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Creation a Passing Gap-Acceptance Model for Egyptian Two-Lane Two-Way Roads

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Abstract

Passing is one of the complicated manoeuvres on the two-lane two-way (TLTW) roads, where the follower vehicles use the opposing lane to overtake the leader slower vehicles, especially with the presence of oncoming vehicles from the opposite direction. This paper presents the development of a new passing model for the Egyptian TLTW roads. The developed model is calibrated and validated using data from 6 TLTW roads, with about 20-hours of videotaped data, from the Delta region in Egypt.

The results show that the new passing model is matching the observed passing maneuvers which confirms that the new passing model is a good representative for modeling passing maneuvers for the Egyptian TLTW roads under mixed conditions.

The new model results are compared with previously developed international models, namely: the Tang's and Ghods models. The results are based on Ghods' gap-acceptance model matched observed overtakes by 76.45 % while Tang's model was rejected due to the higher differences between their outputs and actual measures. Moreover, the new developed passing model for calculation of passing duration and corresponding distance was more representative than Ghods' and Tang's models for TLTW Egyptian roads.

Key words: Passing, two-lane two-way (TLTW), Egypt, Time-To-Collision.

1- INTRODUCTION

Cirianni et al. (Cirianni et al., 2016) defined the successful passing maneuvers as they must achieve safely Passing Sight Distance (PSD) of follower quicker vehicles which overtakes slower leader vehicles on two-lane undivided highways using the lane normally reserved for opposing traffic. Overtaking manoeuvres on a road traffic facility occur when traffic moves slower than the design speed. Therefore, these processes become necessary when some follower vehicles in the traffic stream move fast while other leader vehicles move slowly (Asaithambi & Shravani, 2017). The success of an overtaking process is depended on factors such as the type of the overtaking vehicle, volume of traffic flow in the opposite direction and characteristics of the overtaken vehicle (Cirianni et al., 2016).

LIorca and Garcia (Llorca & García, 2011) new the design of a methodology to observe passing maneuvers on four passing zones on two-lane highways in Spain. Six video cameras were installed at a fixed point next to passing sections. About 234 manoeuvres were collected. At high design speeds, higher differences (greater than 100 m) were found between observed data and previous existing models of PSD. Furthermore, the observed average speed difference between passing and overtaken vehicles was higher than that in any other model. Hassan et al. (Hassan et al., 2014) Studied factors affecting speed of overtaking vehicle for a single carriageway road section in Johor, Malaysia. It was concluded that the speed of overtaking vehicle was influenced by the speed of overtaken vehicle, drivers' decision times, safety margin, overtaking durations and acceleration. Chandra and Shukla (Chandra & Shukla, 2012) found whether the speed differential between the follower vehicle and the leader vehicle increases, the overtaking vehicle for all vehicle types require shorter time to overtake. Moreover, LIorca et al. (Llorca et al., 2013) compared the passing operations under daytime and night time conditions on a two-lane rural road segment located near Valencia, Spain. The road observed by four passing zones with six video cameras. A total of 291 maneuvers were observed, up to 20% of which were at night.

Various methods have been investigated for modeling the overtaking gap-acceptance logic and its application in traffic operations. Lovell et al. (Lovell et al., 1993) mentioned that TRAffic on Rural Roads (TRARR) model, developed by the Australian Road Research Board (ARRB), is used to design passing lanes in highway segments. In TRARR model, the decision of overtaking was depended on available overtaking time gap multiplied by a vehicle-specific safety factor. Furthermore, Hegeman (G. Hegeman, 2004) applied TRARR model in Netherlands in two-lane highways. He found that TRARR overtaking rate is higher than that was obtained from field observations.

The TWOPAS model is a microscopic model of traffic on two-lane highways. It is developed by Midwest Research Institute (MRI) in the early seventies. This model was also applied to estimate two-lane highway capacity and level-of-service (LOS) in the Highway Capacity Manual.(St. John & Kobett, 1978) mentioned that TWOPAS model was based on vehicle type, road geometry, passing and no passing zones, traffic volume, relative leader/ follower speed, driver desired speed, acceleration of each vehicle, gap between leader and follower vehicles and available passing distance.

Ghods (Ghods, 2013) developed an overtaking gap-acceptance model to simulate traffic operations and safety performance measures on TLTW highway in Southern Italy. A total of 97 vehicles trajectories of 900 m road section were extracted from the three-hour videotaping.

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Polus et al (Polus et al., 2000) analyzed stages of the observed overtaking process. They collected about 1500 passings by videotaping from high vantage points on two-lane highway sections in Israel. A model showing that 54% of passings were characterized as "single passing," in which one driver passed a single, slower vehicle. Bella and Gulisano(Bella & Gulisano, 2020) modelled motorcyclists' overtaking duration onto two-lane suburban road in Rome, Italy. About 101 overtaking maneuvers were recorded by video camera. The overtaking duration was modelled using a log-logistic distribution, which was the best-fitted distribution. Initial distance and speed difference have a major impact on overtaking duration while final lateral distance has a minor impact on it.

Farah et al. (Farah, H. et al., 2009) simulated drivers' passing maneuvers on two-lane rural roads . They collected passing data using an interactive driving simulator. The gap acceptance model was influenced by passing gap size, speed of the overtaking vehicle and the following distance it keeps from the overtaken vehicle. Also, the personality and socio-demographic characteristics of the driver affected directly on passing decision. Farah (Farah, 2016) collected a trajectory data at a resolution of 0.1 seconds including speed, acceleration and position of all vehicles in two-lane roads in Netherlands. He developed a logistic regression model to predict the probability that a driver will abort an overtaking maneuver. It was concluded that possibilities of aborted overtaking are fully depended on the gap in the opposite direction, desired speed of overtaking vehicle, type and speed of the front vehicle. Farah and Toledo (Farah & Toledo, 2010) attempted to capture a model for drivers' desire to pass and their gap acceptance decisions on two-lane highways in Sweden. The passing maneuvers were collected using driving simulators. The passing maneuver model was affected by geometric characteristics of the road section and the driver characteristics and account for unobserved heterogeneity in the driver population.

Budhkar and Maurya (Kishor BUDHKAR & Kumar MAURYA, 2018) modelled overtaking decision under mixed traffic conditions in five cities of India. The overtaking probability model was based positions of the transverse directions for the two moving vehicles using logistic regression.

There are many parameters that microscopic simulation programs depend on modeling overtaking Hegeman (Geertje Hegeman, 2008) mentioned that TWOPAS is based on speed of proceeding vehicle and the distance available for overtaking. Moreover, (Minderhoud et al., 2004) mentioned that the Dutch model (SiMoNe) is applied on two-lane rural roads with oncoming traffic. When the time needed for overtaking is smaller than the estimated available gap until the next opposite vehicle arrives, an overtaking is accepted.

(Barceló, 2010) mentioned that Simulation of Urban MObility (SUMO) simulates overtaking process depending on (1) oncoming traffic volumes, and (2) the presence of free-space at the end of the column being overtaken

Despite there are various microscopic software's can model overtaking, there are others that failed to model it. For example, Fransson (Fransson, 2018) and (Barceló, 2010) mentioned that VISSIM cannot be able to model overtaking process.

2-METHODOLOGY

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Figure 1 illustrates methodology flow chart while it represents the steps included the study of this research. Selected six TLTW Egyptian roads are studied. The data is collected by videotaping and traffic parameters needed on overtaking maneuvers are extracted. A new passing model is developed to represent Egyptian conditions. If the overtaking decision is accepted, overtaking duration and corresponding distance will be calculated by the new model and then the results are compared to other models and actual observed overtakes.

