BridgeTrafficLoadSim:

Long Run Simulation Model for Bridge Loading

Version 1.2.2

User Manual

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Acknowledgements

This program is based on three separate programs developed as part of the author's PhD research from 2001. In turn, these were based on work by Dr Samuel Grave, former PhD student at Trinity College Dublin. The current program which encompasses the functions of two of the previous programs has evolved since 2007 and has been much influenced by the work of Dr Bernard Enright, DIT.

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1. Introduction

1.1 The BridgeTrafficLoadSim Program

BridgeTrafficLoadSim will be referred to as BTLS hereafter.

BTLS generates artificial traffic and passes it across bridges determining various load effects. The traffic is generated according to a relatively simple model. There are several built-in influence lines for various load effects, but the user can input their own influence line also. The program outputs various quantities of interest, which are controllable by the user.

These programs have been in use in DIT and University College Dublin over a 10-year period. There have been multiple users, and so exhibit a fair degree of maturity. That is, the user should not get unexpected results when used correctly. Whilst the routines have been thoroughly tested many times, with ongoing changes, it is good practice to satisfy oneself as to the accuracy of the programs. Various forms of output should assist with this process.

1.2 The User Manual

Purpose

This User Manual has been written to explain the use of the BTLS program, and to explain its capabilities and limitations.

Notices

Points of significant importance are denoted as:

Important!

Typically, failure to adhere to these points will result in unexpected behaviour or a program crash.

Glossary

Load Effect — The result of a calculation using any influence line. Total load on the bridge is sometimes referred to as a load effect therefore.

1.3 Program Release History

Version	Date	Description
1.0.0	5/7/12	• Initial release to international users
1.0.1	21/7/12	• Added version number on screen output • Fixed problem with AllEvents output – it now outputs the last unfilled buffer properly.
1.0.2	24/7/12	• Added a FatigueEvents output file type with max and min values of loading events in it. Only output if AllEvents is output - temporarily
1.0.3	27/7/12	• Bug fix: truck departures not always correctly calculated - fixed using 1e300 for timeOff variables. • Bug fix: reading single lane vehicle files caused crash - fixed. • Minor console output changes for more user information
1.0.4	13/8/12	• Console output for missing files. • Bug fix: reading multiple lane vehicle files crashed following v1.0.3 fix for single lanes!
1.0.5	27/8/12	• Separate discrete influence lines now possible for each lane (IL option 2 in bridge definition file).
1.1.0	27/10/12	• Peaks over Threshold output • Basic statistics output • Created inheritance structure for output types • Flow Data statistics output • Restructured the BTLSin file • Fixed some bugs, especially one on flow generation • Renamed output files for consistency
1.2.0	28/11/12	• Added Influence Surface (IS) calculations • Amended BTLSin file structure accordingly • Added new file structure – DITIS for ISs, including wheel track width for each axle • Added POT counter file output and input specs in BTLSin • Program can now run without IL or IS files being present in folder, once not required. • Added option for vehicle output file format • Traffic folder location now can be specified in BTLSin • Updated generation of tri-modal-normal distributions to include deterministic and single-generation value for

		axle track widths • Added transverse position in lane variability through BTLSin • Added transverse axle track width generation file (ATW.csv) input and default value options
1.2.1	20/12/12	• Bug fix: influence surface calculations did not take transverse position into account – now fixed. • Bug fix: crash caused by traffic files with no vehicles in a lane is fixed.
1.2.2	27/3/2014	• Bug fix: VehicleBuffer.h(31) now max axles 20 • Improved feedback on incorrect load effect definitions •

Installing the Program

BTLS does not require installation, it is a standalone executable program. It has been tested on Windows XP, Vista, and Windows 7.

BTLS can be run in a 64 bit version, which is more efficient that the 32 bit version. The program is a single- threaded application and so cannot take advantage of multi-core processors. Therefore for maximum speed, prefer a computer with a fast single processor over a computer with a multi-core slower processor.

The program does not require much memory because:

- Only a small amount of input information is held in memory;
- Traffic is generated in 1-day blocks on a rolling basis;
- Output to file is made according to user input: this balances accessing eh hard drive (which is slow) and memory requirements. Prefer to use memory than output to the hard drive often.

A computer with 1 GB of RAM is sufficient and other programs can continue to operate successfully.

BTLS uses two folders to operate:

- **Working folder**: the current folder in which configuration files and the executable exist;
- **Traffic folder**: a folder on the computer in which the traffic characteristics for sites are stored.

2. About BTLS

2.1 Introduction

BTLS performs efficient calculations of static traffic actions on bridges. It can generate artificial traffic and write it to file. It can calculate load effects from traffic files. However such simulations are limited by the file size that can be held in the computer memory. In an alternate mode, it can generate traffic and determine load effects simultaneously without recourse outputting traffic to file. In this mode the program can simulate 100s of years of load effect data quite quickly. The exact speed depends on many parameters, but in the worst case, 1000 years has been simulated in under 20 hours. For more typical cases 100 years takes about 1 hour to simulate.

BTLS is provided in two versions:

- `BridgeTrafficLoadSim.exe`: the 32-bit version.
- `BridgeTrafficLoadSim_x64.exe`: the 64-bit version, found to run faster than 32-bit version on 64-bit machines.

2.2 BTLS: Capabilities and Limitations

Capabilities

BTLS is able to:

- Generate artificial traffic from the traffic model of Caprani (2005 & 2012).
- Read in traffic and pass it over influence lines and surfaces;
- Use lane factors to account for lateral distribution of load effect due to transverse stiffness of the bridge;
- Use user-defined influence lines;
- Use separate influence lines for each lane of traffic (user-defined or in-built);
- Determine static load effects from generated or read-in traffic passing over defined bridges and either user-defined or built-in influence lines;
- Model one or two directions at the same time, with any number of lanes in each direction;
- Output different types of data for debugging and further analysis, as specified by the user.
- Output a file suitable for further fatigue analysis.
- Output data for block maxima or peaks over threshold approaches.
- Output traffic flow statistics and load effect statistics

Future plans include:

- Built-in fatigue calculation;
- Improved traffic model for greater generality;
- Possibly a visual user input interface.

Limitations

BTLS is not able to:

- Generate trucks with more than 5 axles;
- Determine the number of lanes or directions of traffic in the specified input traffic file, in advance of a simulation;
- Determine the input traffic file format;
- Determine dynamic load effects;
- Perform extrapolations for return periods.

Note that cars are assumed to be 4 m long and have GVW of 2 tonnes evenly distributed to each axle.

3. BTLS Input

3.1 Introduction

BTLS operates in one of three modes, which are numbered:

1. ***Gen & Sim***: In this mode traffic is generated in the program and simulated crossing the defined bridges;
2. ***Gen***: In this mode traffic is generated and output to file;
3. ***Read & Sim***: In this mode traffic is read from a file and simulated crossing the defined bridges.

Different types of input are required:

1. Traffic model files: for the generation of artificial random traffic;
2. Configuration file: the main user input file which configures each run of the program;
3. Supporting files: define bridges, influence lines and traffic flows to be used in the simulation.

Thus for a successful run the files required are:

Location	**Files**
Traffic folder defined in `BTLSin.txt`, usually `C:\Traffic\`[The Site]	Several – see Traffic Data input files section
Working Folder (anywhere on computer)	`BridgeTrafficLoadSim.exe` (or 64 bit version) `BTLSin.txt` Lane flow definition file Bridge definition file Influence line definition file

	Influence Surface definition file

Depending on the program mode and input values, BTLS will run if some of the above files are missing or not accessible. Warnings are usually given.

3.2 Traffic Files

The model describing the physical characteristics of the traffic is defined in a series of files located in a folder, named after the site which is located, which is a sub-folder to the Traffi Folder. As of v1.2.0 this location can be specified in `BTLSin.txt`, but it is recommended to keep it at `C:\Traffic\`.

> **Important!**
>
> The traffic folder must reside at the location specified in `BTLSin.txt` (usually `C:\Traffic\`).

The traffic model is described by Caprani (2005), and is based on Grave (2001). Presently, 13 sites have been modelled accordingly and are indexed by BTLS as follows, and are located in sub-folders of the site name below:

Site Indices	
Index	**Site**
1	Angers
2	Auxerre
3	A196
4	B224
5	A296
6	SAMARIS\D1
7	SAMARIS\D2
8	SAMARIS\D3
9	SAMARIS\S1
10	SAMARIS\S2
11	SAMARIS\S3
12	SAMARIS\D
13	SAMARIS\S

Auxerre is particularly important as the Eurocode load model LM1 was initially calibrated upon this traffic.

Traffic Data Input Files

The files then placed in this folder are of type comma separated values (`*.csv`). These file types are easily created in a spread sheet program, but can also be read or edited in a text editor.

Many of the vehicles properties are modelled with a three-mode normal distribution; that is, the data may be multi-modally normally distributed. There are three parameters required for each of the modes: the weight, ρ; the mean, μ and the standard deviation, σ. The maximum number of modes allowed for is three; hence the 3×3 tabular format of the data. The units of the data are as per the traffic file convention explained in the Output section.

> **Important!**
> The files names must be as given for each modelled property.

The input defining the traffic flow and composition is made in the working folder as the executable.

