# Multi-Modal Intelligent Traffic Signal Systems (MMITSS) –Sample Data, from Anthem, Arizona

## Identification Information

### Citation

#### Citation Information

**Originator:** MMITSS Prototype Development and Impacts Assessment Team

**Publication Date:** 20151101

**Title:** MMITSS – Field Test Data and a sample simulation data

**Edition:** Version 1

**Geospatial Data Presentation Form:** Latitude and longitude

#### Publication Information

**Publication Place**: Washington, D.C.

**Publisher**: U.S. Department of Transportation’s (USDOT) Intelligent Transportation Systems (ITS) Joint Program Office (JPO)

**Online Linkage**: <https://www.its-rde.net/>

## Description

**Abstract** The file contained in this data environment were collected during the Multi-Modal Intelligent Transportation Signal Systems (MMITSS) study. MMITSS is a next-generation traffic signal system that seeks to provide a comprehensive traffic information framework to service all modes of transportation. MMITSS is one of six bundles of Dynamic Mobility Applications (DMA) program. The DMA program have been prioritized by the U.S. Department of Transportation (U.S. DOT) for further development and investigation to expedite efficient deployment of technologies and applications to improve the safety, mobility, and environmental impact of the transportation system. Fully integrated, the MMITSS bundle seeks to improve mobility through signalized corridors using advanced communications and data to facilitate the efficient travel of passenger vehicles, pedestrians, transit, freight, and emergency vehicles through the system. This capability is based on a conceptual understanding of the individual applications, but has not yet been assessed to quantify the potential performance improvements. Moving beyond conceptual formulations of the applications, the next challenge for the MMITSS bundle and larger DMA program is to determine the feasibility of application deployment, to determine the impacts of each application, and to identify any compound benefits from coordinated deployment of multiple applications. DMAs include the Enable Advanced Traveler Information System (EnableATIS), the Freight Advanced Traveler Information System (FRATIS), the Integrated Dynamic Transit Operation (IDTO), Intelligent Network Flow Optimization (INFLO), MMITSS, and the Response, Emergency Staging and Communications, Uniform Management, and Evacuation (R.E.S.C.U.M.E.) system.

MMITSS is composed of several component applications, including: The Intelligent Traffic Signal System (I-SIG), an overarching system optimization application accommodating signal priority, preemption, and pedestrian movements; Transit Signal Priority (TSP) and Freight Signal Priority (FSP), which provide signal priority to transit vehicles at intersections and along arterial corridors or to freight vehicles along an arterial corridor near a freight facility, respectively; Mobile Accessible Pedestrian Signal System (PED-SIG), an application that allows for an automated call from the smart phone of a visually impaired pedestrian to the traffic signal, as well as audio cues to safely navigate the crosswalk; and Emergency Vehicle Preemption (PREEMPT), which provides signal preemption to emergency vehicles and accommodates multiple emergency requests.

The focus of the project is on prototyping and testing practical infrastructure-oriented applications that lead to deployment rather than developing theoretical applications. The University of Arizona in partnership with the University of California, Berkeley, Savari, Econolite, and SCSC collaborated in the MMITSS Prototype Development (PD), which included the MMITSS system, software development, and real-time field implementation for testing and data collection. The PD team was responsible for the development of the prototype and for testing to verify that the prototype was functioning correctly. The Impacts Assessment (IA) team was responsible for integrating the field-collected data and resulting output from the prototype field test into a broader and independent assessment of the impacts of the prototype field test.

The objective of field data collection was to evaluate the Arizona MMITSS applications. The study quantified the effectiveness of Arizona MMITSS applications and investigated the performance of side streets using field data. The following three operational scenarios were selected:

1. I-SIG: Basic Signal Actuation

2. FSP: Basic Freight Signal Priority Scenario

3. Transit Signal Priority and Freight Signal Priority at a corridor

The I-SIG scenario investigates the effectiveness of optimum traffic signal control system for On-Board Equipment (OBE) equipped vehicles to reduce vehicle stops and maximize throughput volume. When OBE-equipped vehicles reach the DSRC communications range, the roadside equipment (RSE) begins to receive BSMs from the vehicle. Using the vehicle information from the RSE processor, the system calculates estimated vehicle arrival time. Then, using the strategic priority algorithm and vehicle arrival time, the system finds the desired service phase with a phase allocation algorithm. Finally, the optimum phase sequence and timing is processed to the signal controller.

In the FSP case, when an equipped truck reaches the communications range, the RSE receives a signal request message (SRM) from the truck. The MMITSS system continuously tracks the movement of the truck, estimates its arrival time at the stop bar, and matches the estimated arrival time with Signal Phase and Timing (SpaT) to determine the signal phase when the truck is going to arrive at the intersection. The MMITSS system determines the best priority timing based on the prevailing traffic conditions and the level of priority requested by the truck. The RSE either holds the green for the truck’s direction of travel if the level of requested priority indicates the truck cannot make a safe stop, or decides if the phase should terminate based on prevailing traffic conditions. When the truck clears the intersection, the OBE sends a cancel SRM to the RSE. The RSE receives the cancel SRM and manages the traffic signal controller to end the priority granting and returns to the normal traffic signal control.

The combination of TSP and FSP applications investigates how equipped transit and freight vehicles operate in a single intersection and how priority is given to multiple equipped vehicles. Equipped vehicles, including transit and freight vehicles, can actively participate in requesting SRMs. The MMITSS system can process multiple requests for priority that may be received from multiple vehicles, as well as multiple modes, at any time. To manage these multiple requests, the MMITSS system provides a hierarchical level of priority that can facilitate preferences for priority control. During the field data collection, the same level of priority was given to both equipped transit and freight vehicles.

The file contained in this data environment includes MMITSS field data collections and microscopic traffic simulation results. The field data were collected from on board vehicle devices (OBE) and roadside units (RSE) on October 21, 2014 and three weekdays (2nd, 3rd, and 4th) in March 2015. This study utilized portable GPS units to quantify the impact of MMITSS on the study corridor for March 2015 data collection.

To investigate the impacts of MMITSS applications, natural driving data and queue data were collected at the Arizona Connected Vehicle Test Bed in Anthem, Arizona. The test bed consists of six intersections along a major arterial road, Daisy Mountain Drive. The test bed starts at Gavilan Peak Parkway to the west and extends to Anthem Way to the east. The section extends 1.9 miles (3.04 km) and covers six signalized intersections. The study corridor is a divided six-lane neighborhood road (three lanes for direction) with a speed limit of 40 mi/hr (or 64 km/h). The study section is closely located (within 0.5 miles) and connected to an interstate highway (I-17), which is a major link that connects to the Phoenix metropolitan area. Thus, the study corridor is frequently used as a commuter route to Phoenix, Arizona, and traffic flows along the corridor are typically directional. Figure 1 illustrates the Arizona test bed.

