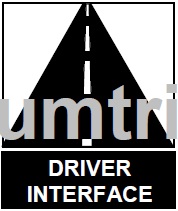
Technical Report UMTRI-2016-\* September, 2016

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**Instructions for Using the UMTRI Expressway Scenario Creation Software for the NADS Minisim**

Raymond Pressly



Technical Report Documentation Page

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| 16. Abstract  Research studies involving the testing of vehicle controls, displays, and warning systems often involve the use of driving simulators. The creation of driving scenarios is a lengthy and costly process.  In this project, software was developed to generate driving scenarios based on a set of parameters given by the user. The user inputs a two lane expressway .scn file that contains the subject vehicle. The user then specifies the length of the scenario in number of trials (a 5000 ft. section of highway). Then the interface allows for major scenario settings to be changed (follow/lead vehicle generation, generation of opposing traffic, etc.) as well as manipulation of traffic over each trial (shoulder/left lane vehicle control and follow/lead vehicle control).  The user then can save the new .scn file once satisfied with their settings. The .scn can immediately be placed onto the Minisim to be used or can be opened in ISAT to be modified further. | | | | | | |
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**Introduction**

The NADS Minisim is a 3D driving simulator used to study driver controls, visuals, and information systems in vehicles. In order to conduct research, a driving scenario must be created. The scenario is then loaded onto the Minisim for test subjects to drive in while data is collected. A typical driving scenario for a study takes approximately two months to be created and tested before being used in a study. This process is much longer than the testing itself, therefore a more efficient process of creating driving scenarios was needed.

The purpose of this project was to develop a program that creates scenario templates for the Minisim based on a series of parameters defined by the user. This program would accelerate the creation of driving scenarios from a period of months to possibly less than a week. The resulting software named the “Expressway Scenario Interface” is a single window, file in/file out, interface for creating driving scenarios. The software is currently set up to control a two lane, bidirectional highway scenario but can be modified to handle more lanes. The length of the scenario can be changed by specifying the number of trials in the scenario and giving an input scenario to match the number of trials given.

The Expressway Scenario Interface was designed with the idea that general elements of the driving scenario would be created and test specific elements would be left to the user’s creation. The first set of general parameters that the user can control are the major file settings. These settings are global settings for the entire scenario and include: follow and lead vehicle instructions across the entire experiment, the creation of blind spot warnings for the subject, the customization of the frontal crash warning, and the generation of opposing lane traffic.

The second set of parameters the user can control are the instructions across each trial. This is done by use of the trial manager: a series of buttons allowing the user to iterate back and forth over trials, making changes to the scenario when necessary. The trial manager allows the user to create left lane and road side vehicles as well as alter the follow and lead vehicles behavior over the period of the trial.

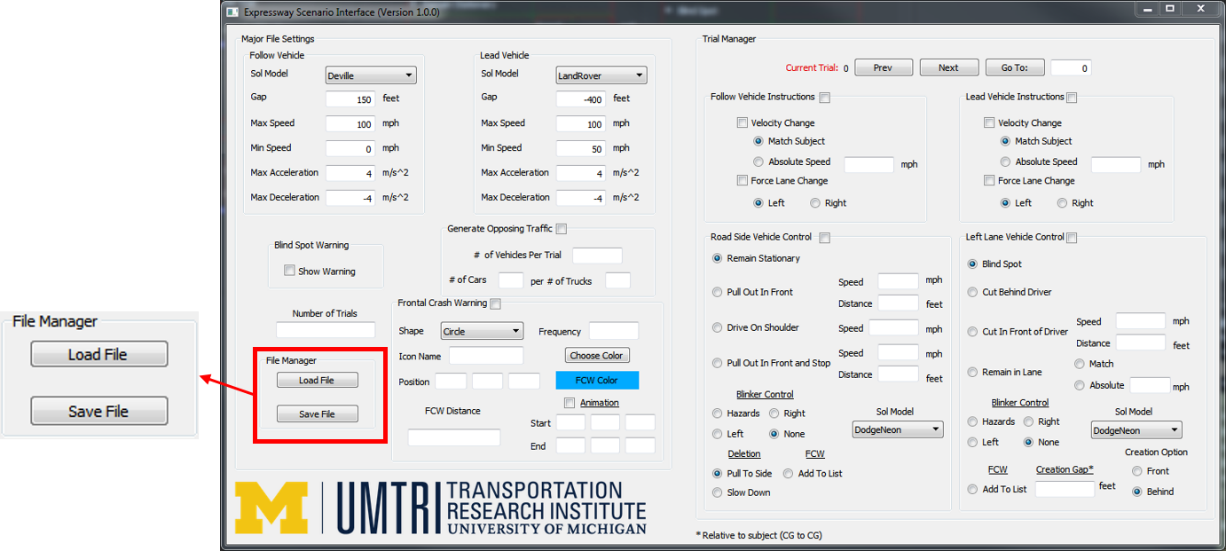
The scenarios created by the software are ready to be tested on the Minisim or to be altered in ISAT after being saved. This allows the researcher to create more specific scenarios per their research. The following sections cover how to use the software, what the software does directly, and updating/installing the software on the Minisim system.

