

## Chapter 5: Comparing HCM Vs CORSIM Results

One of the critical analytical formulations not found in 85 HCM model is the prediction of speed and volume in the upstream of the ramp. These predictions depend upon several parameters such as the type of ramp (off,on) total upstream freeway volume, ramp volume, length of acceleration lane, anticipatory warning sign distance, advanced warning sign distance, time to change lanes, lag to accelerate and lag to decelerate and freeflow speed of the ramp. The freeflow speed is dependent upon the geometric characteristics such as angle of convergence, superelevation, degree of curvature etc. The 85 HCM can't address these parameters or other factors, which are relevant to weaving operations.

Thus, in assessing the applicability of CORSIM to an existing model in 85 HCM. Several parameters need to be studied. The following section describes about the various default values used in CORSIM and their sensitivity analysis.

### 5.1 Observations:

On Simulating the above data set using the Corridor Simulator for fifteen minutes, in general the following results were observed

- Lots of vehicles (40%) were missing destinations. By this we mean that vehicles that are coming from the on-ramp and trying to merge onto the mainline could not complete the maneuver and hence are missing destinations and therefore being reassigned.
- Average weaving speed and non weaving speed was found to be higher in the simulation model than in the HCM

### 5.2 Model Calibration:

As there are no field data available to calibrate the simulation model, we use the HCM results as a baseline and try to calibrate the simulation model based on the HCM results. Although this approach is not recommended, it is only used for testing the model validation for this particular experimental study.

Based on the observation above it can be noted that there are lots of vehicles missing destinations (40%). Most of vehicles that are missing destinations are originating from the ramp and are trying to merge onto the mainline. Moreover the speed in the auxiliary lane cannot be faster than the speed in the main lanes. Hence the model needs to be calibrated. In calibrating the model, we varied several variables such as off ramp warning sign distance, lag to accelerate, lag to decelerate, lane change maneuver time etc and showed their impacts on shortcomings found earlier.

#### 5.2.1. Off-ramp Warning Sign Distance in CORSIM

The function of the off ramp warning sign in CORSIM is to inform the vehicle to move to the proper lane given that a safe gap exists on their candidate lanes. CORSIM begins with the assumption that the warning sign for the vehicles upstream instructs the vehicles that there is an on ramp and people are merging. The default value used in CORSIM is 2500ft. Various other internal parameters such as driver characteristics, time required to maneuver to correct lane etc. control the driver aggressiveness in lane changing, resulting in lane distribution based upon individual behavior at points downstream.

To test the logic of the simulator, a series of scenarios described earlier, i.e. figure 4-2 through figure 4-5 were used. Other values used in the simulator were retained to be default. The warning sign distance was varied from 2500ft to 9000 ft to investigate

the effect of the warning sign on the merging vehicles. figure 5-1 and figure 5-2 illustrates the results of warning sign distance effect for the different cases simulated.

As illustrated in figure 5-1, as the warning sign distance increases, the number of vehicles being reassigned decreases. This is because, as the warning sign distance increases, the vehicles are given more time to perform lane change. Hence the anticipation of the vehicles to change lanes in the upstream of the freeway much earlier to the ramp increases. This enforces the fact that as the warning sign distance increases, the number of vehicles missing with destinations reduces therefore the speed also reduces. However figure 5-2 shows changes in warning sign distance predicts an abnormal behavior. This is due to the fact that the driver reactions to a warning sign are very different. Not every driver passing the warning sign will move to his/her candidate lane even if there is a safe gap. As the vehicles pass the warning sign, most vehicles try to move to the right lane as the risk value assigned to them are very low. As the concentration of vehicles increases in the right lane, the probability of number of vehicles trying to merge decreases. In addition this abnormal behavior is may be due to the fact that in reality there may be more than one warning sign providing specific ramp information. Thus in real world, lane changing activities may be distribute very differently from what is being reported in CORSIM.

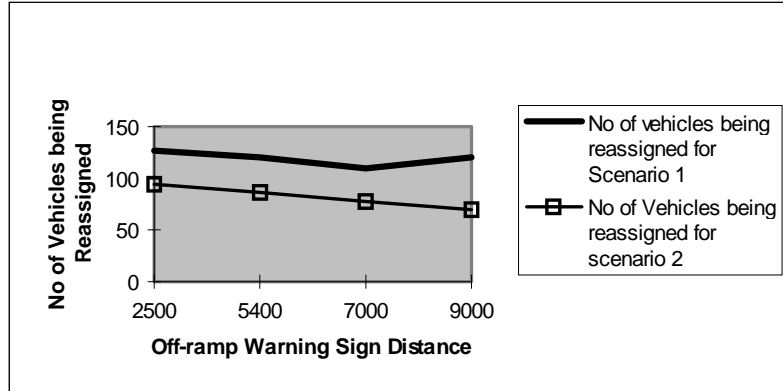
In real world situations the off-ramp warning sign usually starts a mile (1985 HCM) before the vehicle has to exit or before the vehicle realizes that it has to merge. This value is set at 5280 ft, which is roughly equivalent to one mile.

### **5.2.2. Lag To Accelerate and Lag to Decelerate**

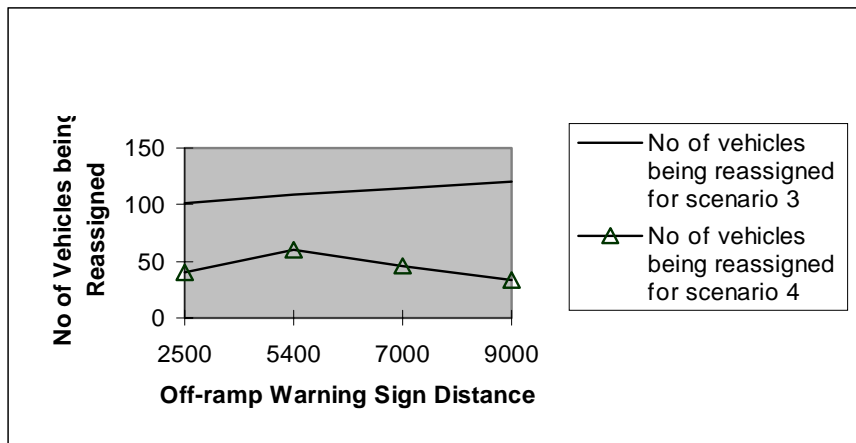
Lag to accelerate/decelerate are defined as the time lag required by the drivers to accelerate/decelerate when making required maneuvers. The changes in lag time affects the safe distance kept between a pair of vehicles. Thus the freeway capacity will be influenced by this factor under the reason: if the response lag time is long, the safe distance kept for avoiding collision between the vehicle is long and hence the vehicle density will be reduced. On the other hand as the response lag time is short, the freeway capacity increases and hence the number of vehicles being reassigned (vehicles from the mainline to the on-ramp) decreases. The default value used in CORSIM for is 0.3 sec for lag to accelerate and 0.3 sec for lag to decelerate. These values are varied from 0.3 sec to 0.1 sec to test the sensitivity of the parameter. The variation in the parameter to 0.1 second is agreeable because, when a driver is desperate to change lanes, the time require to accelerate or decelerate is very less.

