HVE-WP-2020-1

Vehicle Speed Analysis using Dash Mounted Camera Video and HVE

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ABSTRACT

More and more video footage is available from dash mounted cameras (dashcams). Some of these cameras only record video and do not record corresponding speed or other data. A methodology is required for producing accurate simulations that are based on video footage from the viewpoint of the dashcam. The simulations allow for the determination of the speed of the vehicle the dashcam is mounted in, and also the speeds of other vehicles in the video as well as provides the ability to add cameras anywhere within the environment.

This paper presents a best practice for analyzing vehicle speeds using dashcam video via an iterative approach that directly compares the dashcam view with HVE simulation. HDS-3D (High Definition Survey-3D) scanning techniques were used to develop accurate HVE environment models which included roadway characteristics as well as features that can be identified in the dashcam video. HDS-3D scanning techniques were also used for the development accurate models of vehicle interiors which allow for an accurate mounting position of the simulated HVE camera. The accuracy of the iterative method was validated using a comparison to speed measurement data collected with a test vehicle. The benefits and limitations related to the use of HVE, HDS-3D scanned environments, and HDS-3D scanned vehicles are discussed as well as the limitations in accuracy for the video comparison technique.

Results showed that the speed determined using the HVE and dashcam footage comparison method closely matched the speed measured in the test vehicle. There were no statistically significant differences ($p>0.05$) in the average speed of the vehicle determined using the two different methods over a 30 second time period.

INTRODUCTION

HVE currently has the capability of viewing a simulation not only from a stationary position in the environment (e.g. overhead) but also from a virtual camera positioned in a simulated vehicle. Typically, this feature is used for showing the driver's view of a simulation, however, the camera can be accurately positioned at any location relative to the CG of the vehicle and set to view any direction, and the camera settings (depth of field, focal length) can be adjusted. These capabilities allow for the accurate positioning and replication of the dashcam view.

Sneddon (2019) presented a study on photogrammetric methods for positioning vehicles and other objects using surveillance video and HVE. The study presented methodology for establishing the surveillance camera location, optical axis, and effective focal length by using HVE's 3D environment. The study detailed several factors concerning video files, such as video resolution, aspect ratio, motion blur, and frame rate. The study also detailed how the HVE camera handles the optical axis and focal length, and outlines concerns with camera swing and camera orientation and how to address them.

This paper expands upon the paper by Sneddon by focusing on dash mounted cameras in vehicles rather than a stationary surveillance camera. By using an iterative method that involves video matching the HVE simulation to the dashcam, this paper also presents a methodology for determining vehicle speed. A validation of the methodology is also presented by comparing vehicle speed results using the HVE analysis to speed measurement data from a test vehicle.

METHODOLOGY

A baseline driving scenario was first captured from a 2014 Dodge Grand Caravan using a WINYCAM Insight FX dashcam mounted to the windshield. The dashcam is depicted below in Figure 1, and it was placed close to the center of the windshield below the rear-view mirror. The position of the dashcam was documented accurately using HDS-3D interior scan of the Dodge (Figure 2).

Figure 1: WINYCAM Insight FX Dashcam

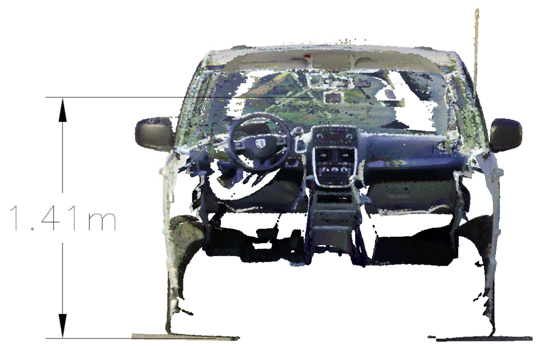

Figure 2: HDS-3D Scan of Dodge interior including dashcam location

The user's guide for the WINYCAM Insight FX Dashcam stated that the Field of View (FOV) was approximately 113 degrees. This was confirmed by considering the video output of the camera, placing pylons at the edges of the FOV shown on the screen, and completing HDS-3D scan and measuring the angle (Figure 3).

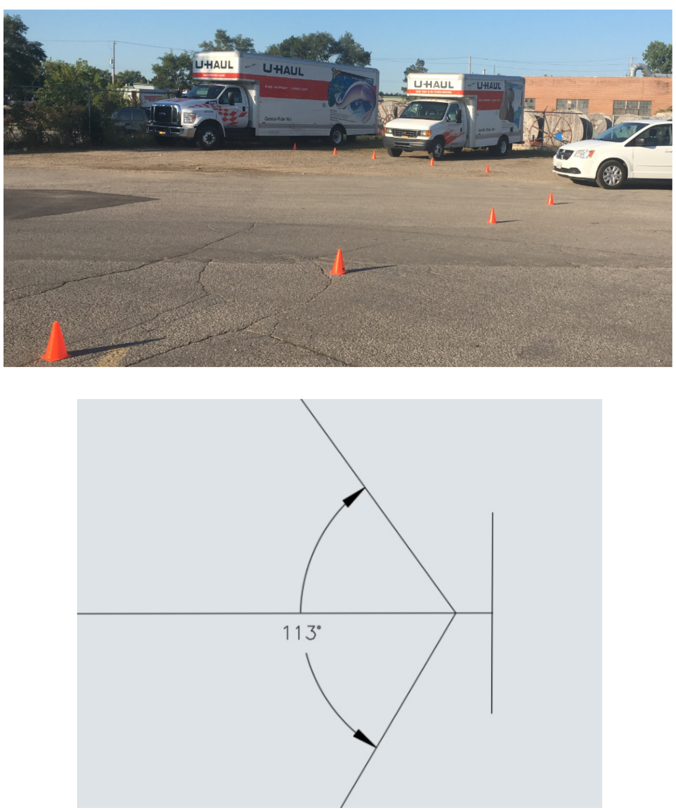

Figure 3: Evaluation of dashcam field of view in the Dodge Grand Caravan. The dashcam had a field of view of approximately 113 degrees.

Vehicle testing was conducted on a roadway that consisted of westbound and an eastbound through lanes and a T-intersection. To the west of the intersection the roadway consisted of an eastbound and a westbound lane which was separated by a left turning lane for eastbound traffic, and to the east of the intersection the roadway consisted of an eastbound lane, a westbound through lane, and a right turning lane for westbound traffic. On the northwest corner of the intersection there was a building which was visible in the dashcam video, as well as several lamp standards, signs, utility poles, and traffic signals on both sides of the roadway. The roadway geometry was documented via HDS-3D scanning; an overhead view of the resulting point cloud is shown below in Figure 4. The 3D point cloud was then used to produce a 3D environment for HVE using Rhino as shown below in Figure 4.

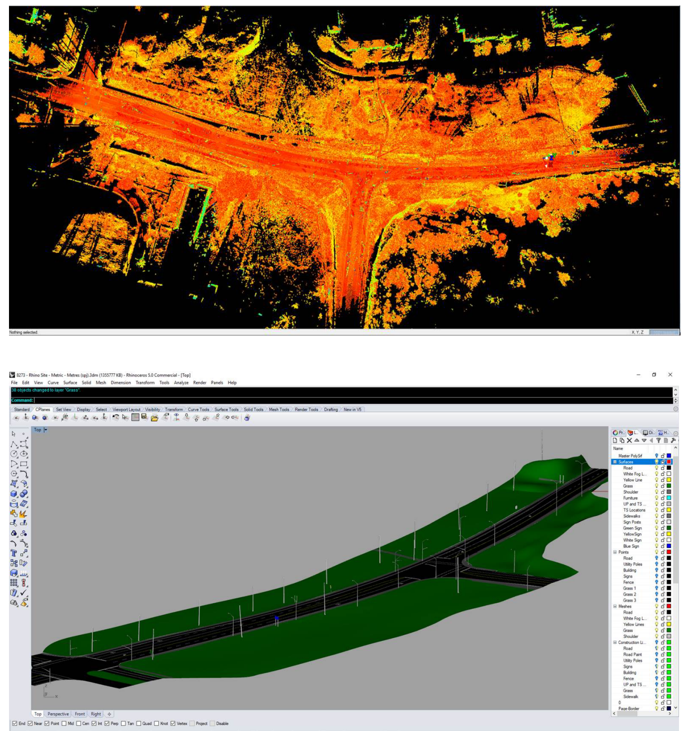

Figure 4. HDS-3D Scanning of Environment and resulting 3D Rhino Model

The test vehicle was equipped with the WINYCAM Insight FX dashcam unit that captured and recorded a forward-facing view of the activity in front of the vehicle. The video ran at 30 fps (frames per second). The video also captured the time, date, and forward and lateral acceleration of the camera. The GPS speed that the camera would have been experiencing as it was mounted in the test vehicle is not displayed in the video.

In addition to the dashcam footage being collected, the test vehicle was also instrumented with a VBOX III by Racelogic, which collected vehicle speed and GPS location at a logging rate of 20 Hz.

The vehicle was driven at speeds of 52 km/h eastbound and 57 km/h westbound through the test site, and test data was captured for 29 and 28 seconds respectively. To establish as close to a steady-state speed as possible, the Dodge's cruise control was applied while driving through the test site, and any slight variations in vehicle speed were therefore collected with the VBOX data.

HVE SIMULATIONS

The HVE simulations involved a 2008-2015 Dodge Grand Caravan test vehicle which was driven eastbound and then westbound through the 3D environment using SIMON. The dashcam video accurately showed the path the Dodge followed with respect to time and with respect to the roadway geometry for the 29 second (westbound) and 28 second (eastbound) periods. Using HVE software we placed a camera in our 3D Dodge model matching the location of the dashcam, and then we modeled the vehicle dynamics to match the motion shown in the dashcam video. This motion as viewed from the dashcam and from our camera in our 3D model was matched second by second using photogrammetry to verify that our analysis of the position-time history of the movement of the Dodge was accurate. The motion was matched by iteration, adjusting HVE driver inputs until the roadway geometry in the simulation (e.g. pavement markings, utility poles) accurately matched the dashcam video using photogrammetry for each frame interval. It would also be possible to use the Path Follower (rather than driver controls) to setup the vehicle at known intervals, however both methods require iteration and matching the dashcam video using photogrammetry for each frame interval.

Once the motion was developed, we were able to reposition our camera in our 3D model to show what the motion of the Dodge was for each second increment when viewed from a bird's eye or overhead perspective. The comparison of the motion showing the dashcam view, our replicated view from the Dodge matching the dashcam view, the corresponding overhead view of the vehicle's position relative to the intersection geometry, and the data collected from the VBOX is shown for the 52 km/h and 57 km/h test runs the Appendix.

DATA ANALYSIS

Two test runs were considered, one at 52 km/h traveling eastbound through the test site, and one at 57 km/h traveling westbound through the test site. The measured speed of the vehicle (Vbox data) was compared to the speed determined by the image matching method (using HVE and dashcam footage comparison). For this study, we considered the independent variable to be the vehicle speed (Vbox) and the dependent variable to be the speed of the vehicle determined using the video matching method (HVE).

It was found that the speed data in this study did not follow a normal distribution, and therefore the test for equality of means in the two independent samples was with a Mann-Whitney (two-tailed) test, where a p-value greater than 0.05 indicates no significant differences between the two data sets.

RESULTS

Results showed that the speed of the test vehicle could be accurately determined using the HVE and dashcam footage comparison method. Appendix A shows the dashcam vs. HVE view comparison along with an overhead view of the test vehicle in HVE, for both the 52 km/h (eastbound) and 57 km/h (westbound) conditions. The independent vehicle speed data (collect from the Vbox) is also shown at each instance.

For the 52 km/h (eastbound) condition, there was no significant difference between the speed recorded using Vbox (mean = 52.22 ± 0.11 km/h) and the speed determined using the HVE method (mean = 52.35 ± 0.21 km/h) (N=30, p=0.26). Figure 5 presents box plots comparing the two datasets, along with the speed data plotted vs. time.

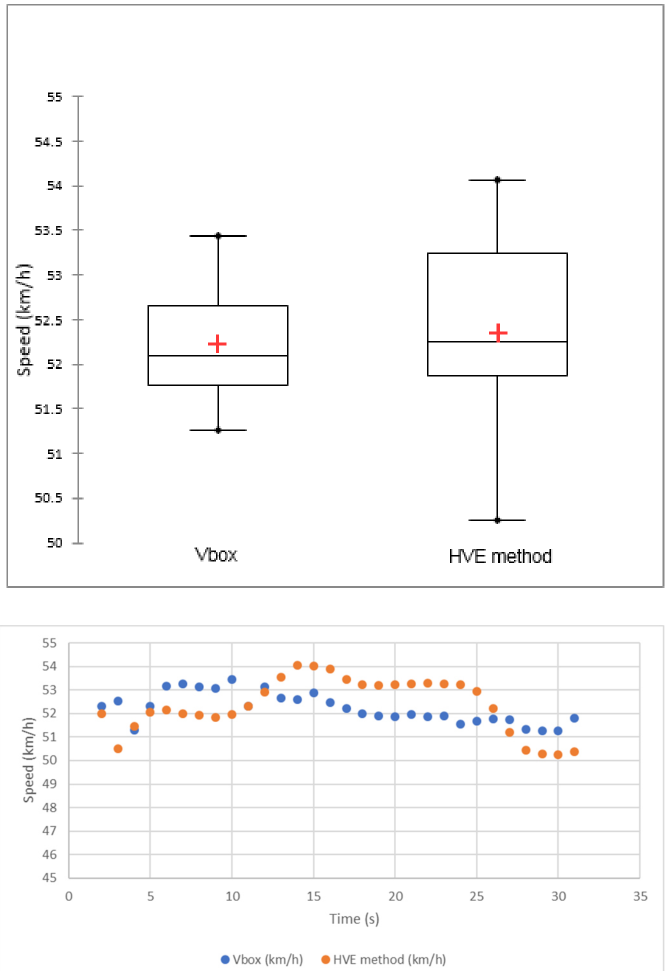

Figure 5. Box plot and Speed vs Time – 52 km/h (eastbound)

Similarly, for the 57 km/h (westbound) condition, there was no significant difference between the speed recorded using Vbox (mean = 57.25 ± 0.19 km/h) and the HVE method (mean = 57.38 ± 0.11 km/h) (N=29, p=0.08). Figure 6 presents box plots comparing the two datasets, along with the speed data plotted vs. time.

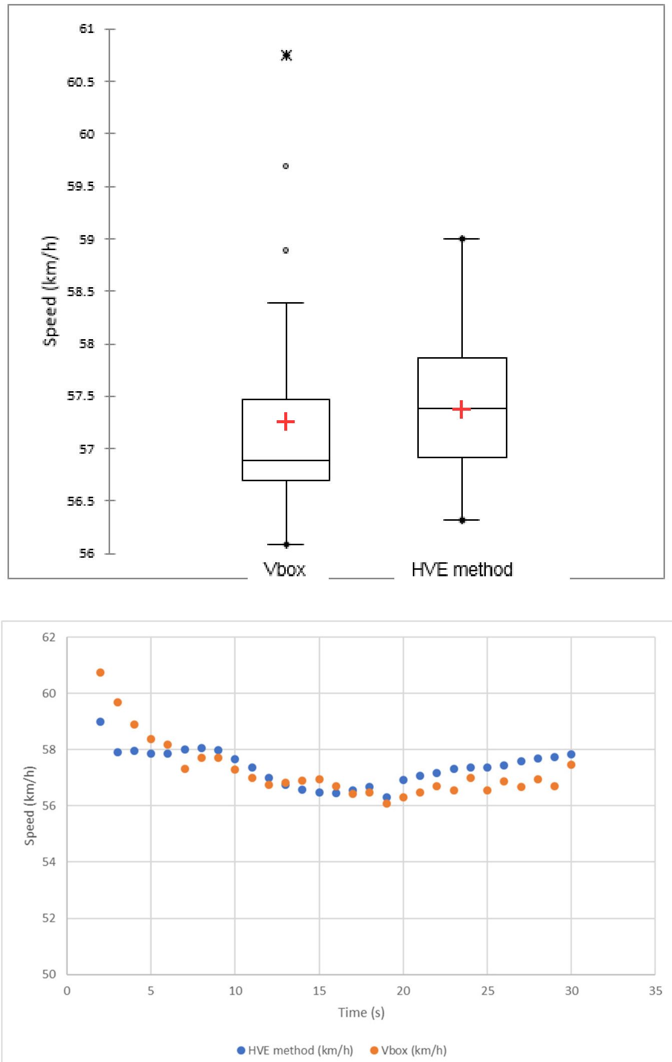

Figure 6. Box plot and Speed vs Time – 57 km/h (westbound)

In summary, results from this exercise show that the video matching method using HVE has similar accuracy to on-board instrumentation in the vehicle.

ADDITIONAL SCENARIOS

The same process can be used to determine the speeds of other vehicles that appear in the dashcam footage. An example shown below is footage from a dashcam from a vehicle driving eastbound on the test site, and an oncoming motorcycle. The speed of the motorcycle can by determined by considering traditional engineering methods (i.e. speed = distance divided by time, positions in dashcam footage shown in Figure 7 below). By using an accurate site diagram, the position of the motorcycle at two different points can be determined, and the time between the two instances can be calculated by knowing the frame rate and determining the number of frames between the two positions. The speed of the motorcycle can also be determined using HVE and the video matching approach outlined above, by setting and adjusting the speeds and driver controls of both vehicles to match the dashcam footage to the HVE output video (shown in Figure 8 below). For the purposes of this paper the motorcycle is highlighted with a yellow arrow, however, this is not necessary if larger images were used.


Figure 7: Traditional position vs. time analysis for other vehicles shown in dashcam footage. Shown above are two positions of an oncoming motorcycle, 1.27 seconds apart.

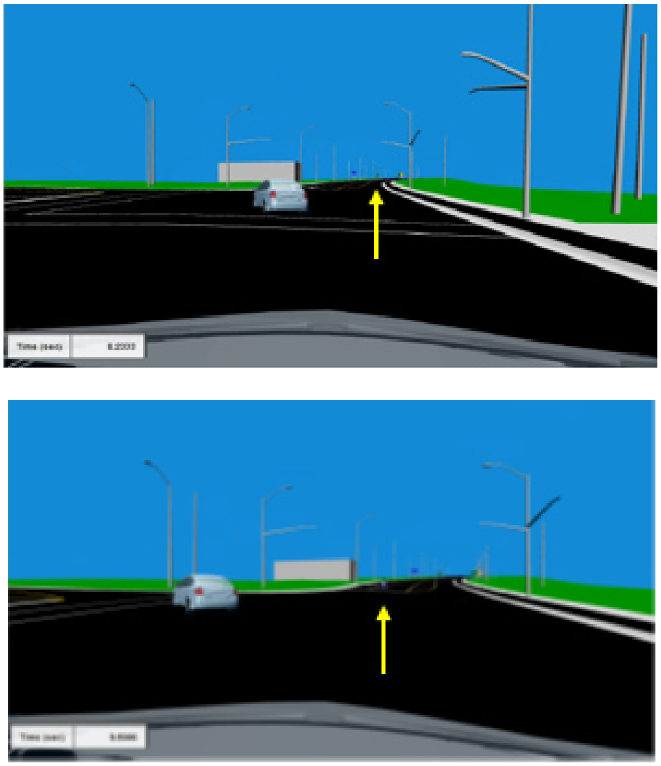

Figure 8: Using HVE to match the vehicle positions shown in the dashcam to determine vehicle speeds

DISCUSSION

Rotation about the optical axis is known as camera swing, equivalent to roll in vehicle convention. Dashcams are typically positioned so that the horizontal axis is positioned as level as possible, although they are typically mounted by a user with adhesive tape or a suction cup and only “eyeballed” into place. Although the location of the dashcam can be determined using HDS-3D scanning, the amount of camera swing is best evaluated by considering still frames from the dashcam itself. HVE does not permit the user to edit the camera swing, instead it aligns the vertical axis of the view to be parallel to the Z axis. Therefore, in instances where there is noticeable camera swing, it will be necessary to rotate the video with editing software.

The accuracy of the iterative process is dependent somewhat on the HVE user’s ability to match the dashcam view to the HVE view, adjusting driver input to achieve a suitable match frame by frame. Therefore, when performing the comparison between HVE and dashcam video, it is a best practice to break down any dashcam video single into frames (noting the frame rate), and comparing a single frame of the dashcam to a single instance in HVE rather than attempting to use a slider on a video media player. This will allow for more accuracy as the slider in a video player often does not have the same timestep as the frame rate of the video. This source of error can be eliminated by comparing single frames.

FUTURE TESTING

Future testing methodology should involve vehicle acceleration and slowing at various rates. Testing should also be done at very slow and very fast speeds in order to determine if there is any difference in the accuracy able to be achieved.

CONTACT

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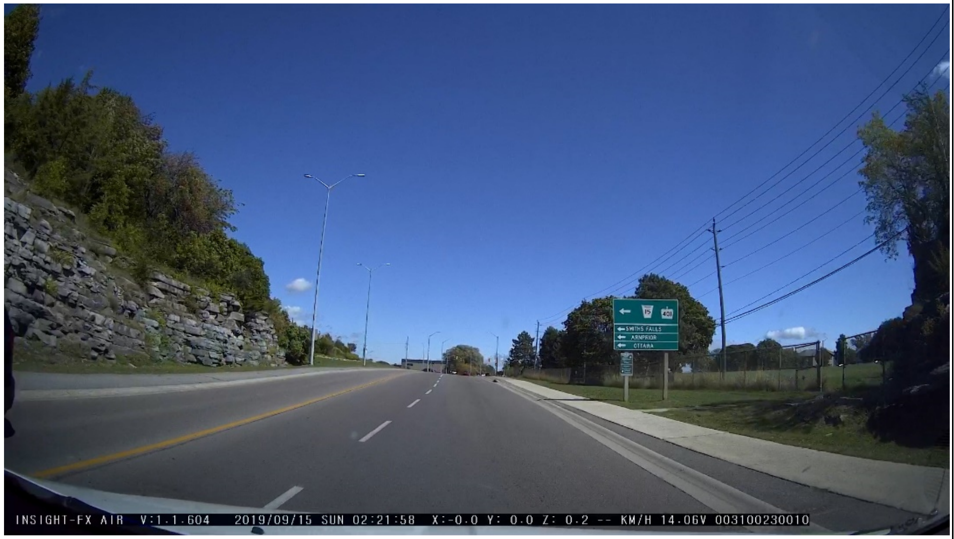
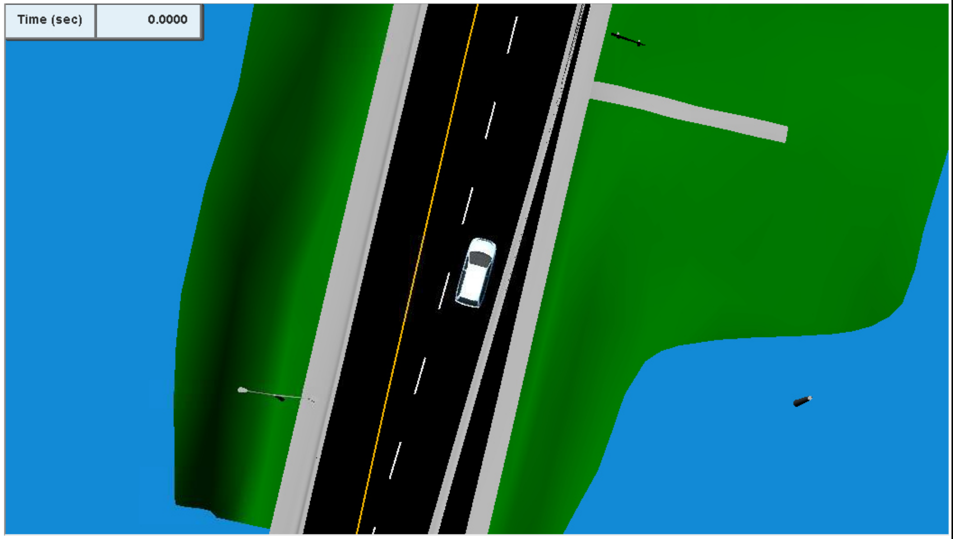
2. Day, T.D., Roberts, S.G., and York, A.R., "SIMON: A New Vehicle Simulation Model for Vehicle Design and Safety Research,” SAE Technical Paper 2001-01-0503, 2003.
3. Wheeler, A.J. and Ganji, A.R., “Introduction to Engineering Experimentation,” Englewood Cliffs, N.J., Prentice Hall, 1996.
4. Rose, N., Carter, N., Pentecost, D., Bortles, W. et al., "Using Data from a DriveCam Event Recorder to Reconstruct a Vehicle-to-Vehicle Impact," SAE Technical Paper 2013-01-0778, 2013

APPENDIX A – VIDEO MATCH OF DASHCAM, HVE, AND VBOX DATA

T= 0s





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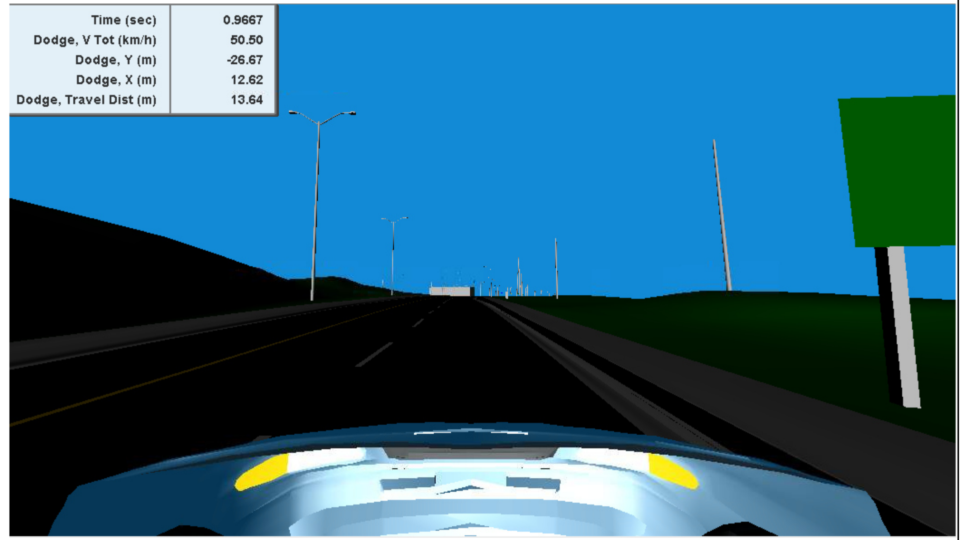

