



Alternative Approaches to Analyze Road Safety in Cairo, Egypt: Two Case Studies

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Case Study (1): Evaluating Pedestrian Safety Using Macro- and Micro-level Safety Analysis in Eastern Cairo



The Challenges

- ☐ Expanding Cairo road network in the absence of a comprehensive road safety program
- ☐ The safety of crossing pedestrians after road network expansion is crucial
- ☐ Lack of operation and maintenance of traffic control devices
- ☐ Low enforcement levels and high-speeding rates
- ☐ Inadequate infrastructure facilities (i.e. pedestrian crossing, sidewalks, etc.)
- ☐ Difficulty in collecting field data to analyze safety
- ☐ The absence of reliable traffic collisions data in Egypt



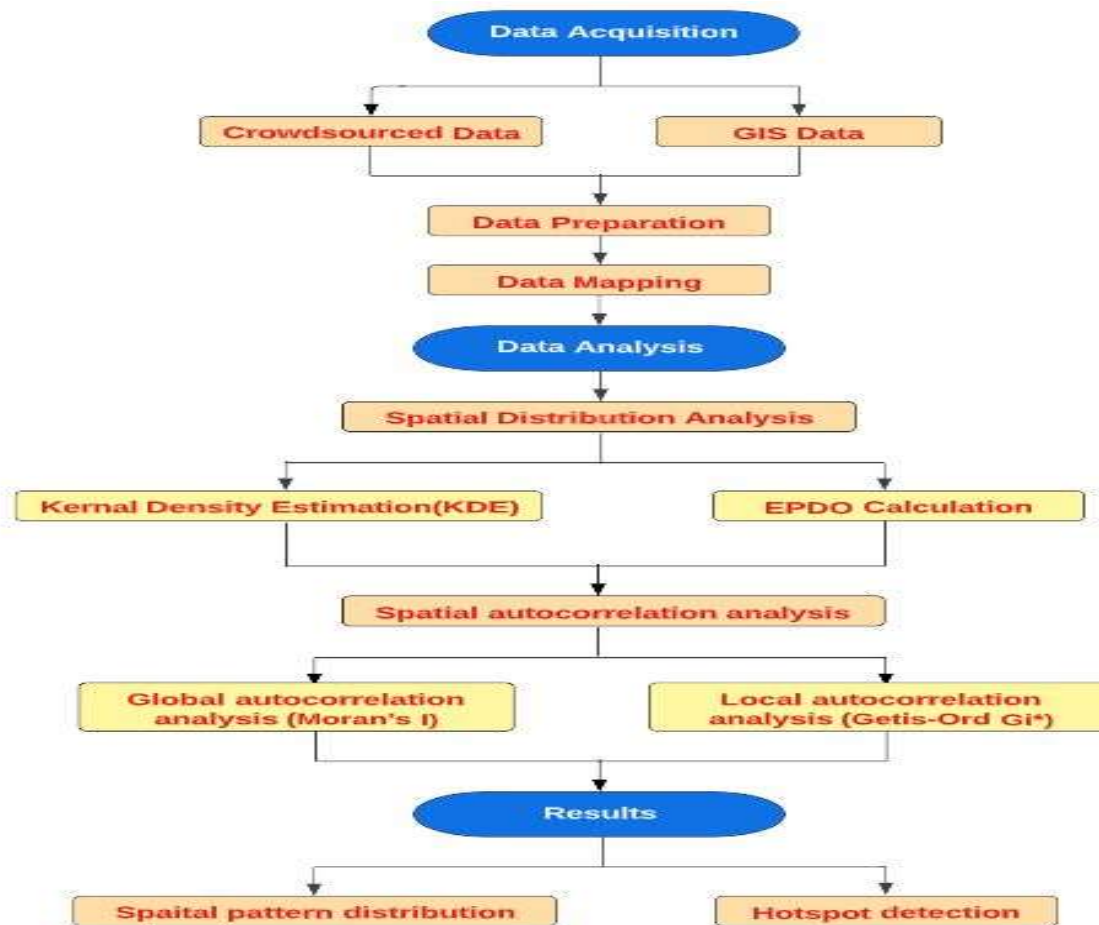


Motivation & Methodology

- ❑ Innovative data collection tools, **e.g. StreetGuards/StreetKey**
- ❑ Non-traditional techniques to analyze road safety, **e.g. traffic micro-simulation and computer vision**
- ❑ A framework to fuse macro and micro-level safety techniques to analyze pedestrian safety:
 - **Macro-level:** using crowdsourced data and GIS tools to identify pedestrian facilities with potential safety issues
 - **Micro-level:** utilizing computer vision techniques to study pedestrian-vehicle conflicts at the problematic locations

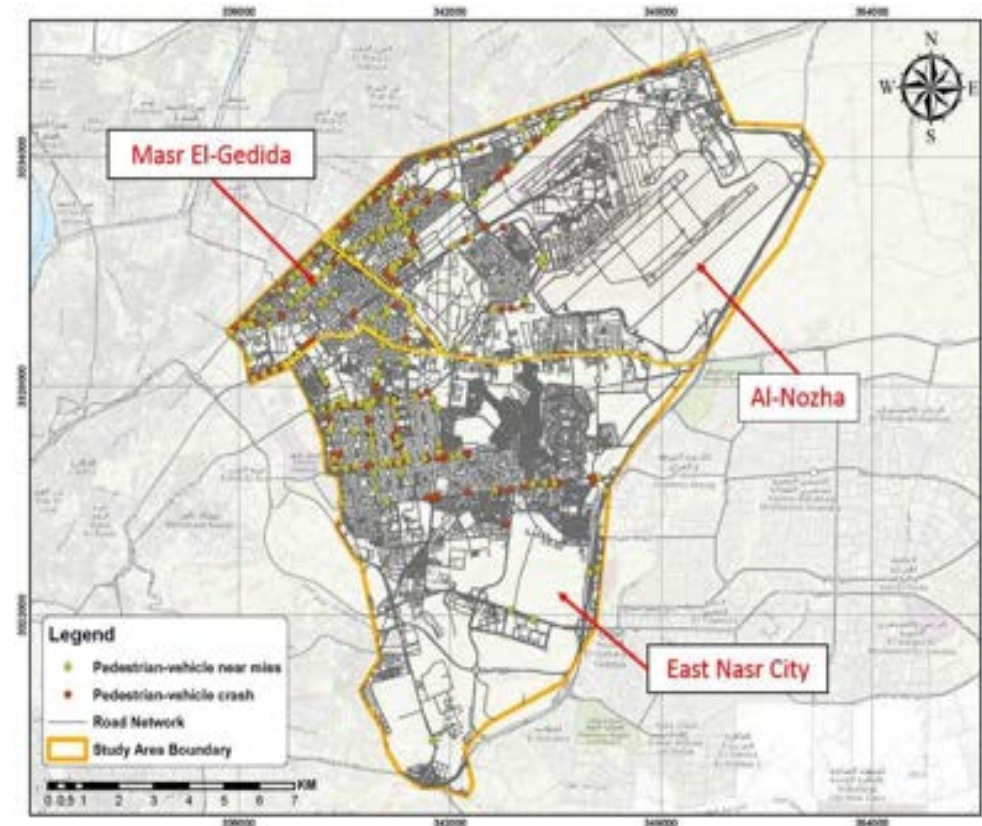
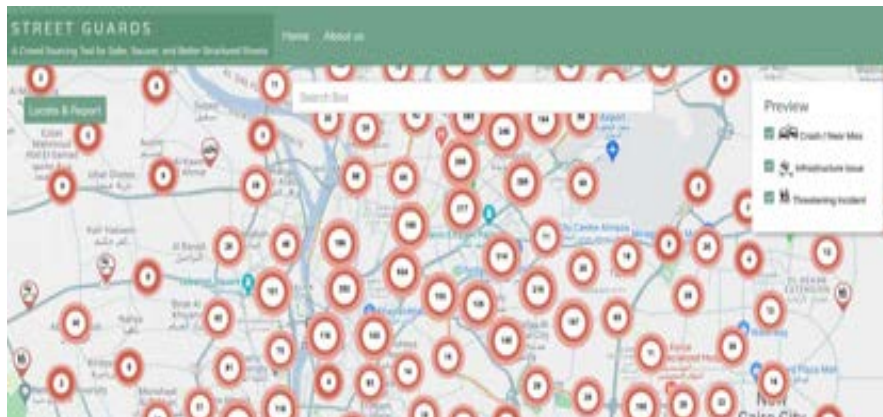


Methodology: *Macro-level Analysis*



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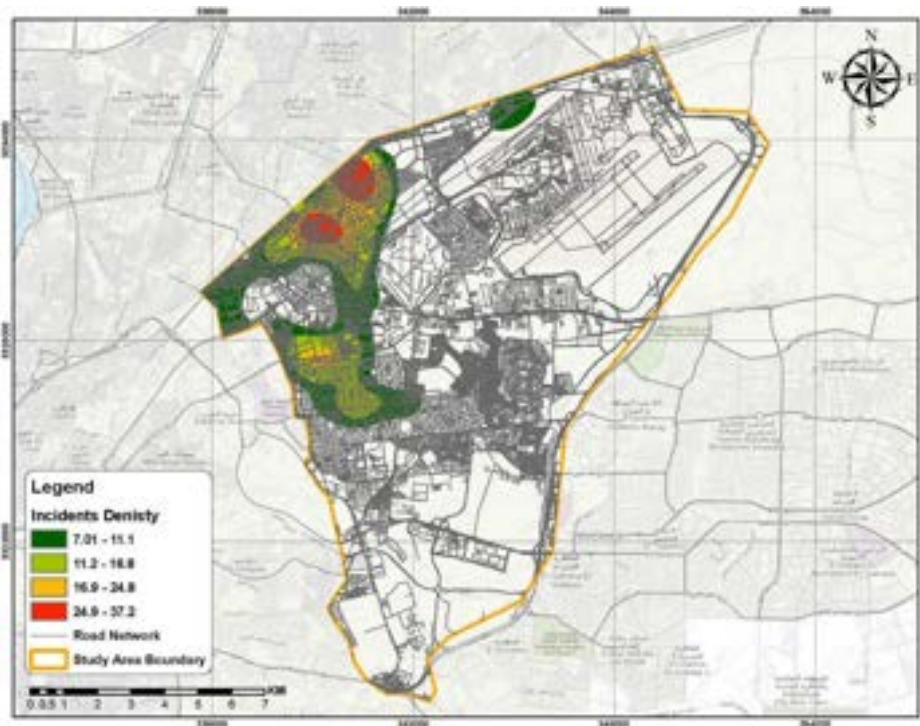
- ❑ StreetKey was utilized to collect reported collisions and near misses in three urban neighborhoods in Eastern Cairo
- ❑ 226 pedestrian-vehicle collisions and 295 conflicts were recorded on the road network of the study area
- ❑ The collected data was filtered, mapped, and analyzed in ArcGIS