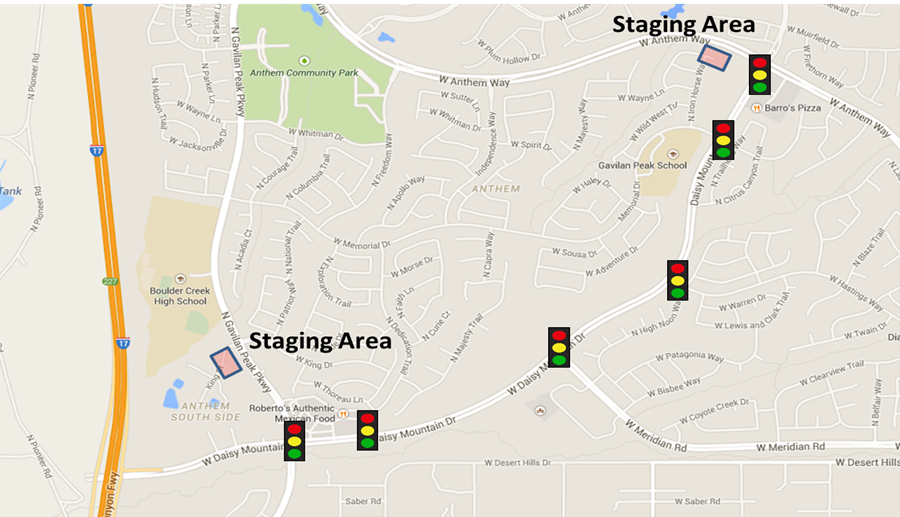


Figure 1. Arizona Test Bed (Source: Map data ©2015 Google)

Large portion of the MMITSS field data was obtained from OBE and RSE. Onboard devices collected accurate location data, at a frequency of 10Hz and vehicle operational data including speeds and accelerations. These collected data includes trajectory information, which includes an individual trip origin and destination. Files containing such information, and other related files, were sanitized – to rid them of such Personally Identifiable Information (PII) before posting them on the RDE. Roadside equipment which also collects trajectory information, albeit for a limited span in time and space, will also be sanitized to eliminate PII.

For GPS data collection, the study utilized a portable Wide Area Augmentation System (WAAS)-enabled GPS receiver to gather second-by-second vehicle trajectories along the study sections. The WAAS-enabled GPS receiver provides longitude and latitude data to an accuracy of 2.5 m, altitude data to an accuracy of 3 m, and speed measurements to an accuracy of 0.1 m/s. The GPS used was a BT-Q1000eX 10Hz, manufactured by QSTARZ International Co. This unit is designed to record the date, time, vehicle longitude, vehicle latitude, vehicle altitude, vehicle speed, vehicle heading, and the number of tracking satellites. The system is completely configurable, and the user can change the setup of the DIP switches to select the recording interval from 0.1 s to 5 s as well as the data recording format. The device is operated as a stand-alone unit without the need for a PC or other equipment. Once the GPS unit is powered up, the GPS unit collects the data automatically. The GPS units were configured to collect time, speed, and location data at 0.1 s intervals. The accelerations were calculated based on the successive second-by second speed measurements as the first derivative of speed with respect to time. The accuracy of the speed data was examined carefully by using MATLAB code and by manually checking for dropouts and unrealistic speeds. If any unrealistic raw data were found, the trip data were not utilized for the study.

A summary of the GSP data collection is provided in Table 1. “Base case” (or “MMITSS off”) and “MMITSS on” field data collections were conducted to assess performance of individual MMITSS applications under real-world conditions. Eighteen drivers collected GPS data using 16 test vehicles (8 passenger cars and 10 light duty utility vehicles). The passenger drivers were asked to drive to maintain the traffic stream without any specific instructions about the purpose of the study in order to maintain natural driving patterns. Transit and truck drivers were asked to follow transit vehicles and/or trailer truck driving patterns, to use slow acceleration and deceleration rates, to maintain longer headways than passenger cars, and to refrain from frequent lane changes. Each driver was instructed to drive their test vehicle according to a scheduled departure plan to maintain a uniform departure rate. For example, five GPS vehicles (using northbound and southbound data collection for the FSP scenario) departed the staging area at Gavilan Peak Parkway at 2-minute intervals. Each driver completed 10 valid round trips for each operational scenario, except for the I-SIG MMITSS scenario, which completed 5 round trips. A significant number of trips were executed (930 trips) during the 3-day field data collection period.

Table 1. GPS Field Data Collection Summary

| Operational Scenarios | Date | Test Vehicle | Test Route | Total Number of Trips (Total 930 Trips) |
| --- | --- | --- | --- | --- |
| I-SIG MMITSS | 3/2/2015 (Monday) p.m. | 5 OBE and 2 GPS cars | Northbound (NB) and southbound (SB) at Gavilan Peak Pkwy. and Daisy Mountain Dr. intersection | 25 NB and 25 SB OBE car trips and 10 NB and 10 SB GPS car trips (Total 70 trips) |
| FSP MMITSS | 3/3/2015 (Tuesday) a.m. | 2 OBE trucks and 5 GPS cars | NB and SB at Gavilan Peak Pkwy. and Daisy Mountain Dr. intersection | 20 NB and 20 SB OBE truck trips and 50 NB and 50 SB GPS car trips (Total 140 trips) |
| 5 GPS cars | Eastbound (EB) and westbound (WB) at Gavilan Peak Pkwy. and Daisy Mountain Dr. intersection | 50 EB and 50 WB GPS car trips (Total 100 trips) |
| FSP Base Case | 3/4/2015 (Wednesday) a.m. | 1 GPS truck and 4 GPS cars | NB and SB at Gavilan Peak Pkwy. and Daisy Mountain Dr. intersection | 10 NB and 10 SB GPS truck trips and 40 NB and 40 SB GPS car trips (Total 100 trips) |
| 4 GPS cars | EB and WB at Gavilan Peak Pkwy. and Daisy Mountain Dr. intersection | 50 EB and 50 WB GPS car trips (Total 100 trips) |
| TSP/FSP Bundle MMITSS | 3/3/2015 (Tuesday) p.m. | 2 OBE trucks and 4 GPS cars | NB and SB at Gavilan Peak Pkwy. and Daisy Mountain Dr. intersection | 20 NB and 20 SB OBE truck trips and 40 NB and 40 SB GPS car trips (Total 120 trips) |
| 2 OBE transits and 4 GPS cars | EB and WB on Daisy Mountain Dr. Corridor (six intersections) | 20 EB and 20 WB OBE transit trips and 40 EB and 40 WB GPS car trips (Total 120 trips) |
| TSP/FSP Bundle Base Case | 3/4/2015 (Wednesday) p.m. | 2 GPS trucks and 2 GPS cars | NB and SB at Gavilan Peak Pkwy. and Daisy Mountain Dr. intersection | 20 NB and 20 SB GPS truck trips and 20 NB and 20 SB GPS car trips (Total 80 trips) |
| 2 GPS transits and 3 GPS cars | EB and WB on Daisy Mountain Dr. Corridor (six intersections) | 20 EB and 20 WB GPS transit trips and 30 EB and 30 WB GPS car trips (Total 100 trips) |

The file format included in the GPS data collection is comma separated files. The data collected from OBE and RSE including BSM, SRM, SPaT, and MAP data, can be opened using any text editor. Each file is store in one of data sets that are a part of this environment. The name of each file is informed by the data set to which it belongs.