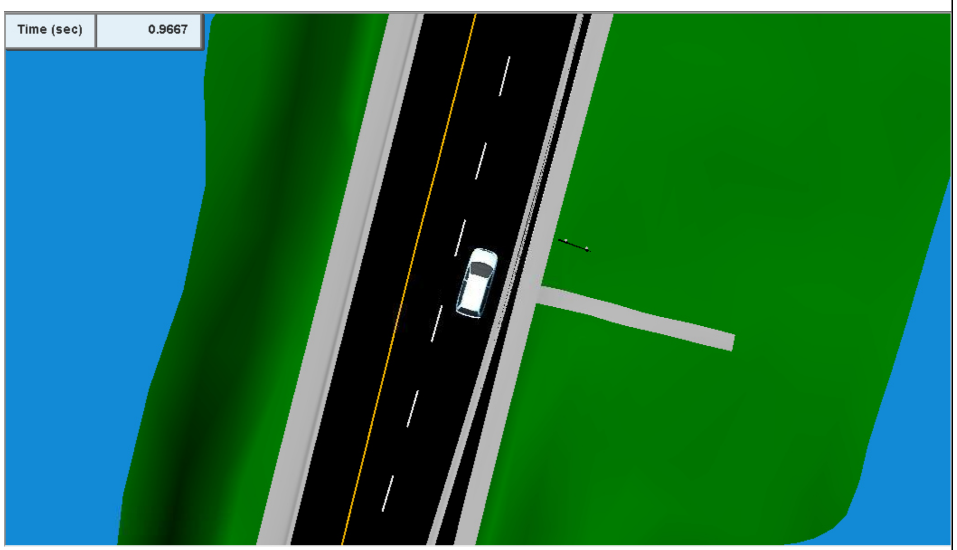

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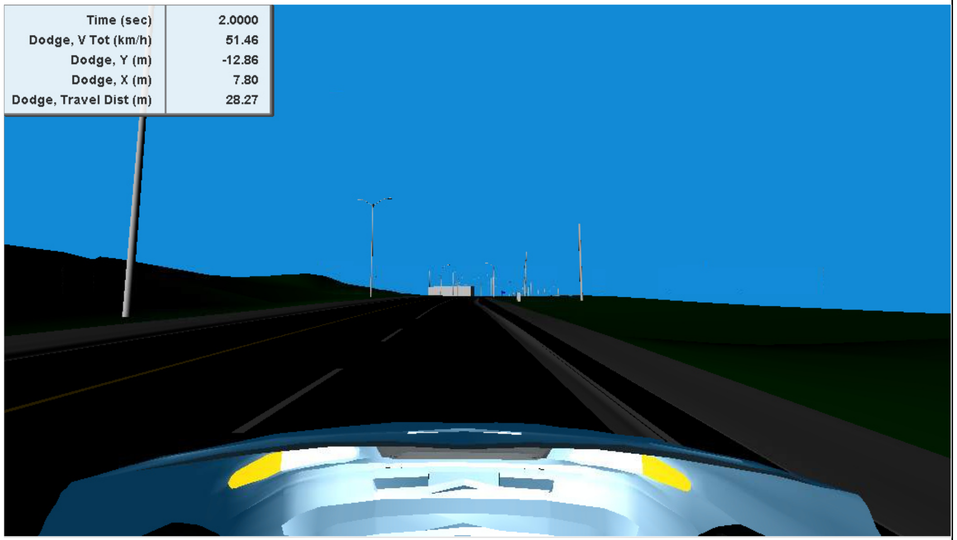

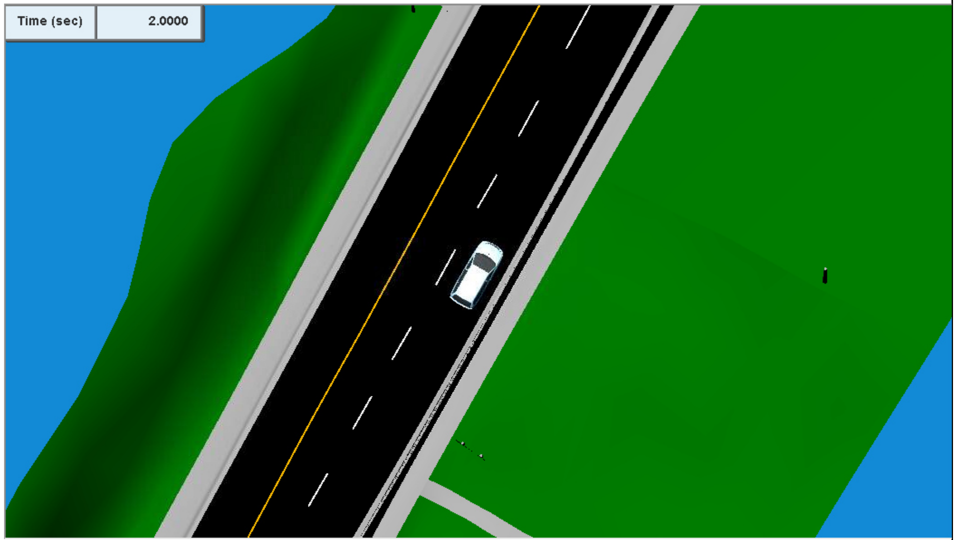

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8	172946.3	2654.343027	4587.616697	51.285	63	71.06	0.94

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sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
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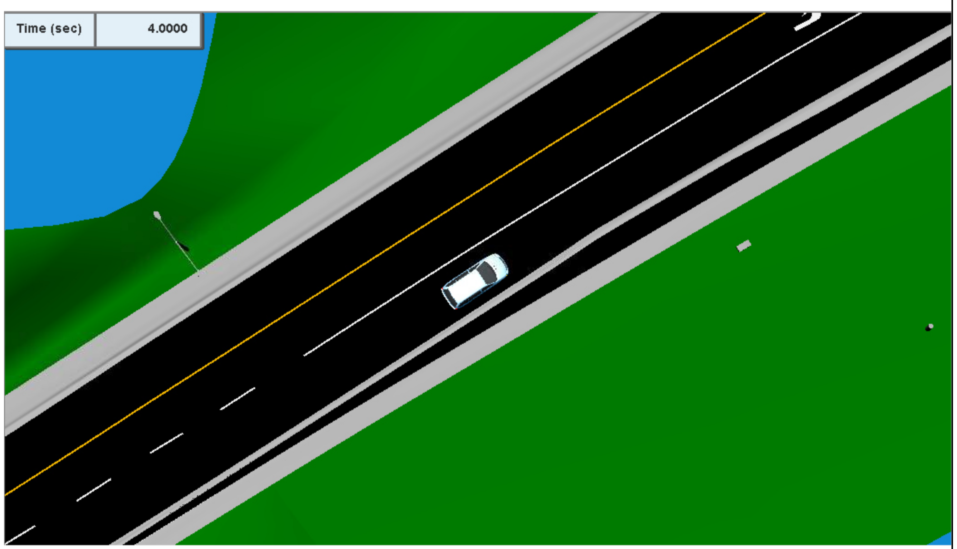

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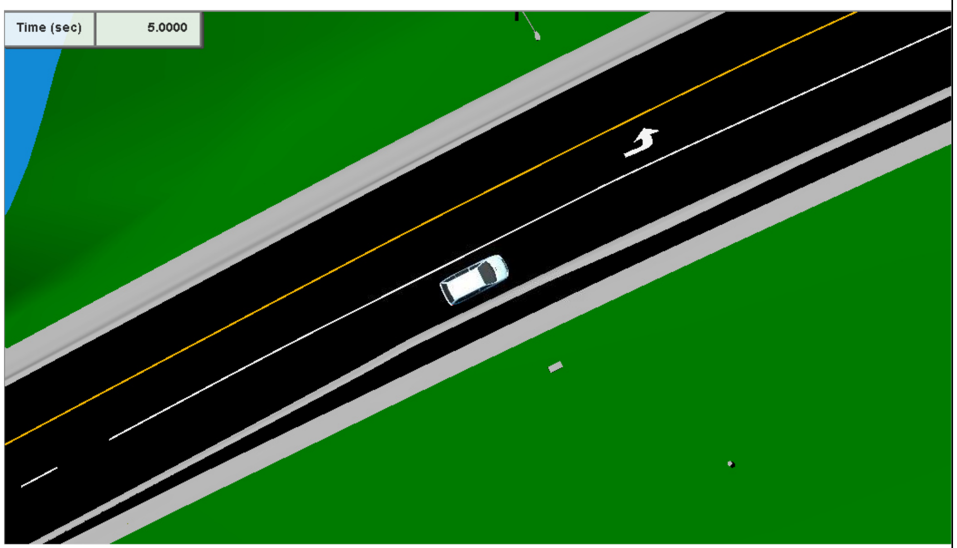

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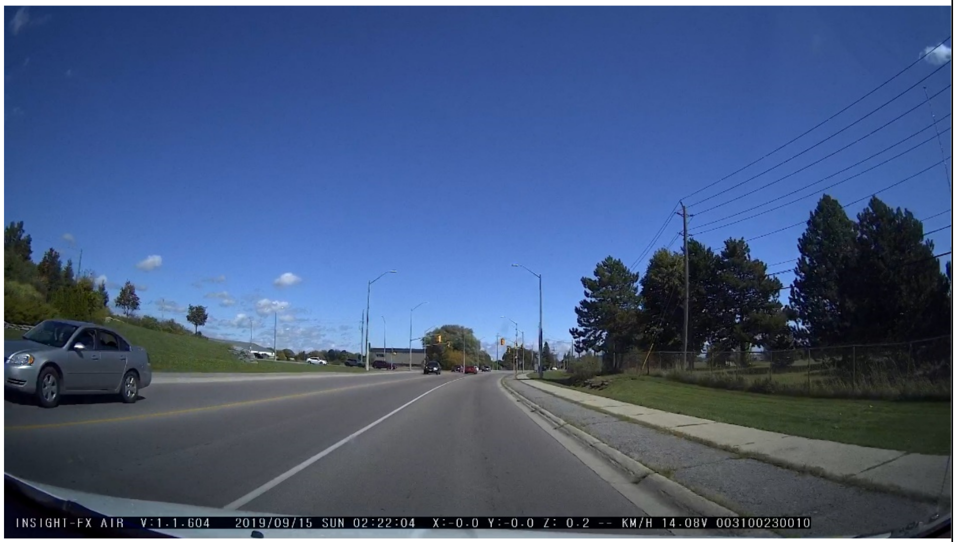

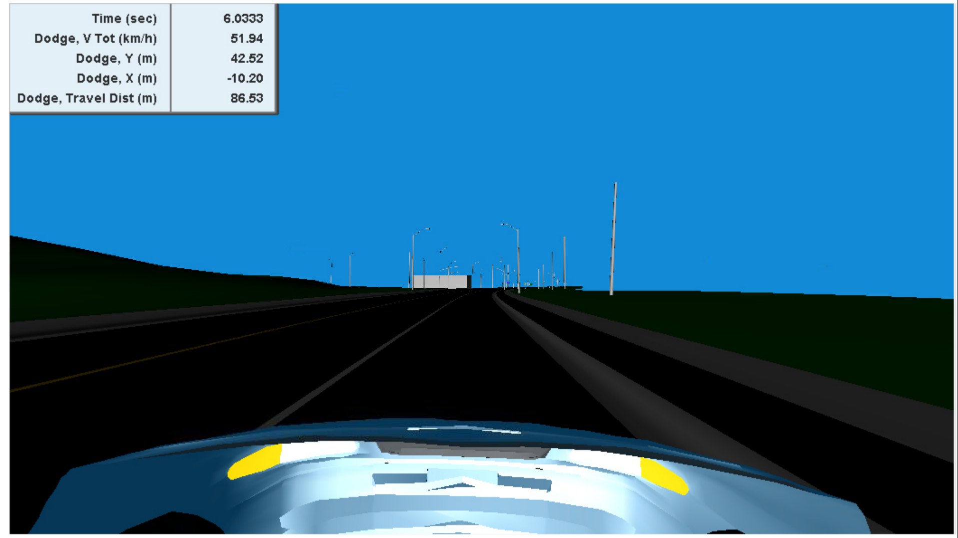

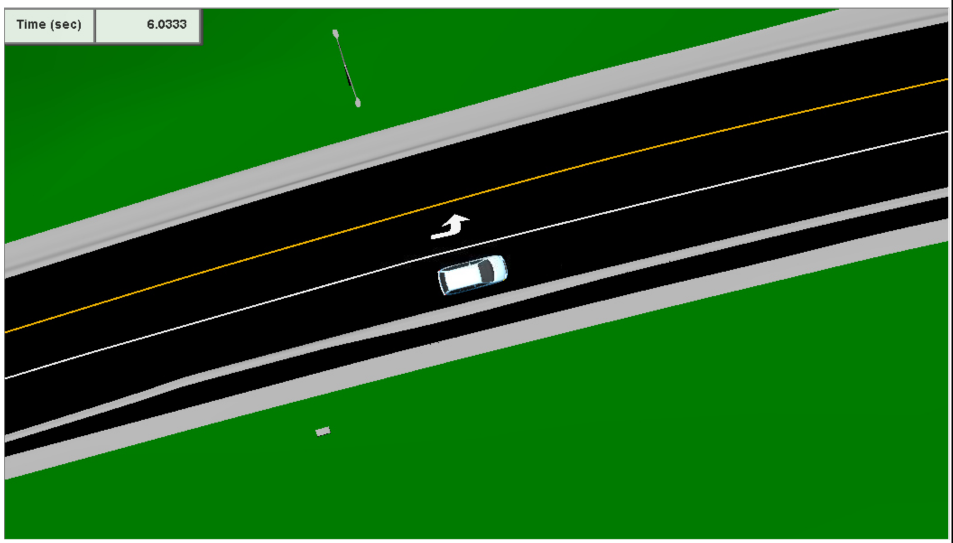

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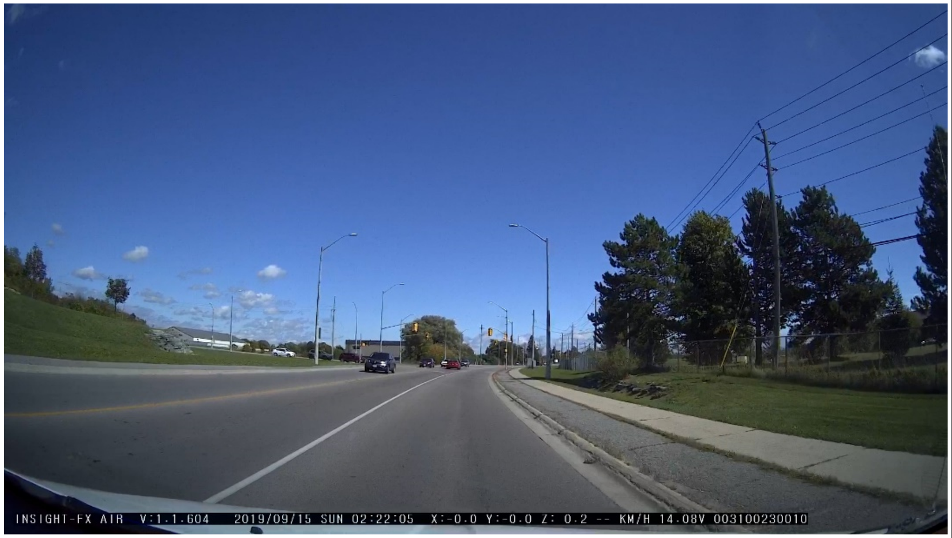

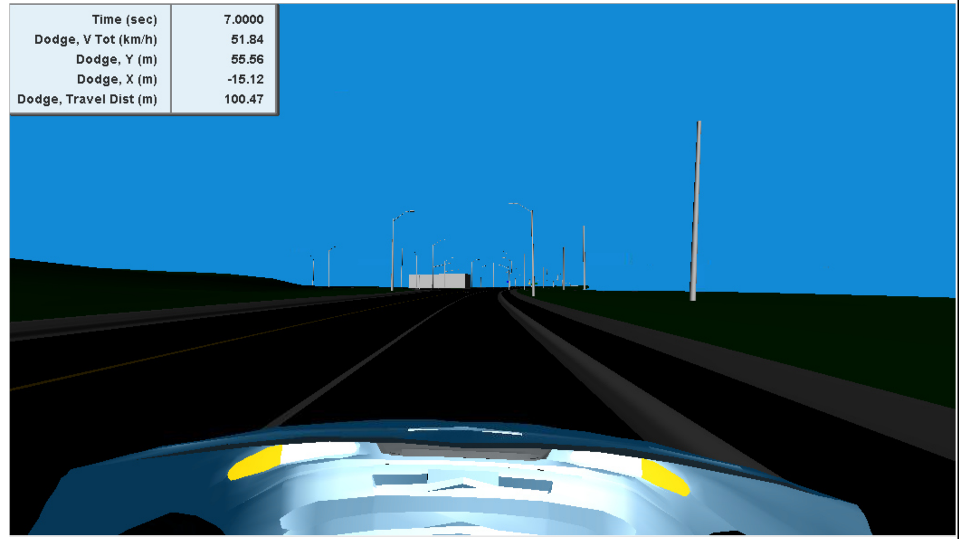

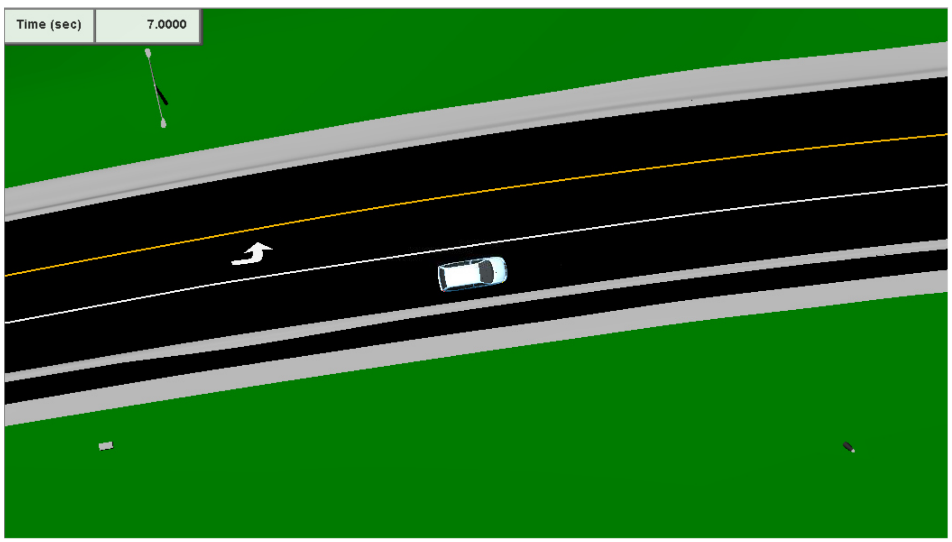

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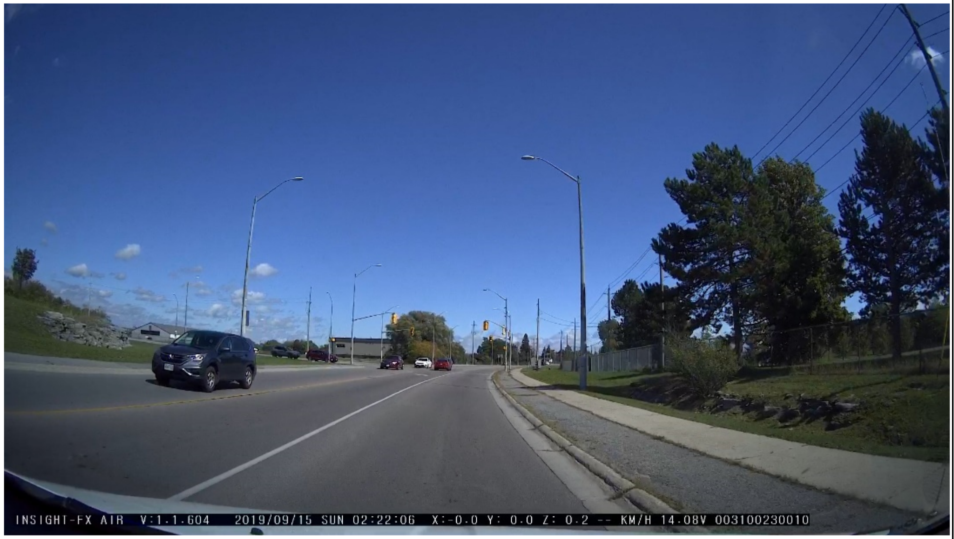

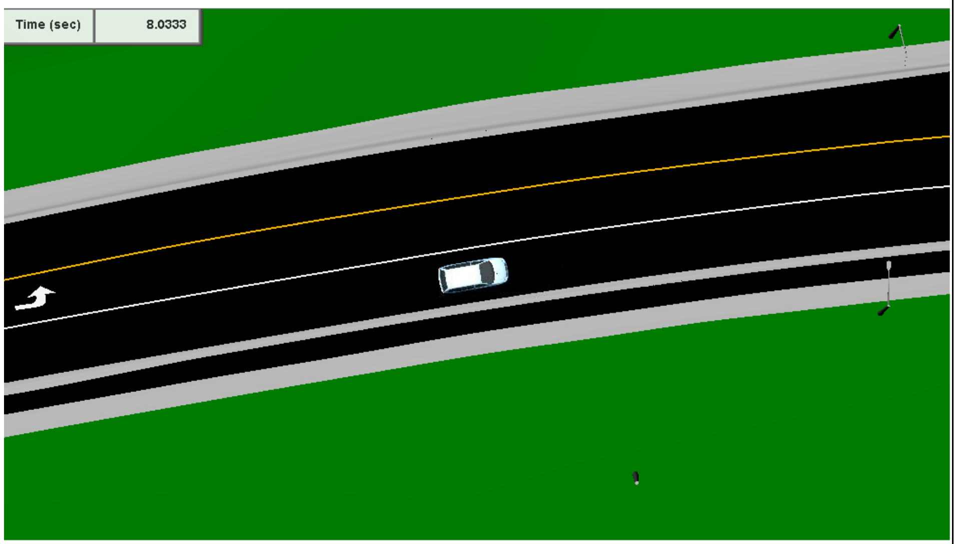

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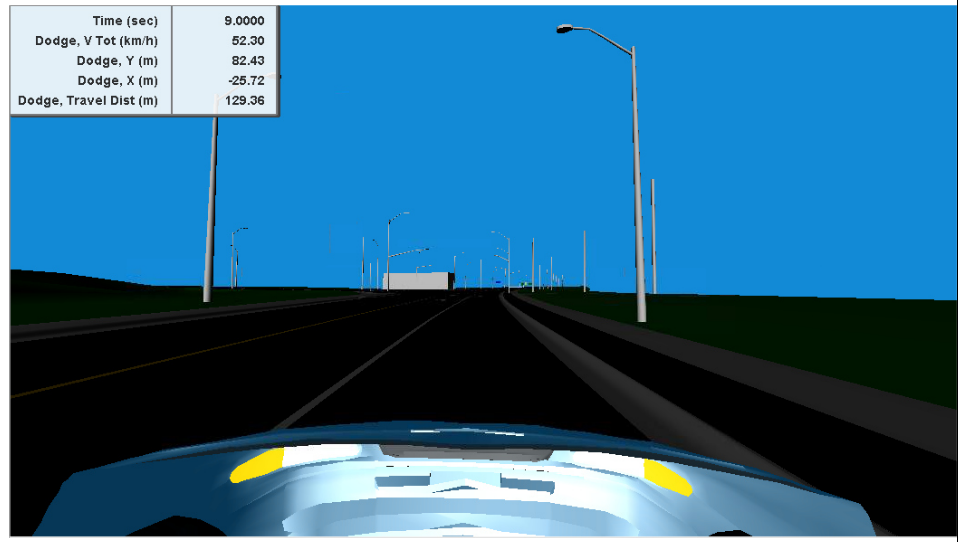