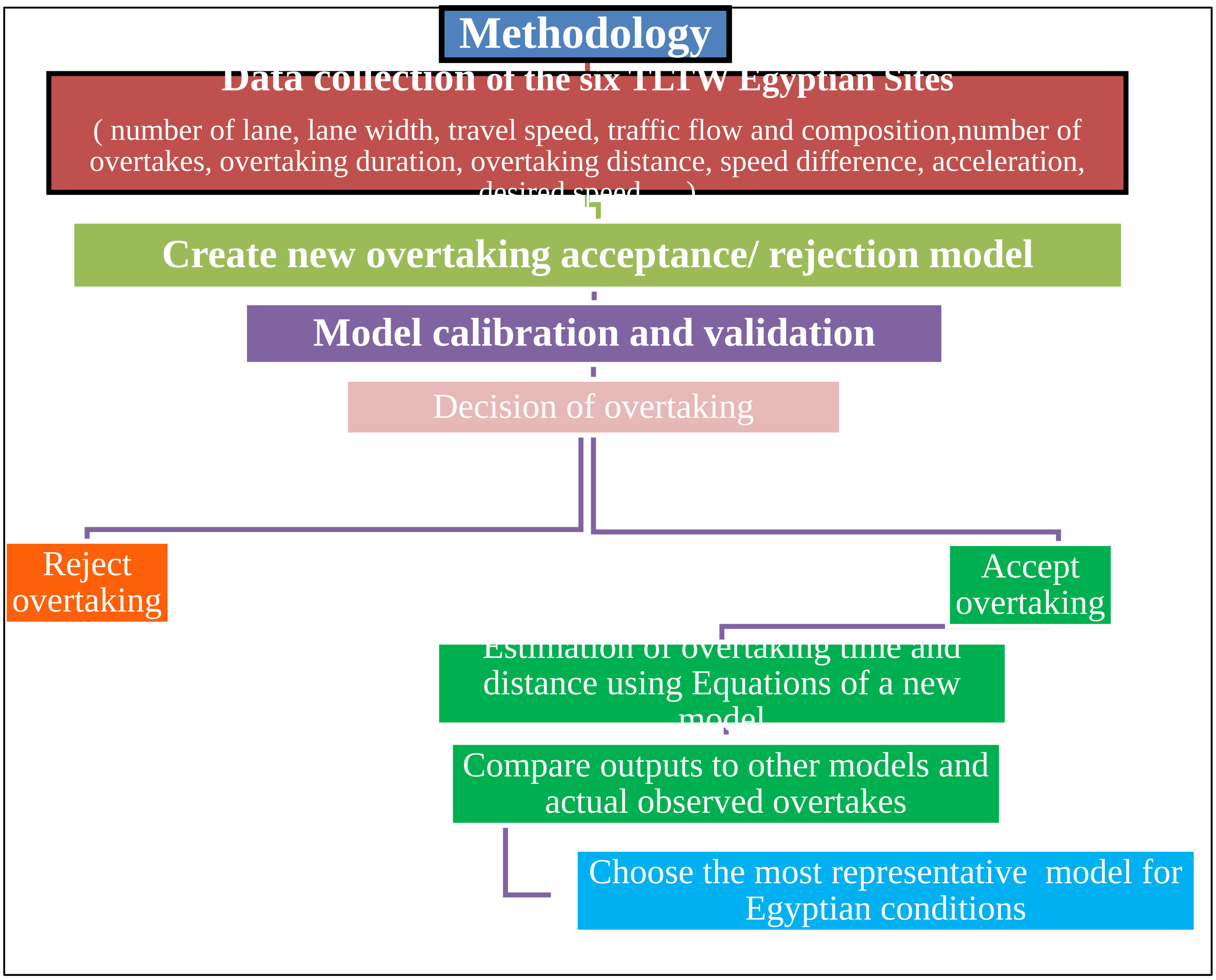

Figure 1: Methodology Flowchart

3- A NEW OVERTAKING MODEL FOR ESTIMATING OVERTAKING DURATION AND CORRESPONDING DISTANCE

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Overtaking process is divided into three main phases; total overtaking durations and its corresponding distances are calculated according to (Equation 1 to Equation 5). Vehicle "A" represents an overtaking vehicle, vehicle "B" represents an overtaken vehicle and vehicle "c" represents an opposing vehicle in the opposite direction. The three main phases for achieving a successful overtaking process are shown in **Figure 2.**

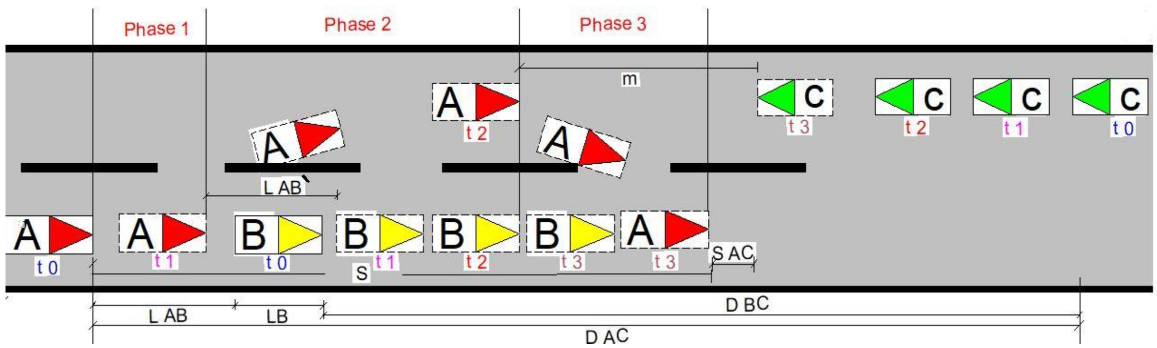

Figure 2: Phases of overtaking process for developed overtaking model

Phase (1): it represents the distance covered by follower vehicle during decision time to begin overtaking maneuver process for passing the leader vehicle which has lower speed.

Phase (2): it represents the distance covered in the opposite lane by follower vehicle during overtaking to be at the same position / line of front bumper of leader vehicle.

Phase (3): it represents the distance covered by the follower vehicle to achieve safe separation with the overtaken vehicle while returning to its original travel lane.

Let the distance "d_1" is the distance required for taking a decision to overtake LV, which can be estimated as follows:

$$d_1 = V_{A(initial)} * t_1 \qquad (1)$$

Where;

$V_{A(initial)}$ = The initial speed of overtaking vehicle (km/hr.)

t_1 = The decision time for overtaking (i.e. assume 2.0 seconds).

Then, the distance "d_2" covered in the opposite lane by follower vehicle to be parallel to LV. This distance is calculated depending on the acceleration / deceleration of follower and leader vehicles during overtaking time.

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Let is the distance between FV and LV at the end of phase (1) and is calculated according to

$$\grave{L}_{AB} = L_{AB} + (\Delta v_{(initial)}) * t_1$$

Where,

$L_{AB} =$ The initial distance between leader and follower vehicles (meters);

$\Delta v_{(initial)} =$ The initial speed difference between leader and follower vehicles (km/hr.)

Then, $d_2 = a_{1(Avg.)} * t_2^{\,2} = \grave{L}_{AB} + \grave{a}_{(Avg.)} * t_2^{\,2} + L_B$

Then, $(a_{1(Avg.)} - \grave{a}_{(Avg.)}) * t_2^{\,2} = \grave{L}_{AB} + L_B$

Where,

$a_{1(Avg.)} =$ The average acceleration of overtaking vehicle during the phase (2);

$\grave{a}_{(Avg.)} =$ The average deceleration/ acceleration of overtaken vehicle during phase (2);

$L_B =$ The length of overtaken / leader vehicle (meters).

