, the management of port activities is significant on both local and national level. The setting for this research study is an oil spill on the Mississippi River near the Port of New Orleans, Louisiana. The objective of this research study is to develop a quick and efficient plan for the operation of Port of New Orleans (NOLA) from being shut down due to an oil spill scenario. Microsimulation platform VISSIM is coded to develop a quick and efficient plan. VISSIM is a microscopic multi-modal traffic flow simulation software package developed by PTV (*1–3*). Oil spill in this port generally occurs in the ocean waters itself, however, due to the speed of the flow of ocean water, it would move it further upstream. By shutting down the port, return of port operations would take between few hours up to several days in range. This would in turn cause negative effects on the port operations and local economy.

Due to oil spills in the past, numerous plans have been devised to return to operations from shutdown, efficiently and effectively. In 2010, deep water horizon oil spill showed marked impacts on Gulf Coast residents as commercial ties to renewable resources were heavily damaged (*4*). An idea to devise an efficient plan, the recognition of human dimensions of spills and response is crucial to properly construct a plan of action (5). Exercises in plan execution and conclusions of effectiveness are currently run to properly re-engage in daily activities after facing an oil spill. Most often, traffic software by simulating controls and routes were used, help aid in the resumption of port operations.

Various journals are reviewed and described about the past oil spills that occurred in, or near the vicinity of the Port of New Orleans. Numerous gathered information proved useful in gaining relevant and critical information on how the shutdown of port operations could have been prevented, determining the best ways to mitigate an oil spill, and getting the port back to work and running in the most expeditious and efficient manner possible.

The Liberian tanker, Westchester, ran aground in the Mississippi River, spilling a half-million gallons of crude oil, effectively closing 26 miles of one of the busiest shipping routes in the United States of America (*6*). It was noted that, due to the tanker's Liberian ownership and Bahamian registration, the tanker was an antiquated carrier that possessed only one hull, unlike modern American tankers which are built with two hulls to prevent such spills in circumstances such as this. Federal law dictated that all tankers operating in U.S. waters must be double hulled by 2015, which the Westchester was scheduled to do in 2006 (*6*). It was unclear what exactly caused the tank to rupture, though it was speculated that the carrier could have hit something already on the river bottom or that its very own anchor could have become pinned between the hull and the river bottom causing the puncture in the hull. Unfortunately, due to the nearby wetland's drought-stricken conditions, several cuts had been made to divert river water into the parched areas, potentially exposing various wildlife species to hundreds of thousands of gallons of oil. Containment booms were set out, accordingly, to prevent such a disaster. Two days after the spill occurred, the coast guard expected the closed route to be reopened for business, as usual.

Oil spill in 2005 showed devastating effects of hurricane Katrina were undeniable. One of the most under-reported disasters resulting from the Category 4 hurricane where 46 destroyed and 20 damaged oil platforms occurred in the Gulf of Mexico (*7*). Approximately, 50 oil spills were reported in the Louisiana and Mississippi shoreline areas, with Murphy Oil responsible for the largest release of oil at approximately 819,000 gallons due to an above-ground storage tank becoming dislodged because of storm surge and flooding that was associated with Hurricane Katrina (*7*). The oil was spilled into a densely-populated area of St. Bernard Parish and impacted roughly 1,700 homes and local canals (*7*). While all the spills were because of Hurricane Katrina, the cleanup efforts were significantly different for each event due to the location of the spills, residential versus marsh areas, and accessibility complications. The *in situ* burn technique proved to be the most effective method for the reduction of impact on the sensitive coastal marsh areas (*7*).

A 61-foot barge carrying 419,000 gallons of heavy fuel collided with a 600 feet tanker ship early morning on July 23rd, 2008 (*8*). The leaking fuel went undetected for two days thus polluting the Mississippi River (*8*). It was noted that the smell of the fuel was so pungent that it could be smelled from miles, which detoured tourists from visiting the famous New Orleans French Quarters or walking along the boardwalk. Tens of thousands of feet of plastic booms were deployed to keep the fuel from reaching secondary passes. These plastic booms were also placed around the Delta National Wildlife Refuge, located at the mouth of the Mississippi River (*8*). Skimmer boats were used to extract the oil from the top of the water, while most of the oil would be pushed out to the Gulf of Mexico due to the fast-moving waters (*8*). During the time of the cleanup efforts, the Mississippi River was closed to all boat traffic, which consisted of nearly 200 vessels (8). After two days of extensive cleanup, the Coast Guard opened the river for limited use. It was estimated that the city's ports lost a minimum of $100,000 USD per day while the river was closed (*8*). Coast Guard officials also noted that the towboat operator that was responsible for the barge was not licensed for this line of work.