> **Important!**
> The current traffic model only accounts for vehicles with up to 5 axles.

Note:
In the following, tri-modal normal distributions are often used to model parameters. Should deterministic values be needed instead, the distribution should have only one mode, set the mean to the required value, and set the standard deviation to zero.

Axle Spacing Definition

`Asall.csv`

This file stores the axle spacing data for all classes of trucks measured at the site. The values must be separated by commas. An example is:

```
1,50.7,3.7,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0

0.65,34.1,6.9,1,11.5,1.7,0,0,0,0,0,0
0.268,34,1.5,0,0,0,0,0,0,0,0,0
0.082,61.5,6,0,0,0,0,0,0,0,0,0

0.672,30.6,1.5,0.153,34.7,3,0.317,11.8,0.6,0,0,0
0.328,30.2,3.9,0.386,54.8,8.6,0.598,12.1,1.7,0,0,0
0,0,0,0.461,59.5,3.4,0.085,18.3,0.9,0,0,0

0.041,23.2,1.4,0.133,42,5.6,1,10.9,1.7,1,11,1.7
0.959,30.4,1.8,0.867,51.2,3.4,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0
```

This data may be more easily understood viewed in tabular form. The meaning of the rows and columns is also shown in relation to the ti-mode normal distribution adopted.

Class	Line	Spacing 1-2			Spacing 2-3			Spacing 3-4			Spacing 4-5		
		ρ	μ	σ	ρ	μ	σ	ρ	μ	σ	ρ	μ	σ
2-Axle	1	1	50.7	3.7	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0
	4												
3-Axle	5	0.65	34.1	6.9	1	11.5	1.7	0	0	0	0	0	0
	6	0.268	34	1.5	0	0	0	0	0	0	0	0	0
	7	0.082	61.5	6	0	0	0	0	0	0	0	0	0
	8												
4-Axle	9	0.672	30.6	1.5	0.153	34.7	3	0.317	11.8	0.6	0	0	0
	10	0.328	30.2	3.9	0.386	54.8	8.6	0.598	12.1	1.7	0	0	0
	11	0	0	0	0.461	59.5	3.4	0.085	18.3	0.9	0	0	0
	12												
5-Axle	13	0.041	23.2	1.4	0.133	42	5.6	1	10.9	1.7	1	11	1.7
	14	0.959	30.4	1.8	0.867	51.2	3.4	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0

Axle Track Width

`ATW.csv`

This file is required when generating vehicles for use with an influence surface. It specifies the width from centre of pressure of the wheels on one side of the axle, to the other. In general this dimension is different to that of vehicle width, since the tyre width and number of tyres must be accounted for. This file is optional, and if it is missing then a default value specified in `BTLSin.txt` will be used instead.

This file again uses tri-modal normal distributions to model the track width of each axle for each class of vehicle. The distributions are specified using 3×3 matrices as is done for Axle Spacings. The file structure is then:

Class	Line Nos.	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5
2-axle	1-3	3×3	3×3	N/A	N/A	N/A
	4					
3-axle	5-7	3×3	3×3	3×3	N/A	N/A
	8					
4-axle	9-11	3×3	3×3	3×3	3×3	N/A
	12					
5-axle	13-15	3×3	3×3	3×3	3×3	3×3

An example file is shown below which illustrates three separate model types for the track width:

1. A typical implementation using tri-modal distributions for each axle track width is shown for the 2-axle truck type. Notice the zero values for the redundant axles 3, 4, and 5.
2. Single values of track width can be specified for all the axles by only defining a distribution for the first axle, and leaving subsequent values all zero. This is done for 3-axle trucks in the example below.

3. Deterministic values can be defined as noted previously by specifying only one model, with mean of the require value and standard deviation of zero. This is done in the example file below for 4- and 5-axle trucks, showing the different track widths for the different axle types (steering, drive, trailer with dual tyres).

The track widths are specified in units of **centimetre**.

```
0.109,188,27.3,0.109,188,27.3,0,0,0,0,0,0,0,0,0
0.847,193.9,6.4,0.847,193.9,6.4,0,0,0,0,0,0,0,0,0
0.045,167.6,6.1,0.045,167.6,6.1,0,0,0,0,0,0,0,0,0

0.109,188,27.3,0,0,0,0,0,0,0,0,0,0,0,0
0.847,193.9,6.4,0,0,0,0,0,0,0,0,0,0,0,0
0.045,167.6,6.1,0,0,0,0,0,0,0,0,0,0,0,0

1,196,0,1,184,0,1,199,0,1,199,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0

1,196,0,1,184,0,1,199,0,1,199,0,1,199,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
```

Axle Weights

```
Aw2&3.csv
```

Two files are used, one for 2 and 3 axle trucks, the other for 4 and 5 axle trucks. This file contains the axle weight information for the 2- and 3- axle trucks of the site. An example is:

```
0.560,33.4,3.7,0.440,59.4,7.4,0.000,0.0,0.0
0.440,40.6,7.4,0.560,66.6,3.7,0.000,0.0,0.0
0.000,0.0,0.0,0.000,0.0,0.0,0.000,0.0,0.0

0.066,20.4,1.5,0.769,34.6,6.8,0.558,30.5,5.9
0.522,26.0,4.9,0.227,39.2,2.2,0.442,37.7,3.5
0.412,38.7,8.6,0.004,54.4,3.7,0.000,0.0,0.0
```

This data is explained as follows:

Class	**Row**	**Weight Axle 1**			**Weight Axle 2**			**Weight Axle 3**		
		ρ	μ	σ	ρ	μ	σ	ρ	μ	σ
2-Axle	1	0.56	33.4	3.7	0.44	59.4	7.4	0	0	0
	2	0.44	40.6	7.4	0.56	66.6	3.7	0	0	0
	3	0	0	0	0	0	0	0	0	0
	4									
3-Axle	5	0.066	20.4	1.5	0.769	34.6	6.8	0.558	30.5	5.9
	6	0.522	26	4.9	0.227	39.2	2.2	0.442	37.7	3.5
	7	0.412	38.7	8.6	0.004	54.4	3.7	0	0	0

`Aw4&5.csv`

This file contains the axle weight information for the 4- and 5-axle trucks. It has been found that the axle weights of the 4- and 5-axle trucks depend on the Gross Vehicle Weight (GVW). Thus the data governing these axle weights have been assembled for 12 classes of truck GVW, beginning at 25 kN and increasing in steps of 50 kN.

```
0.0,0.0,0.0,0.0,0.0,0.0
20.9,39.8,39.3,5.2,6.9,7.3
25.6,36.5,38.0,5.4,4.8,5.7
23.9,35.5,40.7,4.3,4.6,5.2
20.3,36.1,43.6,3.6,4.6,5.4
17.4,34.9,47.7,3.0,4.1,5.5
14.8,33.4,51.8,2.1,3.1,4.1
14.5,33.6,51.9,1.5,2.6,3.2
13.9,32.4,53.7,1.3,2.3,3.1
11.9,31.4,56.7,0.9,1.4,0.9
0.0,0.0,0.0,0.0,0.0,0.0
0.0,0.0,0.0,0.0,0.0,0.0

0.0,0.0,0.0,0.0,0.0,0.0
0.0,0.0,0.0,0.0,0.0,0.0
19.1,36.5,44.5,6.0,7.4,7.2
23.6,32.8,43.7,4.6,4.2,5.0
21.4,33.4,45.3,3.2,4.8,5.4
18.1,33.8,48.1,2.4,4.5,5.5
15.7,32.3,52.0,1.8,3.8,4.7
14.3,31.0,54.6,1.5,3.3,3.9
13.4,29.6,57.1,1.2,2.9,3.4
12.7,27.7,59.6,1.0,2.7,3.1
0.0,0.0,0.0,0.0,0.0,0.0
0.0,0.0,0.0,0.0,0.0,0.0
```

A single line separates the 4- and 5-axle data. The six entries for each line, or GVW range of truck, represent the parameters of the single-mode Normal distributions for the first (W1) and second (W2) axles and the total weight of the tandem or tridem (WT) in the following order:

Mean W1	Mean W2	Mean WT	SD W1	SD W2	SD WT

This has resulted from previous research which has found that the weights of the axles in the tandem or tridem of 4- and 5-axle trucks (respectively) are equal and thus the tandem/tridem may be considered as one weight. The calculated tandem/tridem weight are divided by the number of axles to give each axle a weight in the processing of this data. The values must be separated by commas.

Gross Vehicle Weight

```
GVWpdf.csv
```

This file holds the parameters of the distributions that characterize the GVW and speed of each class of truck for both directions. An example of this file is:

```
1,194.5,27.4,0.152,44.2,6.5,0.069,51.2,9.7,0.583,231.1,61.9,0.274,199.9,36.7
0,0,0,0.395,76.4,20.7,0.887,166.3,53.2,0.24,176.6,29.6,0.553,308.7,49.9
0,0,0,0.453,117.4,30.5,0.044,268.4,34.7,0.177,331,30.1,0.173,383.2,35.4

1,181.1,22.4,0.143,46.5,8,0.093,56.4,12.4,0.493,243.6,64.6,0.16,205.3,40.1
0,0,0,0.524,82.9,23.8,0.653,141.5,31.1,0.301,162.1,28.8,0.441,300.6,53.6
0,0,0,0.333,132.3,31.8,0.254,218.5,33.4,0.206,361.9,31.6,0.399,400.4,35.9
```

Again this is best explained by reference to the following table:

	Speed	**2-Axle GVW**	**3-Axle GVW**	**4-Axle GVW**	**5-Axle GVW**
Direction 1	3×3	3×3	3×3	3×3	3×3
Blank Line					
Direction 2	3×3	3×3	3×3	3×3	3×3

In the above table the entry 3×3 refers to the allowance for multi-modal distributions (up to a maximum of three modes) and includes, for each mode, the weight, mean and standard deviation, as explained previously. The values must be separated by commas.

