Traffic Processing Report of 2009 Testing for Construction Cycle 5

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Executive Summary

Construction cycle 5 (CC5), built in the National Airport Pavement Test Facility (NAPTF), was designed to evaluate the performance of flexible pavements under simulated aircraft loads. The primary objective of the experiment was to investigate the interaction of closely spaced multiple-wheel landing gear on pavement performance. The secondary objective was to study the performance of crushed quarry screenings conforming to FAA P-154 and a dense graded aggregate (DGA) meeting New Jersey highway specifications.

The experiment included 4 test items designed into 12 sections; 6 sections on the north and 6 sections on the south of the pavement centerline. The test sections were built with 2 different subbase thicknesses, 2 different subbase materials and were trafficked with four different gear configurations. One of the gear configurations included six wheels. Two gear configurations included ten-wheel with different spacing between wheels. The last gear configuration was also ten-wheel simulating the Antonov aircraft. The test design included three different wheel loading levels. Table E.1 presents these variations of the test sections.

Table E1. Test Design Summary.

Sections	Test Items			
	Gear configuration	Subbase Material	Subbase Thickness (inches)	Loading Level
LFC1-NW	six-wheel	P-154	34	50-70k lbs.
LFC1-NE	ten-wheel (narrow spacing)	P-154	34	50-70k lbs.
LFC2-NW	ten-wheel (narrow spacing)	P-154	38	50-70k lbs.
LFC2-NE	six-wheel	P-154	38	50-70k lbs.
LFC3-N	six-wheel	DGA	38	59-70k lbs.
LFC4-N	six-wheel	DGA	34	59-70k lbs.
LFC1-SW	ten-wheel (wide spacing)	P-154	34	70k lbs.
LFC1-SE	six-wheel	P-154	34	70k lbs.
LFC2-SW	ten-wheel (wide spacing)	P-154	38	70k lbs.

Sections	Test Items			
	Gear configuration	Subbase Material	Subbase Thickness (inches)	Loading Level
LFC2-SE	six-wheel	P-154	38	70k lbs.
LFC3-S	ten-wheel (Antonov)	P-154	38	70k lbs.
LFC4-S	ten-wheel (Antonov)	P-154	34	70k lbs.

An enormous amount of data was collected during testing from 2008 to 2012. This report intended to analyze the transverse profile of the test sections to calculate the rut depth progression concurrent with pavement loadings.

This study evaluated the availability of the profile data for this testing cycle. Over the course of CC5 testing, the FAA implemented 3 different profilers. Testing started with trafficking north sections, and transverse profiles were collected using an FAA profiler that was 21 feet long. The challenge with using this profiler was that it was too short to capture the entire 30 foot width of the sections in one run. So additional profiles, called center profiles and extension profiles, were taken and were stitched to the original profiles. This profiler was retired after 71 wanders (4,686 passes).

Then, the FAA implemented a 30-foot Profiler. Although this profiler could capture the entire width of the sections, additional profiles were needed since upheavals were rising around the centerline and into the south sections when loading with the ten-wheel gear. These profiles, too, were stitched to the original profiles for a complete profile analysis.

In 2012, the FAA implemented a 66-foot profiler which could capture the width of the entire test pavement (south and north) in one run. A reference line was tested prior to every profile measurement. This reference profile was used to adjust the measured profile for beam curvature of the 66-foot profiler. These reference profiles were used to infer that temperature induced beam curvature does not appear to significantly impact measurements of 21 and 30-foot profilers.

Three software programs were created to process data from each profiler. The study identified the suitable version of the programs and used them for processing. Various naming conventions were used throughout the experiment for the profiles. The profile names usually include the cumulative pass number, transverse line profiled and other details that allow recognition of the profile.

A series of post traffic testing, select sections were trenched to characterize the deformation of each pavement layer as a result of traffic. Surface profiles obtained from trenched sections

were compared with the last processed profile of test sections to validate the processing of the measured profiles. Profiles from trenched sections and processed profiles were generally in good agreement.

Two methods were used in this study to calculate the rut depth: baseline method and straightedge method. The baseline method calculates the rut depth with respect to the profile initially measured in each section. The straightedge method calculates the rut depth by implementing an imaginary straightedge placed on upheavals. In both methods, the maximum rut depth associated with the cumulative traffic pass was recorded. While the maximum rut depth in baseline method is easily obtained by subtracting the initial profile from the subsequent profiles, a MATLAB script was developed to implement the straightedge method. One advantage of the straightedge method over the baseline method is that it incorporates the presence and the development of the upheavals in calculating the rut depth, while baseline method is only concerned with the depth of rut with respect to the original surface elevation. The rut depth results indicate the following:

- When other factors were similar, higher rut depth was observed in sections with thinner subbase. The effect of subbase thickness is pronounced as the number of cumulative passes increase. This was the case when comparing LFC1-NW with LFC2-NE, LFC1-NE with LFC2-NW as well as LFC3-N with LFC4-N.
- When other factors were the same, sections loaded with six-wheel gear initially demonstrated higher rut depth than sections loaded with ten-wheel gear. The difference decreased and ultimately reversed as sections loaded with ten-wheel gear had final rut depth higher than sections loaded with six-wheel gear. This is illustrated when comparing LFC1-NW with LFC1-NE as well as when comparing LFC2-NW and LFC2-NW.
- When other factors were the same, section that was built according to the P-154 specifications had lower rut values than the section built with dense graded aggregate. This is demonstrated by comparing section LFC3-N built with DGA subbase and section LFC2-NE built with P-154 subbase.
- Wheel load levels play a significant role in rut depth progression. Expectedly, sections loaded with heavier loads had deeper rutting. This is the case when comparing LFC1-NW with LFC1-SE. Even though the number of passes on LFC1-NW was almost twice as much, its final rut depth is about 35% less than LFC1-SE. Testing of the north sections was conducted fairly soon after the pavement was constructed. Testing of the south sections was conducted two to four years after construction. In comparison of the performance of the north and the south sections, aging is a factor that's not quantified in this study. In general however it is expected that aging contributes to lower rut depth progression.

- Sections loaded with Antonov gear configuration initially developed higher rut depth than sections loaded with narrow and wide ten-wheel gear configurations, when other factors remained the same using the straightedge method. After about 6,000 passes, the trend was reversed. This was the case when comparing LFC3-S and LFC4-S with LFC2-SW and LFC1-SW, respectively.

Introduction

Construction cycle 5 (CC5) consisted of flexible pavement sections that were built in the National Airport Pavement Test Facility (NAPTF) to conduct full-scale testing. The performance of various flexible pavement sections was evaluated as they were repeatedly trafficked under simulated aircraft loads. Pavement testing started in 2008 and continued in 2009, 2010, and 2012. An enormous amount of data was accumulated during the four years of testing and was processed to characterize pavement response in meeting the objectives of the CC5 experiment.

Besides other data collected, two components of the dynamic data produced during trafficking were the vehicle (aircraft simulator) information and the sensors embedded in the test pavement.

Some difficulties were encountered while reviewing the traffic and sensor data generated and collected during 2008 and 2009 testing. A data investigation report was prepared by Durgesh Gupta[1] in an effort to identify the key factors that caused the problems impacting the data processing. The challenges of data processing and data collection during the 2008 testing were discussed in that report and some recommendations were provided for traffic and sensor data processing. Some of the issues of 2009 data were also identified in that report; however, it was concluded that a number of missing critical parameters prohibited the processing of 2009 traffic data.

The 2009 data includes approximately 45 percent of the testing data on the north sections. This report is an effort to review the traffic data from the 2009 testing and make recommendations for batch processing of the data to generate the traffic tables. This report documents the challenges that were encountered while processing the traffic logs and presents methods that were implemented to resolve the difficulties.

CC5 Trafficking Plan

The CC5 test experiment included 4 test items designed into 12 sections; 6 sections on the north and 6 sections on the south of the pavement centerline as shown in Figure 1. Test items were designated as LFC1, LFC2, LFC3, and LFC4. Test items LFC1 and LFC2 were further split into four sections denoted as northeast (NE), northwest (NW), southeast (SE), and southwest (SW). Test items LFC3 and LFC4 were split into 2 sections designated as north and south.

[1] Durgesh Gupta, CC5-North Side Data Investigation Report and Future Recommendations From the Data Processing Perspective, CSRA.

The 2008 and 2009 trafficking took place on the north sections. The trafficking started in August 2008 and paused in November 2008 when 12,540 passes were made. Each test section was loaded with a different combination of gear load levels and configurations. Trafficking resumed in September 2009 until a total of 22,572 passes were completed on the north sections. The trafficking continued on section LFC1-NW to complete 27,918 total passes and on section LFC1-NE to complete 28,312 total passes. Trafficking was concluded on the north sections in October 2009.

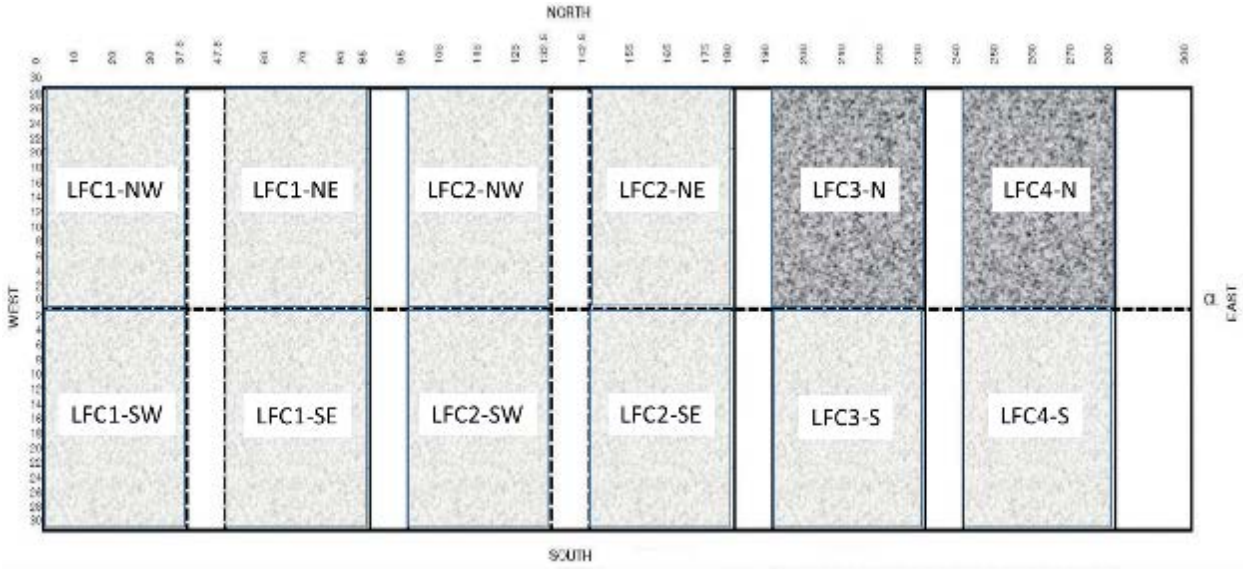
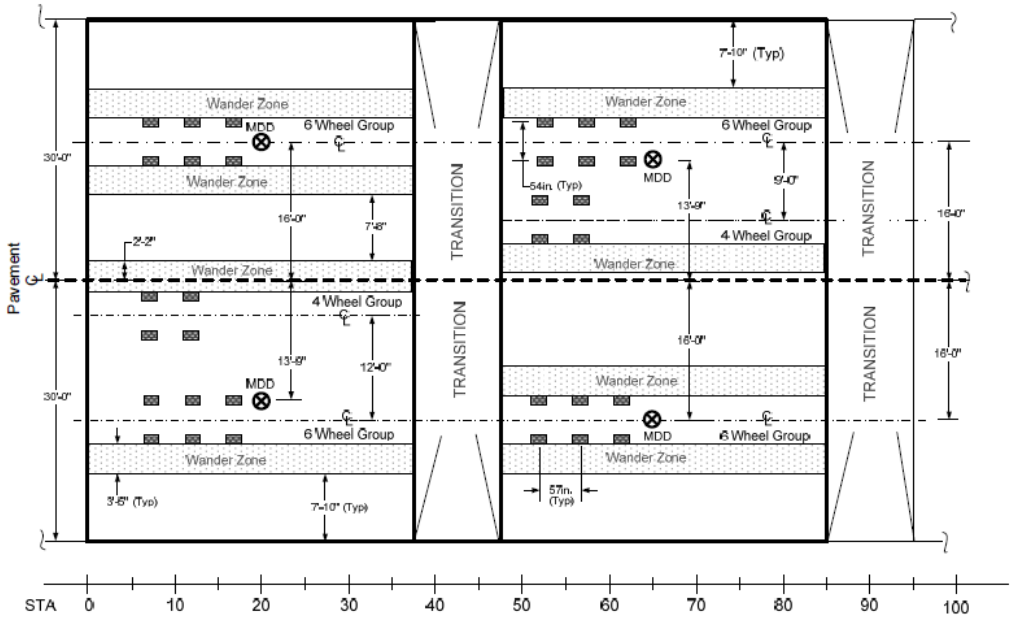
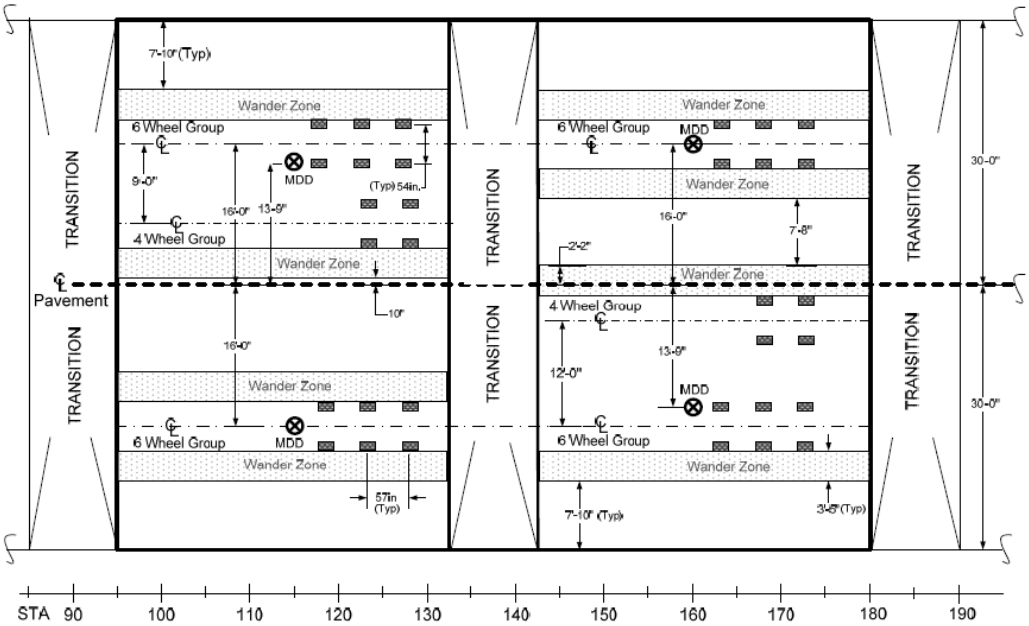