**Purpose:**  The data environment is intended to serve as the preview of the larger connected vehicle data environment that includes a significant amount of the data that was collected during the entirety of the deployment exercise. This preview is intended to help prepare researchers and application developers to ingest these data to inform their research and development activities.

## Time Period of Content

### Time Period Information

#### Range of Dates:

**Beginning Date:** 20141021

**Ending Date:** 20141021

**Beginning Date:** 20150302

**Ending Date:** 20150304

#### Currentness Reference:

Ground condition (i.e., the previous dates refer to the time the information was collected)

## Status

**Progress:** Complete

**Maintenance and Update Frequency**: None planned

## Spatial Domain

### Bounding Coordinates

**West Bounding Coordinate**: 33.841425, -112.144655

**East Bounding Coordinate**: 33.859997, -112.111926

**North Bounding Coordinate**: 33.847506, -112.137677

**South Bounding Coordinate**: 33.836775, -112.139544

## Keywords

### Theme

**Theme Keyword**: Basic Safety Message

**Theme Keyword**: BSM

**Theme Keyword**: Vehicle Awareness Device

**Theme Keyword**: VAD

**Theme Keyword**: Aftermarket Safety Device

**Theme Keyword**: ASD

**Theme Keyword**: Signal Request Message

**Theme Keyword**: SRM

### Place

**Place Keyword**: Anthem, Arizona

### Temporal

**Temporal Keyword**: Oct. 21, 2014, Mar. 2, 2015, Mar. 3, 2015, Mar. 4, 2015

## Access Constraints:

To access the data set, users must register through the USDOT Research Data Exchange (RDE) portal (<https://www.its-rde.net/>). The registration process will include a request for contact information and agreement to terms of use for the data What information is optional versus mandatory for registration has not been finalized ; however in order to encourage broad access and use, mandatory information will be kept to a minimum and ease of use maximized. See the RDE Terms of Use and Data Privacy Policy on how registration information is kept secure and for uses only applicable to the RDE administration.

## User Constraints:

Those who use data and data processing tools distributed by the Research Data Exchange have the following responsibilities:

1. Where the contributed materials have been utilized to any extent to enable, verify, supplement or validate performance measurement, analysis, research or software development, to fully reference the Research Data Exchange Program and the contributions of the individuals in all subsequent and related publications or public events, specifically:
   1. In publications, reference the Research Data Exchange website and the date accessed, data and/or data processing tools (by name and version number), and the individual contributors identified on the reference template associated with each data and/or data processing tool.
   2. In presentations or other oral communication, by noting the data and/or data processing tool by name and version number, and communicating the address of the Research Data Exchange website.
2. Users are encouraged to accurately post and update within the Research Data Exchange website a description of the project utilizing the data and/or the data processing tools, including:
   1. A description of the project, including a brief statement of the project goals.
   2. A summary of the hypotheses and findings (when available) of the project.
   3. Individuals directing and/or substantively participating in the project.
   4. The name and version number of the data and/or data processing tools downloaded and utilized in the project.
   5. The current state of the project (upcoming, underway, completed).
   6. References to published materials (if any).
3. Users are encouraged to report anomalies, errors or other questionable data elements using the Data Forum of the Research Data Exchange website, referencing the specific data or data processing tool by name and version number.
4. To refrain from duplication and dissemination of the data and data processing tools to third parties.

Publication of certain derived information such as location of residence, specific stores visited, purpose of trips, etc. must be cleared with the data set originator prior to publication.

## Point of Contact

### Contact Information

#### Contact Organization Primary

**Contact Organization:** Booz Allen Hamilton

**Contact Person**: Dwayne Henclewood

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### Contact Organization Secondary

**Contact Organization:** USDOT Federal Highway Administration (FHWA)

**Contact Person**: Gene McHale

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### Data Set Credit:

## Cross Reference:

**None currently**

### Citation Information

**Originator:** USDOT

**Publication Date:** 20151101

**Title:** Multi-Modal Intelligent Transportation Signal Systems

**Online Linkage:** https://www.its-rde.net/

## Data Quality Information

**Attribute Accuracy**: No accuracy assessment has been performed for the data set. However a number of the data collection devices were tested for conformance to the requirements given in “System Requirement Description, 5.9GHz DSRC …” for RSEs, VADs, ASDs and other such specification.

**Completeness Report**: The USDOT does not make any claims regarding data completeness. There may be gaps in the data provided.

### Lineage

#### Source Information

##### Source Citation

###### Citation Information

**Originator:** All data were collected and provided by the Leidos / USDOT

**Publication Date:** 2015

#### Process Step

**Process Description:** The data were not processed.

#### Process Contact:

##### Contact Information

###### Contact Organization Primary

**Contact Organization:** USDOT FHWA

**Contact Person:** Jon Obenberger

**Contact Electronic Mail Address:** Jon.Obenberger@dot.gov

## Entity and Attribute Information

### Detailed Description for Basic Safety Message (BSM) Data set

A BSM is one of the messages belonging to the Society of Automotive Engineers (SAE) J2735 Standard. This standard is geared toward supporting the interoperability of DSRC applications through the use of a standardized message set and its data frames and data elements. A BSM, which is at times referred to as a “heartbeat” message, is a frequently transmitted message (usually at approximately 10Hz) that is meant to increase a vehicle’s situational awareness. These messages are intended to be used for a variety of applications to exchange safety data regarding a vehicle’s state.

A typical BSM contains up to two parts. Part I, the binary large object (blob), is included in every BSM. It contains the fundamental data elements that describe a vehicle’s position (latitude, longitude, elevation) and motion (heading, speed, acceleration). Part II of a BSM contains optional data that is transmitted when required or in response to an event. Typically Part II contains data that serves as an extension of vehicle safety information (path history, path prediction, event flags) and data pertaining to the status of a vehicle’s components, such as lights, wipers, and brakes.

Each file in the BSM data set contains a time field. The values for each time entry are informed by the 1609.2 Security Services for Applications and Management Messages layer, a member of the IEEE 1609 family standards for the management and security of networks—vehicle network, specifically. The secured time stamp is an Epoch-based time measurement, measuring the number of milliseconds (or microsecond) elapsed since midnight, January 1, 2004 (2004-01-01-00:00:00). In addition, these timestamps were supposed to be relative to UTC, but due to some inaccuracies in the 1609.2 documentation there is a 35-second offset with respect to UTC (which also includes the recent addition of another leap second during the summer). Timestamps in the BSM data set also include a factor of 1,000,000 that needs to be accounted for in order to use these time stamps.