To test the logic of the simulator, a series of scenarios described earlier, i.e. figure 4-2 through figure 4-5 were used. Other values used in the simulator were retained to be default. The lag to accelerate/lag to decelerate was varied from 0.3 sec to 0.1 sec to investigate the effect of the response lag time on the merging/diverging vehicles. figure 5-3 and figure 5-4 illustrates the results of response lag time effect for the different cases simulated

As illustrated in figure 5-3 as the response lag time decreases, the number of vehicles being reassigned decreases. This is because, as the lag to accelerate decreases the reaction time required for vehicles to accelerate and merge with the mainline or to change lanes increases. As "Lag to decelerate" decreases, the reaction time for the vehicles to decelerate and merge onto the auxiliary lane to exit to the ramp increases and



**Figure 5-1: Graph between off-ramp warning sign distance and number of vehicles being reassigned**



**Figure 5-2: Graph between off-ramp warning sign distance and number of vehicles being reassigned**

so vehicle maneuvers happen easily. However figure 5-4 shows changes in response lag time predicts an abnormal behavior. This is due to the reason that response lag time varies with various situations. Hence a change in response lag time may impact several modules like adjusting vehicles max. acceleration and deceleration rates , adjusting the driver reaction time etc

In order to test the most sensitive parameter among the “lag to accelerate ” was kept the same (0.3 sec) and “lag to decelerate ” was decreased to 0.1 sec .It was observed that there was no change in the number of vehicles being reassigned. The same test was repeated with “lag to accelerate” to be 0.1 sec and the “lag to decelerate” to be 0.3 sec . The results clearly showed that the number of vehicles being reassigned drastically reduced. This is due to the fact that ,on closer observation of the output, the vehicles being reassigned were those vehicles, which were emerging from the on- ramp. Hence by increasing the response time i.e. “lag to accelerate”, more vehicles were able to merge onto the mainline .

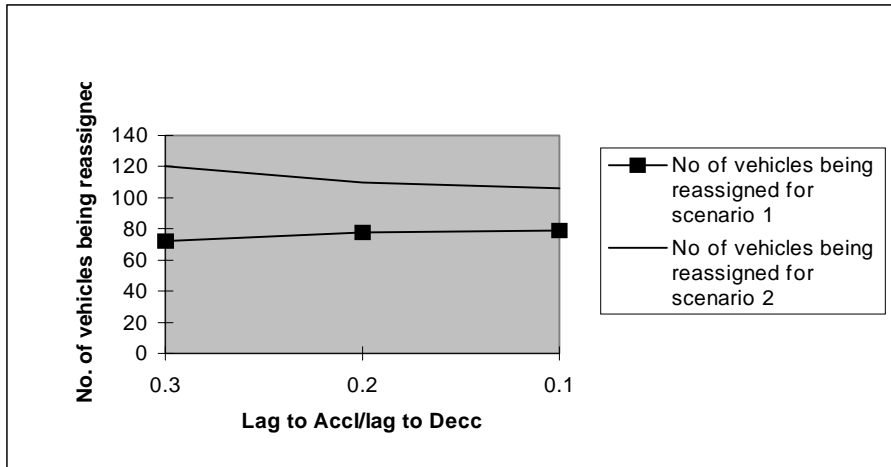
The above observation clearly shows that on simulation of all the scenarios mentioned the vehicles that are being reassigned are emerging from the ramp. In order to decrease the number of vehicles being reassigned, the response lag time parameter (“lag to accelerate”) is decreased while the other parameter (“lag to decelerate”) is retained to be the default value.

In real life scenario , we know that vehicles on all the lanes tend reduce speed in anticipation to a vehicle merging . When the reaction time for acceleration is decreased , it means that vehicles are going to merge easily from the auxiliary lane. When the reaction time for the deceleration is decreased then the vehicles tend to accelerate in anticipation of vehicles trying to merge onto the mainline. So the possibility of lots of vehicles missing destination increases. Hence a value of 0.1 for “lag to accelerate” and a value of 03 (default) for “lag to decelerate” is used

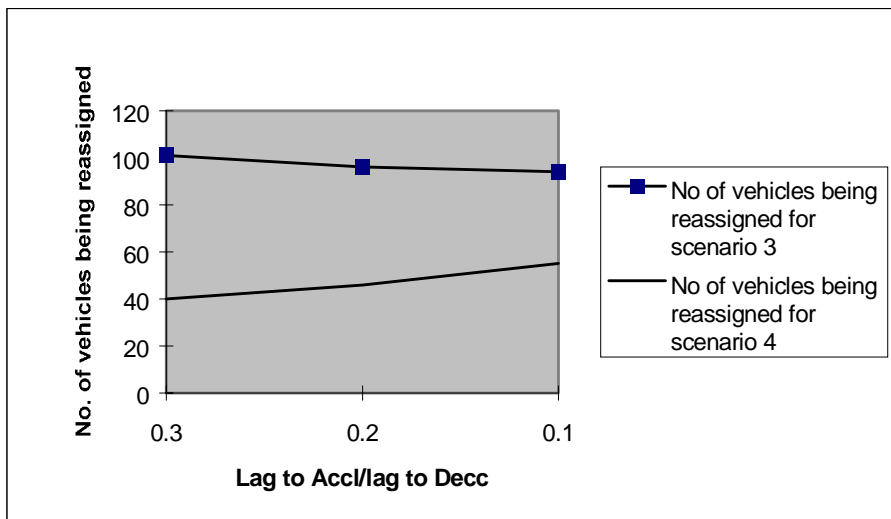
### **5.2.3 Maneuver Time**

Maneuver time is defined as the time required to complete a lane change maneuver. During this period the vehicles are allowed to operate in unsafe mode. By increasing the maneuver time implies that the driver is becoming very aggressive. The default value used in CORSIM is 3 sec. This value is specified in record type 70 in FRESIM.

To test the logic of the simulator, a series of scenarios described earlier, i.e. figure 4-2 through figure 4-5 were used. Other values used in the simulator were retained to be default . The maneuver time was varied from 3 sec to 1 sec to investigate the effect of the time required to change lanes on vehicles merging/diverging. Figure 5-5 and Figure 5-6 illustrate the results of changes in maneuver time effect for the different cases simulated.



