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# Calibration of car-following model for Indian traffic conditions

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**Abstract**

In order to implement transport polices effectively and efficiently on the ground, it is prudent to evaluate such policies using high accurate techniques such as microscopic traffic simulation models. Car-following model is regarded as vital in representing individual vehicle behaviour and highly influences the accuracy of the simulation model predictions. Though, there are number of car-following models available especially for developed countries where the traffic conditions are highly homogeneous in nature. Adopting these car-following models for Indian traffic conditions would result inaccurate estimations and unrealistic evaluation of transport policies due to the existence of highly heterogeneous traffic conditions, different driver behaviour, no lane discipline etc. on the Indian roads. In view of this, an attempt has been made in this paper to develop car-following model for Indian traffic conditions. Accordingly, data of latitude, longitude positions and speed has been collected precisely for each one tenth of second time interval on both urban corridor and non-urban corridor using VBOX equipments which are fitted in both leader and following vehicles. To develop car-following models for Indian traffic conditions, the formulations of standard car-following models namely General Motors (GM) Model and Hidas Model have been considered and accordingly modified car-following models have been developed by calibrating the parameters using the collected data on both urban and non-urban corridors. By comparing the RMSE and MAE values from estimated and observed data, it can be inferred that the developed car-following models are able to estimate the following vehicle accelerations with fair amount of accuracy.


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*Keywords:* Car-following; Microscopic traffic simulation; GM model; Hidas model; Indian traffic conditions; Urban Corridor; Non-Urban Corridor;

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# 1. Introduction

## *1.1. Microscopic Traffic Simulation*

The increasing traffic congestion is a major problem in urban areas that brings with its environmental pollution and accidents because of recent rapid motorization and changes in urban traveler behavior. Transport policies such as Travel Demand Management (TDM) especially encouraging public transport system are most appropriate in managing such situations because they can influence and bring change in urban commuters. However, their expected benefits and impacts must be carefully assessed before they are implemented. It is not always wise to increase the supply in terms of infrastructure facilities etc. to combat traffic congestion. If appropriate management measures/ policies are not implemented, this can make the situation more worse in terms of increasing the number of cars on the urban roads thus increasing congestion and high travel times. Sometimes, the increase in supply of infrastructure facilities can further increase demand, hence proper care must be taken to deal the situation.

Before implementing any transport policy, it is prudent to assess their expected impacts and benefits. The effects of transport policies are generally evaluated by estimating vehicular behavior on the road network under them. In the absence of realistic estimation of vehicle operations under different policy measures, the conventional evaluation techniques may tend to undervalue/ overvalue the policy measures. To overcome these problems in evaluation, the appropriate techniques which estimate the realistic behavior of driver are clearly required. Since two decades, traffic simulation technique has been widely using to analyze and represent the traffic condition of the road or network. Microscopic traffic simulation analysis has received higher attention in the last decade and it has been acknowledged that they are proven tools for aiding transportation feasibility studies. It is mainly because they try to analyze each and every individual vehicle/ driver behavior in a given time interval more precisely and realistically compared to any other method (Barcelo and Casas, 2002). As the microscopic simulation models consider individual vehicle behavior, the outputs are going to be realistic. In microscopic traffic simulation, car-following model is regarded as vital in representing individual vehicle behavior and highly influences the accuracy of the simulation model predictions. Though microscopic simulation is considered as most suitable for these purposes, its accuracy and validity mainly depends on the quality of underlying models of driver behavior in the simulation model.

## *1.2 Need for Indian Car-Following Model*

India being a developing country has been facing many traffic and transport related problems. The use of desirable modes such as walk, bicycle, and public transport is declining and the use of personalized modes namely car and motorised two wheelers is growing day by day. As a result, traffic congestion is increasing and urban mobility as well as road safety is declining on the road networks of India. Hence there is a major requirement to new transport policies which are well scrutinized about their need and suitability for the condition by using varied statistical analysis, review with international practice, accurate and realistic traffic flow models.

In this process of bringing up new policies and plans, the system should have a very accurate and efficient method to make complete assessments of the pros and cons which would occur if the policy is implemented. In another rebound however efficient the policy may be, the behaviour of the driver is the key which is highly random and fluctuating. Primarily, the Indian traffic conditions are typical and have a variety of driver behaviours as there is no proper lane discipline. The traffic in India is basically heterogeneous and has many vehicle types. The driver behaviour is observed to be fluctuating with respect to the road conditions. The Indian drivers tend to maintain very minimal gap with the front vehicle which is unsafe and have chances of rear end collisions and tailgating. Unlike in other countries, where drivers tend to maintain lane discipline, but in India as there are virtual lanes being created and the tendency is to fill up all the gaps and road surface as much as possible. Due to these conditions, the flow increases and reaches maximum in a less period of time. The Indian Driver Behaviour is also slightly aggressive in nature and has a road rage which is also a cause for accidents and tailgating.

In view of the above, an attempt has been made in this paper to develop car-following model for Indian traffic conditions which would consider heterogeneous traffic conditions, different driver behavior, no lane discipline etc.

on the Indian roads. This would in turn expected to enhance the accuracy levels compared to car-following models available especially for developed countries where the traffic conditions are highly homogeneous in nature.