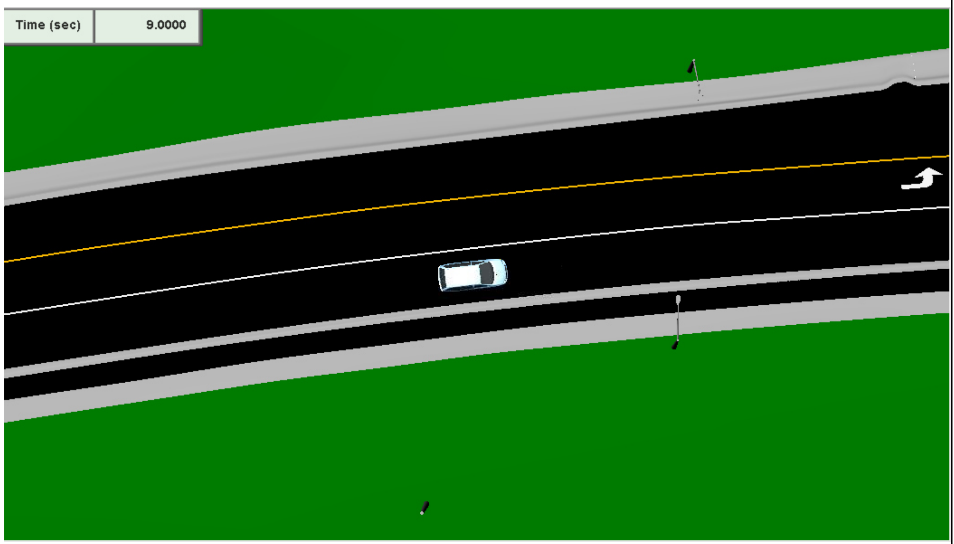

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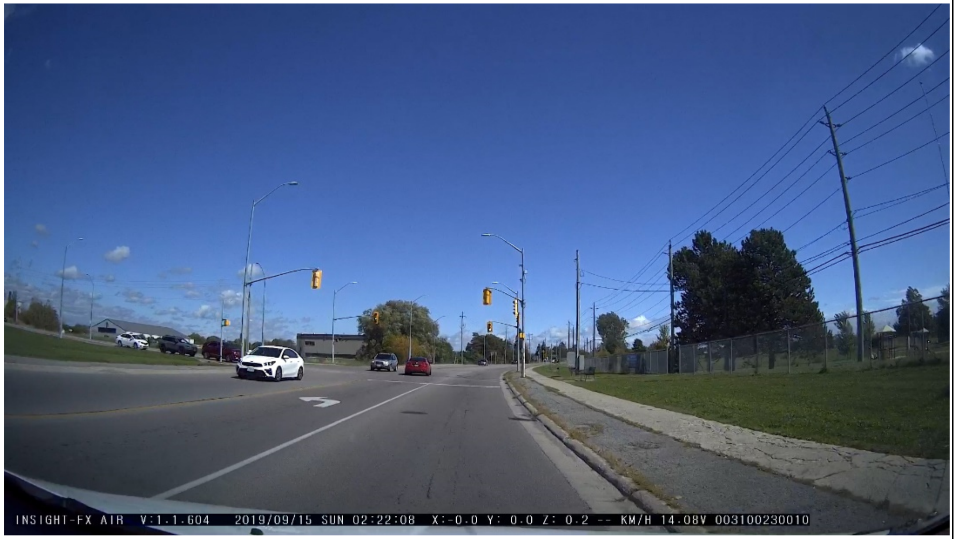

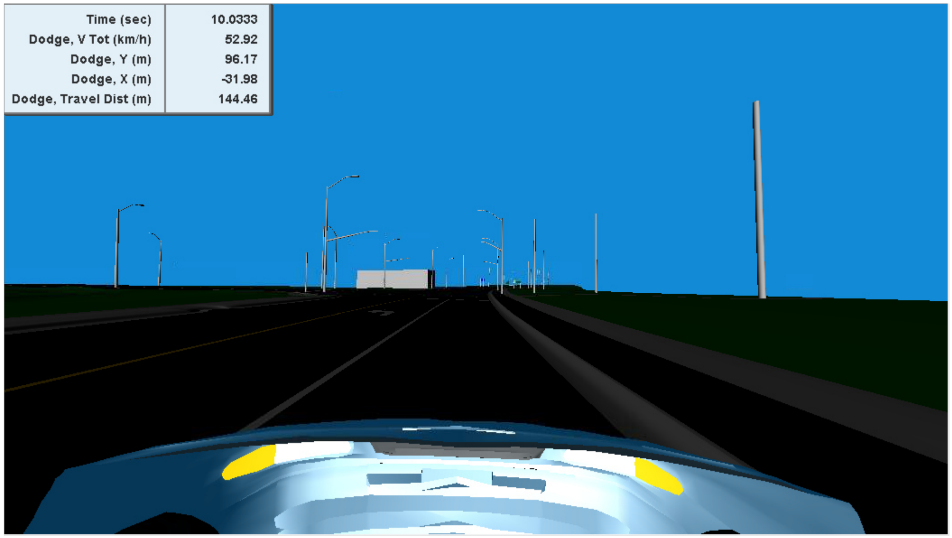

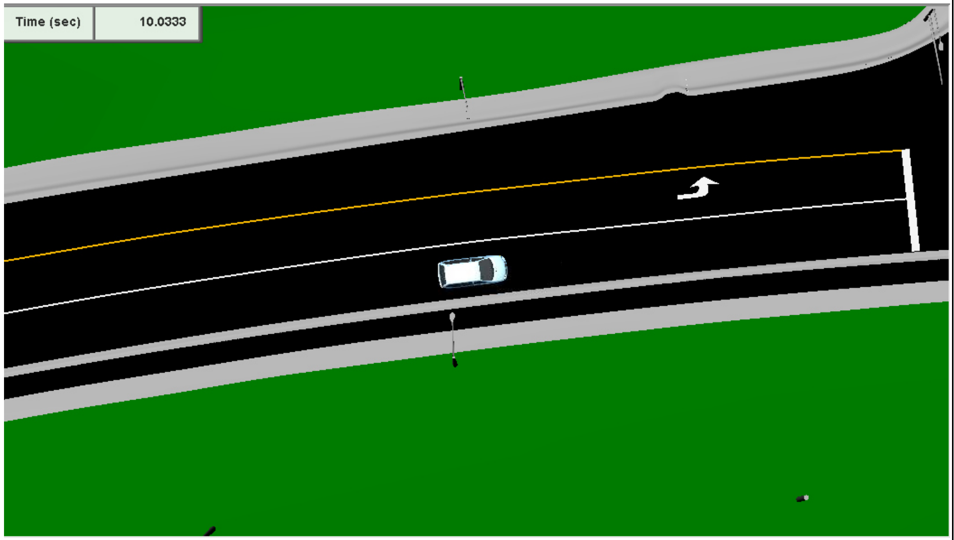

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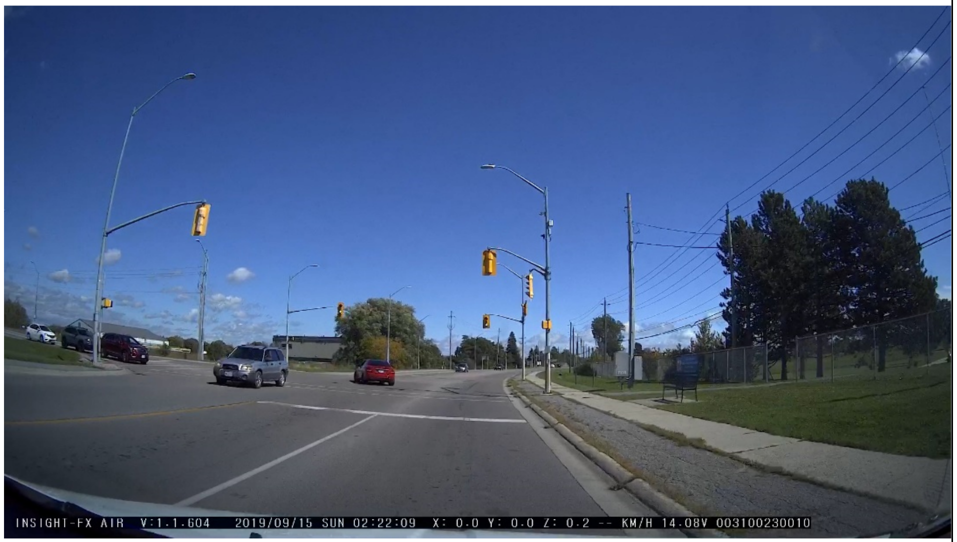

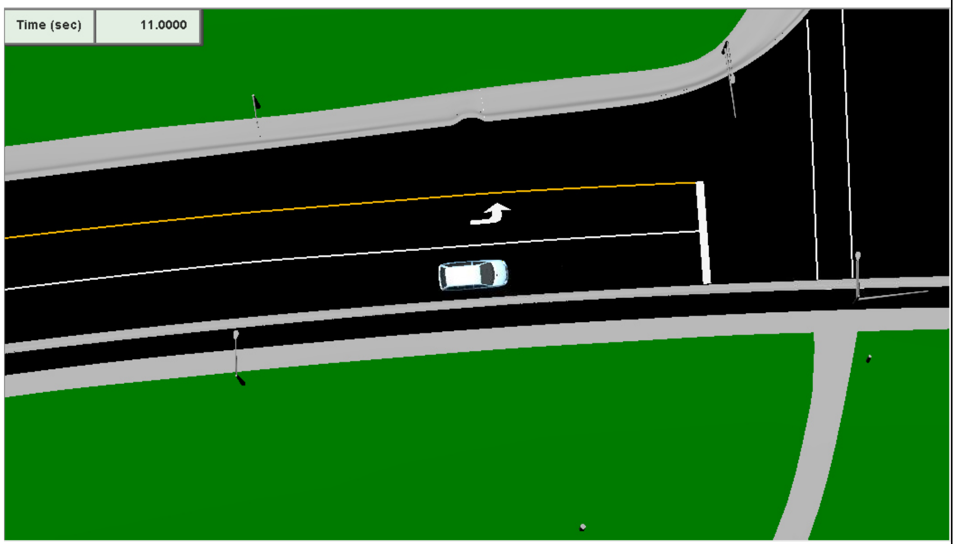

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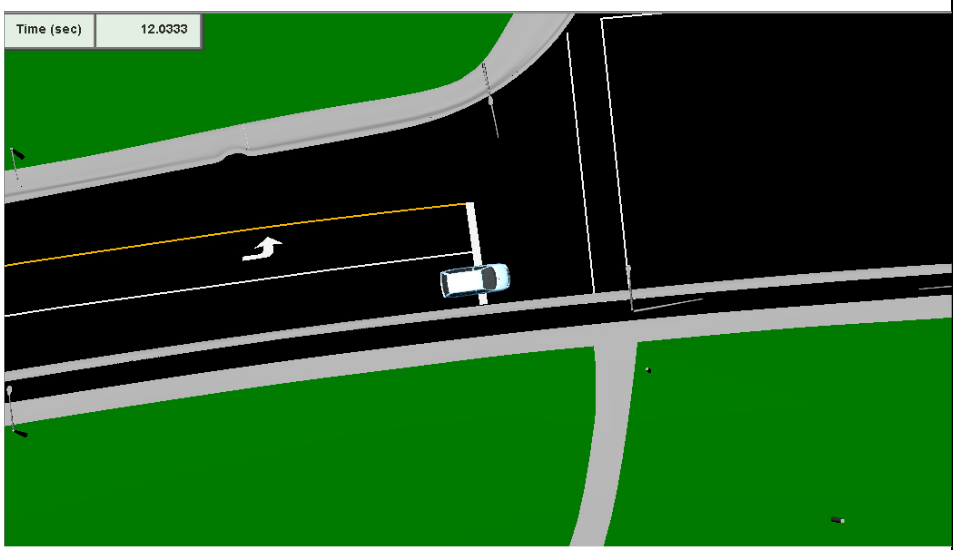

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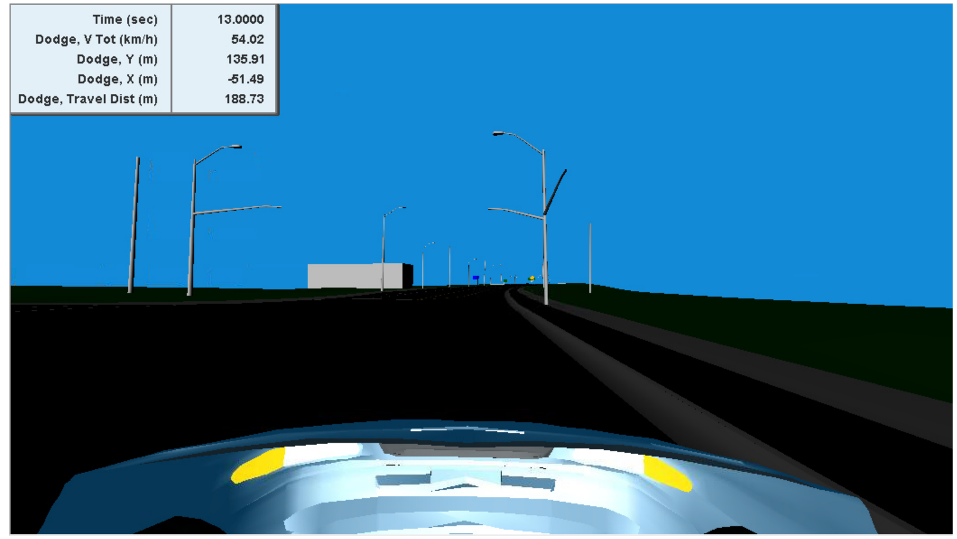
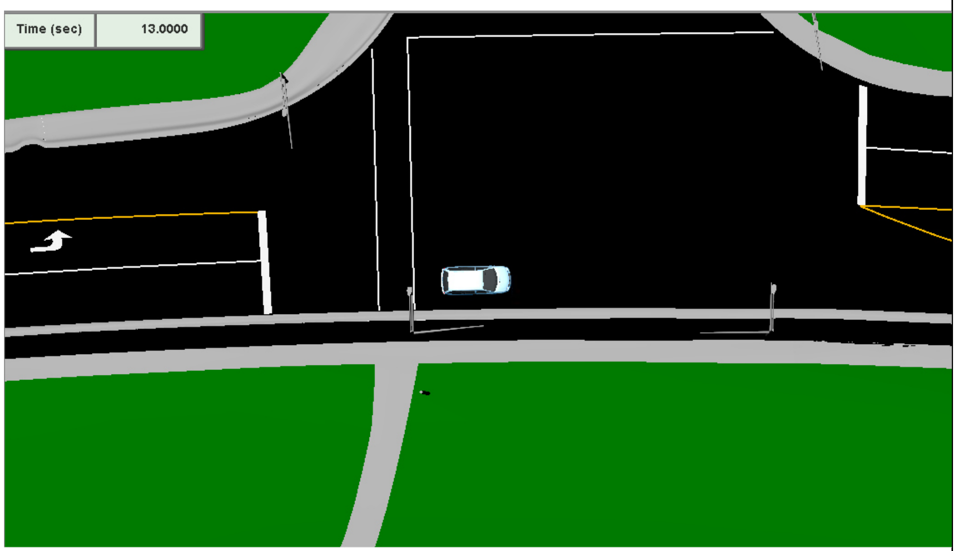
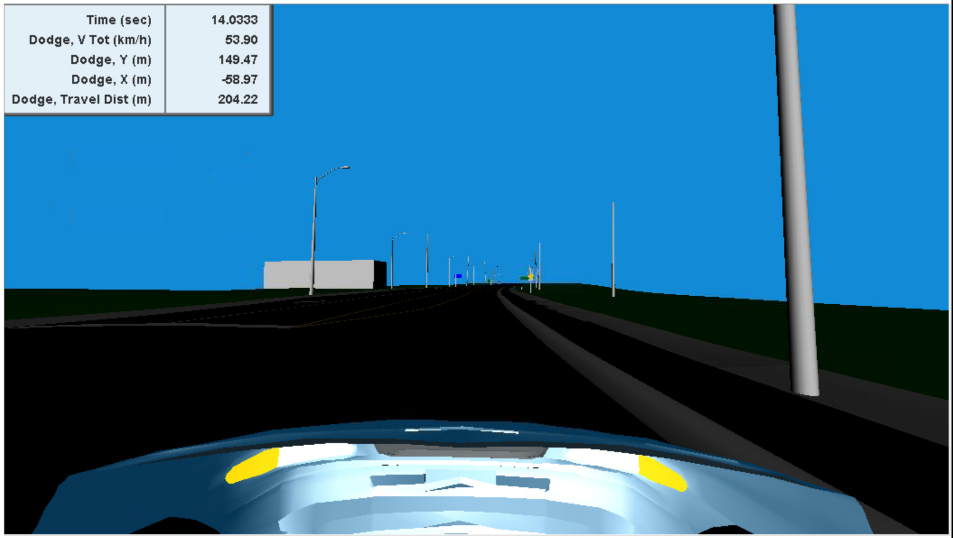
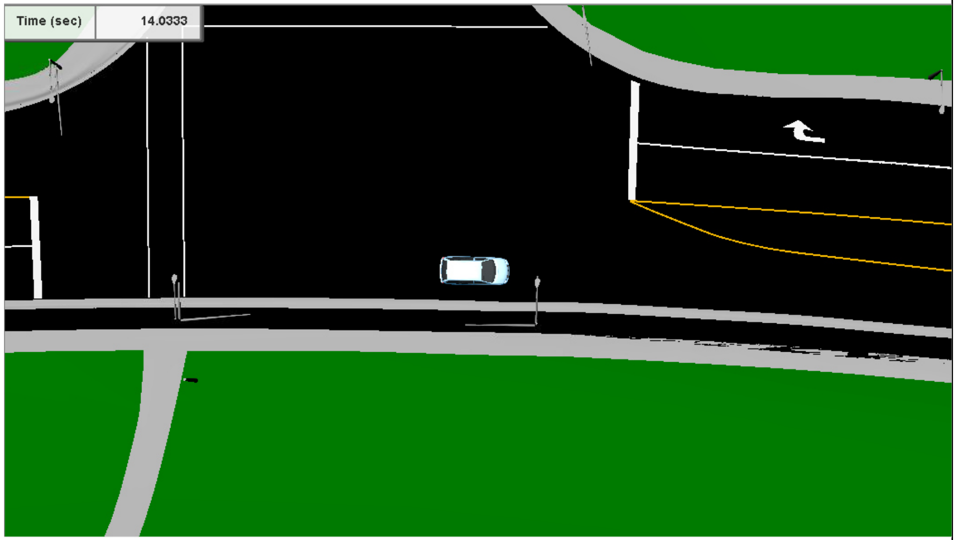




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	172957.3	2654.379005	4587.505075	52.893	71.9	69.74	-0.05

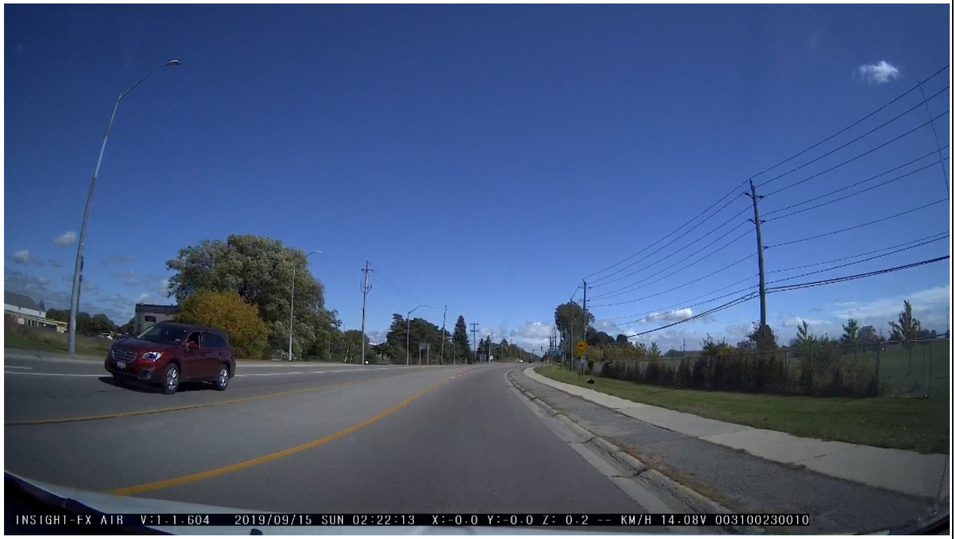
T= 14.0s

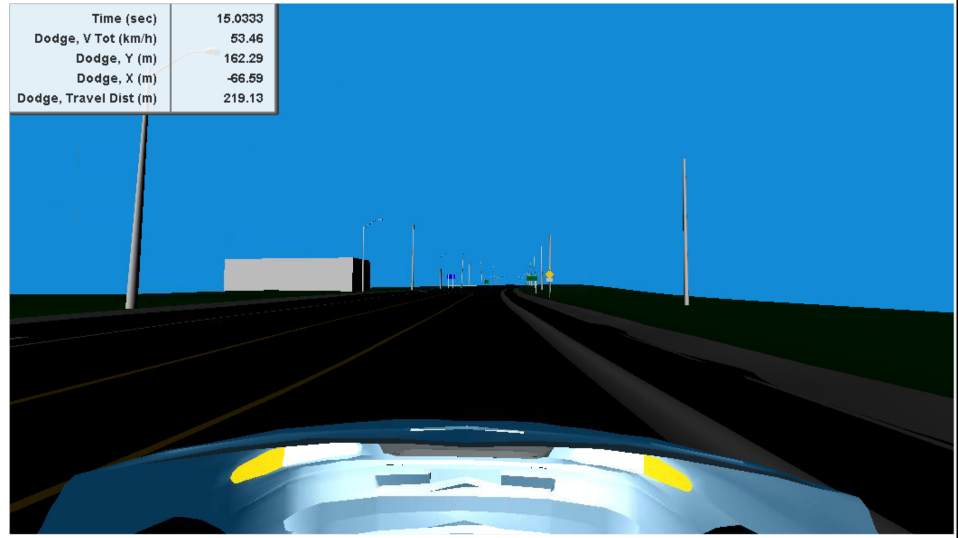


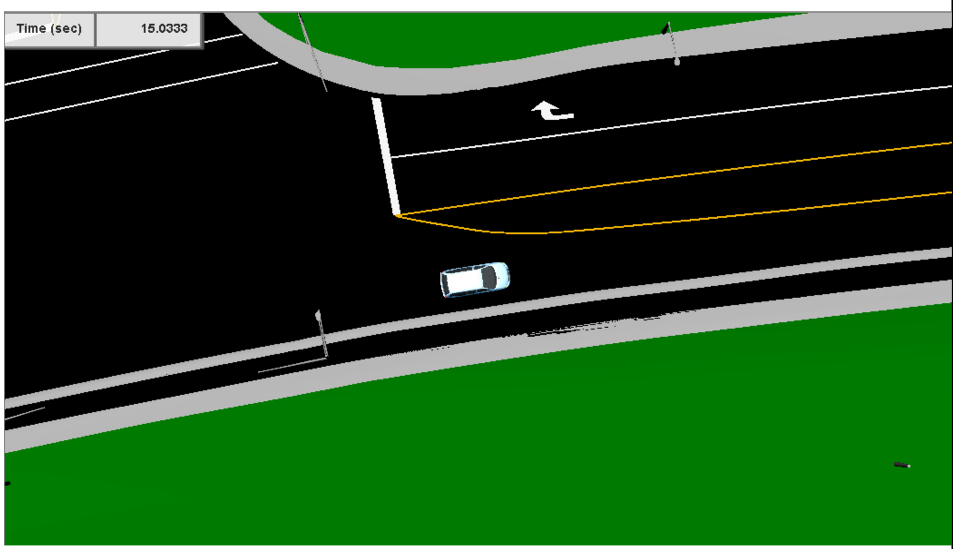


sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	172958.3	2654.381278	4587.49458	52.473	74.29	69.7	0.01

T= 15.0s

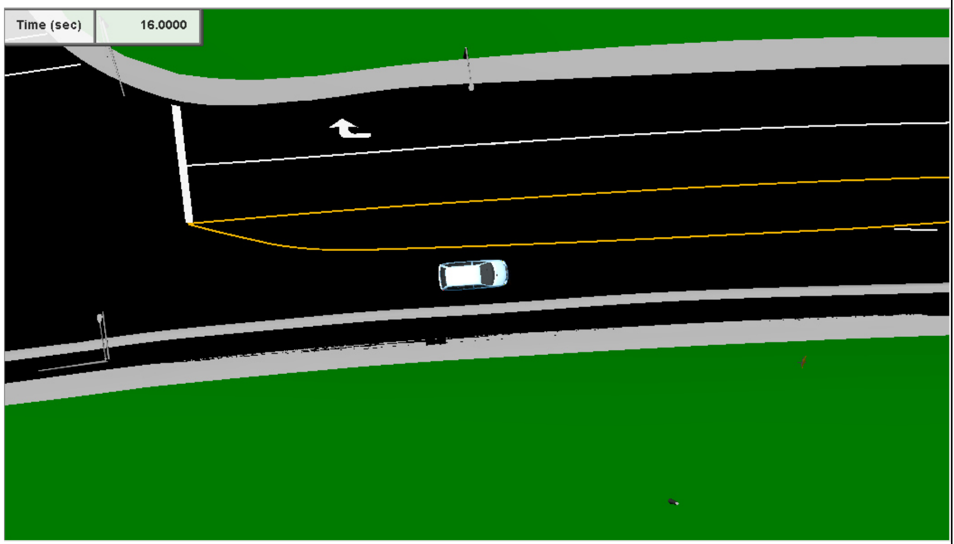






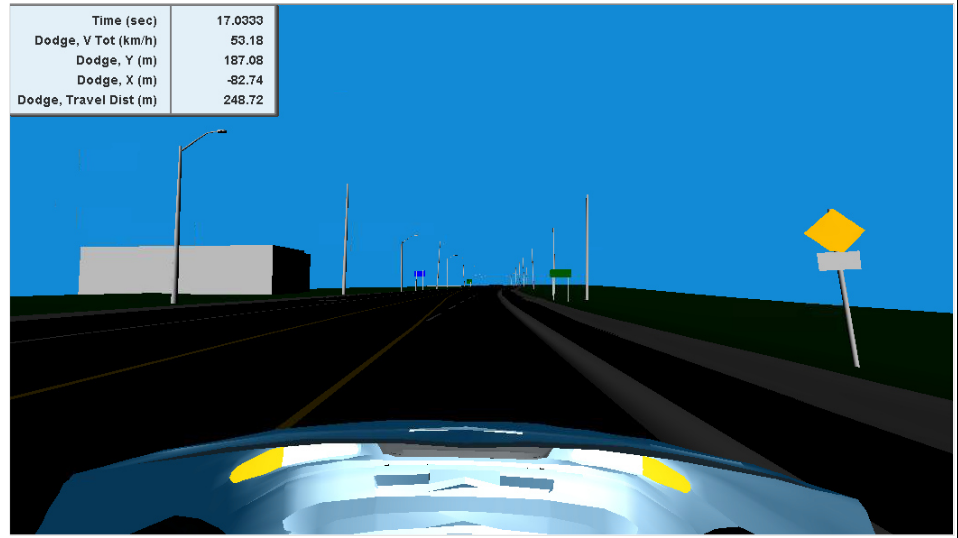
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	172959.3	2654.383347	4587.483969	52.216	76.15	69.7	-0.01