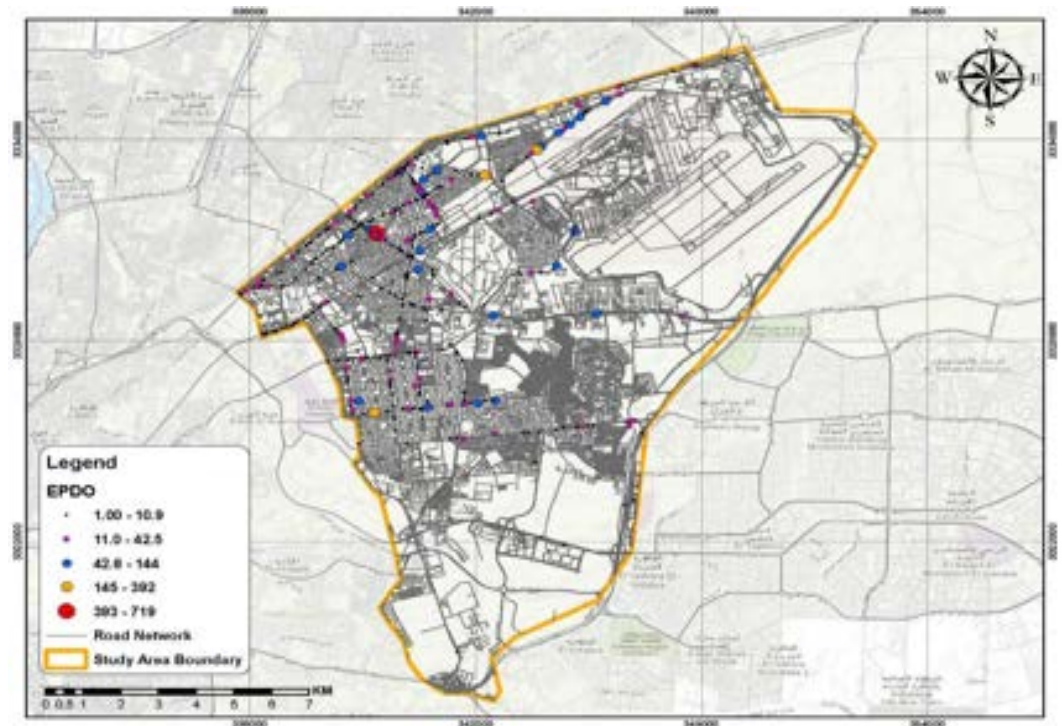
Methodology: *Macro-level Analysis*

Spatial Distribution Analysis

Planar Kernel Density Estimation (KDE)



Distribution of EPDO incidents

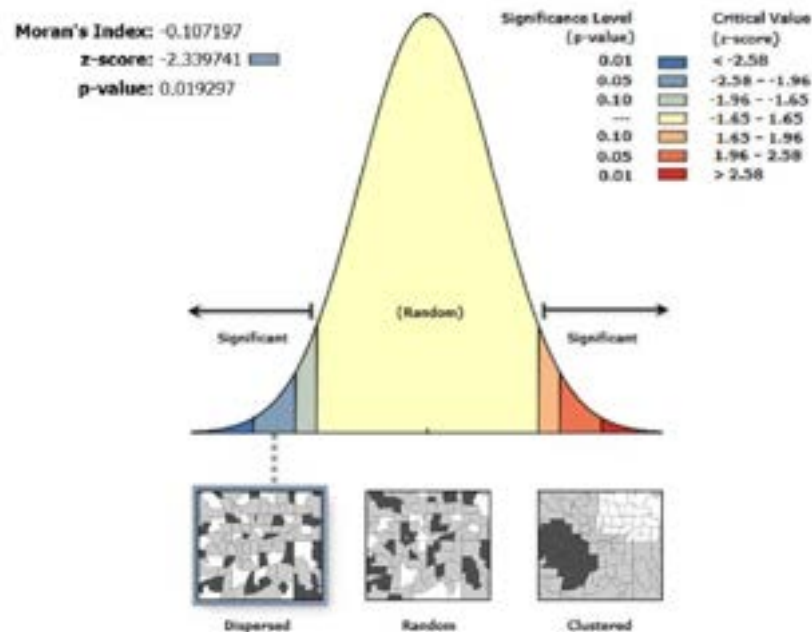


Density of Pedestrian-vehicle Incidents in the Study Area

Methodology: *Macro-level Analysis*

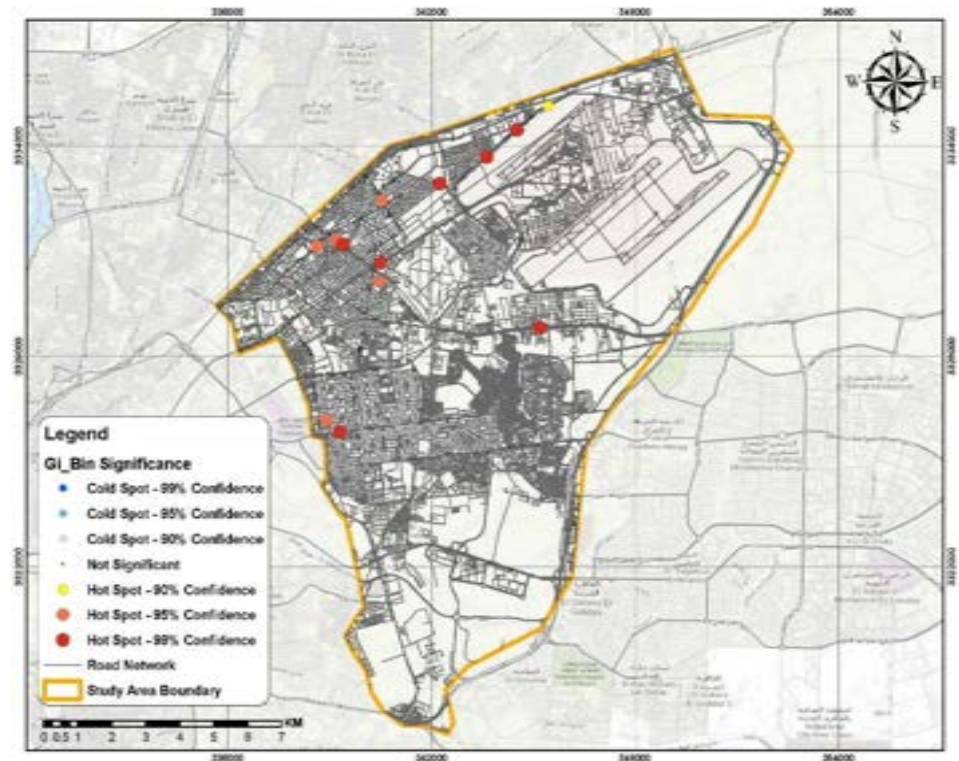
Spatial Distribution Analysis

Global autocorrelation analysis (Moran's I statistic)



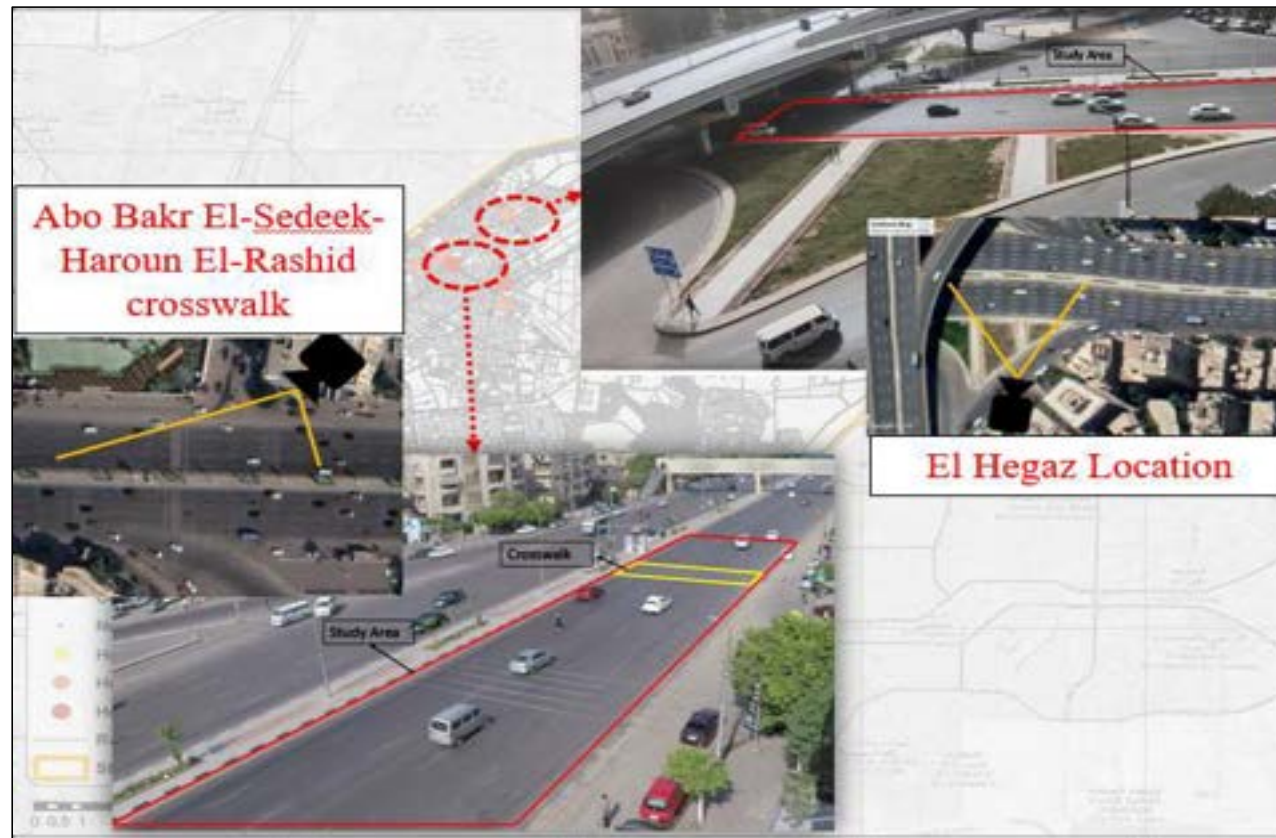
Given the z-score of -2.33974103499, there is a less than 5% likelihood that this dispersed pattern could be the result of random chance.