## 2. Car-Following Models

A fundamental and vital component of any microscopic traffic simulation model is car-following model which describes the movement of individual vehicles on the road network. Because of this reason, car-following model highly influences the accuracy of the simulation model predictions. The car-following is a control process in which the driver of the following vehicle attempts to maintain a safe distance between with respect to the vehicle ahead by accelerating or decelerating in response to the actions of the vehicle ahead. Car-following model works basically on the principle of one car being followed by the other car. In general, the tendency of driver is to follow the front car by maintaining a safe following distance. From the origin to the destination, the driver tends to follow many vehicles in the whole of his journey. The vehicle which is being followed is called Leader Vehicle (LV) and the one which follows is called Follower Vehicle (FV). The schematic representation of car-following behavior on a typical road section is shown in Figure 1.

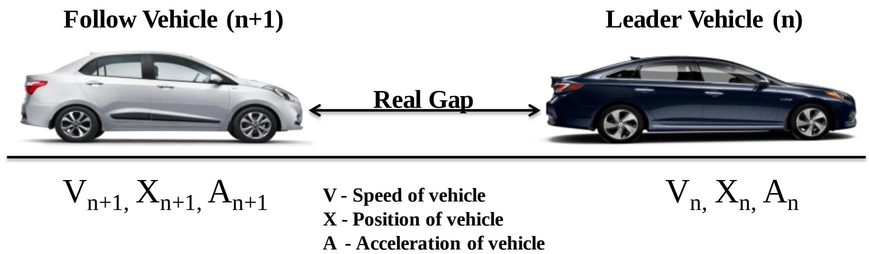



Fig. 1. Schematic representation of car-following behavior and their notations.

Mathematical models of car-following developed in the early 1950s are based on the hypothesis that a following driver adjusts speed according to the stimuli perceived from the leading vehicle. While these models have performed reasonably in many situations, however these were found to be unable to simulate properly the full range of flow conditions usually occurring in urban networks. Since 1950s, the concept of car-following model has come into picture, many researchers have developed their own models which are true to their studied traffic conditions. Some of such models were developed by Gipps (1981), Gazis-Herman-Rothery (GHR, 1959), Chandler, et. al. (1957), Hidas (1998) etc. Among these models, the model developed by Chandler, et. al. (1958) also known as General Motors (GM) car-following model is most famous and is capable of evaluating driver behavior in different traffic conditions which also gives good correlation to field data. This was a simple linear model, in the sense that the response (acceleration or deceleration) of the following vehicle was assumed to be proportional (linear) in the stimuli between the lead and following vehicles. The GM model is most popular of the Car-Following theories because of the following reasons:

1. Agreement with field data, the simulation models developed based on GM car-following models shows good correlation to the field data.
2. Mathematical relation to macroscopic model (Greenberg's logarithmic model) for speed-density relationship can be derived from GM car-following model.

The General Motors (GM) model has proposed various forms of sensitivity coefficient term resulting in five generations of models. The most general model has the form given below.

$$a_{n+1}^{t} = \left[\frac{\alpha\left(V_{n+1}^{t-\delta t}\right)^{m}}{\left(X_{n}^{t-\delta t}-X_{n+1}^{t-\delta t}\right)^{l}}\right]\left(V_{n}^{t-\delta t} - V_{n+1}^{t-\delta}\right) \quad (1)$$

Where,

$a_{n+1}^{t}$ = acceleration of follower vehicle *(n+1)* at a time interval *t* seconds,

$X_{n}^{t-\delta t}$ = position of leader vehicle *(n)* at previous time interval,

$X_{n+1}^{t-\delta t}$ = position of follower vehicle *(n+1)* at previous time interval,
$V_{n}^{t-\delta t}$ = speed of leader vehicle *(n)* at previous time interval,
$V_{n+1}^{t-\delta}$ = speed of follower vehicle *(n+1)* at previous time interval,
$t$ = time lag in seconds,

***l*** is a distance headway exponent and ***m*** is a speed exponent, and ***α*** (alpha) is a sensitivity coefficient. These parameters are calibrated using field data. This equation has become the core of many traffic simulation models.

Hidas (2002) identified that it may be difficult to follow the safe distance by all the drivers that has to be maintained between Follower Vehicle and Leader Vehicle. In fact, drivers tend to follow closer than safe distance in some situations. Furthermore, all the above mentioned models were developed for freeway conditions and therefore are not directly appropriate for more complex urban interrupted flow situations. Hidas model is based on the assumption that when approaching and following a leader vehicle *(n)* at any time *t*, the driver of the following vehicle *(n+1)* attempts to adjust his acceleration so as to reach a desired spacing after a time lag which takes *T* seconds.

$$a_{n+1} = \frac{T}{\varepsilon\alpha_n T + \frac{1}{2T^2}}(V_n - V_{n+1}) \quad + \frac{1}{\varepsilon\alpha_n T + \frac{1}{2T^2}}(X_n - X_{n+1} - \varepsilon\alpha_n V_{n+1} - \varepsilon\beta_{n+1}) + \frac{\frac{1}{2T^2}}{\varepsilon\alpha_n T + \frac{1}{2T^2}} a_n \tag{2}$$

Where,

$a_n$ = acceleration of leader vehicle,
$a_{n+1}$ = acceleration of follower vehicle,
$X_n$ = position of leader vehicle,
$X_{n+1}$ = position of follower vehicle,
$V_n$ = speed of leader vehicle,
$V_{n+1}$ = speed of follower vehicle,
$T$ = time lag in seconds,
*α, β* and *ε* are constants to be estimated from the field data.

