* Outline of data:
  + Is the data being provided as a one-time action or will it be provided in a continuous fashion? One time.
  + How large is the data being provided?
    - Size of files:
      * Multivehicle data collection CSV: 2.35 GB
    - Number of number of instances (rows) in each CSV files:
      * Multivehicle data collection CSV: 2530154
    - Number of data collection runs included in each appended CSV:
      * Multivehicle data collection CSV: 68
    - Number of hours of collected data included in each appended CSV:
      * Multivehicle data collection CSV:24
  + Please outline the hierarchy of the data: Not applicable.
  + If it is not clear from the file name, please provide the exact file names here and a one-sentence description of the file’s purpose.
    - Multivehicle data collection CSV: Data set of vehicle interaction for two advanced driver assistance system (ADAS)-equipped vehicle with SAE level 2 partial driving automation capabilities operating in central Ohio.
  + Other documentation:
    - **Will link to Final Report when it becomes available.**
* Description: Please provide a brief description of the data being made available and a background on the project that generated the data.
  + Multivehicle CSV: Datasets contains two subject vehicles’ trajectory data connected in naturalistic traffic conditions in central Ohio. Instrumented subject vehicles were either a discreet or readily-identifiable ADAS-equipped vehicle with SAE L2 capabilities. Dataset also contains trajectories for adjacent vehicles in traffic (observed by the subject vehicles’ onboard sensors).
* Geographic coverage:

|  |  |  |
| --- | --- | --- |
| Route Number | Start Point | End Point |
| [US 33](https://www.google.com/maps/dir/Kroger+Fuel+Center,+1501+W+5th+St,+Marysville,+OH+43040/''/@40.1959603,-83.3606238,12z/data=!4m29!4m28!1m20!1m1!1s0x8838c5a735f7be9d:0xf8d943bf248ee689!2m2!1d-83.3946926!2d40.2417045!3m4!1m2!1d-83.3757916!2d40.2369846!3s0x8838c454776a627b:0xcd3c1d8e9505a30f!3m4!1m2!1d-83.3702513!2d40.2366323!3s0x8838c456d5749b57:0x6689e1758d765a41!3m4!1m2!1d-83.358738!2d40.2358924!3s0x8838c45e0a968e0d:0xa581daf9207de77f!1m5!1m1!1s0x8838c45877edd771:0xe857929bc0f71eb4!2m2!1d-83.2342645!2d40.1581108!3e0) | Kroger Fuel Center (1501 W 5th St, Marysville, OH 43040) | Marathon Gas station (10152 US-42, Marysville, OH 43040) |
| [US 33](https://www.google.com/maps/dir/40.0990141,-83.1074064/''/@40.0321614,-83.1499639,12z/data=!3m1!4b1!4m9!4m8!1m0!1m5!1m1!1s0x88388fade2b020ff:0x306c8a015b6af19!2m2!1d-83.046124!2d39.972729!3e0) | Wendy’s(4555 W Dublin Granville Rd, Dublin, OH 43017) | Starbucks(1093 Dublin Rd, Columbus, OH 43215) |
| [I 270,71](https://www.google.com/maps/dir/40.0990141,-83.1074064/''/@40.0321614,-83.1499639,12z/data=!3m1!4b1!4m9!4m8!1m0!1m5!1m1!1s0x88388fade2b020ff:0x306c8a015b6af19!2m2!1d-83.046124!2d39.972729!3e0) | Marathon Gas Station, 700 E N Broadway, Columbus, OH 43224 | bp, 4024 Morse Rd, Columbus, OH 43219 |
| [US 23](https://www.google.com/maps/dir/bp,+262+N+Marion+St,+Waldo,+OH+43356/''/@40.4005823,-83.3208286,11z/data=!4m13!4m12!1m5!1m1!1s0x883902d346f6aecf:0x94f0f6db6746c9e6!2m2!1d-83.0778879!2d40.4622422!1m5!1m1!1s0x8838fb4dcaae53c9:0x907a66c07cdd6cb9!2m2!1d-83.0745412!2d40.33333) | Speedway, 2381 U.S. Hwy 23 N, Delaware, OH 43015 | bp, 262 N Marion St, Waldo, OH 43356 |
| [US 315](https://www.google.com/maps/dir/40.0990141,-83.1074064/1090+Dublin+Rd,+Columbus,+OH+43215/@40.0518122,-83.1844279,11.96z/data=!4m10!4m9!1m0!1m5!1m1!1s0x88388fadefc1c1ef:0xe4174dc32f2276c!2m2!1d-83.0461434!2d39.9733981!3e0!5i2) | Wendy’s(4555 W Dublin Granville Rd, Dublin, OH 43017) | BP(1090 Dublin Rd, Columbus, OH 43215) |
| [I 750](https://www.google.com/maps/dir/''/''/@40.1333978,-82.9797312,13.3z/data=!3m1!5s0x8838f3c7686e7011:0x77be75bc2f93ddfd!4m19!4m18!1m10!1m1!1s0x8838f3c782427093:0xd50151c7abe376fa!2m2!1d-83.0225914!2d40.1607542!3m4!1m2!1d-82.9733446!2d40.1417678!3s0x8838f460d59b601f:0x68e02d8aa2296ca6!1m5!1m1!1s0x8838f59111e7cfad:0x3c2e67257682553e!2m2!1d-82.9213328!2d40.1471532!3e0) | Meijer, 8870 Columbus Pike, Lewis Center, OH 43035 | Wendy's, 5771 Maxtown Rd, Westerville, OH 43082 |
| [US 33](https://www.google.com/maps/dir/''/''/@40.0645734,-83.1530796,13z/data=!3m1!5s0x883893fef4925a0f:0x2dafa3af95187949!4m14!4m13!1m5!1m1!1s0x883893fef374dd0b:0x2e698c43d9467d26!2m2!1d-83.1605702!2d40.0282015!1m5!1m1!1s0x88389351677e1b21:0x89a0f1b157bd36e8!2m2!1d-83.1583915!2d40.1014128!3e0) | Panera Bread, 6665 Perimeter Loop Rd, Dublin, OH 43017 | Speedway, 3760 Main St, Hilliard, OH 43026 |
| [US 23](https://www.google.com/maps/dir/Used+Kids+Records,+2500+Summit+St,+Columbus,+OH+43202/Evolved+Body+Art,+2520+Summit+St,+Columbus,+OH+43202/@39.9816052,-83.0049873,2640m/data=!3m1!1e3!4m29!4m28!1m20!1m1!1s0x88388ebb910b5c55:0x45b49750b3bb9919!2m2!1d-82.999854!2d40.0147029!3m4!1m2!1d-83.0003798!2d39.9869048!3s0x88388ece43cd0d5b:0xd083e201f4b5c92e!3m4!1m2!1d-82.999678!2d39.9868751!3s0x88388ece423ce3b1:0x4bcade385a636a16!3m4!1m2!1d-82.9983374!2d40.0055329!3s0x88388eadff04392d:0x4d21cd3b2f1cf08d!1m5!1m1!1s0x88388ebbde417071:0xad574ee835404831!2m2!1d-82.9998185!2d40.014924!3e0) | Used Kids Records, 2500 Summit St, Columbus, OH 43202 | Evolved Body Art, 2520 Summit St, Columbus, OH 43202 |

