Unconventional Design of U-turn for Road Safety and Operational Effectiveness - The Case of Safoot U-turn-Jordan

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Abstract

With the increase in traffic volumes in Jordan and the high rate of growth in population and vehicles in the last 10 years, highway systems suffer from different problems like congestion high rates of accidents, delays and long travel times. Intersections and U-turns in major highways are considered from the hazard location in this system. Looking for a solution to this problem depended on effectively redesigning the intersection without main changes in the infrastructure. Traffic accidents are one of the major health hazards in Jordan. They are considered the second leading cause of death. Therefore, maintaining safety and operational efficiency on arterial highways remains a constant goal. This study provides a practical solution for solving the U-turn problem and proposes a new design for improving safety and operational characteristics for an existing arterial segment of the Amman- Jerash highway. The study evaluated the current situation by conducting a survey. Results led to the proposed design solution which eliminated the hazard of merging after the U-turn and provided a safe manoeuvre of turning for highway users.

Keywords: Transportation, U-turn design, Road safety and operational, MOE, Delay, LOS.

1. Introduction

With increases in populations and vehicles, traffic accidents and low speeds in traffic flow occur and cause problems such as congestion and delay. These problems are mostly seen in developing countries due to several factors, among which is the lack of an efficient, reliable public transport system, as well as the lack of adequate infrastructure for greener modes of transport (such as walking and cycling). According to the annual report of traffic accidents in Jordan for 2019 issued by the Public Security Directorate (PSD, the annual increase in the number of vehicles averaged around 4.4% over the past five years. Car ownership per person touched its highest levels, in which one in six persons owns a vehicle in Jordan (Public Security Directorate, 2020). This increasing reliance on private cars has resulted in traffic congestion, delays, and accidents, especially in big cities like Amman. According to the PSD data, a total of 161,511 accidents occurred in Jordan in 2019 (Public Security Directorate, 2020). Several studies conducted in Jordan concluded that most accidents that happened in Amman were recorded at intersections (Al-Khateeb, 2010; Ismeik & Al-Kaisy, 2010; Jadaan, et al., 2013; Abojaradeh, et al., 2014). Traffic systems in Jordan including traffic signals also suffer significant problems such as inappropriate lane grouping, improper phasing systems, low saturation flow rates for approach lanes due to existing traffic and geometric conditions at intersections that are highly deviated from standard or ideal conditions, inadequate lane width, high traffic demands at intersections, and absence of pedestrian phases (Abojaradeh, et al., 2014; Miqdady & de Oña,, 2020). Considering this, improving highway performance to satisfy transportation system performance (efficiency, effectiveness, safety, energy, and environment compatibility), helps in achieving a more sustainable transportation system in a developing country, such as Jordan. The main contribution of this study is to provide insight into the possibility of implementing a super street (Unconventional Roundabout) as an unconventional arterial intersection design for improving mobility and safety for arterials in Jordan. The following sections of this paper are organized as follows; the second section is a brief literature on the concept of a super street; the third section describes the methodology including site description and data collection; the fourth provides an analysis results for the simulation scenarios; and the last section provides the conclusions and recommendations.

2. Research Questions

The main questions of the study are:

- To what extent do unconventional intersection designs mitigate traffic congestion and reduce accident rates?
- Are unconventional intersection designs viable solutions within constrained right-of-way environments?
- What data collection methodologies are required to effectively analyze and model the performance of unconventional intersection designs across a spectrum of traffic conditions?

3. Related Work

Due to the growing applications of the super street concept in recent years, several fundamentals combined with its operational efficiency have become known as the main concern research subjects in the traffic community (Xu, Yang, and Chang 2017). For example, Hummer et al. (2010)

developed a technique to establish the capacity of super streets by modifying the critical lane volume used in the highway capacity manual (HCM). To recognize the insufficient operational guidance, Haley et al. (2011) compared the super street performance with equivalent conventional intersections and concluded that adopting a super street concept is effective when the arterial's left-turn volume per lane is greater than 80% of the volume on the minor roads during the same signal phase. This agrees with Kim et al. (2007) results that highlighted the benefits of the operational and safety offered by super streets under high-volume conditions. Moon et al. (2011) presented the potential of implementing a strategy for improving mobility and safety in South Korea. This study evaluated how a superstreet design performs successfully within given traffic circumstances compared to an existing design. The authors used VISSIM to simulate the operations of subject intersections and the Surrogate Safety Assessment Model (SSAM), to perform conflict analysis by processing vehicle trajectory data extracted from micro-simulations to evaluate safety estimations. The results showed that the corridor with super streets has the most effective progression of traffic along the entire road section with the fewest stops and lowest delays.

More recent studies presented unconventional intersection solutions. For example, a series of guidelines to support practitioners in evaluating superstreet implementation have been offered by the Federal Highway Administration (Hughes et al. 2010; Hummer et al. 2014). Jae et al. (2011) used VISSIM to evaluate the ability to use the super street unconventional intersection design for arterial in Korea, the researcher found less delay and better performance during the peak hour volumes. Naghawi and Idewu (2014) used CORSIM to compare the operational efficiency of a conventional signalized intersection with an unconventional super street intersection, The result of this study showed that super street design decreased delay time and queue length compared to conventional design. Naghawi et al (2017) investigated the possibility of implementing an unconventional intersection design, to improve the operational characteristics of an existing signalized arterial intersection in Jordan. Authors in this study used VISSIM and SYNCHRO microsimulation models to compare the existing and the proposed superstreet design. Their study shows that using the unconventional super street design decreased the delay per vehicle by 70.44% and the maximum queue length by 72.34%. Another study conducted by Bara'h Al-Mashaikh et al (2020) focused on improving the operational performance of highly congested urban arterial intersections by using Unconventional Arterial Intersection Designs (UAIDs) as a solution for congestion intersections. In this study signal timing optimization was used as an initial solution before doing any modification on the geometric design. Then, testing the effect of implementing some types of UAIDs including single quadrant, jug-handle, bowtie and Continuous Green T-Intersection (CGTI) as suggested solutions for three highly congested urban arterial intersections in Jordan. The analysis revealed that the proposed UAIDs succeeded in improving the current intersections in terms of Level of Service (LOS).

