INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND STUDIES
VOLUME03ISSUE08

‘’ESTIMATE FREEWAY EXIT SIGN LOCATIONS’’

DR. JEOB L.F; MICKAL KHIR; PROF. Y. GEORGE

ABSTRACT

Considering that a driver decides to exit a highway upon seeing the guide sign up-stream of an exit, subsequently, the driving force in an enclosed lane or the center lanes must move onto the skin lane before exiting. The priority is whether or not the motive force can accomplish this task safely and smoothly. It’s apparent that an upstream exit sign cannot be placed too near an exit or too far beyond several exits upstream. The MUTCD recommends that the sign should be placed 1 mile and a couple of miles up-stream of an exit without explaining the explanations for choosing the 1-mile distance. By integrating driver decisions, vehicle acceleration characteristics, tire-road traction in-to one analytic framework, the situation upstream of an exit where an exit sign should be installed is set for a driver to induce off at the proper exit successfully. Practitioners can easily apply these user-friendly formulae and equations derived from the framework to compute the specified distance ‘D’ between a highway exit and an upstream exit sign for guiding drivers to exit the highway safely. Additionally, parameters for these formu-lae are adjusted to resemble various exiting scenarios.

Keyword

Freeway, Exit Sign Locations, Freeway Exit Sign.

1. INTRODUCTION

According to the Manual on Uniform control Devices (MUTCD) [1], freeway exit guide signs are placed 2 miles ahead, 1 mile prior the exit, and right at the exit gore area. The exit sign which drivers see first would alert driver the exit is 2 miles ahead and that they should adjust the traveling speed; the exit sign which the drivers see next would remind the drivers to induce into the proper lane, and therefore the exit sign at the gore shows the motive force where the exit is. However, the explanations for installing the guide sign 1 mile aside from the exit and 1 mile except one another haven't been explained in literature with clarity supported user-oriented physical scenarios. An analytical formulation is presented during this paper attempting to work out quantitatively the installation location for these advance exit guide signs. it's suggested that the exit guide sign should be placed at a location to permit a passenger vehicle driver to possess sufficient time to accomplish the mandatory lane change by either overtaking or following a vehicle ahead. This exit maneuvering becomes tougher if the overtaken vehicle is long/heavy as schematically sketched in Figure 1.

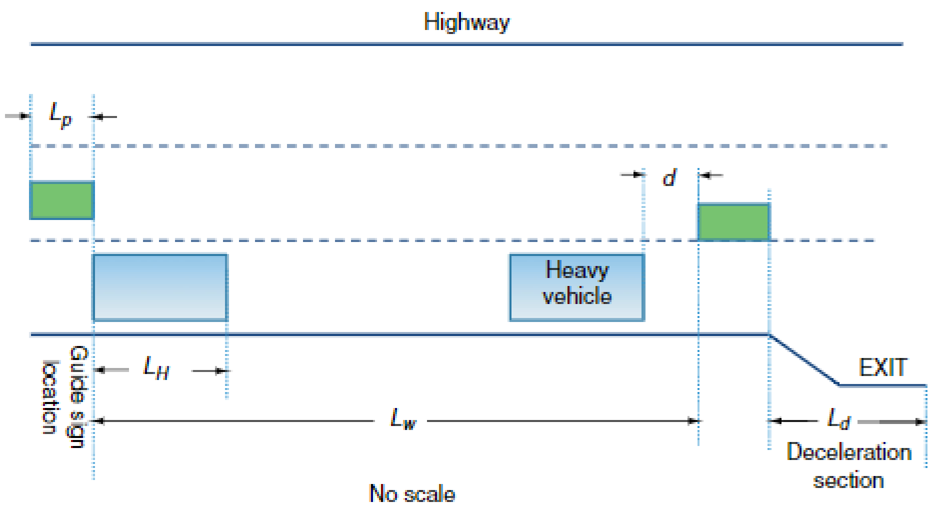

FIGURE 1. A schematic plot of the exit sign location before an off-ramp with an overtaking scenario.

When a passenger vehicle driver is preparing to exit upon seeing the exit sign, the motive force must decide either to weigh down to merge behind the heavy vehicle or to accelerate to pass the heavy vehicle. The exit guide sign must be installed far enough upstream to permit the passenger vehicle driver to decelerate to coast behind the heavy vehicle or pass the heavy vehicle to exit the freeway ahead. to work out the gap where the exit sign should be placed upstream of the exit, one may break the whole existing process into two phases, the primary one is to accelerate to overtake the heavy vehicle within the outside lane, and also the other is to decelerate to an intended or desired speed right before moving onto the off-ramp. The exit sign location will then be found supported a physical framework by rundown the specified distance traveled by the passenger vehicle in each phase [2].