**Using the Software**

This section goes in depth on how to use each part of the interface to meet the user’s specific needs. This section will also describe what is added to the scenario when a certain option is selected from the interface.

**Loading and Saving Files**

A file must be loaded into the Expressway Scenario Interface in order to start building an expressway scenario. A new file must also be saved once the interface has processed all user inputs. This process is handled by the **File Manager** in the lower left corner of the interface (see Figure 1).



**Figure 1.** The location of the **File Manager** within the interface.

Loading a file into the interface is the first step taken when using the interface. This is due to the fact that the Expressway Scenario Interface was created by reverse engineering objects found in scenario files created through ISAT. There may be bugs in the current version of the Expressway Scenario Interface due to this design process. Thus it is recommended to load a basic input scenario file and not a complex or almost complete file in fear of losing data when the interface reads the file.

To begin loading a file, click the **Load File** button within the **File Manager** group box. The user then can navigate to the desired input file to the interface. The input file must include the subject vehicle’s starting location and orientation. To insert the external driver in the scenario, begin by opening or creating a new scenario file in ISAT. If creating a new file, the necessary .bli file ES175.bli can be found in the folder ES175Files in the Minisim pathway “insert pathway here”. If using the base file included with the interface, open the file base.scn found in the Minisim pathway “insert pathway here”. With the .scn file now open, navigate to **Insert > External Driver** and place the external driver on beginning of the roadway.

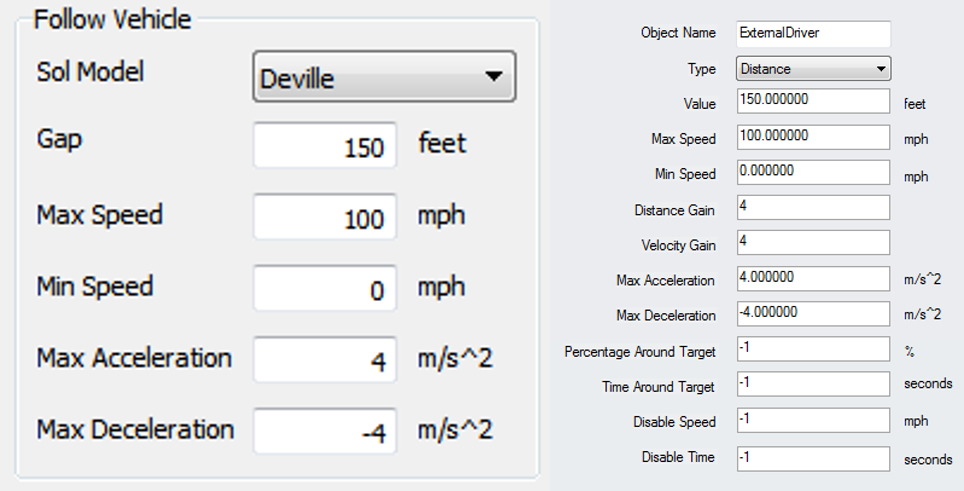
The user can now begin making changes to the interface selections once the base scenario file has been loaded in. To save a file when completed, click on the **Save File** button in the **File Manager** group box. This will prompt the user to select a location to place the new file.