An explosion on the Deepwater Horizon oil rig caused history's largest marine oil spill (*9*). The explosion was caused by a surge of natural gas which cracked the recently installed concrete core (*9*). It was later found that, due to the concrete's curing process, the new core was too weak to withstand the level of pressure to which it was exposed. The ascending natural gas then made its way to the platform, where it ignited and killed 11 workers (*9*). With the rig now detached from the ocean floor, oil was flowing freely without any opposing forces stopping it. In addition, oil volumes of 60,000 barrels per day were leaking, contamination efforts were of high urgency (*9*). Apparatus called as Marine Riser Package Cap was soon placed over the leaking oil to siphon it to a nearby tanker. The apparatus, as mentioned above, was only a temporary solution as it was not a perfect fit and oil was still being released into the Gulf of Mexico. A more permanent seal was placed, but by that time an estimated 4,900,000 barrels of oil had already been released into the Gulf. Due to the enormous size of the leak, several styles of cleanup measures were taken. Approximately 1.8 million gallons of dispersants were placed in the oil-filled water as means for bacteria to metabolize the oil. Booms were placed at strategic points to corral the oil, after which it siphoned or burned. Manual removal of the oil was required for all beaches affected throughout the gulf. It is estimated that 1,100 miles of shoreline were polluted (*9*). The impacts of the spill are irreversible as its impact affected marine life and the fishing industries to levels beyond measure. Proper action plan by using a microsimulation platform and taking the right guidelines to get the port back to operation during an oil spill are the gaps in the literature on this topic. Therefore, the objective of this research study was to develop a quick and efficient solution by using microsimulation platform to New Orleans Port operations from being shut down due to an oil spill scenario.

METHODOLOGY

The aim of this research study is to develop a quick and efficient plan of action by using microsimulation platform to get the port back in operation during an oil spill incident. This avoids delays to the movement of cargo on the roads and within the port. By using micro-simulation platform VISSIM, an action plan is designed to bring Port of New Orleans back to normal operating condition during an oil spill incident. VISSIM version 9.0 micro-simulation platform is selected to build the model, as this software is one of the most widely used microscopic simulation packages for traffic engineering studies worldwide.

Port Operation Plan during an Oil Spill Incident

Port of New Orleans consists of three parts: Uptown terminal, downtown terminal and inner harbor terminal. Normally all goods are delivered at the uptown terminal. However, in case of an oil spill incident the downtown terminal is chosen for deliveries of containership and barge goods. The Uptown Terminal in port NOLA is the main terminal for loading and unloading of cargo goods, moreover, all cargo storage facilities are located in this terminal area.