Figure 1. CC5 Test Items Layout

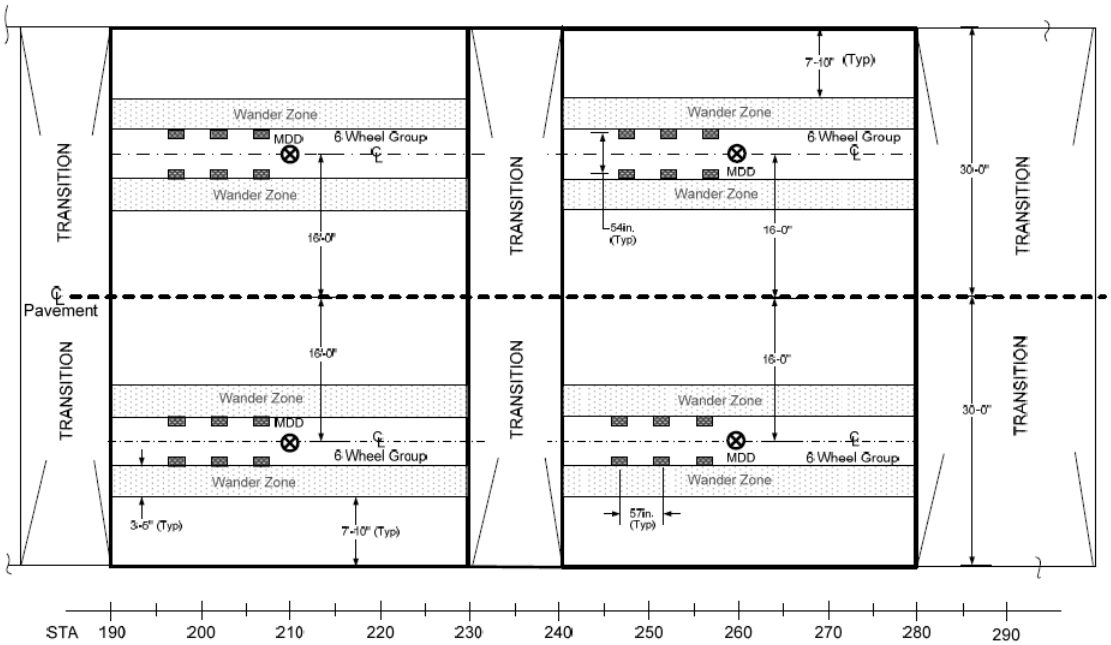
Sections LFC1-NW, LFC2-NE, LFC3-N, and LFC4-N were planned to be loaded with a 6-wheel gear configuration. Sections LFC1-NE and LFC2-NW were planned to be loaded with a 10-wheel gear configuration. The aircraft simulator vehicle consists of two carriages, north carriage and south carriage. Each carriage has 5 Modules consisting of 2 wheels. For north side trafficking, the north carriage had 6 active wheels and the south carriage had 4 active wheels. Figure 2 depicts the 6-wheel and 10-wheel gear configurations on the north and south sections. The figure also depicts wander zones for each group of wheels. Figure 3 depicts the wander pattern of the sample sections that were loaded with the 10-wheel gear on the north side and 6-wheel gear on the south side with 9 track positions within the wander zones. Figure 4 presents the wander pattern for a sample of sections that were loaded with 6-wheel gears on both sides. Similarly, there are 9 track positions within the wander zones on both sides. Each wander contained 66 passes on the sections.



a) Gear Configuration on LFC1 Sections



b) Gear Configuration on LFC2 Sections



c) Gear Configuration on LFC2 Sections

Figure 2. Gear Configurations of CC5 Test Sections

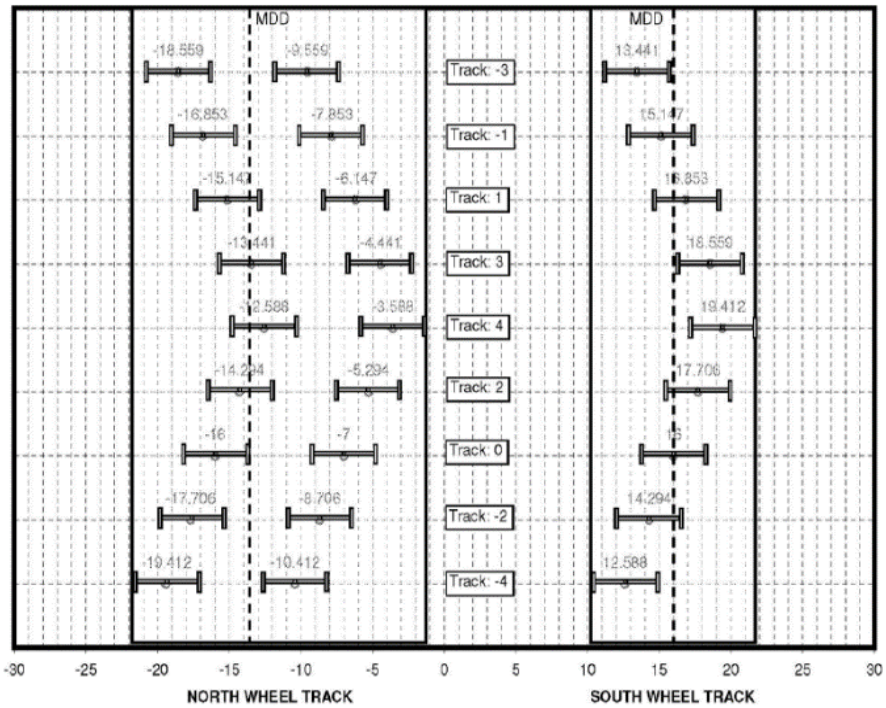


Figure 3. Wander Pattern of Sample Sections Loaded with 10-Wheel Gear on North and 6-Wheel Gear on South.[2]

[2] FAA Website: http://www.airporttech.tc.faa.gov/Airport-Pavement/National-Airport-Pavement-Test-Facility-/NAPTF-Databases/Construction-Cycle-5/Test-Plan/Wander-Pattern

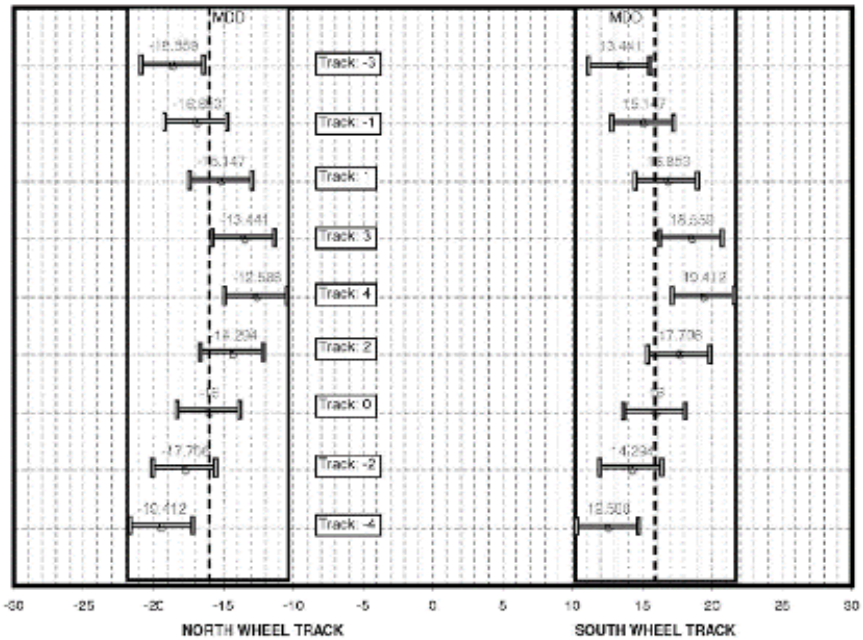


Figure 4. Wander Pattern of Sample Sections Loaded with 6-Wheel Gear on Both Sides.[1]

Contents of Traffic Table

Traffic tables contain necessary information to track the time, position, load and gear configuration of the aircraft simulator in every pass. Traffic tables are available in the FAA database for 2008, 2010, and 2012 test data. The traffic table for 2009 testing is missing. The following are the elements of the traffic tables:

Traffic ID: Unique number assigned to identify each vehicle passing event. Traffic ID refers to the number of accumulated passes.
EventNo: A number assigned to a traffic event. An event is defined as a movement of the vehicle with loads.
SequenceNo: Position within the wander sequence corresponding to event. The wander pattern consists of wander sequences 1 through 66.
WanderID: Numbers 1 to 66 indicate the north side test items and 67 to 132 are used for the south side test items respectively. WanderID and SequenceNo are the same for north sections.
EventStartTime: Date and time of the start of a traffic event.
EventEndTime: Date and time of the end of a traffic event.
Gearparameter: Gear configuration for the event. Gear parameter is always “1” for the north sections which indicates North Carriage has 6 tires and South Carriage has 4 tires.