2. FORMULATION

In Figure 1, the railway car and therefore the heavy vehicle are traveling at speed μp, and μT. the gap 'D' from the choice point to the exit is given by

$$D = L_d + L_p + L_w \qquad (1)$$

For the carriage to pass safely before moving onto the exit off-ramp, the gap 'Sp' traveled by the carriage in phase 1 of the exiting process, should be associated with the gap 'LT' traveled by the heavy vehicle for the identical duration via the subsequent equation

$$S_p(L_T / v_T) - L_w = L_p \qquad (2)$$

Distance LT traveled by the heavy vehicle at constant speed vT is given by

$$L_T = L_w - L_H - d \qquad (3)$$

The distance 'Sp' traveled by the railway car has got to do with its acceleration power. The attainable acceleration of a passenger vehicle, known to decrease with speed, is characterized by the maximal attainable acceleration α at very low speed, and also the rate of decreasing acceleration β. Namely, the attainable acceleration 'a' for a passenger vehicle at a given speed v is capable α – βv for 0 > v > α/β. One now can find the gap traveled by the coach over a duration time 't' to be

$$S_p(t) = v_p t \aleph(\delta - t) + \frac{1}{\beta^2}\left[v_p \delta \beta^2 + \alpha\beta\left(t-\delta\right) + \left(\alpha - \beta v_p\right)\left(e^{-\beta(t-\delta)} - 1\right)\right]\aleph(t-\delta) \qquad (4)$$

The detailed derivation of this equation is found elsewhere [2]. The symbol ℵ represents a step function. The parameter Δ now stands for a choice time rather than a straightforward perception-reaction time.

By solving Equation (2) and Equation (4), one can determine the minimal distance LT needed for the railway car to complete the overtaking before moving onto the intended off-ramp. Once the space LT is set, one can use Eq. (1) to search out the minimum required distance for installing a warning/guide sign at an upstream location faraway from the exit off-ramp. Equations (2) and (4) will be combined to yield

$$(\alpha - \beta v_T)\bar{\tau} / \beta + (\alpha - \beta v_p)(e^{-\beta\bar{\tau}} - 1) / \beta^2 = \bar{d} \qquad (5)$$

Where parameters, and, and also the speed differential Δ = VP – vT. By finding the answer for time, one obtains the space LT, which successively may be inserted into Eq. (3) to calculate the gap LW for determining 'D' in Eq. (1).

Equation (5) is solved by iterating the subsequent expression

$$\bar{\tau}_{n+1} = \frac{\beta}{\alpha_2}\bar{d} + \frac{\alpha_1}{\beta\alpha_2}\left[1 - \exp\left(-\beta\bar{\tau}_n\right)\right] \qquad (6)$$

Parameters α1 and α2 represent respectively α – βvp, and α – βvT. Equation (6), which has been discussed elsewhere to deal with an onramp merging scenario [2], may be iterated to approximate the precise solution to an arbitrary accuracy. Since an answer that's accurate beyond the 3rd digit after the percentage point for Eq. (6) isn't needed, iterating Eq. (6) some dozen times should yield a practically ok solution providing that an initial guess hasn't been unreasonably chosen to start out Eq. (6). Here, we use to represent the answer for Eq. (6). The length LT can then be computed via the subsequent expression

$$L_T = v_T \times \left[\delta + \bar{\tau}_{30}\right] \qquad (7)$$

Plotted in Figure 2 is that the length LT against the speed differential Δ(= vp – vT) by setting parameters α, β, Δ, vT, d, Lp, and LH to be 2.25 m/s2, 0.05625/s, 5.0 s, 29 m/s (104.4 kph), 11.6 m, 5.8 m, and 22.4 m respectively. This length LT is that the distance traveled by the heavy vehicle during the passenger vehicle's overtaking. Here, parameter 'd' is chosen to be twice of the railway car length and 'LH' to be the length of the WB-20 design vehicle [3]. the desired weaving length as shown in Figure 2 decreases with the speed differential Δ because overtaking ahead takes less time with a comparatively faster passenger vehicle.

