

**Feasibility Study and Assessment of Communications Approaches for Real-Time Traffic Signal Applications Study Dataset**

Dataset available at: <http://doi.org/10.21949/1520082>.

(This dataset supports report **Feasibility Study and Assessment of Communications Approaches for Real-Time Traffic Signal Applications— Final Report**)

This U.S. Department of Transportation-funded dataset is preserved in the U.S. Department of Transportation's data repository (<https://data.transportation.gov>), and is available at <http://doi.org/10.21949/1520082>.

The related final report **Feasibility Study and Assessment of Communications Approaches for Real-Time Traffic Signal Applications— Final Report**, is available from the National Transportation Library's Digital Repository at <https://rosap.ntl.bts.gov/view/dot/50751>.

**Metadata from the data.transportation.gov Repository record:**

Description: This dataset contains Signal Phasing and Timing (SPaT), MAP, and Basic Safety Messages (BSM) data from the "Feasibility Study and Assessment of Communications Approaches for Real-Time Traffic Signal Applications" project in the hexadecimal string and pcap formats. The project characterizes and assesses the feasibility of SPaT messages for infrastructure-based safety applications by comparing messages received through cellular networks with those received through Dedicated Short Range Communication (DSRC).

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**Dataset description:**

This dataset contains 4 .zip file described below.

The associated raw data have also been uploaded to data.transportation.gov (DTG) at <http://doi.org/10.21949/1520082>.

### Data management: File information

This document provides information on the data files.

All header-less message log csv files have the following columns unless otherwise noted in the description:

- `coreData_timestamp`: unix timestamp in seconds, taken at the time record was captured in the field.
- `coreData_payload_hex`: message payload in hexadecimal string. The data collected will primarily be Signal Phasing and Timing (SPaT), MAP, and Basic Safety Message (BSM) data as defined in SAE J2735 standard. As defined in the standard, the data uses UPER encoding and is in ASN.1 format.

### File Manifest

Data files are included as zipped attachments to this dataset. **Names for the zipped attachments are bolded and underlined.** **Names of folders within the zipped file are bolded.** **Names of files within the zipped file are underlined.**

- **PROCESSED\_TEST\_09\_19.zip**: All data logs for test conducted on 09/19/2019
  - **RSUCapture**: All logs for data generated and recorded at the RSU
    - **morning\_spat\_2**: Recorded during morning session of the test run
      - **tx\_ota\_spat.csv**: transmitted SPAT only messages recorded at ota interface in csv format
      - **tx\_ota.csv** and **.pcap**: all transmitted messages recorded at ota interface in csv and pcap format
      - **tx\_r1a.pcap**: all messages transmitted at r1a interface and this log did not contain any spat messages
      - **tx\_r1c\_spat.csv**: transmitted SPAT only messages recorded at r1c interface in csv format. This is the primary log of interest in this study.
      - **tx\_r1c.csv** and **.pcap**: all transmitted messages recorded at r1c interface in csv and pcap format
    - **afternoon\_spat\_2**:
      - **RSU\_4\_1-cw-mon-tx-20190919160953\_spat.csv**: all transmitted SPAT messages at cw-mon-tx interface of the RSU logged in csv format
      - **RSU\_4\_1-cw-mon-tx-20190919160953.csv** and **.pcap**: All transmitted messages at the cw-mon-tx interface of the RSU logged in csv and pcap format
      - **RSU\_4\_1-cw-mon-txa-20190919160953\_spat.csv**: all transmitted SPAT messages at cw-mon-txa interface of the RSU logged in csv format