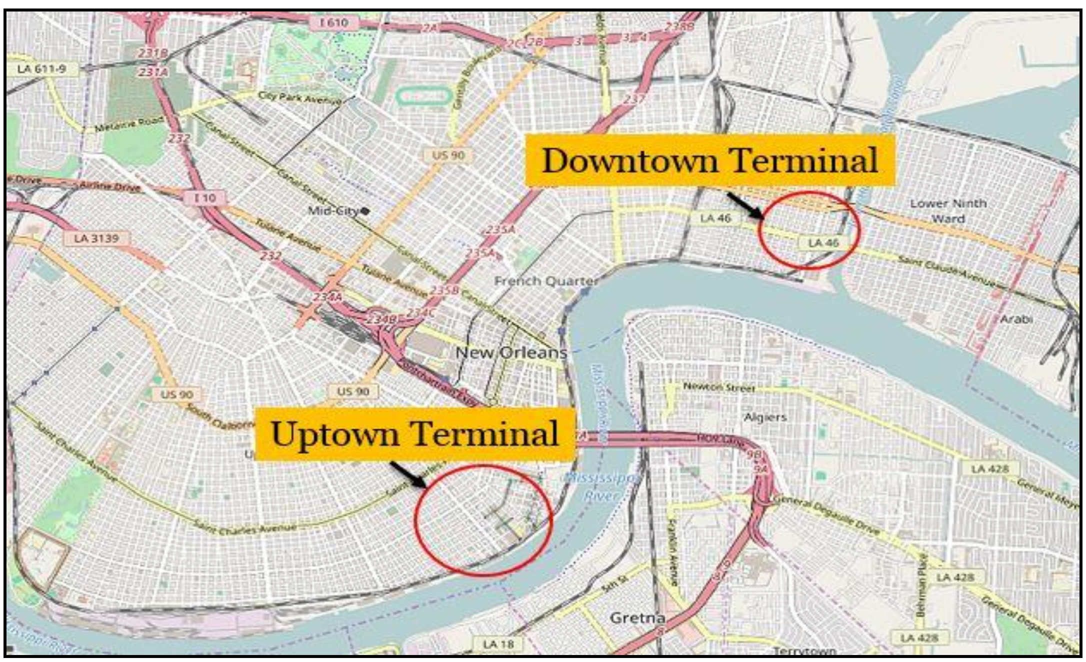

Figure 1. Port of New Orleans

The contingency plan for the oil spill incident would move the containership and barge deliveries intended for the Uptown Terminal to be directed to the Downtown Terminal. All the oil spill incidents occur in or near the vicinity of the Uptown Terminal facilities. Redirecting of marine traffic from the Downtown Terminal to the Uptown Terminal would increase the number of deliveries and heavy vehicles/truck traffic, as all the cargo storage facilities are located in the Uptown Terminal.

During an oil spill incident, the heavy vehicles/truck traffic increase traffic congestion near the port Uptown and Downtown terminal. Subsequently, due to the traffic congestion the total travel time and delay increase, in addition, the average speed decrease of the heavy vehicle. This cause an overall delay of the port operations due an oil spill situation. Therefore, a micro simulation VISSIM model is built to replicate the exact traffic situation of the field, and signal retiming was performed and before and after analysis is conducted. 5 signalization intersection was selected for this research study. The research study is comprised of total 2.1 miles, near the Uptown terminal. Tchoupitoulas St. & Henderson St. is the east border and Tchoupitoulas St. & Louisiana Ave is the west border of the study corridor. The analysis was conducted for both eastbound and westbound directions of travel and for morning peak period from 7 AM - 9 AM. The list of the intersection of the selected corridor near the uptown terminal for the simulation model are listed in the following table:

Table 1. List of Intersection of the Study Area in Uptown Terminal, Port of New Orleans, Louisiana

No.	Signalized Intersections
1.	Tchoupitoulas St. & Henderson St.
2.	Tchoupitoulas St. & Felicity St.
3.	Tchoupitoulas St. & St Mary St.
4.	Tchoupitoulas St. & Jackson Ave.
5.	Tchoupitoulas St. & Louisiana Ave.

Signalized Intersection Design

Designing of signalized intersection was performed by using micro simulation platform VISSIM version 9.0. In order to design a signalized intersection in VISSIM 9.0, various traffic data was required. Various field data for building the microsimulation model was collected from Louisiana Department of Transportation & Development, Port of New Orleans Authorities and from traffic counters from Louisiana Geocounts such as:

- Geometric data: length of lanes, number of lanes, lane location, and lane assignment.
- Signal timing plan: number of phases, cycle lengths, duration of phases for different time of the day
- Heavy vehicles/ Truck travel time, delay time, dwell times and distribution of dwell times
- Volume data, speed data, turning movement counts

Geometric data were obtained from aerial images; information on heavy vehicle operation was obtained from Port of New Orleans authorities, traffic data and signal timing plans were obtained from traffic counters in Louisiana Geocounts. The port directory provided up to date information on the average daily truck cargo deliveries, annual break-bulk cargo tonnage, and annual containers received. On a normal day about 2130 truck drivers haul cargo in and out of the Port.

Measures of Effectiveness (MOE): The MOE's for evaluating the impacts of signal retiming and performing before and after analysis are travel time, total travel time, delay time and total delay time. Total delay measures the difference between free flow travel time and actual travel time including control delay. Total delay also measures the time the truck was below the desired velocity for a signalized intersection approach. The MOEs used here are consistent with the reviewed studies and provides a good representation of the signal retiming impact to truck operations.

Truck Travel Time: Truck travel time is an aggregate measurement of travel times on all truck route included in the analysis. Therefore, this measure will include benefits received by truck movements and losses received by others arriving near the transition to or from a signal retiming. Therefore, this MOE will provide a good representation of the performance of the entire system and the applied signal retiming.