Local autocorrelation analysis (Getis-Ord Gi* statistic)



Methodology: *Macro-level Analysis*

Results: Two Identified Hotspot Locations

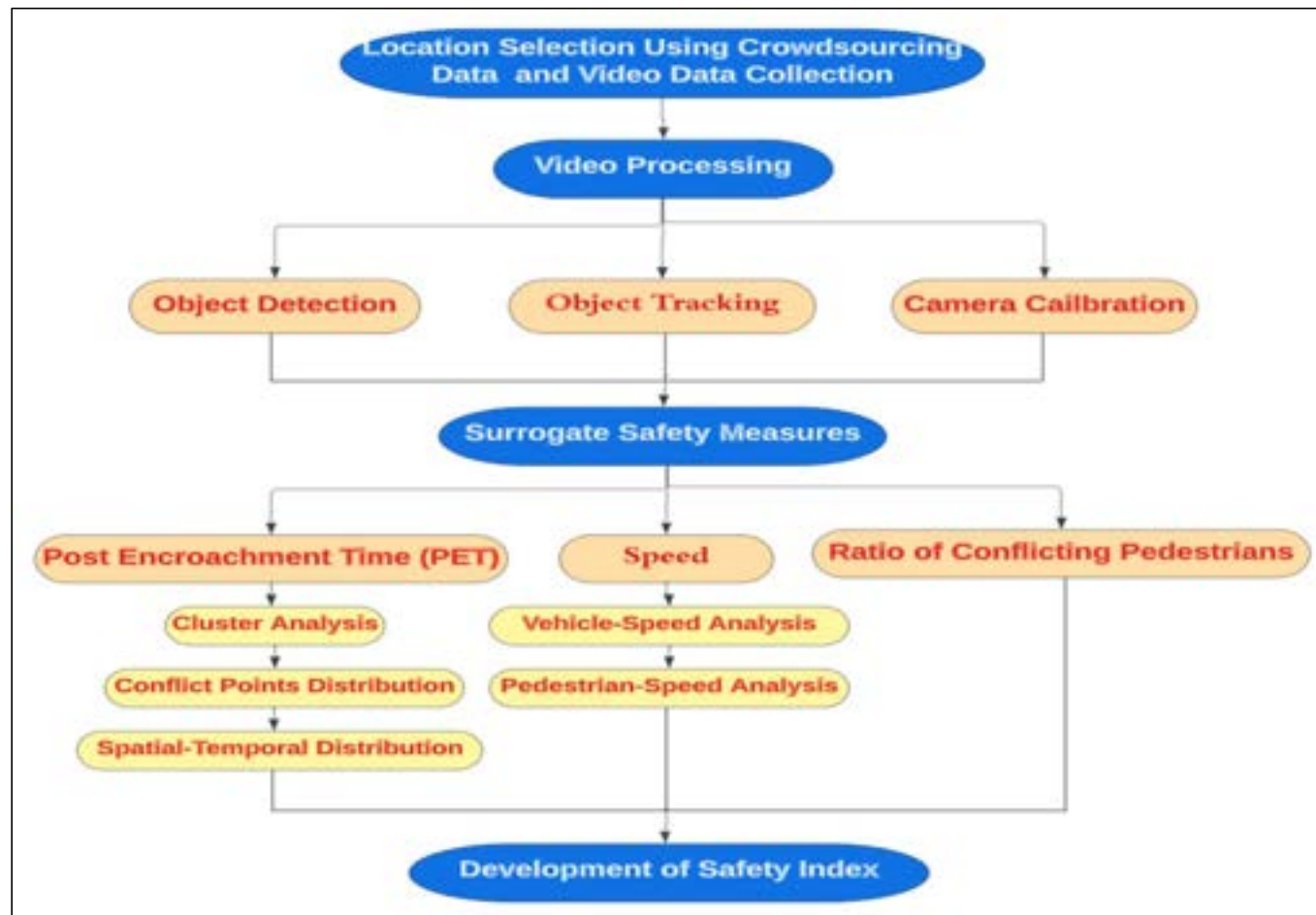


Location	Speed Limit (km/h)	No of lanes per dir	Lane width (m)	Type of Control
Abo Bakr El Sedeek	60.00	7	3.40	Painted crosswalk
El Hegaz	60.00	7	3.00	Unprotected crosswalk

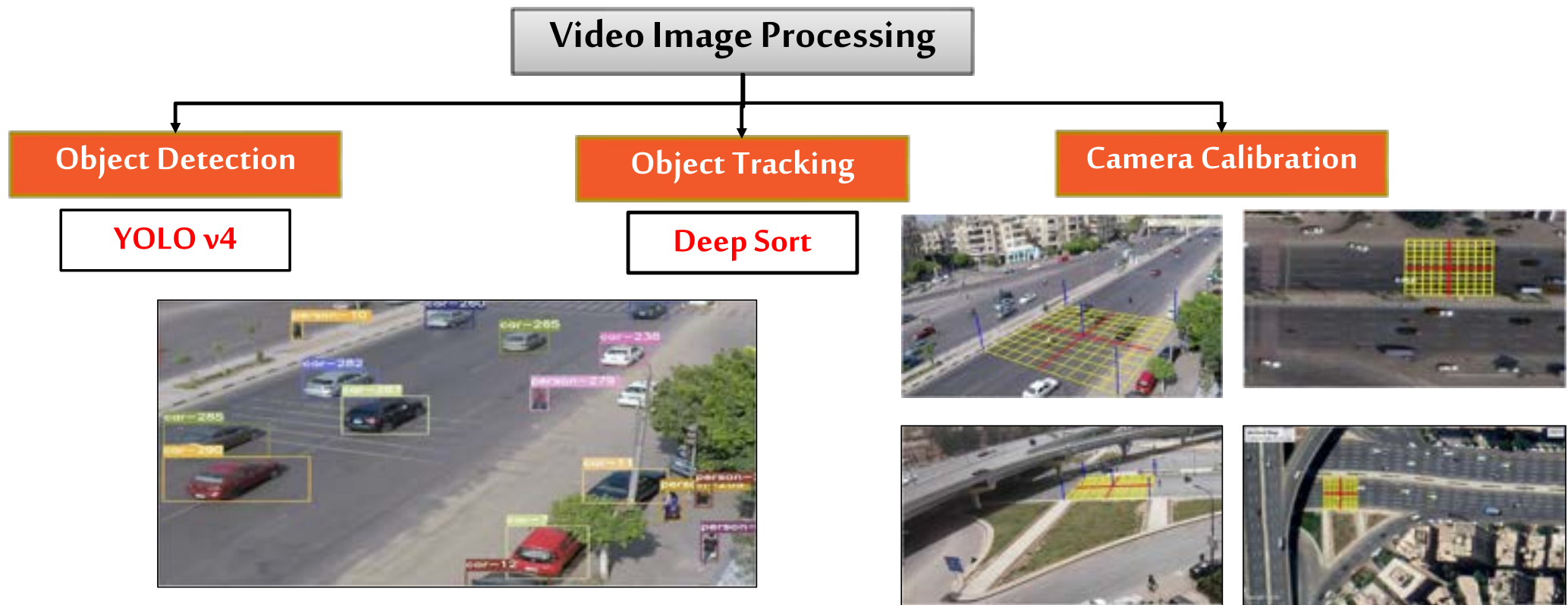
Location	Hour	Day 1		Day 2	
		Veh Volume (veh/hr)	Ped Volume (Ped/hr)	Veh Volume (veh/hr)	Ped Volume (Ped/hr)
Abo Bakr El Sedeek	1 (Morning Peak hour)	3312	216	3104	249
	2(1 st Evening Peak hour)	5310	208	5531	260
	3 (2 nd Evening Peak hour)	5893	230	5883	240
El Hegaz	1 (Morning Peak hour)	2288	115	2353	99
	2(1 st Evening Peak hour)	2487	218	2558	221
	3 (2 nd Evening Peak hour)	1965	151	2002	184



Methodology: *Micro-level Analysis*



Methodology: *Micro-level Analysis*



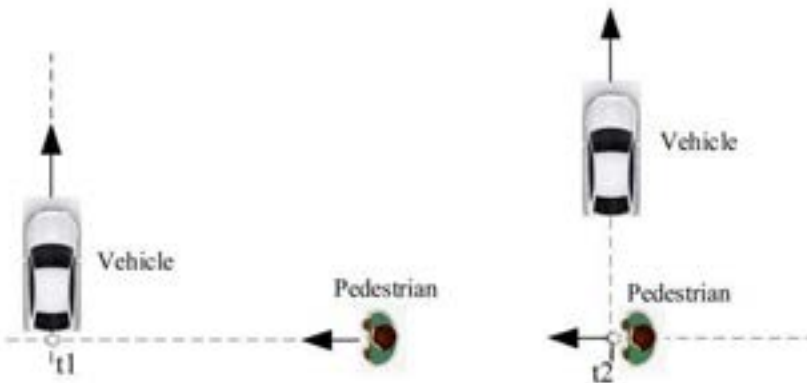


Methodology: *Micro-level Analysis*

Surrogate Safety Measures (SSM)

Post Encroachment Time (PET)

$$PET = \text{Vehicle Intersection Time} - \text{Pedestrian Intersection Time}$$



Speed

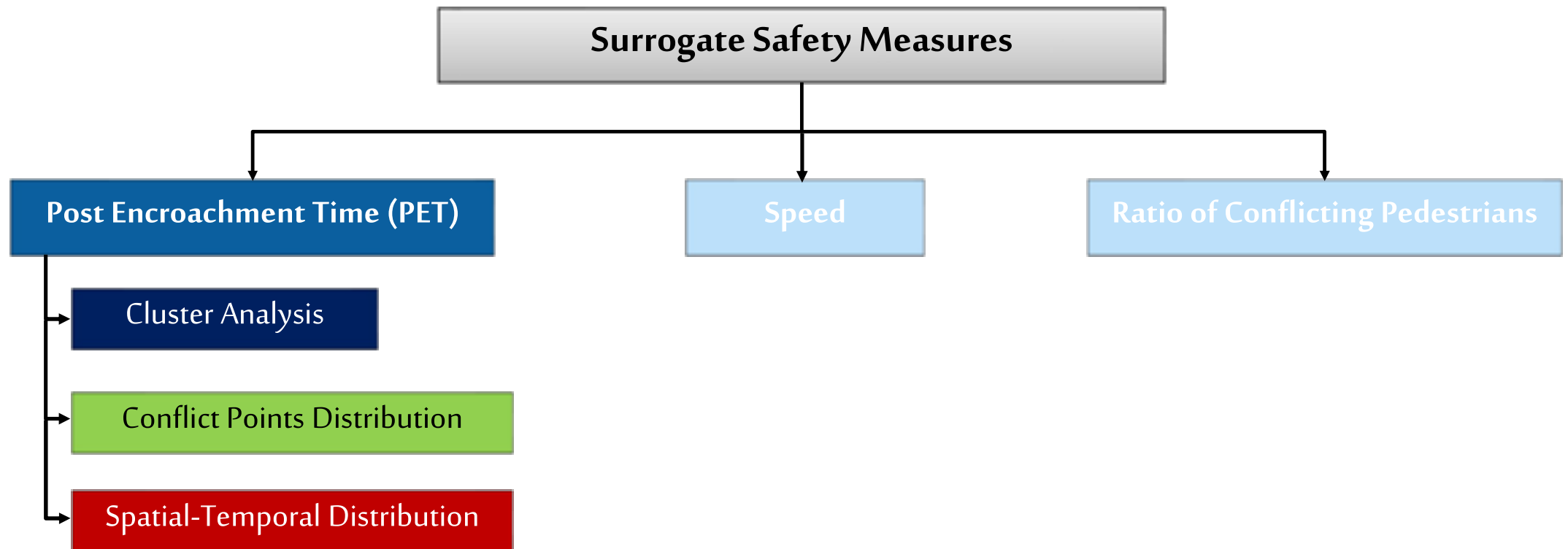
$$\text{Speed} = \frac{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}}{\frac{f_2 - f_1}{fps}}$$