- RSU\_4\_1-cw-mon-txa-20190919160953.csv and .pcap: All transmitted messages at the cw-mon-txa interface of the RSU logged in csv and pcap format
  - RSU\_4\_1-cw-mon-txb-20190919160953\_spat.csv: all transmitted SPAT messages at cw-mon-txb interface of the RSU logged in csv format. This is the most relevant log for our study
  - RSU\_4\_1-cw-mon-txb-20190919160953.csv and .pcap: All transmitted messages at the cw-mon-txb interface of the RSU logged in csv and pcap format
- **VCCLOG\_09\_19\_mov**: This folder contains logs for the moving (mov) vehicle
  - **OBUCapture**: (where X = {1,2,3,4} and Y = {a,b}. Tests 1 and 2 were conducted during the morning session and tests 3,4 were conducted during the afternoon session.)
    - testXY\_spat.csv: OBU receive logs containing SPAT messages only recorded during test run XY in csv format
    - testXY.csv and .pcap: OBU receive logs containing all messages recorded during test run XY in csv and pcap format
  - rsuobu\_r1c\_test1a.csv: This file contains latency information for SPAT between RSU and OBU for test1a. The RSU log is using interface r1c for this case. We don't have the latency results for test case 1b, 2a and 2b because the RSU logs we obtained did not cover those tests.
  - rsuobu\_tx\_test3a.csv: This file contains latency information for SPAT between RSU and OBU for test1a. The RSU log is using interface tx for this case. This was not used in our study as interface tx was not considered reliable.
  - rsuobu\_txb\_testXY.csv: (where X = {3,4} and Y = {a,b}) This file contains latency information for SPAT between RSU and OBU for testXY in the afternoon session. The RSU log is using interface txb for this case. This was used in our study.
  - vccmov.csv: This file contains SPAT messages, recorded through VCC using cellular networks, at the laptop installed in the moving vehicle.
  - vccobu\_XY.csv: (where X = {1,2,3,4} and Y = {a,b}) This file contains latency difference between time of reception at VCC and OBU respectively for test XY.
  - vccrsu\_r1c\_Morning.csv: This file contains the latency between RSU and VCC during the morning session. The r1c interface of the RSU is used for the logging.
  - vccrsu\_tx\_Afternoon.csv: This file contains the latency between RSU and VCC during the afternoon session. The tx interface of the RSU is used for the logging. This log file is not considered in our study as interface txb of RSU was found to be have more complete logs.
  - vccrsu\_txb\_Afternoon.csv: This file contains the latency between RSU and VCC during the afternoon session. The txb interface of the RSU is used for the logging.
- **VCCLOG\_09\_19\_sta**: This folder contains logs collected at the stationary vehicle during the same test time. The filenames have similar structure as the moving vehicle logs.

- **PROCESSED TEST 09 26.zip:** All data logs for test conducted on 09/26/2019.
  - **RSUCapture:**
    - **morning\_1:** (where X = {tx,txb} and Y is the different timestamps that are recorded in the filenames)
      - RSU 4 1 cw-mon-X-Y.csv and .pcap: RSU logs for all messages recorded at interface X. There are multiple logs with different Y's and the value of Y determines when the logs were completed.
      - RSU 4 1 cw-mon-X-Y spat.csv: RSU logs for SPAT messages recorded at interface X. There are multiple logs with different Y's and the value of Y determines when the logs were completed.
      - rsulogtx.csv: This log is generated by combining all the logs at interface tx.
      - rsulogtxb.csv: This log is generated by combining all the logs at interface txb.
    - **afternoon\_1:** (where X = {tx,txb} and Y is the different timestamps that are recorded in the filenames)
      - RSU 4 1 cw-mon-X-Y.csv and .pcap: RSU logs for all messages recorded at interface X. There are multiple logs with different Y's and the value of Y determines when the logs were completed.
      - RSU 4 1 cw-mon-X-Y spat.csv: RSU logs for SPAT messages recorded at interface X. There are multiple logs with different Y's and the value of Y determines when the logs were completed.
      - rsulogafternoon tx.csv: This log is generated by combining all the logs at interface tx.
      - rsulogafternoon txb.csv: This log is generated by combining all the logs at interface txb.
  - **VCCLOG\_09\_26\_mov:** This folder contains logs for the moving (mov) vehicle
    - **OBUCapture:** (where Y = {1,2,3,4})
      - testY X.csv: OBU logs in csv format for the SPAT message collected at the moving vehicle. If X = 131, it contains the SPAT message received from intersection id 131. If X = spat, it contains all the SPAT messages received during the tests which are not limited to intersection id 131.
      - testYspat.csv: raw OBU logs in csv format for SPAT message collected at the moving vehicle.
      - testY.csv and .pcap: This includes OBU logs and all the messages received during the test.
    - rsu\_obu X Y.csv: (where X = {afternoon,morning} and Y = {1,2,3,4}) These contain latency logs between RSU and OBU collected at either morning or afternoon test sessions. The morning tests are defined as test 1 and test 2, and afternoon tests are defined as test 3 and test 4. There is a file here named rsu\_obu\_morning\_3.csv and this file includes any data collected in the morning test that contained information for tests ran in the afternoon.
    - rsuobuYmov.csv: this file with Y = {3,4} contains all the RSU to OBU latency logs for the afternoon test.
    - rsuvcc\_after\_tx.csv, rsuvcc\_morning\_tx.csv, rsuvccmornaft.csv, and rsuvccmovaft.csv: these four files are subsidiary files for the analysis and can be removed if needed.