Then, the time for achieve distance "d_2" is calculated as the following:

$$t_2 = \sqrt{\frac{\grave{L}_{AB} + L_B}{\Delta a_{(Avg.)}}} \quad \text{...} \qquad (2)$$

The distance "m" between overtaking vehicle "A" and opposite vehicle "C" at the end of phase (2) is based on the change of speed of leader and opposite vehicles during overtaking process as the following formula;

$$m = D_{BC} - (v_c * t_1 + \grave{v}_c * t_2 + v_B * t_1 + \grave{v}_B * t_2)$$

Where,

$v_c =$ The initial speed of opposite vehicle (km/hr.);

$\grave{v}_c =$ The speed of opposite vehicle at the end of the phase (2);

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$\grave{v}_B$ = The speed of overtaken vehicle at the end of the phase (2);

D_{BC} = The initial distance between overtaken vehicle and opposite vehicle (meters)

Also, the distance “m” can be calculated by the following formula:

$$m = a_2 * t_3^{\,2} + S_{AC}$$

Where,

a_2 = The average acceleration of overtaking vehicle at the phase (3);

t_3 = The time elapsed by overtaking vehicle to return to its original lane

S_{AC} = The residual distance between overtaking vehicle and opposite vehicle at the end of the phase (3);

Then, the time needed by the overtaking vehicle (vehicle A) to return to its original lane.

$$t_3 = \sqrt{\frac{m - S_{AC}}{a_{2(Avg.)}}} \quad \text{...} \quad (3)$$

Then, the total overtaking duration “T” can be calculated according to the following Equation:

$$T = t_1 + t_2 + t_3 \quad \text{...} \quad (4)$$

Also, the total overtaking distance “S” can be calculated according to the following Equation:

$$S = L_{AB} + (m - S_{AC}) + L_B + v_B * t_1 + \grave{v}_B * (t_2 + t_3) \text{.......} \quad (5)$$

4- STUDY AREA AND DATA COLLECTION

Six sites from TLTW roads within Delta region in Egypt were used in this analysis. The first site (i.e. site S1) is from the Mansoura-Damietta TLTW road that connects the two cities. The second site (i.e. site S2) is from the Mansoura-Dikirnis TLTW road. The third site (i.e. site S3) is from the Mansoura- Aga TLTW road. The fourth site (i.e. site S4) is from Aga-Samanoud TLTW road in Dakahila Governorate. The fifth site (i.e. site S5) is from Damietta-Zarqa TLTW road in Damietta Governorate. The sixth site (i.e. site S6) is from Zagaziq- Darub negem TLTW road in Sharqia Governorate. The camera was placed at a high vantage location to capture the moving traffic of the entire width in both directions for all sites. **Table 1** illustrates geometric properties of and date of data collection. Paved road width and its shoulder for each site were measured by the tape in the field and they are checked by Google Earth. The TLTW roads are classified as “Class II” TLTW roads, according to HCM (TRB, 2016). **Figure 3** shows the six studied locations.

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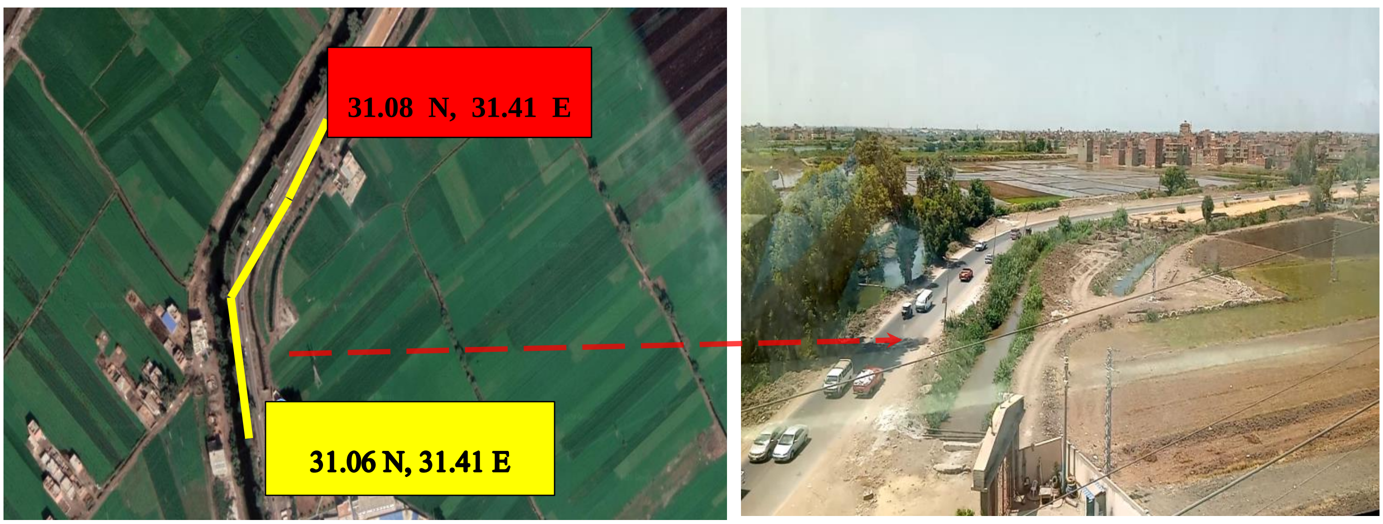
Table 1: Geometric Properties and date of data collection

Road	Site S1	Site S2	Site S3	Site S4	Site S5	Site S6
Collection date	June 17, 2019	April 19, 2019 and March 15, 2021	June 15, 2021	June 27, 2021	May 27, 2021	July 07, 2021
Paved road width	6.5 meters	6 meters	6 meters	6.5 meters	6 meters	6.5 meters
Right shoulder width	1.5 meters	1.0 meters	1.0 meters	1.5 meters	1.0 meters	1.5 meters
Left shoulder width	1.0 meters	1.0 meters	1.0 meters	1.0 meters	1.0 meters	1.0 meters

(a)



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(c)

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(F)

Figure 3: Location Coordinates from Google Earth and Snap Shota of the studied Sites

Traffic composition for the studied sites is shown in **Figure 4.** For all sites, pick-up commercial vehicles have the highest percentage while taxis have the lowest percentage in traffic composition. Furthermore, speed distribution is shown in **Figure 5.** The speed distributions are closer to be normally distributed for sites (S1 to S6). Road properties are observed for sites (S1 to S6) during 20 -hours videotaping as in **Table 2.**

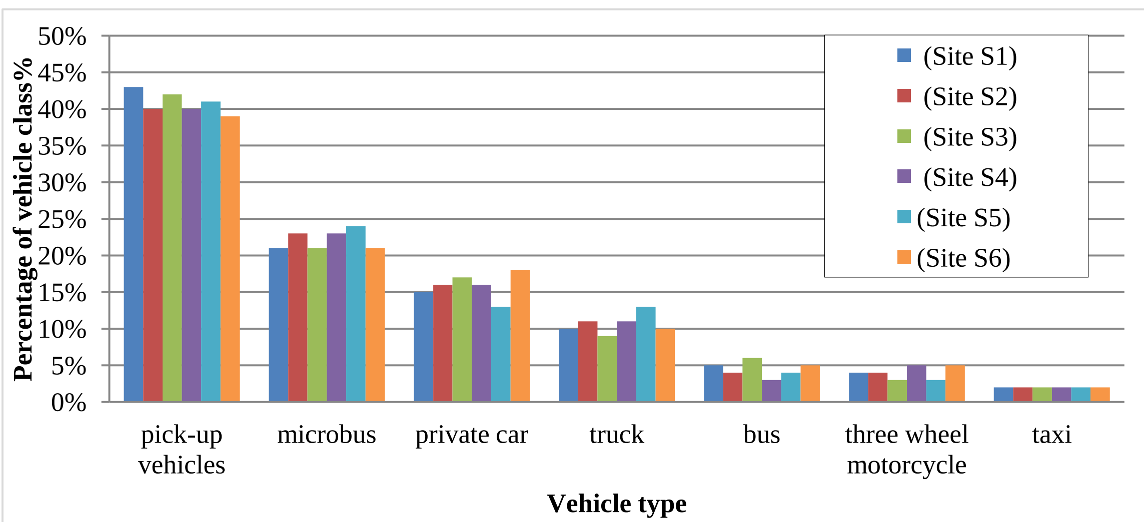

Figure 4: Traffic composition for the six studied sites (S1 to S6)