* Column description:

The outputs of the data processing pipeline include the position, velocity, acceleration, and orientation of objects of interest in difference reference frames. This data is all stored in CSV files. The contents of the CSVs produced by the data processing pipeline are described in the following subsections.

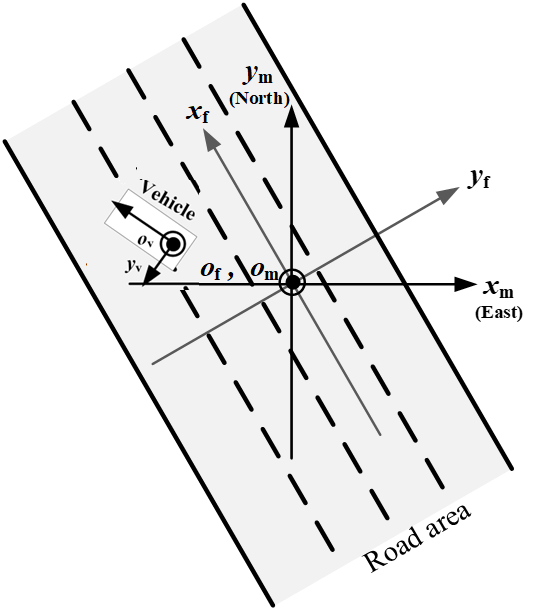
Variables for adjacent vehicles

The variables for the adjacent vehicles are described in table 1. The variables are presented in different frames shown in figure 1.