In order to calculate the acceleration of the follower vehicle with above equation, the time-lag *T* during which the follower vehicle attempts to reach his desired distance behind the leader must be known. Hidas model has apparently eliminated problems related to the reaction time element. The simulation model such as ARTEMiS has adopted this formulation. Chakraborty and Kikuchi (1999) identified some limitations in these models especially in GM model and emphasised the need of fuzzy logic technique to consider all the approximations and uncertainties involved in car-following behaviour. They have also identified five distinct types of car-following driver behavior, which the traditional GM models ignore as given below:

1. *Approximate in nature:* One of the main features of human decision making and response processes is their inherent approximate nature. This can be attested in many forms and has been long recognized.
2. *Asymmetric response:* Drivers react differently when decelerating and when accelerating. Drivers pay closer attention to decrease in spacing than to increase in spacing simply on the basis of their own safety.
3. *Closing-in and shying away:* When the following vehicle is reasonably behind the leader, the follower accelerates even if leader is decelerating. Such behaviour is seen when follower intends to close-in, situations in which the relative speed is necessarily negative. Similarly if the follower finds itself too close to the leader then the follower decelerates and shies away from the leader, the follower keeps decelerating even though the leader accelerates.
4. *Drift:* The distance headway at which the leader-follower pair stabilizes does not remain constant but oscillates (drifts) around what might be termed as the stable distance headway. This happens because drivers can neither judge the speed of the leader accurately nor can they maintain their own speed precisely.
5. *Stability:* The fact that the distance headway between leader and follower reaches a particular value after a perturbation (to the distance headway) caused by the actions of the leader is referred to as stability in Car-Following behaviour. Note that maintaining particular distance headway implies that the relative speed is maintained at zero.

Errampalli (2008) also developed fuzzy logic based car-following model by identifying the importance of considering parameters of difference in desire speeds, lateral clearance etc. apart from the relative speed and relative distance. However, all these car-following models are developed for homogeneous traffic conditions and not suitable for Indian traffic conditions which are mentioned in previous section. Though there are some researchers who have developed car-following models considering heterogeneity and other Indian driver behavior, these are sometimes site specific and cannot be transferred uniformly to other road sections. Keeping this in view, the development of car-following model has been attempted in the present study and the methodology followed for this has been presented in the next section.

## 3. Methodology and Data Collection

### *3.1. Methodology Adopted*

In the present study, the methodology adopted to develop car-following models for Indian traffic conditions has been shown in Fig. 2. From the Fig. 2, it can be seen that the data collection on selected stretches have been considered at a first step. For this purpose, two types of study stretches have been considered: urban corridor and non-urban road corridor. The V-Box equipment has been installed in both leader and follower vehicles to record their locations with respect to time. In the present study, the time interval of one tenth of a second has been considered. The data on latitude and longitude from the installed V-Box equipment of leader and follower vehicles have been collected and extracted for further analysis. A total of three runs each on urban and non-urban corridors has been carried out with in order to spread the data collection during the time of day. The collected data has been analysed to estimate the position, speed and acceleration of leader and follower vehicles with respect to common time periods. The formulations of GM model and Hidas model has been considered and estimated the parameters by performing non-linear regression analysis in SPSS Software.