**Major File Settings**

The Major File Settings are global settings throughout the entirety of the scenario. These settings are important for controlling visual displays, lead and follow vehicle instructions, and opposing traffic.

*Follow and Lead Vehicle*

The **Follow Vehicle** group box is used to set the instructions of the follow vehicle. The parameters that the user can define are very similar to the setup of the follow vehicle in ISAT (see figure 2). The **Sol Model** drop down menu is used to select the vehicle type and a random color is then selected by the interface for that vehicle. The user can then specify the maximum gap that is allowed between the follow vehicle and the subject’s vehicle in the **Gap** line edit box. The minimum and maximum speed of the follow vehicle can be altered in the **Min Speed** and **Max Speed** line edits respectively. The last two parameters defined by the user are the max acceleration and max deceleration of the follow vehicle (the max deceleration must be a negative number).



**Figure 2.** Side by side comparison of **Follow Vehicle** group box against ISAT MaintainGap.

The resulting objects added to the scenario file will be the follow vehicle (an ADO) itself and an Expression Trigger to maintain the gap between the follow vehicle and external driver. The Expression Trigger has a “MaintainGap” Set Dial that matches the settings defined in the **Follow Vehicle** group box. The **Lead Vehicle** group box matches the **Follow Vehicle** group box except that the **Gap** group box must be a negative value for the lead vehicle.

*Generate Opposing Traffic*

The **Generate Opposing Traffic** group box is used to create opposing traffic as the driver travels through the scenario. Traffic will only be generated when the **Generate Opposing Traffic** check box is selected. When this option is selected, the user must specify the number of vehicles per trial on the opposing expressway and the number of cars per the number of trucks in the trial. The number of vehicles per trial is used to define the level of traffic in the opposing lane. The number of cars per truck ratio is used to control the type of traffic that the subject will see.

The interface will generate the specified number of vehicles per trial with each vehicle being randomly selected to be a truck or car (dependent upon the car to truck ratio), placed in a randomly selected lane, placed in a random position in that section of the lane, and with a color randomly selected based on the vehicles model. Below are recommendations on levels of traffic for scenarios where the trial length is 5000 ft.

|  |  |
| --- | --- |
| **Level of Traffic** | **# of Vehicles Per Trial** |
| Light | 1-9 |
| Moderate | 10-19 |
| Heavy | 20-24 |
| Extremely Heavy | 25+ |

**Table 1.** Levels of traffic and recommended numbers of vehicles per trial.

*Blind Spot Warning*

The **Blind Spot Warning** is a visual display that is triggered when a vehicle is in the driver side or passenger side blind spot. This is done by displaying a graphic in the driver side or passenger side mirror when the subject drives past a stationary vehicle or a vehicle is within a certain distance of the driver. The interface will only display a blind spot warning for the following trial situations except for the left lane **Cut Behind Driver Option**.

Selecting the **Blind Spot Warning** option will create a graphic for the right blind spot warning named “BSW\_Right\_Graphic” and another graphic for the left blind spot warning named “BSW\_Left\_Graphic”. These graphics can be customized further if the user wishes. The blind spot warning variables are initialized by the Time Trigger “BSWInit” where the “Right\_Blind” and “Left\_Blind” variable are set to 0. Four other triggers control when the left and right graphics are displayed throughout the scenario. The right blind spot warning is displayed whenever the “Right\_Blind” variable is 1 and hidden otherwise. The left blind spot warning is displayed the same way except with “Left\_Blind” being the controlling variable. Table 2 below describes how the graphics are triggered for different trial scenarios.