Conventional transportation infrastructure, though foundational, often struggles to address the complexities of modern urban mobility demands, necessitating the exploration and implementation of innovative strategies (Fitzpatrick et al., 2005). These novel approaches aim to optimize traffic flow, enhance safety, and accommodate diverse transportation modes, leading to more sustainable and efficient urban environments (Ivanova et al., 2023). The primary motivations for exploring alternative intersection and interchange designs are to alleviate delays and improve safety for both passengers and pedestrians (Bared et al., 2005). Unconventional intersection designs require a meticulous examination of their operational and safety performance through diverse analytical methods, each with unique objectives, scopes, experimental designs, analysis tools, and evaluation measures (Esawey & Sayed, 2012). The design of intersections focuses on improving the convenience, comfort, and safety of all users—motor vehicles, buses, trucks, bicycles, and pedestrians—while also enhancing the efficient movement of traffic (Fitzpatrick et al., 2005). One such innovative design is the double crossover intersection, which, along with the diverging diamond interchange, has demonstrated superior performance during peak hours compared to conventional designs, offering better levels of service, reduced delays, smaller queues, and higher throughput (Bared et al., 2005).

The integration of advanced technologies, such as connected vehicle systems, presents additional opportunities to refine intersection management and enhance overall network efficiency (Wang et al., 2021). Digital twin technology, for instance, can aid in cooperative driving strategies at non-signalized intersections, optimizing traffic flow and minimizing potential conflicts. Adaptive traffic signal control, particularly within a connected vehicle environment, showcases significant potential in mitigating urban traffic congestion by dynamically adjusting timing patterns based on real-time traffic demand, a capability absent in traditional static signal systems (Jing et al., 2017). However, the deployment of traffic signals requires careful consideration, as unnecessary or poorly designed signals can negatively impact both safety and mobility, highlighting the inherent trade-offs between these two objectives (Wang et al., 2021). Therefore, a holistic approach that considers both design and operational aspects is essential for maximizing the benefits of unconventional road and intersection designs (Jing et al., 2017) (Wang et al., 2021) (Bared et al., 2005) (Fitzpatrick et al., 2005).

Traffic simulation software, such as PTV Vissim, plays a pivotal role in contemporary transportation planning and engineering, enabling detailed analysis and optimization of road networks (Zhang et al., 2022). Vissim, in particular, stands out as a powerful tool for modelling complex traffic scenarios and evaluating the impact of various design and control strategies, especially in the context of unconventional road configurations (Li et al., 2014). Its capacity to simulate traffic flow at a microscopic level, considering individual vehicle behaviour and interactions, makes it indispensable for assessing the performance of innovative or non-standard road designs (Zhang et al., 2022). This is due to the rising need for effective traffic management, particularly in urban areas where traditional methods frequently fall short, leading to an increase in the use of unconventional road designs intended to enhance capacity, improve safety, or alleviate congestion. These designs may include diverging diamond interchanges, continuous flow intersections, and other creative geometric configurations that challenge conventional traffic flow patterns (Andronov et al., 2019).

Vissim's strength lies in its ability to replicate real-world traffic conditions with a high degree of fidelity. This involves accounting for a variety of elements, including driver behaviour, vehicle characteristics, and traffic control systems (Zhang et al., 2022). The software's sophisticated algorithms can simulate how drivers react to various stimuli, such as changes in speed limits, the presence of other vehicles, and traffic signals. This level of detail is essential for accurately predicting how traffic will behave in response to unconventional road designs. Furthermore, Vissim's versatility allows for the integration of various data sources, such as traffic counts, speed data, and origin-destination matrices, which can be used to calibrate and validate the simulation model, ensuring that it accurately reflects the specific characteristics of the road network under study (Zhang et al., 2022). By adjusting the parameters within the simulation, engineers can test different scenarios and fine-tune the design to maximize its effectiveness (Zhang et al., 2022). Vissim stands out as especially well-suited for examining traffic flow stability, which deterministic approaches find difficult to measure, to optimize traffic management (Andronov et al., 2019).

Vissim's capacity to simulate complicated traffic scenarios is essential for assessing the effectiveness of unconventional road designs. These designs frequently aim to disrupt conventional traffic flow patterns to boost capacity, improve safety, or alleviate congestion. Vissim enables transportation engineers to thoroughly evaluate the advantages and disadvantages of these designs by simulating vehicle interactions.

Vissim serves as a valuable tool for optimizing traffic control strategies for unconventional road designs (Zhang et al., 2022). The software's capacity to model the interaction between the traffic control system and traffic flow dynamics allows engineers to identify optimal signal timings for various traffic scenarios (Zhang et al., 2022). Furthermore, Vissim can be utilized to evaluate the effectiveness of other traffic management measures, such as variable speed limits and ramp metering, in alleviating congestion and enhancing safety on unconventional road configurations (Zhang et al., 2022). The insights gained from these simulations can inform design enhancements and mitigate potential adverse effects. Additionally, Vissim can simulate the impacts of variable speed limit control strategies on traffic flows, enabling transportation professionals to fine-tune these strategies to maximize their influence on traffic flow and safety (Zhang et al., 2022).

The use of Vissim in analyzing unconventional road designs also contributes to improved safety (Zhang et al., 2022). By simulating diverse crash scenarios, engineers can identify potential safety risks and implement design modifications to mitigate these hazards (Zhang et al., 2022). For instance, Vissim can be employed to assess the impact of geometric features, such as lane widths, curve radii, and sight distances, on driver behaviour and crash risk (Zhang et al., 2022). The software's detailed modelling of driver behaviour provides a realistic assessment of how drivers respond to various road conditions, offering valuable insights for enhancing road safety (Zhang et al., 2022).

In summary, the existing literature reiterated the potential of applying the superstreet concept to enhance operational efficiency, particularly when the traffic on its major arterial dominates those from the minor approaches (Naghawi and Idewu 2014; Naghawi, AlSoud, and AlHadidi 2018). Yet, such a desirable operation cannot be achieved without a proper design that considers the population density, the road's importance, and future expansion.

4. Methodology

4.1 Site Description

This study selected a segment arterial section, where is possible to implement an assessment and evaluation of U-turn safety and operational characteristics on the Amman to Jerash highway. This main highway connects the northern and central governorates. The highway is the main road to the touristic city of Jerash and different public and private universities. This main arterial highway is a crowded arterial, especially on weekend days and has different U-turns and left turns which are considered reasons for the increased number of accidents. Figure 1 shows the location of Amman Jerash highway, while Figure 2 shows an aerial photo of the selected U-turn. The land use beside this arterial has a high density of population, and high speed, especially the road from the side of Sweileh to Safoot.