To convert these timestamps to a more standard format, facilitating their usage with other data sets, the following formula can be used to convert the timestamps to the number of seconds elapsed since January 1, 2004 at 00:00:00.

# of seconds since 2004-01-01 00:00:00 = (Gen/Start/End Time)/1,000,000 - 35

The results from the above formula can then be used to further convert BSM timestamps into Epoch timestamps by adding it to 1072933200 (seconds).

The files, and their names, contained in the BSM data set are based on the data frame dictated by the SAE J2735 Standard. Therefore for additional details for some of the above files, please consult the SAE J2735 Standard.

The BSM data set includes two file types, BSM file (bsm\_log\_××\_××\_××\_××\_××) or SRM file ( bsm\_srm\_d\_log\_××\_××\_××\_××\_××), which are listed and described below. The last 6 digits in the filename, e.g. “00\_35\_51” in “bsm\_mar02\_2015\_vehicle1235\_log\_02\_03\_00\_35\_51”, stands for the time in GMT at which the records in that particular file begin.

##### Bsm File

The Bsm File is the BSM metadata file for the transmitted BSMs from a single vehicle. The Bsm file can be considered as the main BSM file. It contains BSM measures that change frequently, approximately 10 Hz. These measures mainly include motion (speed and acceleration) and location (longitude and latitude) elements. The format of the BSM files were customized for MMITSS applications.

The BSM file contains a total of 11 fields. Below is a brief overview of each of these fields.

##### Attribute

Attribute Label: Type

Attribute Definition: This field contains the type of the collected data.

Attribute Domain Values: Character

##### Attribute

Attribute Label: Timestamp

Attribute Definition: This field contains the time in deciseconds with an Epoch time format.

Attribute Domain Values: Float

##### Attribute

Attribute Label: MsgId

Attribute Definition: The DSRC Message ID is a data element used in each message to define which type of message follows from the message set defined by this Standard. This data element is always the first value inside the message and is used to tell the receiving application how to interpret the remaining bytes (i.e. what message structure has been used). This value is enumerated and the values and corresponding meaning are as follows: 0 – Reserved, 1 – A La Carte Message (ACM), 2 – Basic Safety Message (BSM – heartbeat message), 3 – Basic Safety Message Verbose (BSM used for testing only), 4 – Common Safety Request (CSR), 5 – Emergency Vehicle Alert (EVA), 6 – Intersection Collision Alert (ICA), 7 – Map Data (MAP, GID, intersections), 8 – nmea Corrections (NMEA), 9 – probe Data Management (PDM), 10 – probe Vehicle Data (PVD), 11 – Roadside Alert (RSA), 12 – rtcm Corrections (RTCM), 13 – Signal Phase And Timing Message (SPAT), 14 – Signal Request Message (SRM), 15 – Signal Status Message (SSM), 16 – Traveler Information (TIM)

Attribute Domain Values: Integer

##### Attribute

Attribute Label: MsgCount

Attribute Definition: This data element is used to provide a sequence number within a stream of messages from the same sender with the hexadecimal numeral system.

Attribute Domain Values: hexadecimal

##### Attribute

Attribute Label: TempID

Attribute Definition: This field contains the ID (number) of the device (or vehicle) that transmits a BSM.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: SecMark

Attribute Definition: This field SecMark is a simple value consisting of integer values from zero to 59900 representing the milliseconds of a wall clock minute.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Latitude

Attribute Definition: This field contains the current latitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Longitude

Attribute Definition: This field contains the current longitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Elevation

Attribute Definition: This field contains the current elevation, in feet, of vehicle according to GPS.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Speed

Attribute Definition: This field contains the vehicle speed in km/hr.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Heading

Attribute Definition: This field contains the vehicle heading/direction, in degrees.

Attribute Domain Values: Float

##### SRM File

The SRM File is the metadata file for the transmitted SRMs from a transit or freight vehicle. The MMITSS applications process a signal request message (SRM) from an equipped transit vehicle or an equipped freight vehicle to determine the traffic signal phase and desired time of service associated with the request. The SRM file has the same format as the BSM file. These measures mainly include motion (speed and acceleration) and location (longitude and latitude) elements. The format of the SRM files were customized for MMITSS applications. The SRM file contains a total of 11 fields. Below is a brief overview of each of these fields.

##### Attribute

Attribute Label: Type

Attribute Definition: This field contains the type of the collected data.

Attribute Domain Values: Character

##### Attribute

Attribute Label: Timestamp

Attribute Definition: This field contains the time in deciseconds with an Epoch time format.

Attribute Domain Values: Float

##### Attribute

Attribute Label: MsgId

Attribute Definition: The DSRC Message ID is a data element used in each message to define which type of message follows from the message set defined by this Standard. This data element is always the first value inside the message and is used to tell the receiving application how to interpret the remaining bytes (i.e. what message structure has been used). This value is enumerated and the values and corresponding meaning are as follows: 0 – Reserved, 1 – A La Carte Message (ACM), 2 – Basic Safety Message (BSM – heartbeat message), 3 – Basic Safety Message Verbose (BSM used for testing only), 4 – Common Safety Request (CSR), 5 – Emergency Vehicle Alert (EVA), 6 – Intersection Collision Alert (ICA), 7 – Map Data (MAP, GID, intersections), 8 – nmea Corrections (NMEA), 9 – probe Data Management (PDM), 10 – probe Vehicle Data (PVD), 11 – Roadside Alert (RSA), 12 – rtcm Corrections (RTCM), 13 – Signal Phase And Timing Message (SPAT), 14 – Signal Request Message (SRM), 15 – Signal Status Message (SSM), 16 – Traveler Information (TIM)

Attribute Domain Values: Integer

##### Attribute

Attribute Label: MsgCount

Attribute Definition: This data element is used to provide a sequence number within a stream of messages from the same sender with the hexadecimal numeral system.

Attribute Domain Values: hexadecimal

##### Attribute

Attribute Label: TempID

Attribute Definition: This field contains the ID (number) of the device (or vehicle) that transmits a BSM.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: SecMark

Attribute Definition: This field SecMark is a simple value consisting of integer values from zero to 59900 representing the milliseconds.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Latitude

Attribute Definition: This field contains the current latitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Longitude

Attribute Definition: This field contains the current longitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Elevation

Attribute Definition: This field contains the current elevation, in feet, of vehicle according to GPS.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Speed

Attribute Definition: This field contains the vehicle speed in km/hr.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Heading

Attribute Definition: This field contains the vehicle heading/direction, in degrees.

Attribute Domain Values: Float

### Detailed Description for Map Information for Roadside Equipment (RSE) Data set

"Roadside Equipment" (RSE) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short Range Communications (DSRC). This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other roadside equipment, and centers that provide back office support.