Table 1. Variables for the adjacent vehicles

| Variable | Description | Column in CSV | Unit | Frame[[1]](#footnote-1) | Access method |
| --- | --- | --- | --- | --- | --- |
| ID | Identification number of the adjacent vehicles (ascending by time of entry into the sensor range of the subject vehicle) | A | n/a | n/a | Calculated |
| Time | Timestamp (ascending by start time) of the corresponding row in CSV | B | s | n/a | Calculated |
| distance\_adjv (headway)[[2]](#footnote-2),[[3]](#footnote-3) | Distance between the center of the adjacent vehicle and SV | C | m | n/a | Calculated |
| pos\_x\_adjv\_f | x position of adjacent vehicle | D | m | Frenet | Calculated |
| pos\_y\_adjv\_f | y position of adjacent vehicle | E | m | Frenet | Calculated |
| pos\_x\_adjv\_m | x position of adjacent vehicle | F | m | map | Calculated |
| pos\_y\_adjv\_m | y position of adjacent vehicle | G | m | map | Calculated |
| heading\_adjv\_m | heading angle of adjacent vehicle | H | degree | map | Calculated |
| dim\_x\_adjv[[4]](#footnote-4) | length of adjacent vehicle | I | m | vehicle | Calculated |
| dim\_y\_adjv4 | width of adjacent vehicle | J | m | vehicle | Calculated |
| dim\_z\_adjv4 | height of adjacent vehicle | K | m | vehicle | Calculated |
| speed\_adjv | speed of adjacent vehicle | L | m/s | Frenet/  map | Calculated |
| acc\_adjv | acceleration of adjacent vehicle | M | m/s2 | Frenet | Calculated |
| closest\_distance\_longitudinal (gap)2,[[5]](#footnote-5) | The closest distance between adjacent vehicle and SV1 in the longitudinal direction | AH | m | Frenet | Calculated |
| closest\_distance\_lateral[[6]](#footnote-6) | The closest distance between adjacent vehicle and SV1 in the longitudinal direction | AI | m | Frenet | Calculated |
| lanelet\_id\_adjv[[7]](#footnote-7) | Lanelet ID of the adjacent vehicle’s center point | AQ | n/a | n/a | Calculated |
| lane\_id\_adjv7 | Lane ID of the adjacent vehicle’s center point | AR | n/a | n/a | Calculated |
| total\_lanes | Total lanes at the current position | AW | n/a | n/a | Calculated |

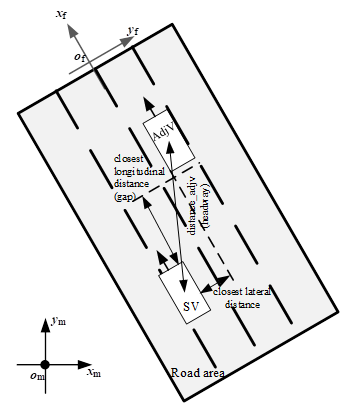
f = frenet; m = map; v = vehicle; ID = identification; SV = subject vehicle; n/a = not applicable.



Source: FHWA.

v = vehicle frame; f = Frenet frame; m = map frame; o = origin.

Figure 1. Frame definition.



Source: FHWA

SV = subject vehicle; AdjV = adjacent vehicle.

Figure 21. Descriptions of distance, closest longitudinal distance, and closest lateral distance.



Source: FHWA.

SV = subject vehicle; AdjV = adjacent vehicle.

Figure 3. Demonstration of lanelet and lane information.

Variables for subject vehicles

The variables for SV1 are described in table 2 and the variables for SV2 are described in table 3.

Table 2. Variables for the SV1

| Variable | Description | Column in CSV | Unit | Frame | Access method |
| --- | --- | --- | --- | --- | --- |
| Time | Timestamp (ascending by start time) of the corresponding row in CSV | B | s | n/a (not applicable) | Measured |
| pos\_x\_sv1\_f[[8]](#footnote-8),[[9]](#footnote-9) | x position of SV1 | N | m | Frenet | Calculated |
| pos\_y\_sv1\_f8,9 | y position of SV1 | O | m | Frenet | Calculated |
| pos\_x\_sv1\_m | x position of SV1 | P | m | map | Measured |
| pos\_y\_sv1\_m | y position of SV1 | Q | m | map | Measured |
| heading\_sv1 | heading angle of SV1 | R | degree | map | Measured |
| dim\_x\_sv1 | length of SV1 | S | m | vehicle | Measured |
| dim\_y\_sv1 | width of SV1 | T | m | vehicle | Measured |
| dim\_z\_sv1 | height of SV1 | U | m | vehicle | Measured |
| speed\_sv18,9 | speed of SV1 | V | m/s | Frenet/  map | Measured |
| acc\_sv18,9 | acceleration of SV1 | W | m/s2 | Frenet | Calculated |
| lanelet\_id\_sv17 | Lanelet ID of the SV1’s center point | AS | n/a | n/a | Calculated |
| lane\_id\_sv17 | Lane ID of the SV1’s center point | AT | n/a | n/a | Calculated |