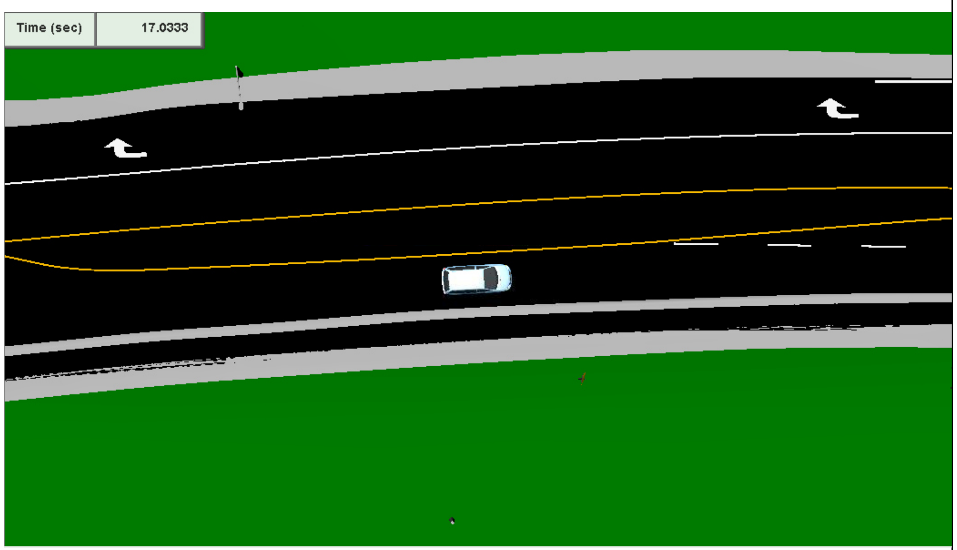
T= 16.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173000.3	2654.38509	4587.47336	51.995	77.84	69.63	0.2

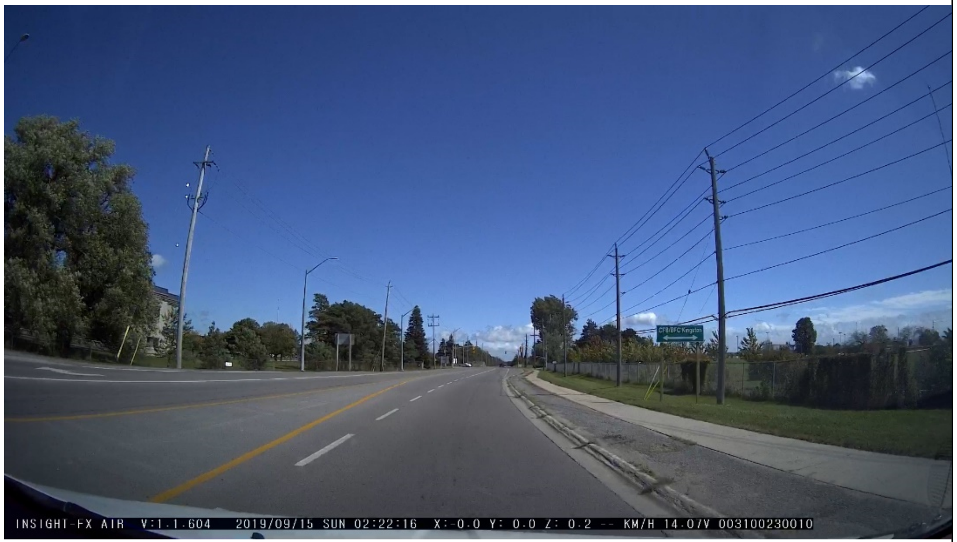
T= 17.0s

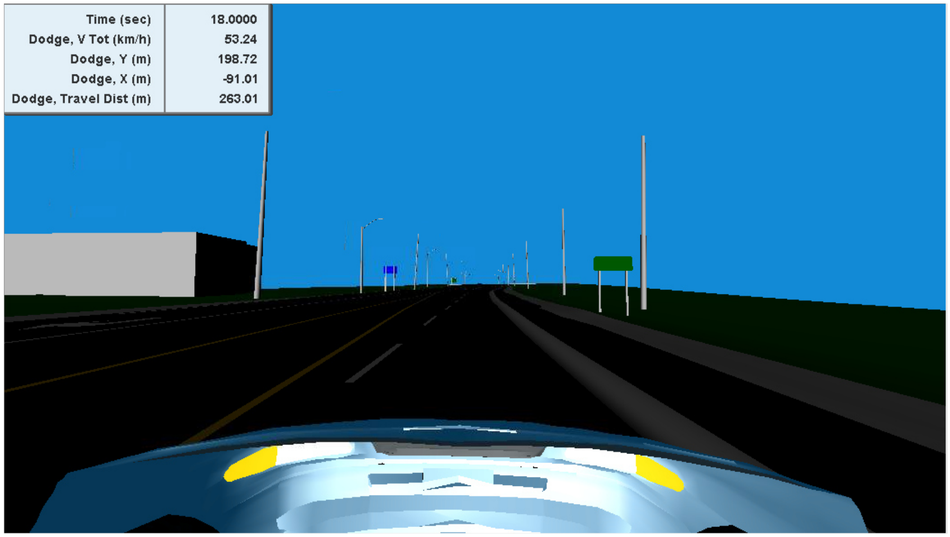




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173001.3	2654.386661	4587.462719	51.898	78.69	69.58	0.05

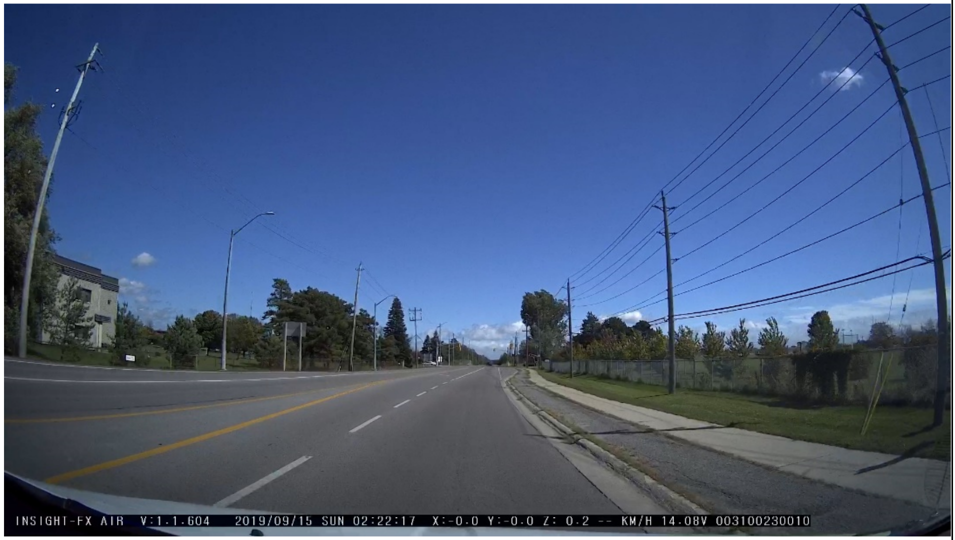
T= 18.0s

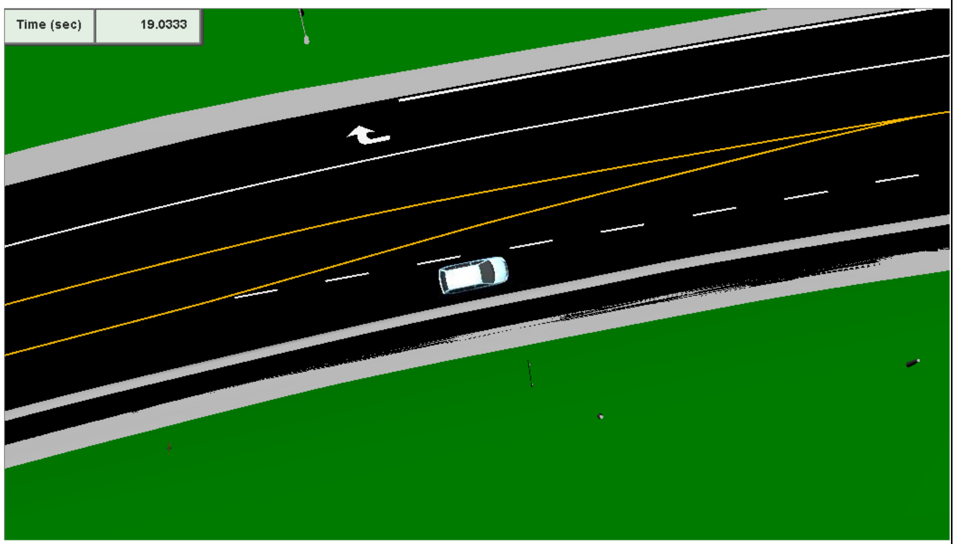




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173002.3	2654.388071	4587.452044	51.864	80.47	69.58	0.23

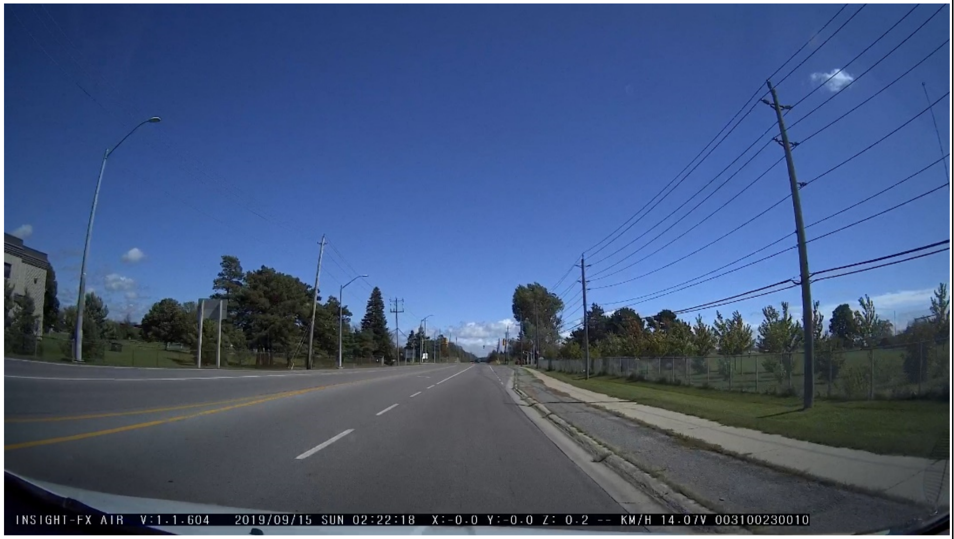
T= 19.0s

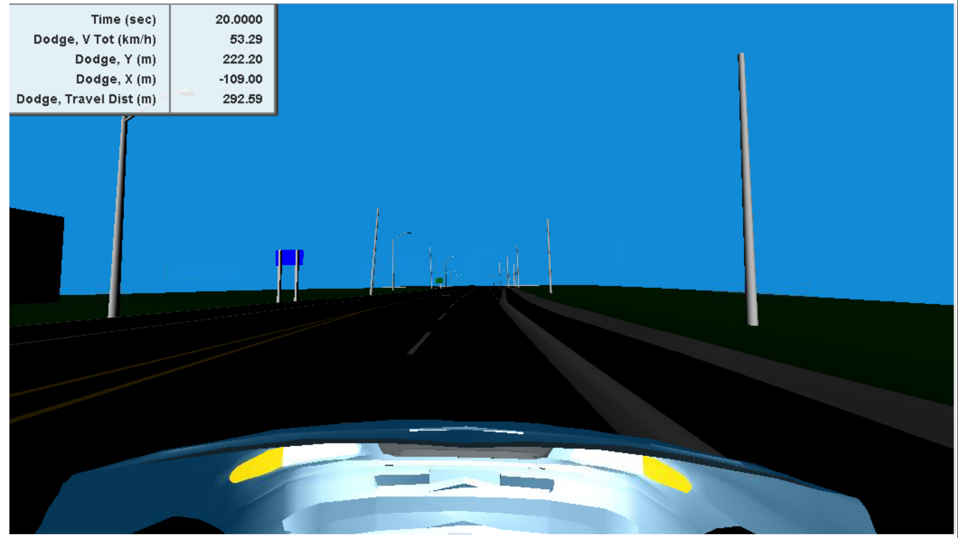


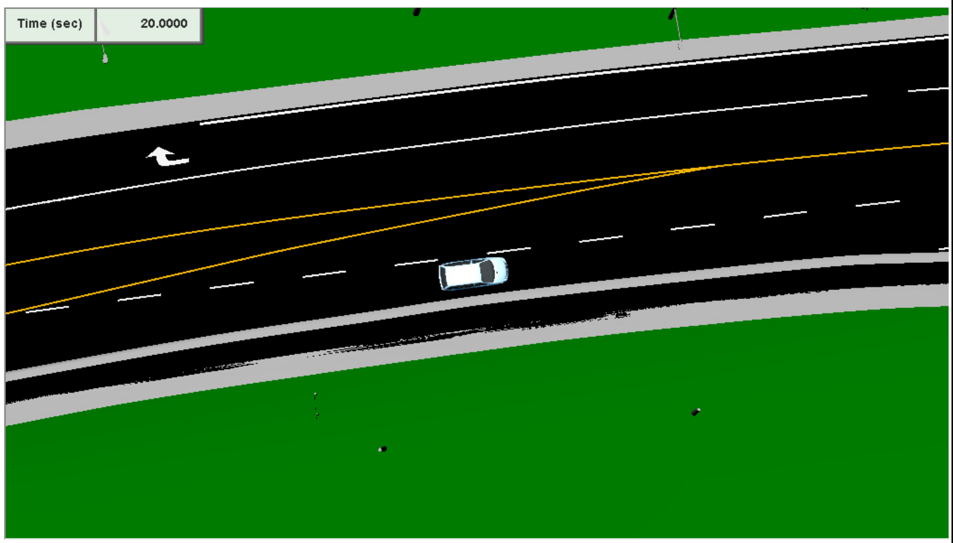


sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173003.3	2654.389313	4587.441337	51.953	81.28	69.58	0.08

T= 20.0s

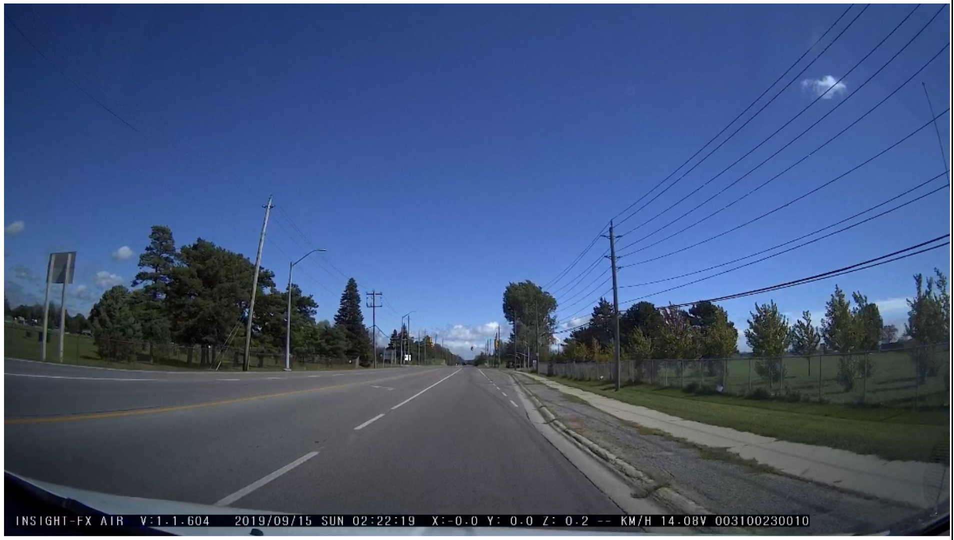


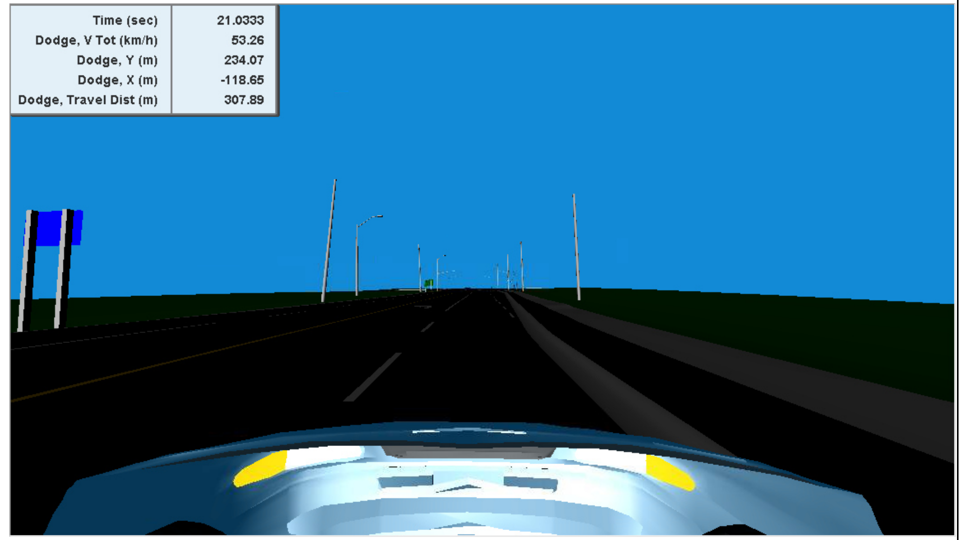


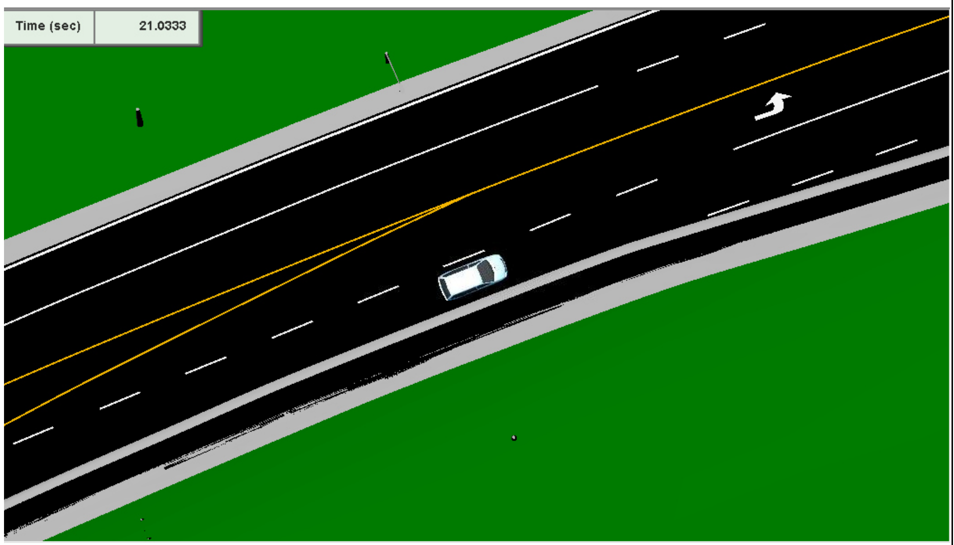


sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173004.3	2654.390503	4587.430514	51.866	82.95	69.76	0.17

T= 21.0s

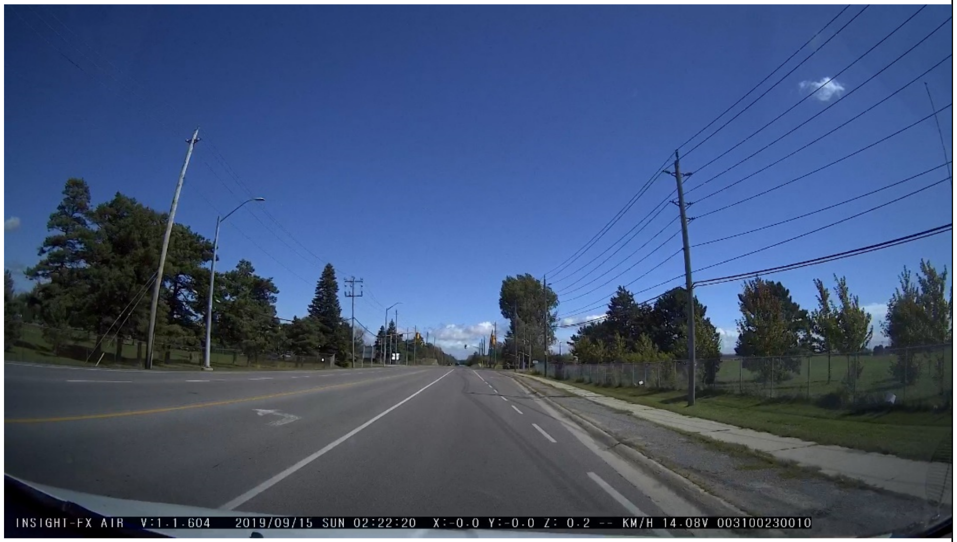


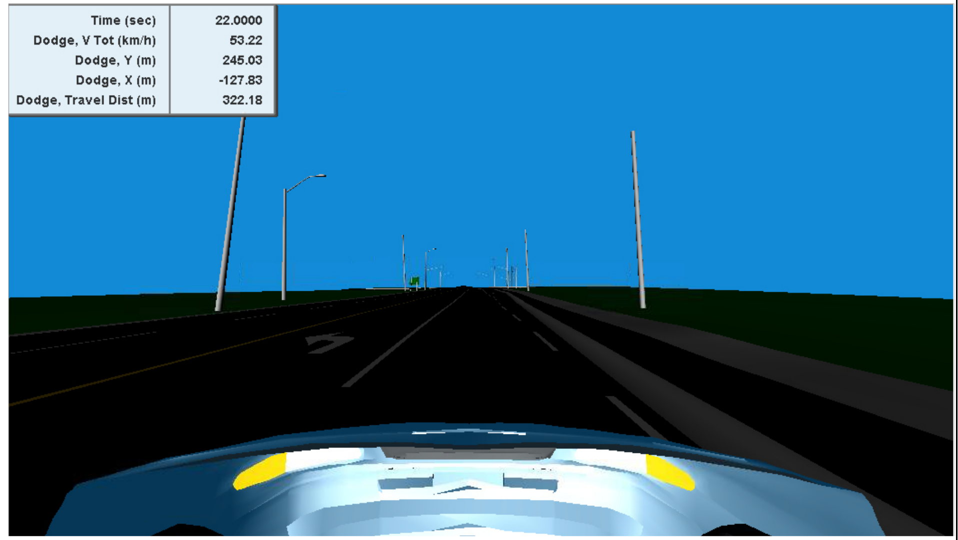


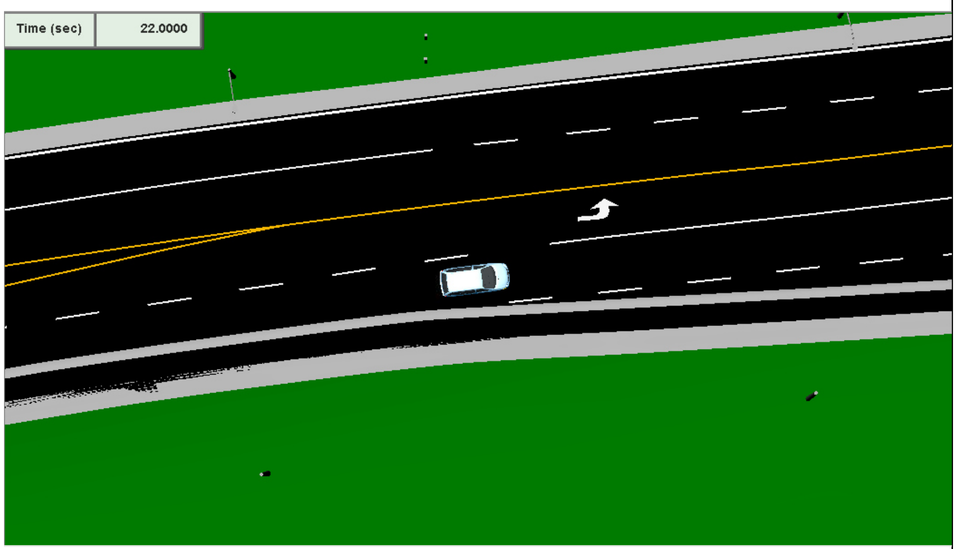


sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173005.3	2654.391274	4587.419869	51.887	83.97	69.6	0.15

T= 22.0s

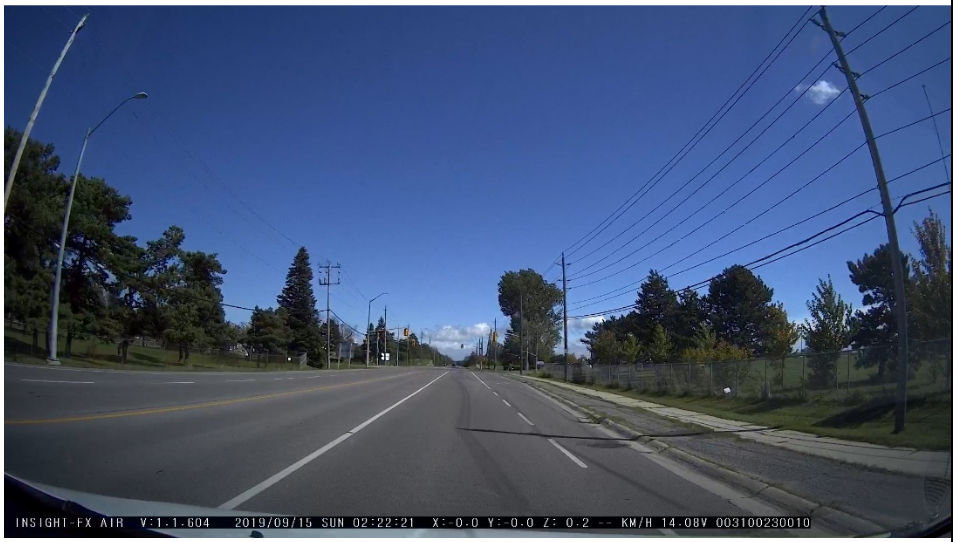


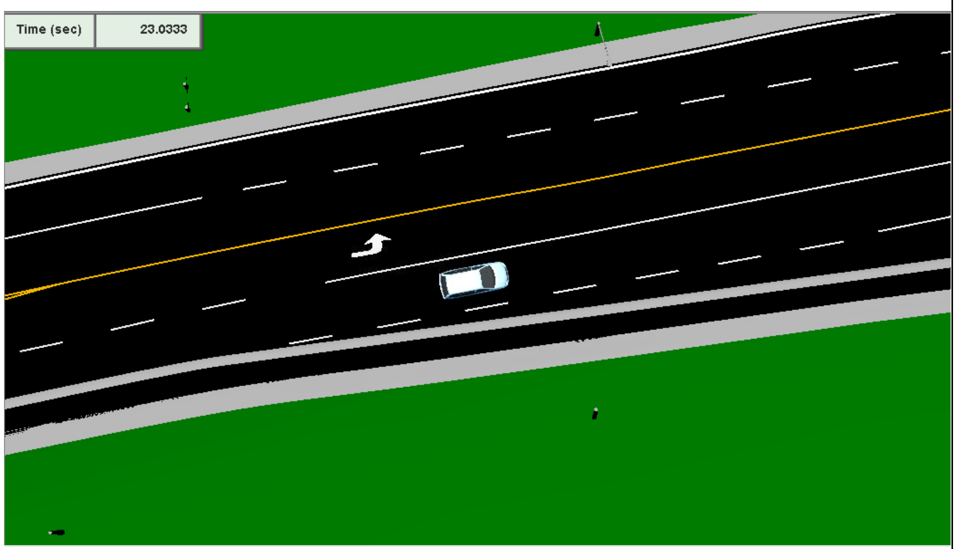




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173006.3	2654.392045	4587.409125	51.541	84.57	69.65	0.23