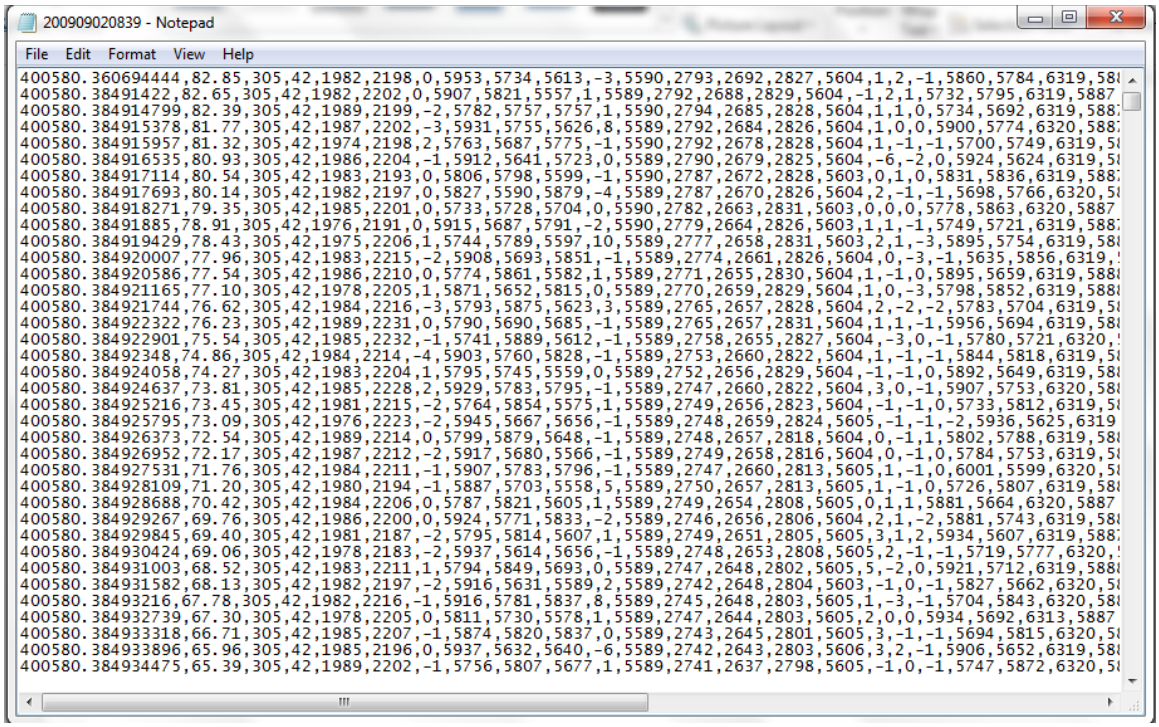
TestItem: Test item(s) loaded during an event.
AvgModuleLoads_LB: Average wheel loads corresponding to traffic event.

Vehicle Information and Traffic Logs

As the vehicle moves over the test pavement, the vehicle information is recorded through data acquisition devices. The vehicle information that contains the condition of vehicle and carriage modules is stored in two files. Some of the vehicle information such as wander number, carriage module loads and positions are recorded in files with extension *.log. Other information such as carriage position, tire loads, and tire temperature are recorded in a separate file with an extension *Additional.log. Key information such as time and vehicle position is present in both files so the files can be matched for processing. Log and Additional Log files are expected to contain event recording of ten minutes, and may contain the information of more than one pass.

The 2009 traffic log file format differs from the 2008 traffic log file format. In 2008, the log files contain text (ASCII) header and binary data, while in 2009 the log files contain text (ASCII) data without any header.

Traffic Logs: Figure 5 presents a sample traffic log file of 2009 testing. The name convention of the log files represent the date and time of the vehicle pass. For example, "200909020839" contains a ten minute log of the vehicle passes on September 02, 2009 starting at 8:39 A.M. As mentioned earlier, the log files do not include any header, which poses difficulty describing the content of each file. After some iterations and comparison with the 2008 traffic log headers, content of some of the critical columns, represented as Channels, were identified with the following description:
Column 1: Channel 0 –Time in numeric format. The integer part refers to the date which is the number of days from a fixed date. The decimals denote the time.
Column 2: Channel 1 – The vehicle position
Column 3: Channel 2 – Accumulated pass number
Column 4: Channel 3 – Sequence number
Columns 7 to 11: Channels 6 to 10 – North carriage module loads
Columns 12 to 16: Channels 11 to 15 – North carriage module positions
Columns 17 to 21: Channels 16 to 20 – South carriage module loads
Columns 22 to 26: Channels 21 to 25 – South carriage module positions



200909020839 - Notepad

File Edit Format View Help

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400580.384914799,82.39,305,42,1989,2199,-2,5782,5757,5757,1,5590,2794,2685,2828,5604,1,1,0,5734,5692,6319,5887
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```

Figure 5. Sample Log File from September 2nd, 2009.

The tab-delimited representation of the sample log file is also provided as figure 6 to better illustrate the content. The figure shows a few rows of the beginning and end of the recorded log. The rows in between are replaced with dots. As shown, when the first column data format is changed to "HH:MM:SS", the data changes from "400580.360694444" to 8:39:24 AM, which is consistent with the file name.

Columns 2 to 4 of the log file in figure 6 indicate that the log file contains the vehicle record from location 82.85 feet offset at wander 42 (pass number 305) to location 183.97 at wander 48 (pass number 311). Columns 7 to 10 represent the load of each module of the north carriage. The calibration factor for the module load is 10. Columns 11 to 15 represent the position of each modulus of the north carriage.

File Edit Format View Help

8:39:24	AM	82.85	305	42	1982	2198	0	5953	5734	5613	-3	5590	2793	2692	2827	5604
9:14:17	AM	82.65	305	42	1982	2202	0	5907	5821	5557	1	5589	2792	2688	2829	5604
9:14:17	AM	82.39	305	42	1989	2199	-2	5782	5757	5757	1	5590	2794	2685	2828	5604
9:14:17	AM	81.77	305	42	1987	2202	-3	5931	5755	5626	8	5589	2792	2684	2826	5604
9:14:17	AM	81.32	305	42	1974	2198	2	5763	5687	5775	-1	5590	2792	2678	2828	5604
9:14:17	AM	80.93	305	42	1986	2204	-1	5912	5641	5723	0	5589	2790	2679	2825	5604
9:14:17	AM	80.54	305	42	1983	2193	0	5806	5798	5599	-1	5590	2787	2672	2828	5603
9:14:17	AM	80.14	305	42	1982	2197	0	5827	5590	5879	-4	5589	2787	2670	2826	5604
9:14:17	AM	79.35	305	42	1985	2201	0	5733	5728	5704	0	5590	2782	2663	2831	5603
9:14:17	AM	78.91	305	42	1976	2191	0	5915	5687	5791	-2	5590	2779	2664	2826	5603
9:14:17	AM	78.43	305	42	1975	2206	1	5744	5789	5597	10	5589	2777	2658	2831	5603
9:14:17	AM	77.96	305	42	1983	2215	-2	5908	5693	5851	-1	5589	2774	2661	2826	5604
9:14:17	AM	77.54	305	42	1986	2210	0	5774	5861	5582	1	5589	2771	2655	2830	5604
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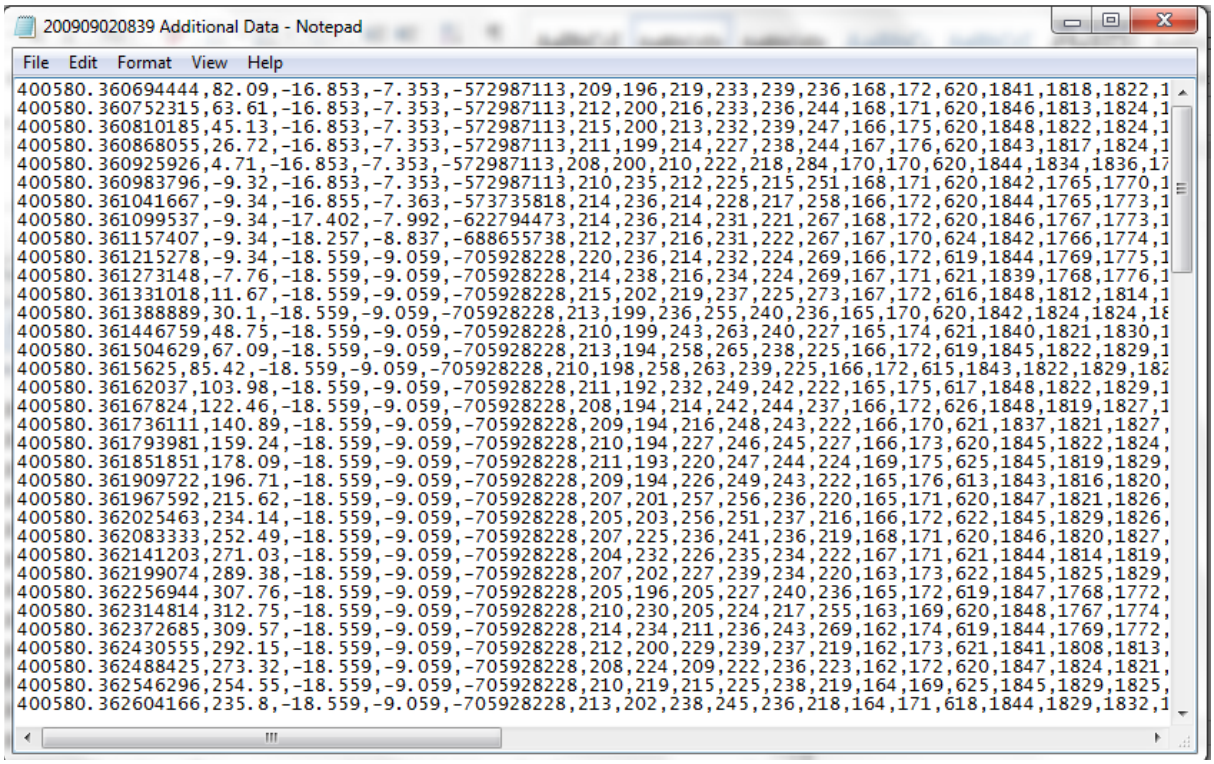
9:18:01	AM	193.05	311	48	1983	2161	-1	6096	5895	5792	-2	5592	2739	2727	2926	5609
9:18:01	AM	192.51	311	48	1994	2155	1	6060	5874	5685	0	5592	2753	2733	2929	5609
9:18:01	AM	192.16	311	48	1990	2148	2	6040	5868	5777	-1	5592	2760	2738	2933	5609
9:18:01	AM	191.62	311	48	1979	2159	-1	6035	5861	5732	-2	5593	2769	2742	2933	5607
9:18:01	AM	191.2	311	48	1976	2149	-3	6034	5852	5714	-7	5592	2775	2746	2939	5609
9:18:01	AM	190.85	311	48	1984	2160	-2	6039	5841	5850	-1	5593	2779	2749	2938	5610
9:18:01	AM	190.4	311	48	1976	2145	1	6043	5838	5680	-2	5593	2785	2752	2940	5610
9:18:01	AM	189.97	311	48	1976	2145	1	6048	5827	5816	1	5593	2791	2754	2943	5610
9:18:01	AM	189.43	311	48	1970	2130	0	6056	5807	5892	-9	5593	2799	2757	2943	5610
9:18:02	AM	188.86	311	48	1976	2137	-3	6052	5793	5832	-2	5593	2810	2758	2946	5610
9:18:02	AM	188.29	311	48	1974	2128	-1	6023	5807	5848	-1	5593	2820	2759	2949	5610
9:18:02	AM	187.94	311	48	1977	2134	0	6016	5797	5790	-2	5594	2826	2760	2948	5610
9:18:02	AM	187.42	311	48	1980	2131	-2	6012	5801	5666	1	5594	2832	2761	2947	5611
9:18:02	AM	186.91	311	48	1978	2131	-1	5994	5794	5783	1	5594	2836	2762	2949	5611
9:18:02	AM	186.35	311	48	1978	2131	-1	5996	5799	5780	-2	5594	2838	2762	2945	5610
9:18:02	AM	185.97	311	48	1981	2138	0	5998	5796	5738	-1	5593	2842	2763	2952	5609
9:18:02	AM	185.57	311	48	1981	2144	-3	5995	5795	5775	-1	5594	2845	2763	2949	5610
9:18:02	AM	185.13	311	48	1977	2136	-2	5987	5798	5831	-1	5594	2847	2764	2953	5610
9:18:02	AM	184.42	311	48	1983	2130	-1	5971	5802	5705	1	5594	2850	2764	2948	5610
9:18:02	AM	183.97	311	48	1986	2127	0	5936	5797	5672	0	5594	2851	2766	2951	5609

Figure 6. Sample Log File from September 2nd, 2009 (Tab-delimited Format).