These devices are intended to support vehicle to infrastructure (V2I) safety communications capability. An RSE device may be installed in conjunction with advanced traffic signal controllers in order to provide and number of different messages including Signal Phase and Timing (SPaT), Traveler Information Messages (TIM), and geographic data (MAP). These message are broadcasted to vehicles; with isolated traffic signal controllers to provide vehicle presence information to the controller for signal actuation; or as stand-alone devices to provide a variety of safety application broadcasts (e.g.: notification of times of reduced speed limits in school zones).

For the MMITSS project six RSEs were installed throughout the Anthem, AZ study corridor. The following section will detail the data elements capture and/or transmitted by RSEs during this study.

The Map Information for RSE file contains the map information of the intersection and the vehicle trajectory data. The file captures a few descriptive fundamentals of the intersections that were accompanied by RSEs, during the MMITSS field data collection. This file contains descriptors such as intersection and geometry direction IDs, as well as longitude, latitude, and elevation of the intersection.

##### Attribute

Attribute Label: ApproachID

Attribute Definition: This field contains the information of approach. This value is enumerated and the values and corresponding meaning are as follows: 1 Southbound Approach, 2 Northbound Egress, 3 Westbound Approach, 4 Eastbound Egress, 5 Northbound Approach, 6 Southbound Egress, 7 Eastbound Approach, 8 Westbound Egress

Attribute Domain Values: Integer

##### Attribute

Attribute Label: LaneNumber

Attribute Definition: The LaneNumber data element conveys a unique index value for a lane used to refer to that lane by other objects in the intersection map data structure. Lanes may be ingress (inbound traffic) or egress (outbound traffic) in nature, as well as barriers and other types of specialty lanes. All lanes are numbered.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: NodeNumber

Attribute Definition: This data element contains the number of the node that a lane is associated with.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Reference\_North

Attribute Definition: This data element contains a reference location using the Cartesian coordinate system on an intersection with a northern orientation. Northern offsets are positive while southern offsets are negative.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Reference\_East

Attribute Definition: This data element contains a reference location using the Cartesian coordinate system on an intersection with an eastern orientation. Eastern offsets are positive while western offsets are negative.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Latitude

Attribute Definition: This field contains the current latitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Longitude

Attribute Definition: This field contains the current longitude, in degrees, of the vehicle.

Attribute Domain Values: Float

### Detailed Description for Vehicle Trajectories for Roadside Equipment (RSE) Data set

The Vehicle Trajectories file is populated with basic safety messages received from equipped vehicle within the communication range of an RSE. The data also contains elements that communicate additional details about the vehicle that is used for vehicle safety applications, and elements that communicate specific items of a vehicle‘s status that are used in data event snapshots which are gathered and periodically reported to an RSEs. These data are transmitted at a rate of 10 Hz. The data also include motion (speed and acceleration) and location (longitude and latitude) elements of connected vehicles.

##### Attribute

Attribute Label: VehicleID

Attribute Definition: This field contains the ID (number) of the device (or vehicle) that transmits a BSM.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Latitude

Attribute Definition: This field contains the current latitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Longitude

Attribute Definition: This field contains the current longitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Speed

Attribute Definition: This field contains the vehicle speed in m/s.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Heading

Attribute Definition: This field contains the vehicle heading/direction, in degrees.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Timestamp

Attribute Definition: This field contains the time in deciseconds with an Epoch time format.

Attribute Domain Values: Float

### Detailed Description for Signal Plans for Roadside Equipment (RSE) Data set

The Signal Plans for RSE file contains the basics of a SPAT message. This file includes SPAT message and the timestamp of the SPAT message. The file also provides the signal phase and timing information for one or more movements at an intersection.

##### Attribute

Attribute Label: Timestamp

Attribute Definition: This field contains the time in deciseconds with an Epoch time format.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Phase\_Ring1

Attribute Definition: This attribute is a unique identifier for the phase of Ring 1.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: CumulativeCurrentState1

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current state of the phase of Ring 1.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Phase\_Ring2

Attribute Definition: This attribute is a unique identifier for the phase of Ring 2.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: CumulativeCurrentState2

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current state of the phase of Ring 2.

Attribute Domain Values: Float

##### Attribute

Attribute Label: CumulativeTime1

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current data file.

Attribute Domain Values: Float

##### Attribute

Attribute Label: CurrentIndication\_MajorStreet

Attribute Definition: This attribute defines the current indication for a major street approach (or Barrier 1). Possible values are: 1, indicating the red; 3 indicating green; and 4 indicating yellow.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Duration\_Indication\_\_MajorStreet

Attribute Definition: This attribute defines the duration of the current indication in second for a major street approach (or barrier 1).

Attribute Domain Values: Float

##### Attribute

Attribute Label: CumulativeTime2

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current data file.

Attribute Domain Values: Float

##### Attribute

Attribute Label: CurrentIndication\_MinorStreet

Attribute Definition: This attribute defines the current indication for a minor street approach (or barrier 2). Possible values are: 1, indicating the red; 3 indicating green; and 4 indicating yellow.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Duration\_Indication\_MinorStreet

Attribute Definition: This attribute defines the duration of the current indication in second for a minor street approach (or barrier 2).

Attribute Domain Values: Float

##### Attribute

Attribute Label: PhaseCheck1

Attribute Definition: This attribute examines the phases 2 and 5 for checking the possible phase errors. Possible values are: 1, indicating the red; 3 indicating green; and 4 indicating yellow.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: CumulativePhaseCheck1

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current phasecheck1.

Attribute Domain Values: Float

##### Attribute

Attribute Label: PhaseCheck2

Attribute Definition: This attribute examines the phases 2 and 6 for checking the possible phase errors. Possible values are: 1, indicating the red; 3 indicating green; and 4 indicating yellow.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: CumulativePhaseCheck2

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current phasecheck2.

Attribute Domain Values: Float

##### Attribute

Attribute Label: CumulativeTime3

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current data file.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Duration\_Indication\_MinorStreet2

Attribute Definition: This attribute defines the duration of the current indication in second for a minor street approach (or barrier 2). This field is same with Duration\_Indication\_MinorStreet2.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Timeremaining\_Phase\_Ring1

Attribute Definition: This attribute specifies the time remaining (in seconds) before the signal phase will change to the next phase (for yellow and red indications).

Attribute Domain Values: Float

##### Attribute

Attribute Label: Timeremaining\_Phase\_Ring2

Attribute Definition: This attribute specifies the time remaining (in seconds) before the signal phase will change to the next phase (for yellow and red indications).

Attribute Domain Values: Float

##### Attribute

Attribute Label: CumulativeGreenRing1

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current green indication of the phase of Ring 1.

Attribute Domain Values: Float

##### Attribute

Attribute Label: CumulativeGreenRing2

Attribute Definition: This attribute shows the cumulative time (in seconds) of the current green indication of the phase of Ring 2.