|  |  |
| --- | --- |
| **Trial Situation** | **How Graphic is Triggered** |
| Road Side – Remain Stationary | Roadpad Trigger placed alongside vehicle to activate graphic. |
| Road Side – Pull Out in Front | Expression Trigger that is activated when the car is within 36 ft. of the subject. The Expression Trigger is created when the road side vehicle changes lanes for the second time. |
| Road Side – Drive On Shoulder | Expression Trigger that is activated when the car is within 36 ft. of the subject. |
| Road Side – Pull Out In Front and Stop | Expression Trigger that is activated when the car is within 36 ft. of the subject. The Expression Trigger is created when the road side vehicle stops. |
| Left Lane – All Options | Expression Trigger that is activated when the car is within 36 ft. of the subject. |

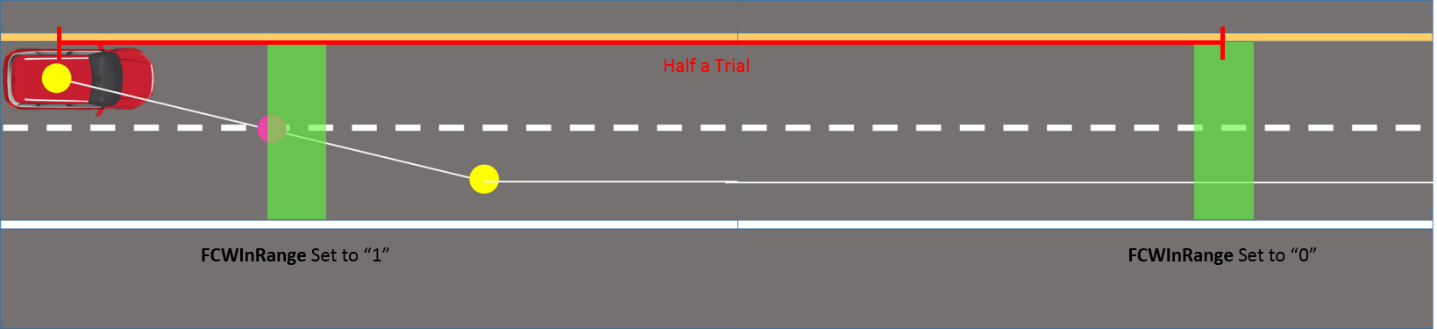
**Table 2.** How blind spot warnings are activated.

*Frontal Crash Warning*

The Frontal Crash Warning (FCW) is an optional selection that will generate a display to warn the driver of a potential crash with a vehicle moving in front of the subject. The user is able to choose the shape, color, frequency (Hz), period the FCW is on, position, and activation distance of the frontal crash warning through the **Frontal Crash Warning** group box. The user can select which vehicles around the subject will have a frontal crash warning by selecting the **FCW – Add to List** option in the **Trial Manager**. The FCW will only be activated for the road side **Pull Out in Front** and **Pull Out in Front and Stop** options as well as the left lane **Cut in Front of Driver** option. If any other options are chosen by the user, the FCW will not be activated even if the user selected the **FCW – Add to List** option is selected.

The **FCW Distance** is an addition to the new way of displaying the FCW visual. The FCW was previously displayed using RoadPad Triggers that were placed manually in ISAT. This method required testing of each RoadPad to ensure the correct placement. This method is not a simple process for a computer program to complete which lead to the new method: FCW display activation by a combination of RoadPad Triggers and Expression Triggers with a second variable. The first RoadPad Trigger is used to set the **FCWInRange** variable (new variable) to “1”, signifying that the collision may occur soon. The second RoadPad Trigger is placed later in the trial, after the possible collision and sets the **FCWInRange** variable to “0”, signifying that the potential for collision has ended. The first Expression Trigger sets the variable **FCWCenter** to “1”, activating the FCW visual, when the **FCWInRange** is “1” and the distance from the subject’s vehicle to the trial vehicle is less than the specified **FCW Distance**. The second Expression Trigger sets **FCWCenter** to “0” deactivating the FCW visual when the distance between the subject vehicle and the trial vehicle is greater than the specified **FCW Distance**.