Ratio of Conflicting Pedestrians

$$\text{Ratio of Conflicting Pedestrians} = \frac{\text{Pedestrians Conflicting Volumes}}{\text{Total Pedestrians Volumes}}$$



Methodology: *Micro-level Analysis*





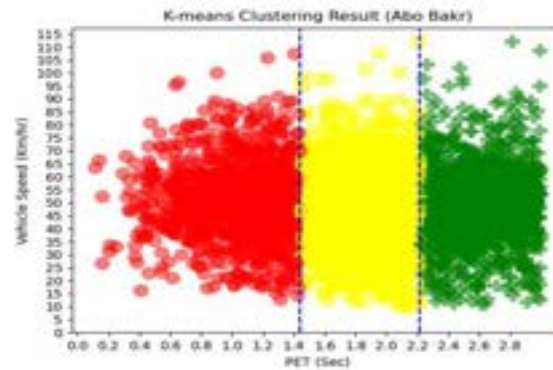
Methodology: *Micro-level Analysis*

Surrogate Safety Measures

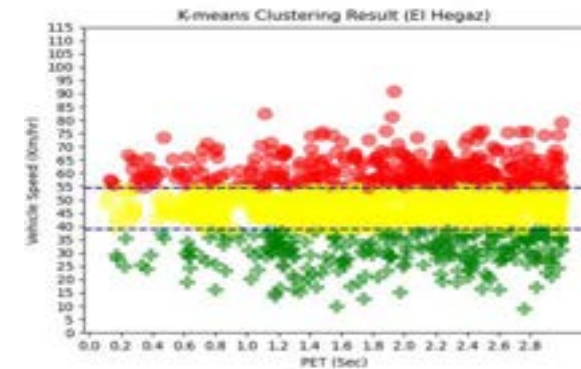
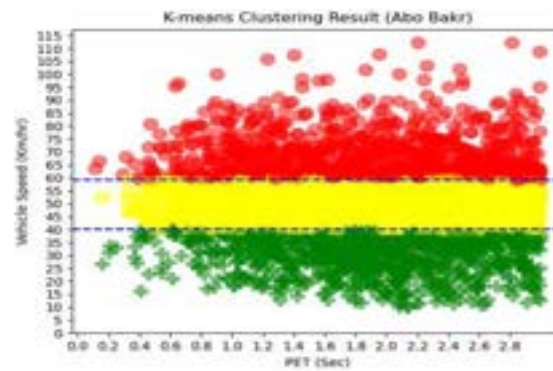
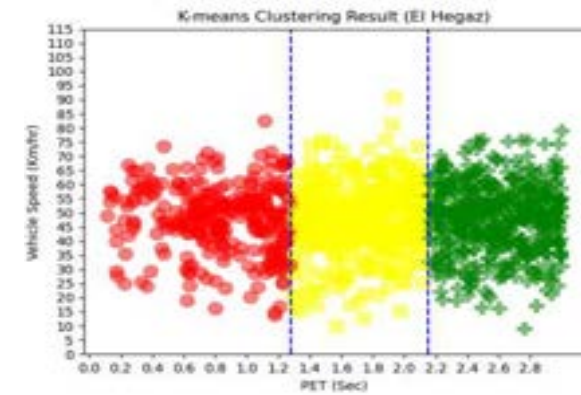
Post Encroachment Time (PET)

Cluster Analysis
K-Means Cluster

Abo Bakr Location



El Hegaz Location



PET and Approaching Speed Thresholds for Abo Bakr Location PET and Approaching Speed Thresholds for El Hegaz Location



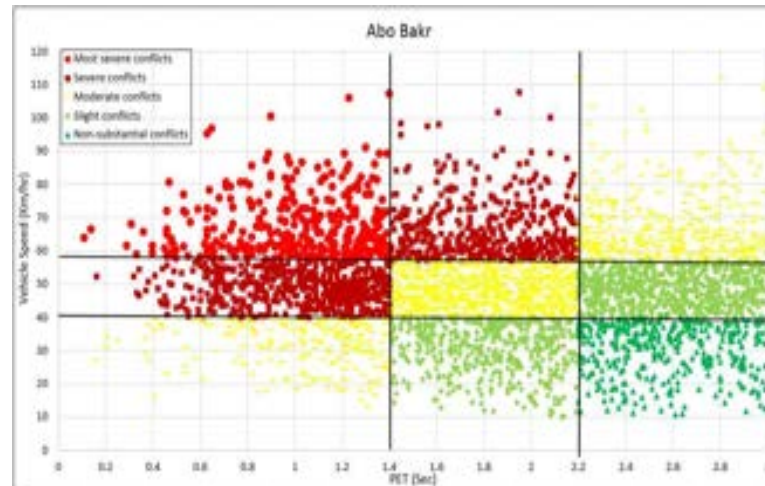
Methodology: *Micro-level Analysis*

Surrogate Safety Measures

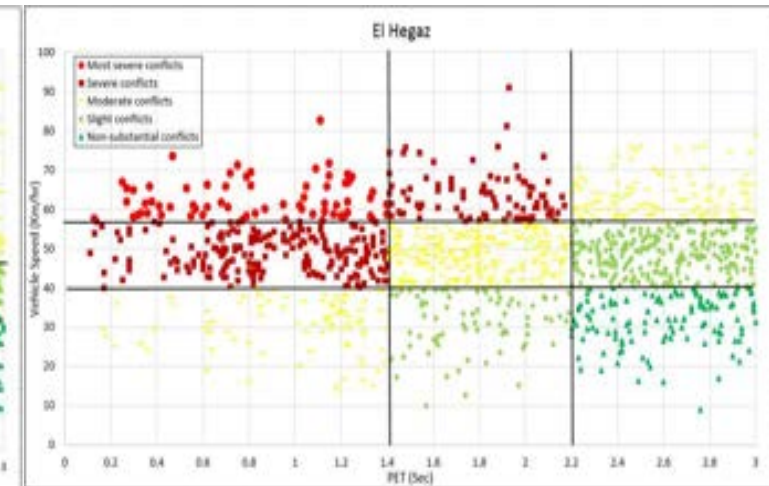
Post Encroachment Time (PET)

Cluster Analysis
K-Means Cluster

Abo Bakr Location



El Hegaz Location



	Abo Bakr		El Hegaz	
	No of Conflicts	Percentage	No of Conflicts	Percentage
<i>Most severe conflicts</i>	327	7.63%	68	5.39%
<i>Severe conflicts</i>	945	22.04%	298	23.61%
<i>Moderate conflicts</i>	1450	33.82%	438	34.71%
<i>Slight conflicts</i>	1185	27.64%	333	26.39%
<i>Non-substantial conflicts</i>	381	8.89%	125	9.90%
Total	4288	100%	1262	100%



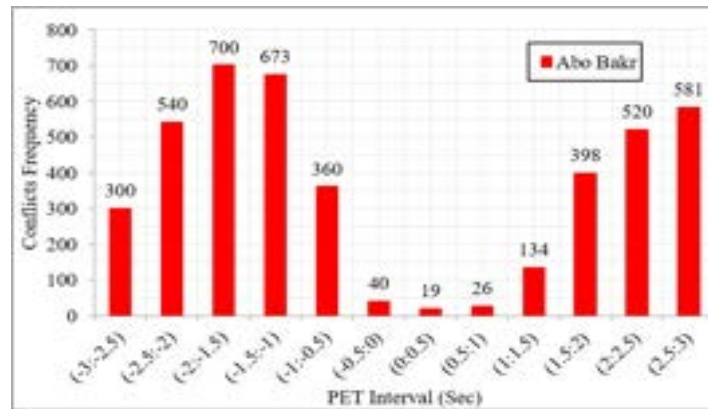
Methodology: *Micro-level Analysis*

Surrogate Safety Measures

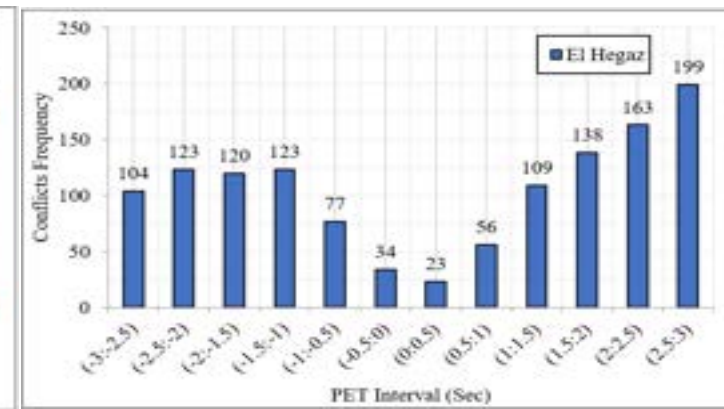
Post Encroachment Time (PET)

Conflict Points Distribution

Abo Bakr Location



El Hegaz Location



Impact of PET on the number of conflicts identified



Impact of PET on the number of conflicts identified





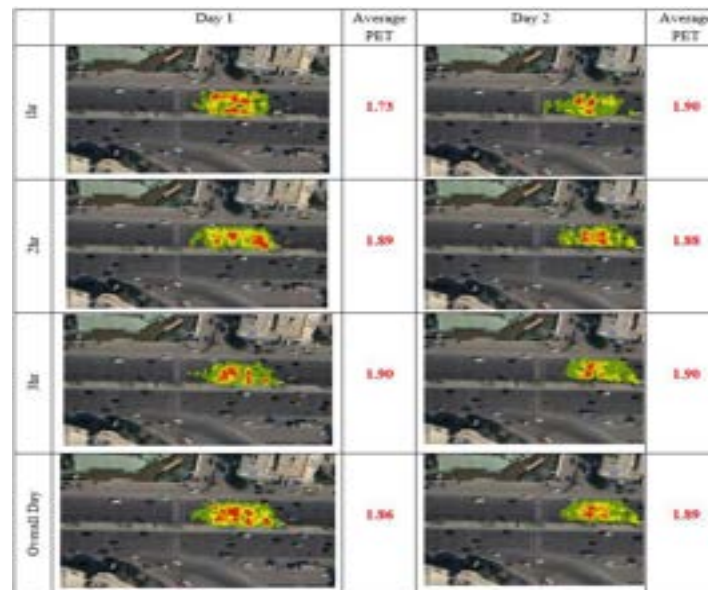
Methodology: *Micro-level Analysis*

Surrogate Safety Measures

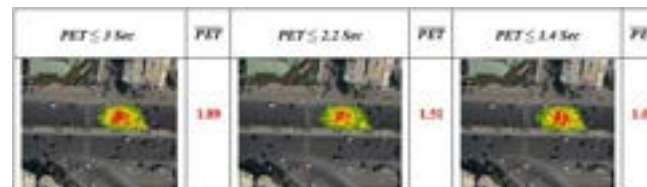
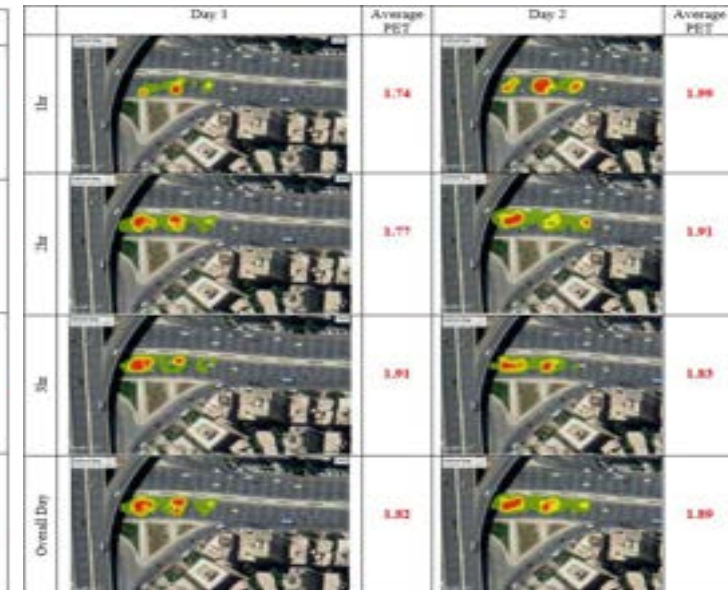
Post Encroachment Time (PET)