Traffic Additional Log: There were two different Additional Log file formats recorded in 2009 data. Both formats contain text (ASCII) data without any header. Format A was recorded from September 25 to September 29. Format B was recorded from September 29 to October 14 when some changes were made by interchanging some channels of format A.

Figure 7 presents a sample Additional Log file in Format A, and is named "200909020839 Additional Data". Therefore it can be inferred that it is associated with the Log file presented in figure 5. The naming convention of this Additional Log file is similar to the Log file and includes the date and the time of the start of the vehicle pass. This Additional Log file contains about a ten minute log of the vehicle information from September 02, 2009, testing starting at 8:39:24 A.M. Content of some of the critical columns of Additional files Format A, represented as Channels, were identified with the following description:

Column 1: Channel 0 –Time in numeric format.
Column 2: Channel 1 – The vehicle position
Column 3: Channel 2 – North carriage position
Column 4: Channel 3 – South carriage position
Columns 5 to 43: Channel 6 to 44 – Tires temperature and pressure



200909020839 Additional Data - Notepad

File Edit Format View Help

```
400580.360694444,82.09,-16.853,-7.353,-572987113,209,196,219,233,239,236,168,172,620,1841,1818,1822,1
400580.360752315,63.61,-16.853,-7.353,-572987113,212,200,216,233,236,244,168,171,620,1846,1813,1824,1
400580.360810185,45.13,-16.853,-7.353,-572987113,215,200,213,232,239,247,166,175,620,1848,1822,1824,1
400580.360868055,26.72,-16.853,-7.353,-572987113,211,199,214,227,238,244,167,176,620,1843,1817,1824,1
400580.360925926,4.71,-16.853,-7.353,-572987113,208,200,210,222,218,284,170,170,620,1844,1834,1836,17
400580.360983796,-9.32,-16.853,-7.353,-572987113,210,235,212,225,215,251,168,171,620,1842,1765,1770,1
400580.361041667,-9.34,-16.855,-7.363,-573735818,214,236,214,228,217,258,166,172,620,1844,1765,1773,1
400580.361099537,-9.34,-17.402,-7.992,-622794473,214,236,214,231,221,267,168,172,620,1846,1767,1773,1
400580.361157407,-9.34,-18.257,-8.837,-688655738,212,237,216,231,222,267,167,170,624,1842,1766,1774,1
400580.361215278,-9.34,-18.559,-9.059,-705928228,220,236,214,232,224,269,166,172,619,1844,1769,1775,1
400580.361273148,-7.76,-18.559,-9.059,-705928228,214,238,216,234,224,269,167,171,621,1839,1768,1776,1
400580.361331018,11.67,-18.559,-9.059,-705928228,215,202,219,237,225,273,167,172,616,1848,1812,1814,1
400580.361388889,30.1,-18.559,-9.059,-705928228,213,199,236,255,240,236,165,170,620,1842,1824,1824,18
400580.361446759,48.75,-18.559,-9.059,-705928228,210,199,243,263,240,227,165,174,621,1840,1821,1830,1
400580.361504629,67.09,-18.559,-9.059,-705928228,213,194,258,265,238,225,166,172,619,1845,1822,1829,1
400580.3615625,85.42,-18.559,-9.059,-705928228,210,198,258,263,239,225,166,172,615,1843,1822,1829,182
400580.36162037,103.98,-18.559,-9.059,-705928228,211,192,232,249,242,222,165,175,617,1848,1822,1829,1
400580.36167824,122.46,-18.559,-9.059,-705928228,208,194,214,242,244,237,166,172,626,1848,1819,1827,1
400580.361736111,140.89,-18.559,-9.059,-705928228,209,194,216,248,243,222,166,170,621,1837,1821,1827,
400580.361793981,159.24,-18.559,-9.059,-705928228,210,194,227,246,245,227,166,173,620,1845,1822,1824,
400580.361851851,178.09,-18.559,-9.059,-705928228,211,193,220,247,244,224,169,175,625,1845,1819,1829,
400580.361909722,196.71,-18.559,-9.059,-705928228,209,194,226,249,243,222,165,176,613,1843,1816,1820,
400580.361967592,215.62,-18.559,-9.059,-705928228,207,201,257,256,236,220,165,171,620,1847,1821,1826,
400580.362025463,234.14,-18.559,-9.059,-705928228,205,203,256,251,237,216,166,172,622,1845,1829,1826,
400580.362083333,252.49,-18.559,-9.059,-705928228,207,225,236,241,236,219,168,171,620,1846,1820,1827,
400580.362141203,271.03,-18.559,-9.059,-705928228,204,232,226,235,234,222,167,171,621,1844,1814,1819,
400580.362199074,289.38,-18.559,-9.059,-705928228,207,202,227,239,234,220,163,173,622,1845,1825,1829,
400580.362256944,307.76,-18.559,-9.059,-705928228,205,196,205,227,240,236,165,172,619,1847,1768,1772,
400580.362314814,312.75,-18.559,-9.059,-705928228,210,230,205,224,217,255,163,169,620,1848,1767,1774,
400580.362372685,309.57,-18.559,-9.059,-705928228,214,234,211,236,243,269,162,174,619,1844,1769,1772,
400580.362430555,292.15,-18.559,-9.059,-705928228,212,200,229,239,237,219,162,173,621,1841,1808,1813,
400580.362488425,273.32,-18.559,-9.059,-705928228,208,224,209,222,236,223,162,172,620,1847,1824,1821,
400580.362546296,254.55,-18.559,-9.059,-705928228,210,219,215,225,238,219,164,169,625,1845,1829,1825,
400580.362604166,235.8,-18.559,-9.059,-705928228,213,202,238,245,236,218,164,171,618,1844,1829,1832,1
```

Figure 7. Sample Additional Log File (Format A) from September 2nd, 2009.

The tab-delimited representation of the sample Additional Log files is also provided in figure 8. The figure shows a few rows of the beginning and the end of the recorded log. In this figure, the first column is converted to time format ("HH:MM:SS"). The time starts at 8:39:24 AM, which is consistent with the file name, and ends at 8:49:09 AM. The sampling rate used in Additional Log files was consistently 0.2 Hz which equates to one record every 5 seconds. The Additional Log files include approximately 10 minutes of the vehicle record.

File Edit Format View Help

8:39:24	AM	82.09	-16.853	-7.353	-572987113	209	196	219	233	239	236	168	172	620	1841
8:39:29	AM	63.61	-16.853	-7.353	-572987113	212	200	216	233	236	244	168	171	620	1846
8:39:34	AM	45.13	-16.853	-7.353	-572987113	215	200	213	232	239	247	166	175	620	1848
8:39:39	AM	26.72	-16.853	-7.353	-572987113	211	199	214	227	238	244	167	176	620	1843
8:39:44	AM	4.71	-16.853	-7.353	-572987113	208	200	210	222	218	284	170	170	620	1844
8:39:49	AM	-9.32	-16.853	-7.353	-572987113	210	235	212	225	215	251	168	171	620	1842
8:39:54	AM	-9.34	-16.855	-7.363	-573735818	214	236	214	228	217	258	166	172	620	1844
8:39:59	AM	-9.34	-17.402	-7.992	-622794473	214	236	214	231	221	267	168	172	620	1846
8:40:04	AM	-9.34	-18.257	-8.837	-688635738	212	237	216	231	222	267	167	170	624	1842
8:40:09	AM	-9.34	-18.559	-9.059	-705928228	220	236	214	232	224	269	166	172	619	1844
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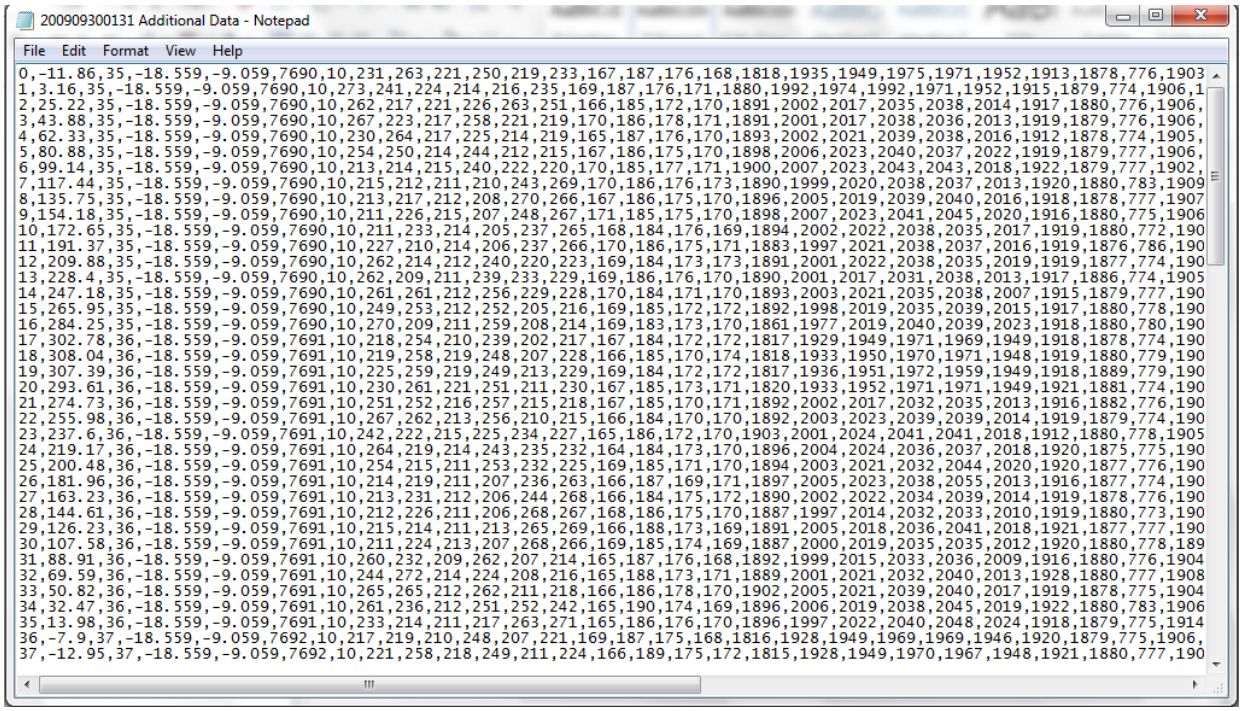
8:48:24	AM	298.58	-16	-6.5	-506516556	208	199	202	223	225	288	165	174	618	1844
8:48:29	AM	312.62	-16	-6.5	-506516556	211	222	203	223	211	247	166	170	620	1846
8:48:34	AM	312.66	-16	-6.5	-506516556	212	231	210	230	222	267	165	172	622	1849
8:48:39	AM	303.43	-16	-6.5	-506516556	215	223	203	218	231	296	165	172	620	1847
8:48:44	AM	284.91	-16	-6.5	-506516556	235	206	207	221	228	291	165	172	611	1846
8:48:49	AM	266.56	-16	-6.5	-506516556	252	205	207	223	224	295	167	173	620	1847
8:48:54	AM	248.08	-16	-6.5	-506516556	244	201	208	221	219	289	167	174	618	1846
8:48:59	AM	229.73	-16	-6.5	-506516556	246	210	209	223	218	294	165	171	620	1845
8:49:04	AM	211.27	-16	-6.5	-506516556	247	219	206	220	219	293	165	172	622	1847
8:49:09	AM	192.78	-16	-6.5	-506516556	237	211	206	223	222	295	167	173	620	1849

Figure 8. Sample Additional Log File (Format A) from September 2nd, 2009 (Tab-delimited Format).