Figure 1. Location of Amman Jerash highway.

Figure 2. Aerial Photo of the Selected U-turn

The arterial currently suffers from the following problems:

- High number of accidents
- Different U-turns and left-turns in the same location.
- Long queue of vehicles on all approaches.
- Massive delays on all approaches.

The primary steps undertaken in this study were as follows:

1. **Data Collection –** Gathering the necessary traffic data to assess and understand the existing issues.
2. **Data Analysis** – Examining traffic volume and accident data to identify patterns and contributing factors.
3. **Solution Development** – Proposing potential interventions to address the identified issues.
4. **Microsimulation Analysi**s – Utilizing VISSIM software to simulate both the existing conditions and the proposed solutions.
5. **Results Comparison –** Evaluating and comparing the outcomes of the microsimulation analysis for both scenarios.
6. **Findings** – Interpreting the results and drawing key conclusions based on the analysis.

4.2 Data Collection

Real traffic volume data were made available by the Ministry of Public Works and Housing using Automatic Traffic Count (ATC). Automatic traffic counts were collected for one week between (10 MAR 2020 and 16 MAR 2020) for two directions. The average daily traffic (ADT) is 29567 per direction (Jerash to Swelih direction.) while the average weekday traffic (AWT) is 31437 from Jerash to Swelih direction. Figure 3 shows the location of the fixed station used by ATC.

Figure 3. Location of Fixed Station used to ATC.

The variation of the 15-minute traffic volumes over the seven days and for both directions is shown in Figure 4. It can be noticed that the major arterial road suffers from high traffic volumes during the first (Sunday) and last (Thursday) days of the week due to a large number of employees who work in Amman and their families living in the Northern governorates such as Irbid.

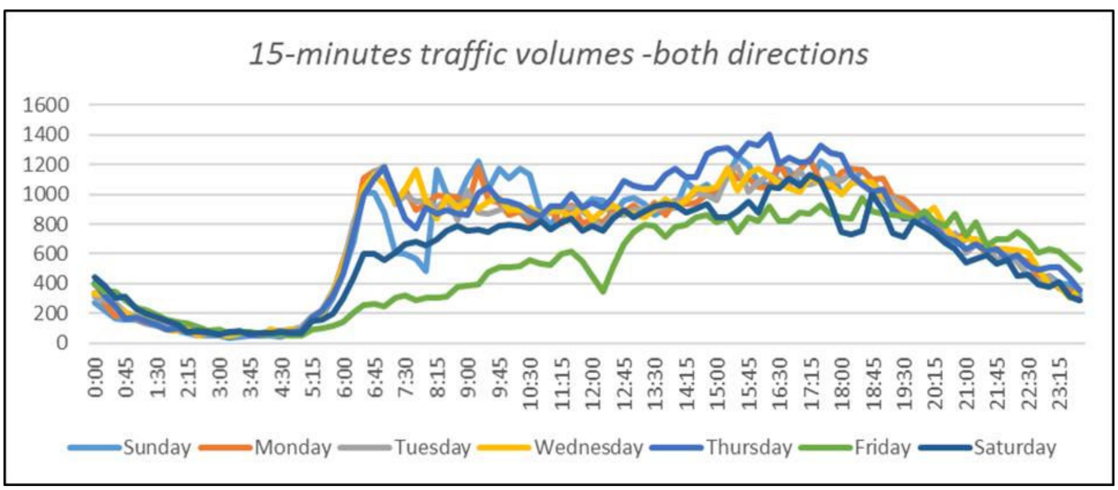
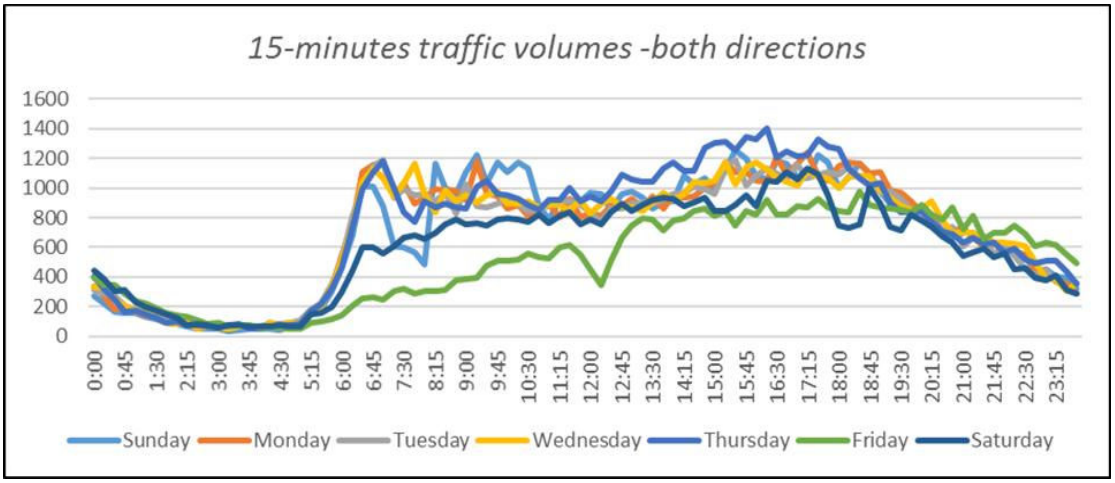


Figure 4. Flow Rate Variation for Seven Days for both Directions.

For the redesign Safoot U-turn, the flow rate for six weekdays for the two directions is calculated as shown in Figure 5.