A visual display of how this new system works can be seen in Figure 3 below. For each occurrence the **FCW – Add to List** option is selected for a valid vehicle, the RoadPad Trigger that sets **FCWInRange** to “1” is placed when the vehicle changes lanes for the first time and the RoadPad Trigger that sets **FCWInRange** to “0” is placed at the midpoint of the trial.



**Figure 3.** FCWInRange variable handling and RoadPad Triggers.

**Trial Manager**

The **Trial Manager** is used to make changes to trials and to navigate from one trial to another. The user can make changes to lead and follow vehicles over the trial or generate left lane and road side vehicles. The **Current Trial** alerts the user to the trial that is being modified. This number is zero indexed, meaning that the **Current Trial** indicator starts at 0 and ends at one less than the number of trials. For example, if the **Number of Trials** input is 10, the user can make changes to trials 0 – 9. Any changes made to trial 0 will not affect the final scenario. This is in place so that the subject can have a section of roadway to accelerate to an expressway level speed and also so that the user can add any research study specific elements (FCW examples, test start indicators, etc.).

*Navigating Trials*

Navigating trials is controlled by the series of widgets at the top of the **Trial Manager** group box. All settings of the current trial are saved when navigating trial to trial. This allows the user to review changes to a given trial at any time during the creation process. The **Prev** button will decrease the current trial by one unless the current trial is zero (no change occurs). The **Next** button will increase the current trial by one unless the current trial is one less than the **Number of Trials** (no changes will occur). The **Go To** button will change the current trial tothe input given in the **Go To** line edit. For example, if the user wished to navigate to trial 20 out of 23 trials, they would change the **Go To** line edit to 19 (zero indexed trial manager) and press the **Go To** button. If the number given in the **Go To** line edit is not in range (less than 0 or greater than the number of trials minus 1), then no changes will occur.

*Follow and Lead Vehicle Instructions*

The **Follow Vehicle Instructions** and the **Lead Vehicle Instructions** are identical group boxes of the interface. The instructions that can be given to the lead/follow vehicle are limited to a velocity change and a lane change. The velocity change option will force the follow/lead vehicle to match the speed of the subject or to travel at an absolute given speed. If any of the following options are chosen in a trial, **do not select a velocity change for the lead or follow vehicle**: road side **Pull Out in Front** or **Pull Out in Front and Stop** or the left lane **Cut in Front of Driver** or **Cut Behind Driver**. The reason a velocity change option should not be checked is that there is already a velocity change for either the lead or follow vehicle occurring in those trials (lead vehicle velocity change for the first three and follow vehicle velocity change for the last one). The lane change option will force the respective vehicle to change lanes left or right at the beginning of the trial. The user is responsible for forcing the vehicle to change lanes at the end of the trial and to ensure that the vehicle is able to change lanes (ex. a lane change left when the vehicle is currently in the right hand lane is possible).

*Road Side and Left Lane Control*

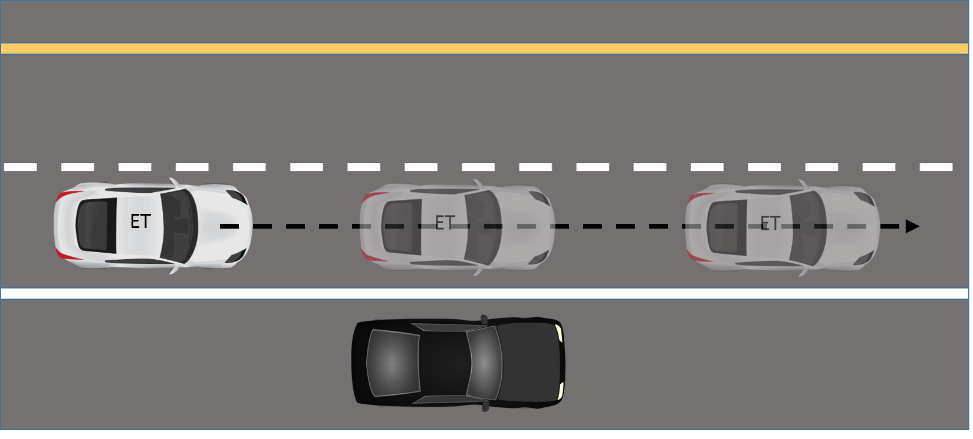
The user is able to generate both left lane and road side vehicles within the same trial but it is not recommended to do so. Having multiple DDO’s or DDDO’s on the same section of roadway may cause irregular behavior between the vehicles. An in depth instruction on road side vehicle control can be found on page (insert page number) and Left Lane Vehicle Control can be found on page (insert page number).