- tXm.csv: (where  $X = \{1,2,3,4\}$ ) are the latency logs for RSU to VCC for different test runs.
  - vcclog0926.csv: this is the SPAT log captured through cellular networks at the moving vehicle laptop.
  - vccobu\_X.csv: (where  $X = \{1,2,3,4\}$ ) is the latency between cellular networks through VCC at laptop and through DSRC at the OBU. These are collected for different test runs as specified.
- **VCCLOG\_09\_26\_sta**: This is the folder for logs collected at the stationary vehicle during the test. The filenames have similar structures as the moving vehicle logs.
- **PROCESSED\_TEST\_10\_09.zip**: All data logs for test conducted on 10/09/2019. This time we were only able to conduct three test runs 1A, 1B, and 2A.
  - **OBUCapture**: Contains OBU logs for all the test runs. These can be BSM and SPAT.
    - runX\_rxb\_Y.csv: These contain receive logs at the OBU on the moving vehicle. The values for X can be {1A, 1B and 2A}. The receive logs contain SPAT message coming from only intersection id  $Y = \{156, 131\}$ .
    - runX\_rxb.csv and .pcap: These contain receive logs at the OBU on the moving vehicle. The values for X can be {1A, 1B and 2A}. The receive logs contain SPAT message coming from all the intersections.
    - runX\_txb.csv and .pcap: These contain transmit logs at the OBU on the moving vehicle. The transmit logs contain BSM. The values for X can be {1A, 1B and 2A}
  - **RSUCapture**: These files contain RSU logs for the SPAT broadcasts from the RSUs
    - rsulog.csv: This is the combined file for all the RSU SPAT broadcasts logged at the RSU during this day of test.
    - spat\_vcc.csv and .pcap: This file was also captured at the RSU but it includes messages being sent to the VCC cloud from the RSU's backhaul network. This file was only used for internal analysis of any issues with latency at different locations and never used in the final output of the project
    - tx\_X.csv and .pcap: These are transmit logs of SPAT and MAP messages being transmitted by the RSU at X interfaces. X can be r1a, r1c1, r1c2, r1c3 and r1c4. Among these files, files where  $X = r1a$  was not used for the analysis as it was not complete. The other files that contain  $X = \{r1c1, r1c2, r1c3, r1c4\}$  contain the logs that are grouped incrementally over time.
  - latgpsRSUOBURun1A.csv: this file contains latency with GPS (latitude and longitude) of the moving vehicle during the test. This file was not eventually used and was developed for mid process testing.
  - latgpsRSUvcc.csv: This file contains latency and GPS locations of the vehicle when it was receiving messages from VCC cloud server using the cellular network. The latency is between RSU and laptop.
  - obu\_vcc\_X\_spat.csv: With  $X = \{1A, 1B, 2A\}$ , these files contain latency difference values between messages received at laptop through cellular network and at OBU through DSRC.