Headway

NHM.csv

Of the headway models, only the HeDS model requires an input file. This model is defined in OBrien & Caprani (2005). An example is:

```
15,0,0,0
0,0.011855673,-0.014268241,0.004048786
0,0.039251526,-0.05978246,0.02212043
70,-0.004412997,0.054824101,-0.066907905
80,-0.004685721,0.052127816,-0.053475193
90,0.001537014,0.020896587,-0.013787689
100,-0.003853623,0.064555837,-0.069172155
110,-0.002530238,0.054511802,-0.059714977
120,-0.001307981,0.048010242,-0.051645258
130,-0.000487752,0.049738587,-0.057875119
140,-0.004995115,0.081041256,-0.086465967
150,-0.004547469,0.080310658,-0.083351351
160,-0.004938412,0.092219287,-0.105416601
170,-0.005000644,0.086893379,-0.097048852
180,0.001987438,0.052114614,-0.058245039
190,0.003366332,0.044909211,-0.063187142
210,0.000379907,0.068461437,-0.077769612
230,-0.006466786,0.117770005,-0.141174818
```

Line 1 indicates the number of flow-dependent headway models (always less than, or equal to, 24). Lines 2 and 3 give the parameters of the quadratic-fit headway cdf for under 1.0 s and between 1.0 s and 1.5 s respectively. The following lines (of number 15 in this example, from Line 1), return the parameters of the quadratic fit to the headway cdf for that flow (trucks per hour) of the first column. The values must be separated by commas.

3.3 Configuration File

The user interacts with the program through the configuration file.

Important!

The input file must be called “BTLSin.txt” and it must be in the working folder.

An example input file is shown next, and each input line explained following.

Line	BTLSin.txt
	// --
	// START OF BRIDGE TRAFFIC LOAD SIMULATION INPUT
	// --
	//
	// --
	// *** INPUT SPECIFICATIONS ***
	// --
	//
	// Program Mode (1 - Gen & Sim, 2 - Gen, 3 - Read & Sim)
1	1
	//
	// TRAFFIC GENERATION PARAMETERS
	// --
	// No. of days of traffic simulation:
2	2
	// Location of Traffic folders
3	C:\Traffic\Auxerre\
	// Default truck track width (cm)
4	190.0
	// Standard deviation of eccentricity in lane (cm) (about 20 cm usually)
5	0
	// Headway model to be used:
	// (0 - Auxerre NHM, 5 - Congestion (w/ or w/out cars), 6 - free-flow, cars included)
6	0
	// Lane and flow definition file:
7	LaneFlowData.csv
	// Nominal congested spacing, front to back (m):
8	5
	// Congested speed (km/h):
9	30
	// Congested gaps coefficient of variation:
10	0.05
	//
	// TRAFFIC INPUT FILE PARAMETERS
	// --
	// Traffic input file to be analysed:
11	BTLSvehicles_in.txt
	// Traffic input file format (CASTOR - 1, BeDIT - 2, DITIS - 3):
12	3
	// Impose constant speed on all vehicles (1 or 0):
13	0
	// Use average speed of vehicles in file if constant speed imposed (1 or 0)
14	1

```
    // Constant speed of vehicles if not average used (km/h):
15  80
    //
    // LOAD EFFECT CALCULATION PARAMETERS
    // --------------------------------------------
    // Bridge definition file:
16  IS_test_bridge.txt
    // Influence Line definition file:
17  IS_test_DiscreteIL.txt
    // Influence Surface definition file:
18  IS_test.csv
    // Time step (s):
19  0.1
    // Minimum GVW for inclusion in calculations (t/10):
20  35
    //
    // --------------------------------------------
    //        *** OUTPUT SPECIFICATIONS ***
    // --------------------------------------------
    //
    // MISC. OUTPUT PARAMETERS
    // --------------------------------------------
    //
    // Write full time history - slow & large file (1 or 0):
21  0
    // Write each loading event value (1 or 0):
22  0
    // Write each event buffer size:
23  10000
    // Write a fatigue event file (1 or 0)
24  0
    //
    // VEHICLE FILE
    // --------------------------------------------
    // Write vehicle file (1 or 0)
    // WARNING: a large file may result in long-run simulations
25  1
    // Traffic output file format (CASTOR - 1, BeDIT - 2, DITIS - 3):
26  3
    // Vehicle file name
27  BTLSvehicles.txt
    // Vehicle file buffer size
28  10000
    // Write vehicle file flow statistics (1 or 0)
29  0
    //
    // BLOCK MAXIMUM LOAD EFFECTS
    // --------------------------------------------
    // Analyse for Block Max (overrides remaining params) (1 or 0)
30  1
    // Block size for maxima (days):
31  1
    // Block size for maxima (seconds):
32  0
    // Write block max separated vehicle files (1 or 0):
33  0
    // Write block max summary files (1 or 0):
34  1
    // Do and write block max mixed vehicle analysis (1 or 0):
35  0
    // Write block max buffer size:
36  1000
    //
    // PEAKS OVER THRESHOLD LOAD EFFECTS
    // --------------------------------------------
    // Analyse for POT (overrides remaining params) (1 or 0)
37  1
    // Write POT vehicle files (1 or 0):
```

```
38  0
    // Write POT summary files (1 or 0):
39  1
    // Write POT counter files (1 or 0):
40  1
    // POT counter size (days):
41  1
    // POT counter (seconds):
42  0
    // Write POT buffer size:
43  10000
    //
    // LOAD EFFECT STATISTICS OUTPUT
    // ---------------------------------------------
    // Analyse for Statistics (overrides remaining params) (1 or 0)
44  1
    // Write cumulative statistics file (1 or 0)
45  1
    // Write statistics at intervals files (1 or 0)
46  1
    // Interval size for statistics output (seconds)
47  3600
    // Write interval statistics buffer size:
48  10000
    //
    // ---------------------------------------------
    // END OF BRIDGE TRAFFIC LOAD SIMULATION INPUT
    // ---------------------------------------------
```

\\ Comments:

The program reads all lines of the configuration file except those preceded with C++ style commenting: “\\”. The user is free to add further commenting to the file as they wish, once the order of the input variables is not altered.

> **Important!**
>
> Depending on the program mode, some inputs are redundant. However, they must still be specified as ‘placeholders’ to keep the order of inputs the same.

Line 1:

The user specifies the program mode using 1, 2, or 3 for the modes as defined on page 14.

Line 2:

Specify the number of days of traffic to simulate in Modes 1 or 2. This input is redundant in the case of Mode 3 when the traffic file is specified.

Line 3:

Specify the location of the traffic generation files used in Program Modes 1 and 2.

Line 4:

Specify the truck track width (axle width) to be used if there is no `ATW.csv` file for the site in the folder of Line 3 – only strictly relevant for influence surface calculations.

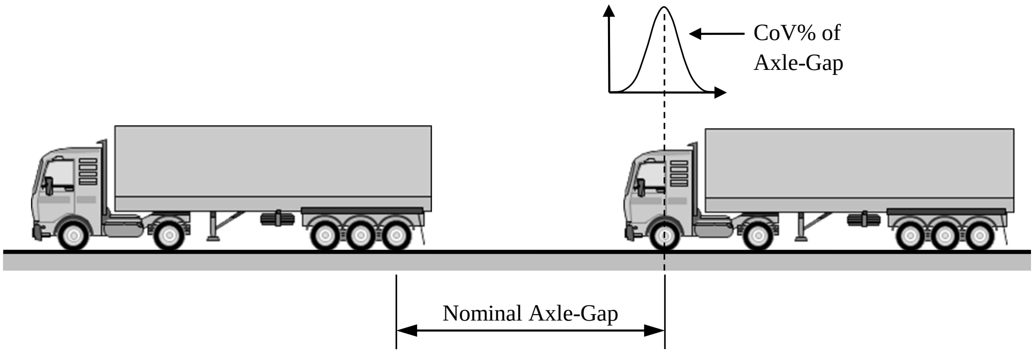
Line 5:

Specify the standard deviation of the eccentricity of the vehicles in their lane. This approach assumes a mean of zero and a normal distribution. Some site data suggests about 20 cm is a reasonable value. Again only really necessary for influence surface calculations.

Line 6:

Specify the headway model to be used in the generation of artificial traffic. The options are (note the odd-numbering for 'historical' reasons):

- "0" – The HeDS (Headway Distribution Statistics) model of OBrien & Caprani (2005). This is suitable for the Auxerre site-measured flowrates only. It is a free-flow model that generates only trucks.
- "5" – Congestion model as per Caprani (2012), summarized in the following diagram. A nominal axle gap is specified (Line 6), along with a coefficient of variation between successive vehicles in all lanes (i.e. trucks and cars) (Line 8) and gaps are then generated using a normal distribution.