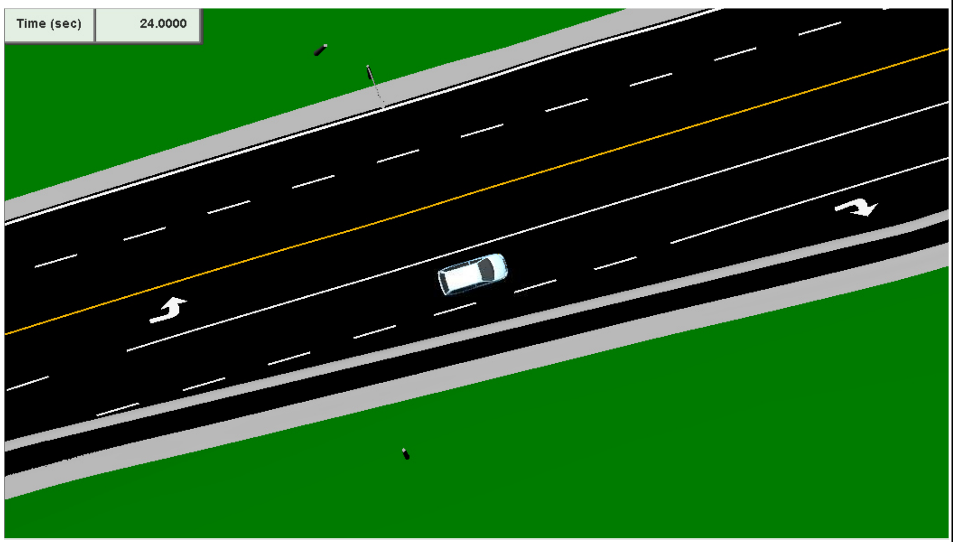
T= 23.0s





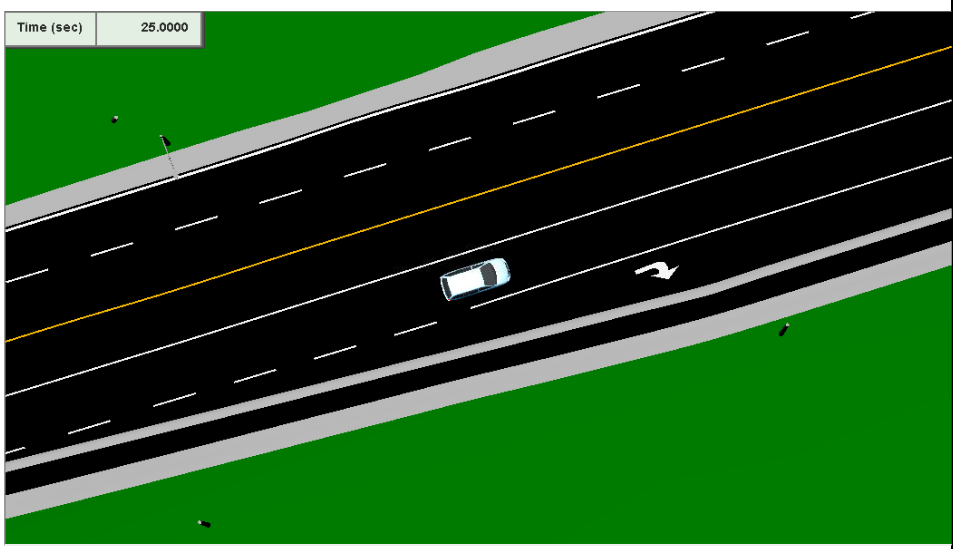
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173007.3	2654.392778	4587.398373	51.665	84.25	69.7	0.1

T= 24.0s



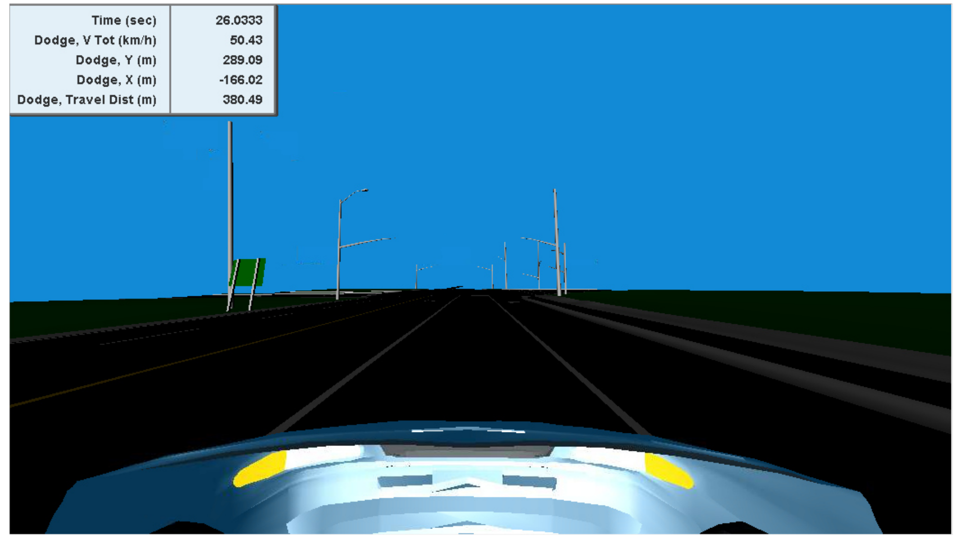
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173008.3	2654.393665	4587.387475	51.761	84.98	70.06	0.06

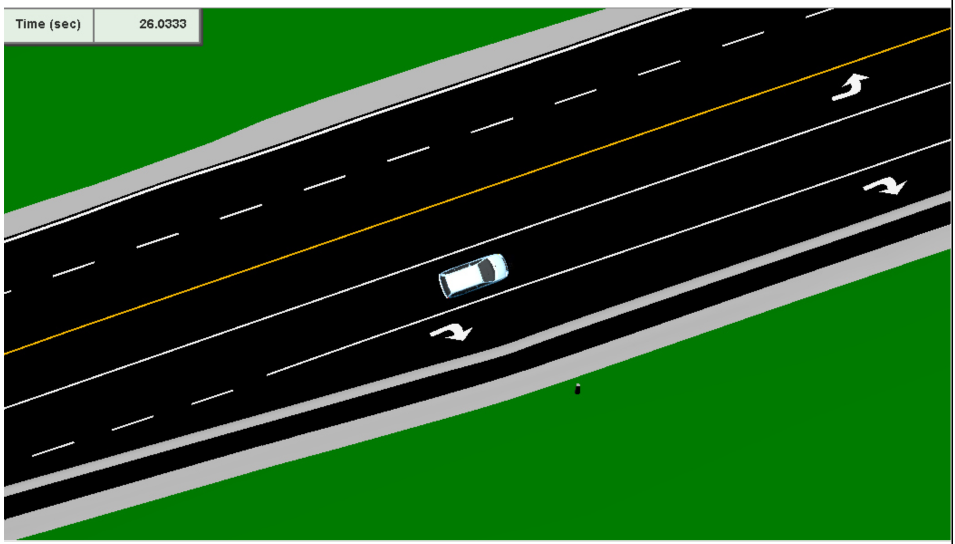
T= 25.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173009.3	2654.394369	4587.376738	51.727	85.17	70.2	0.33

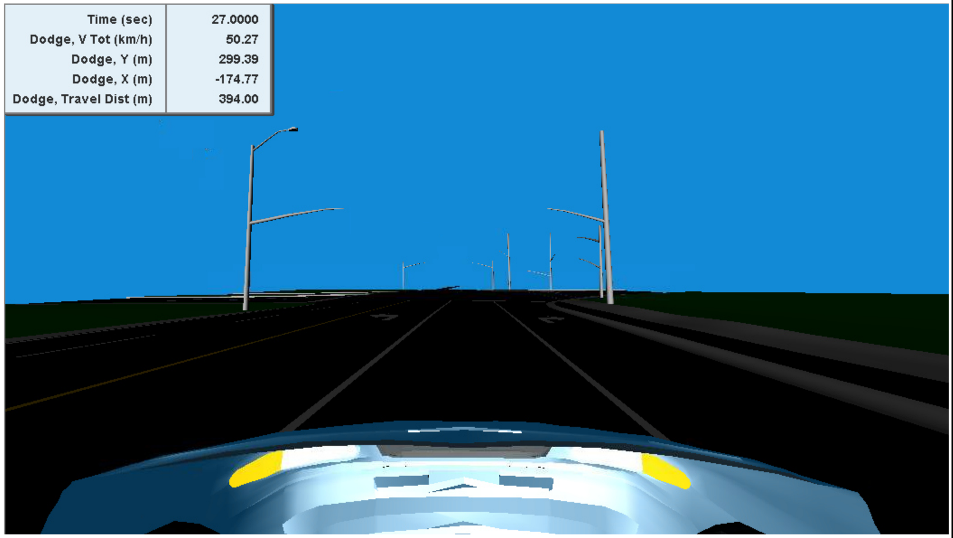
T= 26.0s

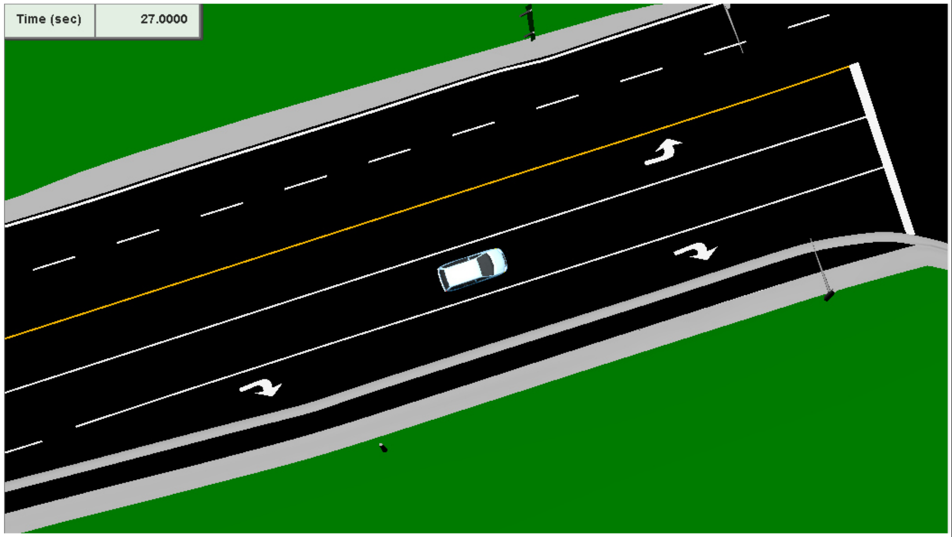




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173010.3	2654.395124	4587.366026	51.325	84.43	70.3	0.15

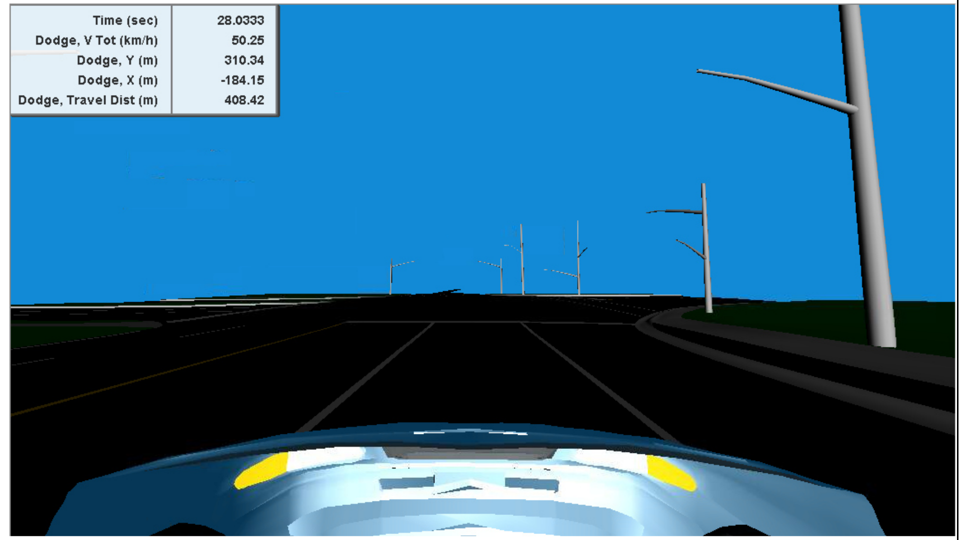
T= 27.0s

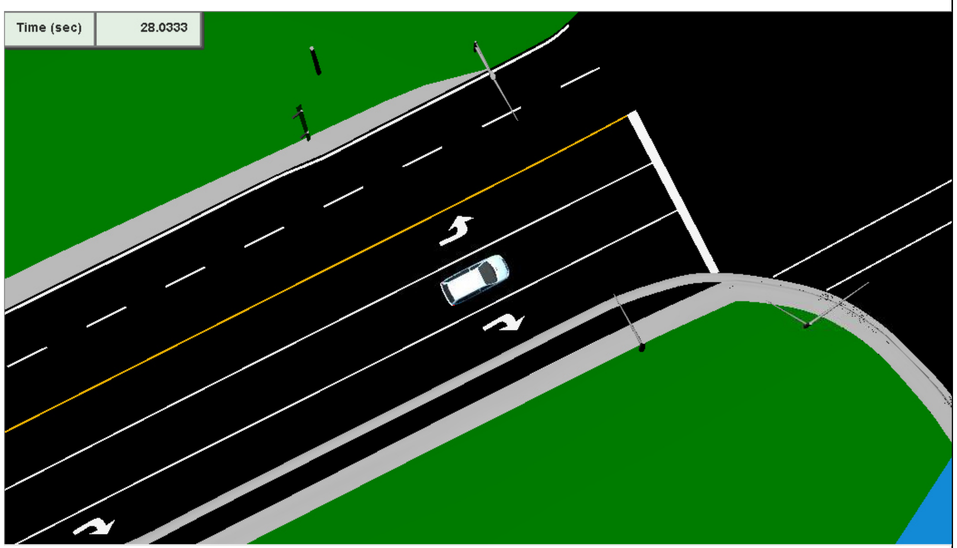




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173011.3	2654.395904	4587.355328	51.258	84.69	70.43	0.23

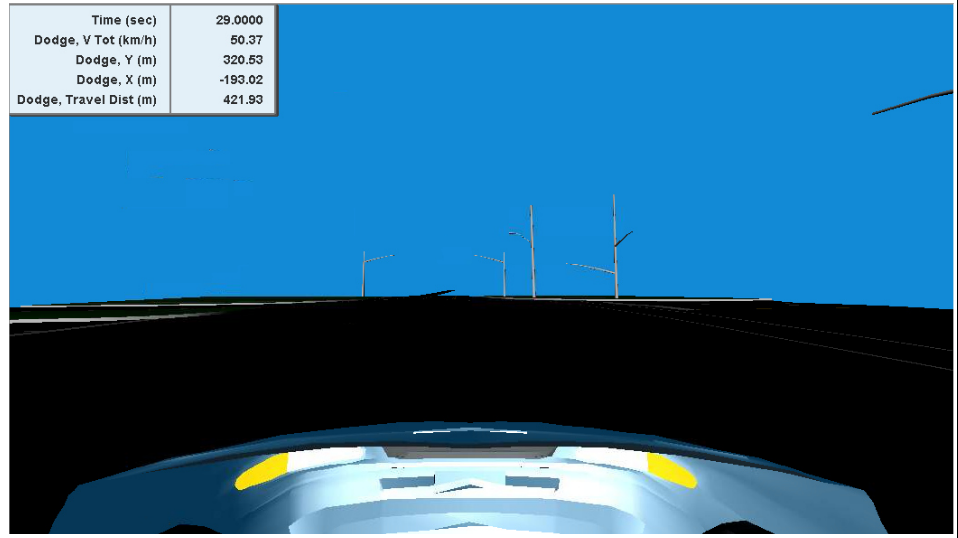
T= 28.0s

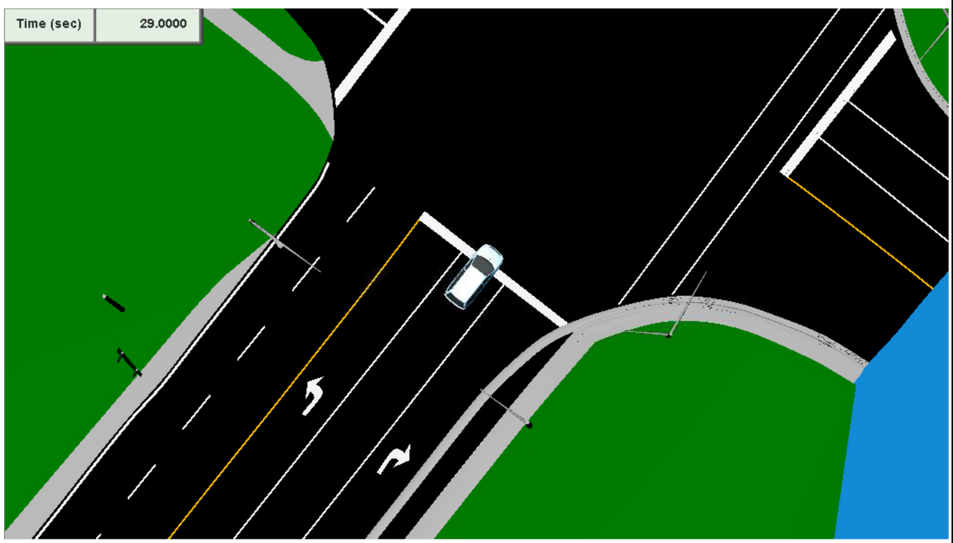




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173012.3	2654.396661	4587.344616	51.27	85.17	70.57	0.35

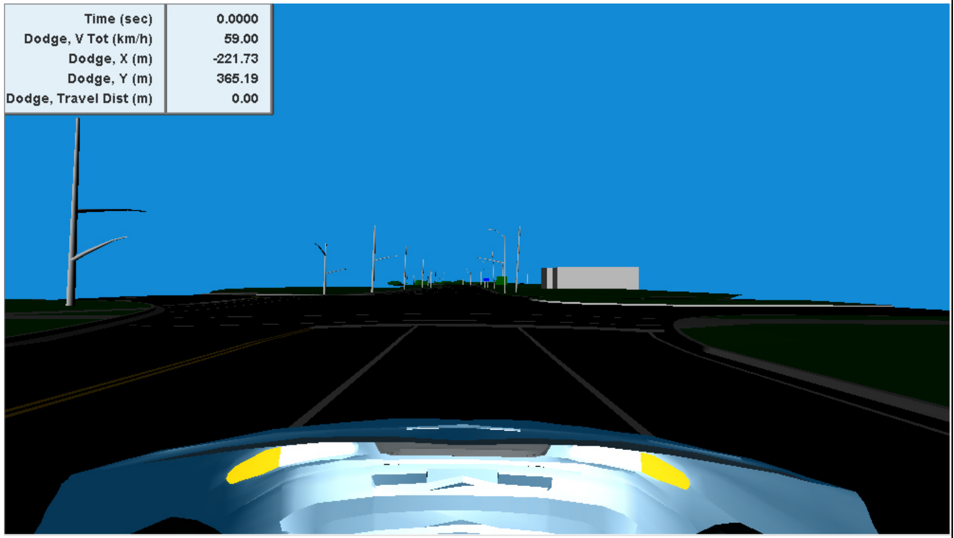
T= 29.0s

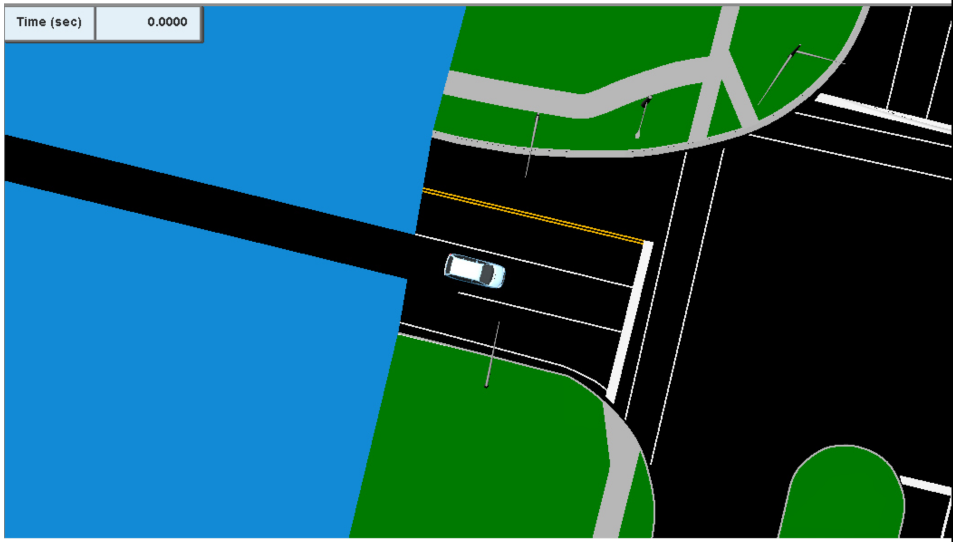




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173013.3	2654.397269	4587.333989	51.816	84.24	71.08	-0.04

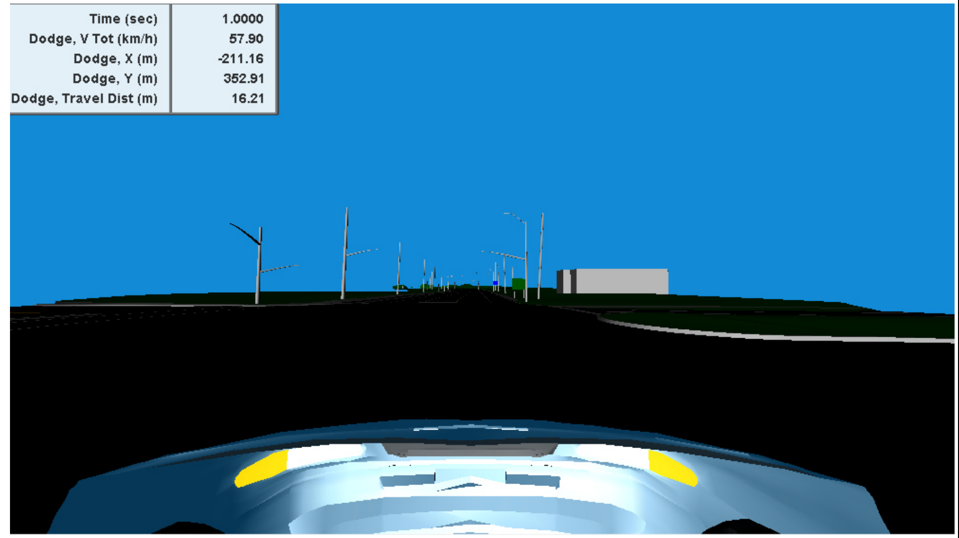
T= 0s

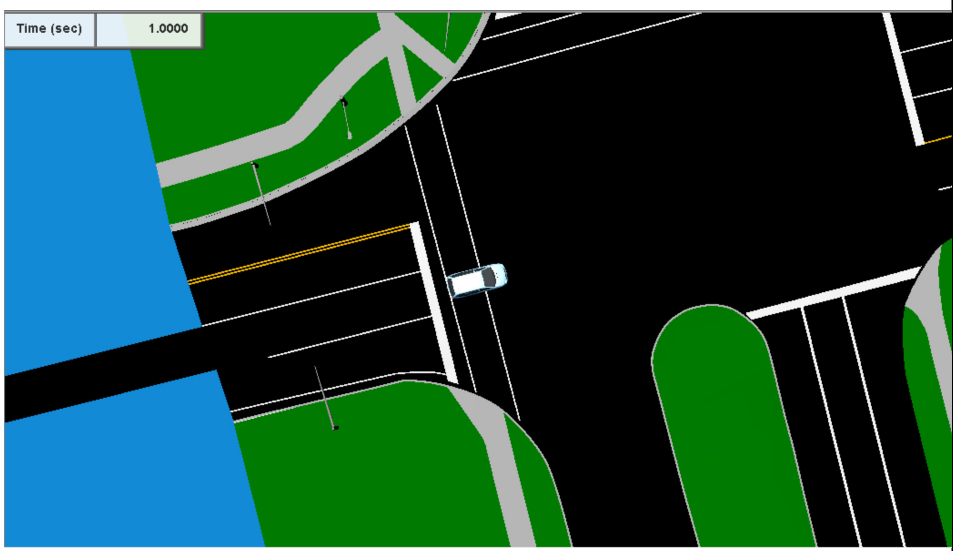




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173111.6	2654.40428	4587.295304	60.75	264.26	70.07	-0.04