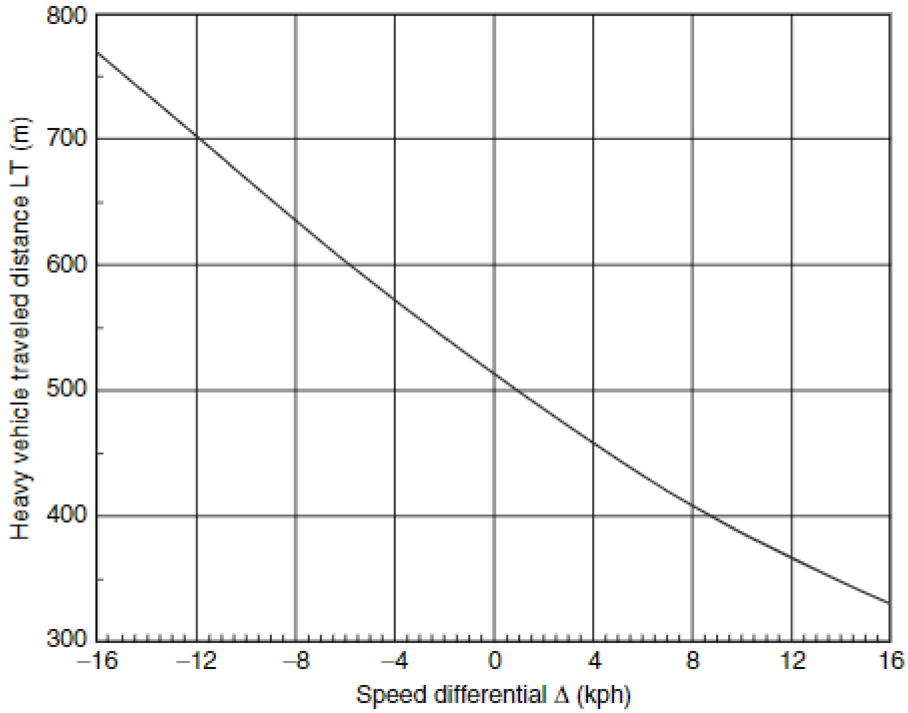

FIGURE 2. The heavy vehicle traveled distance LT for a group of physical parameters is plotted against the speed differential between the passenger vehicle and also the heavy vehicle

In order to accommodate most overtaking scenarios, speed differential Δ is al-
so chosen within the neighborhood of –2.78m/s, approximately –10 kph.

In phase 2 of the exiting process, the passenger vehicle merges into the skin lane and decelerates to an intended off-ramp speed v0 from its higher speed vF when completing the overtaking. The corresponding deceleration time duration τd are given by

$$\tau_d = -\frac{1}{\beta_-} ln\left\{\frac{\alpha_- - \beta_- v_o}{\alpha_- - \beta_- v_F}\right\} \qquad (8)$$

Where the passenger vehicle speed vF at the tip of the overtaking is given by

$$v_F = \frac{1}{\beta}\left[\alpha - \left(\alpha - \beta v_F\right)e^{-\beta\tau_{30}}\right] \quad (9)$$

The vehicle's deceleration is characterized by the expression

$$a_- = \left(\alpha_- - v\beta_-\right)\aleph\left(t - \delta_-\right)$$

Where expression ℵ (t – Δ–) represents a step function, and both parameters α– and β– aren’t positive. The passenger vehicle traveled distance Ld during this deceleration duration тd is calculated via Eq. (4)

$$L_d = v_F\delta_- + \alpha_-\tau_d / \beta_- + (\alpha_- - \beta_- v_F)\left[e^{-\beta_-\tau_d} - 1\right] / \beta_-^2 \quad (10)$$

Upon slowing down, the deceleration may vary with driver, speed, weather, paved surface, and pavement condition. The deceleration decision time Δ– made after the lane switching is assumed to be around 3 seconds here, slightly beyond the time interval applied to compute highway sight distance. A panic situation where a driver would suddenly slam the brake causing the vehicle to skid onto the off ramp isn’t perceived here as a standard driver's behavior. A driver is probably going to decelerate a vehicle during a controllable and comfy manner. Hence, a relentless deceleration with parameter β– set to zero, may be used here to approximate the vehicle deceleration. Equation (10) now is reduced to the known expression of constant deceleration,

$$L_d = v_F\delta_- + v_F\tau_d + \frac{\alpha_-\tau_d^2}{2} = v_F\delta_- - \frac{v_F^2 - v_0^2}{2\alpha_-} \quad (11)$$