- "6" – Free-flow model which uses a Poisson arrival assumption based upon the Normalized Headway Model of Crespo-Minguillón and Casas (1997). This accounts for different flow rates (Q) as follows:

$$F(t) = 1 - e^{-\lambda t}$$

  Where $1/\lambda$ is the mean headway, i.e. the average time gap between vehicles in the hour of the current total (cars and trucks) flowrate Q and so is given by Q/3600.

For all models the program checks that no overlapping of vehicles can occur by ensuring the generated gap is greater than the required minimum gap (taking account of the maximum bridge length, vehicle lengths, and speed difference between them).

Line 7:

Specify the name of the Lane Flow definition file that is in the working folder.

Line 8:

Specify the nominal axle gap for Headway Model 5 – congestion.

Line 9:

Specify the speed of all vehicles for Headway Model 5 – congestion. Note that this, combined with the calculation time step (Line 16), effectively renders a distancestepping algorithm and so this speed can be notional to achieve a required distance step.

Line 10:

Specify the coefficient of variation of the nominal congested gap for Headway Model 5 – congestion.

Line 11:

Specify the name of the traffic input file in the working folder for Program Mode 3.

Line 12:

Specify the format of the input file: 1 – CASTOR format, 2 – BeDIT, 3 – DITIS format. See Appendix for traffic file format definitions.

Line 13:

BTLS normally passes each vehicle across the bridge according to its own speed when in Program Mode 3. Setting this option to “1” imposes constant speed on all vehicles for comparison with some other algorithms – mostly to do with congestion traffic files.

Line 14:

When constant speed is imposed (Line 11), if this option is “1” then the average speed of all vehicles in the file will be used, otherwise the speed specified in Line 13 will be used.

Line 15:

Specifies the constant speed if Line 13 is “1” and Line 14 is “0”.

Line 16:

Specify the name of the bridge definition file (see Section 3.4) in the working folder.

Line 17:

Specify the name of the influence line definition file (see Section 3.6) in the working folder.

Line 18:

Specify the name of the influence surface definition file (see Section 3.7) in the working folder.

Line 19:

Specify the calculation time step which is used in passing the vehicles over the bridges. 0.1 s has been found a good compromise between accuracy and efficiency. For some very sharp influence lines (e.g. shear forces) a finer step may be required. A sensitivity study is recommended.

Line 20:

To avoid unnecessary computation of smaller vehicles, this specifies the minim GVW for a vehicle's load effect to be calculated. Its spatial arrangement on the road is not affected if its GVW is less than this number. The units are deci-tonnes (t/10)

Line 21:

Specify "1" to write a full time history of the load effects – see section on BTLS Output for more details. This should be set to "0" for long simulations due to enormous resulting file size and slow execution.

Line 22:

Specify "1" to write the load effect value for each loading event that occurs. Again this can be a large file and cause slow execution for long-run simulations. See section on BTLS Output for more details.

Line 23:

If each loading event value is to be written (Line 24), this option if set to “1” specifies the number of events that are stored in memory before writing to the hard drive. See section on BTLS Output for more details (Section 5).

Line 24:

Writes a file suitable for further fatigue calculations, giving load cycles.

Line 25:

For all program modes, this option if “1” will write the generated or read-in vehicle file. For long run simulations this should be “0” as very large files can result, filling hard drive space and causing very slow computation. Mostly useful for short debugging or test runs.

Line 26:

This specifies the format of the output file traffic file: 1 – CASTOR format, 2 – BeDIT, 3 – DITIS.

Line 27:

The name of the file to be written if Line 25 is “1”.

Line 28:

If the vehicle file is to be written (Line 22 set to “1”), this specifies the number of vehicles that are stored in memory before writing to the hard drive. See section on BTLS Output for more details.

Line 29:

If this is set to “1” files are output giving the traffic flow and composition information for each hour of the simulation for each lane.

Line 30:

If this option is "1" calculations are performed that can be used to write block maxima output. Set to "0" to override all block maxima output and calculations.

Line 31:

For block maximum output, this specifies the block size in days for which the maximum is retained (it can be zero if Line 32 has a number > 0).

Line 32:

For block maximum output, this specifies the block size in seconds for which the maximum is retained (it can be zero if Line 31 has a number > 0).

Line 33:

Specify "1" to write block maximum load effect and vehicle output files for each number of vehicles comprising the events. See section on BTLS Output (Section 5.4) for more details.

Line 34:

Specify whether to write the block maximum summary files ("1" or "0"). See section on BTLS Output (Section 5.4) for more details.

Line 35:

Specify "1" to write block maximum load effect output files for which the events are not separated by the number of vehicles in the event, or "0" to not. See section on BTLS Output (Section 5.4) for more details.

Line 36:

If block maximum output is to be written (Line 30), this option if set to "1" specifies the number of events that are stored in memory before writing to the hard drive. See section on BTLS Output (Section 5.4) for more details.

Line 37:

If this option is "1" calculations are performed that can be used to write peaks-over-threshold (POT) output. Set to "0" to override all POT output and calculations. Note that the thresholds for each load effect are set in the Bridge Definition File (Section 3.4).

Line 38:

For POT output, this specifies if the vehicles comprising the peak events are to be output to a vehicle-event file. See section on BTLS Output (Section 5.5) for more details.

Line 39:

For POT output, this specifies if summary files are to be written. See section on BTLS Output (Section 5.5) for more details.

Line 40:

For POT output, this specifies if a peaks counter file is to be written. See section on BTLS Output (Section 5.5) for more details.

Line 41:

For peaks counter output, this specifies the interval size in days for which the peaks are counted (it can be zero if Line 42 has a number > 0).

Line 42:

For peaks counter output, this specifies the interval size in seconds for which the peaks are counted (it can be zero if Line 41 has a number > 0).

Line 43:

If POT output is to be written (Line 37), this option if set to "1" specifies the number of events that are stored in memory before writing to the hard drive. See section on BTLS Output (Section 5.5) for more details.

Line 44:

If this option is "1" calculations are performed that accumulate simple statistics of load effect and vehicles throughout the simulation. Set to "0" to override all statistics output and calculations.

Line 45:

This specifies if the statistics for each load effect accumulated through the whole simulation are to be output. See section on BTLS Output (Section 5.6) for more details.

Line 46:

This specifies if the statistics for each load effect are to be output at particular time intervals. See section on BTLS Output (Section 5.6) for more details.

Line 47:

If interval statistics are to be output, this specifies the interval duration. See section on BTLS Output (Section 5.6) for more details.

Line 48:

If interval statistics are to be output, this specifies the number of intervals that are stored in memory before writing to file.

3.4 Bridge Definition File

The bridges over which vehicles are to pass are defined in the bridge definition file, specified in the configuration file (`BTLSin.txt`). The file name is arbitrary.

> **Important!**
>
> A bridge definition file must be included in the working folder.

An example bridge definition file for a single bridge with 4 load effects is shown:

Line No.	File
1	`1,    40.0,     2,    4`
2	`1,    1,    3000.0`
3	`1,    1,    0.728125, 0.271875`
4	`2,    1,    3000.0`
5	`2,    1,    0.728125, 0.271875`
6	`3,    2,    3000.0`
7	`2,    2,    0.728125`
8	`2,    2,    0.271875`
9	`4,    3,    3000.0`
10	`1`

Any number of bridges can be defined, as can any number of load effects for each bridge. Each bridge definition is formatted as follows:

Bridge Information: (e.g. "`1, 40.0,  2,  4`")

This first line specifies some general information about the bridge:

- Column 1: the bridge number, a positive integer – 1 in this case;
- Column 2: the span of the bridge in metres, a real positive number – 40.0 m in this case;
- Column 3: the number of lanes on the bridge, a positive integer – 2 in this case;

- Column 4: the number of load effects to be considered for this bridge, a positive integer – 4 in this case.

Each load effect is then defined on the following lines with a format depending on the type of load effect. The first line in each case is the basic information, formatted as follows:

Load Effect Information: (e.g. "`1, 1, 3000.0`**")**

- Field 1: the load effect number, a positive integer – e.g. 1.
- Field 2: the load effect definition type:
    - 1 – lane factors are applied to a single influence line;
    - 2 – separate influence lines and lane weights are applied to each lane;
    - 3 – an influence surface is used for the load effect.
- Field 3: the threshold to be used for this load effect in peaks-over-threshold analysis, e.g. 3000.0 kNm. If this number is absent it is assumed to be zero.

The line(s) following the load effect information line are formatted differently depending on the load effect definition type, 1, 2, or 3, as follows:

Load Effect Definition Type 1 – Lane factors applied to single IL

Only one line is required in this case, for example "`1, 1, 0.728125, 0.271875`" (line 3) in the file above. This line is formatted as follows:

- Field 1: The type of influence line:
    - 1 – if it is a built-in influence line;
    - 2 – if it is a user-defined discrete influence line.
- Field 2: The influence line number (whether built-in or discrete).
- Fields3+: the lane factors to be applied to the influence line for Lane 1, 2 etc.

Line 5 in the file above shows that a discrete influence line is being used for Load Effect 2 with lane factors for all lanes.