Truck Delay Time: Truck delay is reflected in the truck travel time, but it is also a measurement of the effectiveness of the signal retiming since it specifically examines delay due to traffic signal operations. A large decrease in truck delay equates to an increased green time by the traffic signal controller.

Strategy used for Signal Retiming

As all 5 intersection are fully actuated. Green extension strategy is used to extend the green interval by up to a preset maximum value if a heavy vehicle is approaching. Detectors are located so that any heavy vehicle that would just fail to catch the green light ("just" meaning by no more than the specified maximum green extension time) extends the green and is able to clear the intersection rather than waiting through an entire red interval. Green Extension provides a benefit to a relatively small percentage of trucks (only trucks that arrive during a short window each cycle benefit), but the reduction in delay for those trucks that do benefit is large (an entire red interval).For the west and east bound approach the maximum green time was increased by 30 seconds for all five intersection.

Table 2. Maximum Green Before and After Study

No.	Signalized Intersections	Max. Green Interval Before Study	Max. Green Interval After Study
1.	Tchoupitoulas St. & Henderson St.	60	90
2.	Tchoupitoulas St. & Felicity St.	60	90
3.	Tchoupitoulas St. & St Mary St.	40	70
4.	Tchoupitoulas St. & Jackson Ave.	40	70
5.	Tchoupitoulas St. & Louisiana Ave.	50	80

Therefore, successful port operations have to be insured in the event of an oil spill. As ports are best known for their intermodal activity, connecting rail lines, truck lines, barge lines, cruise lines, and ocean carriers. Therefore, a plan of execution was documented that fits during an oil spill incident. The following figure shows the steps to be taken in case of an oil spill incident at Port of New Orleans.

The steps taken during an oil spill incident are in the following figure. This research project only focusses on the signal retiming part.