Attribute Domain Values: Float

### Detailed Description for Priority Request Server for Roadside Equipment (RSE) Data set

The Priority Request Server (PRS) file is responsible for managing all Requests for Priority that are received in terms of determining eligible requests based on the N-Level priority policy and determining the best signal timing strategy based on the prevailing traffic conditions and signal controller capability. The priority request server chooses the best method for serving the active priority requests under the current traffic conditions.

##### Attribute

Attribute Label: MsgId

Attribute Definition: The DSRC Message ID is a data element used in each message to define which type of message follows from the message set defined by this Standard. This data element is always the first value inside the message and is used to tell the receiving application how to interpret the remaining bytes (i.e. what message structure has been used). This value is enumerated and the values and corresponding meaning are as follows: 0 – Reserved, 1 – A La Carte Message (ACM), 2 – Basic Safety Message (BSM – heartbeat message), 3 – Basic Safety Message Verbose (BSM used for testing only), 4 – Common Safety Request (CSR), 5 – Emergency Vehicle Alert (EVA), 6 – Intersection Collision Alert (ICA), 7 – Map Data (MAP, GID, intersections), 8 – nmea Corrections (NMEA), 9 – probe Data Management (PDM), 10 – probe Vehicle Data (PVD), 11 – Roadside Alert (RSA), 12 – rtcm Corrections (RTCM), 13 – Signal Phase And Timing Message (SPAT), 14 – Signal Request Message (SRM), 15 – Signal Status Message (SSM), 16 – Traveler Information (TIM)

Attribute Domain Values: Integer

##### Attribute

Attribute Label: VehicleType

Attribute Definition: This attribute is used to indicate vehicle type. The name and description of each of these values is the following: 100 – Regular Passenger Car; 2 – Connected Transit.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: ETA

Attribute Definition: This field contains the estimated time of arrival in seconds. If the transit vehicle has cleared the intersection (egress), the ETA is 0.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: RequestedPhase

Attribute Definition: This field contains the requested signal phase. If the transit vehicle has cleared the intersection (egress), the requested phase is 0.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Timestamp

Attribute Definition: This field contains the time with an Epoch time format.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Inlane

Attribute Definition: This field specifies the approach and the lane number of the approaching transit vehicle. The desired direction of travel including the inlane and outlane SRM data is utilized to determine the service phase. The first value is enumerated and the values and corresponding meaning are as follows: 1 Southbound Approach, 2 Northbound Egress, 3 Westbound Approach, 4 Eastbound Egress, 5 Northbound Approach, 6 Southbound Egress, 7 Eastbound Approach, 8 Westbound Egress. The second value specifies the lane number.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Outlane

Attribute Definition: This field specifies the information of the desired egress direction and the lane number of the transit vehicle. The desired direction of travel including the inlane and outlane SRM data is utilized to determine the service phase. The first value is enumerated and the values and corresponding meaning are as follows: 1 Southbound Approach, 2 Northbound Egress, 3 Westbound Approach, 4 Eastbound Egress, 5 Northbound Approach, 6 Southbound Egress, 7 Eastbound Approach, 8 Westbound Egress. The second value specifies the lane number. If the transit vehicle has cleared the intersection (egress), the outlane is 0.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: StartingHour

Attribute Definition: This field contains the hour of the current time.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: StartingMinute

Attribute Definition: This field contains the minute of the current time.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: StartingSecond

Attribute Definition: This field contains the second of the current time.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: EndingHour

Attribute Definition: This field contains the hour of the estimated arrival time at the intersection

Attribute Domain Values: Integer

##### Attribute

Attribute Label: EndingHour

Attribute Definition: This field contains the minute of the estimated arrival time at the intersection

Attribute Domain Values: Integer

##### Attribute

Attribute Label: EndingHour

Attribute Definition: This field contains the second of the estimated arrival time at the intersection

Attribute Domain Values: Integer

##### Attribute

Attribute Label: VehicleState

Attribute Definition: This field specifies the direction of travel. Possible values are: 1 Approach; 2 Egress.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Msg\_cnt

Attribute Definition: This field specifies the message count.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Vehicle\_ID

Attribute Definition: This field contains Vehicle unique ID.

Attribute Domain Values: Integer

### Detailed Description for Map Data set

The intersections map file provides the geometric intersection description data that defines a digital map of an intersection down to the lane level. The extent of the map in each direction depends on factors such as topology, signal reception, and other intersections in the area. The MAP file provides local geo-referenced coordinates of the intersection, lane geometry, and permitted navigation maneuvers.

##### Attribute

Attribute Label: Map\_name

Attribute Definition: This attribute contains a unique map name.

Attribute Domain Values: Character

##### Attribute

Attribute Label: RSE\_ID

Attribute Definition: This attribute contains a unique RSE name.

Attribute Domain Values: Character

##### Attribute

Attribute Label: IntersectionId

Attribute Definition: According to the SAE J2735 Standard the IntersectionId element is used to globally and uniquely define an intersection within a country or region. Assignment rules for this value are established elsewhere and may use regional assignment schemas that vary.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Intersection\_attributes

Attribute Definition: The Attributes data object is a bit-mapped byte that provides information about the format and content of the rest of the MAP message. The bits of the MAP message attributes object are as follows. A bit set to a logic zero indicates that the described condition is present while a bit set to one indicates that it is not present.

0 Elevation data is included.

1 Lane Width data is included in the node list.

2 Node data is packed in 12-bit format instead of standard 16-bit.

3 Node offset resolution; 0-centimeter, 1-decimeter.

4 Message contains the intersections geometric data.

5 Message contains navigational movement data.

6 Reserved

7 Reserved

Attribute Domain Values: Unsigned 8-bit Integer

##### Attribute

Attribute Label: Reference\_point

Attribute Definition: This attribute contains a definitive and precise location of the intersection in the world geodetic system (WGS-84) coordinate system from which short offsets may then be used to define lane node positions using the flat earth projection. This data object provides the latitude and longitude of the center of the intersection in decimal degrees to one-tenth of a micro-degree. When included, the elevation data is provided in decimeters above or below the reference ellipsoid.

Attribute Domain Values: Float (latitude and longitude) and Integer (elevation)

##### Attribute

Attribute Label: No\_Approach

Attribute Definition: This attribute specify the number of approaches of the intersection.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Approach

Attribute Definition: This field specifies the information of the direction of the road. The value is enumerated and the values and corresponding meaning are as follows: 1 Southbound Approach, 2 Northbound Egress, 3 Westbound Approach, 4 Eastbound Egress, 5 Northbound Approach, 6 Southbound Egress, 7 Eastbound Approach, 8 Westbound Egress.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Approach\_type

Attribute Definition: The attribute indicates the beginning of an approach structure used to relate one or more motor vehicles lanes for an intersection approach or egress description with any associated pedestrian and special purpose lanes and lane barriers. The enumerated values of Direction data are as follows.