The sample Additional Log files in Format B is presented in figure 9. The tab-delimited representation of it is shown in figure 10. The time column does not exist in Format B, instead it starts with numbers from zero (column 1). Format B contains the wander number and accumulated pass number, which did not exist in Format A. The content of other channels are as follow:

Column 2: Channel 1 – The vehicle position
Column 3: Channel 2 – Wander number
Column 4: Channel 3 – North carriage position
Column 5: Channel 4 – South carriage position
Column 6: Channel 5 – Accumulated pass number

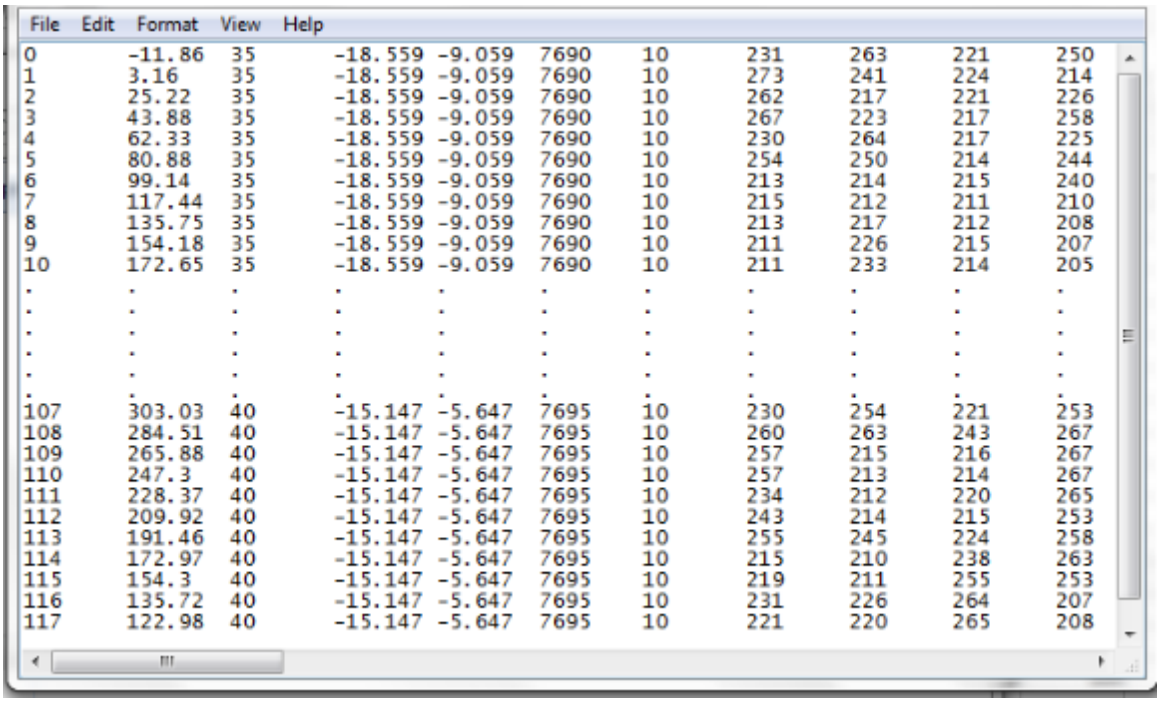


200909300131 Additional Data - Notepad

File Edit Format View Help

```
0,-11.86,35,-18.559,-9.059,7690,10,231,263,221,250,219,233,167,187,176,168,1818,1935,1949,1975,1971,1952,1913,1878,776,1903
1,3.16,35,-18.559,-9.059,7690,10,273,241,224,214,216,235,169,187,176,171,1880,1992,1974,1992,1971,1952,1915,1879,774,1906,1
2,25.22,35,-18.559,-9.059,7690,10,262,217,221,226,263,251,166,185,172,170,1891,2002,2017,2035,2038,2014,1917,1880,776,1906,
3,43.88,35,-18.559,-9.059,7690,10,267,223,217,258,221,219,170,186,178,171,1891,2001,2017,2038,2036,2013,1919,1879,776,1906,
4,62.33,35,-18.559,-9.059,7690,10,230,264,217,225,214,219,165,187,176,170,1893,2002,2021,2039,2038,2016,1912,1878,774,1905,
5,80.88,35,-18.559,-9.059,7690,10,254,250,214,244,212,215,167,186,175,170,1898,2006,2023,2040,2037,2022,1919,1879,777,1906,
6,99.14,35,-18.559,-9.059,7690,10,213,214,215,240,222,220,170,185,177,171,1900,2007,2023,2043,2043,2018,1922,1879,777,1902,
7,117.44,35,-18.559,-9.059,7690,10,215,212,211,210,243,269,170,186,176,173,1890,1999,2020,2038,2037,2013,1920,1880,783,1909
8,135.75,35,-18.559,-9.059,7690,10,213,217,212,208,270,266,167,186,175,170,1896,2005,2019,2039,2040,2016,1918,1878,777,1907
9,154.18,35,-18.559,-9.059,7690,10,211,226,215,207,248,267,171,185,175,170,1898,2007,2023,2041,2045,2020,1916,1880,775,1906
10,172.65,35,-18.559,-9.059,7690,10,211,233,214,205,237,265,168,184,176,169,1894,2002,2022,2038,2035,2017,1919,1880,772,190
11,191.37,35,-18.559,-9.059,7690,10,227,210,214,206,237,266,170,186,175,171,1883,1997,2021,2038,2037,2016,1919,1876,786,190
12,209.88,35,-18.559,-9.059,7690,10,262,214,212,240,220,223,169,184,173,173,1891,2001,2022,2038,2035,2019,1919,1877,774,190
13,228.4,35,-18.559,-9.059,7690,10,262,209,211,239,233,229,169,186,176,170,1890,2001,2017,2031,2038,2013,1917,1886,774,1905
14,247.18,35,-18.559,-9.059,7690,10,261,261,212,256,229,228,170,184,171,170,1893,2003,2021,2035,2038,2007,1915,1879,777,190
15,265.95,35,-18.559,-9.059,7690,10,249,253,212,252,205,216,169,185,172,172,1892,1998,2019,2035,2039,2015,1917,1880,778,190
16,284.25,35,-18.559,-9.059,7690,10,270,209,211,259,208,214,169,183,173,170,1861,1977,2019,2040,2039,2023,1918,1880,780,190
17,302.78,36,-18.559,-9.059,7691,10,218,254,210,239,202,217,167,184,172,172,1817,1929,1949,1971,1969,1949,1918,1878,774,190
18,308.04,36,-18.559,-9.059,7691,10,219,258,219,248,207,228,166,185,170,174,1818,1933,1950,1970,1971,1948,1919,1880,779,190
19,307.39,36,-18.559,-9.059,7691,10,225,259,219,249,213,229,169,184,172,172,1817,1936,1951,1972,1959,1949,1918,1889,779,190
20,293.61,36,-18.559,-9.059,7691,10,230,261,221,251,211,230,167,185,173,171,1820,1933,1952,1971,1971,1949,1921,1881,774,190
21,274.73,36,-18.559,-9.059,7691,10,251,252,216,257,215,218,167,185,170,171,1892,2002,2017,2032,2035,2013,1916,1882,776,190
22,255.98,36,-18.559,-9.059,7691,10,267,262,213,256,210,215,166,184,170,170,1892,2003,2023,2039,2039,2014,1919,1879,774,190
23,237.6,36,-18.559,-9.059,7691,10,242,222,215,225,234,227,165,186,172,170,1903,2001,2024,2041,2041,2018,1912,1880,778,1905
24,219.17,36,-18.559,-9.059,7691,10,264,219,214,243,235,232,164,184,173,170,1896,2004,2024,2036,2037,2018,1920,1875,775,190
25,200.48,36,-18.559,-9.059,7691,10,254,215,211,253,232,225,169,185,171,170,1894,2003,2021,2032,2044,2020,1920,1877,776,190
26,181.96,36,-18.559,-9.059,7691,10,214,219,211,207,236,263,166,187,169,171,1897,2005,2023,2038,2055,2013,1916,1877,774,190
27,163.23,36,-18.559,-9.059,7691,10,213,231,212,206,244,268,166,184,175,172,1890,2002,2022,2034,2039,2014,1919,1878,776,190
28,144.61,36,-18.559,-9.059,7691,10,212,226,211,206,268,267,168,186,175,170,1887,1997,2014,2032,2033,2010,1919,1880,773,190
29,126.23,36,-18.559,-9.059,7691,10,215,214,211,213,265,269,166,188,173,169,1891,2005,2018,2036,2041,2018,1921,1877,777,190
30,107.58,36,-18.559,-9.059,7691,10,211,224,213,207,268,266,169,185,174,169,1887,2000,2019,2035,2035,2012,1920,1880,778,189
31,88.91,36,-18.559,-9.059,7691,10,260,232,209,262,207,214,165,187,176,168,1892,1999,2015,2033,2036,2009,1916,1880,776,1904
32,69.59,36,-18.559,-9.059,7691,10,244,272,214,224,208,216,165,188,173,171,1889,2001,2021,2032,2040,2013,1928,1880,777,1908
33,50.82,36,-18.559,-9.059,7691,10,265,265,212,262,211,218,166,186,178,170,1902,2005,2021,2039,2040,2017,1919,1878,775,1904
34,32.47,36,-18.559,-9.059,7691,10,261,236,212,251,252,242,165,190,174,169,1896,2006,2019,2038,2045,2019,1922,1880,783,1906
35,13.98,36,-18.559,-9.059,7691,10,233,214,211,217,263,271,165,186,176,170,1896,1997,2022,2040,2048,2024,1918,1879,775,1914
36,-7.9,37,-18.559,-9.059,7692,10,217,219,210,248,207,221,169,187,175,168,1816,1928,1949,1969,1969,1946,1920,1879,775,1906,
37,-12.95,37,-18.559,-9.059,7692,10,221,258,218,249,211,224,166,189,175,172,1815,1928,1949,1970,1967,1948,1921,1880,777,190
```

Figure 9. Sample Additional Log File (Format B) from September 30th, 2009.



File Edit Format View Help

0	-11.86	35	-18.559	-9.059	7690	10	231	263	221	250
1	3.16	35	-18.559	-9.059	7690	10	273	241	224	214
2	25.22	35	-18.559	-9.059	7690	10	262	217	221	226
3	43.88	35	-18.559	-9.059	7690	10	267	223	217	258
4	62.33	35	-18.559	-9.059	7690	10	230	264	217	225
5	80.88	35	-18.559	-9.059	7690	10	254	250	214	244
6	99.14	35	-18.559	-9.059	7690	10	213	214	215	240
7	117.44	35	-18.559	-9.059	7690	10	215	212	211	210
8	135.75	35	-18.559	-9.059	7690	10	213	217	212	208
9	154.18	35	-18.559	-9.059	7690	10	211	226	215	207
10	172.65	35	-18.559	-9.059	7690	10	211	233	214	205
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107	303.03	40	-15.147	-5.647	7695	10	230	254	221	253
108	284.51	40	-15.147	-5.647	7695	10	260	263	243	267
109	265.88	40	-15.147	-5.647	7695	10	257	215	216	267
110	247.3	40	-15.147	-5.647	7695	10	257	213	214	267
111	228.37	40	-15.147	-5.647	7695	10	234	212	220	265
112	209.92	40	-15.147	-5.647	7695	10	243	214	215	253
113	191.46	40	-15.147	-5.647	7695	10	255	245	224	258
114	172.97	40	-15.147	-5.647	7695	10	215	210	238	263
115	154.3	40	-15.147	-5.647	7695	10	219	211	255	253
116	135.72	40	-15.147	-5.647	7695	10	231	226	264	207
117	122.98	40	-15.147	-5.647	7695	10	221	220	265	208

Figure 10. Sample Additional Log File (Format B) from September 30th, 2009 (Tab-delimited Format).