Spatial-temporal Distribution

Abo Bakr Location

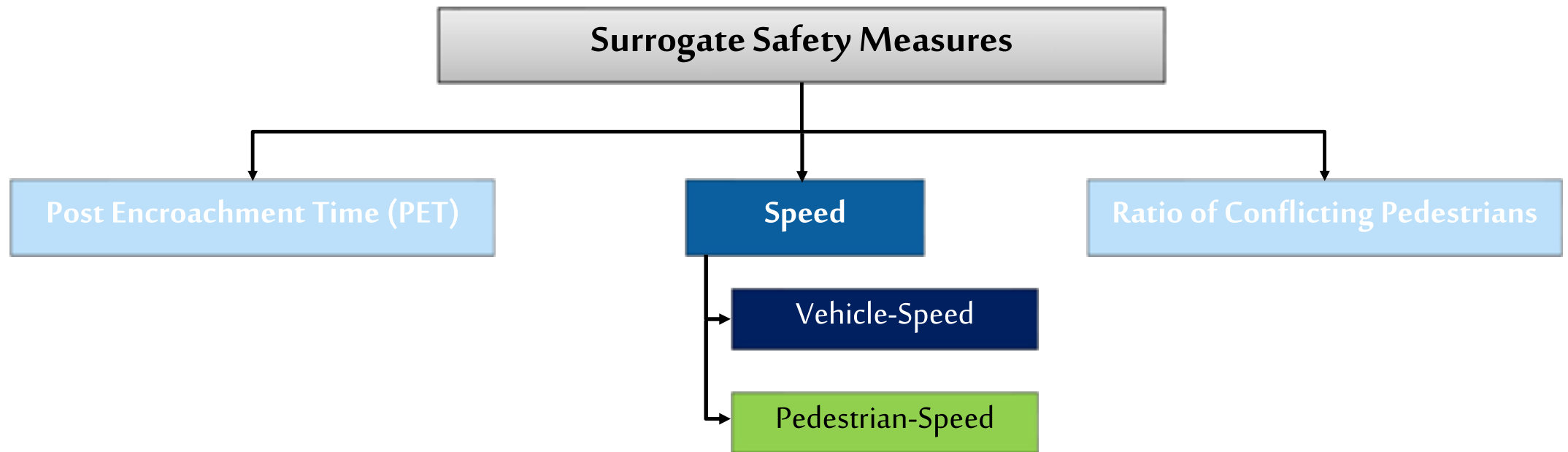


El Hegaz Location





Methodology: *Micro-level Analysis*





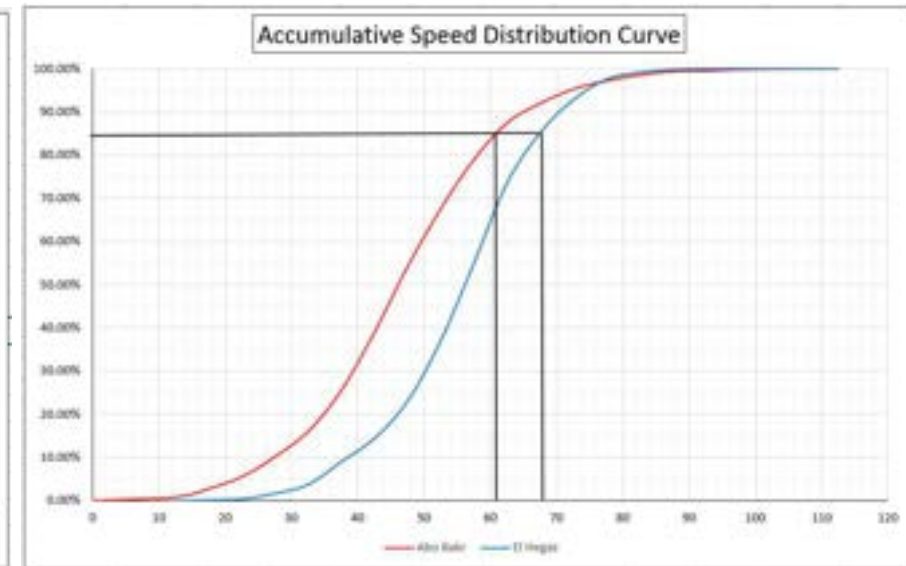
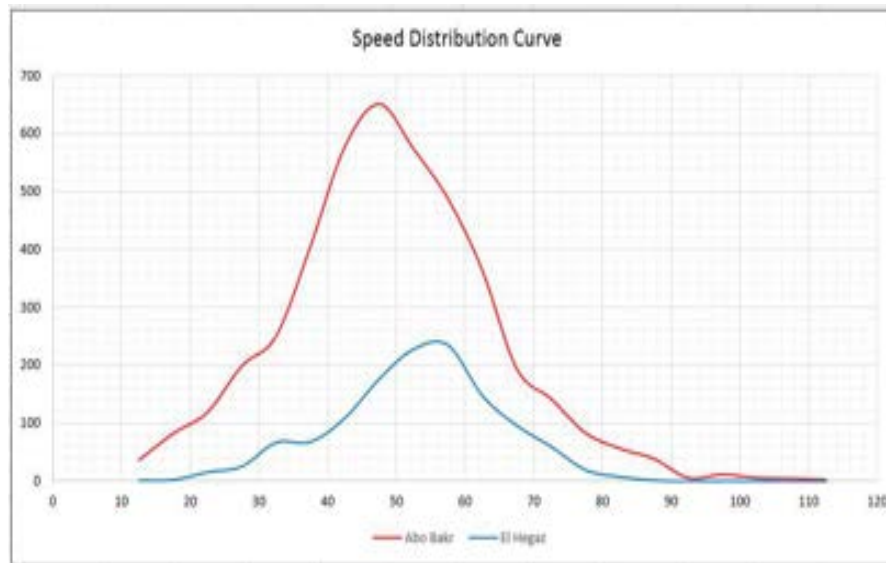
Methodology: *Micro-level Analysis*

Surrogate Safety Measures

Speed

Vehicle Speed

	<i>Abo Bakr</i>	<i>El Hegaz</i>
<i>V85%</i>	61	67
<i>Mode Speed</i>	47.5	57.5





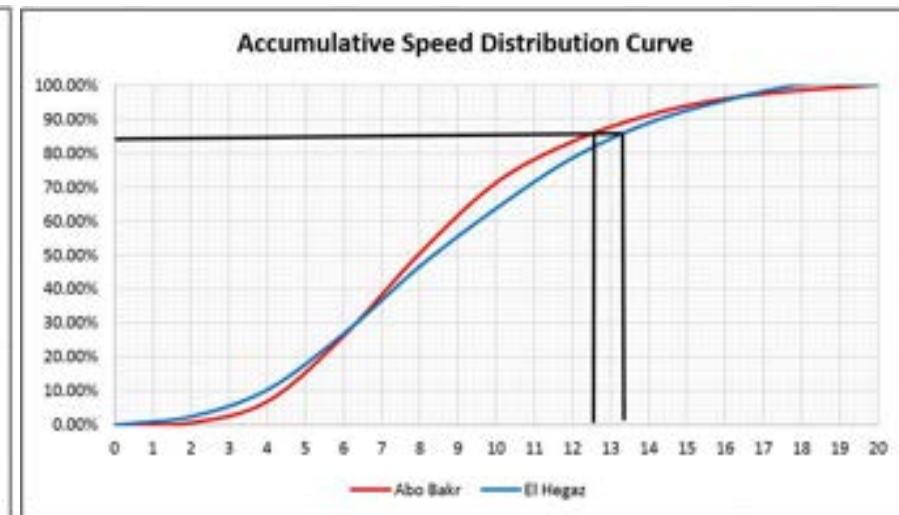
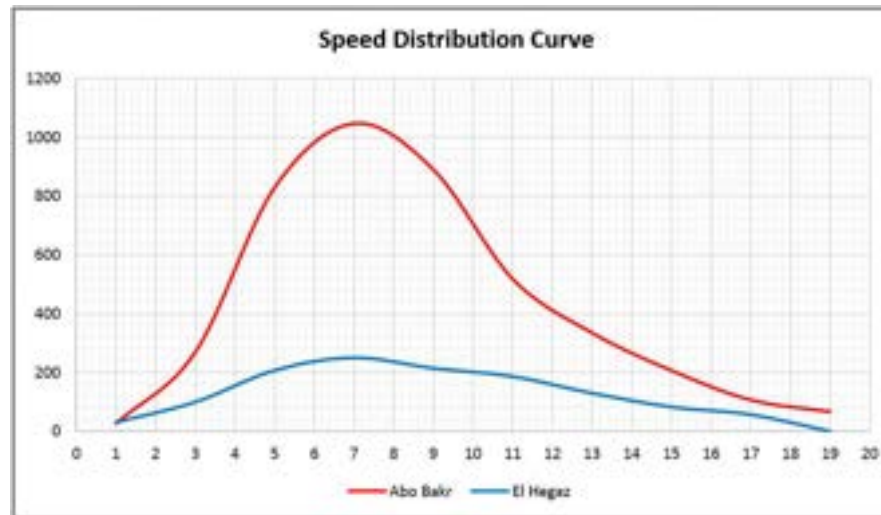
Methodology: *Micro-level Analysis*