**Road Side Vehicle Control**

The **Road Side Vehicle Control** group box is used to create and control a road side vehicle (shoulder vehicle). The vehicle is a DDO or DDDO that is created at the beginning of the trial and deleted shortly after the end of the trial. This section discusses how to control the road side vehicle.

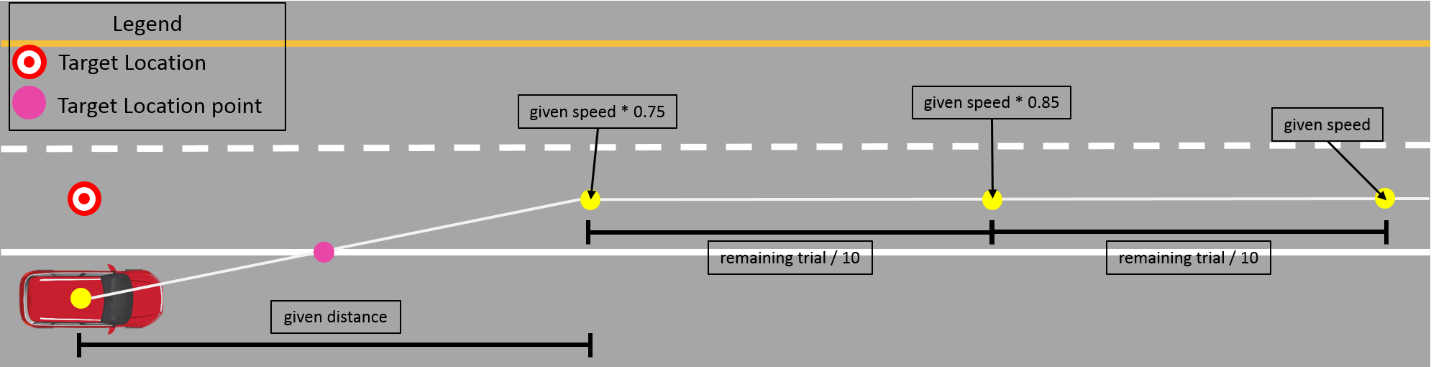
*Movement Options*

The road side vehicle has four movement options: **Remain Stationary**, **Pull Out in Front**, **Drive on Shoulder**, **Pull Out in Front and Stop**. The **Remain Stationary** option will create a shoulder vehicle that remains on the shoulder and does not move (see Figure 4). The subject will drive past this vehicle and will not have any interaction with the vehicle other than the BSW (if BSW is enabled).



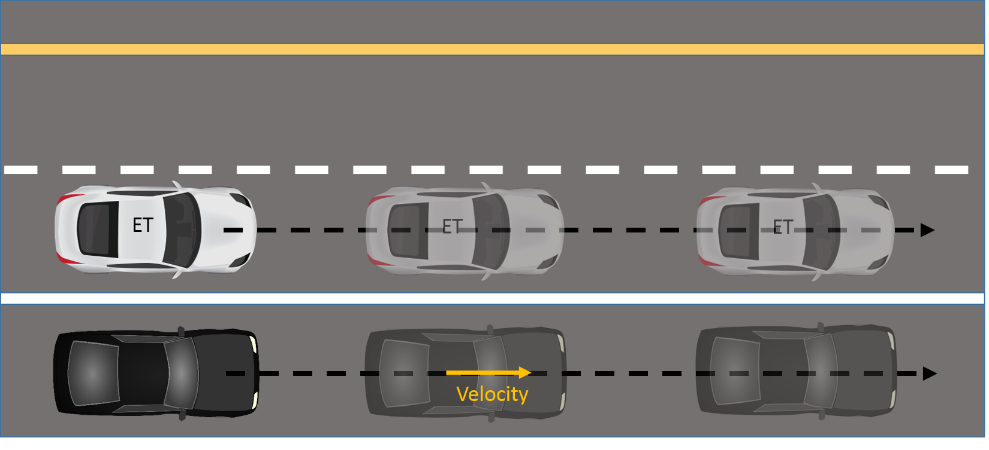
**Figure 4.** Road side remain stationary option.