Traffic Data Processing

Developing the traffic tables requires processing of the key data elements of the Log and Additional Log files. This process identifies the data points associated with each pass from the Log and Additional Log files, matches and aligns them and then calculates the components of the traffic table. Since there are hundreds of Log files that include information of thousands of passes, a MATLAB script was developed for batch processing of the traffic data.

Each Log may contain information of multiple passes. Also, the data associated with each pass may not all be stored in one Log file. To batch process the traffic data, the MATLAB script takes all the 2009 testing Log files, sorts them by date and time, and combines them in sequence in a single matrix. The matrix is called the Logs matrix. The same process applies to the Additional Logs and a matrix of Additional Logs is created.

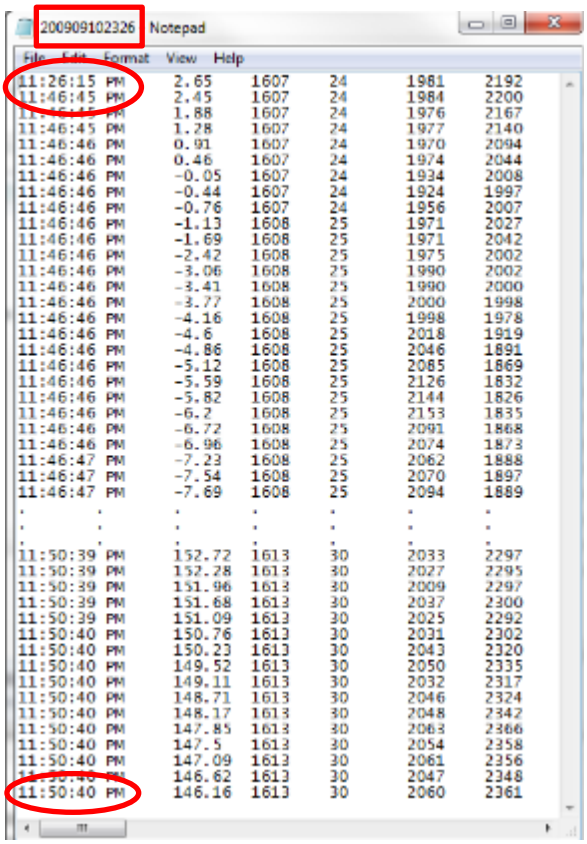
Additional Log files were recorded in two different formats as explained earlier in the report. Accumulated pass number and wander number are not present in Format A (figures 7 & 8). Time is not present in Format B (figures 9 & 10). When the Additional Logs are in Format A, the time columns are common in the Log and Additional Log matrices. This is used to match other vehicle information associated with the run critical to the development of the traffic table from the matrices. Time, vehicle location, sequence number, accumulated pass number, and carriage module loads are taken from the Log matrix and the carriage positions along with the time and vehicle location are taken from the Additional Log matrix. The MATLAB script calculates the average carriage module loads for each section being trafficked in every run. When the Additional Logs are in Format B, the vehicle position is common in the Log and Additional Log files and is used to match the information from the files for each run.

It is critical that the information required to match and align data from the Logs and Additional logs exist in the data files. It is also imperative for an effective batch processing that a consistent pattern be present in the input data. Batch processing of the 2009 traffic data encountered some difficulties for various reasons. One critical difficulty was the inconsistency between the data in the Log and Additional Log files. Another challenge was existence of what appears to be erroneous data. Inconsistencies in the Additional Logs formats as well as missing files further complicated the batch processing. In the following section, the key problems found during 2009 traffic data processing are identified.

Key Problems Encountered in Traffic Data Processing

The following are the critical challenges encountered during batch processing of 2009 traffic data:

1- Times were not correctly recorded in Log files. The time of the first record in the Log file, referred to as the reference time in this report, is consistent with the file name, but the second record starts after a time gap. This was the case for all the Log files recorded in 2009. As shown in figure 11, the second record has a 20 minute gap from the first one. The last record in the file is recorded approximately 5 minutes after the second record. This contradicts the expectation that every Log file contains 10 minutes of vehicle record. This discrepancy was consistent among all Log files. The sampling frequency between the second and last records was consistently 20 Hz which equates to every 0.05 seconds.



200909102326 Notepad

File Edit Format View Help

11:26:15 PM	2.65	1607	24	1981	2192
11:46:45 PM	2.45	1607	24	1984	2200
11:46:45 PM	1.88	1607	24	1976	2167
11:46:45 PM	1.28	1607	24	1977	2140
11:46:46 PM	0.91	1607	24	1970	2094
11:46:46 PM	0.46	1607	24	1974	2044
11:46:46 PM	-0.05	1607	24	1934	2008
11:46:46 PM	-0.44	1607	24	1924	1997
11:46:46 PM	-0.76	1607	24	1956	2007
11:46:46 PM	-1.13	1608	25	1971	2027
11:46:46 PM	-1.69	1608	25	1971	2042
11:46:46 PM	-2.42	1608	25	1975	2002
11:46:46 PM	-3.06	1608	25	1990	2002
11:46:46 PM	-3.41	1608	25	1990	2000
11:46:46 PM	-3.77	1608	25	2000	1998
11:46:46 PM	-4.16	1608	25	1998	1978
11:46:46 PM	-4.6	1608	25	2018	1919
11:46:46 PM	-4.86	1608	25	2046	1891
11:46:46 PM	-5.12	1608	25	2085	1869
11:46:46 PM	-5.59	1608	25	2126	1832
11:46:46 PM	-5.82	1608	25	2144	1826
11:46:46 PM	-6.2	1608	25	2153	1835
11:46:46 PM	-6.72	1608	25	2091	1868
11:46:46 PM	-6.96	1608	25	2074	1873
11:46:47 PM	-7.23	1608	25	2062	1888
11:46:47 PM	-7.54	1608	25	2070	1897
11:46:47 PM	-7.69	1608	25	2094	1889
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11:50:39 PM	152.72	1613	30	2033	2297
11:50:39 PM	152.28	1613	30	2027	2295
11:50:39 PM	151.96	1613	30	2009	2297
11:50:39 PM	151.68	1613	30	2037	2300
11:50:39 PM	151.09	1613	30	2025	2292
11:50:40 PM	150.76	1613	30	2031	2302
11:50:40 PM	150.23	1613	30	2043	2320
11:50:40 PM	149.52	1613	30	2050	2335
11:50:40 PM	149.11	1613	30	2032	2317
11:50:40 PM	148.71	1613	30	2046	2324
11:50:40 PM	148.17	1613	30	2048	2342
11:50:40 PM	147.85	1613	30	2063	2366
11:50:40 PM	147.5	1613	30	2054	2358
11:50:40 PM	147.09	1613	30	2061	2356
11:50:40 PM	146.62	1613	30	2047	2348
11:50:40 PM	146.16	1613	30	2060	2361

Figure 11. Incorrect Vehicle Record in Log Files.

2- A time lag was observed between two consecutive Additional Logs. For example, the lag between the last record of "200909081146 Additional Data" and the first record of "200909081156 Additional Data" is 17 seconds (figure 12). However, the vehicle location has changed from station 84.82 to 103.16. The distance travelled of 18.34 feet is much less than anticipated for the 17 seconds. The 18.34 feet movement of the vehicle is expected to occur in approximately 5 seconds based on prior samples in the file. This issue was observed in all consecutive Additional Log files. This is an indication that the sampling rate of 0.2 Hz in Additional Logs is not accurate.

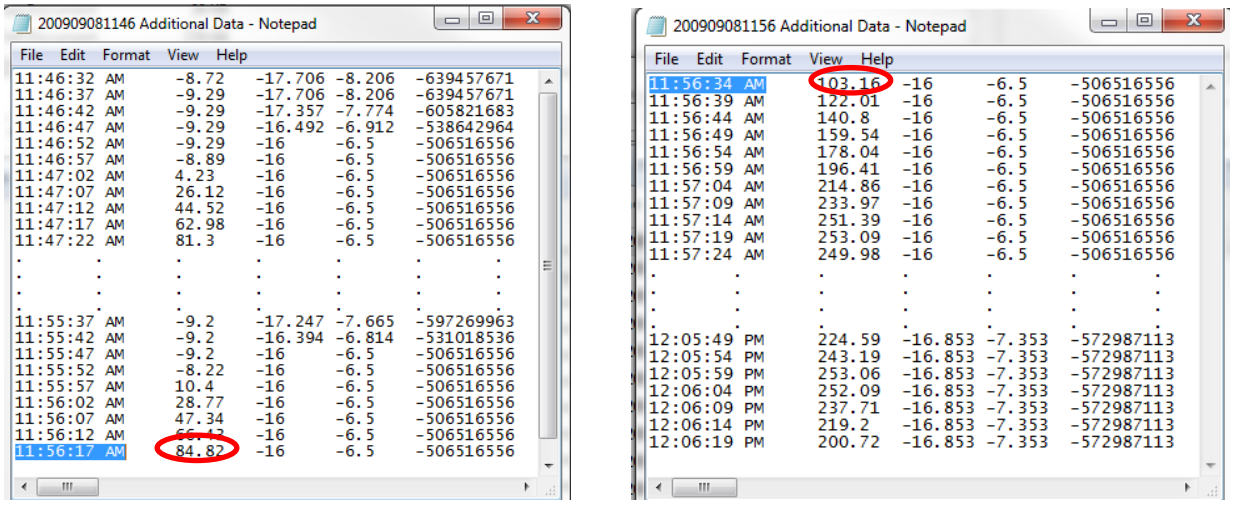
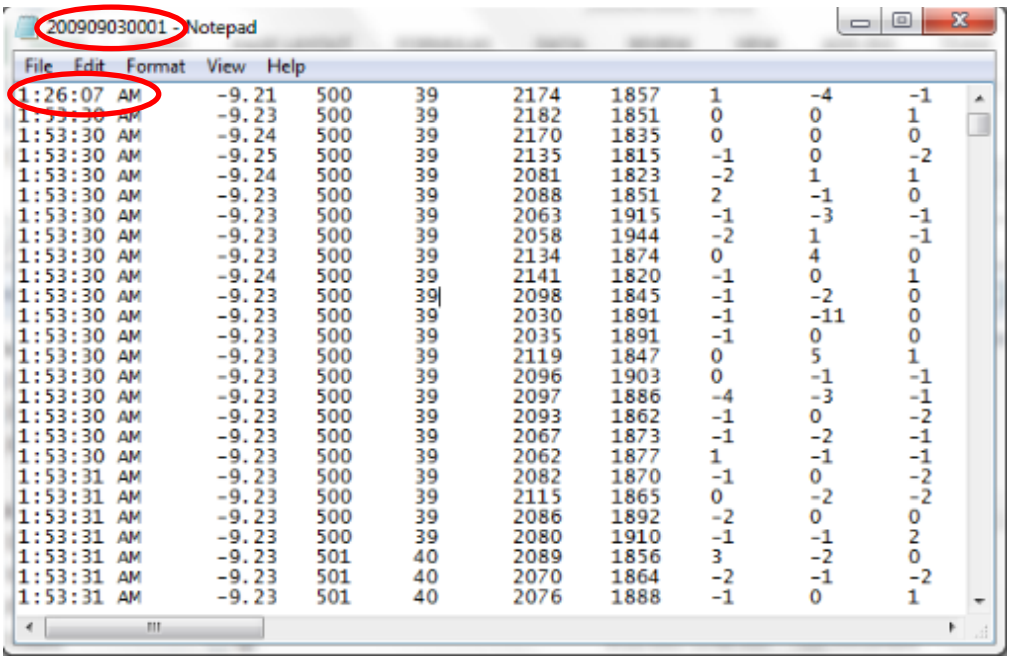


Figure 12. Time Lag between Two Consecutive Additional Log Files.

3- The reference time in some Log and Additional Log files did not match the file name. This frequently occurred in the Logs that start at 12 AM and 1 AM and was observed in about 15% of the files. For example, Log file 200909030001 refers to testing on September 3rd, 2009 starting at 00:01 AM; however, the reference time in the log is recorded as 1:26:07 AM as shown in figure 13.