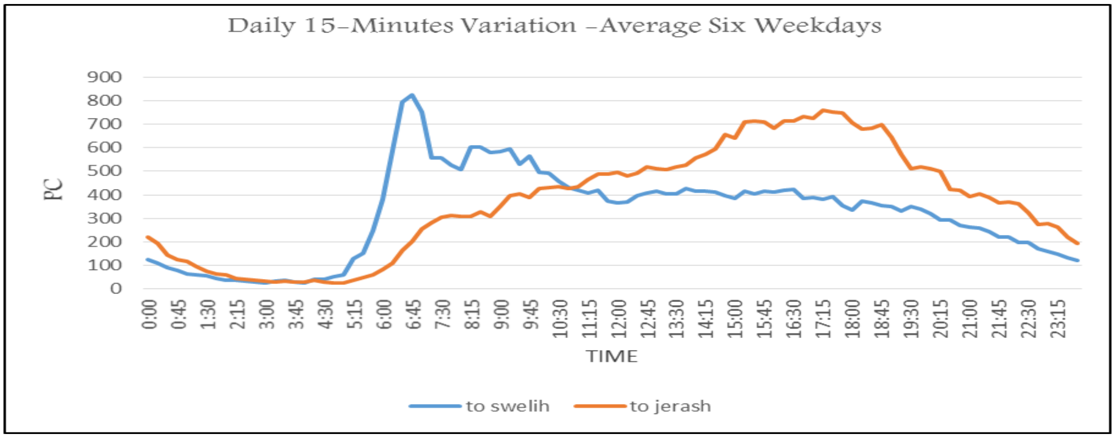


Figure 5. Average Flow Rate for both Directions.

The highest value of the daily traffic volume is 71132 vehicles for both directions. While Figure 6. shows the total daily traffic volume for both directions for Thursday which was found to be the peak day, while the lowest value is 49802 vehicles, and this volume was recorded on Friday.

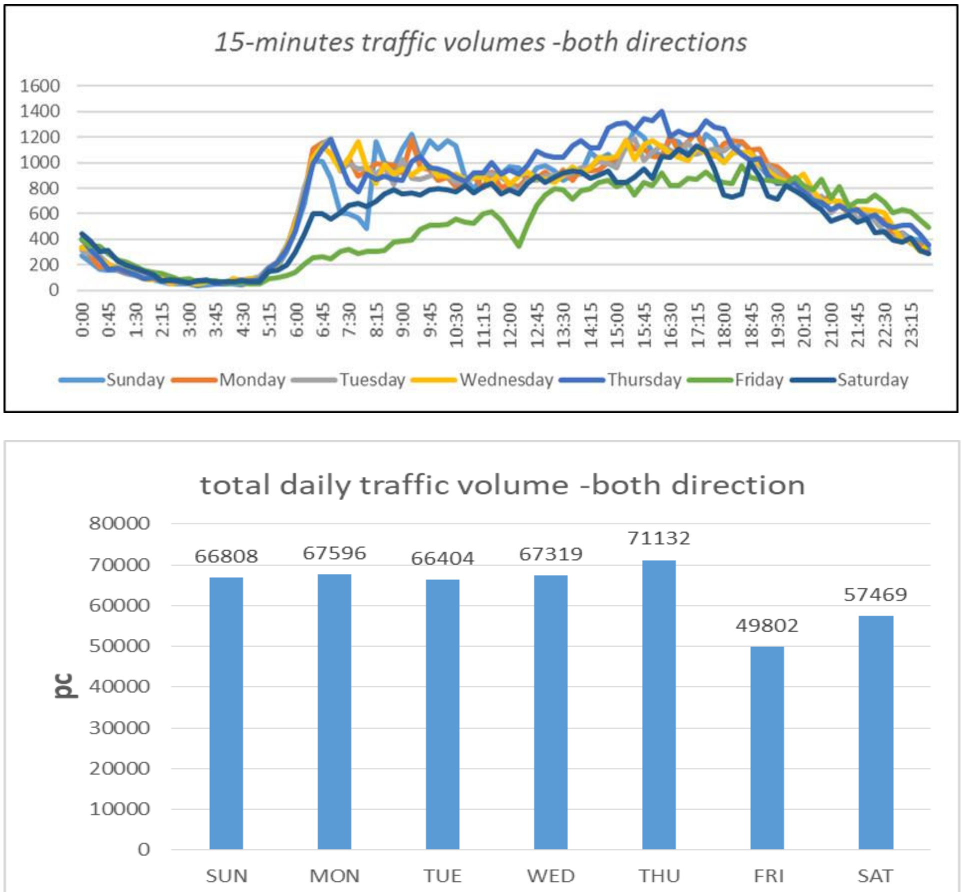


Figure 6. Total Daily Traffic Volume in both Directions.

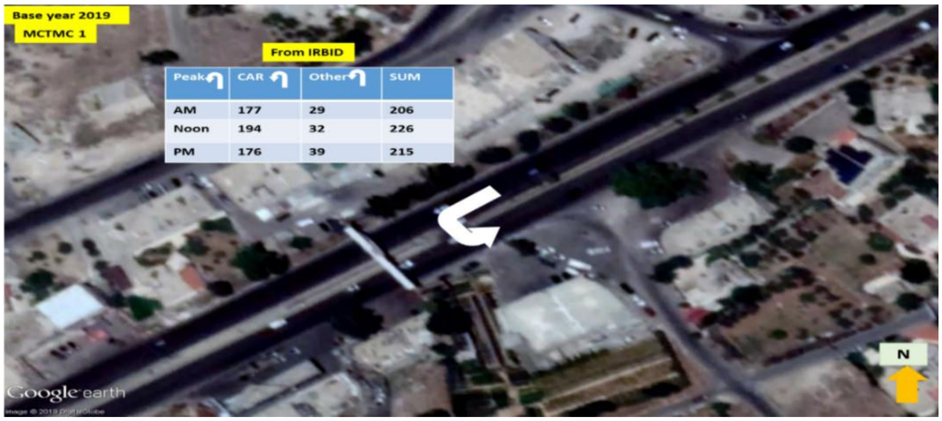


Figure 7. shows the flow rate at the U-turn which was counted for further analysis.

To understand the highway use and the main causative factors of high accident rate, a survey has been conducted to capture the U-turn movements, (to/from) and where the vehicles need to turn. For this purpose, seven main locations are considered for the origin or destination. These are the Swelih intersection, Safoot, Al-Baqa, Ain Albasha, Abu Nsair village, North of Jordan (Irbid, Jerash) and Hanou and Sulihi. The survey was done at two U-Turns; the first one is at Al-Blewi Neighborhood U-turn (2), and the second one is at Ain Al_Basha Neighborhood U-turn (3).