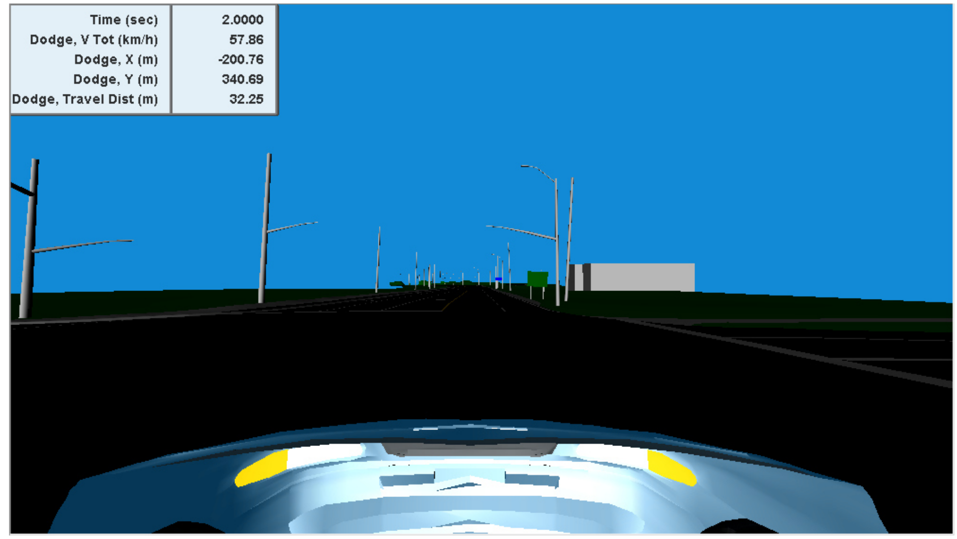
T= 1s

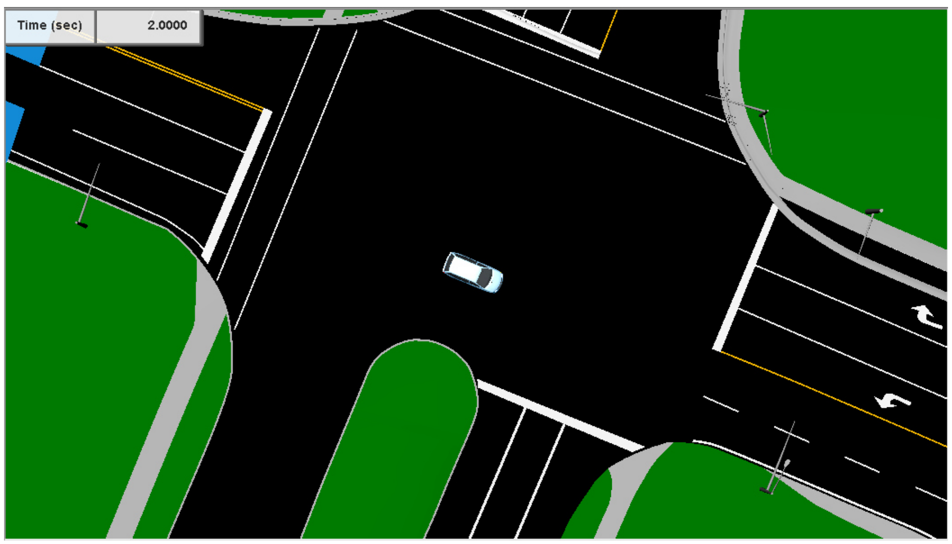




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173112.6	2654.403445	4587.307783	59.685	264.68	70.05	-0.1

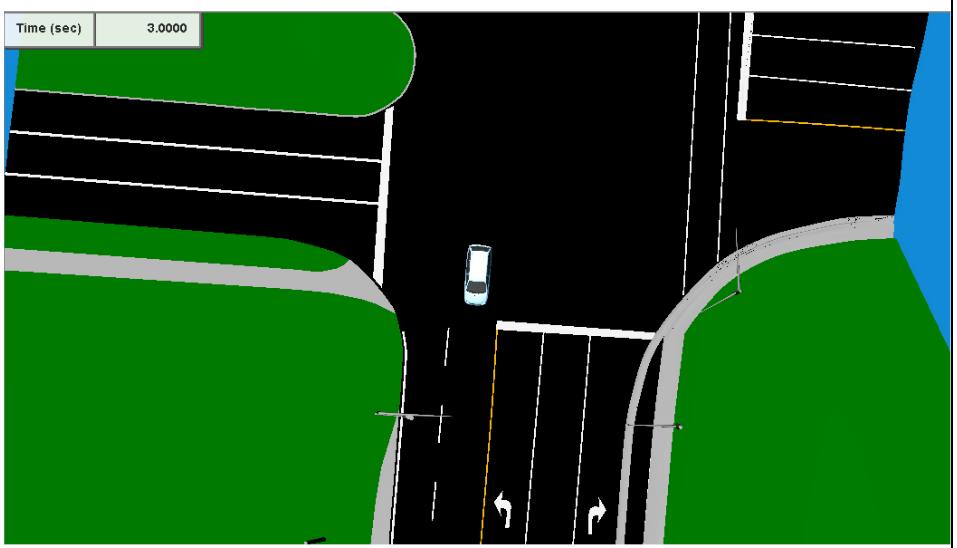
T= 2.0s





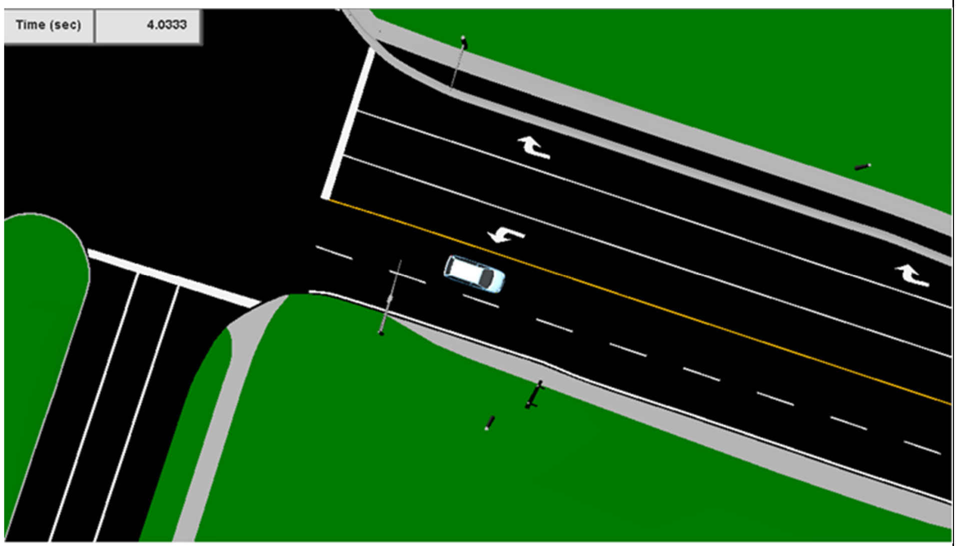
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173113.6	2654.402457	4587.320231	58.887	264.36	70.24	-0.15

T= 3.0s



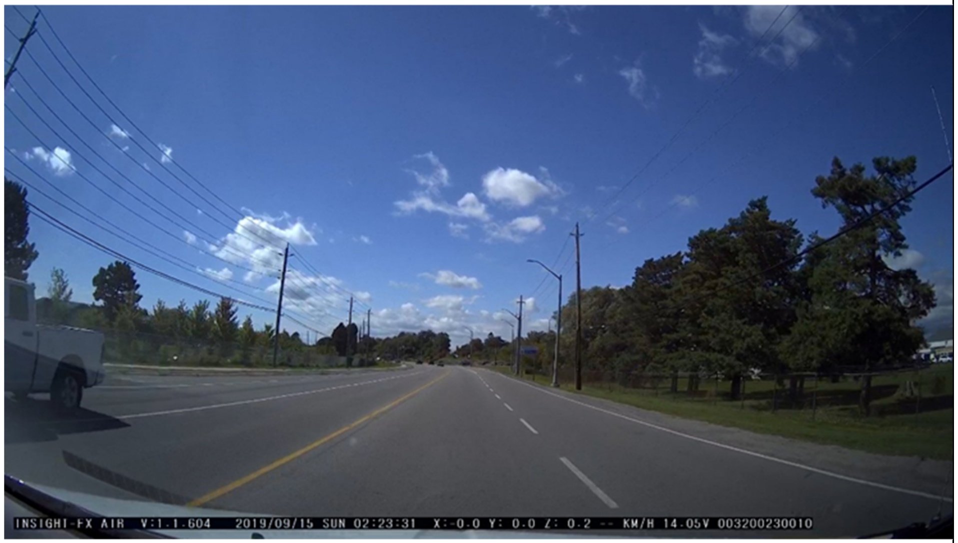
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173114.6	2654.401597	4587.332398	58.393	264.58	70.22	-0.23

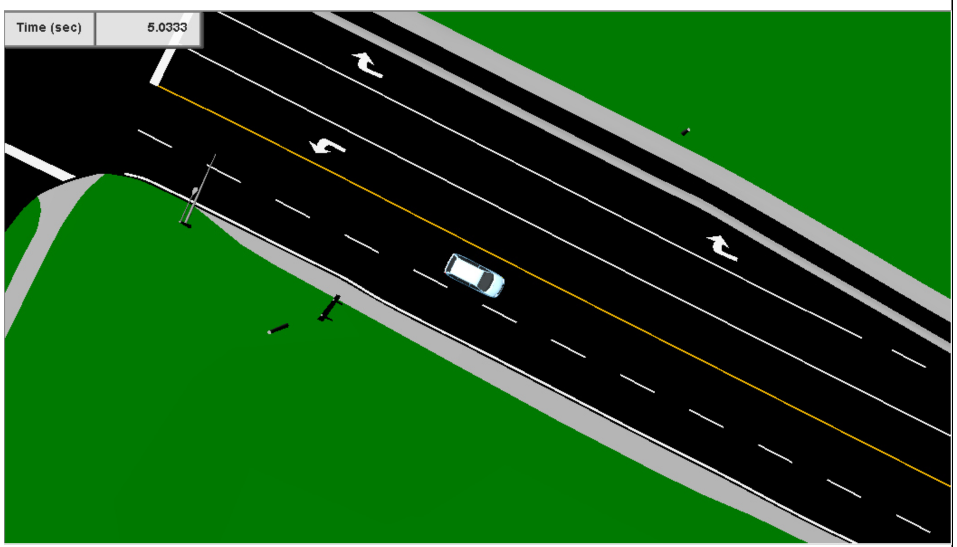
T= 4.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
6	173115.6	2654.400616	4587.344679	58.189	264.39	71.16	0

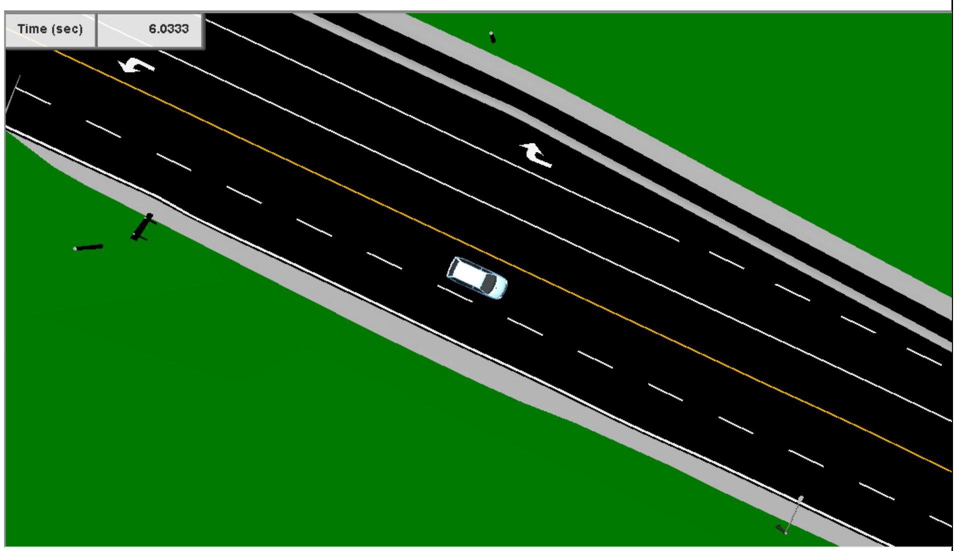
T= 5.0s





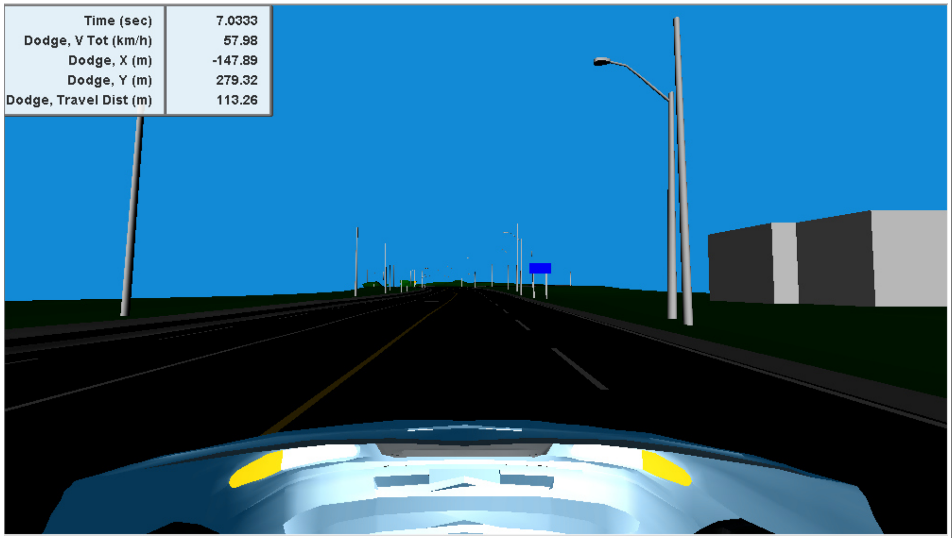
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173116.6	2654.399758	4587.356751	57.319	264.37	71.01	-0.3

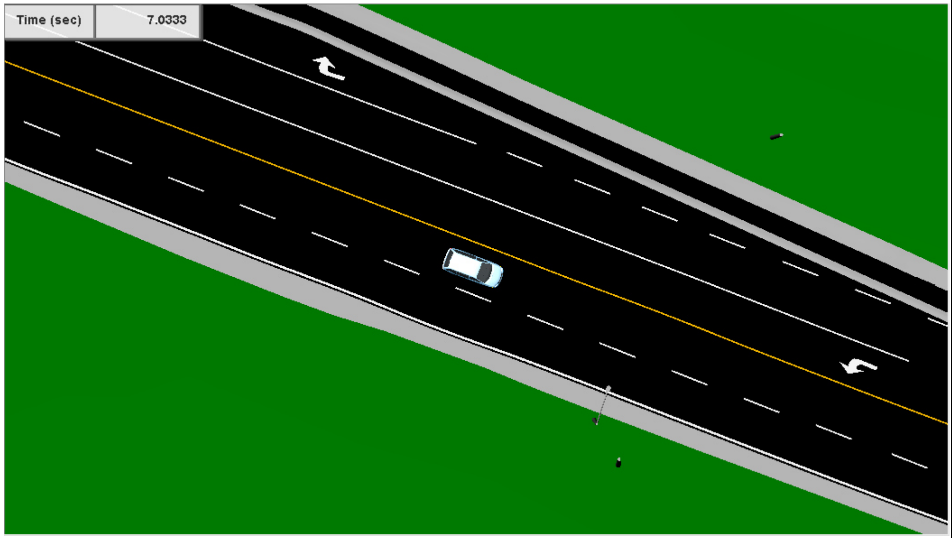
T= 6.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173117.6	2654.398954	4587.36868	57.707	264.11	70.62	0.13

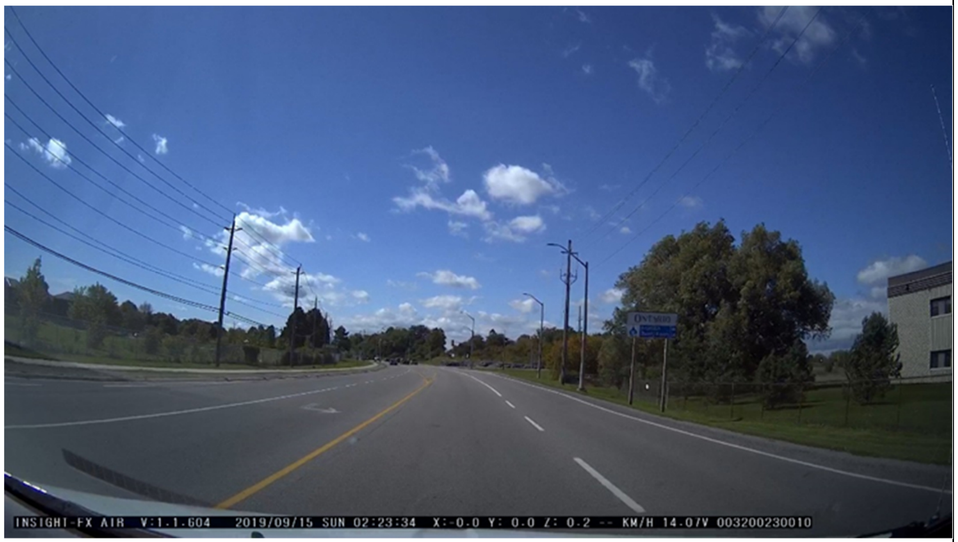
T= 7.0s

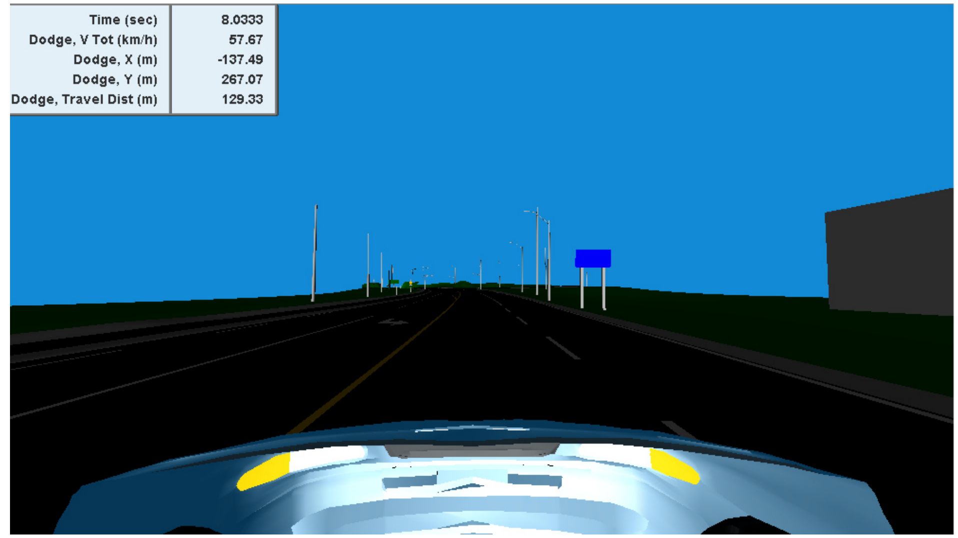


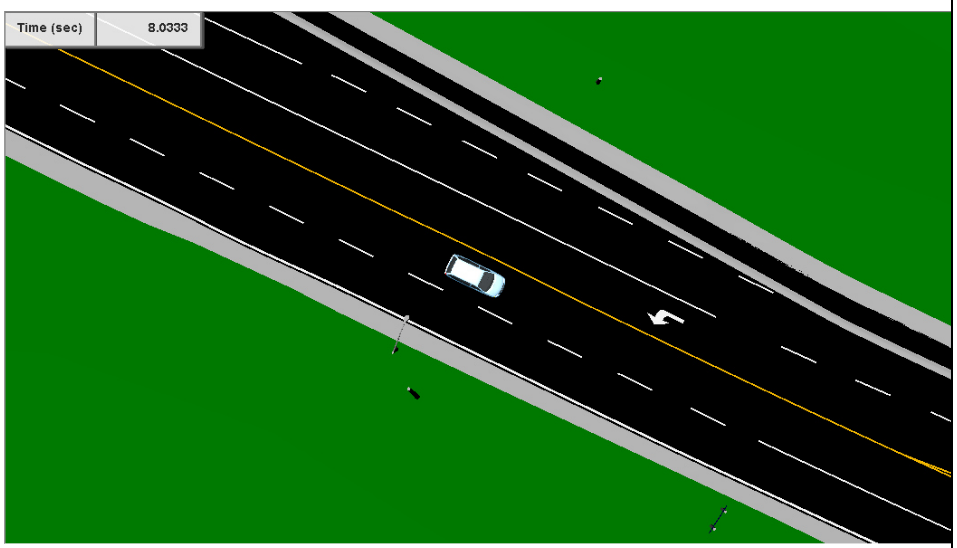


sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173118.6	2654.398068	4587.380668	57.706	264.14	70.19	0.03

T= 8.0s

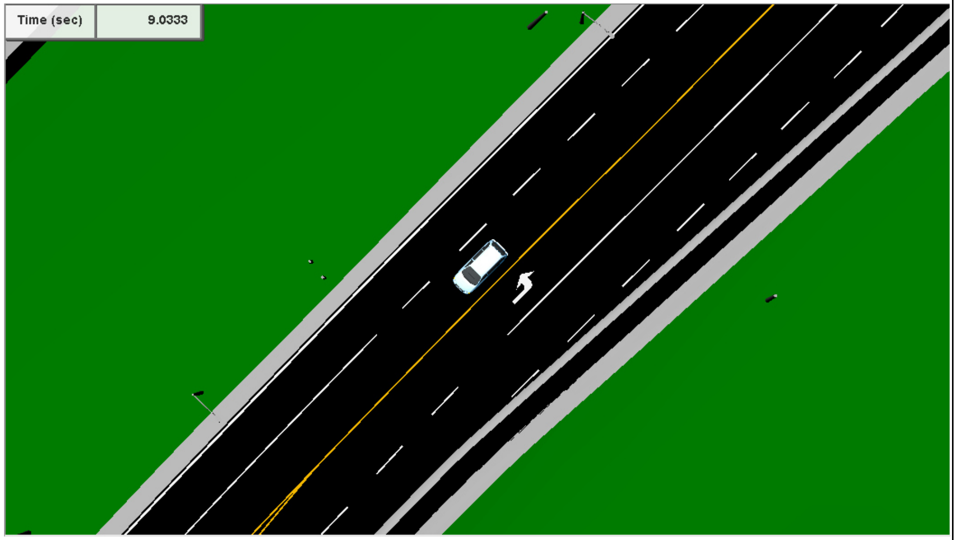






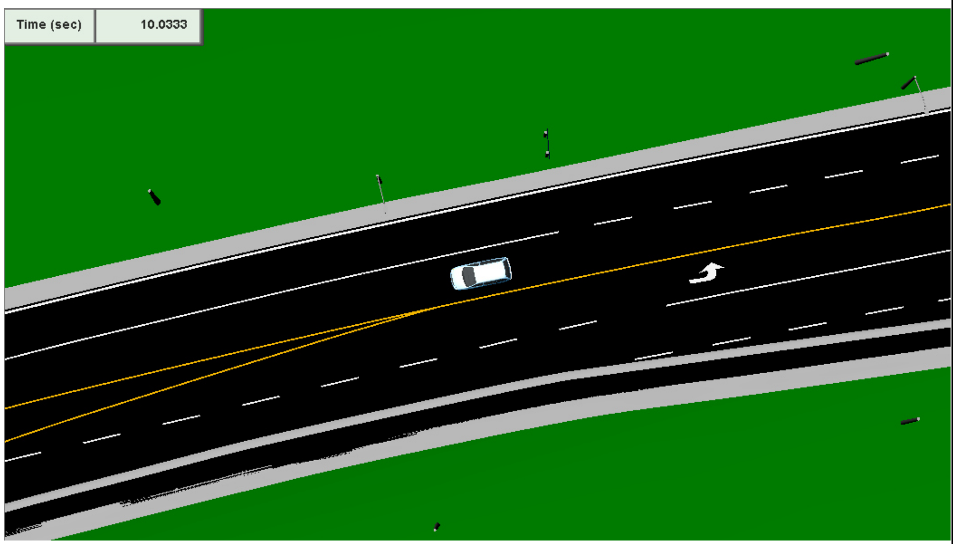
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173119.6	2654.397228	4587.392565	57.302	264.16	70.11	0.02

T= 9.0s



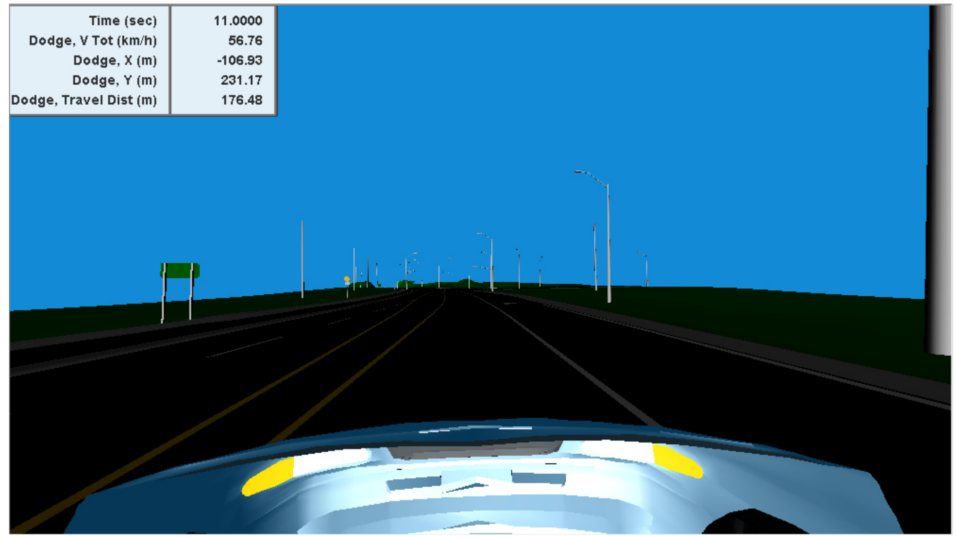
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173120.6	2654.396387	4587.40441	57.004	264.24	70.01	-0.09