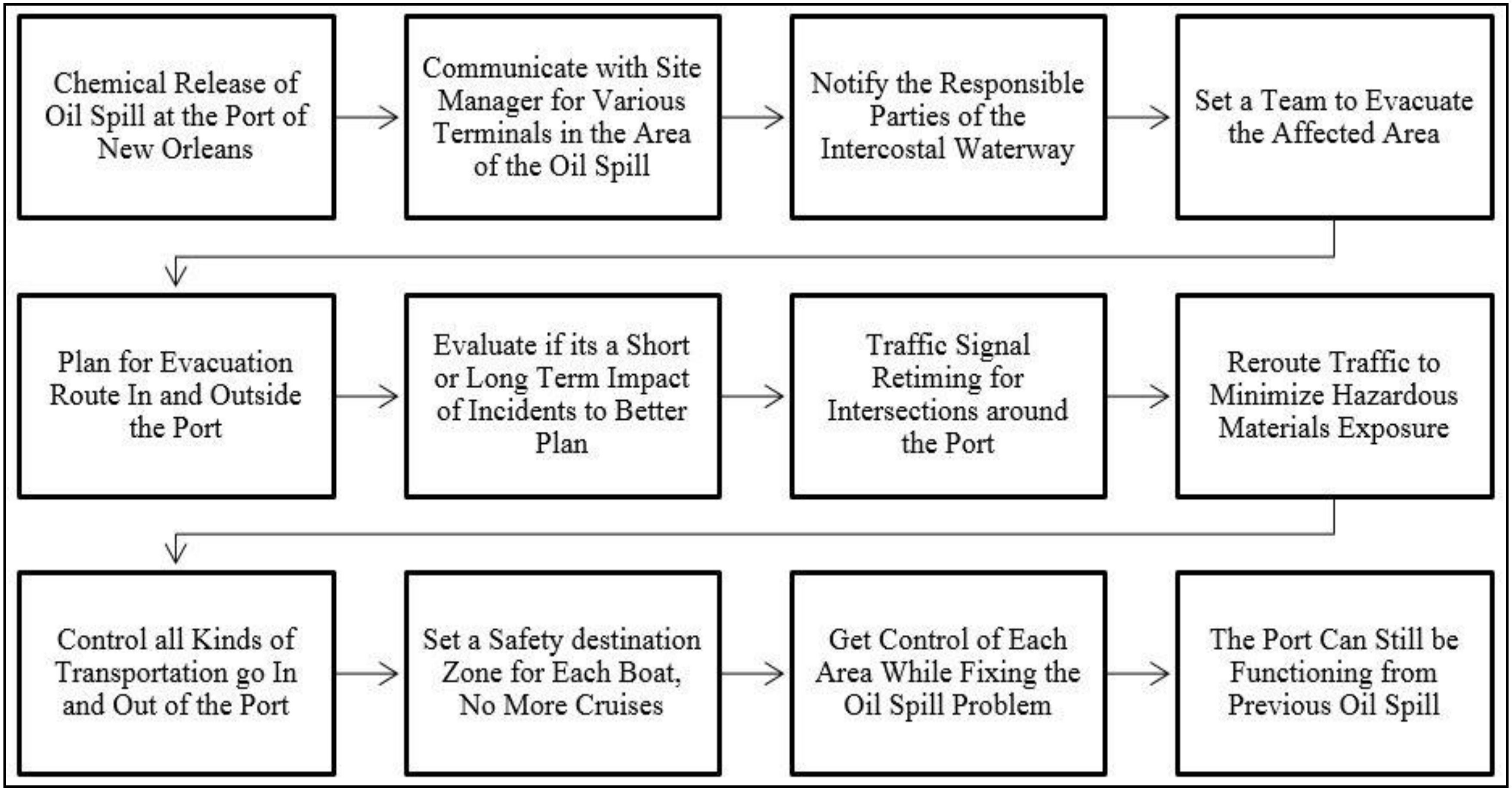

FIGURE 1 Steps Taken during an Oil Spill Incident at port NOLA

RESULTS & DISCUSSION

This section evaluates the before and after analysis results through implementation of Signal Retiming. Achieved benefits are described by using different MOEs and their evaluation before and after the implementation of signal retiming for the study corridor. MOEs used in this project for evaluation are total travel time, travel time, delay time and total delay time for all vehicles and for truck only. MOE comparison for both before and after signal retiming scenarios are presented by tables and graphs.

Evaluation of effectiveness of Signal Retiming applied on Tchoupitoulas St. Corridor, Port of New Orleans from Louisiana Ave (West Border) and Henderson St. (East Border) is presented in this section. For easy understanding, results are presented for both directions. In this evaluation of effectiveness of Signal Retiming, travel time and delay between the intersections were considered. Next, results are presented for all vehicles in the system, as well as, for truck only.

Table 3. All Vehicles Travel Time Comparison

Travel Time (Seconds) - All Vehicles					
Westbound			**Eastbound**		
Segment	*Before Signal Retiming*	*After Signal Retiming*	Segment	*Before Signal Retiming*	*After Signal Retiming*
Tchoupitoulas St. & Henderson St.	67.57	64.68	Tchoupitoulas St. & Henderson St.	63.34	47.89
Tchoupitoulas St. & Felicity St.	69.89	55.35	Tchoupitoulas St. & Felicity St.	40.67	32.67
Tchoupitoulas St. & St Mary St.	44.4	40.73	Tchoupitoulas St. & St Mary St.	29.4	25.07
Tchoupitoulas St. & Jackson Ave.	30.72	25.39	Tchoupitoulas St. & Jackson Ave.	55.31	47.08
Tchoupitoulas St. & Louisiana Ave.	104.63	99.32	Tchoupitoulas St. & Louisiana Ave.	101.91	95.77
Total Travel Time	**317.21**	**285.47**		**290.63**	**248.41**

The total travel time is estimated separately for westbound and eastbound directions, and for all vehicles and truck only separately. Table 3 and Figure 2 provides all vehicles travel times along the study corridors before and after signal retiming.

- Overall, after signal retiming simulation model results are better than the before signal retiming, in addition, the total travel time results of truck only are lower after signal retiming.

- Moreover, the simulation results of the travel time for east and west bound direction are also similar for both all vehicles and truck only. It was also noticed that the travel time for each segment in the model are different for each direction.
- Furthermore, simulation results of total travel time of all vehicles are considerably lower in the model compared to the total travel time of truck only.

In the tables presented below (Table 4 & Figure 2) provides for travel times truck only in the system. Moreover, comparison for all vehicles and truck only showed that travel time was less at all intersections for the model after signal retiming. It indicated that the highest benefits achieved through implementation of signal retiming occurred on segments between Tchoupitoulas St. and Felicity St. for west bound, and Tchoupitoulas St. and Henderson St. for east bound.