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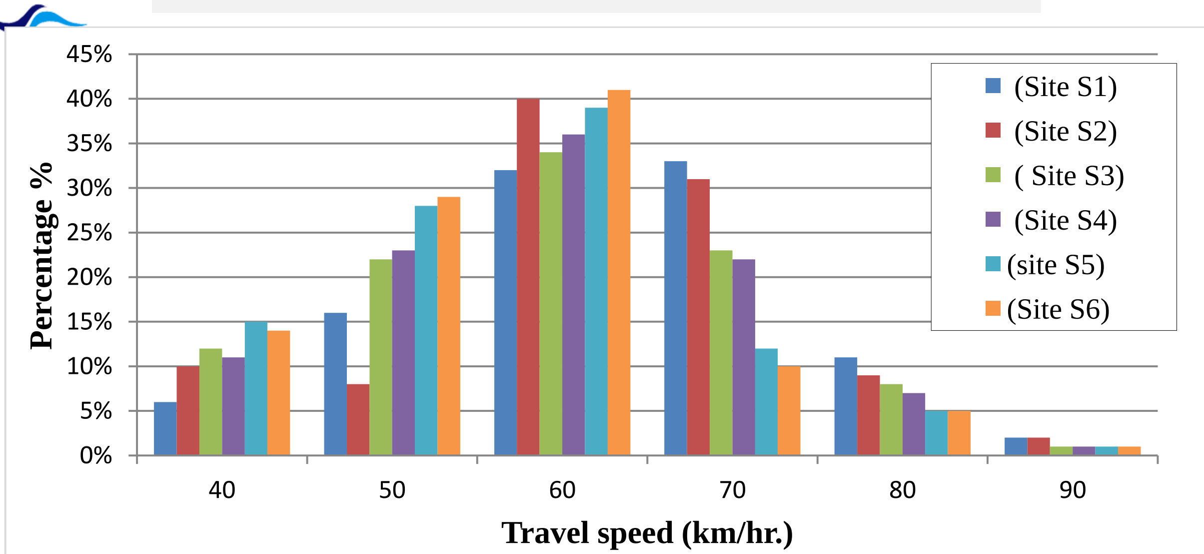

Figure 5: Speed distribution of the six studied sites (S1 to S6)

Table 2: Road properties for both directions of six sites (S1 to S6)

Site		Site S1	Site S2	Site S3	Site S4	Site S5	Site S6
Average Traffic flow (veh. /hr.)		237	261	317	332	341	334
Data collection duration (hr.)		2.0	2.0	4.0	4.0	4.0	4.0
Section length (m)		375	205	220	280	215	250
Paved Lane width (m)		4.5	4	4	4.5	4	4.5
Average travel speed (km. /hr.)	**Max.**	92.83	92.96	90.44	94.33	90.12	90.90
	AVG.	57.92	55.71	50.30	49.76	59.32	56.44
	Min.	38.97	36.14	34.66	35.79	34.23	37.07
Average travel time (sec.)	**Max.**	34.65	20.43	22.86	28.19	22.63	24.29
	AVG.	23.33	13.20	15.62	20.22	13.05	15.95
	Min.	14.55	8.04	8.76	10.71	8.61	9.93
Average headway (sec.)	**Max.**	22.17	23.43	19.98	20.32	21.21	20.54
	AVG.	16.40	16.42	13.21	14.32	13.98	14.39
	Min.	1.11	2.23	3.03	2.98	2.57	3.21
Average density (veh. /km)	**Max.**	6.08	7.22	9.14	9.27	9.96	9.00
	AVG.	4.09	4.68	6.25	6.65	5.74	5.91
	Min.	2.55	2.80	3.50	3.51	3.78	3.67

Overtaking collected data including (number of observed overtakes, overtaking speed (during overtaking process), maximum desired observed speed (after achieving overtaking) that is closer to the speed in free-flow conditions, maximum acceleration, spacing between overtaking vehicle and overtaken vehicle, average speed difference between the two vehicles and average time –to-collision) is investigated during the twenty observing hours for all studied sites as shown in the following **Table 3.**

Table 3: Overtaking data for both directions of six sites (S1 to S6)

Site	Site S1	Site S2	Site S3	Site S4	Site S5	Site S6
Overall number of overtakes	33	29	20	32	29	37
Average Gap between overtaking and overtaken vehicles (m)	26.25	12.48	11.67	10.87	10.11	10.67
Average distance between overtaking and opposite vehicles (m)	126.65	71.82	188.70	214.32	167.32	202.45
Average overtaking speed (km. / hr.)	73.81	70.89	52.72	51.86	63.36	58.47
Maximum desired observed speed (km./hr.)	92.83	92.96	90.44	94.33	90.12	90.90
Average observed overtaking duration (sec.)	4.88	3.95	4.48	4.43	4.22	4.32
Average observed overtaking distance (m)	97.21	64.84	55.67	58.12	70.45	61.09
Average TTC (sec.)	3.59	2.22	4.19	2.87	1.69	2.31

5- OUTPUTS' ANALYSIS OF ABORTED OVERTAKES COMPARED TO COMPLETED OVERTAKES

Figure 6 illustrates the cumulative observed speed frequency of the front (i.e. overtaken) vehicles in case of completed and aborted overtakes. It shows that average observed front vehicle' speed increases by average 17.55 km/hr. in case of aborted rather than completed overtakes for all studied sites. Moreover, average desired overtaking speed of overtaking vehicles increases by average 12.88 km/hr. in case of completed rather than aborted overtakes as shown in **Figure 7**. Finally, the average SD between follower and leader vehicles is increased by average 10.78 km/hr. for completed rather than aborted overtakes as shown in **Figure 8**.

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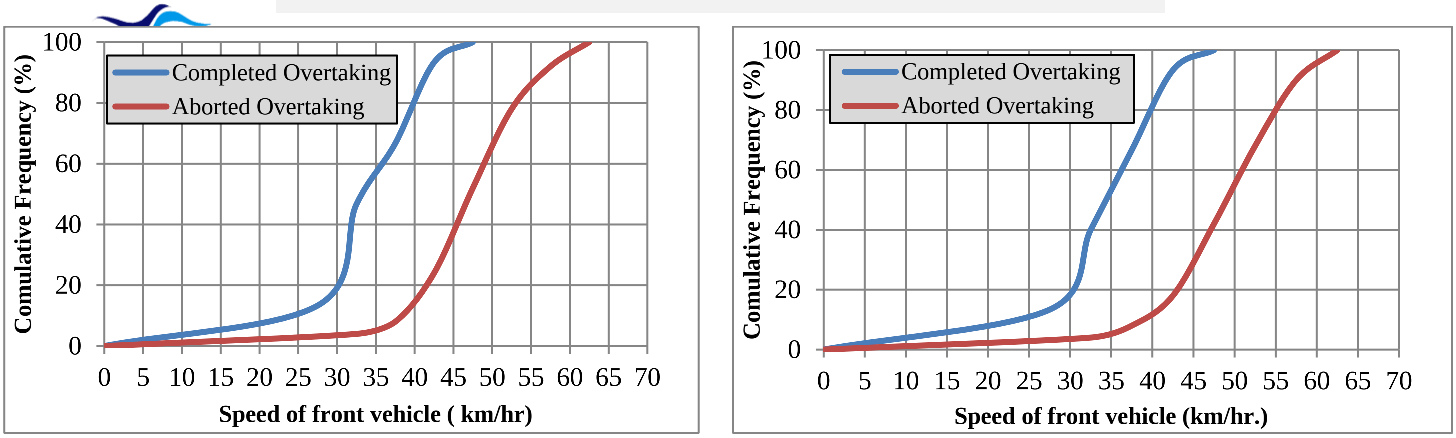
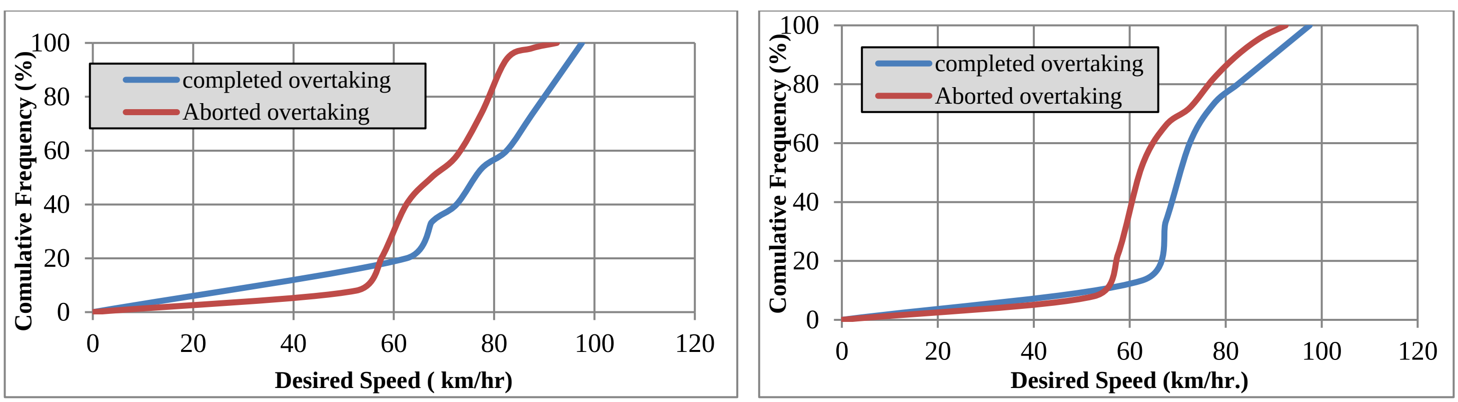