**Figure 5-3 : Graph between lag to Acc/lag to Dec and number of vehicles being reassigned**



**Fig 5-4 : Graph between lag to Acc/lag to Dec and number of vehicles being reassigned**

As illustrated in figure 5-5, as the maneuver time decreases, the number of vehicles being reassigned decreases. This is because as the maneuver time decreases, the time required to change lanes decreases. A vehicle would change lanes only if the gap in the lane adjacent to the auxiliary lane is greater than the critical gap. Mathematically speaking the gap required to change lanes is equivalent to critical gap plus the lag to decelerate/accelerate. So by decreasing the time required to change lanes the probability of gap acceptance can be increased whereby no of vehicles being reassigned can be reduced. Hence the number of vehicles trying to merge from the on -ramp to mainline increases and so the freeway capacity increases. Figure 5-6 illustrates similar results to Figure 5-5. This enforces the fact that as the maneuver time decreases, the number of vehicles being reassigned decreases. In addition, on observation of Figure 5-6, an abnormal behavior to changes in maneuver time is also observed. This is due to the changes in maneuver time are different. The Driver reactions are based on several other parameters like lag to accelerate/ lag to decelerate, geometric characteristics etc.

In real world situation not every driver is aggressive. However since a comparative analysis is being done between HCM and CORSIM, the maneuver time is set to 1 sec. In addition the HCM does not describe the behavior of the driver. So we assume that the driver is very aggressive and hence a maneuver time of 1 sec is used.

#### **5.2.4 Percentage of Drivers yielding to lane Change**

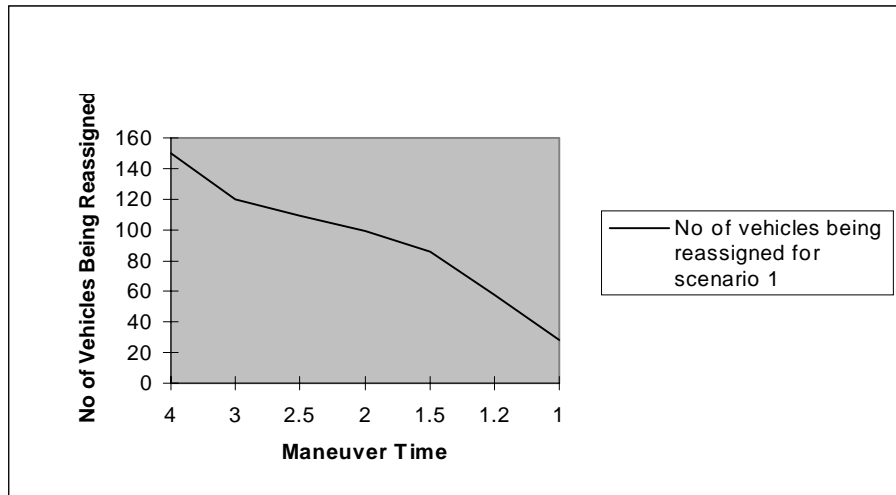
The percentage of cooperative drivers who will yield their right of way for the vehicle is allowed to be specified in card type 70 in CORSIM. The logic behind this states that if there is a vehicle trying to change lanes, the cooperative driver code of its putative follower will be checked. If a vehicles putative follower is a cooperative driver, the vehicle will have a bigger chance shifting from its desired lane. The default value used in CORSIM is 20%.

To test the logic of the simulator, a series of scenarios described earlier, i.e. Figure 4-2 through Figure 4-5 were used. Other values used in the simulator were retained to be default. The driver yielding percentage was varied from 20% to 100% to investigate the effect of the driver yielding characteristics on the merging vehicles. Figure 5-7 and Figure 5-8 illustrate the results of driver yielding characteristics effect for the different cases simulated

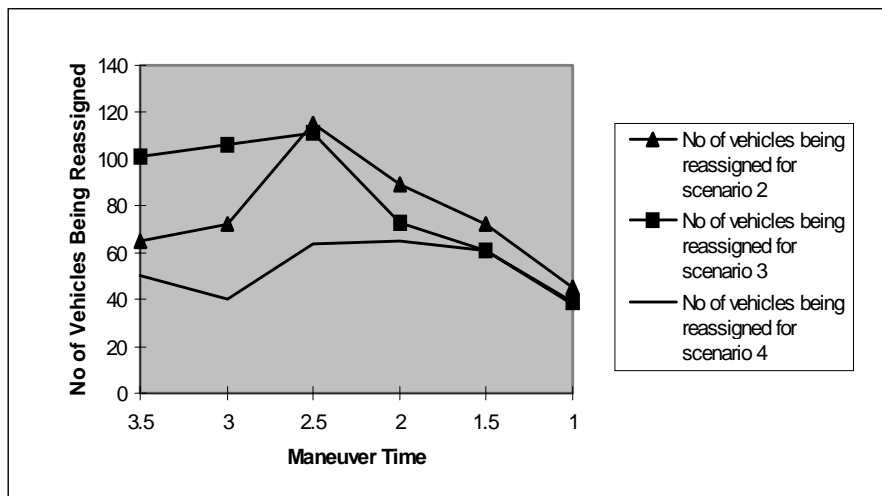
As illustrated in Figure 5-7, as the percentage of vehicles yielding to lane change increases the number of vehicles being reassigned increases. Theoretically speaking, as the percentage of cooperative drivers increases, the total number of lane change increases. So the number of vehicles being reassigned decreases. Figure 5-8 also illustrates results similar to Figure 5-7. This abnormal behavior is may be due to the fact that percentage of cooperative drives is implemented in every link. This percentage cannot reflect the heterogeneous condition of the driver type characteristics.

Another reason for the abnormal behavior is the risk value. The Risk value assigned to each lane changer is arbitrary. This value is constrained by maximum deceleration rate for emergency (-10 ft/sec) and that for non-emergency (-8ft/sec).

Moreover a program bug is also detected. According to the current logic if the vehicle meets a cooperative driver in the adjacent lane, the value assigned to cooperative driver is -10 otherwise it is -8. However in the current version of the program, this value of -8 ft/sec is assigned to the cooperative driver.



*Figure 5-5: Graph between maneuver time and number of vehicles being reassigned*



*Figure 5-6: Graph between maneuver time and number of vehicles being reassigned*

In real world situations not all drivers are cooperative. The regression models used in HCM does not describe about the driver yielding characteristics. So to override the program bug the default value of 20% is used.