Table 4. Truck Only Travel Time Comparison

Travel Time (Seconds) - Truck Only					
Westbound			**Eastbound**		
Segment	*Before Signal Retiming*	*After Signal Retiming*	Segment	*Before Signal Retiming*	*After Signal Retiming*
Tchoupitoulas St. & Henderson St	129.50	117.40	Tchoupitoulas St. & Henderson St	116.03	110.99
Tchoupitoulas St. & Felicity St.	85.80	63.77	Tchoupitoulas St. & Felicity St.	76.18	68.05
Tchoupitoulas St. & St Mary St.	55.42	42.65	Tchoupitoulas St. & St Mary St.	60.73	58.21
Tchoupitoulas St. & Jackson Ave.	85.62	82.53	Tchoupitoulas St. & St Mary St.	65.63	60.57
Tchoupitoulas St. & Louisiana Ave.	172.92	152.30	Tchoupitoulas St. & St Mary St.	155.89	143.53
Total Travel Time	**529.26**	**458.65**		**474.46**	**441.35**

Total travel time for all vehicles with Before Signal Retiming was 317.21 seconds for the west bound, 290.63 seconds for the east bound, and, total travel time for all vehicles with After Signal Retiming was 285.47 seconds for the west bound, and 248.41 seconds for the east bound.