The **Pull Out in Front** option creates a DDDO that pulls in front of the subject at the given distance. Once the DDDO has pulled in front of the subject, it will begin accelerating towards the given target speed. After the DDDO pulls in front of the subject it will be travelling at 75% of the target speed at the first node, 85% of the target speed at the second node, and at the target speed at the third node. The distance between these nodes is 10% of the remaining trial length. See Figure 5 for a visual representation of the DDDO’s path.



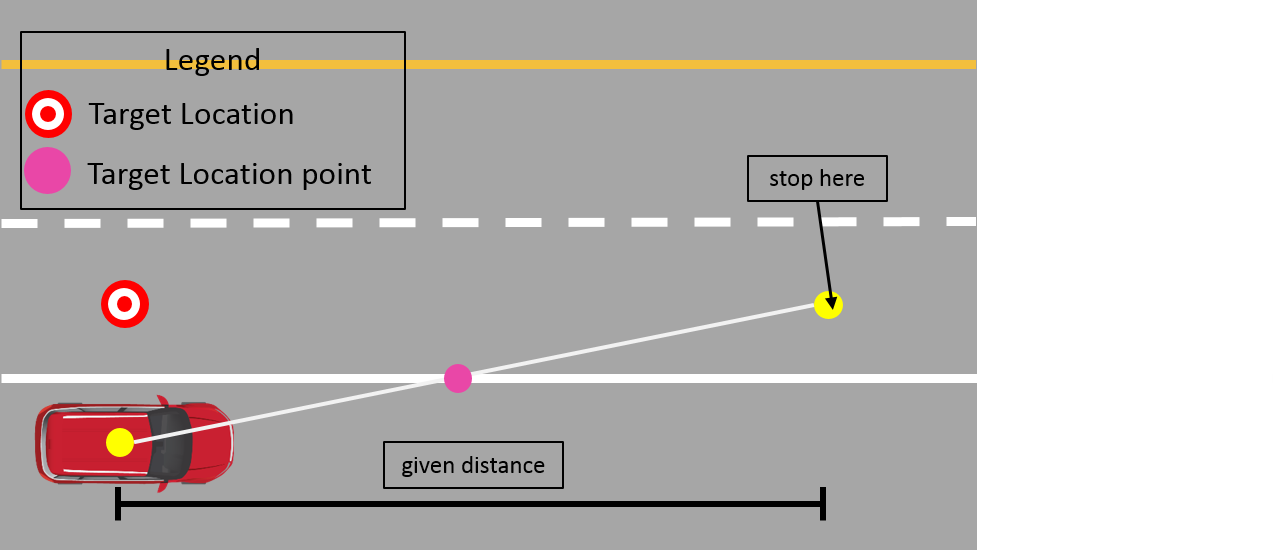
**Figure 5.** Road side **Pull Out in Front** DDDO path.

The **Drive On Shoulder** road side movement option creates a DDDO that drives on the shoulder only. The deletion option specified for this option is not relevant as the DDDO will slow down on the shoulder no matter the deletion option selected. The DDDO will travel at the given velocity and will have a final velocity of 25 mph at the end of the trial. See Figure 6 for a visual representation of the DDDO.