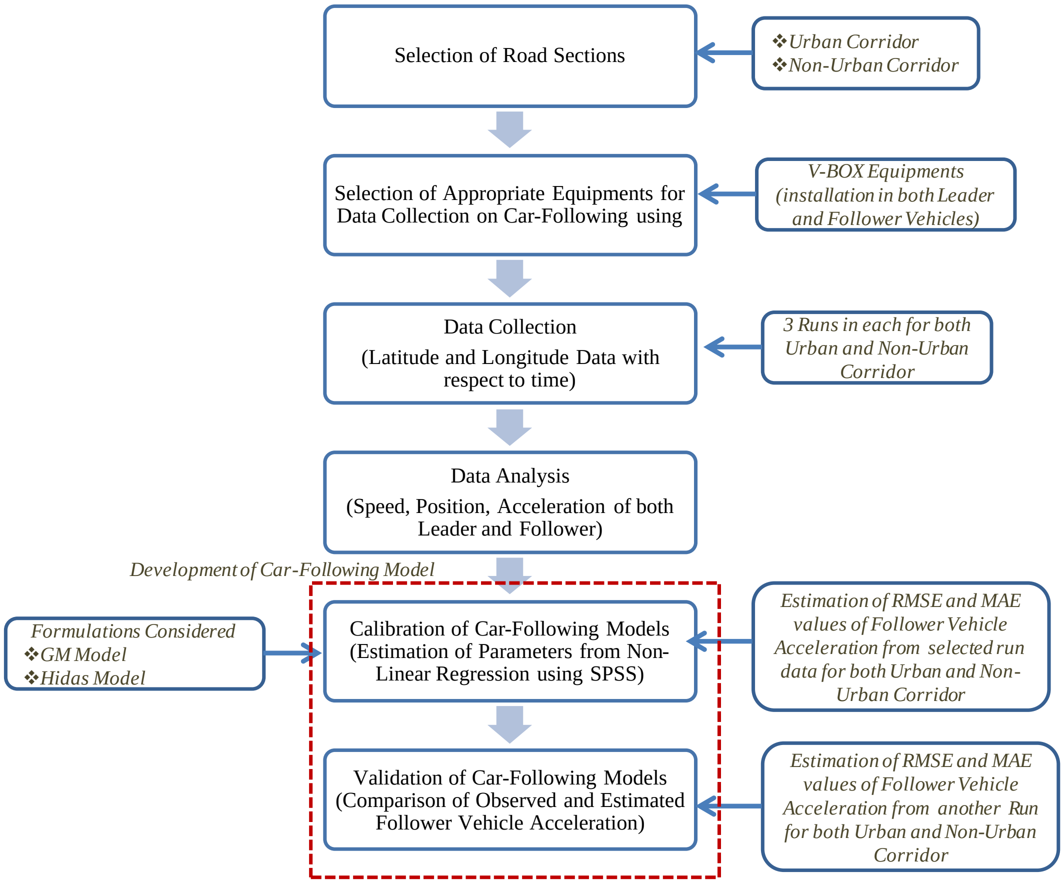



Fig. 2. Methodology adopted to develop car-following model.

The estimated follower acceleration has been compared with observed data by calculating the Sum of Squares ($SS_{Reg}$), Root Mean Square Error (RMSE) and Mean Average Error (MAE) values to determine the performance of the developed car-following models. The validation of the developed models has been done considering other data which is not used for calibration purpose. The typical V-Box equipment that has been used for the data collection is shown in Fig. 3 along with setup of this equipment in leader and follower vehicles.


Fig. 3. Typical V-BOX equipment and its setup in leader and follower vehicle in the present study.

## 3.2. Study Sections

In case of the data collection on urban corridor, the road section from CRRI to Ashram Chowk in South Delhi, India has been selected. This section is a six-lane divided carriageway having 3 km length. The survey has been carried out for both directions by performing a total of three runs. This section has interrupted flow conditions as three major signalised intersections are there. For the purpose of non-urban corridor data collection, the road section from Mahamaya Intersection (Noida) to Pari Chowk (Greater Noida), Uttar Pradesh, India has been selected. This section is a six-lane divided carriageway having 25 km length. The survey has been carried out for both directions by performing a total of three runs. This section has uninterrupted flow conditions as it is fully access controlled carriageway. The location of these study sections are shown in Fig. 4.