Surrogate Safety Measures

Speed

Pedestrian Speed

	Abo Bakr	El Hegaz
V85%	12.4	13.4
Mode Speed	7	7





Methodology: *Micro-level Analysis*

Surrogate Safety Measures

Ratio of Conflicting Pedestrians

	<i>Day 1</i>			<i>Day 2</i>		
<i>Location</i>	<i>Total Pedestrian Volume (Ped/hr)</i>	<i>Conflicting Pedestrian Volume (Ped/hr)</i>	<i>Ratio</i>	<i>Total Pedestrian Volume (Ped/hr)</i>	<i>Conflicting Pedestrian Volume (Ped/hr)</i>	<i>Ratio</i>
<i>Abo Bakr</i>	654	594	0.91	749	712	0.95
<i>El Hegaz</i>	484	293	0.61	504	277	0.55



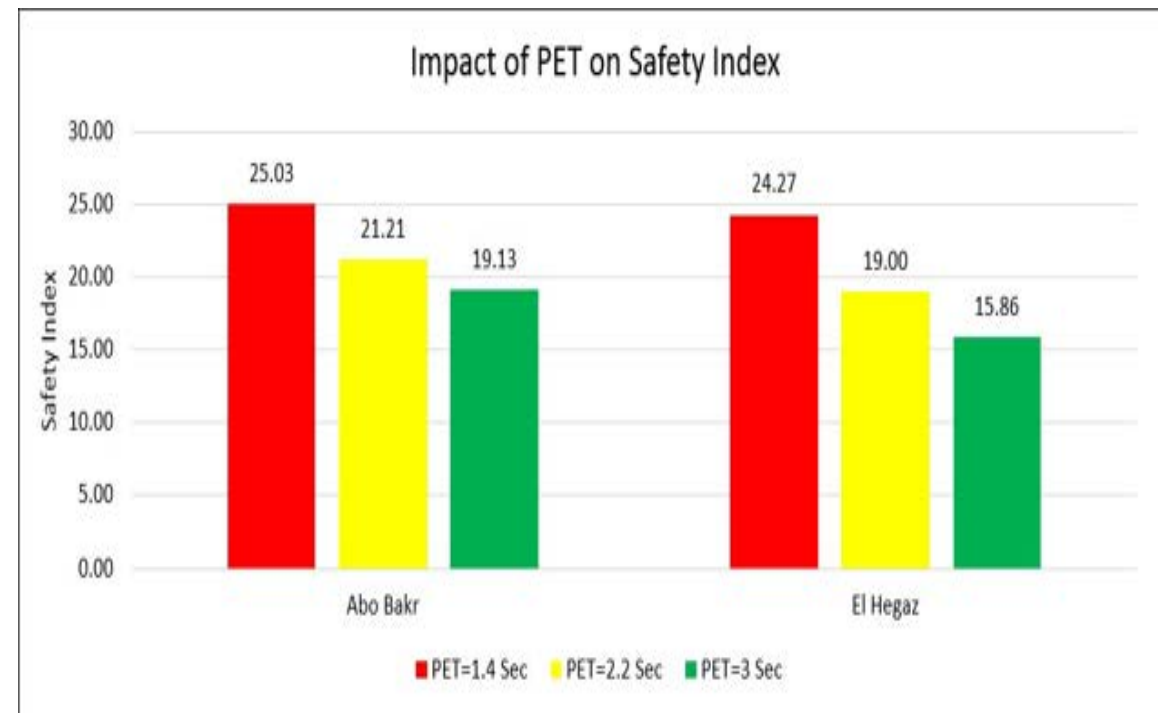
Methodology: *Micro-level Analysis*

Overall Safety Index (SI)

$$\text{Risk Score (RS)} = \frac{\text{Approaching Vehicle Speed}}{e^{PET}}$$

$$\text{Exposure} = \sqrt{\text{Pedestrians Conflicting Volume} * \text{Vehicles Conflicting Volume}}$$

$$\text{Safety Index} = \frac{\sum RS}{\text{Exposure}}$$





Conclusions

- ☐ Crowdsourcing is a rich source of information for pedestrian safety analysis
- ☐ The discipline level of pedestrians in Egypt is different from developed countries
- ☐ The perceived risk of crossing pedestrians in Egypt is significantly low
- ☐ Different thresholds should be used for surrogate safety measures to accurately assess pedestrian safety



Case Study (2): Safety Performance of Microcars as a Smart Mobility Solution



Why Microcars?

- ☐ A single-occupancy vehicle (SOV) is a privately-operated vehicle whose sole occupant is the driver
- ☐ High percentage of SOVs in the traffic stream is deemed inefficient
- ☐ Mega-cities like Cairo suffer:
 - Limited space for new roads / upgrade existing ones
 - Unjustified traffic congestion & shortage in available parking spaces



Average Private Car occupancy (Person/Car):

- USA: 1.54-1.59 (1995-2017)
- Greater Cairo: 1.24 (2010)





What are Microcars?

- Small-sized vehicles, lightweight, < 3 m in length
- Serve different classes of users (1-2 individuals)
- Due to their small size, they are beneficial for cities suffering from limited space
- They offer many advantages compared to motorcycles and bikes:
 1. They provide shelter from adverse weather conditions
 2. They allow for storage space for carrying personal belongings
 3. More culturally accepted in many eastern societies



GCR (2002): 14 Million Trip (72% Public Transit)

GCR (2022): 25 Million Trip (58% Public Transit)

Limited Success For Car Pooling!

Minicars Vs Microcars





Minicars Vs **Microcars**





Objective & Methodology

- ❑ To explore the effects of microcars on traffic safety and the environment
- ❑ VISSIM microsimulation models and surrogate safety assessment model (SSAM) were used to assess safety impacts of microcars for:
 - Two case studies:
 - Case Study 1: Hypothetical corridor similar to GCR urban corridors
 - Case Study 2: Sub-urban expressway in GCR (26th July Corridor)
 - Mixed and exclusive lane configurations were analyzed using different modal shares for microcars
 - Trajectory (.trj) files were extracted from VISSIM and imported to SSAM to calculate different safety measures that were used to evaluate the safety performance of microcars:
 - Time to Collision (TTC), Post Encroachment Time (PET), Deceleration Rate (DR), and number of lane changes



Methodology: **Data Collection**

Case Study 1: **Hypothetical Corridor**

Traffic data: insight on the % of SOVs in the traffic stream and traffic information (e.g., vehicle composition)

HD video recordings of the entire data collection periods were revised manually

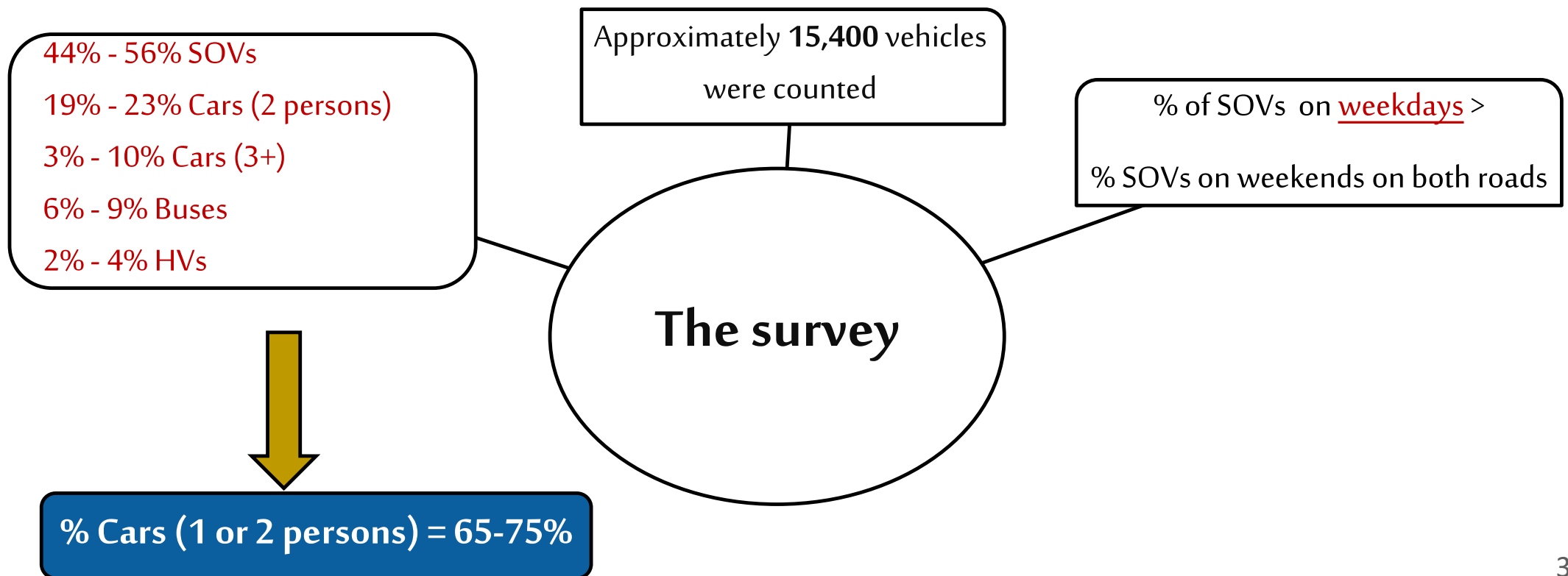
Two collectors in Cairo on
typical weekdays and weekends

2 pm to 5 pm
One normal weekday
One normal weekend



Methodology: Data Collection

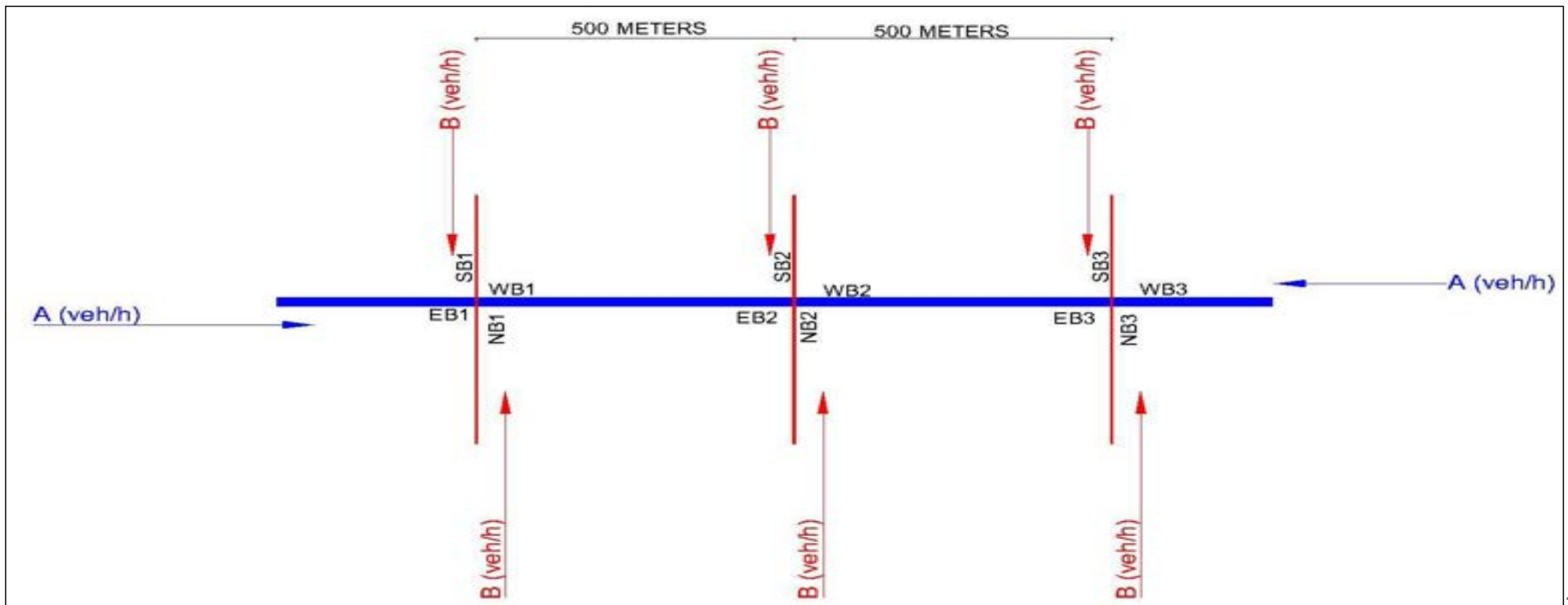
Case Study 1: Hypothetical Corridor





Methodology: Modeling Data

Case Study 1: Hypothetical Corridor





Methodology: **Modeling Data**

Case Study 1: **Hypothetical Corridor**

Input traffic volume on major road = 2000 to 4000 vph/dir.
(500 vph increment each trial)