Load Effect Definition Type 2 – Separate ILs and lane weights for each lane

In this case a line is required, corresponding to each lane, formatted as follows:

- Field 1: The type of influence line:
    - 1 – if it is a built-in influence line;
    - 2 – if it is a user-defined discrete influence line.
- Field 2: The influence line number (whether built-in or discrete).
- Fields3: the lane factor to be applied to the influence line for this lane.

In the example file above, load effect 3, starting on line 6, is using this form of definition. Line 7 defines that Lane 1 uses discrete IL number 2 with lane weight 0.728125. Similarly, line 8 defines that Lane 2 uses the same discrete IL number 2 with lane weight 0.271875.

Load Effect Definition Type 3 – An influence surface is used for the bridge

In this case only a single line is required, assigning an influence surface number to the load effect. Thus, in the above file, line 9 shows that load effect 4 is using an influence surface, whilst line 10 assigns influence surface 1 to it.

Lane factors represent the proportion of load of the corresponding lane (i.e. lane factor 3 is for lane 3) that contributes to the load effect in the element under consideration. In this way, an influence surface is effectively defined as slices along each lane. Note that this model means that the influence surface must be a scaled version of itself transversely across the bridge – this is not always the case however.

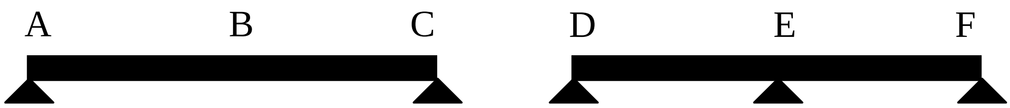
Finally, it can be noted that the above example file is a test file: all of the load effects use different means of arriving at the same outcome once the discrete influence line is for mid-span bending moment, and the influence surface is that given as the example influence surface later on.

Built-In Influence Functions

The built-in influence functions are mathematical expressions that apply for any bridge length and can be weighted with any value of lane factor. Consequently, these built-in functions execute more quickly than read-in influence lines.

The description and index for the built in functions are:

Index	Influence Line	Location
1	Mid-span bending moment for a simply supported beam	B
2	Bending moment over the central support of a two-span beam	E
3	Left-hand shear in a simply-supported beam	A
4	Right-hand shear in a simply-supported beam	C
5	Right-hand shear for a two-span beam	F
6	Left-hand shear for a two-span beam	D
7	Total amount of load on the bridge (i.e. the unit influence line)	



3.5 Lane Flow Data File

This file contains all information relating to the number of lanes, the flow in each lane throughout the day, and the traffic composition. It applies when artificial traffic is being created using one of the free-flow headway models.

Important!

A lane flow definition file must be included in the working folder.

This file must be in `*.csv` format (but can have a `*.txt` extension). In `*.csv` format it is easily edited in a spread sheet program as shown:

	A	B	C	D	E	F	G	H	I
1	1	1							
2	0	153.8	248	10	80	23	2.8	31.7	42.5
3	1	131	248	10	80	23	2.8	31.7	42.5
4	2	131.8	248	10	80	23	2.8	31.7	42.5
5	3	123.8	248	10	80	23	2.8	31.7	42.5
6	4	114	248	10	80	23	2.8	31.7	42.5
7	5	121.2	248	10	80	23	2.8	31.7	42.5
8	6	141.2	248	10	80	23	2.8	31.7	42.5
9	7	155.4	248	10	80	23	2.8	31.7	42.5
10	8	154	248	10	80	23	2.8	31.7	42.5
11	9	141	248	10	80	23	2.8	31.7	42.5

Each lane of the simulation is defined by 25 rows of data:

- The first row defines the lane number (sequential) and direction number (1 or 2) in columns 1 and 2 (or A and B in the screenshot);
- The next 24 rows describe the traffic flow for each hour of the day (i.e. rows 2, 3, 4… in the screenshot above).

Note that it is assumed that every day of the simulation is the same. Typically only economic days of traffic are simulated of 5 days per week, 50 weeks per year (250 days per year). It is assumed that each such day has the same properties.

The structure of each hour description is as follows, with numbers given from hour 0 of the screen shot above (at row 2):

- Column 1: The hour identifier, starting at midnight, 0 to 23 (e.g. 0)
- Column 2: The mean truck flow rate in this hour (trucks/hour) (e.g. 153.8)
- Column 3: Mean velocity of traffic (dm/s) (e.g. 248)
- Column 4: Standard deviation of the velocity (dm/s) (e.g. 10)
- Column 5: Percentage of cars in this traffic model (e.g. 80)
- Column 6: Percentage of trucks that are 2 axle (e.g. 23)
- Column 7: Percentage of trucks that are 3 axles (e.g. 2.8)
- Column 8: Percentage of trucks that are 4 axles (e.g. 31.7)
- Column 9: Percentage of trucks that are 5 axles (e.g. 42.5)

The rationale for having the input in this form is the ease of altering the percentage cars and overall flow rate without modifying the truck flow and composition. This is best explained through an example of the calculations the program performs:

1. From Column 5, the truck percentage is 100-80 = 20%;
2. This 20% represents a flow of 153.8 vehicles per hour (Column2);
3. Thus the total flow rate is 153.8/0.2 = 769 vehicles per hour.
4. Of the 20% vehicles that are trucks, for example, 42.5% are 5-axle trucks, thus there will be 0.425*153.8 = 65.4 5-axle trucks on average for this hour.

Changing Column 4 then changes the overall flow rate, without changing the number of trucks that arrive.

Note that a normal distribution is assumed for the speed of all vehicles.

Each lane to be included in the simulation must have the above information. An example file with two lanes, one in each direction is given below:

```
1,1,,,,,,,
0,153.8,248,10,80,23,2.8,31.7,42.5
1,131,248,10,80,23,2.8,31.7,42.5
2,131.8,248,10,80,23,2.8,31.7,42.5
3,123.8,248,10,80,23,2.8,31.7,42.5
4,114,248,10,80,23,2.8,31.7,42.5
5,121.2,248,10,80,23,2.8,31.7,42.5
6,141.2,248,10,80,23,2.8,31.7,42.5
7,155.4,248,10,80,23,2.8,31.7,42.5
8,154,248,10,80,23,2.8,31.7,42.5
9,141,248,10,80,23,2.8,31.7,42.5
10,126.4,248,10,80,23,2.8,31.7,42.5
11,101.6,248,10,80,23,2.8,31.7,42.5
12,95.8,248,10,80,23,2.8,31.7,42.5
13,88.2,248,10,80,23,2.8,31.7,42.5
14,93,248,10,80,23,2.8,31.7,42.5
15,109,248,10,80,23,2.8,31.7,42.5
16,124.2,248,10,80,23,2.8,31.7,42.5
17,151,248,10,80,23,2.8,31.7,42.5
18,141.8,248,10,80,23,2.8,31.7,42.5
19,172.2,248,10,80,23,2.8,31.7,42.5
20,141.4,248,10,80,23,2.8,31.7,42.5
21,148,248,10,80,23,2.8,31.7,42.5
22,157.2,248,10,80,23,2.8,31.7,42.5
23,159.4,248,10,80,23,2.8,31.7,42.5
2,2,,,,,,,
0,92.2,222,10,80,21.9,2.3,31,44.8
1,79.6,222,10,80,21.9,2.3,31,44.8
2,67,222,10,80,21.9,2.3,31,44.8
3,74.8,222,10,80,21.9,2.3,31,44.8
4,81.6,222,10,80,21.9,2.3,31,44.8
5,94.8,222,10,80,21.9,2.3,31,44.8
6,102.4,222,10,80,21.9,2.3,31,44.8
7,121.2,222,10,80,21.9,2.3,31,44.8
8,127.4,222,10,80,21.9,2.3,31,44.8
9,127.2,222,10,80,21.9,2.3,31,44.8
10,112.2,222,10,80,21.9,2.3,31,44.8
11,111.4,222,10,80,21.9,2.3,31,44.8
12,110.2,222,10,80,21.9,2.3,31,44.8
13,146,222,10,80,21.9,2.3,31,44.8
14,160.4,222,10,80,21.9,2.3,31,44.8
15,152,222,10,80,21.9,2.3,31,44.8
16,151,222,10,80,21.9,2.3,31,44.8
17,167.2,222,10,80,21.9,2.3,31,44.8
18,179.6,222,10,80,21.9,2.3,31,44.8
19,164.8,222,10,80,21.9,2.3,31,44.8
20,206.6,222,10,80,21.9,2.3,31,44.8
21,228.4,222,10,80,21.9,2.3,31,44.8
22,189,222,10,80,21.9,2.3,31,44.8
23,138.8,222,10,80,21.9,2.3,31,44.8
```

3.6 Influence Line Definition File

This file stores the definitions of any discrete influence lines that are required. It must be in `*.csv` format (but can have a `*.txt` extension).

> **Important!**
>
> An influence line definition file must be included in the working folder if it is required for the analysis.

The first line of the file is the number of influence lines defined within. Subsequently, each influence line is defined with the following structure:

- A first line giving the influence line number (Column 1) and the number of points defining the influence line (Column 2);
- Subsequent lines define the influence line using *x*, *y*, pairs for the location and ordinate values (Columns 1 and 2 respectively).