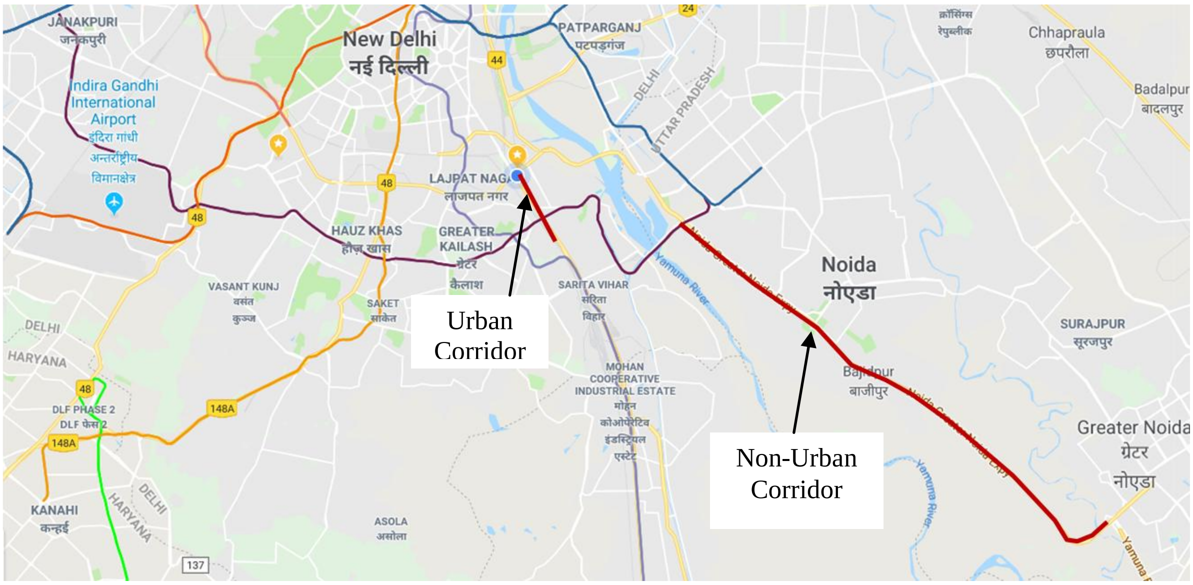


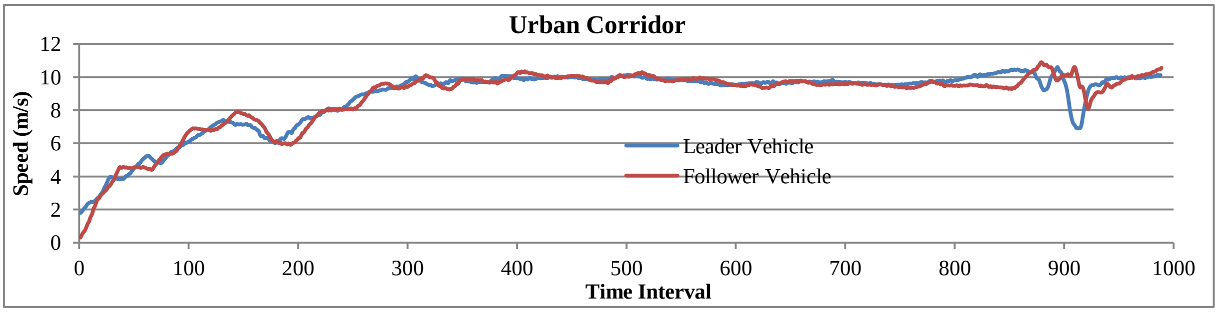

Fig. 4. Location of study sections of urban and non-urban corridors considered for data collection in the present study. (Source: Google Maps)

## 3.3. Data Collection

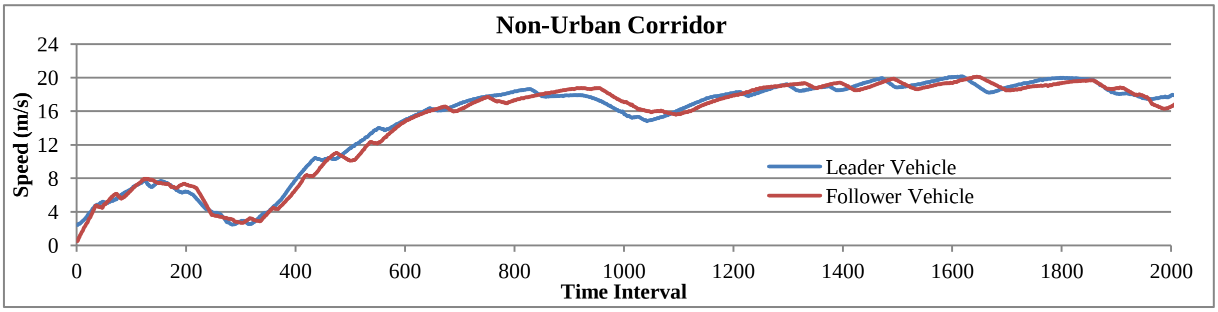
A high accuracy GPS data logging for vehicle testing apparatus called as VBOX (shown in Fig. 3) which is developed by RACELOGIC (UK) has been used for the data collection. It can record high accuracy GPS based speed measurements, distance, acceleration etc. with 0.1 second of precision. This equipment has been setup in two cars (leader and follower) and is made to run successively that is leader car being followed by the follower car in the traffic on the selected corridor. The data extracted is mainly the speeds and positions of the leader and follow vehicles with reference being the time. Data on urban corridor from CRRI to Ashram Chowk for three runs comprising of morning, afternoon and evening time periods has been extracted. The non-urban corridor data collection is done at a stretch from Mahamaya Intersection to Pari Chowk which is 25 km. This road stretch is an Inter Urban Highway which is located in Noida, Uttar Pradesh, India. A total of three runs are done with morning, afternoon, and evening hours in both directions. During the data collection, care has been taken that the distance travelled by the LV is more than FV at any point and coordination between two vehicles has been maintained so that the LV moves first and FV follows. And care also has been taken so that the FV does not lose the LV in the traffic. The LV driver should be instructed to drive in his own way without any influence of the FV. The FV driver is asked to follow the LV by maintaining a safe headway by driving in his own way and not to lose the LV in the traffic.

## 4. Data Analysis

The collected data from the VBOX is extracted by software known as *Performance Box*. From this software preliminary plots between speed versus time, position in each time interval has been extracted. In the data of a run, a stretch of values should be chosen such that the data does not contain values with speed is zero, which would affect the analysis. A typical car-following data from both urban and non-urban has been given in Fig. 5.




(a) Urban Corridor on CRRI - Ashram Chowk Section




(b) Non-Urban Corridor on Mahamaya Intersection - Pari Chowk Section

Fig. 5. Observed speed of leader and follower vehicle on urban and non-urban corridors