The data were gathered from traffic police in Excel format for the accident that occurred around the U-Turn area between the years of 2014 and 2019 for a better understanding of the situation and the reasons for the accident, these data have the georeferenced locations and can be reflected on the satellite image. Table (1) shows a sample of the data.

Table 1: Georeference Locations of the Crashes

Accident_ID	Accident_SerialNo	Accident_Date	Longitude	latitude	Longitude	latitude
1548162	A522056	2/14/2017 13:33	767541	3547990	32.036483	35.8331
1549172	A523172	2/16/2017 17:36	767611	3548029	32.036817	35.8338
1549178	A523180	2/16/2017 17:45	767611	3548029	32.036817	35.8338
1551332	A525570	2/22/2017 19:14	767516	3547991	32.036498	35.8328
1552500	A526839	2/26/2017 7:23	767617	3548087	32.037339	35.8339
1557307	A531000	3/8/2017 8:11	767476	3547984	32.036444	35.8324
1565320	A536563	3/22/2017 10:55	767582	3548038	32.036905	35.8335
1572788	A544806	4/10/2017 7:57	767530	3548016	32.03672	35.833
1573473	A545574	4/11/2017 20:39	767612	3548037	32.036889	35.8338

7. Data Analysis and Results

The collected data is analyzed and presented as follows:

7.1 O-D Survey Results U-Turn 2

The analysis of the O-D survey results has shown that:

1. The percentages of road users are coming from Amman - Swelih is 63%, and those are coming from Safoot is 33%, and a small percentage of those coming from Abu Nseir is 4%. The analysis shows as well that the percentage of users are making U-turn heading back to Amman and Swelih is 46%, to Ain Al-Basha 24%, and to Safoot 19 %.
2. Road users who are coming from the North (Irbid) constitutes 24%, and 57% coming from Ain Al-Basha, which is the highest percentage of users coming from the North direction.
3. Through this survey, it was found that 45% of road users are employees who live in the North Governorates and work in Amman, 46%, of road users go to Amman for shopping and the percentage of users of this road daily is 76%, and the rate of 13% twice a week. The type of transportation and the percentage of each of them was also determined, as it was divided into two types, the private car (83%), and the other (17%) as shown in Figure 8.

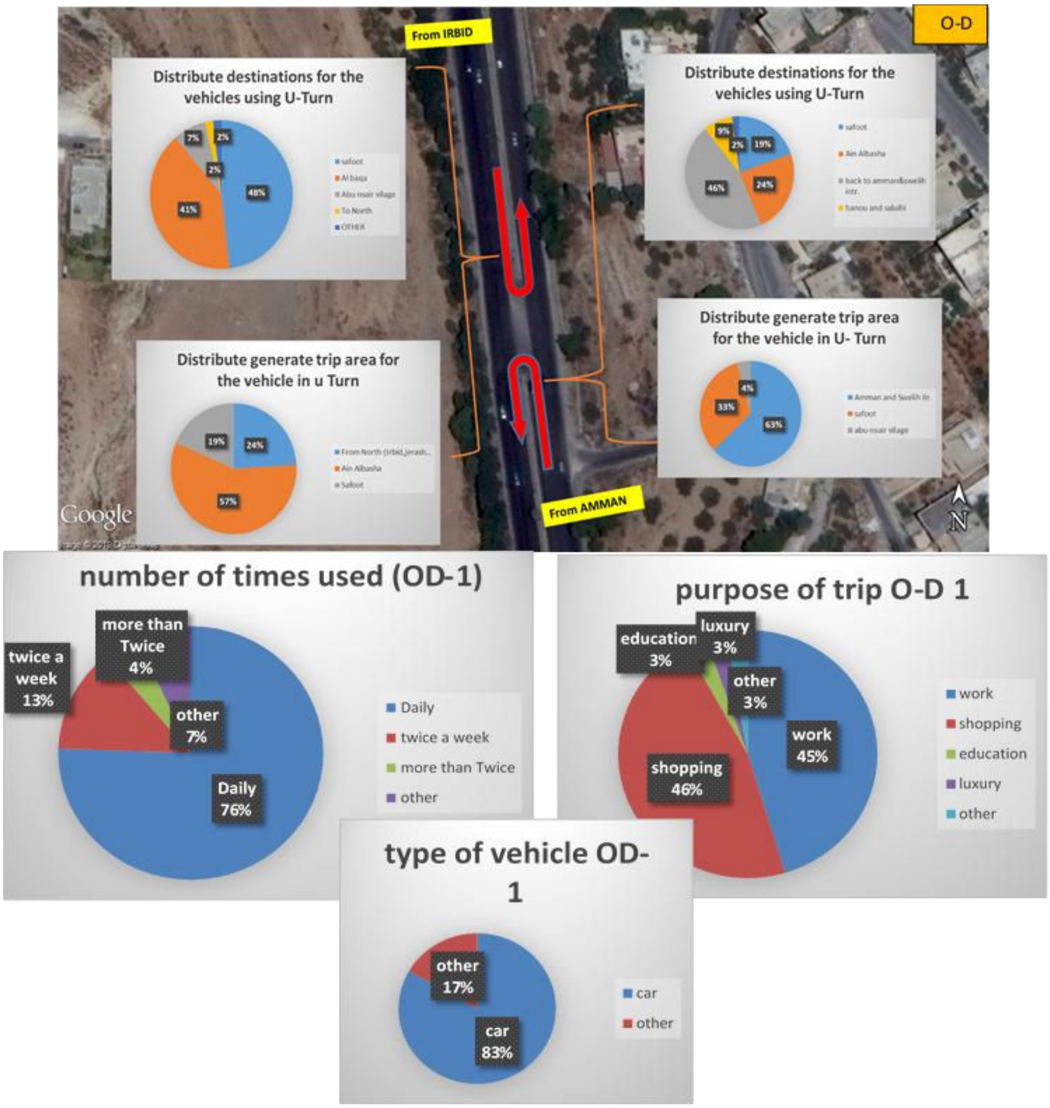


Figure 8. O-D Survey Results U-Turn 2

7.2 O-D Survey Results U-Turn 3

The analysis result of the O-D 2 surveys has shown that:

1. The percentage of vehicles that are coming from from Amman and Swelih intersections is 52%, from Safoot 27% and 21% Abu Nsair. 50% out of these are coming back to the Amman and Swelih intersection, 31% to Ain Al –basha and 14% to Safoot.
2. For vehicles using the road and coming from the North direction, 59% of trips are coming from Ain Albasha, 22% from North Governorates, and 14% from Safoot. These trips end up with 37% heading to Albaqa, 37% heading to Abu Nsair, and 15% heading to Safoot. (60%) of these trips use the road on daily basis, out of which (75%) are using road for work purposes.