Table 3. Variables for SV2[[10]](#footnote-10)

| Variable | Description | Column in CSV | Unit | Frame | Access method |
| --- | --- | --- | --- | --- | --- |
| Time | Timestamp (ascending by start time) of the corresponding row in CSV | B | s | n/a | Measured |
| pos\_x\_sv2\_f8,9 | x position of SV2 | X | m | Frenet | Calculated |
| pos\_y\_sv2\_f8,9 | y position of SV2 | Y | m | Frenet | Calculated |
| pos\_x\_sv2\_m | x position of SV2 | Z | m | map | Measured |
| pos\_y\_sv2\_m | y position of SV2 | AA | m | map | Measured |
| heading\_sv2 | heading angle of SV2 | AB | degree | map | Measured |
| dim\_x\_sv2 | length of SV2 | AC | m | vehicle | Measured |
| dim\_y\_sv2 | width of SV2 | AD | m | vehicle | Measured |
| dim\_z\_sv2 | height of SV2 | AE | m | vehicle | Measured |
| speed\_sv28,9 | speed of SV2 | AF | m/s | Frenet/  map | Measured |
| acc\_sv28,9 | acceleration of SV2 | AG | m/s2 | Frenet | Calculated |
| lanelet\_id\_sv27 | Lanelet ID of the SV2’s center point | AU | n/a (not applicable) | n/a | Calculated |
| lane\_id\_sv27 | Lane ID of the SV2’s center point | AV | n/a | n/a | Calculated |

Variables for origins of the map and road

The variables for the road and maps are described in table 4.

Table 4. Information of map origin and road origin

| Variable | Description | Column in CSV | Unit | Frame |
| --- | --- | --- | --- | --- |
| map\_origin\_x | longitude of map origin | AJ | degree | ECEF |
| map\_origin\_y | latitude of map origin | AK | degree | ECEF |
| map\_origin\_z | altitude of map origin | AL | degree | ECEF |
| road\_origin\_x\_m | x position of map origin | AM | m | map |
| road\_origin\_y\_m | y position of map origin | AN | m | map |
| road\_origin\_x\_ecef | longitude of road origin | AO | degree | ECEF |
| road\_origin\_y\_ecef | latitude of road origin | AP | degree | ECEF |

The variables for meta data are represented in table 5.

Table . Included metadata information.

| Variable | Description | Column in CSV | Unit |
| --- | --- | --- | --- |
| run number | number from the set of processed runs | AX | n/a |
| sub run number | Number of sub run for respective run number from processed data set | AY | n/a |
| date | Date of data collection | AZ | n/a |
| time of day | Time stamp of data collection | BA | n/a |
| sub run start time | Start time from the original run from where data was processed | BB | n/a |
| route starting point(rs) | Google map start point | BC | n/a |
| route ending point(re) | Google map end point | BD | n/a |
| distance | Distance of the route | BE | miles |
| maplink | Google maps link of the route | BF | n/a |
| annual traffic density | AADT for the route | BG | n/a |
| roadway type | Type of roadway: Limited access/Divided/Non-divided arterial | BH | n/a |
| road condition | Condition of surface of road: wet/dry | BI | n/a |
| speed limits | Speed limits along the route | BJ | mph |
| type of vehicle | Mode of operation: RI/DI/Baseline | BK | n/a |
| aggressiveness | Aggressiveness setting for SV1 | BL | n/a |
| following distance | Following distance setting for SV1 | BM | n/a |
| special notes | Any interesting observations | BN | n/a |
| gap level | Intended gap between SV1 and SV2  1: (30–60 m) or 2:(60–80 m) | BO | n/a |