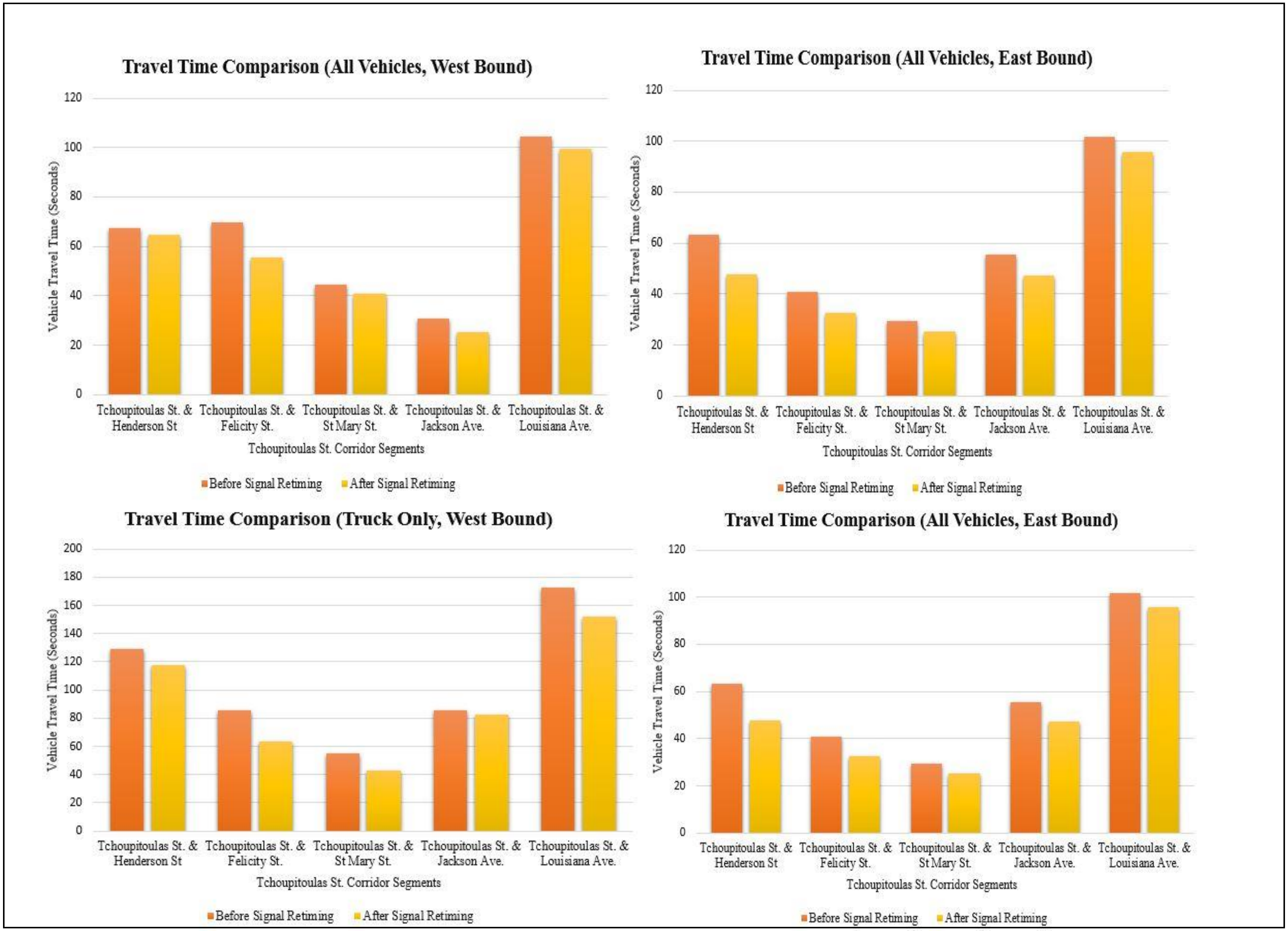

FIGURE 2 All Vehicles and Bus Only Travel Time Comparison for Both Direction

Moreover, the total travel time for truck only Before Signal Retiming was 529.26 seconds for the west bound, and 474.46 seconds for the east bound, and, total travel time for truck only After Signal Retiming was 458.65 seconds for the west bound, and 441.35 seconds for the east bound. The travel time results of After Signal Retiming for all vehicles and truck only for both direction showed enough benefits to be implemented in the area.

Delay time measured the excess time consumed in traversing the intersection. Moreover, delay time MOE is complex due to random arrival of vehicles, lost time due to stopping of vehicles, over saturated flow conditions etc. Next, the results were presented for the MOE Delay for all vehicles in the system, as well as, for trucks only for both east and west bound direction. As for the Tchoupitoulas St. Network, the (Table 5 & Figure 3) provided detailed comparison of the delay time for both direction for all vehicles.

- Overall, after signal retiming model simulation results are better than the before signal retiming model, in addition, the total delay time results are lower after signal retiming.
- Moreover, the simulation results of the delay time for east and west bound direction are also similar for both all vehicles and truck only. It was also noticed that the delay time for each intersection in the model are different for each direction.

Table 5. All Vehicles Delay Time Comparison

Intersection	**Delay Time (Seconds) - All Vehicles**			
	Westbound		**Eastbound**	
	Before Signal Retiming	*After Signal Retiming*	*Before Signal Retiming*	*After Signal Retiming*
Tchoupitoulas St. & Henderson St	22.90	17.13	16.19	15.18
Tchoupitoulas St. & Felicity St.	38.56	33.16	38.94	35.20
Tchoupitoulas St. & St Mary St.	20.32	16.37	11.35	8.26
Tchoupitoulas St. & Jackson Ave.	16.45	11.57	14.53	11.46
Tchoupitoulas St. & Louisiana Ave.	48.84	39.91	34.78	30.01
Total Delay Time	**147.07**	**118.14**	**115.79**	**100.11**

In the tables presented below (Table 6 & Figure 3) delay times between the intersections truck only in the system. Moreover, comparison for all vehicles and truck only showed that delay time was less at all intersections for the model after signal retiming. It indicated that the highest benefits achieved through implementation of signal retiming for all vehicles occurred on intersection between Tchoupitoulas St. and Louisiana Ave. for both directions. Also, for truck only the highest benefit occurred on intersection between Tchoupitoulas St. and Louisiana Ave. for both direction.

Table 6. Truck Only Delay Time Comparison

Intersection	Delay Time (Seconds) - Truck Only			
	Westbound		Eastbound	
	Before Signal Retiming	*After Signal Retiming*	*Before Signal Retiming*	*After Signal Retiming*
Tchoupitoulas St. & Henderson St	19.70	11.65	23.62	20.36
Tchoupitoulas St. & Felicity St.	39.02	31.22	15.45	12.11
Tchoupitoulas St. & St Mary St.	23.42	15.21	20.26	17.13
Tchoupitoulas St. & Jackson Ave.	21.98	17.03	14.91	11.51
Tchoupitoulas St. & Louisiana Ave.	42.98	27.88	38.50	30.5
Total Delay Time	**147.10**	**102.99**	**112.74**	**91.61**

Total delay time for all vehicles with Before Signal Retiming was 147.07 seconds for the west bound, 115.79 seconds for the east bound, and, total delay time for all vehicles with After Signal Retiming was 118.14 seconds for the west bound, and 100.11 seconds for the east bound.

FIGURE 3 All Vehicles and Bus Only Delay Time Comparison for Both Direction

Moreover, the total delay time for truck only Before Signal Retiming was 147.10 seconds for the west bound, and 112.74 seconds for the east bound, and, total delay time for truck only After Signal Retiming was 102.99 seconds for the west bound, and 91.61 seconds for the east bound. The travel time results of After Signal Retiming for all vehicles and truck only for both direction showed enough benefits to be implemented in the area.