Discrete influence line processing takes longer than built-in expressions. The program must search the vector of *x*-coordinates to find the points surrounding the axle location. Linear interpolation of the ordinates is then used to find the ordinate at the axle location. The spacing of points need not be uniform. Therefore, prefer to use as few points as is necessary where the influence line is linear, and more points where it is curved.

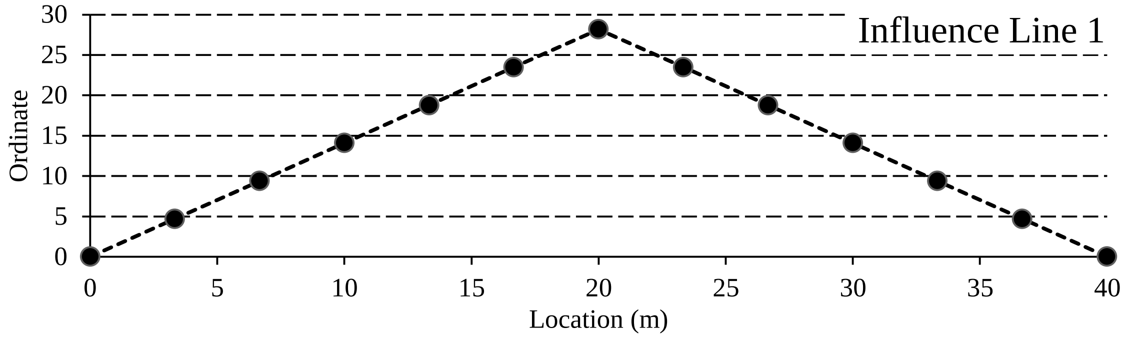
> **Important!**
>
> The program warns if the last *x*-coordinate is not the same as the length of the bridge defined in the Bridge Definition file. Behaviour in this case is generally unpredictable. However this warning can be issued due solely to rounding, and in this case no problems have been observed.

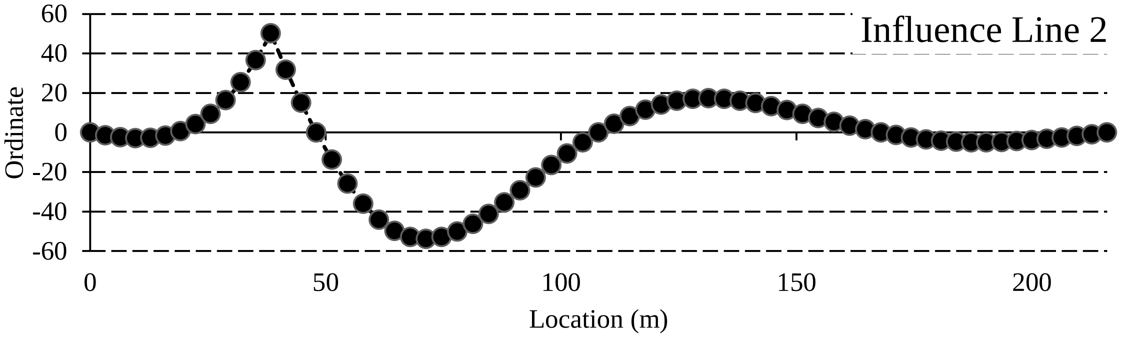
An example file is given below:

- he first influence line is a test of a 40 m simply-supported mid-span bending moment calculation,
- the second is an influence line from the Millau viaduct, courtesy if IFSTTAR, France.

```
2
1, 13
    0.000000,    0.000000
    3.333333,    4.695709
    6.666667,    9.391137
   10.000000,   14.086847
   13.333333,   18.782556
   16.666667,   23.477984
   20.000000,   28.173693
   23.333333,   23.477984
   26.666667,   18.782556
   30.000000,   14.086847
   33.333333,    9.391137
   36.666667,    4.695709
   40.000000,    0.000000
2, 67
    0.000000,    0.000000
    3.200000,   -1.404704
    6.400000,   -2.482683
    9.600000,   -2.967398
   12.800000,   -2.765344
   16.000000,   -1.658346
   19.200000,    0.578218
   22.400000,    4.170048
   25.600000,    9.341767
   28.800000,   16.319074
   32.000000,   25.326593
   35.200000,   36.574975
   38.400000,   50.127631
   41.600000,   31.722458
   44.800000,   15.056238
   48.000000,    0.000000
   51.333333,  -13.793401
   54.666667,  -25.918783
   58.000000,  -36.084887
   61.333333,  -44.196060
   64.666667,  -49.871840
   68.000000,  -52.900498
   71.333333,  -53.815114
   74.666667,  -52.833863
```

```
  78.000000,  -50.155575
  81.333333,  -46.221973
  84.666667,  -41.193196
  88.000000,  -35.436810
  91.333333,  -29.230102
  94.666667,  -22.847134
  98.000000,  -16.583464
 101.333333,  -10.646519
 104.666667,   -5.083589
 108.000000,    0.000000
 111.333333,    4.397896
 114.666667,    8.216499
 118.000000,   11.460109
 121.333333,   14.100781
 124.666667,   15.951508
 128.000000,   16.941357
 131.333333,   17.243363
 134.666667,   16.930610
 138.000000,   16.067582
 141.333333,   14.799371
 144.666667,   13.179716
 148.000000,   11.327914
 151.333333,    9.335319
 154.666667,    7.293285
 158.000000,    5.293167
 161.333333,    3.385477
 164.666667,    1.617506
 168.000000,    0.000000
 171.200000,   -1.360639
 174.400000,   -2.545019
 177.600000,   -3.539167
 180.800000,   -4.268925
 184.000000,   -4.746116
 187.200000,   -4.978264
 190.400000,   -4.989011
 193.600000,   -4.803078
 196.800000,   -4.444110
 200.000000,   -3.936826
 203.200000,   -3.307020
 206.400000,   -2.577262
 209.600000,   -1.773345
 212.800000,   -0.904943
 216.000000,    0.000000
```


Influence Line 1
Ordinate
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
Location (m)


Influence Line 2
Ordinate
60
40
20
0
-20
-40
-60
0
50
100
150
200
Location (m)

3.7 Influence Surface Definition File

This file stores the definitions of any influence surfaces that are required. It must be in *.csv format (but can have a *.txt extension).

Important!

An influence surface definition file must be included in the working folder if it is required for the analysis.

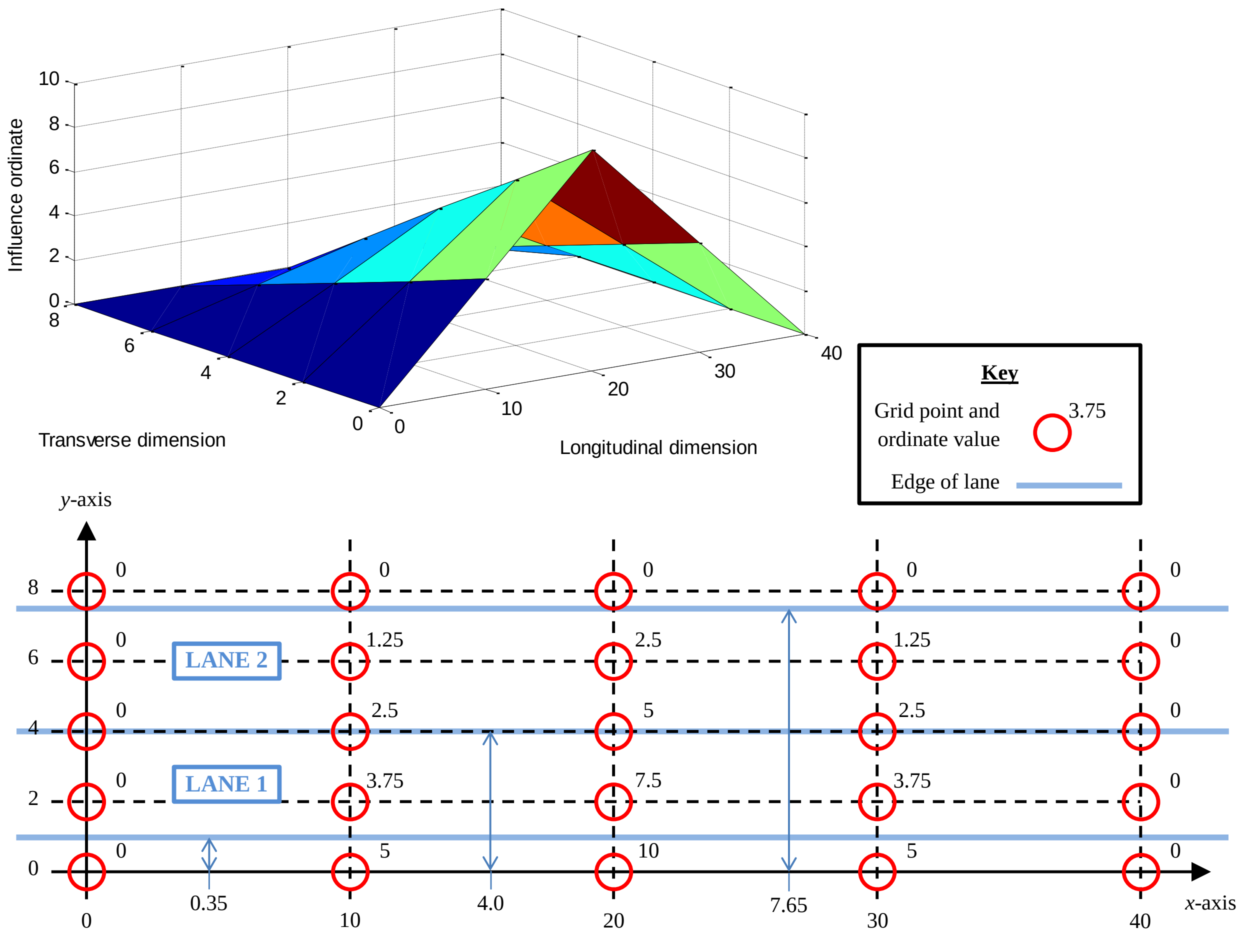
Any number of influence surfaces can be defined in the file. Each influence surface is defined on a rectangular grid according to a specific format as follows:

- The first line defines the basic data as follows:
  - Field 1: the influence surface number;
  - Field 2: the number of rows of data (the number of *x*- or longitudinal coordinates) specifying the influence surface grid points;
  - Field 3: the number of lanes on the bridge/influence line
  - Field 3+*i*: the location of the edge of lane *i* on the influence surface;
  - Last Field: the upper edge of the last lane.
- Line 2 defines the *y*- or transverse coordinates of the grid points.
- Each row then defines the ordinates at the grid points, the first value of which is the *x*-coordinate.

It is taken that Direction 1 traffic travels in the positive *x*-direction. For load application between grid points, linear interpolation is used in both directions. Hence, for flat areas of the influence surface a larger grid size can be used, but for more peaked zones, a more refined grid is required.

An example file is shown below in which a single test influence surface for mid-span bending moment of an edge beam is defined for comparison with a standard method using built-in or discrete influence lines and lane factors. The following figure describes the file and its definitions.

```
1,5,2,0.35,4.0,7.65
0,0,2,4,6,8
0,0,0,0,0,0
10,5,3.75,2.5,1.25,0
20,10,7.5,5,2.5,0
30,5,3.75,2.5,1.25,0
40,0,0,0,0,0
```



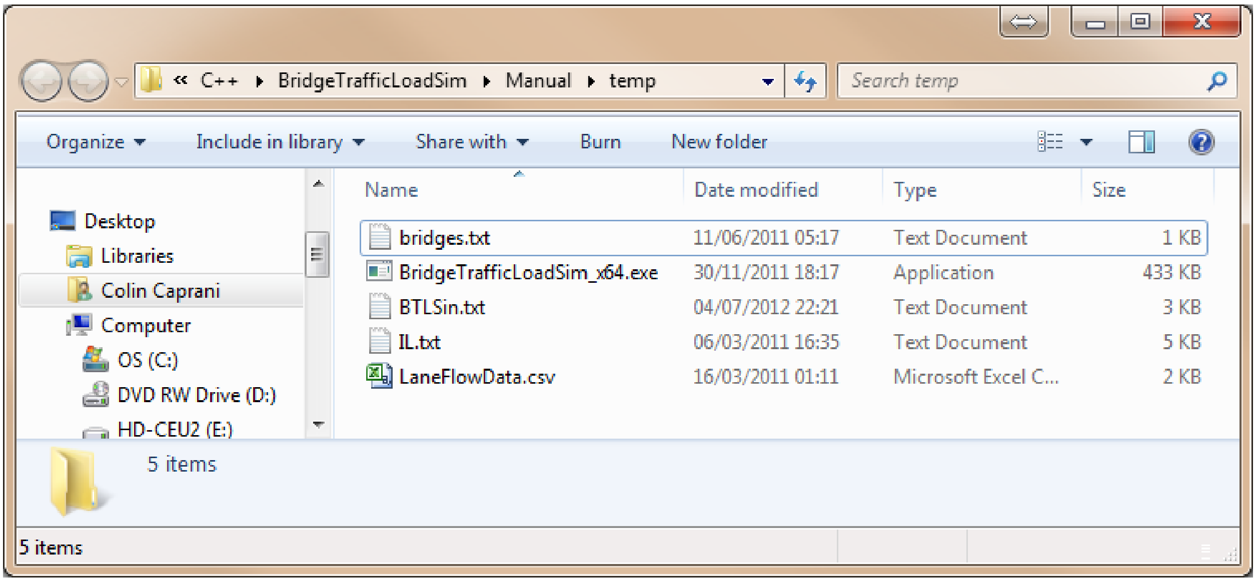
Important!

If multiple influence surfaces are defined for a bridge, the program assumes that the lane coordinates are the same for all influence surfaces. This is as it should be for a single real bridge of course. However, different lane coordinates can be used with different influence surface definitions for different bridges under the same traffic, either read or generated.

4. Using BTLS

4.1 Running the program

The program can be run from any folder as explained previously. An example working folder showing all files necessary to execute the program is given below:



Note that the 64 bit version is being used here.

Important!

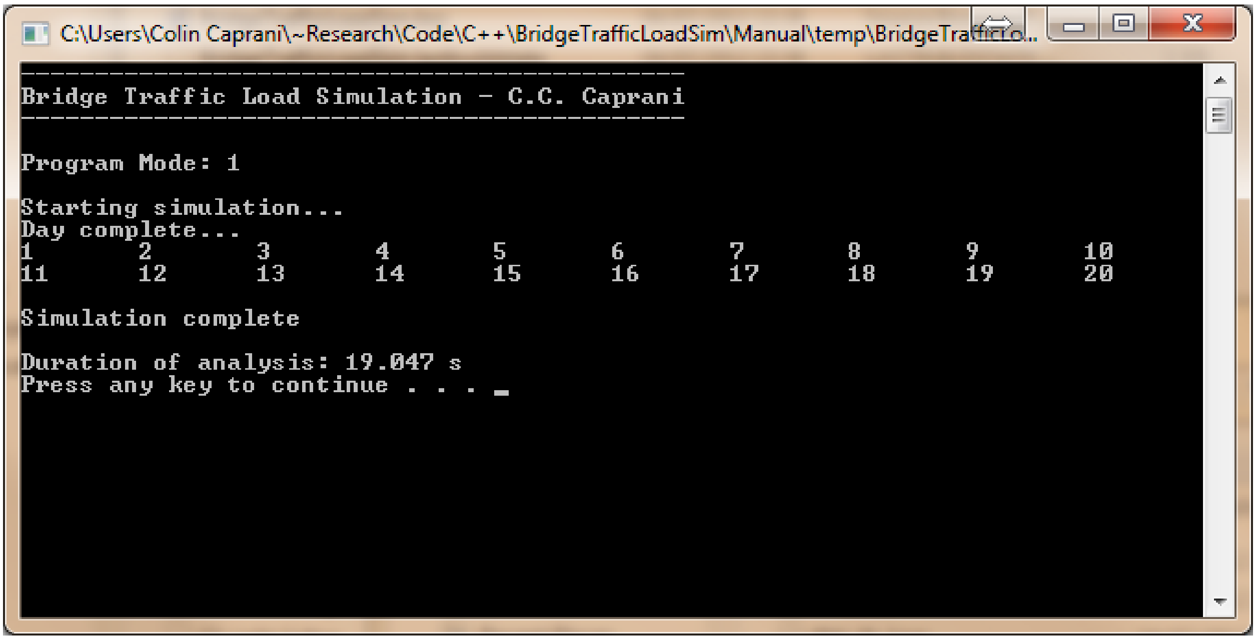
To run the program, double click the executable (`*.exe`) file.

4.2 Console output

Some examples of console output during program execution are given.