- rsu\_obu\_lat\_distance\_X.csv: With  $X = \{1A, 1B, 1B1, 2A\}$ , these files like above contain the latency between RSU and OBU through DSRC network and the distance between the two devices in real time.
  - rsu\_r1c\_vcc\_156.csv: These are preliminary test files that contain latency values between interface r1c logs of RSU and the VCC for the intersection id 156.
  - rsu\_vcc\_distance\_1A.csv: This file contains the latency and distance logs for RSU and VCC data.
  - runX\_bsmlog.csv: With  $X = \{1A, 1B, 2A\}$ , these files contain the GPS locations and timestamp. These values are directly extracted from the BSM logs.
  - runX\_gps.csv: This file also contains the similar data as the one above.
  - runX\_lat\_gps.csv: These files contain the GPS location from above files along with the latency values between RSU and OBU for run  $X = \{1A, 1B, 2A\}$
  - runX\_Y.csv: with  $X = \{1A, 1B, 2A\}$  and  $Y = \{rx, tx\}$  these files contain receive or transmit logs for the OBU. The logs are SPAT messages if they are rx and BSM logs if they are tx.
  - vcc09\_10\_X.csv: With  $X = \{131, 156\}$ , these files contain VCC logs collected at the laptop in the moving vehicle for the intersection ids X.
  - vcc09\_10.csv: This file contains all the messages received at the laptop irrespective of the intersection id.
- **PROCESSED TEST 11 07.zip**: All data logs for test conducted on 11/07/2019. This test was conducted on the arterial network with different intersections. The intersections ids are  $X = \{115, 116, 119, 122\}$ , which corresponds to intersections at Barkley Dr, Cedar Ln, Javier Rd, and William Dr. Two tests run were made, test 1 and test 2 (also called test 1a and test 2a). An extension of .pcap1 may be used when multiple pcap captures were generated per session.
    - **RSU LOG**
      - **BarkleyDr\_1**: RSU logs at Barkley Dr intersection for test 1 (first session)
        - rsu\_eth\_txa.csv: This file contains message logged at the backhaul interface of the RSU. These messages were sent to the VCC server from the RSU.
        - spat.csv and .pcap: This contains all the spat messages collected into one file, in csv and pcap formats. This was used for further analysis in our project.
        - tx\_Y.csv and .pcap: with  $Y = \{ota, ota1, ota2, ota3, r1a, r1c\}$ , these files contain transmitted logs for all messages from the RSU over the DSRC network, in csv and pcap formats.
        - tx\_Y\_spat.csv and .pcap: with  $Y = \{ota, ota1, ota2, ota3, r1a, r1c\}$ , these files contain transmitted logs from the RSU over the DSRC network in the csv and pcap formats. These logs only contain SPAT messages.
      - **BarkleyDr\_2**: RSU logs at Barkley Dr intersection for test 2 (second session)

- RSU\_4\_1\_cw-mon-X-Y.csv and .pcap: where  $X = \{tx, tx1, tx2, txa, txb\}$  and  $Y$  is the different timestamps that are recorded in the filenames, these files contain logs at the RSU for all the messages being transmitted.
  - RSU\_4\_1\_cw-mon-X-Y\_spat.csv and .pcap: same as the above but contain only SPAT messages.
  - spat.csv and .pcap: This contains all the spat messages collected into one file, in csv and pcap formats. This was used for further analysis in our project.
- **CedarLn\_1**: Same logs and filenames as in BarkleyDr\_1
- **CedarLn\_2**: Same logs and filenames as in BarkleyDr\_2
- **JavierRd\_1**: Same logs and filenames as in BarkleyDr\_1
- **JavierRd\_2**: Does not exist since we did not receive logs from this location.
- **WilliamDr\_1**: Same logs and filenames as in BarkleyDr\_1
- **WilliamDr\_2**: Same logs and filenames as in BarkleyDr\_2
- **Test\_Hwy50\_Mobile**: Logs recorded at the moving vehicle along Hwy 50. In the file names,  $Y = \text{test session } \{1a, 2a\}$ ,  $X = \text{intersection ID } \{115, 116, 119, 122\}$ .
  - **OBUCapture**: Logs recorded at the OBU
    - mapfileallint.csv: This file contains all the MAP messages received during the testing. It contains MAP message for all four intersections.
    - mobiletestY\_gps\_time.csv: this file contains GPS location and time of logging the GPS location in the moving vehicles OBU.
    - mobiletestYrx\_b\_spat.csv: this file contains the receive logs at the OBU through DSRC network. This file only contains the SPAT messages.
    - mobiletestYrx\_b.csv and .pcap: this file contains the receive logs at the OBU for all the messages received.
    - mobiletestYtx\_b.csv: this file contains the BSM messages transmitted by the OBU.
    - obulogreceivegpsY\_X.csv: this file contains GPS locations and intersection id tag for each of the intersections of interest.
    - obulogspatY\_X.csv: this file contains SPAT messages received for tests  $Y$  from each particular intersection.
    - There are other files in this folder such as timegps\*.csv and test1a\*.csv/pcap: these files were generated by the analysis process and contain information already available in the other files mentioned above.
  - allMobileVccLog.csv: This file contains all the messages logged from VCC at the moving vehicle laptop. These messages are from all four intersections of interest.
  - rsu\_obu\_Y\_X\_dist.csv: This file contains latency and distance between the RSU and the OBU in the moving vehicle. The files are separated by each test  $Y$  and each intersection  $X$ .