**Figure 6.** Road side **Drive On Shoulder Option**.

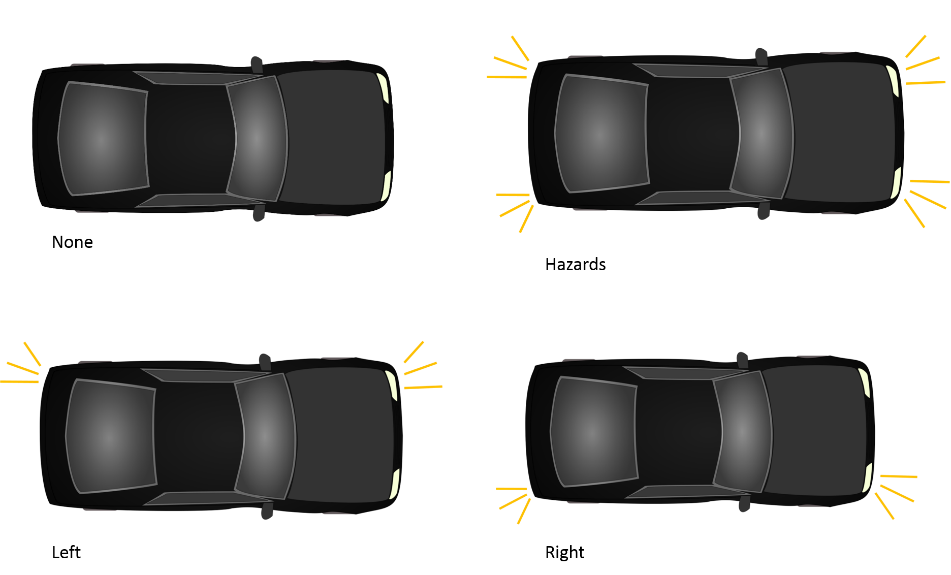
The **Pull in Front and Stop** option creates a DDDO that will pull out in front of the subject’s vehicle and stop. The stop will occur at the given distance. See Figure 7 for a visual example of the option.



**Figure 7.** Road side **Pull Front and Stop** option.

*Blinker Control*

The user can choose the blinker state of the road side vehicle when that vehicle is created by use of the **Blinker Control** group box. If this option is chosen, the road side vehicle will follow the specified blinker option for the entirety of the experiment. See Figure A for blinker option.



**Figure A.** Blinker options.

*Deletion Option*

The **Deletion Option** is a road side vehicle specific setting. This setting gives the user the choice of how the DDO/DDDO is to be deleted at the end of the trial: drive on the shoulder (**Pull to Side**) or drive in the left lane at a slower speed (**Slow Down**).

*FCW – Add to List*

If this option is selected, triggers to activate the FCW for this vehicle will be created. See *Frontal Crash Warning* on page 9 for more details.

*Sol Model*

The Sol Model drop down menu gives the user the option to select the type of vehicle that the road side vehicle will be. A random color is then chosen by the interface for the vehicle.

**Left Lane Vehicle Control**

*Movement Options*

*Blinker Control*

See page 13 – *Blinker Control*.

*FCW – Add to List*

See page 13 *– FCW – Add to List* and page 9 *– Frontal Crash Warning*.

*Creation Gap and Option*

*Sol Model*

See page 13 *– Sol Model*.

**Names of Created Objects**

|  |  |
| --- | --- |
| **Name** | **Details** |
| “FV” | Follow vehicle. |
| “LV” | Lead vehicle. |
| “FV\_Keep\_Distance” | Expression Trigger to maintain follow vehicle gap. |
| “LV\_Keep\_Distance” | Expression Trigger to maintain lead vehicle gap. |
| “OppositeX\_Y” | Opposite expressway vehicle where X is the trial number and Y is how many opposing lane vehicles come before this vehicle. |
| “BSW\_Right\_Graphic”/ “BSW\_Left\_Graphic” | Graphics for the blind spot warnings. |
| “BSWRightOff”/ “BSWRightOn” | Activating and deactivating the right blind spot graphic. |
| “BSWLeftOff”/ “BSWLeftOn” | Activating and deactivating the left blind spot graphic. |
| “BSWInit” | Initializes the BSW variables. |
| “FCWOn”/ “FCWOff” | Controls the display of the FCW. On when FCWCenter = 1 and off when FCWCenter = 0. |
| “FCWGraph” | FCW graphic. |
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