200909030001 - Notepad

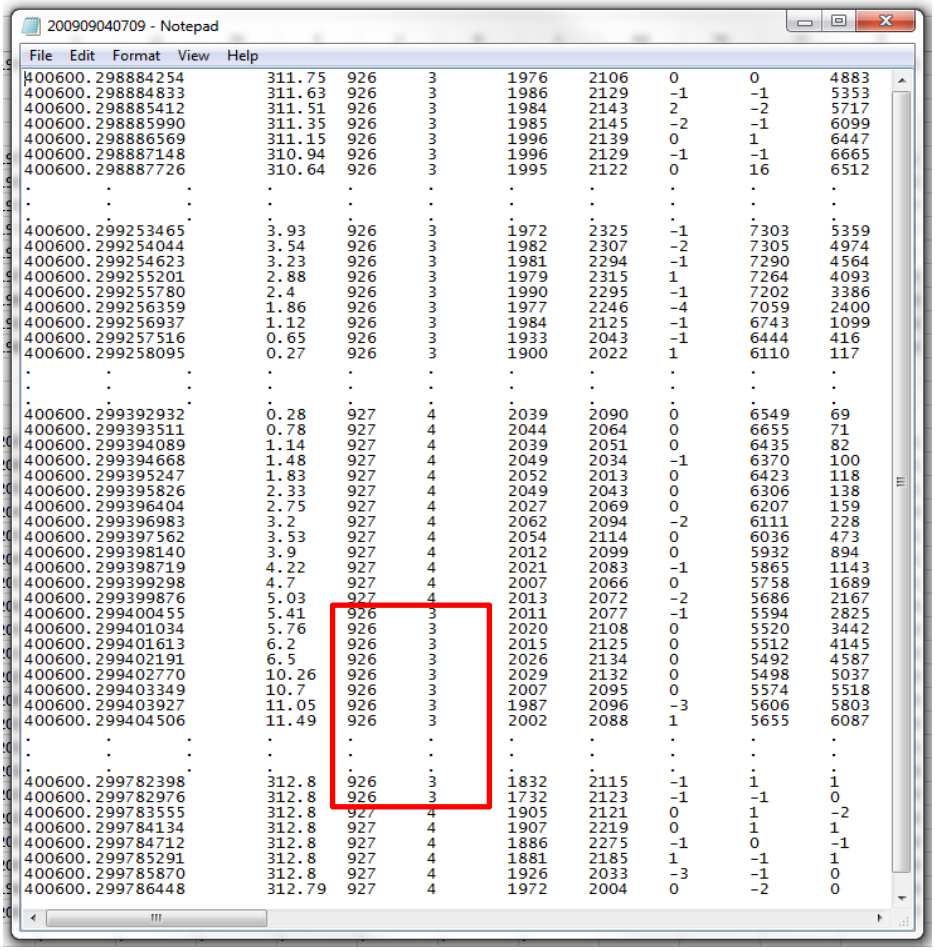
File Edit Format View Help

1:26:07 AM	-9.21	500	39	2174	1857	1	-4	-1
1:53:30 AM	-9.23	500	39	2182	1851	0	0	1
1:53:30 AM	-9.24	500	39	2170	1835	0	0	0
1:53:30 AM	-9.25	500	39	2135	1815	-1	0	-2
1:53:30 AM	-9.24	500	39	2081	1823	-2	1	1
1:53:30 AM	-9.23	500	39	2088	1851	2	-1	0
1:53:30 AM	-9.23	500	39	2063	1915	-1	-3	-1
1:53:30 AM	-9.23	500	39	2058	1944	-2	1	-1
1:53:30 AM	-9.23	500	39	2134	1874	0	4	0
1:53:30 AM	-9.24	500	39	2141	1820	-1	0	1
1:53:30 AM	-9.23	500	39	2098	1845	-1	-2	0
1:53:30 AM	-9.23	500	39	2030	1891	-1	-11	0
1:53:30 AM	-9.23	500	39	2035	1891	-1	0	0
1:53:30 AM	-9.23	500	39	2119	1847	0	5	1
1:53:30 AM	-9.23	500	39	2096	1903	0	-1	-1
1:53:30 AM	-9.23	500	39	2097	1886	-4	-3	-1
1:53:30 AM	-9.23	500	39	2093	1862	-1	0	-2
1:53:30 AM	-9.23	500	39	2067	1873	-1	-2	-1
1:53:30 AM	-9.23	500	39	2062	1877	1	-1	-1
1:53:31 AM	-9.23	500	39	2082	1870	-1	0	-2
1:53:31 AM	-9.23	500	39	2115	1865	0	-2	-2
1:53:31 AM	-9.23	500	39	2086	1892	-2	0	0
1:53:31 AM	-9.23	500	39	2080	1910	-1	-1	2
1:53:31 AM	-9.23	501	40	2089	1856	3	-2	0
1:53:31 AM	-9.23	501	40	2070	1864	-2	-1	-2
1:53:31 AM	-9.23	501	40	2076	1888	-1	0	1

Figure 13. Incorrect Starting Reference Time in Logs Files.

4- The accumulated pass numbers and the sequence numbers, represented in columns 3 and 4 of Figure 13, do not corroborate. Accumulated pass numbers appear to lag one pass. A sequence number must be the remainder of accumulated pass number by a complete wander (66 passes). Therefore, a sequence number of 39 as shown in figure 13, cannot be associated with the accumulated pass number of 500. A sequence number of 39 can correctly associate with accumulated pass of 501. This issue was observed in all Log files.

5- The accumulated pass number and the sequence number are not correctly recorded in some of the Logs. For example, as shown in figure 14, the top portion of the log shows that the vehicle is at pass 926 and sequence 3. The vehicle position is decreasing from 311.75 to zero. Then the vehicle starts a new pass in the opposite direction; thus the cumulative pass becomes 927 and the sequence number changes to 4. Vehicle position also starts increasing from 0 to 312.79. However, somewhere in the middle of this pass, as marked by the red box, the cumulative pass is recorded as 926 and the sequence number is changed to 3 which are erroneous. The log must have recorded the cumulative pass number of 927 and sequence number of 4. This erroneous accumulated and sequence numbers were observed in about 1 percent of the Log files when a new wander started or when the testing resumed after a pause.



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File Edit Format View Help

400600.298884254	311.75	926	3	1976	2106	0	0	4883
400600.298884833	311.63	926	3	1986	2129	-1	-1	5353
400600.298885412	311.51	926	3	1984	2143	2	-2	5717
400600.298885990	311.35	926	3	1985	2145	-2	-1	6099
400600.298886569	311.15	926	3	1996	2139	0	1	6447
400600.298887148	310.94	926	3	1996	2129	-1	-1	6665
400600.298887726	310.64	926	3	1995	2122	0	16	6512
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400600.299253465	3.93	926	3	1972	2325	-1	7303	5359
400600.299254044	3.54	926	3	1982	2307	-2	7305	4974
400600.299254623	3.23	926	3	1981	2294	-1	7290	4564
400600.299255201	2.88	926	3	1979	2315	1	7264	4093
400600.299255780	2.4	926	3	1990	2295	-1	7202	3386
400600.299256359	1.86	926	3	1977	2246	-4	7059	2400
400600.299256937	1.12	926	3	1984	2125	-1	6743	1099
400600.299257516	0.65	926	3	1933	2043	-1	6444	416
400600.299258095	0.27	926	3	1900	2022	1	6110	117
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400600.299392932	0.28	927	4	2039	2090	0	6549	69
400600.299393511	0.78	927	4	2044	2064	0	6655	71
400600.299394089	1.14	927	4	2039	2051	0	6435	82
400600.299394668	1.48	927	4	2049	2034	-1	6370	100
400600.299395247	1.83	927	4	2052	2013	0	6423	118
400600.299395826	2.33	927	4	2049	2043	0	6306	138
400600.299396404	2.75	927	4	2027	2069	0	6207	159
400600.299396983	3.2	927	4	2062	2094	-2	6111	228
400600.299397562	3.53	927	4	2054	2114	0	6036	473
400600.299398140	3.9	927	4	2012	2099	0	5932	894
400600.299398719	4.22	927	4	2021	2083	-1	5865	1143
400600.299399298	4.7	927	4	2007	2066	0	5758	1689
400600.299399876	5.03	927	4	2013	2072	-2	5686	2167
400600.299400455	5.41	926	3	2011	2077	-1	5594	2825
400600.299401034	5.76	926	3	2020	2108	0	5520	3442
400600.299401613	6.2	926	3	2015	2125	0	5512	4145
400600.299402191	6.5	926	3	2026	2134	0	5492	4587
400600.299402770	10.26	926	3	2029	2132	0	5498	5037
400600.299403349	10.7	926	3	2007	2095	0	5574	5518
400600.299403927	11.05	926	3	1987	2096	-3	5606	5803
400600.299404506	11.49	926	3	2002	2088	1	5655	6087
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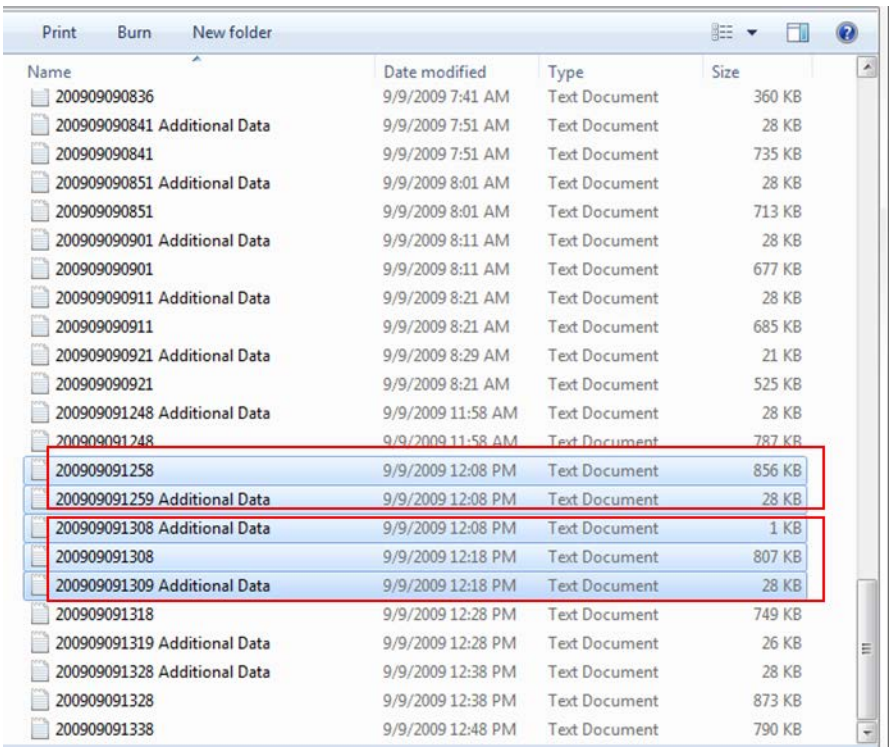
400600.299782398	312.8	926	3	1832	2115	-1	1	1
400600.299782976	312.8	926	3	1732	2123	-1	-1	0
400600.299783555	312.8	927	4	1905	2121	0	1	-2
400600.299784134	312.8	927	4	1907	2219	0	1	1
400600.299784712	312.8	927	4	1886	2275	-1	0	-1
400600.299785291	312.8	927	4	1881	2185	1	-1	1
400600.299785870	312.8	927	4	1926	2033	-3	-1	0
400600.299786448	312.79	927	4	1972	2004	0	-2	0

Figure 14. Erroneous Sequence and Accumulated Pass Numbers in Some Logs.

6- While the associated Log and Additional Log files were usually easy to identify using their common names, that was not always the case. Figure 15 represents two examples where the Log file and its associated Additional Log file had different names. There is usually a small time lag between reference time of the Log files and Additional Log files. If this small time lag spurs into different minutes of time, the files will be recorded with different names. This was the case for Log file "200909091258" and the Additional Log file "200909091259". The former started at 12:58:57 PM while the later started with 3 second time lag at 12:59:00 PM.