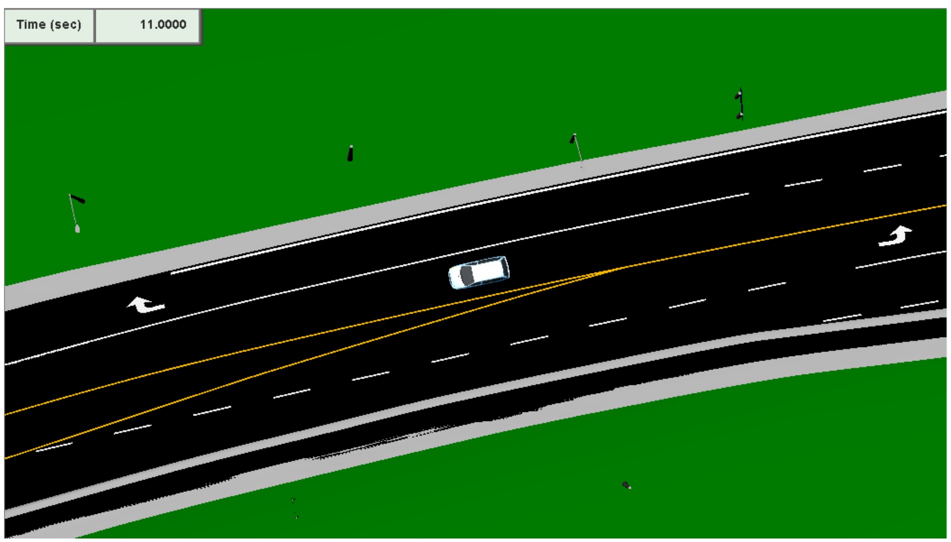
T= 10.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173121.6	2654.395534	4587.416264	56.74	263.4	69.57	0.01

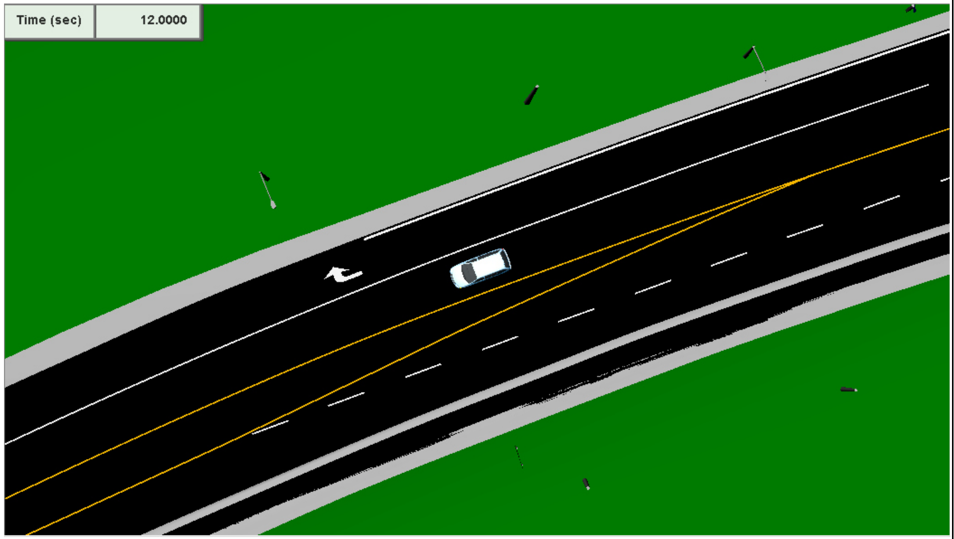
T= 11.0s





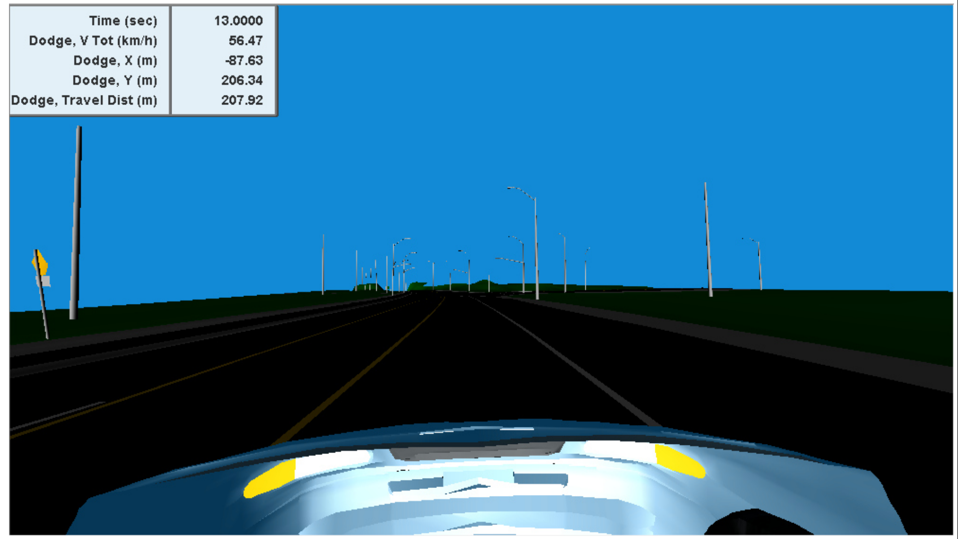
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173122.6	2654.394527	4587.42793	56.833	262.93	69.77	-0.02

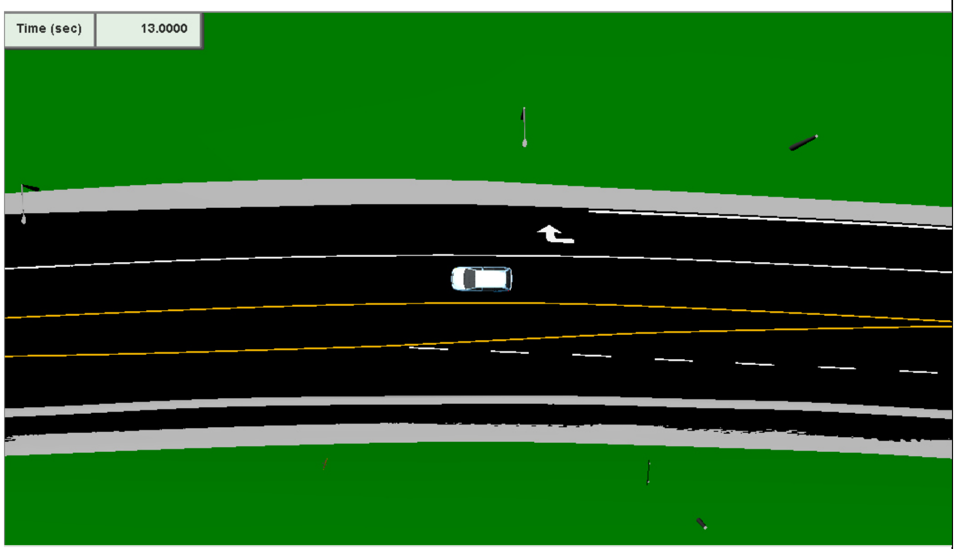
T= 12.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173123.6	2654.393451	4587.439657	56.888	261.99	69.7	0.11

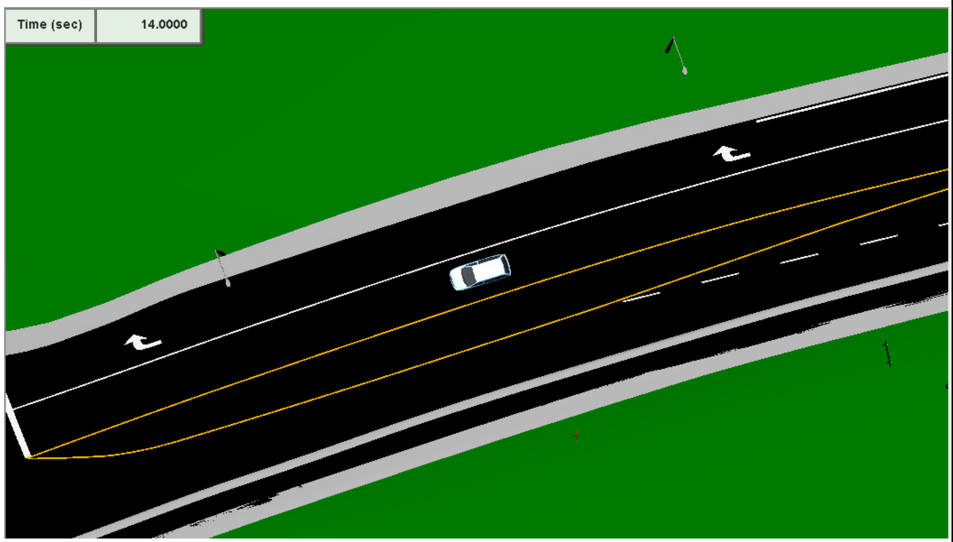
T= 13.0s





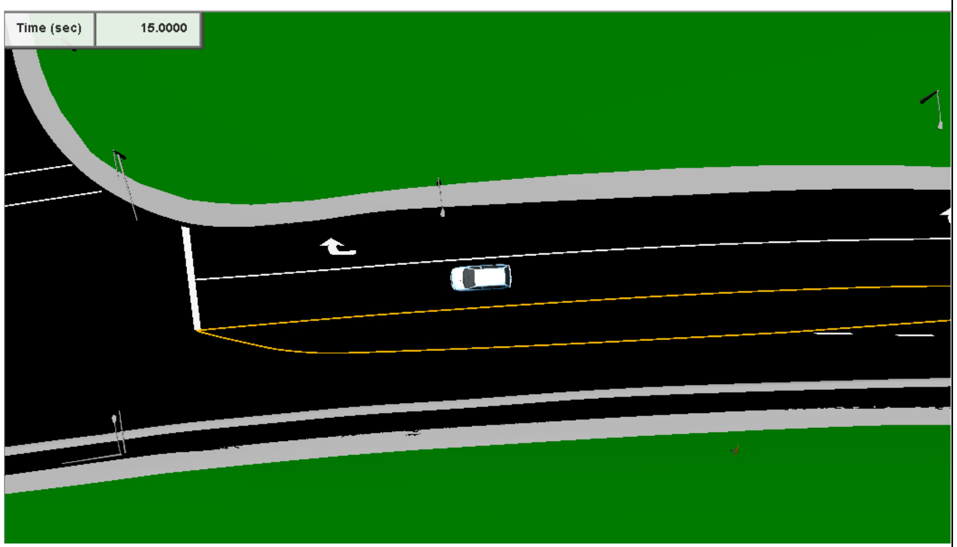
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173124.6	2654.392215	4587.451324	56.943	260.58	69.55	0

T= 14.0s



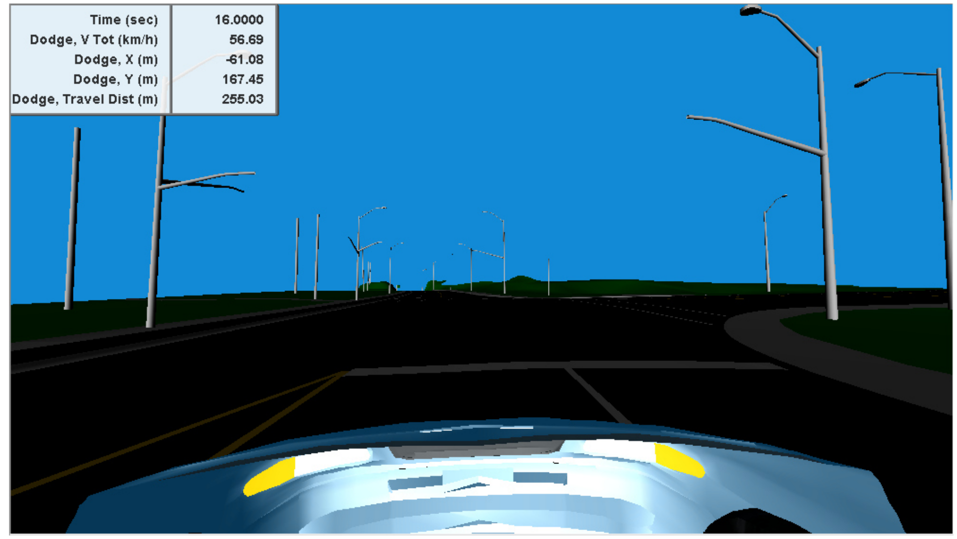
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173125.6	2654.39079	4587.462937	56.707	259.4	69.33	-0.02

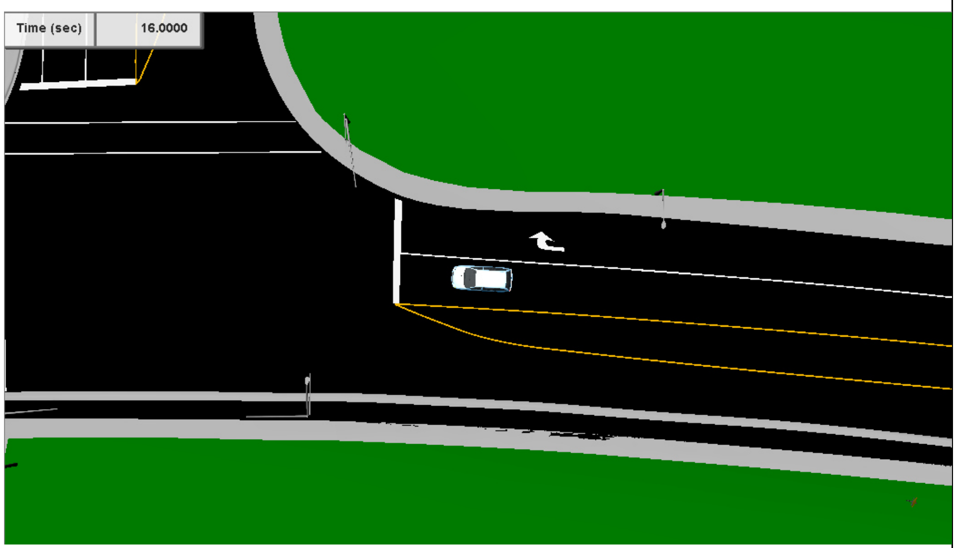
T= 15.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173126.6	2654.389126	4587.474504	56.435	257.53	69.16	-0.1

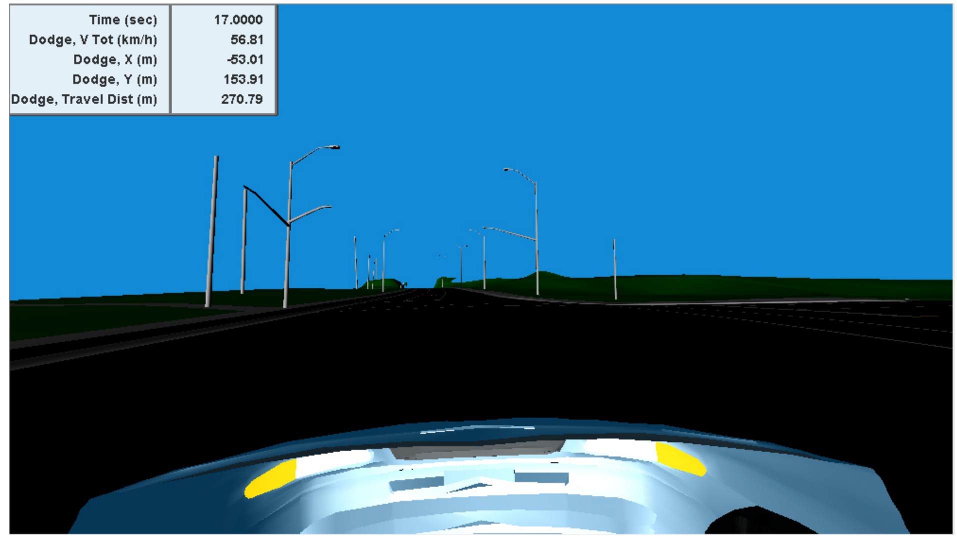
T= 16.0s

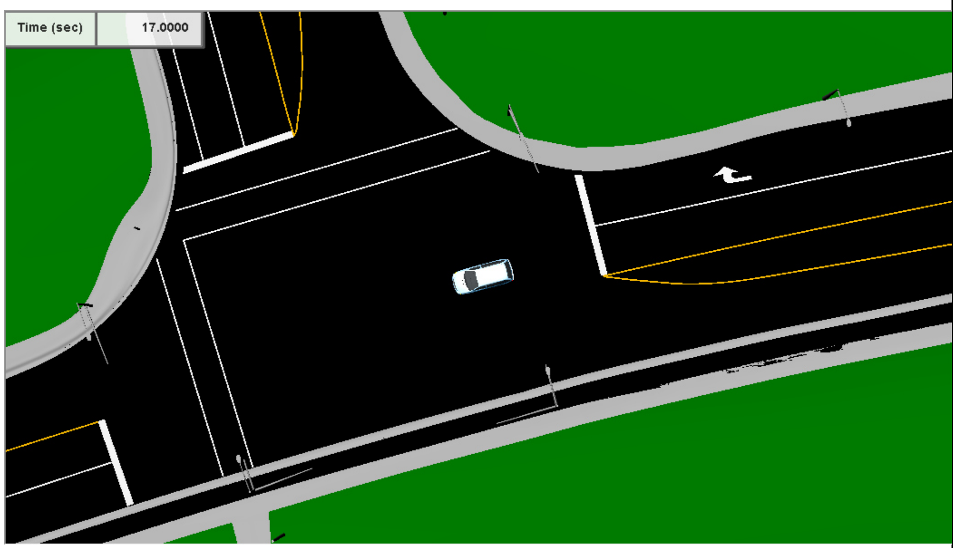




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173127.6	2654.387194	4587.48599	56.476	256.16	69.07	-0.04

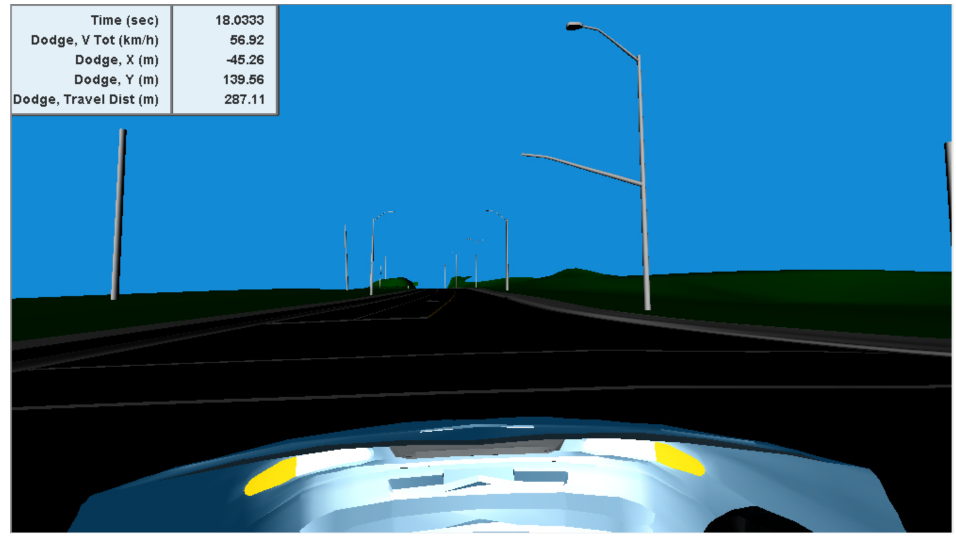
T= 17.0s

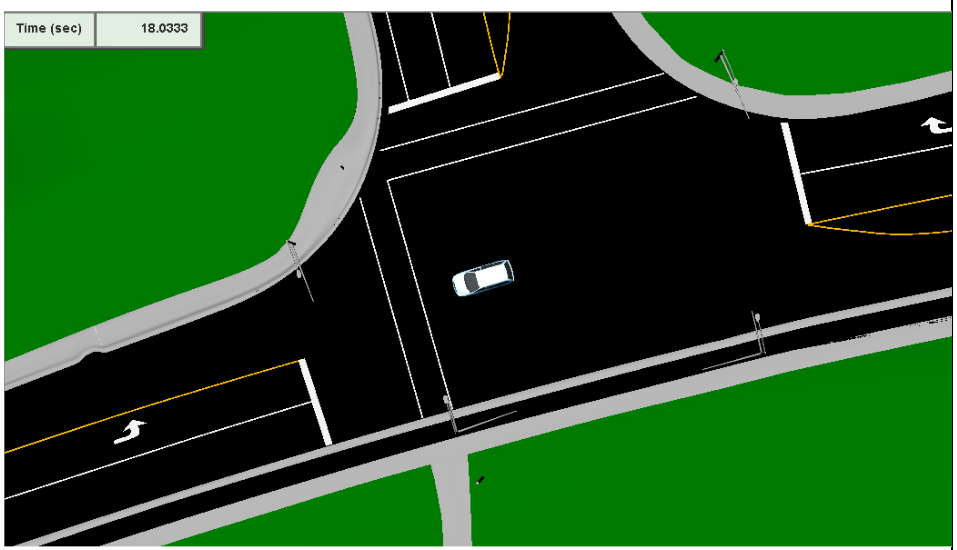




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173128.6	2654.385158	4587.497314	56.087	255.12	69.05	-0.07

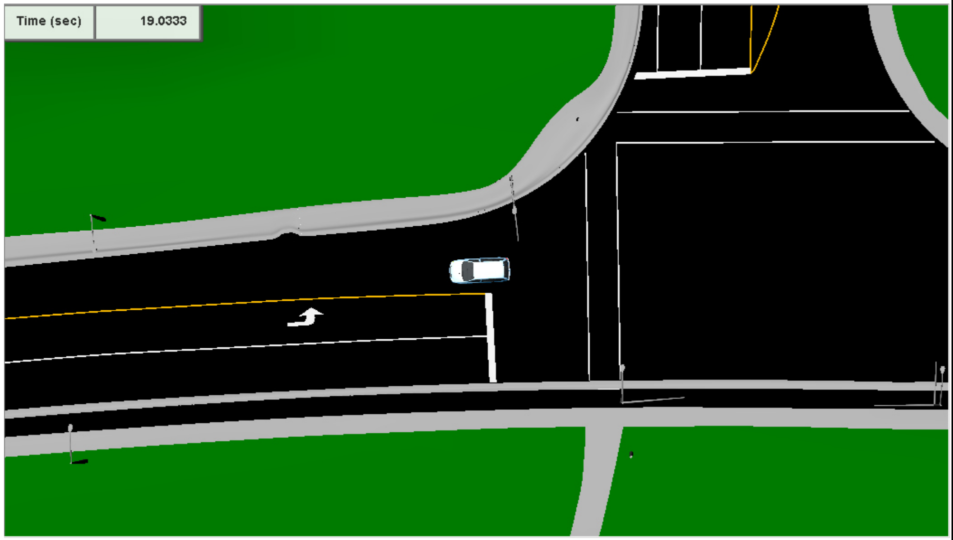
T= 18.0s





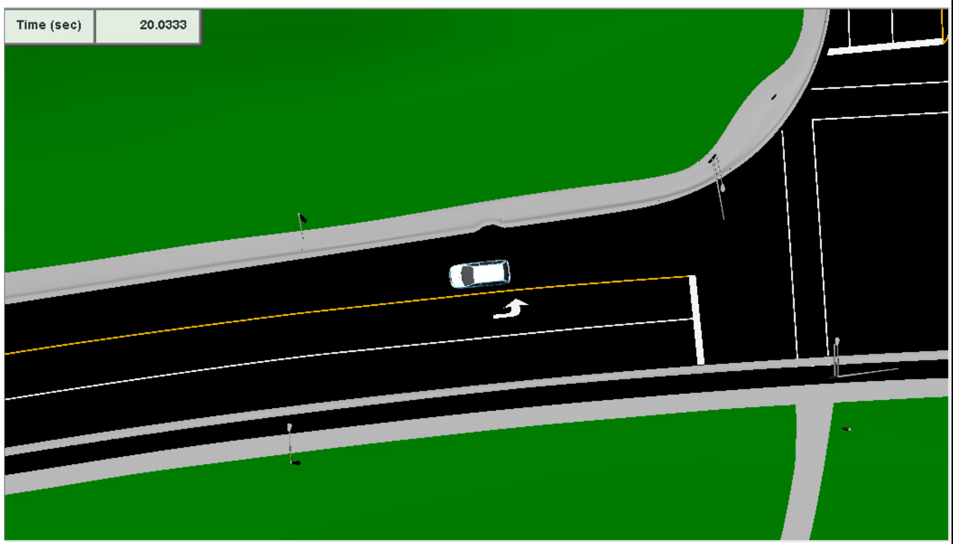
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173129.6	2654.382835	4587.508619	56.306	253.13	68.97	0