#### **5.2.5 : Desired Free Flow Speed:**

The desired freeflow speed means unimpeded freeflow speed that a driver would like to attain in absence of any impedance due to other vehicles or control devices (85 HCM). This information is required to be specified for every link in card type 20 of CORSIM. A vehicle specific desired freeflow speed is defined as the ratio of vehicle freeflow speed and link desired freeflow speed. This speed is determined when the vehicle enters the link

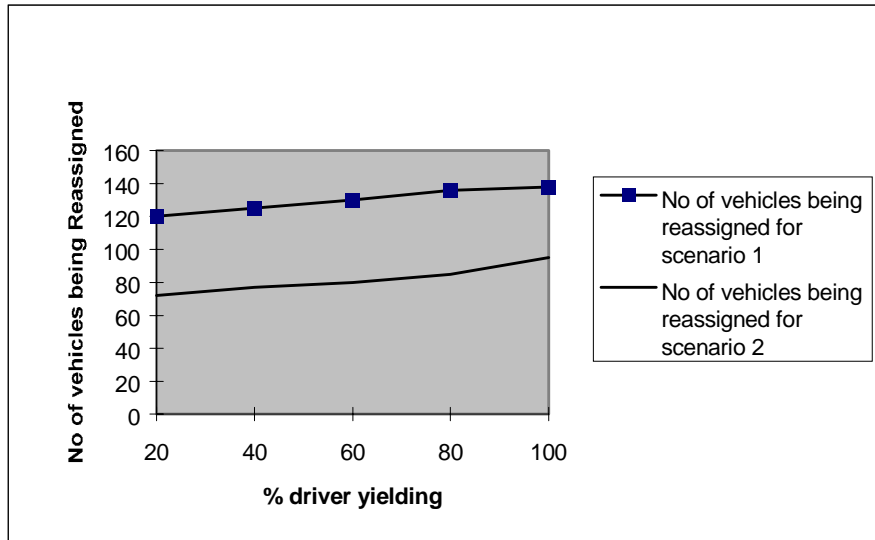
To test the logic of the simulator, a series of scenarios described earlier, i.e. Figure 4-2 through Figure 4-5 were used. Other values used in the simulator were retained to be default. The freeflow speed was varied from 55mph to 65 mph to investigate the effect of speed on the lane changing vehicles. Figure 5-9 and Figure 5-10 illustrates the results of freeflow speed effect for the different cases simulated.

As illustrated in Figure 5-9 ,as the freeflow speed decreases the number of vehicles being reassigned also reduces. In addition an abnormal behavior is also observed. This could be due to the fact that the vehicle specific freeflow speed is a ratio and is calculated based on a vehicle desired freeflow factor, which is fixed as 0.88 to 1.12 for driver types 1 to 10. Moreover according to the design of the simulation model the vehicle desired freeflow speed factor is only suitable for either a 55 mph speed limit or a 65mph desired freeflow speed limit. Figures 5-10 also illustrates similar results to Figure 5-9.

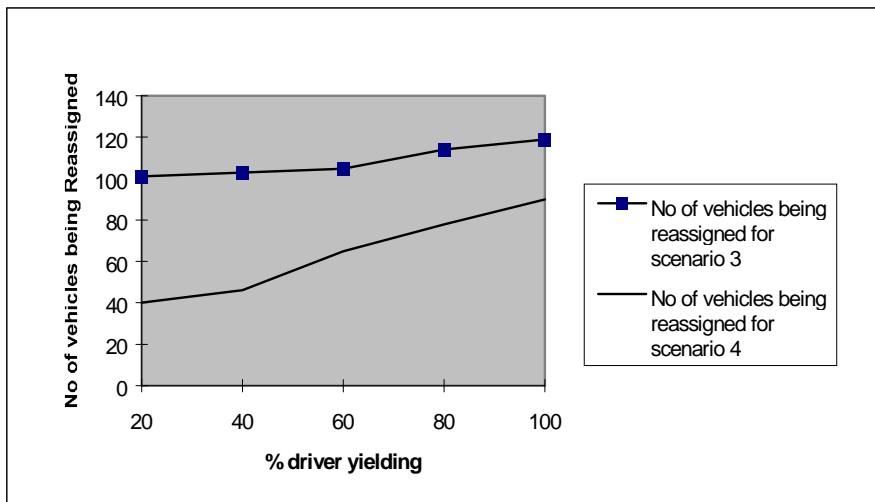
Another reason for an abnormal behavior is due to the fact that the link desired freeflow speed is fixed at all times. Due to this deficiency in the model, the model cannot simulate many situation related to real world traffic operations such as work zones or freeway segments with variable speed signs etc. In addition, if a freeflow speed of 60 mph is specified, the software releases vehicles onto the freeway by following an uniform distribution. However in a real world case there can never be an uniform distribution of vehicles on the freeway. So it is impossible to predict the variation of speed with the number of vehicles being reassigned.

In the Highway Capacity Manual the calculations have been based on large data collected over a large number of years and the speed on the freeway assumed there is 65 mph and the speed on the ramp is 45 mph. Even in real life scenario we know that freeway freeflow speed is 65mph while the ramp speed is 45 mph depending on geometric conditions. Since an comparative analysis is being done, the data set is simulated for a freeflow speed of 65 mph and a ramp speed of 45 mph.

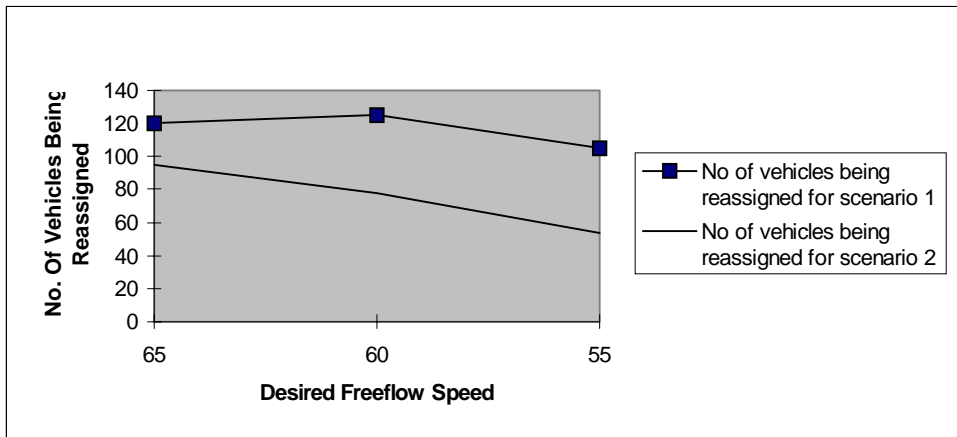




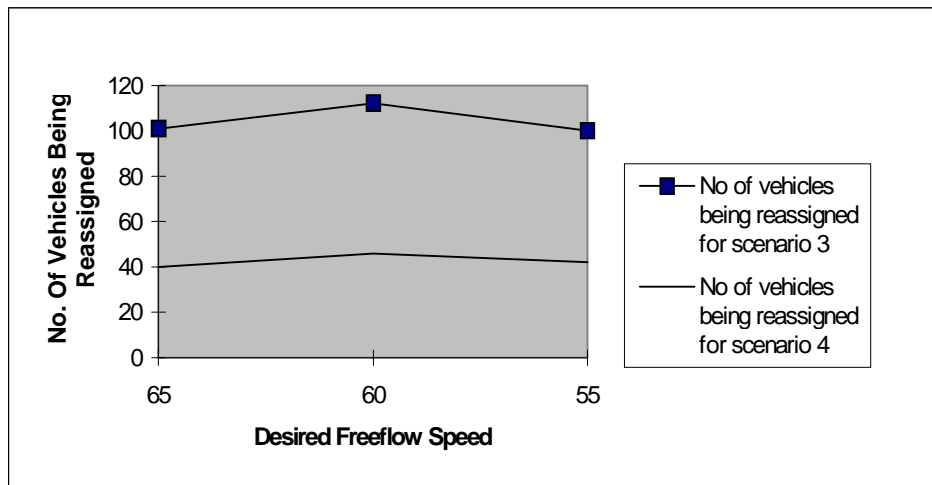
**Figure 5-7 : Graph between percentage of drivers yielding and number of vehicles being reassigned**



**Figure 5-8 : Graph between percentage of drivers yielding and number of vehicles being reassigned**



**Figure 5-9 : Graph between desired freeflow speed and number of vehicles being reassigned**



**Figure 5-10 : Graph between desired freeflow speed and number of vehicles being reassigned**

### **5.2.6: Lane Distributions in FRESIM**

FRESIM begins with an assumption of equal distribution of vehicles among available lanes. The simulator inputs vehicles on this basis. This information can be inputted for the entry link in card type 50 in CORSIM.