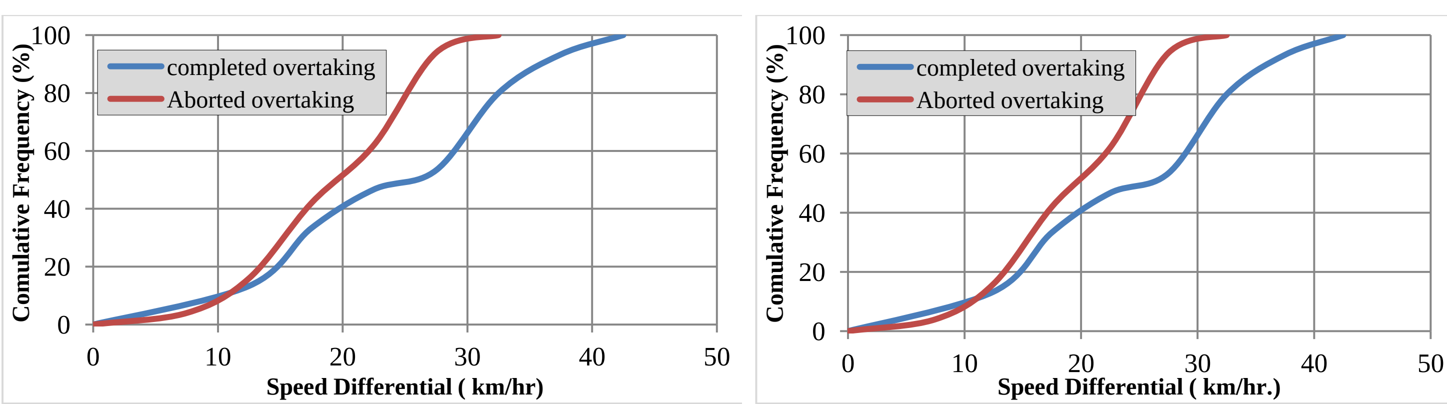
(a) (b)

Figure 6: Cumulative speed Frequency of front vehicles for completed and aborted overtakes (a) Site S1, (b) Site S2



(a) (b)

Figure 7: Cumulative desired speed Frequency of follower vehicles for completed and aborted overtakes (a) Site S1, (b) Site S2



(a) (b)

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Figure 8: Cumulative speed difference Frequency between follower and leader vehicles for completed and aborted overtakes (a) Site S1, (b) Site S2

6- ANALYSIS OF A NEW OVERTAKING MODEL COMPARED TO GHODS' AND TANG'S MODELS

After using a new overtaking gap-acceptance model for accept / reject overtaking, the overtaking time and overtaking distance have been calculated for all acceptable overtakes. The overtaking time and its corresponding distance are calculated by a new model and other two models (i.e. The overtaking model used in the OTSIM software and Tang's model and then their results have been compared. **Table 4** provides the overtaking attributes for the video-recorded segments by the three studied models compared to observed results. **Figure 9** illustrates the relationship between overtaking distances and overtaking durations for the six studied sites (S1 to S6) using Ghods', Tang's and a new model. It was obvious that Exponential function was representative for the relationship between overtaking distance and overtaking duration using the overtaking model used in the OTSIM software. However, 2nd polynomial function was representative for the relationship between overtaking distance and overtaking duration for a new model and Tang's model for most of studied sites. The coefficient of determination "R^2" was enhanced by a new model rather than other two models for most of studied sites, so the relationship is considered to be good between the two variables using a new model.

Table 4: Summary of overtaking attributes using the three models for the six studied sites (S1 to S6)

Site	Actual results	new model	Site	Actual results	new model
Site S3	4.48	4.32	Site S5	4.22	**3.98**
	6.98	6.45		5.34	**4.73**
	3.88	3.40		2.98	**2.84**
	±0.79	±0.84		±0.51	**±0.45**
	55.67	52.17		70.45	**67.81**
	100.4	93.04		109.32	**99.51**
	34.12	29.55		49.23	**44.69**
	±14.60	±13.13		±16.48	**±15.17**
Site S4	4.43	4.34	Site S6	4.32	**4.11**
	7.14	6.98		6.77	**6.01**
	3.34	3.47		3.20	**3.06**
	±0.52	±0.64		±0.56	**±0.74**
	58.12	53.88		61.09	**57.76**
	85.77	83.23		80.14	**70.05**
	29.03	27.65		41.03	**40.4**
	±10.87	±12.36		±7.12	**±6.98**

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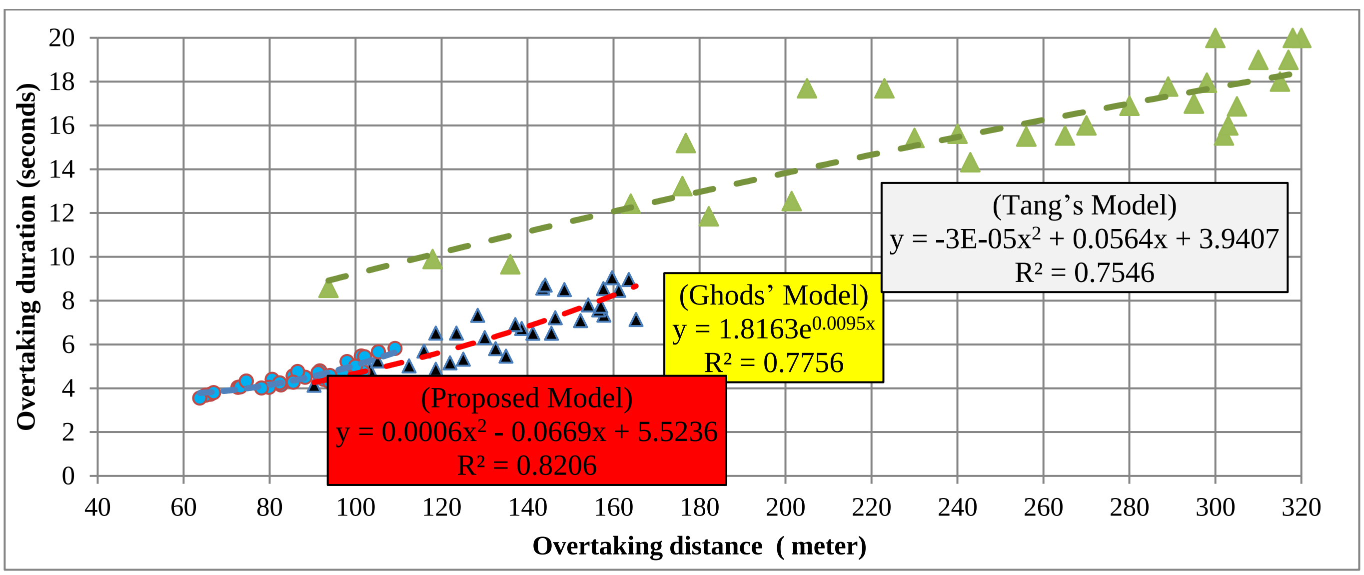
Site			Actual results	new model
Site S1	Overtaking time (sec.)	Mean	4.88	4.45
		Max.	6.22	5.71
		Min.	3.98	3.45
		STDV.	±0.61	±0.57
	Overtaking distance (meter)	Mean	97.21	91.45
		Max.	112.11	110.12
		Min.	73.12	64.32
		STDV.	±12.85	±12.77
Site S2	Overtaking time (sec.)	Mean	3.95	3.65
		Max.	5.39	4.65
		Min.	3.02	3.19
		STDV.	±0.76	±0.45
	Overtaking distance (meter)	Mean	64.84	57.36
		Max.	79.32	72.12
		Min.	49.02	42.50
		STDV.	±11.36	±7.62