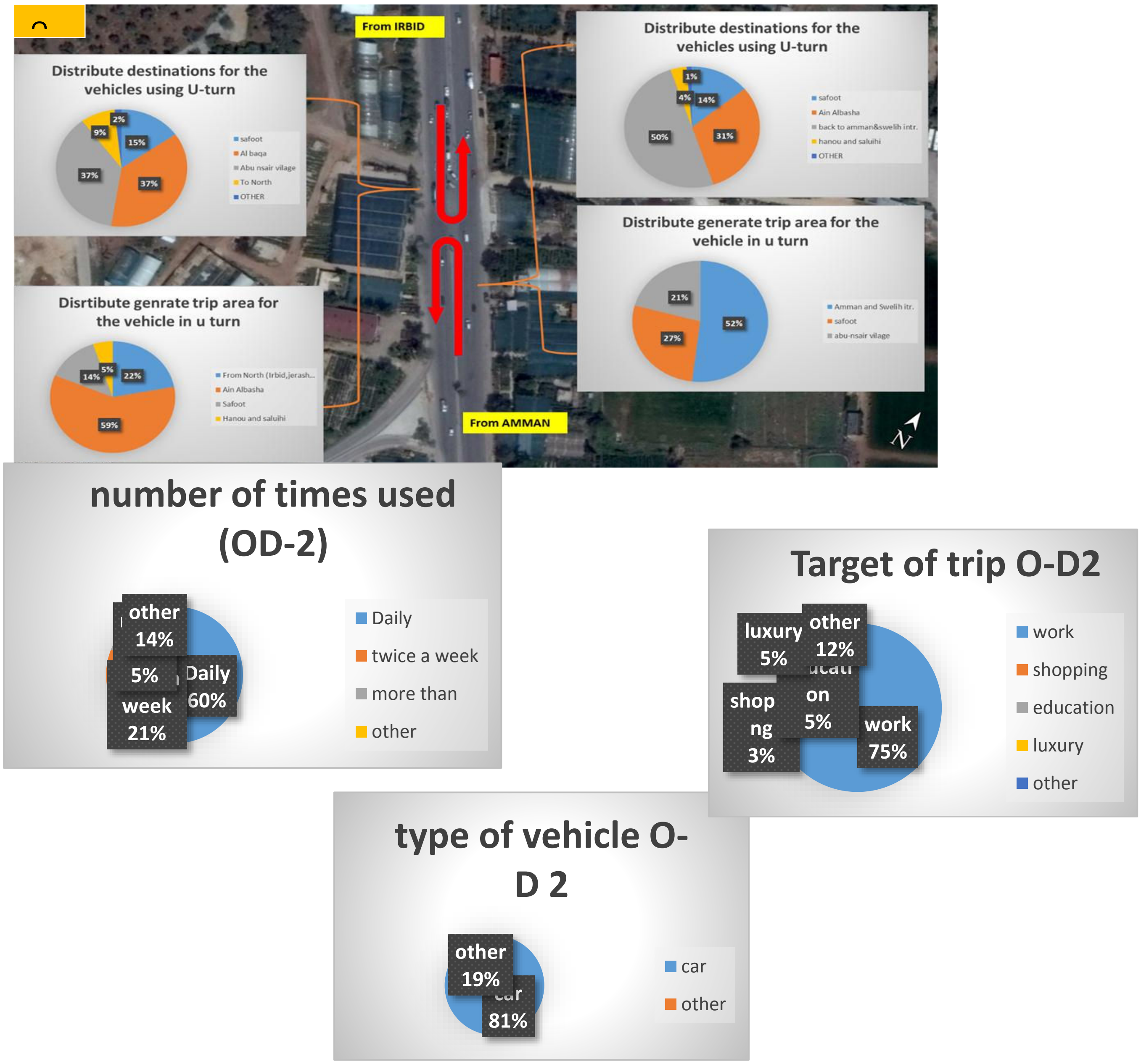


Figure 9. O-D Survey Results U-Turn 3

7.3 Accidents Survey

By using ArcGIS, the geolocation accident data were transferred to Google Earth for a better understanding of the accident's reasons and places.

The analysis of the accidents shows that 47% of the accidents during the years 2014-2016 were rear-end collisions between vehicles while it counted 45% of the years 2017-2018 and 48% of the accidents in 2019.

This site has a short length for the weaving segment about 60m from the point of entrance from the land use near the U-turn. Users who want to make a U-turn face difficulty and risk due to vehicles' high speed in this location.

From the location of the accidents, it looks obvious that the vehicle coming from the roundabout area needed to use the U-turn without sufficient merging area and the turning vehicles caused the main reason for accidents as figures (10,11) show the location of crashes during the years.

Figure 10. Crashes during the year of 2019

Figure 11. Crashes during the years of 2017 and 2018

8. Traffic Analysis

Road traffic accidents one of the main serious problems facing main roads and highways worldwide and specially in developing countries. Approximately 1.3 million people die each year because of road traffic crashes with a global cost of traffic injuries around U$ 518 billion each year (Global status report on road safety, 2018).

The analysis of the existing and proposed situations is necessary in order to understand the Measure of Effectiveness (MOE) for the intersection area and figure out how the merging vehicles conflict and queue in this area.

The above paragraph shows that simulation software that uses driver behaviour at the attributes for the drivers is needed to simulate and calculate the MOEs for the intersection area.

Vissim is a microsimulation software using the driver behaviour pattern and attributes to simulate the traffic and calculate the delay and level of service for the road networks and the intersections. Pakistani (2022)

Vissim was used for the existing and proposed scenarios to calculate the MOEs for the intersection and the network.

8.1 Existing Situation

The evaluation of the existing situation was done by using Vissim, a network was drawn with links and connectors, and the evaluation was done for the network and for the weaving link to figure out what the density and level of service LOS for this approach of intersection and the LOS also determined for the intersection and MOE's were determined for the network overall.