To test the logic of the simulator, a series of scenarios described earlier, i.e. Figure 4-2 through Figure 4-5 were used. Other values used in the simulator were retained to be default. The volume on lane number 1 was varied from 10% to 90 % to investigate the effect of the lane distribution on the merging vehicles. Figure 5-11 and Figure 5-12 illustrates the results of lane distribution effect for the different cases simulated.

As illustrated in Figure 5-11 and Figure 5-12, not all scenarios react in the same way to volume variations. One of the probable reasons for this abnormal behavior is the geometric characteristics of the model. The results observed from the figures clearly suggest a degree of randomness to the process of lane distribution as the trends are neither uniform nor consistent. In addition these illustrations also indicate that CORSIM does not consistently indicate this type of behavior.

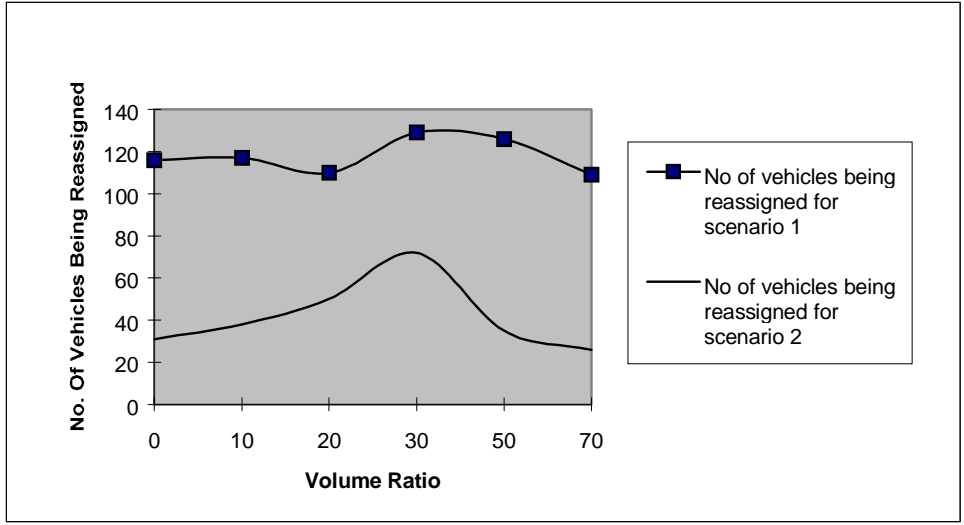
In real life scenario it is not possible to have uniform distribution of vehicles in each lane. Rather the number of vehicles in the other main line lanes will be more than lane number 1. This is due to the fact that conventional wisdom indicates that vehicles tend to move away from the on-ramp junction and only those vehicles who have off-ramp destinations are in lane number 1.

Also Another reason for an uniform distribution not possible is due to the fact that more people would like to travel faster to reach their destination than to avoid being slowed down because of ramp merge or ramp diverge. Hence an volume distribution of 20% in lane 1 and an uniform distribution is assumed in the other main lanes. This percentage is used because of the fact that, on simulation these volume percentages give the lowest number of vehicles being reassigned.

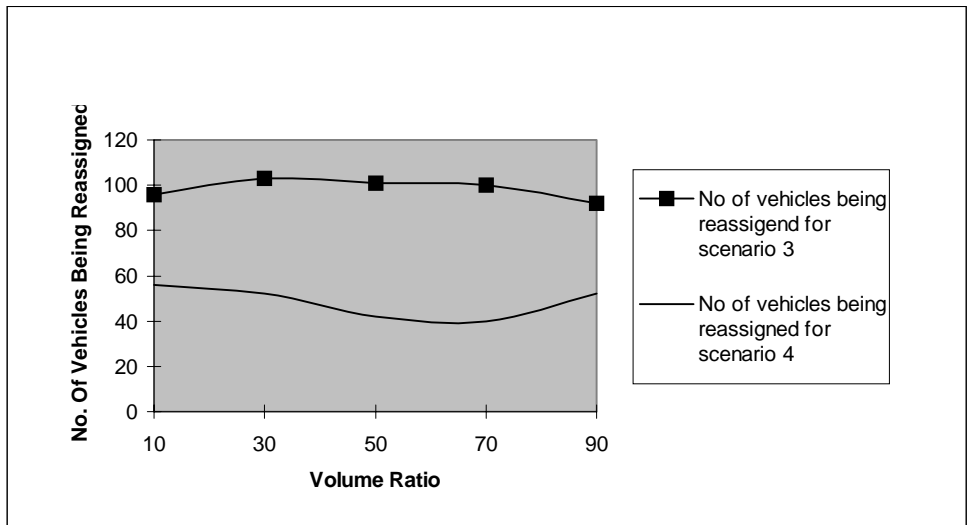
### **5.2.7 Sensitivity factor for car following:**

The car following sensitivity factor are defined by a set of time gaps representing the minimum gap returning between a vehicle and its leader. The default values of car following sensitivity factors are (1.5, 1.4, 1.3, 1.2, 1.1, 1.0, 0.9, 0.8, 0.7, 0.6) seconds for driver types from 1 to 10 respectively. The values of the car following factors can be modified by users through card type 68. During simulation, the vehicle operations will not violate these values. The vehicle will accelerate until its desired free flow speed or the minimum time gap is reached.

To test the logic of the simulator, a series of scenarios described earlier, i.e. Figure 4-2 through Figure 4-5 were used. Other values used in the simulator were retained to be default. The car sensitivity parameter was varied from 1 sec to 2.3 sec to investigate the effect of the sensitivity of car following parameters on the merging vehicles. This variation in value is done while maintaining the same distribution shape as the default. Figure 5-13 and Figure 5-14 illustrate the results of car sensitivity parameter effect for the different cases simulated.