(a)



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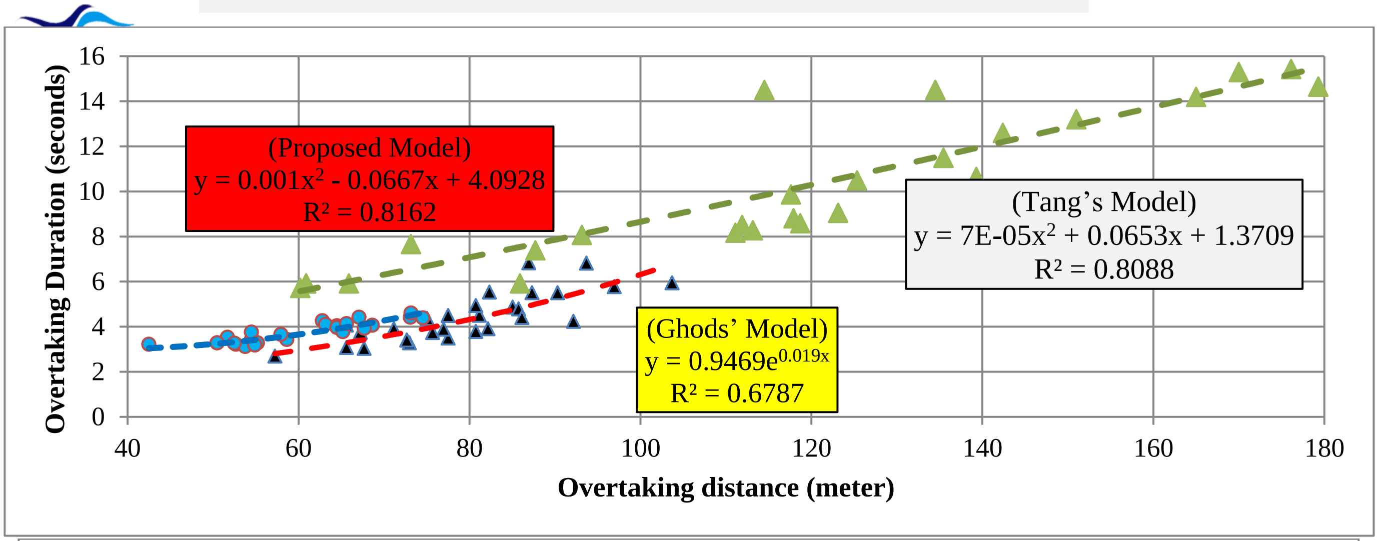

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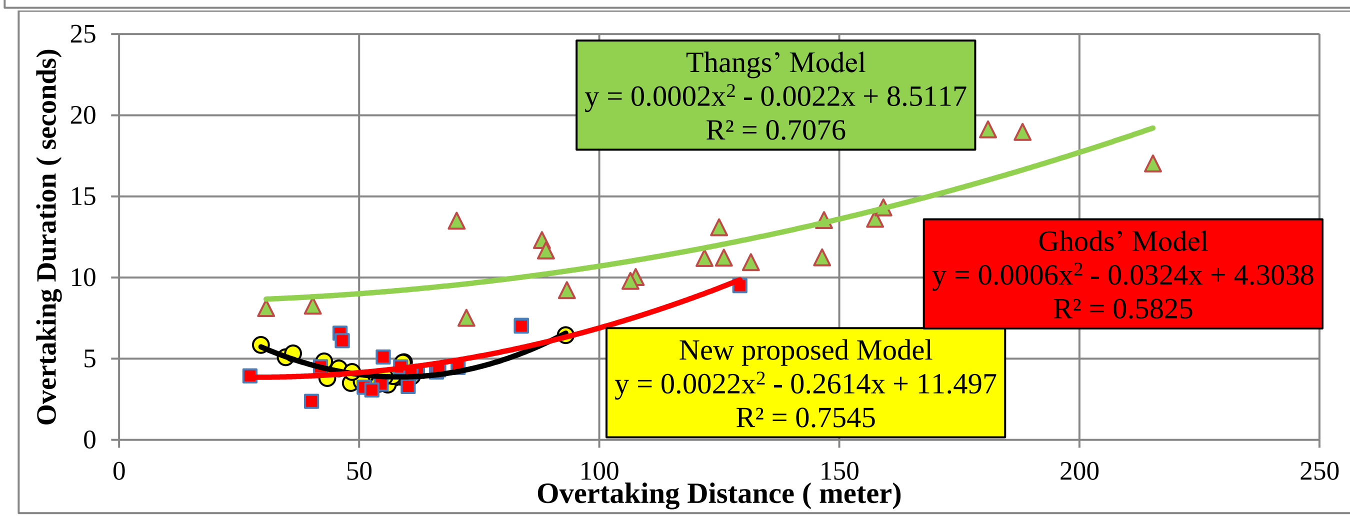

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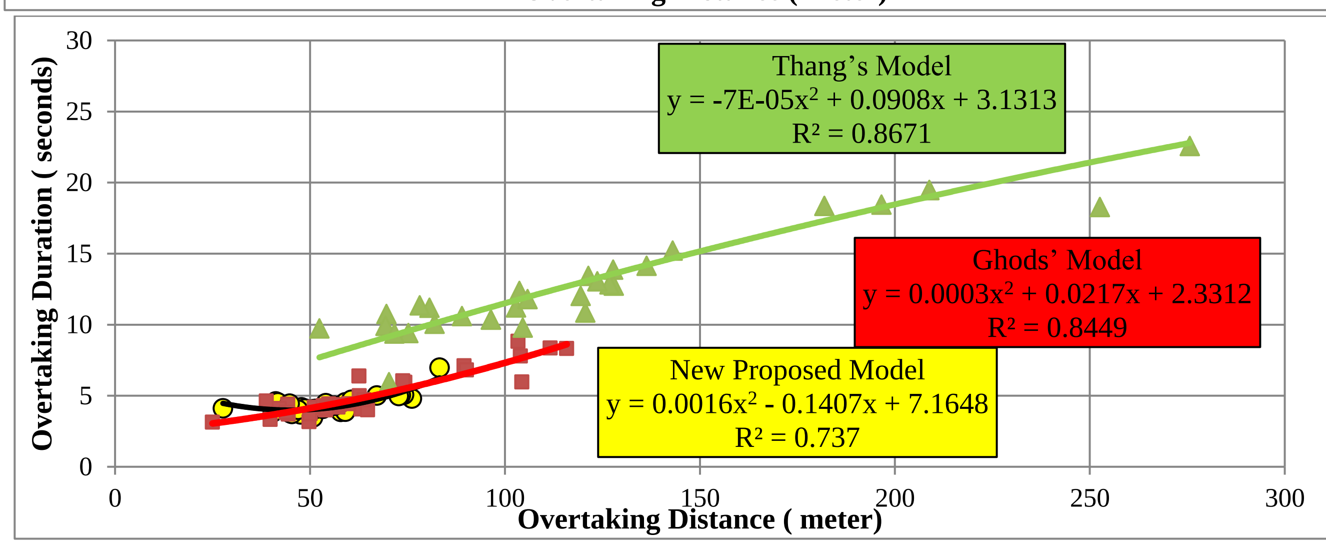