1. The vehicle frame is attached to the center of the rear axle of the subject vehicle and rotated with the subject vehicle as it moves through space. The vehicle frame is a moving frame that will change as the vehicle moves and the road orientation changes. As can be seen from figure 1, the *x*v, *y*v, and *z*v of the vehicle frame are towards the front, left, and upward directions. The origin *o*v is at the center of the rear axle. The Frenet frame is attached to the center of the road and its orientation will change as the road direction changes. As shown in figure 1, the xf and yf are the axes of Frenet frame. The longitudinal forward and lateral right directions of the road are the positive directions of xf and yf. The start point of the subject vehicle’s route is picked as the origin of the map frame (of). The map frame is a fixed frame attached to a certain selected point. Positive values for *x*m, *y*m, and *z*m are towards east, north, and upward directions, respectively, as shown in figure 1. Note that the start point of the subject vehicle’s route is picked as the origin of the map frame (*om*). [↑](#footnote-ref-1)
2. As shown in figure 2, the headway between two vehicles (measured between the same point on the leader-follower pair) is the distance\_adjv. The distance\_adjv is measured from the centroid of the leading vehicle to the centroid of the following vehicle. The gap between vehicles (measured between the rear bumper of the leading vehicle and the front bumper of the following vehicle) is recorded as the closest\_longitudinal\_gap. [↑](#footnote-ref-2)
3. When the vehicles are more than 45 m away from the subject vehicle, the position error may be more significant due to limitations with the LiDAR sensor detection range (only a few point clouds from the LiDAR sensor fall on the objects and this may lead to the bounding boxes error) based on project team’s experience. The project team recommends that future users of the data use caution when using distance\_adjv data that exceeds 45 m. [↑](#footnote-ref-3)
4. The research team set fixed values of the bounding boxes to prevent the variation of the bounding box for the same object over different frames. [↑](#footnote-ref-4)
5. As shown in figure 2, when the adjacent vehicle is ahead of the SV, the closest longitudinal distance is the distance from the front bumper of the SV to the rear bumper of the adjacent vehicle in the Frenet frame. When the adjacent vehicle is behind the SV, the closest longitudinal distance is the distance from the rear bumper of the SV to the front bumper of the adjacent vehicle in the Frenet frame. [↑](#footnote-ref-5)
6. As shown in figure 2, when the adjacent vehicle is on the right side of the SV, the closest lateral distance is the distance from the right doors of the SV to the left doors of the adjacent vehicle in the Frenet frame. When the adjacent vehicle is on the left side of SV, the closest lateral distance is the distance from the left doors of the SV to the right doors of the adjacent vehicle in the Frenet frame. [↑](#footnote-ref-6)
7. As shown in figure 3, in Frenet coordinates, the road with several lanes is divided into lanelets from Lanelet 1 to Lanelet 12. The lanelet ID shows the exact ID where the vehicle is. The lane ID shows which lane the vehicle is. The lanelet ID and lane ID are based on the vector map information. The lane ID starts from the right side of the road and increases to the left side of the road. For instance, the lanelet ID for the SV is 1 and the lanelet ID for the adjacent vehicle is 6. For SV, its lane ID is 4 and the total number of lanes is 4. The lane ID for the adjacent vehicle is 3. [↑](#footnote-ref-7)
8. There may be multiple subject vehicle positions, velocities, and accelerations for the same timestamp. This occurs when there are multiple adjacent vehicles detected and is the result of interpolating data and running it through the processing method detailed in chapter 4. This occurs because the subject vehicle position (Frenet), velocity, and acceleration are all outputs of the data processing method, and this can cause very minimal differences in these variables. [↑](#footnote-ref-8)
9. If a future user of the data plots the subject vehicle’s processed trajectories, they will appear discontinuous. This is NOT because there is missing data. This is because the subject vehicle’s position is only provided if there is an adjacent vehicle detected. This decision was made to simplify how data was stored (every row is an instance where an adjacent vehicle is detected near the subject vehicle). If an adjacent vehicle is not detected, one can assume that the subject vehicle will continue to operate at its desired speed until a new adjacent vehicle is detected and impedes the subject vehicle’s path. [↑](#footnote-ref-9)
10. Note: Although SV2 was an RI-ADAS-equipped vehicle, it was operated as a level 0 nonautomated vehicle during data collection. Thus, SV2 data is not considered reflective of ADAS-equipped vehicle behavior, it is reflective of a human driven non-automated vehicle. Adjacent vehicles interacting with SV2 may still exhibit behavioral changes due to the visibility of the sensor stack on the RI-ADAS. [↑](#footnote-ref-10)