**Figure 5-11 : Graph between volume ratio and number of vehicles being reassigned**



**Figure 5-12 : Graph between volume ratio and number of vehicles being reassigned**

As illustrated in Figure 5-13 it can be easily observed that as the sensitivity parameter increases, the number of vehicles being reassigned decreases. This is because by definition, car following parameter is the drivers desire to follow the car in front of them at a given value of time headway between them. In addition as the time headway increases between the leader and the follower the gap between the vehicles increases. After increasing the sensitivity parameter, if the distance traveled by each vehicle is measured, the distance traveled reduces. We know speed = (distance traveled) / (time). As the sensitivity parameter increases, the distance traveled by an vehicle during same time reduces, hence the speed decreases. As speed of the vehicle decreases, the vehicles merging capabilities increases and so the number of vehicles being reassigned decreases. Figure 5-14 illustrates results similar to Figure 5-13.

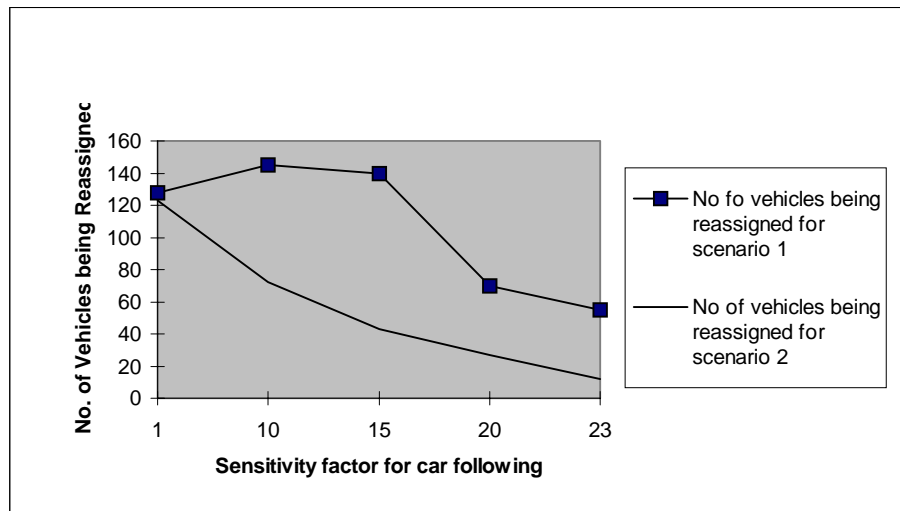
In the real world, driver behaviors vary with different situations. For example, the time gap between the vehicles is not a constant over time and space. Although the sensitivity factor varies with driver code, variation with other factors like incident areas, work zones etc. is not taken into consideration. Therefore, the car following sensitivity factor is suggested to be link specific, time varied and level of congestion dependent. Since there is no mention of the time headway between the car follower and the leader in HCM we assume the default case of 1 sec.

### 5.3 Analysis of Result:

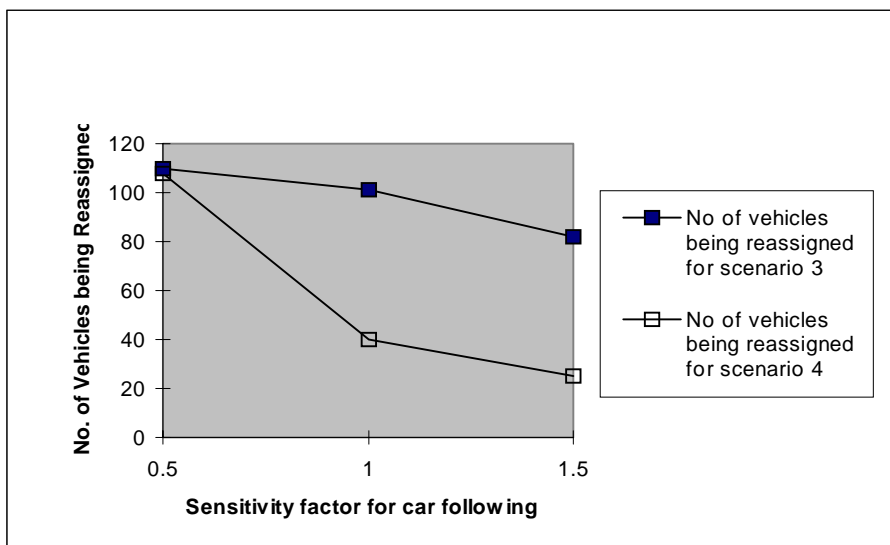
Simulations results were obtained when other parameters like vehicle separation, mean startup delay time etc. used in Table 4-1 were varied from their default value. This suggests that the number of vehicles being reassigned is not affected by maximum deceleration rate, minimum vehicle separation and mean startup delay time. Table 5-1 includes both the default and altered values. These altered values were used to execute the model.

**Table 5-1 : Default Values in CORSIM Vs Changed Values**

| Description                                | Default Values | Altered Values        | Record Type |
|--|----------------|-----------------------|-------------|
| Maneuver Time (Sec)                        | 3              | 1                     | 70          |
| Sensitivity factor for car following (sec) | 1              | 1                     | 68          |
| Driver Yielding Percentage                 | 20%            | 20%                   | 70          |
| Lag To accelerate (sec)                    | 0.3            | 0.3                   | 69          |
| Lag to Decelerate (sec)                    | 0.3            | 0.1                   | 69          |
| Minimum Vehicle Separation (sec)           | 0.2            | 0.2                   | 70          |
| Desired Free Flow Speed (mph)              | 65             | 65                    | 20          |
| Off-ramp Warning Sign Distance (ft)        | 2500           | 5400                  | 20          |
| Mean Startup delay (sec)                   | 1              | 1                     | 20          |
| % of Vehicles in each lane                 | Uniform        | 20%(ln1), 40%(ln 2&3) | 50          |



**Figure 5-13 : Graph between sensitivity factor for car following and number of vehicles being reassigned**



**Figure 5-14 : Graph between sensitivity factor for car following and number of vehicles being reassigned**

### 5.3.1 Observations:

After simulating the data set with the altered values using the Corridor Simulator model (CORSIM) for fifteen minutes, the following results were observed:

- The number of vehicles being reassigned decreased to less than 2%.
- Average weaving speed and non weaving speed were observed to be higher on comparison with HCM

Although the percentage of vehicles are being reassigned is small (<2%), another simulation were made using the changed parameters by varying random seed number in record type 02 in the FRESIM of the input data set and it was observed that there was no change in the output. This may be due to the simulation logic having several parameters like anticipatory warning sign distance, risk value associated with lane change etc. These values cannot be changed. An elaborate description of the hard coded data in the simulation logic is outlined below.

### 5.4 Hard Coded Data:

Hard coded data are those data in the simulation logic, which cannot be changed by an user. These data should be user variable in order to achieve a better understanding of the model. The following are some of the parameters, which may result in reducing the probability of the number of vehicles missing destinations.