## 5. Development of Car-Following Model

### *5.1. Urban Corridor*

As mentioned in the previous sections, for the purpose of development of car-following models, the formulation of GM model and Hidas model have been considered. The extracted values of speed, position and acceleration of both leader and follower vehicles on the selected urban corridor have been considered for development of car-following model. A total of 978 data points have been considered from the total extracted data and utilised for calibration of the model. Initially, standard GM Model has been applied on the field data with standard parameters of *l, m* and *α* which are taken as 0, 0 and 0.17 as mentioned by Chandler, *et. al.* (1957). The Sum of Squares ($SS_{Reg}$), Root Mean Square Error (RMSE) and Mean Average Error (MAE) of Follower Vehicle Acceleration ($m/s^2$) have been calculated using the above parameters which are found to be 681.12, 0.834 and 0.633 respectively. In order to apply this model for Indian traffic conditions to reduce the above error, the calibration of GM model has been carried out and accordingly the parameters are estimated from nonlinear regression analysis using SPSS software. The parameters *l, m* and *α* are estimated utilising observed field data in the software by conducting non-linear regression with option of Sequential Quadratic Programming. The calculated $SS_{Reg}$, RMSE and MAE values from the Modified GM Model are in the range of 643.85, 0.811 and 0.615 respectively. The modified GM Model has brought a reduction of about 3% in these errors. Similarly, the Hidas Model also has been calibrated using the observed field data for the application on Indian traffic condition. For this purpose, SPSS has been utilised and estimated the parameters of *α, β* and *ε* in the model considered from Hidas (2002). Initially, standard Hidas Model has been applied on the field data with standard parameters of *α, β* and *ε* which are taken as 0.46, 1.76 and 1.0 as mentioned by Hidas (2002) and found that the Sum of Squares ($SS_{Reg}$), Root Mean Square Error (RMSE) and Mean Average Error (MAE) of Follower Vehicle Acceleration ($m/s^2$) from the above parameters are in the order of 1205.09, 1.11 and 0.852 respectively. In order to apply this model for Indian traffic conditions to reduce the above error, the calibration of Hidas model has been carried out and accordingly the parameters are estimated using SPSS software where a nonlinear regression analysis has been done. The parameters *α, β* and *ε* are estimated utilising observed field data in the software by conducting non-linear regression with option of Sequential Quadratic Programming. The calculated $SS_{Reg}$, RMSE and MAE values from the Modified Hidas Model are in the range of 1198.01, 1.106 and 0.849 respectively. The modified Hidas Model has brought very insignificant reduction in these errors. The summary of these estimated parameters and evaluation parameters namely $SS_{Reg}$, RMSE and MAE values for different car-following models for urban corridors is given in the Table 1.

Table 1. Estimated parameters from different car-following models for urban corridors and model evaluation parameters.

| Model | Parameter Estimate | Sum of Squares | RMSE Value | MAE Value |
|---|---|---|---|---|
| GM Model | $l = 0$, $m = 0$, $\alpha = 0.17$ (Chandler, *et. al.*, 1957) | 681.12 | 0.834 | 0.633 |
| **Modified GM Model** | **$l = 0.928$, $m = -0.157$, $\alpha = 2.1$** | **643.85** | **0.811** | **0.615** |
| Hidas Model | $\alpha = 0.46$, $\beta = 1.76$, $\varepsilon = 1$ (Hidas, 2002) | 1205.09 | 1.11 | 0.852 |
| Modified Hidas Model | $\alpha = 155.96$, $\beta = -1151.65$, $\varepsilon = 0.012$ | 1198.01 | 1.106 | 0.849 |

From the Table 1, it can be observed that the Modified GM Model would be able to reduce the evaluation parameters namely $SS_{Reg}$, RMSE and MAE values compared to other models and can be applied on Indian traffic conditions to estimate the car-following behavior with fair amount of accuracy. In order to validate the Modified GM Model further, it has been applied on the other 100 data points, which are not been used for calibration and the follower vehicle acceleration has been estimated and compared with observed acceleration as shown in Fig. 6. From the Fig. 6, it can be seen that the trend of the follower vehicle acceleration from Modified GM Model is similar to observed pattern but less variations. Further, the RMSE and MAE values of Follower Vehicle Acceleration ($m/s^2$) for the validation stage are 0.756 and 0.611 which shows that the estimations are relatively accurate.

### *5.2. Non-Urban Corridor*

Similar to urban corridor, the analysis has been carried out for non-urban corridor as well. As there were no separate parameters in the literature for non-urban conditions available, the same parameters of urban areas are used and tested initially. The extracted values of speed, position and acceleration of both leader and follower vehicles on the selected non-urban corridor have been considered for development of car-following model. A total of 13,000 data points have been extracted and utilised for calibration of the model. Modified GM Model is seen predicting efficient results in terms of less error values. The summary of these estimated parameters and evaluation parameters namely $SS_{Reg}$, RMSE and MAE values for different car-following models for non-urban corridors is given in the Table 2.

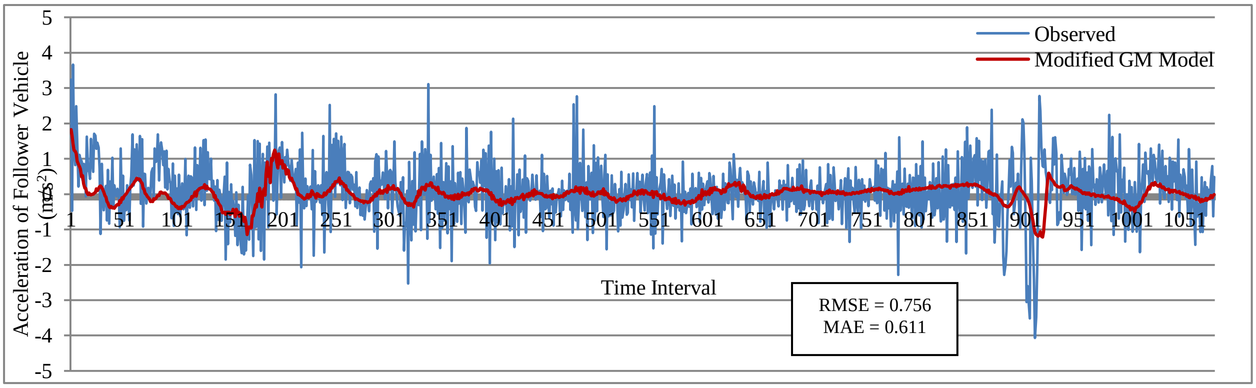



Fig. 6. Comparison of observed and estimated acceleration of follower vehicle for calibration and validation by Modified GM Model for urban corridor.