The speed v0 significantly should do with the radius of the off-ramp or the length of the diagonal ramp. betting on driver behavior and vehicle acceleration characteristics, speed v0 is anticipated to be within the neighborhood of 16 m/s (35 mph) for a circular off-ramp and will be around 20 m/s (45 mph) for a diagonal off-ramp. The deceleration rate α– should be chosen but an alarming rate applied for computing the stopping sight distance on a highway and greater than that caused by rolling friction and air resistance along when the driver's foot is off the gas pedal; namely, ~ – 3 m/s2 > α– > ~ –1 m/s2. The constant deceleration α– should be chosen within the neighborhood of –2 m/s2; but a practitioner may pick an inexpensive deceleration α– to approximate the motive force deceleration behavior near off ramps.

The distance D for the exit sign location is prepared to be expressed as

$$D = v_F\delta_- - \frac{v_F^2 - v_0^2}{2\alpha_-} + L_p + L_H + d + v_T \times \left[\delta + \overline{\tau}_{30}\right] \qquad (12)$$

To illustrate this exiting process, we plot the space 'D' in Figure 3 for various initial speed differential Δ between the car and also the heavy vehicle by setting parameters α–, α, β, β–, Δ, Δ–, vT, v0, d, Lp, and LH to be –1.5 m/s2, 2.25 m/s2, 0.05625/s, 0., 5.0 s, 3.0 s, 29 m/s, 15 m/s, 11.6 m, 5.8 m, and 22.4 m respectively. it's obvious that the gap 'D' decreases with higher initial speed vp of the passenger vehicle. It seems appropriate to recommend selecting the exit sign location such a coach with assumed speed –8 kph (5 mph) slower than the heavy vehicle at the start of the passing would be able to complete the exiting process safely before proceeding onto the off-ramp. Examining Figure 3, one may find that this exit sign location should be approximately 1100 meters for the above presented example. Note that this suggested distance 'D', looking on a group of chosen physical parameters, isn't a universal number. A practitioner can always tune the physical parameters to suit a typical exiting scenario for any off-ramp from design, safe operation, and traffic control/management viewpoints. As a result, the exit sign location at a distance 'D' upstream of the off-ramp may vary substantially. Furthermore, one may even consider more complex exiting scenarios during which for much longer distance 'D' would be anticipated to accomplish the foreseeable exiting maneuvers. the space 'D' given in Eq. (12) is also shortened by noting the actual fact that a driver usually sees the exit sign ahead. However, this shortening within the distance 'D', complicated by the 3-dimensional location of the exit sign, is predicted to be some hundred feet. On the opposite hand, one may view the gap 'D' given by

Eq. (12) provides a diver with sufficient time to exit the freeway safely and comfortably.

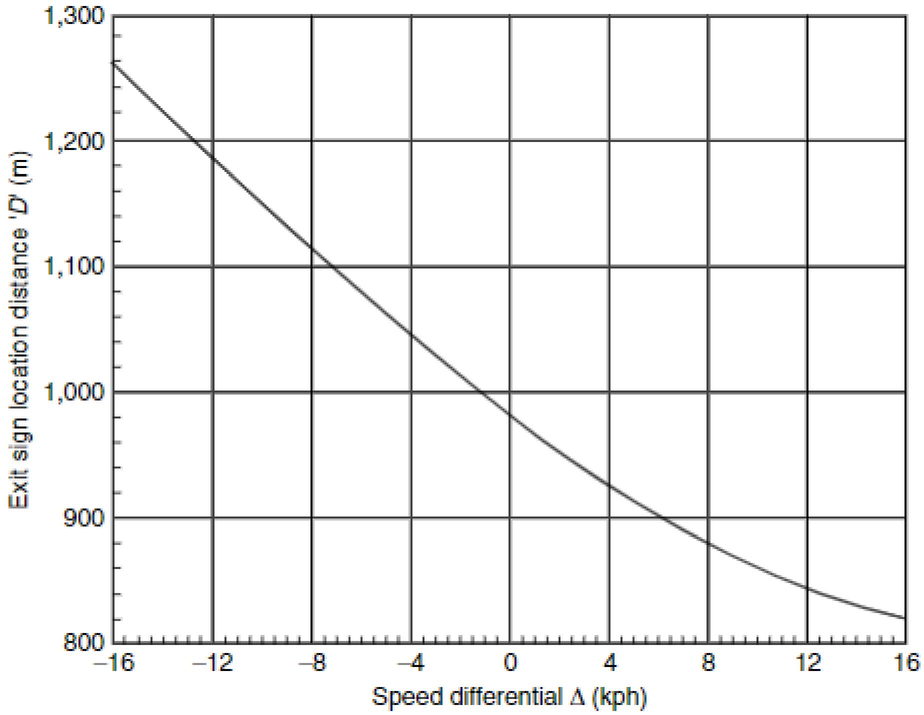

FIGURE 3. the space ‘D’ where an exit sign should be placed far from an off-ramp for a given set of physical parameters is plotted against the speed differential between the passenger vehicle and therefore the heavy vehicle