Statistical Analysis

As the sample size of this research study is below 30, a *t*-paired test at 95% confidence interval was performed to check the null hypothesis that travel time for the before and after travel time for all vehicles and truck only are equal. For all vehicles, the t critical two-tail value was 2.262 and the t statistics value was 4.7452. For truck only, the t critical two-tail value was 2.262 and the t statistics value was 5.4904. Therefore, for both all vehicles and truck only rejected the null hypothesis, therefore, the signal retiming values are significantly different.

CONCLUSIONS

The present challenges with the port operations could be alleviated through signal retiming during an oil spill incident. The after study results shows the heavy vehicles reduce delay time. In addition, it also reduce heavy vehicles travel time, provide better heavy vehicles efficiency, and increase overall road network efficiency.

The objective of this research was the objective of this research study was to develop a quick and efficient solution by using microsimulation platform to New Orleans Port operations from being shut down due to an oil spill scenario. The benefits were quantified based on total travel time and total delay along the study corridor. The study corridor was a 2.1-mile section on Tchoupitoulas St., Port of New Orleans, Louisiana. A microsimulation models were developed in VISSIM: (a) a base model without signal retiming; and (b) an advanced model with signal retiming. Table 7 compares the performance of these two simulation models. The after-signal timing study was found to improve the performance of heavy vehicles, moreover, it greatly reduced the travel times and the total delay times for heavy vehicles and all vehicles.

Table 7. Comparison of Before and After Study of the Performance Measures

Total Travel Time (Sec)	Vehicle Type	Direction	Before Signal Retiming Model	After Signal Retiming Model
	ALL Vehicles	West Bound	317.21	285.47
	ALL Vehicles	East Bound	290.63	248.41
	TRUCK Only	West Bound	529.26	458.65
	TRUCK Only	East Bound	474.46	441.35
Total Delay Time (Sec)	ALL Vehicles	West Bound	147.07	118.14
	ALL Vehicles	East Bound	115.79	100.11
	TRUCK Only	West Bound	147.10	102.99
	TRUCK Only	East Bound	112.74	91.61

Based on the simulation results, it can be concluded that after signal retiming the heavy vehicle system operations is effective and reliable. The effectiveness of this method also helps to cut fuel cost, less environmental pollution and eventually provide better operation of the port from being shut down due to an oil spill incident.

REFERENCES

1. Ali, M. S., E. I. Kaisar, and M. Hadi. Guidance for Identifying Corridor Conditions That Warrant Deploying Transit Signal Priority and Queue Jump. *5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems, MT-ITS 2017 - Proceedings*, No. 2, 2017, pp. 657–662. https://doi.org/10.1109/MTITS.2017.8005595

2. Ali, M. S., L. A. Zerpa, E. I. Kaisar, and K. O. Masters. Guidance for Identifying Corridor Conditions That Warrant Deploying Transit Signal Priority. Transportation Research Board, 97th Annual Meeting, No. 18–05194, 2018, pp. 1–16

3. Kodi, J. H. *Evaluating the Mobility and Safety Benefits of Adaptive Signal Control Technology (ASCT)*. UNF Graduate Theses and Dissertations. 930. https://digitalcommons.unf.edu/etd/930, 2019.

4. Cherry, K. E., Sampson, L., Galea, S., Marks, L. D., Nezat, P. F., Baudoin, K. H., & Lyon, B. A. *Optimism and hope after multiple disasters: relationships to health-related quality of life*. Journal of loss and trauma, 2017. *22*(1), 61-76

5. Webler, Thomas, and Fabienne Lord. "*Planning for the human dimensions of oil spills and spill response*." Environmental management 45, 2010. no. 4: 723-738.

6. Los Angeles Times. *Oil Spill Closes 26 Miles of the Mississippi River*. http://articles.latimes.com/2000/nov/30/news/mn-59358. Accessed March 2, 2018

7. Pine, John C. "*Hurricane Katrina and oil spills: Impact on coastal and ocean environments.*" Oceanography 19, no. 2 (2006): 37-39.

8. Nossiter, Adam. "*Mississippi River Reopened After Oil Spill*." 2008.

9. Pallardy, R. *Deepwater Horizon oil spill of 2010*. Encyclopedia Britannica Inc., 2015

.