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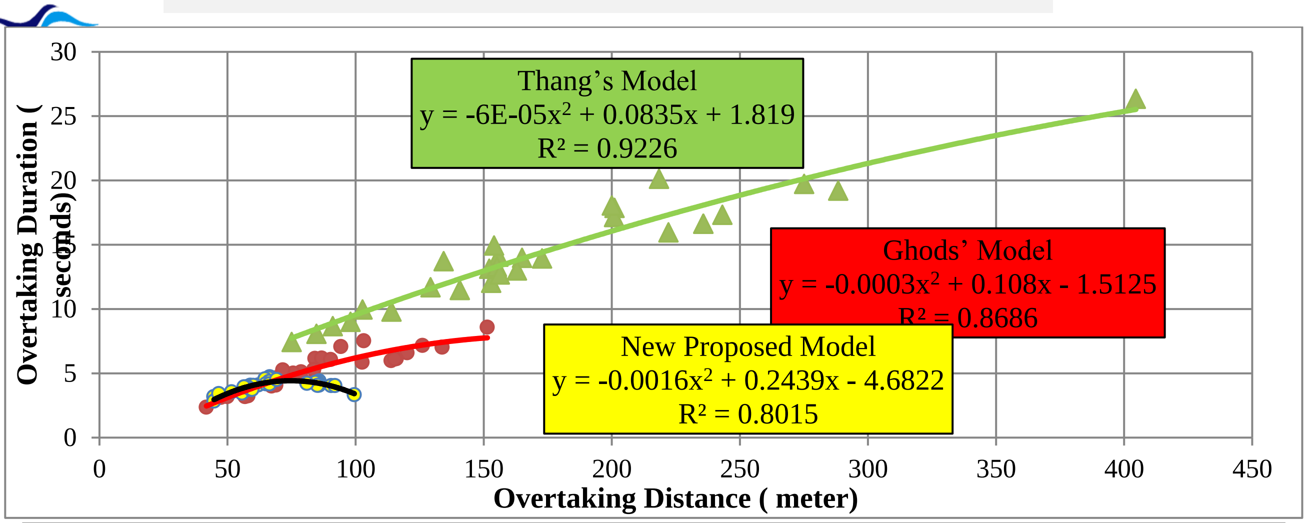

(F)

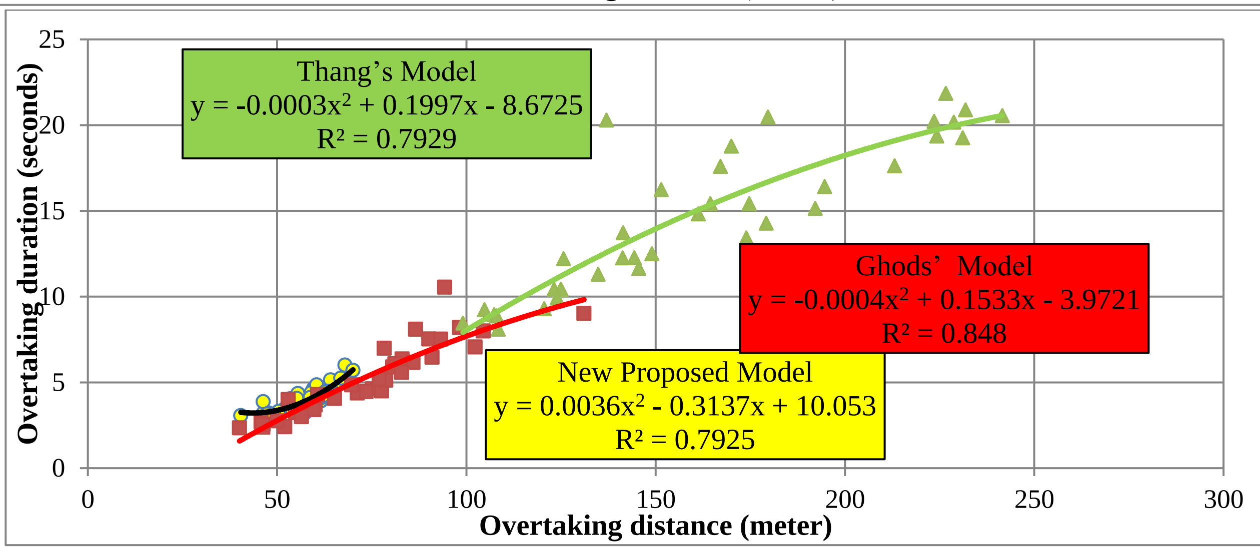

Figure 9: The relationship between overtaking distance and overtaking duration for all studied sites

Figure 10 illustrates the relationship between speed differences (SD) and overtaking durations for all observed overtakes for Ghods', Tang's and new models on studied sites (S5 and S6). It was obvious that the 2nd of polynomial function was representative for the relationship between SD and overtaking durations. **Figure 11** shows the sensitivity of SD with TTC. It is obvious that TTC increases as the SD increases for the studied sites. **Figure 12** illustrates the rate of increase for acceleration of follower vehicles during overtaking for a sample of successful overtakes. It is increased gradually by (30 to 42%) more than its value before overtaking till reaching the half of overtaking duration. After FV passed LV, rate of acceleration returned to be decreased gradually during returning to its original lane.

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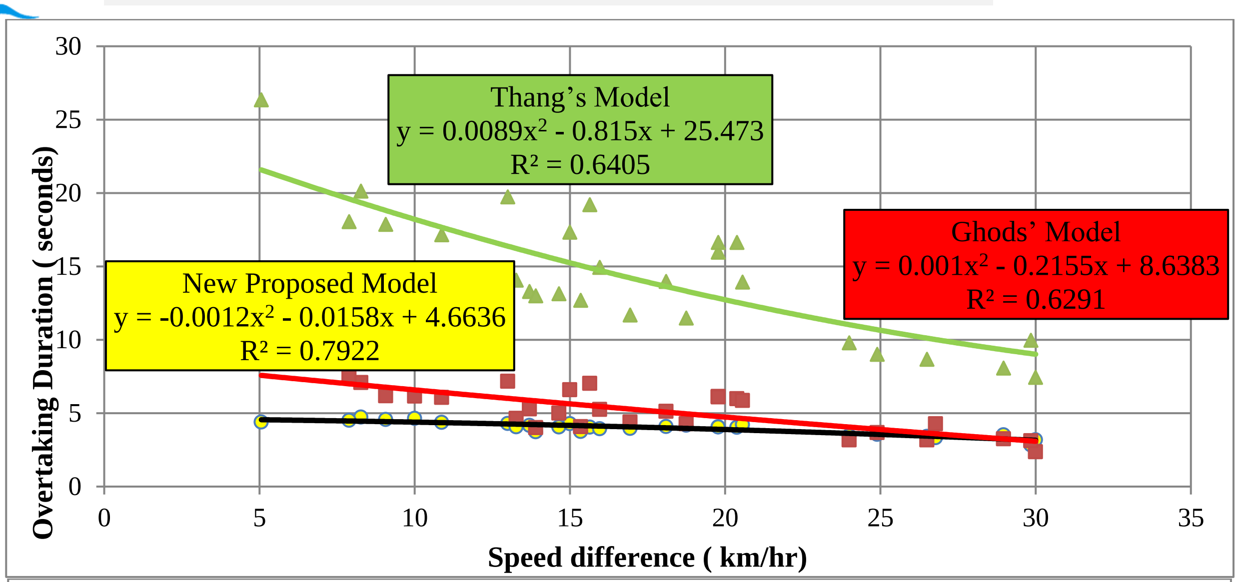
(A)



(B)

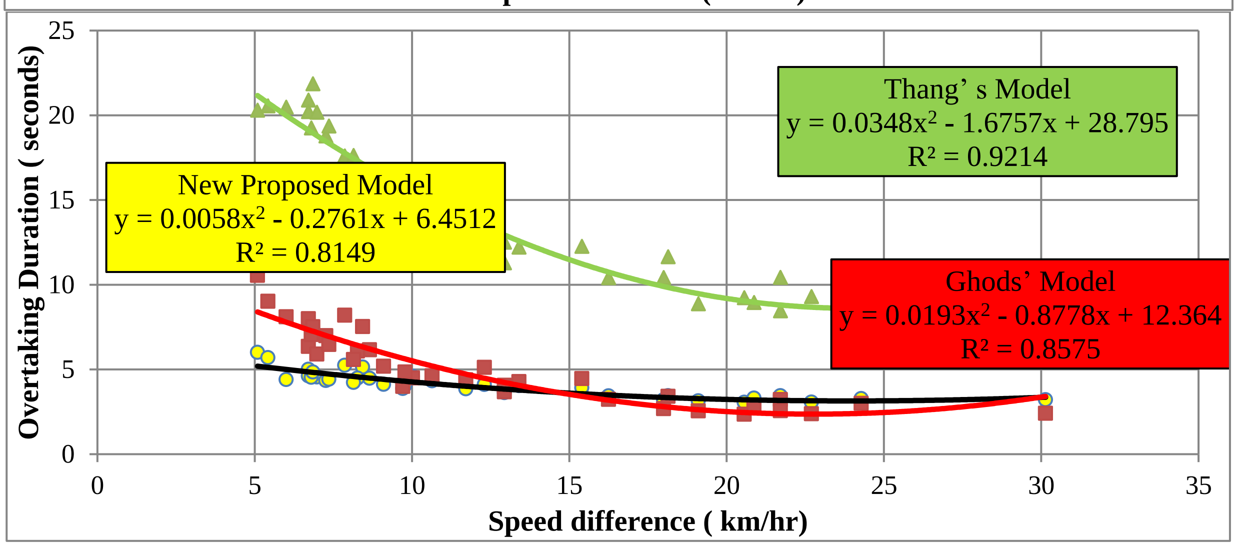


Figure 10: Relationship between SD and overtaking duration for (a) Site S5, (b) Site S6