If a speed dependent deceleration is taken into account before entering into the off-ramp, the expression for distance ‘D’ are going to be computed via a rather more complicated equation.

$$D = v_F\delta_- + \alpha_-\tau_d / \beta_- + \left(\alpha_- - \beta_- v_F\right)\left[e^{-\beta_-\tau_d} - 1\right] / \beta_-^2 + L_p + L_H + d + v_T \times \left[\delta + \overline{\tau}_{36}\right] \quad (13)$$

3. CONCLUSIONS

An analytic framework modeling a freeway exit process is presented by integrating the human-vehicle-roadway interaction. The equation for computing the gap ‘D’ between a highway exit and an upstream exit guide sign springs supported the framework with 11 independent but necessary physical parameters for gauging the exiting process. This frame work is applied to estimate the space ‘D’ by assigning reasonable numeric values to the parameters. the right distance ‘D’ is found to be within the neighborhood of 1100 meters, which a coach at the speed of 100 kph (62.5 mph) would take approximately 40 seconds to travel through. a traditional driver would find this duration acceptable because it takes only around two thirds of a minutes from the time the motive force seeing the exit sign to the time the driving force exit the highway if the driving force value more highly to coast along the surface lane. Moreover, forty seconds duration provides enough time for a conservative driver to seek out a spot between vehicles on a highway to maneuver onto the skin lane from the within or middle lanes. the space ‘D’ was recommended to be 1 mile or 1600 meters for the second exit check in the MUTCD, which is about 45% longer than what has been computed supported the above presented framework; but the suggestion of using two exit signs at two well separated locations makes sure a standard driver wouldn't miss the exit [1]. it's recommended that the space between the 2 exit signs should be roughly up to the gap ‘D’ computed using Eq. (12) or Eq. (13), which is anticipated to be between half a mile (800 m) and three quarters of a mile (1200 m). One may question whether the space ‘D’ computed via Eq. (12) or Eq. (13) is long enough for a driver to exit a highway safely assuming that s/he is on the within lane of a 10-lane freeway upon seeing the exit sign, located 1100 meters removed from the intended downstream exit? The solution can not be straightforward because the motive force can take various possible paths to attain this goal or miss the exit at occasions. it's conceivable that the driving force would favor to switch across 4 lanes and merge behind a vehicle on the skin lane within two thirds of a second. In general, if seeing the primary guide sign upstream of an exit, a driver would are in a very lane next or near the surface lane when seeing the second exit sign.

It is known that almost all drivers navigate their trips with additional information apart from solely wishing on the knowledge provided by the guide signs. One may even argue that a daily commuter pays little attention to the exit guide signs because a programmed route has been stored in her/his mind. Anyway, the exit guide signs provide valuable information to a driver who isn’t quite at home with the intended/planned exit locations on his/her trips.

A practitioner may tune the physical parameters for the framework to see the desired distance ‘D’ for setting the exit sign location upstream. it's anticipated that this framework when let alone engineering experiences and/or a practitioner's engineering judgment, would function the bottom for deciding the highway exit sign locations where upon seeing the exit sign, a driver would be left with enough time to exit the highway safely and smoothly either by merging behind a vehicle on the skin lane or overtaking a slower vehicle on the skin lane to merge ahead.

REFERENCES

1).FHWA,Manual of Uniform control Devices Policy, FHWA, Washington D.C. (2009) May 2012 Google Scholar.

2).C. Liu, Z. Wang
Determination of Onramp Weaving Length for Resolving Merging Dilemma
International Journal of Transportation Science and Technology, 1 (1) (2012), pp. 49-60
Cross Ref View ,Record in Scopus Google Scholar.

3).AASHTO ,A Policy on geometric design of highways and streets, AASHTO, Washington D.C. (2011),Google Scholar.

AUTHOR AFFILIATIAN

DR. JEOB L.F
MICKAL KHIR
PROF. Y. GEORGE