1 Approach

2 Egress

Attribute Domain Values: Integer

##### Attribute

Attribute Label: No\_lane

Attribute Definition: This attribute specify the number of lane.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Lane

Attribute Definition: This attribute specify the approach and lane\_id.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Lane\_ID

Attribute Definition: This attribute specify the lane\_id.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Lane\_type

Attribute Definition: This attribute specify the lane type. The enumerated values of Lane Type data object are as follows.

1 Motorized Vehicle Lane

2 Computed Lane

3 Pedestrian Lane

4 Special Purpose Lane

5 Barrier

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Lane\_attributes

Attribute Definition: This attribute specify the characteristics of each lane based on the lane type. The Lane Attributes data object is a bit-mapped value that describes a combination set of characteristics specific to a lane type. The lane attributes value is obtained by combining (logical OR) the various bit-masks together to produce a single value. A bit set to a logic one indicates that the described attribute is present while a bit set to zero indicates that it is not present.

Motorized Vehicle or Computed Lanes

The lane attributes for motorize vehicle and computed lanes relate the allowed navigational maneuvers and other restrictions. If the egress path bit is set, then a two-way path or an outbound path is described. The bits of the lane attributes object are defined as follows.

0 (LSB) Lane is egress path

1 Straight maneuver permitted

2 Left turn maneuver permitted

3 Right turn maneuver permitted

4 Yield

5 No U-turn permitted

6 No turn on red permitted

7 No stopping permitted

8 HOV lane

9 Bus only lane

10 Bus and taxi only lane

11 Shared two-way left turn lane

12 Bike lane

13-15 Reserved

Pedestrian Lanes

The attributes for a pedestrian lane relate the type of crosswalk, bicycle-crossing, or other non-motorized lane. The bits of the lane attributes object defined are as follows.

0 (LSB) Lane provides a two-way path of travel

1 Pedestrian crosswalk

2 Bicycle crossing

3 Railroad track is present

4-15 Reserved

Special Purpose Lanes

The attributes for special purpose lanes relate the allowed navigational maneuvers and other restrictions. These attributes deal with lanes describing trains and transit vehicles that are part of an intersection. The bits of the lane attributes object are defined as follows.

0 (LSB) Lane is egress path

1 Lane is a railroad track

2 Transit vehicle only lane

3 HOV lane

4 Bus only lane

5 Vehicles entering

6 Vehicles leaving

7-15 Reserved

Barrier Lanes

The attributes for barrier lanes relate the type of barriers being described. A barrier is any lane style or object which normal vehicle traffic cannot transverse. The bits of the lane attributes object are defined as follows.

0 (LSB) Median

1 White line

2 Stripped lines

3 Double-stripped lines

4 Traffic cones

5 Construction barrier

6 Traffic channels

7 No curbs

8 Low curbs

9 High curbs

10 HOV, do not cross

11 HOV, entry allowed

12 HOV, exit allowed

13-15 Reserved

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Lane\_width

Attribute Definition: The Lane Width data conveys the width of the lane in centimeters. This data object is only present when the intersection geometry is included in the message.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: No\_nodes

Attribute Definition: The attribute specifies the number of node on the lane.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Node

Attribute Definition: The attribute contains the information of approach, Lane\_ID, node number, latitude, and longitude.

Attribute Domain Values: Integer and Float (latitude and longitude)

##### Attribute

Attribute Label: No\_Conn\_lane

Attribute Definition: The attribute specifies the number of connected lanes.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Lane\_Connection.

Attribute Definition: The Lane Connection identifies the connected lanes from the current lane and includes the maneuver code of each connected lane. The enumerated values of Maneuver Code data item are as follows.

0 Unknown

1 U-Turn

2 Left Turn

3 Right Turn

4 Straight Ahead

5 Soft Left Turn

6 Soft Right Turn

7 Merge Left

8 Merge Right

Attribute Domain Values: Integer

##### Attribute

Attribute Label: End\_lane

Attribute Definition: The attribute specifies the end of each lane. The beginning of a lane description starts at the following row.

Attribute Domain Values: Integer and Float (latitude and longitude)

### Detailed Description for GPS Data set

The GPS data set catalogs the vehicle operation data of the test vehicles that used for the MMITSS field testing. The data contains the performance and operation details of vehicles. This file contains a number of fields detailing elements such as vehicle position and speed, fidelity measures of GPS-based data elements, and vehicle operation data.

#### Gps log File

The *GPS log* is the main log for the data collected by the portable GPS unit. The GPS data includes time-stamped position, speed, and data quality information. This file contains 19 fields, which are described below.

##### Attribute

Attribute Label: INDEX

Attribute Definition: This data element is used to provide a sequence number since the GPS system started, which (generally) starts when the GPS system is in the on position.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: TRACK ID

Attribute Definition: This field contains the numeric ID assigned to each GPS device.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: LAP ID

Attribute Definition: This field contains the unique, numeric ID assigned to each Trip.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: VALID

Attribute Definition: This field contains the quality of GPS information. The name and description of each of these values is the following: NoFix and Fixed

Attribute Domain Values: Character

##### Attribute

Attribute Label: UTC DATE

Attribute Definition: This field contains the UTC date (m/d/yyyy) on which the trips started.

Attribute Domain Values: Date (m/d/yyyy)

##### Attribute

Attribute Label: UTC TIME

Attribute Definition: This field contains the UTC time stamp of the start of a trip, in the form of hh:mm:ss.

Attribute Domain Values: Time (hh:mm:ss)

##### Attribute

Attribute Label: Local DATE

Attribute Definition: This field contains the local date (m/d/yyyy) on which the trips started.

Attribute Domain Values: Date (m/d/yyyy)

##### Attribute

Attribute Label: Local TIME

Attribute Definition: This field contains the local time stamp of the start of a trip, in the form of hh:mm:ss.

Attribute Domain Values: Time (hh:mm:ss)

##### Attribute

Attribute Label: MS

Attribute Definition: This field contains the time in milliseconds.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Latitude

Attribute Definition: This field contains the current latitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: N/S

Attribute Definition: This field specifies the north-south position of a point on the Earth's surface.

Attribute Domain Values: Character

##### Attribute

Attribute Label: LONGITUDE

Attribute Definition: This field contains the current longitude, in degrees, of the vehicle.

Attribute Domain Values: Float

##### Attribute

Attribute Label: E/W

Attribute Definition: This field specifies the east-west position of a point on the Earth's surface.

Attribute Domain Values: Character

##### Attribute

Attribute Label: ALTITUDE

Attribute Definition: This field contains a GPS-based estimate of height, in meters, above sea level (height above the reference ellipsoid that approximates mean sea level).

Attribute Domain Values: Float

##### Attribute

Attribute Label: SPEED

Attribute Definition: This field contains the vehicle speed in km/hr.

Attribute Domain Values: Float

##### Attribute

Attribute Label: HEADING

Attribute Definition: This field contains the vehicle heading/direction, in degrees.