1. Advanced Anticipatory warning sign: The objective of the warning sign is to warn drivers that they are approaching the mainline. The default distance on the ramp is set at 1500 ft and cannot be changed.
2. In the Logic for anticipatory lane change, the overall advantage factor for lane change is set to 1. This is only if there are more than 1500 veh/ln/hr. In all the four scenarios analyzed our the advantage factor did not reach the value of one. The value of 1500 veh/hr/ln is recommended to be user variable.
3. In the mandatory lane change logic, ( which controls the change of lanes from the freeway to ramp and ramp to the freeway ), the value “e” i.e. maximum emergency deceleration and “a<sub>min</sub>” i.e. maximum non emergency acceleration must be variable from their default value.
4. The current logic states that maximum deceleration rates of all vehicle types are identical. This conflicts with vehicle operation characteristics, which are different for the different vehicles. Therefore an enhancement to bring into effect the different types of vehicle characteristics is recommended to help to reduce the number of vehicles being reassigned.
5. The maximum non-emergency freeway deceleration in entry 5 of RT. 70 is set to be 8 feet per second square. This value should be variable.
6. The current model allows for representation of ten different driver types ranging from cautious to the aggressive. Another assumption that the current model uses is drivers in each driver type occupy 10 % of the total driver population. The conflict arises here regarding the uniform distribution assumed in CORSIM. This restricts the model capacity to model existing freeway networks. Hence the uniform distribution should be variable

As the total number of vehicles being reassigned is less than 2 % of the total volume, its value is considered negligible and therefore this may be neglected. The speeds that were observed from the results of the simulation are link based speeds. HCM

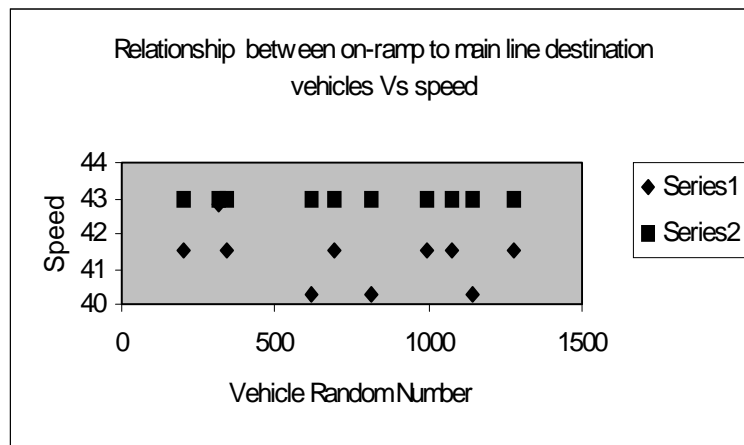
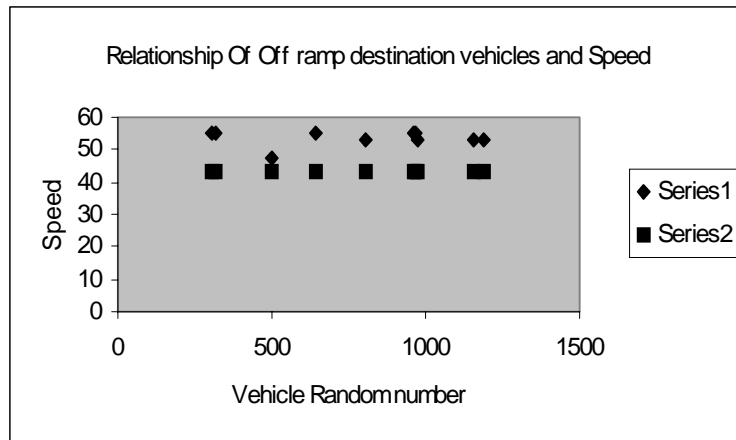
calculates average weaving speed based on each vehicle. In order to make a comparison analysis of the speed in the weaving areas between HCM and CORSIM, a lane by lane analysis of vehicle behavior is needed. This can be achieved by placing double loop detectors in each lane of the freeway at three different locations. The location of these loops are typical for all the four scenarios. Appendix A includes the output mean speed for all the four scenarios.

Appendix A includes cumulative output for all the four different scenarios. Based on analysis of the output, most of the vehicles have completed their lane changes by the second detector location. In addition most of the vehicles are close to achieving their desired freeflow speed by the third detector location. The average between the first two detector location is taken as the weaving and non weaving approximated speeds. On further analysis, it is clearly evident that a simulation approach produces a weaving speed higher than that produced by HCM (Appendix A). In addition to this the non weaving speed was found to be almost the same in comparison with the HCM. So to get a better understanding of the behavior of vehicles to lane changes (weaving speed) a random sampling of data was obtained by using the graphical tool called TRAFVU. This TRAFVU is available in the simulator. This sampling of data was done for 20 random weaving vehicles and their path was traced from ramp to the mainline or from the main line to the ramp. The results were plotted for all the four scenarios. The distance used in calculation is the distance from the first detector location to the second detector location.

As illustrated in Figure 5-16, it is evident that the weaving speed is higher for vehicles having off-ramp destinations than the vehicles originating in the mainline and having mainline destination. This is due to the fact that the freeflow speed in the mainline is 65 mph and that on the on ramp is 45 mph. As most of the weaving is done by the first two detector locations (i.e. within 200 ft), it can be expected to be higher. Figure 5-17 through Figure 5-19 also verify the results. An average between the two speeds are taken to be the average weaving speed per vehicle.

From Figures (5-16 to 5-19) it is clear that a random sampling of data gave a greater accuracy of results than the simulated output. This leads us to the conclusion saying that the simulation tool used is a good tool to evaluate a weaving speed model.

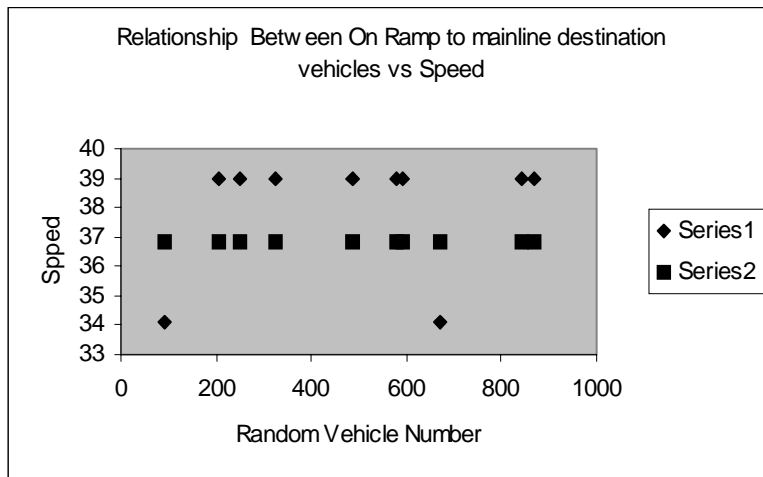
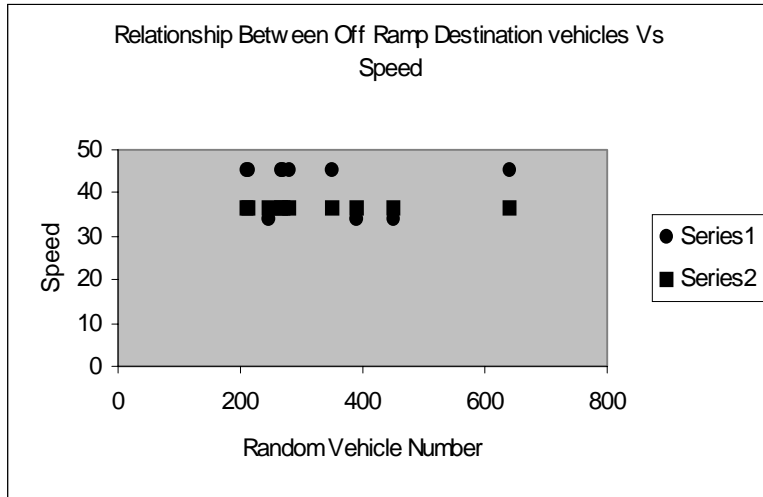