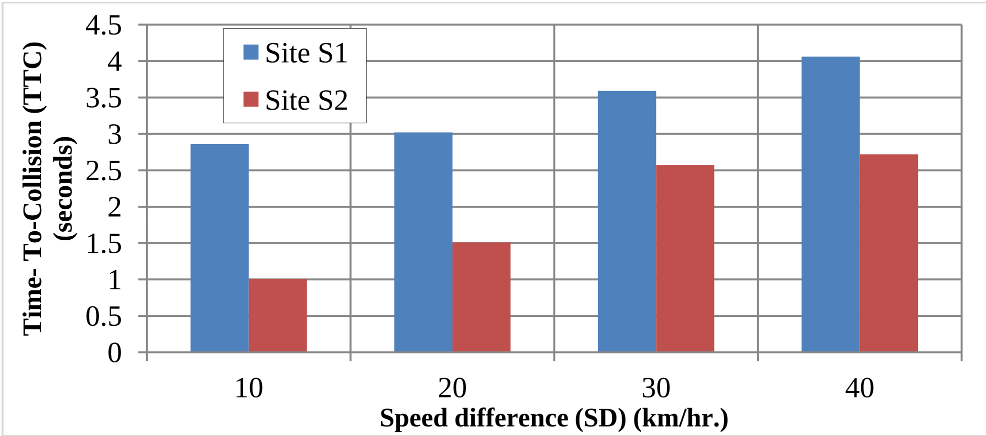


Figure 11: Speed differential sensitivity to TTC for the first two sites (S1 and S2)

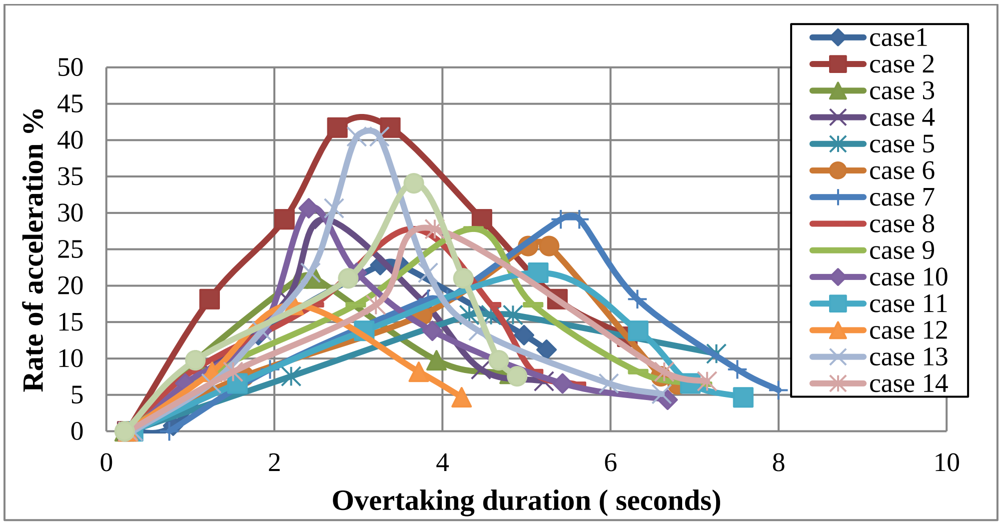


Figure 12: Acceleration profiles during overtaking for a sample of successful overtakes

7- HYPOTHESIS T- TEST BETWEEN FIELD OBSERVATIONS AND OUTPUTS OF THE THREE COMPARATIVE MODELS

Hypothesis t- test is used to compare the average value of two populations at desired confidence level (α level) for small samples. The calculated t- statistic value is based on degree of freedom (DF), sample size, mean and variance of the two tested populations. The t- statistic is compared to the critical t-value that is obtained from t- table (Lyles et al., 2012). Overtaking durations and their corresponding distances obtained from field and outputs of Ghods' and new models are examined using t-test at desired significance level (α=5%). **Table 5** shows the results of t- test for examined measures compared to actual measures for the six studied sites.

Table 5: Results of Hypothesis T-test for the investigated models for the six sites

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parameters	Site S1 Ghods' model Overtaking duration	Site S1 Ghods' model Overtaking distance	Site S1 New Model Overtaking duration	Site S1 New Model Overtaking distance	Site S2 Ghods' model Overtaking duration	Site S2 Ghods' model Overtaking distance	Site S2 New Model Overtaking duration	Site S2 New Model Overtaking distance
t-statistic	4.70	6.89	2.00	1.25	1.16	3.38	1.31	2.04
t- critical	2.07	2.05	2.04	2.04	2.06	2.04	2.06	2.06
decision	Reject H_0	Reject H_0	Accept H_0	Accept H_0	Accept H_0	Reject H_0	Accept H_0	Accept H_0
	Site S3				**Site S4**			
t-statistic	0.59	0.91	0.62	0.81	1.94	1.29	0.59	1.44
t- critical	2.05	2.05	2.04	2.04	2.05	2.04	2.05	2.04
decision	Accept H_0	Accept H_0	Accept H_0	Accept H_0	Accept H_0	Accept H_0	Accept H_0	Accept H_0
	Site S5				**Site S6**			
t-statistic	3.48	2.63	1.99	0.65	2.06	3.34	1.57	2.03
t- critical	2.05	2.04	2.04	2.05	2.05	2.05	2.04	2.05
decision	Reject H_0	Reject H_0	Accept H_0	Accept H_0	Reject H_0	Reject H_0	Accept H_0	Accept H_0

Tang's model will be rejected due to the higher differences between their outputs and actual measures.

8- CONCLUSION

This paper aims to create a new passing gap- acceptance model of vehicles on Egyptian TLTW roads under mixed traffic conditions. Moreover, a comparative study has been applied between Ghods' and Tang's models compared to a new model for estimating overtaking durations and distances under Egyptian conditions. Six TLTW roads "Class II" are studied in Delta region. 20-hour videotaped data were collected. The main conclusions arising out of the study are as follow:

1- The new overtaking gap-acceptance criteria is accepted for most of successful observed overtakes for the studied sites rather than the condition related to TTC mentioned on Ghods' overtaking gap-acceptance model. Then, the two new overtaking gap-acceptance conditions are more representative than the overtaking model used in the OTSIM software for TLTW Egyptian conditions.
2- Exponential function was representative for the relationship between overtaking distances and overtaking durations based on the overtaking model used in the OTSIM software while the average R^2 were around 76.63%. 2nd degree of polynomial function was representative for the relationship between them based on new model and Tang's model while the average R^2 were enhanced to be around 78.71% for the studied sites so, a new overtaking model is more representative than Ghods' and Tang's models for TLTW Egyptian roads.
3- 2nd polynomial function was representative for the relationship between (SD) and overtaking durations based on all three models; the average R^2 were around 65.15 % according to the

overtaking model used in the OTSIM software, 62.04% according to Tang's model while they were enhanced to be around 77.60% based on new model.

4- TTC increases as the SD increases for most of studied sites.
5- Rate of acceleration during overtaking is increased by (30 to 42) % more than that before overtaking.

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