Attribute Domain Values: Float

### Detailed Description for Simulation Data set

The Simulation output data set provides vehicle probe data and signal output data of MMITSS simulation results. The MMITSS impacts assessment study evaluates the impacts of MMITSS using a software-in-the-loop simulation (SILS) system that was developed by The University of Arizona PD Team. The MMITSS simulation platform consists of the VISSIM microscopic traffic simulation software, the basic safety message (BSM) distributor (or Signal Request Messages [SRM] distributor) program, an RSE module, and the Econolite ASC/3 traffic controller emulator. VISSIM, the BSM distributor, and the Econolite ASC/3 traffic controller emulator run on a Windows platform, whereas the RSE module runs on a Linux platform. The two platforms were connected via an Ethernet cable.

MMITSS modeling requires that the link information, including location, width, and length, is matched to the real roadway to identify vehicle location information in the simulation model. The MMITSS modeling requires a precise match between a reference point in VISSIM’s x-y coordinate system and the GPS latitude and longitude values from a map file to identify vehicle locations in VISSIM. The program utilizes high-resolution map information to identify the location of vehicles. Each intersection requires a single map file that includes the latitude and longitude coordinates of each lane of roadway within the communication ranges of each RSE. A straight section of a link requires less map points than a curved section. The reference point in the middle of an intersection is the location of the RSE in the simulation model whereas in actual practice an RSE is typically installed on one of the traffic signal heads.

Vehicle mobility data that include individual Connected Vehicle (CV) location and speed data are generated from VISSIM, and CV data are transmitted to the BSM distributor program. The CV is modeled as a separate vehicle class using a Dynamic Linked Library (DLL) that is utilized in VISSIM.

The BSM distributor sends BSM data to an RSE when vehicles enter a preset Dedicated Short Range Communications (DSRC) communication range for each traffic signal controller. The vehicle’s BSM data that are transmitted to an RSE when the vehicle enters RSE communication range with a unique vehicle ID and the vehicle location data in VISSIM’s x-y coordinate format. Then, the vehicle location data are converted to latitude and longitude values to identify the precise location of each vehicle using the map file information.

The RSE module utilizes a Containerization Technology provided by a Docker software. Each Docker container runs an individual RSE module, and multiple Docker containers can be run on a single Linux computer. For this study, six containers were run at the same time to operate six signalized intersections. The optimum signal timing data that includes an optimal signal sequence and duration for each phase are estimated by the phase allocation algorithm. The optimal solution is transmitted to the Econolite ASC/3 traffic controller interface. VISSIM updates the signal times through National Transportation Communications for ITS Protocol (NTCIP) commands.

#### Vehicle\_record File

The Vehicle\_record file contains vehicle log data which were recorded during the simulation runs. This file contains a number of fields detailing elements such as vehicle position (or location), speed, delay and queue data. This file contains 14 fields, which are described below.

##### Attribute

Attribute Label: Simulation second [s]

Attribute Definition: This field contains the simulation time in seconds.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Number

Attribute Definition: This attribute is a unique identifier (number) of a vehicle.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Lane/Link/Number

Attribute Definition: This attribute is the current link number of a vehicle.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Lane/Index

Attribute Definition: This field contains the current lane number of a vehicle

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Position [m]

Attribute Definition: This field contains the position on the link in meters

Attribute Domain Values: Float

##### Attribute

Attribute Label: Speed [km/h]

Attribute Definition: This field contains the vehicle speed in km/hr.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Acceleration [m/s2]

Attribute Definition: This field contains the vehicle acceleration in m/s2.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Speed (theoretical) [km/h]

Attribute Definition: This field contains the theoretical vehicle speed in km/hr and can be to estimate the delay.

Attribute Domain Values: Float

##### Attribute

Attribute Label: In queue

Attribute Definition: This attribute is used to indicate if a vehicle is in-queue or not. The name and description of each of these values is the following: 0 – Vehicle is not in-queue.; 1 – Vehicle is in-queue.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Queue encounters

Attribute Definition: This field contains the current queue counter for a vehicle.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Queue time [s]

Attribute Definition: This field contains the cumulative queue time for a vehicle in seconds.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Delay time [s]

Attribute Definition: This field contains the cumulative delay time for a vehicle in seconds.

Attribute Domain Values: Float

##### Attribute

Attribute Label: Number of stops

Attribute Definition: This field contains the cumulative stops for a vehicle.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Vehicle type

Attribute Definition: This attribute is used to indicate vehicle type. The name and description of each of these values is the following: 100 – Regular Passenger Car; 1 – Connected Passenger Car.

Attribute Domain Values: Integer

#### Signal\_changes File

The record file of signal changes contains chronologically sorted records of the signal state changes of all signal controllers. This file contains 8 fields, which are described below.

##### Attribute

Attribute Label: Time

Attribute Definition: This field contains the simulation time in seconds.

Attribute Domain Values: Float

##### Attribute

Attribute Label: SC

Attribute Definition: This field contains the signal controller number.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Signal\_group

Attribute Definition: This field contains the signal group number.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Signal\_state

Attribute Definition: This field provide the information of the signal state.

Attribute Domain Values: Character

##### Attribute

Attribute Label: Time\_change

Attribute Definition: This field contains a time since the last signal state change in seconds.

Attribute Domain Values: Float

##### Attribute

Attribute Label: SC\_type

Attribute Definition: This field contains the signal controller type.

Attribute Domain Values: Character

### Detailed Description for System Detectors Data set

The system detectors data set includes data on the movements which were identified by system detectors at an intersection and thus resulted in system state changes. Data is provided for detectors located at some, or all, of the following locations: the EB Right Lane, EB Center Lane, EB Left Lane, WB Right Lane, WB Center Lane, WB Left Lane, SB Right Lane, SB Center Lane, and SB Left Lane.

**System Detector File**

##### Attribute

Attribute Label: Volume\_data

Attribute Definition: This field contains the amount of passing vehicles found by the detector.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Occupancy\_data

Attribute Definition: The field contains the total occupancy of passengers found in passing vehicles by the detector.

Attribute Domain Values: Integer

##### Attribute

Attribute Label: Time

Attribute Definition: This field contains the time in deciseconds with an Epoch time format.

Attribute Domain Values: Float

## Distribution Information

### Distributor

#### Contact Information

##### Contact Organization Primary

**Contact Organization**: Booz Allen Hamilton

**Contact Electronic Mail Address**: Kandarpa\_Ram@bah.com

## Metadata Reference Information

**Metadata Date**: 20160113

**Metadata Review Date**: 20160113

**Metadata Future Review Date**: not scheduled

### Metadata Contact

#### Contact Information

##### Contact Organization Primary

**Contact Organization**: Booz Allen Hamilton

**Contact Person**: Dwayne Henclewood

**Contact Electronic Mail Address**: Henclewood\_Dwayne@bah.com

**Metadata Standard Name:** FGDC Content Standard for Digital Geospatial Metadata

**Metadata Standard Version:** FGDC-STD-001-1998

**Metadata Time Convention:** Local time