Microcars = 0% to 50% with 10% increments

Input traffic volume on all minor roads = 1000 vph/direction

% Buses = 7%

% HVs = 3%

% Right Turn = 20%

% Left Turn = 10%

The free flow speeds for cars, microcars, buses and heavy vehicles were set to 60, 50, 50 and 40 kph respectively

**Mixed Traffic
Operation**

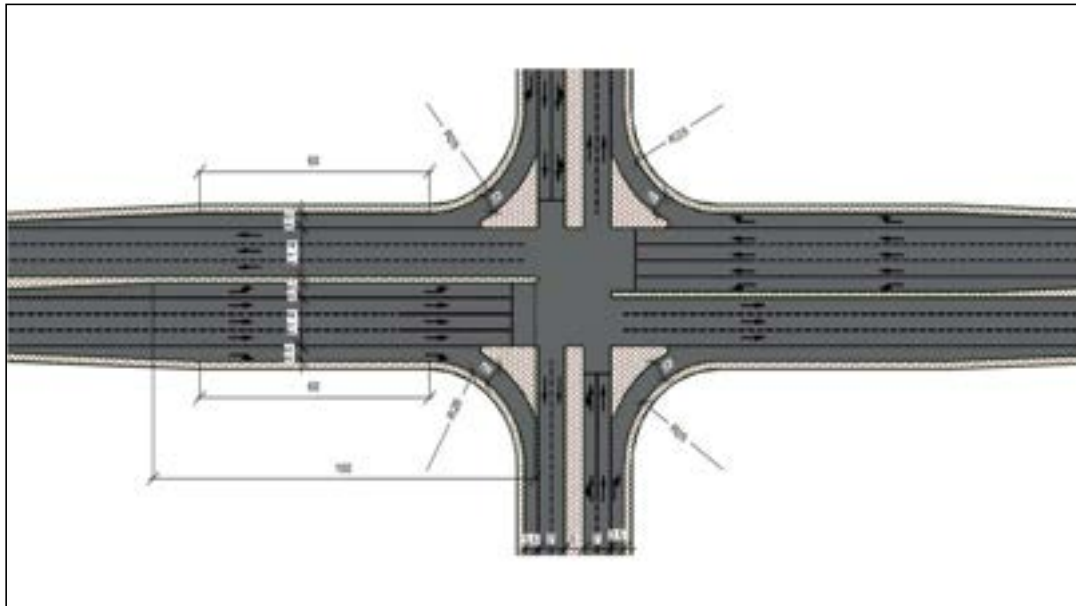
**Exclusive Lane for
Microcars**

**Semi-mixed Traffic
Operation**

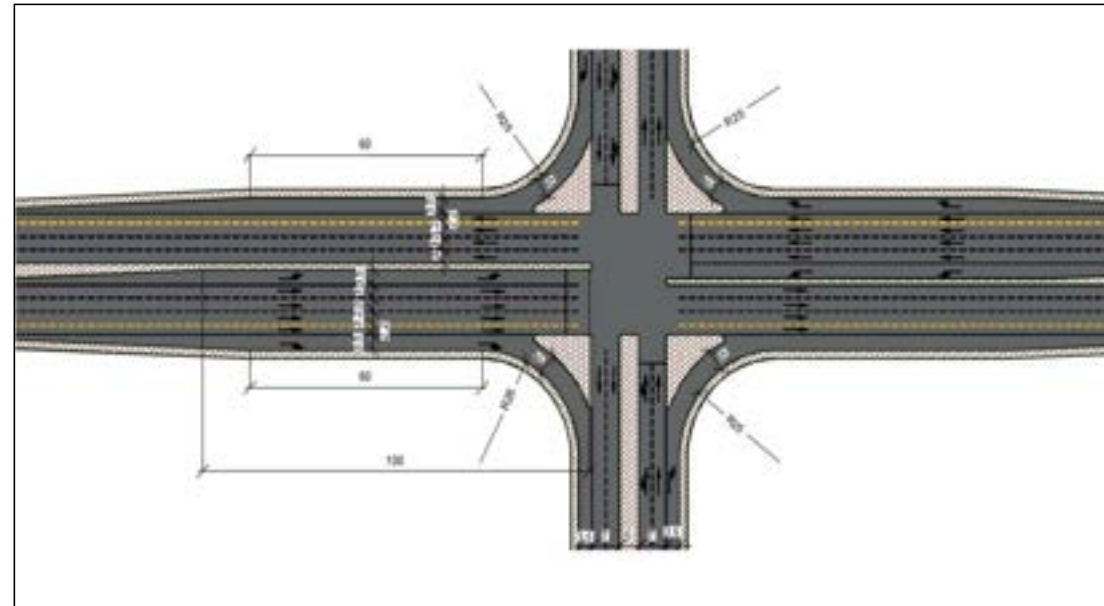


Methodology: Lane Configuration

Case Study 1: Hypothetical Corridor



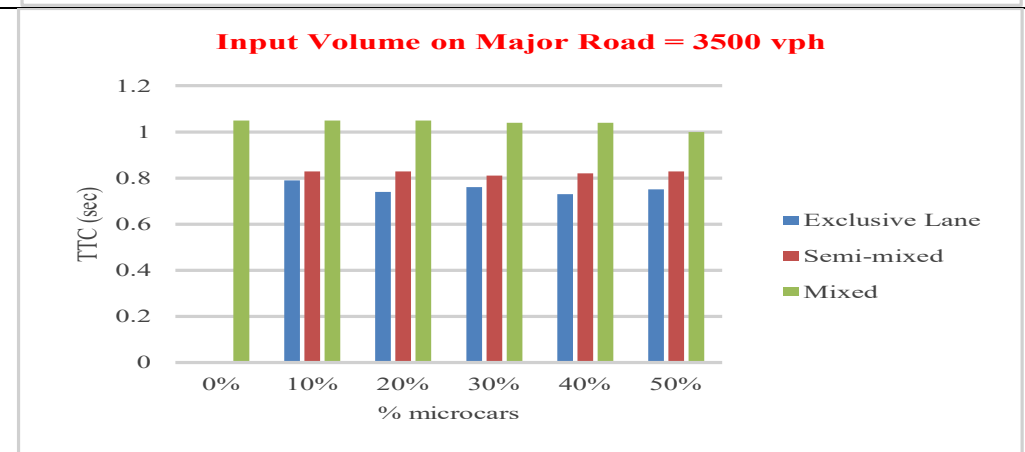
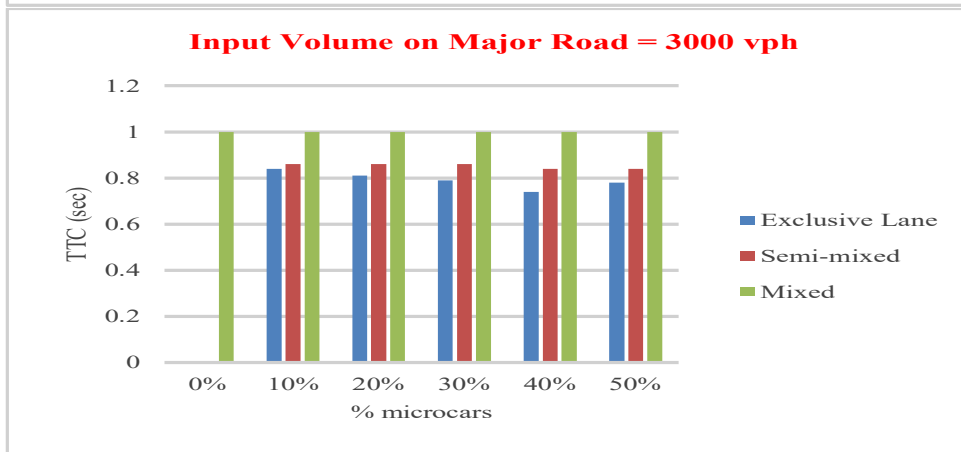
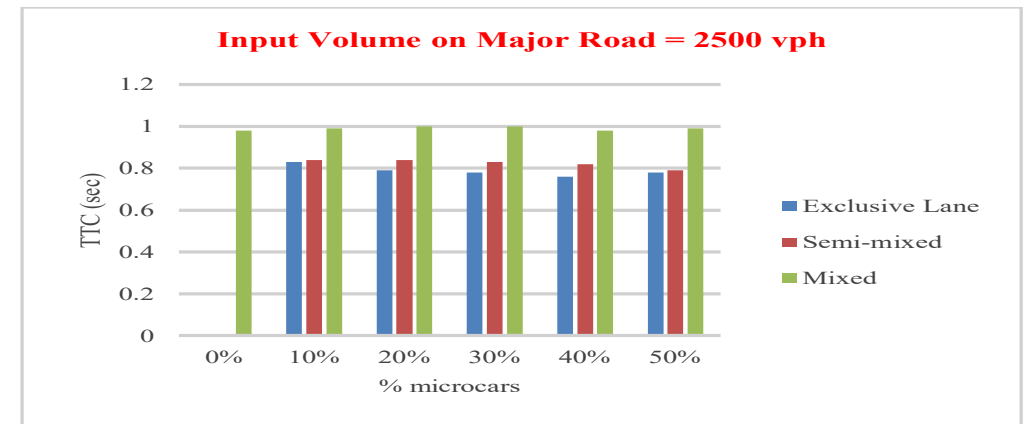
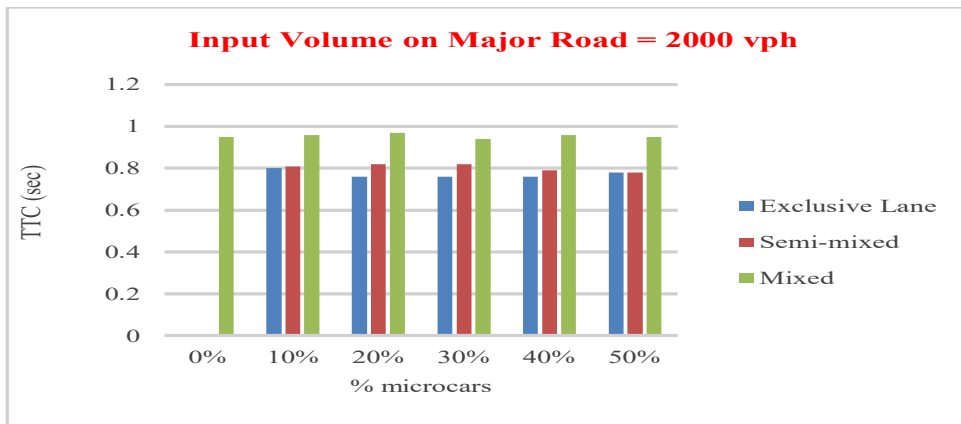
Lane Configuration for Mixed Traffic Operation