**Summary:**

Average Weaving speed per lane = 54.75  
 Average Weaving speed per vehicle = 47.23  
 Average Weaving speed in HCM = 43

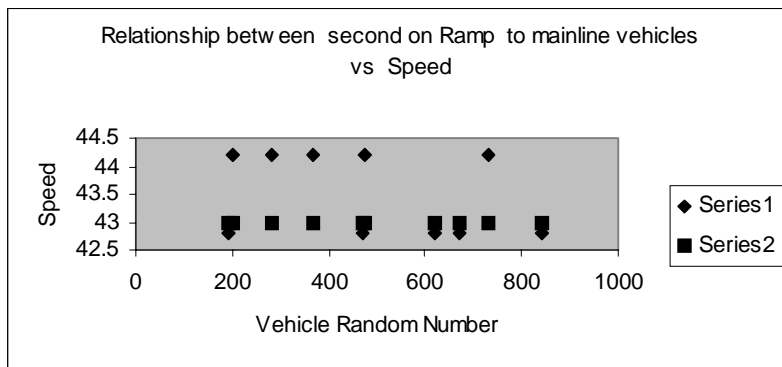
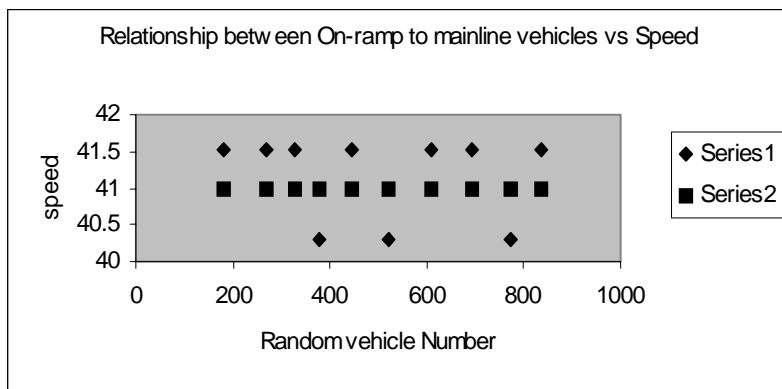
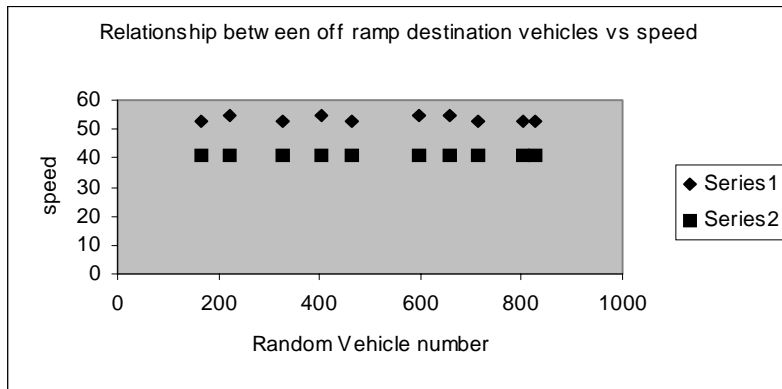
***Figure 5-15: Results of Sampling of Data of 20 Random Vehicles for Scenario 1***



**Summary:**

Average Weaving speed per lane = 45.68  
 Average Weaving speed per vehicle = 40.08  
 Average Weaving speed in HCM = 36.82

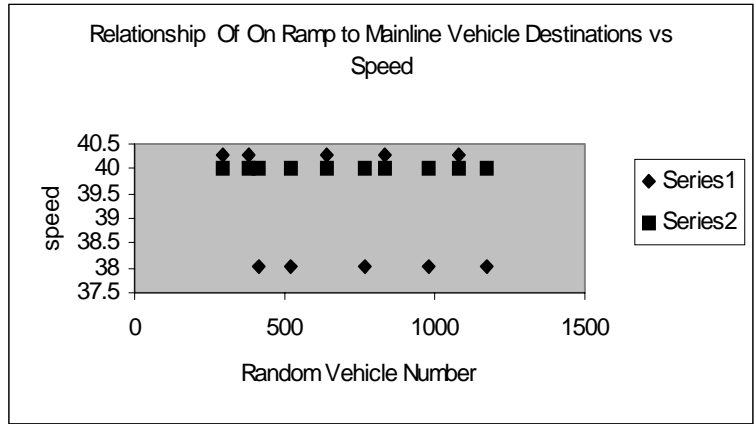
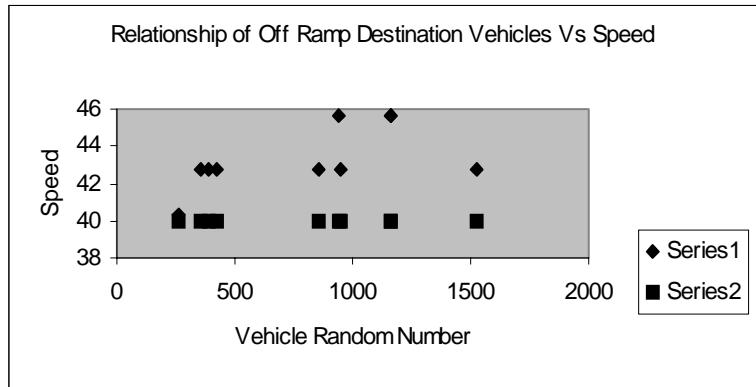
***Figure 5-16 : Results of Sampling of Data of 20 Random Vehicles for Scenario 2***



**Summary:**

Average Weaving speed per lane = 49.9  
 Average Weaving speed per vehicle = 46.1  
 Average Weaving speed in HCM = 41.5

***Figure 5-17: Results of Sampling of Data of 20 Random Vehicles for Scenario 3***



**Summary:**

Average Weaving speed per lane = 45.13  
 Average Weaving speed per vehicle = 41.29  
 Average Weaving speed in HCM = 40

***Figure 5-18: Results of Sampling of Data of 20 Random Vehicles for Scenario 4***