Also, as shown in the other example in figure 15, one Log file was at times associated with 2 Additional Log files. Additional Log files *"200909091308 Additional Data"* and *"200909091309 Additional Data"* are both associated with *"200909091308"* Log file. As shown in figure 16, in about 3 percent of the cases, Additional Log files were missing.



Print Burn New folder

Name	Date modified	Type	Size
200909090836	9/9/2009 7:41 AM	Text Document	360 KB
200909090841 Additional Data	9/9/2009 7:51 AM	Text Document	28 KB
200909090841	9/9/2009 7:51 AM	Text Document	735 KB
200909090851 Additional Data	9/9/2009 8:01 AM	Text Document	28 KB
200909090851	9/9/2009 8:01 AM	Text Document	713 KB
200909090901 Additional Data	9/9/2009 8:11 AM	Text Document	28 KB
200909090901	9/9/2009 8:11 AM	Text Document	677 KB
200909090911 Additional Data	9/9/2009 8:21 AM	Text Document	28 KB
200909090911	9/9/2009 8:21 AM	Text Document	685 KB
200909090921 Additional Data	9/9/2009 8:29 AM	Text Document	21 KB
200909090921	9/9/2009 8:21 AM	Text Document	525 KB
200909091248 Additional Data	9/9/2009 11:58 AM	Text Document	28 KB
200909091248	9/9/2009 11:58 AM	Text Document	787 KB
200909091258	9/9/2009 12:08 PM	Text Document	856 KB
200909091259 Additional Data	9/9/2009 12:08 PM	Text Document	28 KB
200909091308 Additional Data	9/9/2009 12:08 PM	Text Document	1 KB
200909091308	9/9/2009 12:18 PM	Text Document	807 KB
200909091309 Additional Data	9/9/2009 12:18 PM	Text Document	28 KB
200909091318	9/9/2009 12:28 PM	Text Document	749 KB
200909091319 Additional Data	9/9/2009 12:28 PM	Text Document	26 KB
200909091328 Additional Data	9/9/2009 12:38 PM	Text Document	28 KB
200909091328	9/9/2009 12:38 PM	Text Document	873 KB
200909091338	9/9/2009 12:48 PM	Text Document	790 KB

Figure 15. Incompatible Logs and Additional Logs.

Burn New folder

Name	Date modified	Type	Size
200909140515	9/14/2009 4:25 AM	Text Document	852 KB
200909140525 Additional Data	9/14/2009 4:35 AM	Text Document	28 KB
200909140525	9/14/2009 4:35 AM	Text Document	854 KB
200909140535 Additional Data	9/14/2009 4:54 AM	Text Document	16 KB
200909140535	9/14/2009 4:45 AM	Text Document	930 KB
200909140545	9/14/2009 4:55 AM	Text Document	1,017 KB
200909140555	9/14/2009 5:05 AM	Text Document	982 KB
200909140605	9/14/2009 5:15 AM	Text Document	1,026 KB
200909140615	9/14/2009 5:25 AM	Text Document	1,038 KB
200909140625	9/14/2009 5:35 AM	Text Document	1,024 KB
200909140635	9/14/2009 5:45 AM	Text Document	1,031 KB
200909140645	9/14/2009 5:55 AM	Text Document	1,033 KB
200909140655	9/14/2009 6:05 AM	Text Document	1,030 KB
200909140705	9/14/2009 6:15 AM	Text Document	1,021 KB
200909140715	9/14/2009 6:25 AM	Text Document	986 KB
200909140725	9/14/2009 6:35 AM	Text Document	977 KB
200909140735	9/14/2009 6:45 AM	Text Document	985 KB
200909140745	9/14/2009 6:55 AM	Text Document	989 KB
200909140755	9/14/2009 7:05 AM	Text Document	987 KB
200909140805	9/14/2009 7:15 AM	Text Document	982 KB
200909140815	9/14/2009 7:25 AM	Text Document	984 KB
200909140825	9/14/2009 7:35 AM	Text Document	989 KB
200909140835	9/14/2009 7:45 AM	Text Document	990 KB
200909140845	9/14/2009 7:55 AM	Text Document	977 KB
200909140855	9/14/2009 7:56 AM	Text Document	1 KB
200909140856	9/14/2009 8:06 AM	Text Document	968 KB
200909140906	9/14/2009 8:16 AM	Text Document	966 KB

Figure 16. Missing Additional Log Files.

7- Data for accumulated pass number 990 to 993 are presented in the “200909072257” and “200909072257” files. Also, data for accumulated pass number 1520 is presented in the following Log files with contradicting details: “200909090737”, “200909090748” and “200909090812”.

Modifications to Resolve Data Issues of 2009 Testing

In developing the batch process, extensive modifications were made to resolve the issues encountered during data processing discussed in the previous section. The times of the recorded samples were modified in the Log and Additional Log files. Since the reference time (the first recorded time) is consistent with the file name, it was assumed the reference time of each Log and Additional Log was recorded correctly. A sampling rate was then calculated for each Log by dividing the difference of the reference times of the log and its subsequent log by the number of samples per file. Then, the time of the recorded samples were adjusted using the reference time and the sampling rate. If the subsequent Log file was recorded after an interruption in testing, the average sampling rate was used. A similar procedure was applied to the Additional Log files.

The average sampling rate of the Log files obtained from this method was calculated to be 7.7 Hz. This is significantly different from the 20 Hz sampling rate that originally existed between the second and the last record of the Log files. The average sampling rate for all of the Additional Log files was calculated to be 0.197 Hz which is practically the same as the original 0.2 Hz.

This modification to the time column provided integrity between the Log and Additional Log files, which is a key factor for developing the traffic table. The modification also fixed the issue of time lag between the subsequent Additional Log files.

As was explained in the third problem listed in section 6, the reference time in some Log and Additional Log files did not match the file name. To fix the issue, various hypotheses and resolutions were tested. In comparison to the files that did not have the discrepancy, it was found that the numerical format of the times were significantly different. In numerical format, the integer part refers to the date which is the number of days from a fixed date. The decimals denote the time.

An example of the problem is shown in figure 17. The reference time in "200909030001" Log file is recorded as 40.059798611, which converts to 1:26:07 AM when the format is changed from numeric to time. The file name indicates a starting time of 12:01 AM while the converted time denotes 1:26:07 AM. To fix this issue, a "correction factor" was introduced equal to *10 ^ (5 - number of integer digits)*. The time in numeric format is multiplied by the correction factor. Then the resulting decimal part is divided by the correction factor. For this example, the repaired number becomes 40059.000798611, which converts to 12:01:09 AM. This matches the time from the file name.

Another example shown in figure 18, shows the reference time in the Log file is 4005.949479167. The correction factor was calculated to be 10. To repair, the number was multiplied by ten and the decimal part was divided by ten. The result is 40059.049479167, which converts to 1:11:15 AM. Again, the repaired time matches the time from the file name. This repairing procedure was implemented in the MATLAB script.

This repairing procedure was implemented in the MATLAB script andapplied to the reference time of the Log and Additional Log files that had a mismatched file name and reference time.

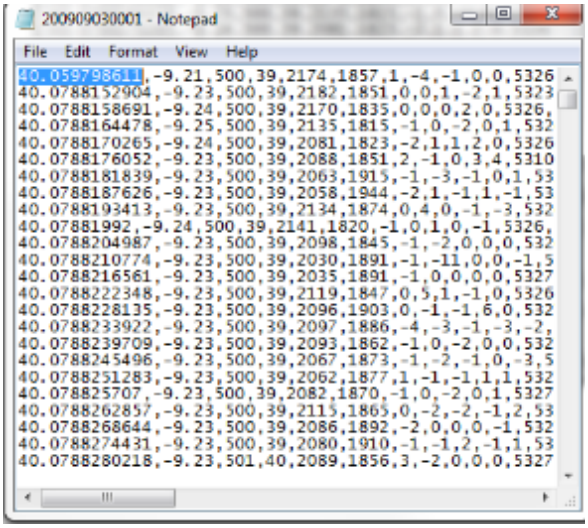


Figure 17. Incorrect Reference Time in Some Log Files, Example 1.

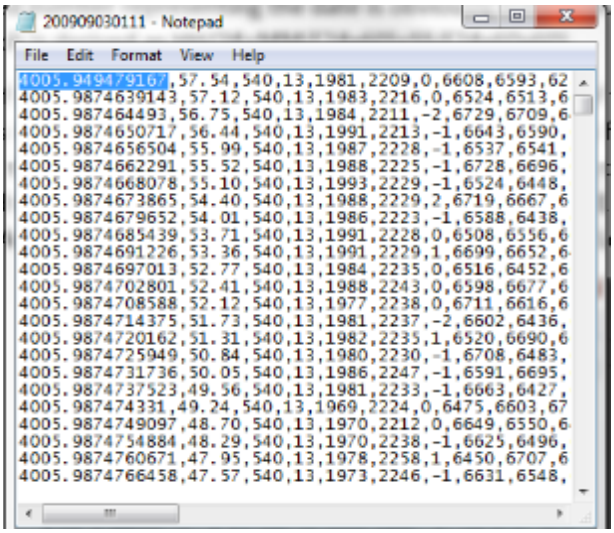


Figure 18. Incorrect Reference Time in Some Log Files, Example 2.

To fix the issue presented as number 4, the accumulated pass number was increased by 1 pass in the traffic table.

The fifth issue discussed in section 6 was manually corrected in Log files identified with the problem. The list of files corrected is as follows:

'200909020709.log'	'200909040709.log'	'200909090216.log'	'200909090530.log'
'200909021301.log'	'200909081136.log'	'200909090226.log'	'200909090540.log'
'200909021311.log'	'200909082106.log'	'200909090236.log'	'200909090550.log'
'200909032252.log'	'200909082216.log'	'200909090316.log'	'200909090600.log'
'200909040452.log'	'200909090056.log'	'200909090326.log'	'200909090610.log'
'200909040502.log'	'200909090146.log'	'200909090500.log'	'200909090709.log'

It was critical to fix the discrepancy in Log and Additional Log file names (problem 6) for batch processing of the traffic data. Therefore, the file names were changed where appropriate and in other instances, the two files were combined into one file with an appropriate name.

Summary and Conclusion

In summary, the available traffic table of the CC5 experiment from the FAA website includes detailed data regarding the position and loading of the testing vehicle over time. The traffic table, however, lacks data from the testing conducted in 2009 which accounts for approximately 45 percent of the testing on the north sections. This study examined the raw data included in the vehicle log files and identified the challenges existing in data processing. This report described the challenges and recommended solutions.

The most common challenge among all recorded log files was the inconsistency in recording the time of the samples. Since the reference time (first recorded time) and the log file name matched, it was assumed that the reference time was recorded correctly. The subsequent reference times of the log files were approximately 10 minutes apart which was another confirmation for the suitability of the assumption. The sampling rate was assumed to be constant within the Log files, but could change between the files.

When the Log file name and the reference time did not match, a correction factor was developed that repaired the reference time in numerical format. When the repaired reference time was converted from numeric format to time format, it matched the file name. This resolved the problem that existed in approximately 15 percent of the Log files.

Additional Log files included important information required in the traffic data. During 2009 testing, Additional Log files were recorded in two formats. When the Additional Log file included the time of sample (Format A), the time was used to pair the records of the Log and Additional Log files. When the file did not include the time (Format B), the vehicle location was used to pair the records.

Other issues were noted in the log files such as erroneous recordation of the pass numbers that were fixed using engineering judgment. In some other exceptional cases, changes were made to the file names to achieve consistency so that the files could be processed in a batch mode. Also, in approximately 3 percent of the cases, the Additional Log files were missing. As a result, the carriage location is missing for these cases in the traffic table.

A MATLAB script was developed to implement the recommended solutions and to develop the traffic table for 2009 testing. The 2009 traffic table implementing these solutions is delivered in combination with this report.

While the traffic table was ultimately developed for the 2009 data, it was evidently based on some assumptions. While the assumptions are sensible from an engineering standpoint and are further verified by other accepted alibis, they may need to be further refined if other information surfaced that is currently unknown to the research team.

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