Lane Configuration for Exclusive Lane and Semi-mixed Traffic Operation



Results: Safety Performance Analysis Using Microsimulation





Results: **Safety Performance Analysis Using Microsimulation**

Case Study 1: **Hypothetical Corridor**

- ☐ Increasing the percentage of microcars does not significantly affect the average TTC
- ☐ The average values of the TTC for the exclusive lane and semi-mixed scenarios were low indicating lower level of safety
- ☐ This was attributed to the large number of interactions at intersections' approaches where numerous conflicts occurred between right turning vehicles and microcars on the dedicated lane
- ☐ A similar trend was found for the average PET



Methodology: **Layout**

Case Study 2: Sub-Urban Expressway, **26th July Corridor**





Methodology: Modeling Data

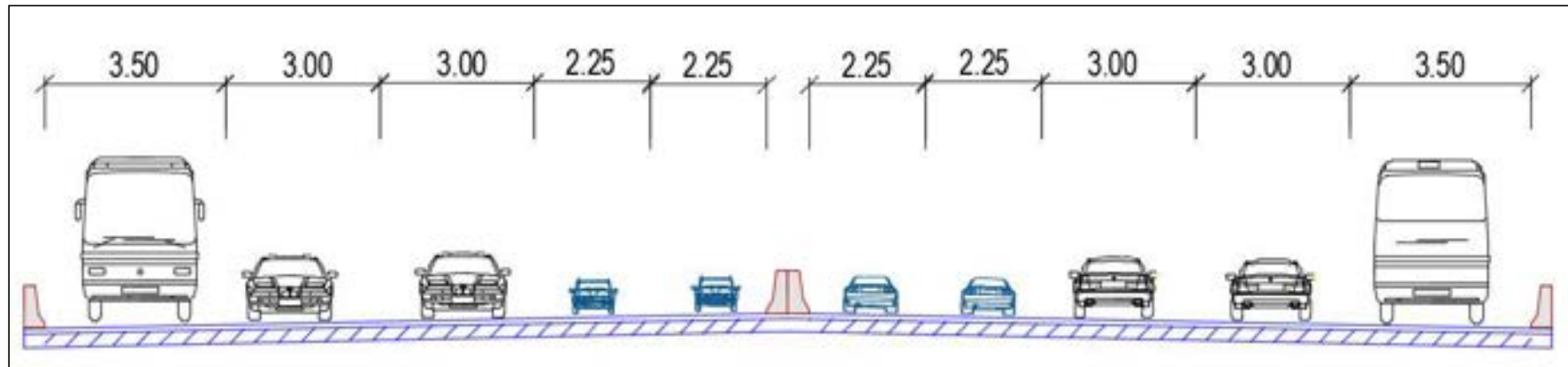
Case Study 2: Sub-Urban Expressway, 26th July Corridor

- ☐ Base case scenario (i.e., existing situation): % microcars = **zero**
- ☐ Scenarios of microcars: assuming a potential modal shift of 10 - 30% from private cars with 10% increments
- ☐ All scenarios were analyzed using both mixed lanes and exclusive lanes configurations

Methodology: **Modeling Data**

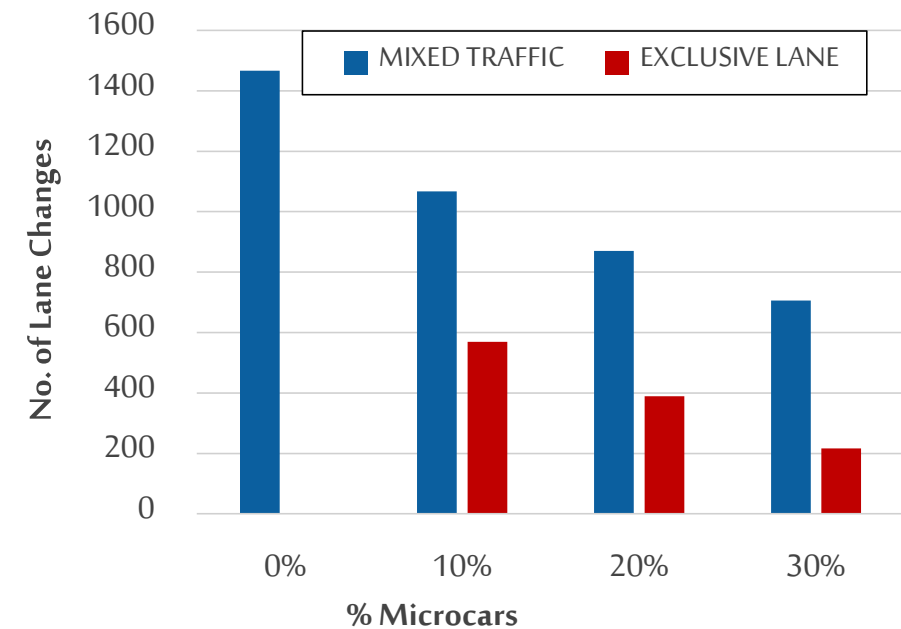
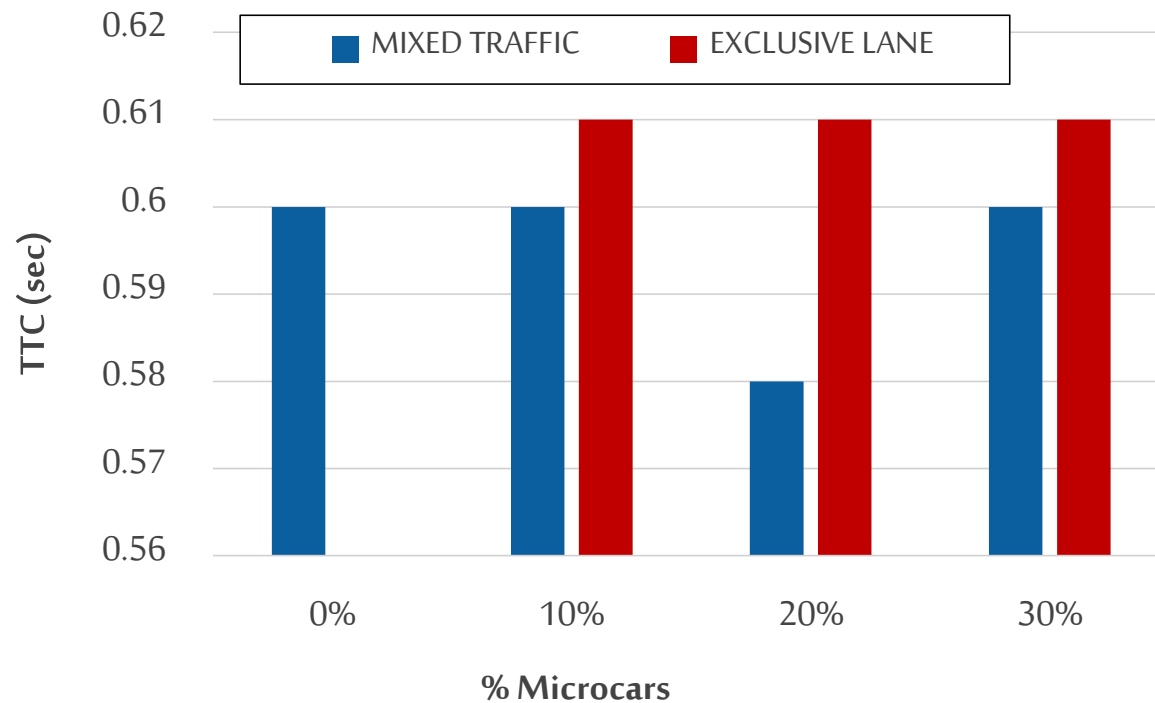
Case Study 2: Sub-Urban Expressway, **26th July Corridor**

- ❑ In the **mixed lane configuration**, the road section was kept as it is in the current situation (i.e., [4 lanes * 3.5 meters] per direction)
- ❑ In the **exclusive lane configuration**, the carriageway was redesigned to accommodate exclusive lanes for microcars without changing the total width of the existing carriageway





Results: *Safety Performance Analysis Using Microsimulation*





Conclusions

- ❑ In urban environments, the safety results were inconclusive as the effect of microcars was contradictory in terms of the safety parameters
 - The introduction of microcars slightly decreased the average values of TTC and PET (i.e., negative safety impact) but also decreased the frequency of lane changing (i.e., positive safety impact)
 - The mixed traffic operation in urban environments is much better, from safety perspective, than exclusive lanes as exclusive lane configuration resulted in many conflicts at the intersections
- ❑ The use of exclusive lanes for microcars on the sub-urban highway can significantly improve safety



Questions & Discussion



Extra Material



What is StreetGuards/StreetKey?

- ❑ Through Street Guards' website and App, road users can report the location and attributes of the incident by clicking the "Locate & Report" button and adding the location where the incident occurred on the map
- ❑ A window appears with the various inquiries according to the incident type; crash/near miss, threatening incident or infrastructure issue
- ❑ StreetKey website has been promoted through social media (i.e., Facebook) to encourage people to report and map issues regarding road safety



StreetKey Data Preparation

- ☐ Removing all the duplicate points (i.e., having the same location, time, and description by the same person),
- ☐ Deleting all recorded events that contained false information e.g., false location
- ☐ Verifying that each incident was classified correctly by carefully checking the description of each reported event
- ☐ Reclassifying the records with incorrect incident categories while having accurate details and description of an incident
- ☐ Dividing the incident categories into subcategories to cluster similar reports within each category. This was based on the underlying causes of the incidents as mentioned in the description.



Results: **Safety Performance Analysis Using Microsimulation**

Case Study 1: **Hypothetical Corridor**

- ☐ The frequency of lane-changing is significantly lower in mixed lane operation compared to the exclusive lane and semi-mixed scenarios
- ☐ The average deceleration rate (DR) for all scenarios was not affected by changing the percentage of microcars nor changing the lane configuration