The analysis shows that the weaving critical approach faces delay and queue length with LOS reaching F at the PM peak hour and compared to the intersection delay this movement using a U-Turn facing bad LOS and high delay and queue length.

Table 2: MOE for the existing situation

Location	**AM Peak**			**Noon Peak**			**PM Peak**		
	Delay	LOS	Qlengthmax	Delay	LOS	Qlengthmax	Delay	LOS	Qlengthmax
Critical Approach	35	E	51	27	D	52	215	F	237
Intersection	3	A	51	7	A	52	18	C	237

An illustration of photos extracted from Vissim for a better understanding of the situation as figures (12,13) shows the density heat map and speed heat map for AM peak hour.

Figure 12. Speed heat map

Figure 13. Density heat map

8.2 Proposed Situation

Proposed designs were prepared in order to solve the weaving issue by minimizing the number of conflict points between vehicles to have safe turning movements and better LOS and decreasing the density at the intersection road network.

The main idea is to have a roundabout with two leg only and use the right of way of the road and the intersection to have safe turning movements for vehicles and use another roundabout in the area to solve the turning issue as Figure (14) shows the design.

Figure 14. Proposed Design

The result found that the critical approach faces an acceptable delay reaching C with a delay reaching 17 seconds while the level of service for the intersection reaches Table (3) shows the analysis results for the proposed design while figures (15,16) show the heat map for density and speed for the proposed design.

Table 3: MOE for the proposed design

Location	AM Peak			Noon Peak			PM Peak		
	Delay	LOS	Qlengthmax	Delay	LOS	Qlengthmax	Delay	LOS	Qlengthmax
Critical Approach	17	C	54	16	C	52	17	C	51
Intersection	9	B	123	10	B	120	10	B	127

Figure 15. Density heat map for the proposed design

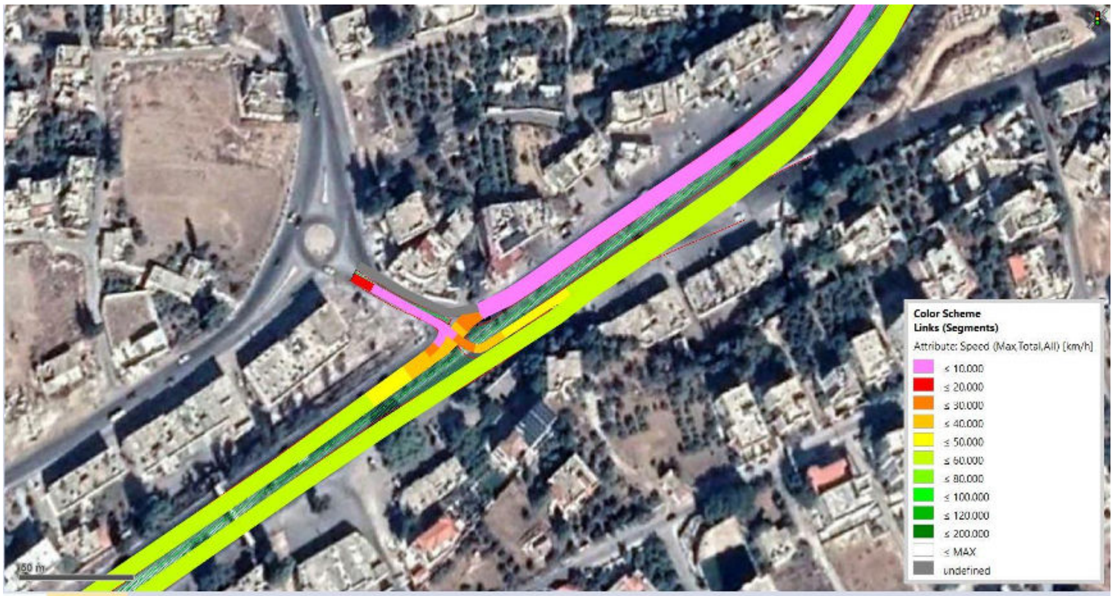


Figure 16. Speed heat map for the proposed design

8.3 Comparison

The criteria for analyzing the improvements is to compare the critical approach at the existing and proposed design and to compare the intersection delay and LOS for each scenario to find the percentage of the improvement at each scenario taking into consideration that the design needs a slight modification since it is a low-cost solution comparing with construct bridges or tunnels.

Table (4) shows the improvements that occurred at the PM peak.

Table 4: Proposed design improvements

Location/Scenario	Existing Scenario		Proposed Scenario		Improvement %
	Delay	LOS	Delay	LOS	
Critical Approach	215	F	17	C	92%
Intersection	18	C	10	B	44%

It showed that the improvement for the critical approach reached 92% at the PM peak hour while reaching 44% for the overall intersection.

9. Conclusion

Road traffic accidents one of the main serious problems facing main roads and highways worldwide and specially in developing countries. Approximately 1.3 million people die each year because of road traffic crashes with a global cost of traffic injuries around U$ 518 billion each year (Global status report on road safety, 2018).

More than half of all road traffic deaths are among vulnerable road users: pedestrians, cyclists, and motorcyclists. 93% of the world's accidents on the roads occur in developing countries, even though these countries have approximately 60% of the world's vehicles (Global Status Report on road safety, 2018).

Jordan like most of the developing countries ranks high rate of traffic accidents. The main causative factors for this high rate are high speed, aggressive driving, geometric design (hard topography), also economic development and population growth increases which produce high increase in traffic accidents (Naghawi and Idewu 2014; Naghawi, AlSoud, and AlHadidi 2018).

During the last ten years' traffic accidents increased and a need to identify effective measures to put a plan to improve road safety. Introducing efficient road safety solutions needs cooperation between authorities and public authorities. Irbid Amman arterial highway, which connects the North of Jordan to the Middle, and South suffers high traffic volume which leads to a high rate of accidents. The long distance between the Middle and North Governorates makes drivers speed to reduce the time of their trip which ends up with a high number of accidents.

Looking for intersection or U-turn with high record of accidents on the main highways, which have high speed and fixed infrastructure with limited changes on it. Irbid Amman highway have high volume of traffic and land use round this corridor is completely finished, also high speed.