- rsu\_obu\_Y\_X\_gpstime.csv: This file is similar to the one above but contains GPS co-ordinates with intersection id for messages received by the OBU from an RSU. This file tells us where the vehicle was when a SPAT was received from an RSU. There should be separate files for each intersection and each test.
- rsu\_obu\_Y\_X.csv: This file contains the SPAT message with time stamps received by the OBU from each intersection X and during each test Y.
- rsu\_vcc\_Y\_X\_dist.csv: This file contains latency and distance between the RSU and the laptop through cellular network in the moving vehicle. The files are separated by each test Y and each intersection X.
- rsu\_vcc\_Y\_X\_gpstime.csv: This file is similar to the one above but contains GPS co-ordinates with intersection id for messages received by the laptop from the VCC server. This file tells us where the vehicle was when a SPAT was received from the VCC. There should be separate files for each intersection and each test.
- rsu\_vcc\_Y\_X.csv: This file contains the SPAT message with time stamps received by the laptop from each intersection X and during each test Y. The messages are routed through VCC server.
- vcc\_obuY\_mob\_X.csv: These files contain the latency difference between the messages received at the OBU from an RSU through DSRC and the laptop from the VCC cloud through cellular network.
- vccgpslatY\_X.csv: These files contain GPS and latency values for messages received through VCC.
- vcclogXmob.csv: These files contain all the messages received from VCC cloud pertaining to intersection X.
- vcclogreceivegpsY\_X.csv: These files contain the GPS position of the messages received from each intersection for each test conducted. The intersection id is also a data field in these files.
- vcclogspat\_X.csv: These files are similar to the files vcclogXmob.csv described above.
- **TestHwy\_50\_stationary**: These files are related to the stationary vehicle logs and have similar filename as in mobile vehicle logs shown above. One exception is listed below:
  - **vcclogs**: This folder contains messages captured from all four different intersections through the cellular network.
    - 20191107-YVCCCloudSPaT-X: Where Y = timestamp in the format of HHMMSS and X = intersection ID. Contains the timestamp and SPAT message received through cellular network using VCC server from intersection id X.

#### National Transportation Library (NTL) Curation Note:

As this dataset is preserved in a repository that is not under the management of NTL and any changes to the data located in the data.transportation.gov repository may not be reflected in the ROSAP record, as allowed by the U.S. DOT's Public Access Plan (<https://doi.org/10.21949/1503647>) Section 7.4.2 Data, the NTL staff has performed **NO** additional curation actions on this dataset.

NTL staff last accessed this dataset at <http://doi.org/10.21949/1520082> on 2021-03-01.



If, in the future, you have trouble accessing this dataset at the host repository, please email [NTLDataCurator@dot.gov](mailto:NTLDataCurator@dot.gov) describing your problem. NTL staff will do its best to assist you at that time.