T= 19.0s



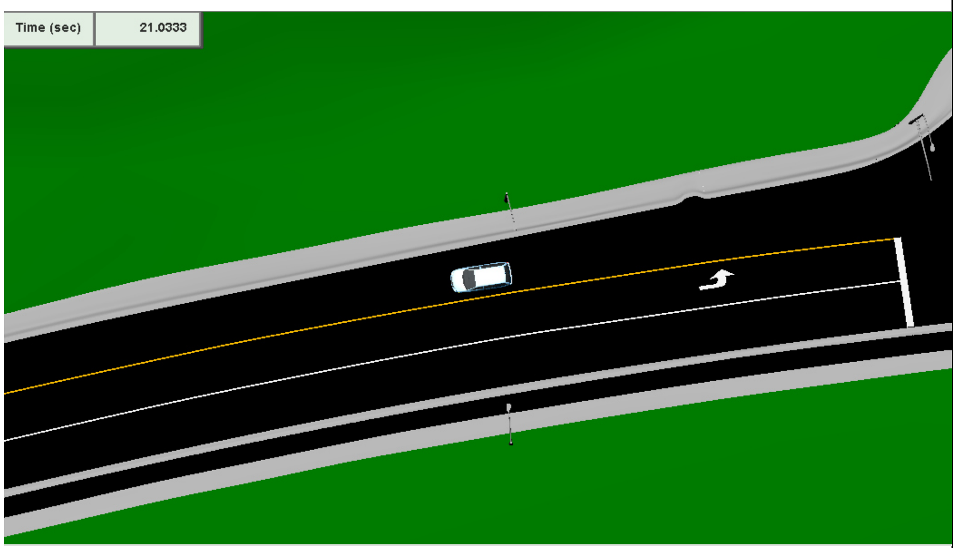
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173130.6	2654.380268	4587.519809	56.479	251.06	68.86	0.01

T= 20.0s



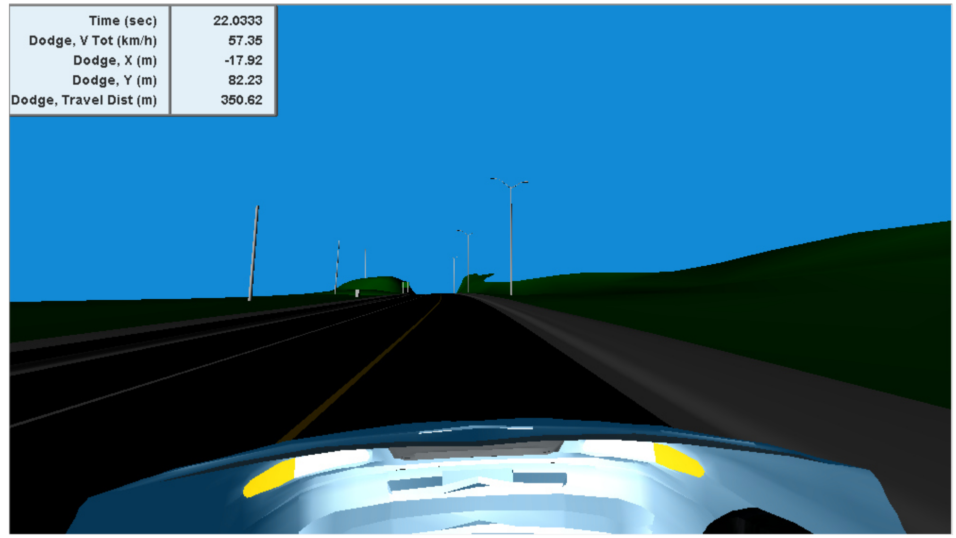
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173131.6	2654.377299	4587.530931	56.705	248.57	68.66	0.11

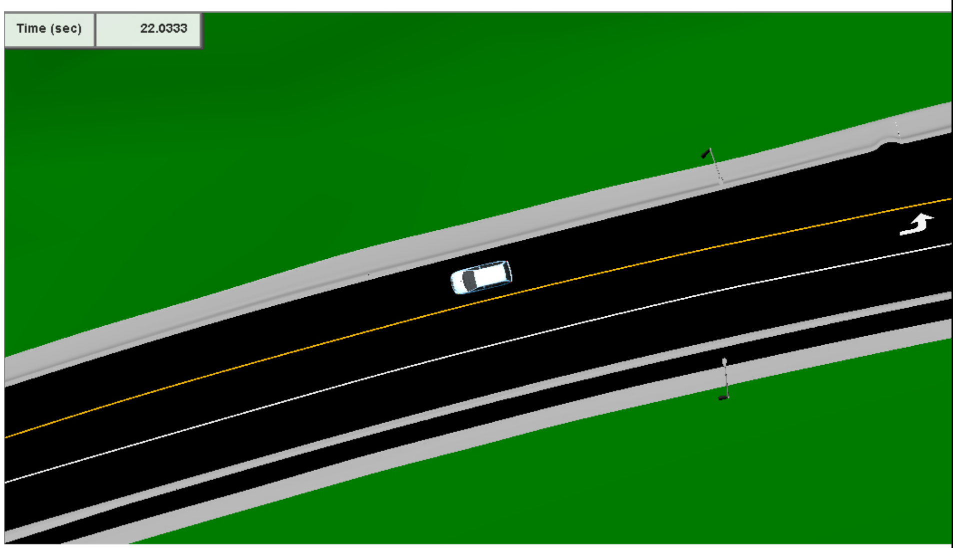
T= 21.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173132.6	2654.374044	4587.541946	56.555	247.19	69.29	0.1

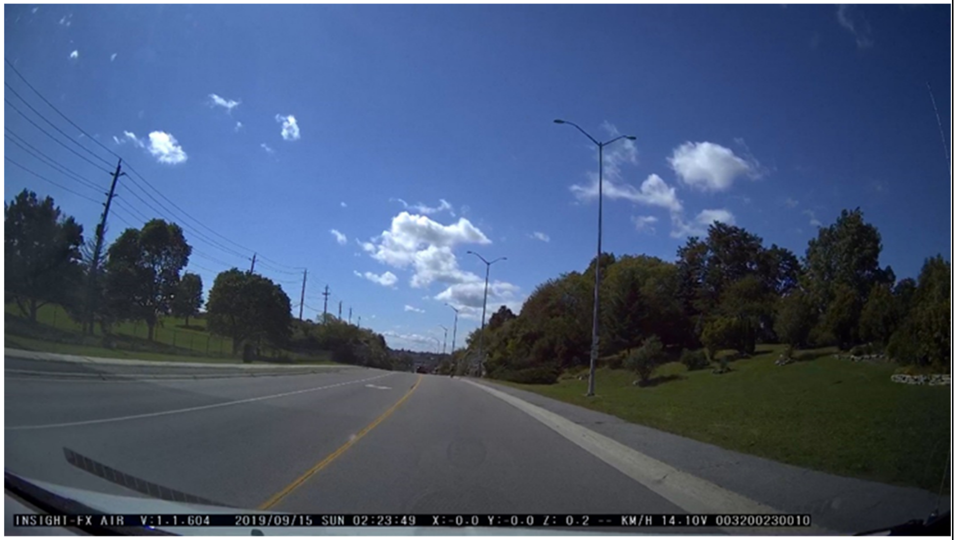
T= 22.0s

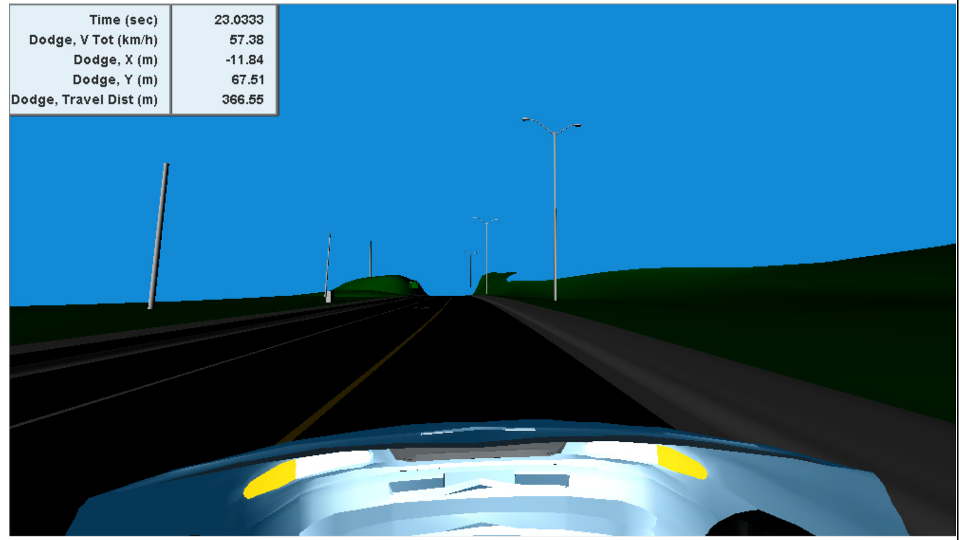


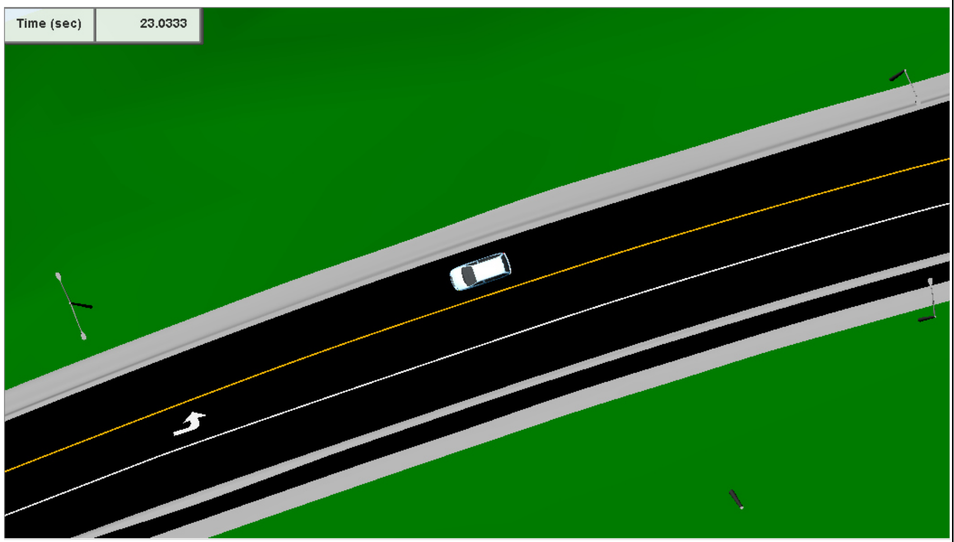


sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173133.6	2654.370711	4587.552787	57.003	246.17	69.13	0.02

T= 23.0s

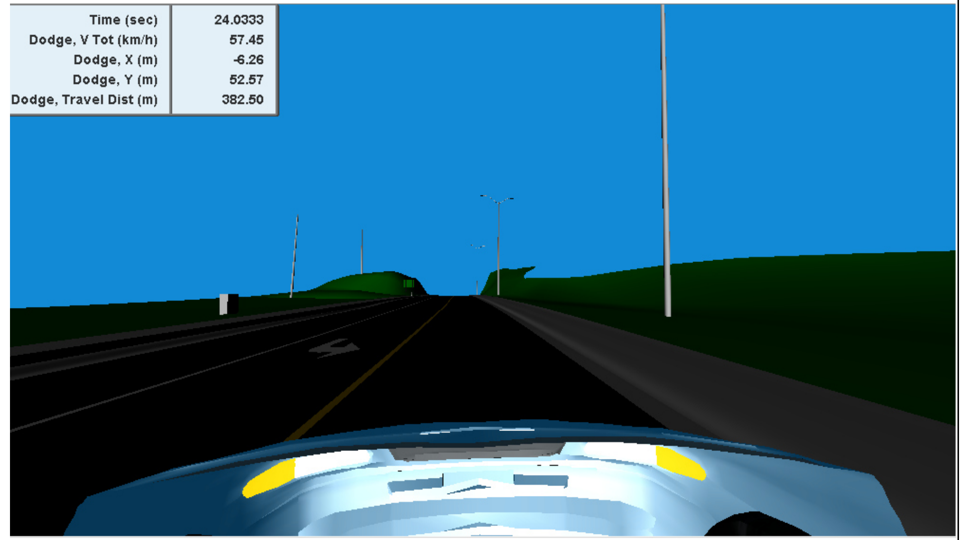


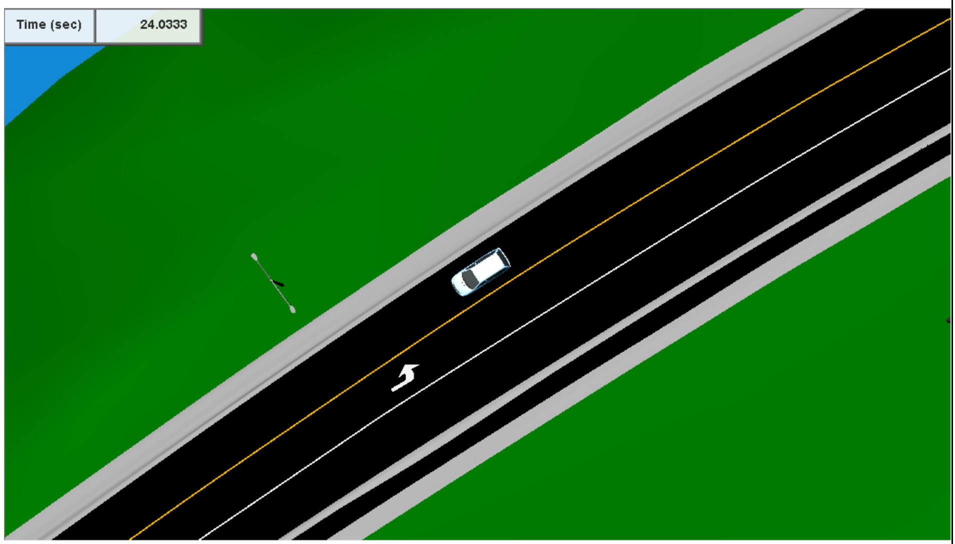




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173134.6	2654.367356	4587.56346	56.543	245.33	68.13	-0.04

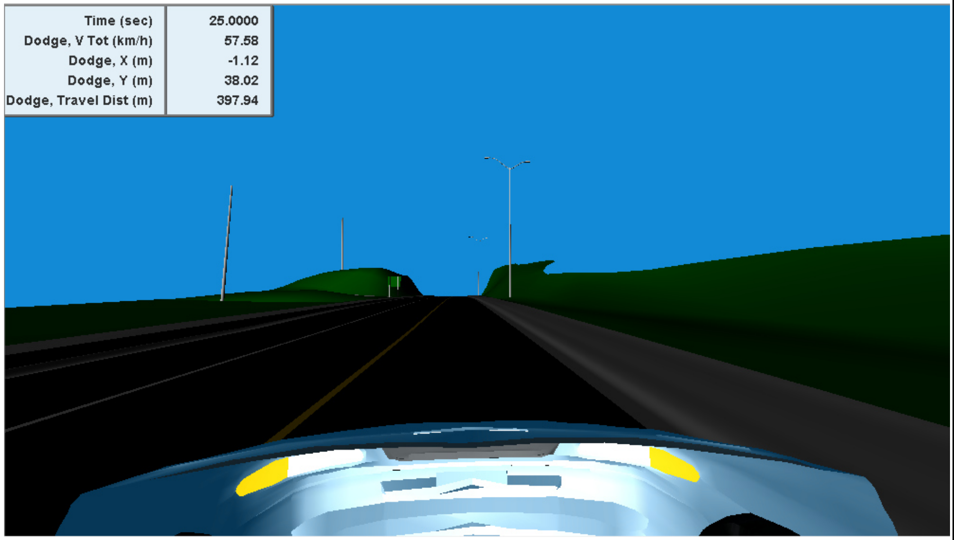
T= 24.0s

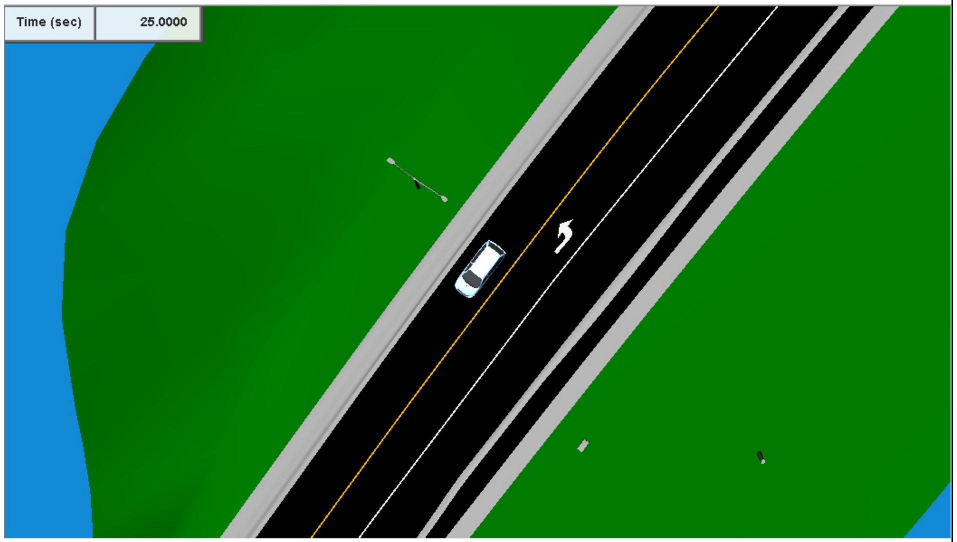




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173135.6	2654.363583	4587.574276	56.884	243.82	68.64	0.07

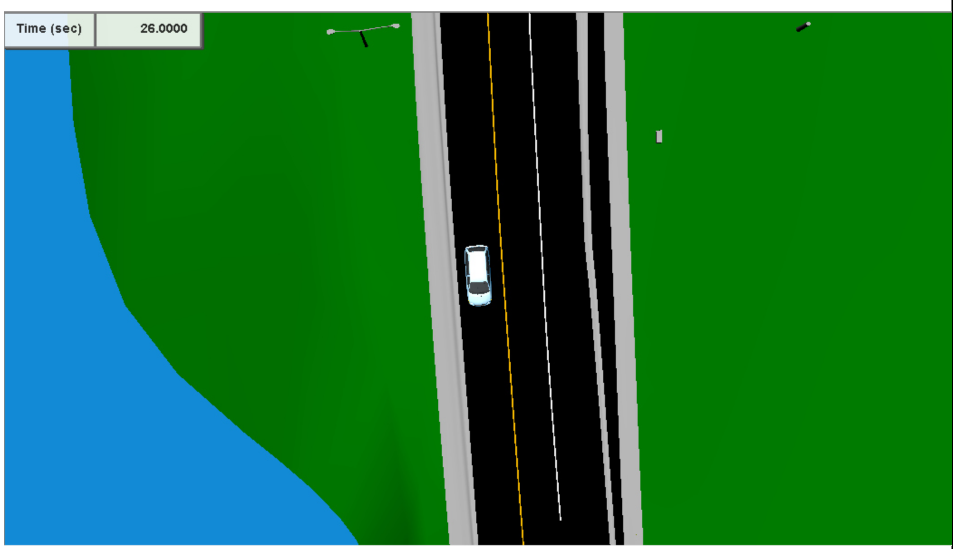
T= 25.0s





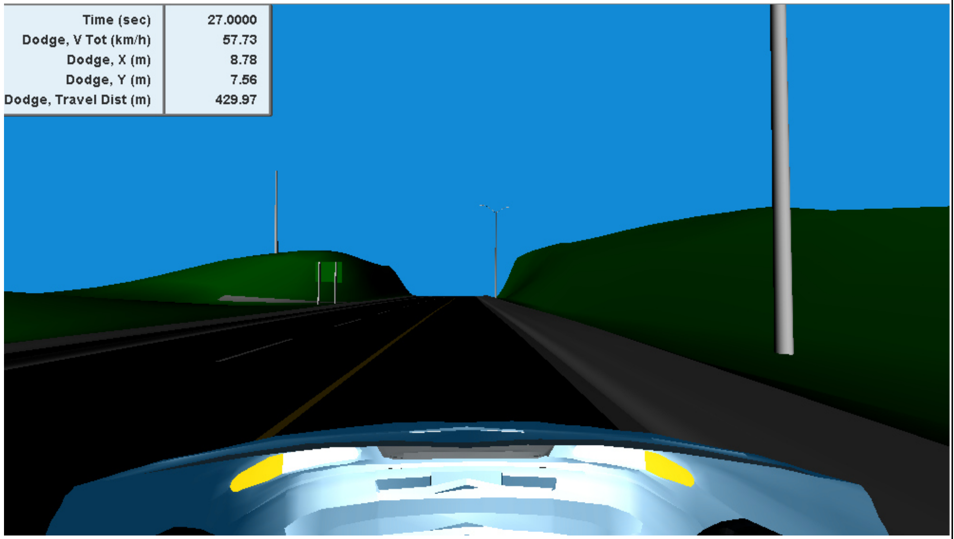
sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173136.6	2654.359935	4587.584756	56.69	242.41	68.58	-0.03

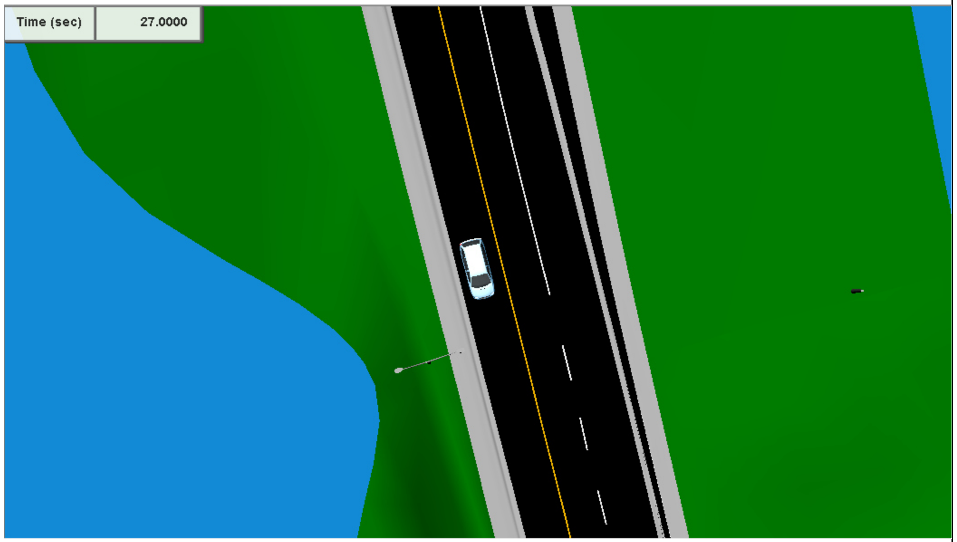
T= 26.0s



sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173137.6	2654.355876	4587.595278	56.938	241.21	68.02	-0.28

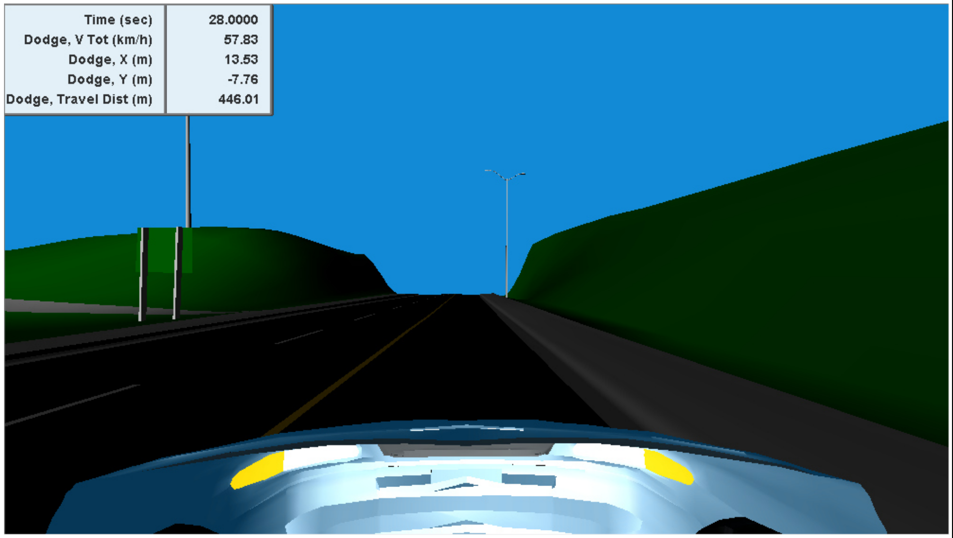
T= 27.0s

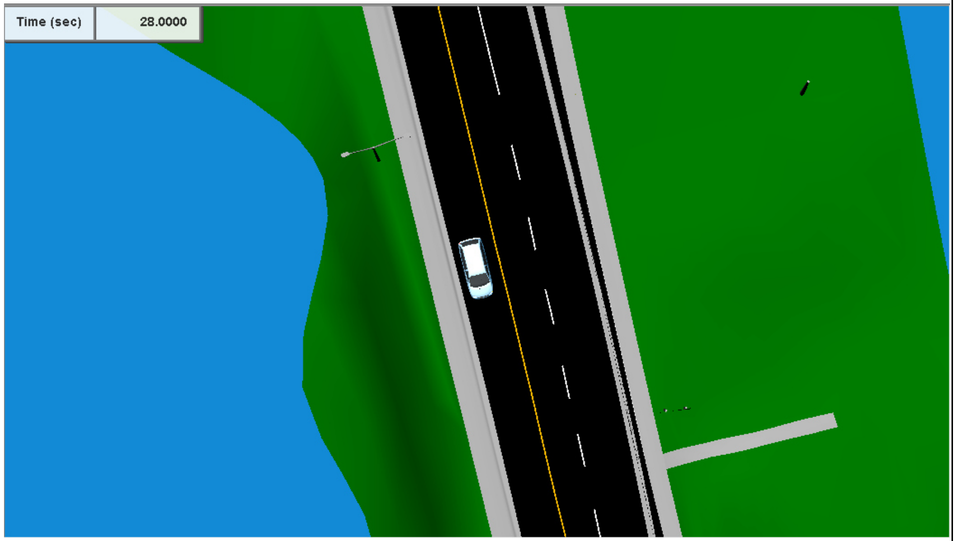




sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173138.6	2654.352022	4587.605401	56.711	240.84	67.15	-0.37

T= 28.0s





sats	time (s)	lat. (min.)	long. (min.)	velocity (kph)	heading (deg.)	height (m)	vert-vel (kph)
7	173139.6	2654.347704	4587.615818	57.468	240.41	66.55	-0.42