This corridor has high-hazard intersections and U-turns along its length, To survey and record the accident rate, which researcher investigated this location needed redesign by giving more protection for the users by dividing different movements and available high rate of safety along these U-turns. Also provide a safe distance for margin for the near land use, as noted the survey show the travel dally for work or education is in high per cent.

This study provides a solution for a segment of this highway which considers the importance of traffic safety. There are six U-turns along the highway, three of them located between Sweileh intersection to the North of Safoot and Al-Baqa. These U- U-turns serve a high dense of population on both sides of this highway. The high speed of vehicles using this highway doesn't allow for safe U-turns.

The conflict points between the vehicles for the weaving section at the roundabout at Safout neighborhoods facing the main traffic accidents in the area, solving these issues the local government proposed a tunnel that can't be implemented due to the shortage of finance and high cost.

A new unconventional proposed intersection was tested to help the local government solve the issue of the accident and this design was simulated using a vissim software this design proved to be less costly and without land acquisitions by implementing a roundabout at two approaches.

The results of the simulation show clearly that the improvement of the intersection delay reached 44% and to 44% for the critical approach.

In conclusion, this study proposes a methodology integrating traffic data analysis, incorporating both Automatic Traffic Counter and Origin-Destination data, to inform the design of unconventional roadway configurations tailored to specific user travel patterns. Following data acquisition, microsimulation techniques were employed. The resultant framework can serve as a procedural roadmap for researchers and practitioners seeking to evaluate and implement novel, unconventional traffic solutions.

References

Alkiswani, M. A. M. (2022). Improving the utilization of public transportation using intelligent transportation systems (Doctoral dissertation, Master Thesis).

Andronov, R., Leverents, E., Genze, D., & Легостаева, E. B. (2019). The effect of the traffic organization method at a controlled intersection on the uniformity of traffic capacity. E3S Web of Conferences, 135. https://doi.org/10.1051/e3sconf/201913502010

Bared, J., Edara, P., & Jagannathan, R. (2005). Design and operational performance of double crossover intersection and diverging diamond interchange. Transportation Research Record Journal of the Transportation Research Board, 1912(1). https://doi.org/10.1177/0361198105191200104

Esawey, M. E., & Sayed, T. (2012). Analysis of unconventional arterial intersection designs (UAIDs): State-of-the-art methodologies and future research directions. Transportmetrica A Transport Science, 9(10). https://doi.org/10.1080/18128602.2012.672344

Fitzpatrick, K., Wooldridge, M. D., & Blaschke, J. D. (2005). Urban Intersection Design Guide: Volume 1 - Guidelines. https://rosap.ntl.bts.gov/view/dot/39610

Haley, R., Ott, S. E., & Hummer, J. E. (2011). Operational effects of signalized super streets in North Carolina. Journal of Transportation Research Board.

HCM (2000). Highway capacity manual (4th ed.). Washington, DC: Transportation Research Board, National Research Council.

Hughes, C., Ensor, R., Wilson, A., & Graham, A. (2010). Tracking executive function across the transition to school: A latent variable approach. Developmental Neuropsychology, 35(1), 20-36.https://doi.org/10.1080/87565640903325691

Hummer, J. E., Haley, R. L., Ott, S. E., Foyle, R. S., & Cunningham, C. M. (2010). Superstreet benefits and capacities (Project 2009-06). North Carolina Department of Transportation, Raleigh, North Carolina.

Ivanova, D., Yeralina, E. M., & Shatila, K. (2023). Strategies for sustainable transportation in roadway systems in urban areas. E3S Web of Conferences, 389. https://doi.org/10.1051/e3sconf/202338905001

Jadaan, K., Al-Hyari, I., Naghawi, H., Ammourah, R., & Al Nabulsi, Z. (2013). Traffic safety in Jordan: Magnitude, cost, and potential countermeasures.

Jing, P., Huang, H., & Chen, L. (2017). An adaptive traffic signal control in a connected vehicle environment: A systematic review. Information, 8(3). https://doi.org/10.3390/info8030101

Kim, T., Edara, P. K., & Bared, J. (2007). Operational and safety performance of a non-traditional intersection design: The super street. Paper presented at the 86th Annual Meeting of the Transportation Research Board, Washington, DC.

Li, Y. H., Zheng, C. Q., Shao, C., & Deng, H. (2014). UC-Win/Road simulation systems application to domestic simulation of road traffic. Applied Mechanics and Materials. https://doi.org/10.4028/www.scientific.net/amm.505-506.1219

Ministry of Public Works and Housing (2020).

Moon, J. P., Kim, Y. R., Kim, D. G., & Lee, S. K. (2011). The potential to implement a super street as an unconventional arterial intersection design in Korea. KSCE Journal of Civil Engineering, 15(6), 1109-1114. https://doi.org/10.1007/s12205-011-1157-1

Miqdady, T., & de Oña, J. (2014). Identifying the factors that increase the probability of an injury or fatal traffic crash in an urban context in Jordan.

Municipality of Greater Amman. Traffic Operation Department Reports.

Naghawi, H. H., & Idewu, W. I. (2014). Analysis of delay and queue length using microscopic simulation for the unconventional intersection design super street. Journal of Transportation Engineering, 56(1), 100-107.

Naghawi, H. H., Al-Hadidi, T., & Al-Soud, A. A. (2017). The possibility of implementing the super street unconventional intersection design in Jordan. Periodica Polytechnica Transportation Engineering. https://doi.org/10.3311/PPtr.11635

Public Security Directorate (2019). Annual report of traffic accidents in Jordan.

Public Security Directorate (2020). Annual report of traffic accidents in Jordan.

Wang, Z., Han, K., & Tiwari, P. K. (2021). Digital twin-assisted cooperative driving at non-signalized intersections. IEEE Transactions on Intelligent Vehicles, 7(2). https://doi.org/10.1109/tiv.2021.3100465

Yang, X., & Cheng, Y. (2017). Development of signal optimization models for asymmetric two-leg continuous flow intersections. Transportation Research Part C: Emerging Technologies, 74, 306-326.

Zhang, Y., Papadopoulos, A. A., Chen, P., Alasiri, F., Yuan, T., Zhou, J., & Ioannou, P. (2022). Integrated traffic simulation-prediction system using neural networks with application to the Los Angeles International Airport road network. 2022 IEEE 61st Conference on Decision and Control (CDC). https://doi.org/10.1109/cdc51059.2022.9992461