Table 2. Estimated parameters from different car-following models for non-urban corridors and model evaluation parameters.

| Model | Parameter Estimate | Sum of Squares | RMSE Value | MAE Value |
|---|---|---|---|---|
| GM Model | $l$ = 0, $m$ = 0, $\alpha$ = 0.17 (Chandler, *et. al.*, 1957) | 2605.42 | 0.448 | 0.335 |
| **Modified GM Model** | **$l$ = -0.182, $m$ = -0.537, $\alpha$ = 0.432** | **2584.69** | **0.446** | **0.334** |
| Hidas Model | $\alpha$ = 0.46, $\beta$ = 1.76, $\varepsilon$ = 1 (Hidas, 2002) | 8028.63 | 0.786 | 0.502 |
| Modified Hidas Model | $\alpha$ = 2.473, $\beta$ = -34.187, $\varepsilon$ = 1.569 | 1198.01 | 0.784 | 0.498 |

From the Table 2, it can be observed that the Modified GM Model would be able to reduce the evaluation parameters namely SSReg, RMSE and MAE values compared to other models and can be applied on Indian traffic conditions to estimate the car-following behavior with fair amount of accuracy. In order to validate the Modified GM Model further, it has been applied on the other 6,000 data points, which are not been used for calibration and the follower vehicle acceleration has been estimated and compared with observed acceleration as shown in Fig. 7. From the Fig. 7, it can be seen that the trend of the follower vehicle acceleration from Modified GM Model is similar to observed pattern. Further, the RMSE and MAE values of Follower Vehicle Acceleration ($m/s^2$) for the validation stage are 0.428 and 0.184 which shows that the estimations are relatively accurate.

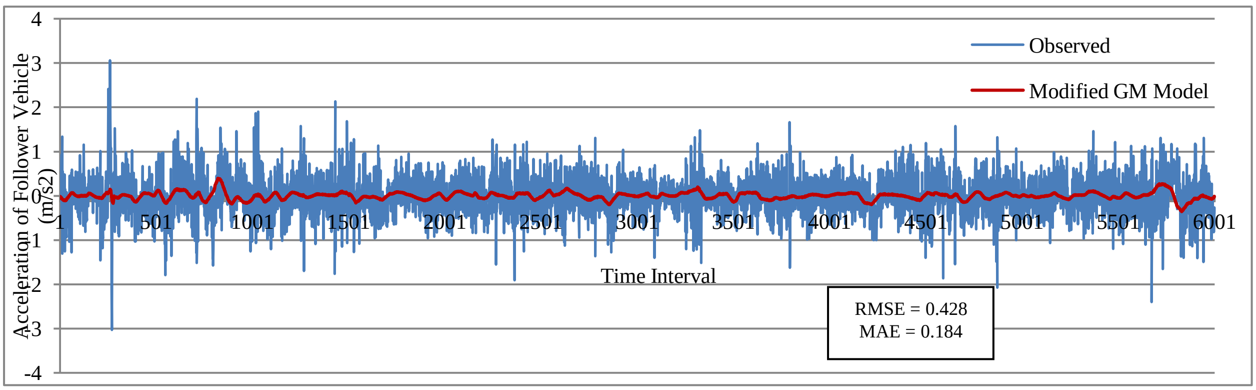
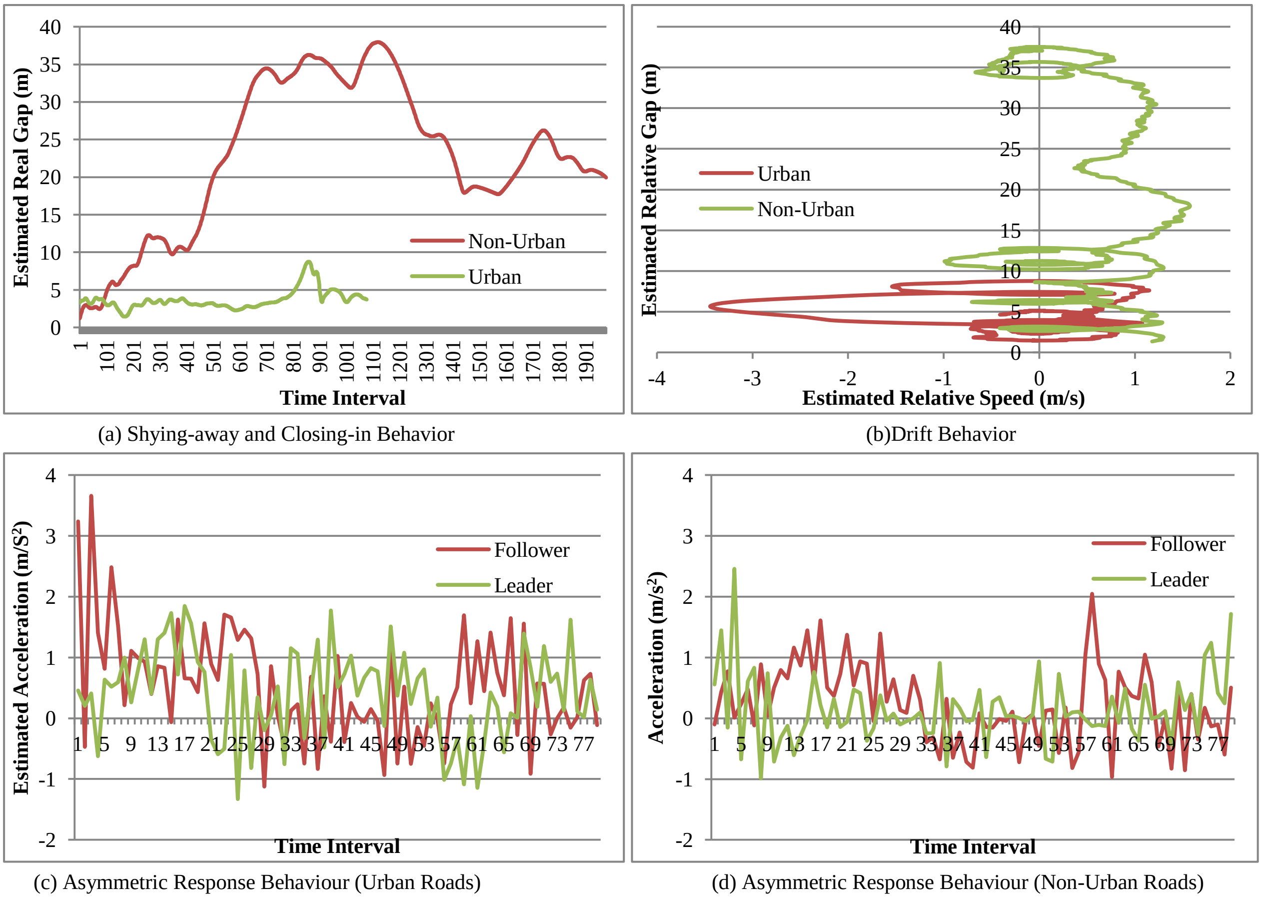



Fig. 7. Comparison of observed and estimated acceleration of follower vehicle for validation by Modified GM Model for non-urban corridor

## 6. Estimation of Car-Following Behavior

As mentioned in the previous sections, the developed Modified GM Model is able to predict the car-following behavior in terms of acceleration of following vehicle with fair amount of accuracy. Utilising the modified GM model, the car-following behavior has been estimated is shown in Fig. 8.




(a) Shying-away and Closing-in Behavior

(b)Drift Behavior

(c) Asymmetric Response Behaviour (Urban Roads)

(d) Asymmetric Response Behaviour (Non-Urban Roads)

Fig. 8. Estimated Car-following behavior from modified GM model.

From the Fig. 8(a), it can be seen that the gap between leader and follower vehicles is continuously varying and not remaining constant. The follower vehicle is accelerating to closing-in and decelerating to shying-away can be observed in Fig. 8(a). The gap maintained by follower vehicle is less than 5 m on urban roads where as it is around 20 m on non-urban roads. In Fig. 8(b), the drift behavior can be observed as relative speed and relative gap are continuously oscillating. In Fig. 8 (c) and (d), the asymmetric response of follower vehicle on urban and non-urban roads can be observed. From these results, it can be reaffirmed that the modified GM model is able to predict the car-following behavior realistically for urban and non-urban roads for Indian traffic conditions.

## 7. Concluding Remarks

### *7.1. Car-following model for Indian Traffic Condition*

On the whole this paper helps to find a realistic car-following model for Indian traffic conditions. The most suited model would be Modified GM model when compared to all other models as it has the least error and is true not only with the change in follower acceleration but also the gap maintenance. The driver behavior can be predicted accurately using the modeled parameters of the Modified GM model for both urban and non-urban corridors. The Modified GM model again promises to be the most popular and efficient model which can fit into multiple situations and traffic flows. Hidas model can also gives good results as error is not very high, although it is capable in predicting driver behavior it is not well suited for Indian conditions.

Adoption of such Car-Following models for the analysis of the transport policy is a key aspect. The individual driver behavior can be known through this model which can increase accuracy in the prediction of the behavior in order to evaluate suitable transport policy.

### *7.2. Applications and Future Work*

This developed Car-Following model has varied applications like evaluation of Driver Reaction Time, Safe Following Distances, Fuel Consumptions, Adaptive Cruise Control, Total Travel Time analysis, Driver Behavior in different weather conditions, Driver Behavior with influence of mobile phone or any intoxication etc. This study can be further applied to assess Driver Reaction Time and to find the Safe Headway for a maximum flow situation. In future research in this subject like new Car-Following formulation for Indian Conditions, Car-Following for different types of vehicle combinations, Car-Following for different types of Indian roads, Car-Following model for rear end collision analysis, Car-Following for Gap acceptance studies, Car-Following for geometric design of roads, Car-Following for congestion studies, Car-Following for pollution and environment assessment, Car-Following for Driving Test etc. can be taken up.

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