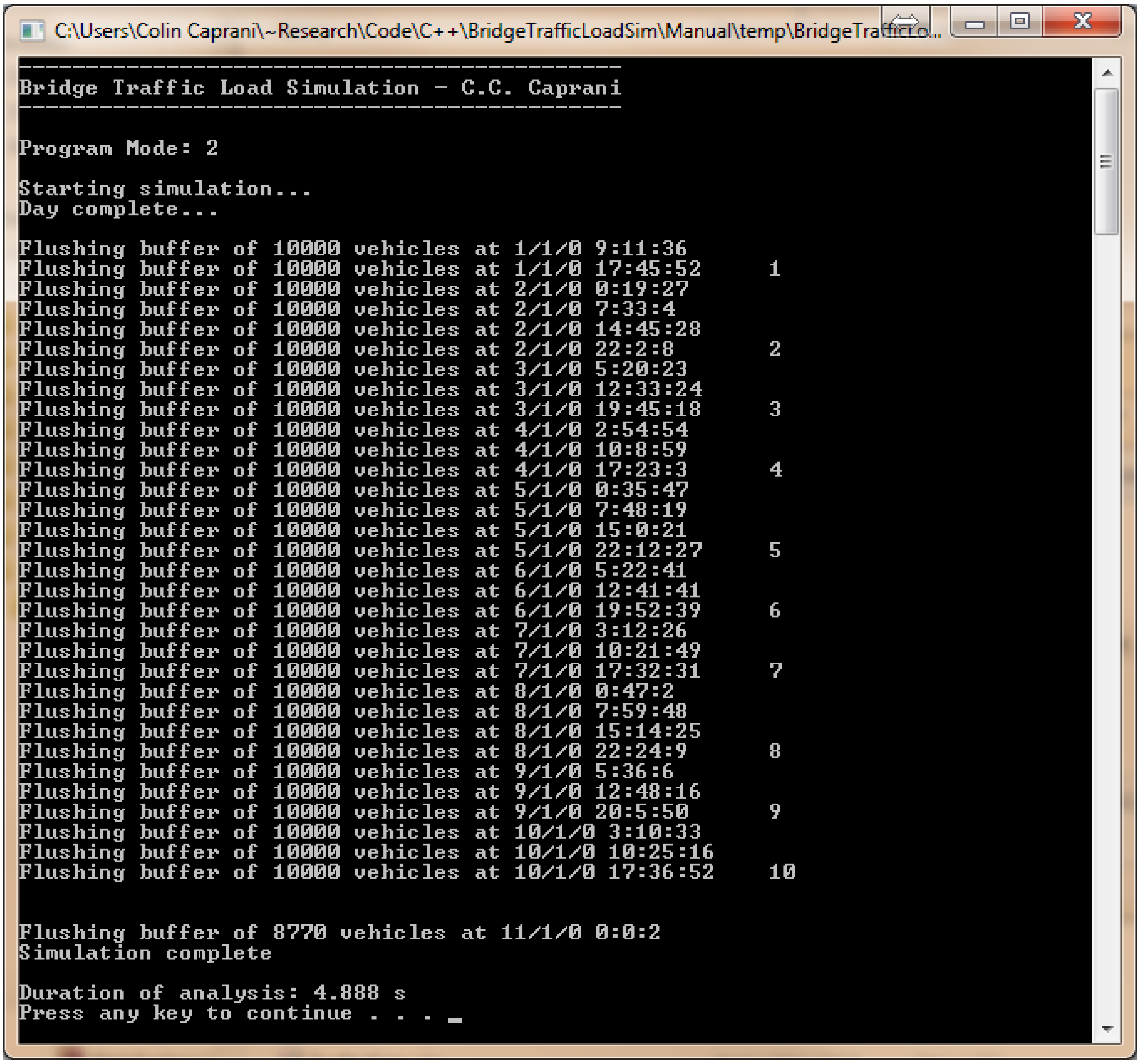
Example 1: Program Mode 1

After each day of simulation is complete, the program outputs a notice. At the end of the simulation the elapsed time is displayed for information. In this case, 20 days of traffic and generated and simulated crossing 5 bridges, each with 3 load effects.



Example 1: Program Mode 2

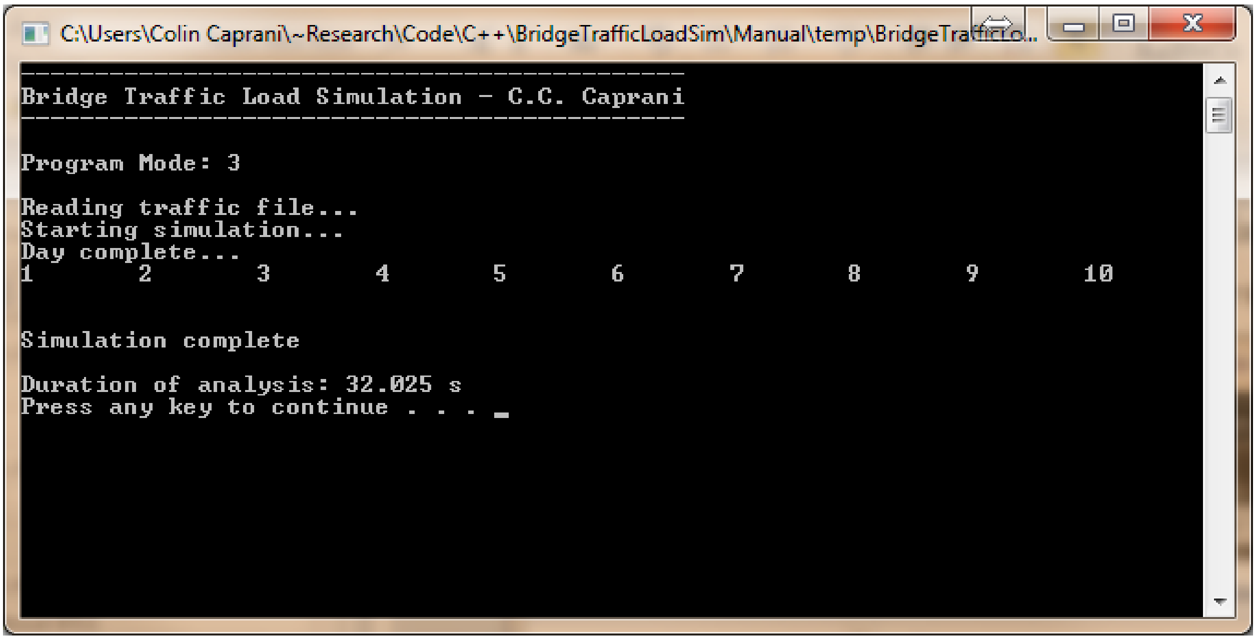
Ten days of vehicles are generated and the current day number is given (right hand columns). Each time the program flushed the vehicle buffer to the file, an output is given of the simulation time at which it occurred.



The fodler is then populated with the outputted vehicle file as named in "BTLSin.txt".

Example 3: Program Mode 3

The traffic file created in the last example is read in and passed over 5 bridges, each with 3 load effects. The output is as follows:



Note the slower execution time than for Program Mode 1 which has 20 days of traffic. This is caused by the additional overhead required to manipulate the 25 MB traffic file that has been read into memory.

4.3 Input Errors

When there are errors in the input, the behaviour is unpredictable. More informative user feedback will be built in soon.

Some potential problems:

- The supporting files (e.g. bridge, lane flow, IL) cannot be found in the working folder;
- The traffic folder cannot be found (it should be at "`C:\Traffic`");
- The vehicle file to be read in cannot be found (Program Mode 3).
- Outputs are not matched to Program Mode (e.g. Program Mode 2 – Generate vehicle file, but no vehicle file is to be output – Line 20 of `BTLSin.txt`.)

In each of these cases, the program may:

- Output helpful warnings;
- Flash open and close immediately;
- Remain open and display unusual text, such as "Conversion Error".

Admittedly, all behaviours should be of the first type – this will improve.

5. BTLS Output

5.1 Introduction

BTLS has the ability to produce large amounts of output, especially for long run simulations or heavily congested traffic. Accessing the hard drive often can significantly slow the program's execution. Therefore keep buffer sizes as large as memory and execution speed can allow.

All outputs are in text file format with specific information layouts and formats for each type of output file.

Effect on Execution Speed

Obviously the more outputs that are needed the slower the simulation. Some general comments to aid execution time are:

- Only output what is needed: this can be ascertained by a few short runs before doing the main long-run simulation.
- Use the buffer size variables to good effect: for sample runs monitor the program's RAM usage, increasing the buffer sizes as much as possible to prevent undue writing to disc, one of the slowest operations.
- The statistics output is intended mainly for short runs to give information for peaks-over-threshold analysis (i.e. threshold levels). Consequently turn it off when it is not required.
- Similarly the flow data output is only intended for short-run verification that the traffic is being properly modelled. Consequently turn it off when it is not required.
- For the Block Max and POT outputs, turn off the vehicle output files if they are not needed.

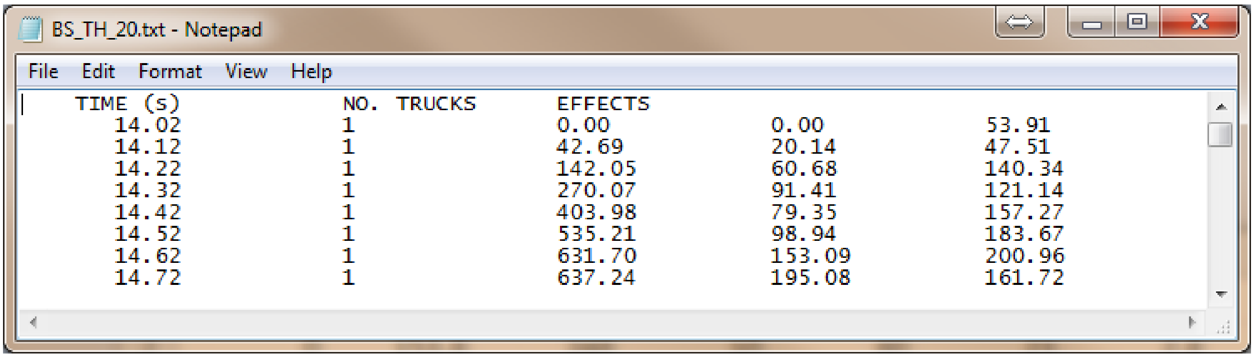
5.2 *Miscellaneous Output*

Time History File

If a full time history is selected to be output (Line 23 of `BTLSin.txt`), BTLS creates a single file for each bridge named:

`TH_L.txt`

Where *L* is the bridge length. The file gives the load effect at each time step of the simulation for each load effect considered for the bridge. Note that no output is given when there is zero load effect. A sample output is:


BS_TH_20.txt - Notepad

File Edit Format View Help

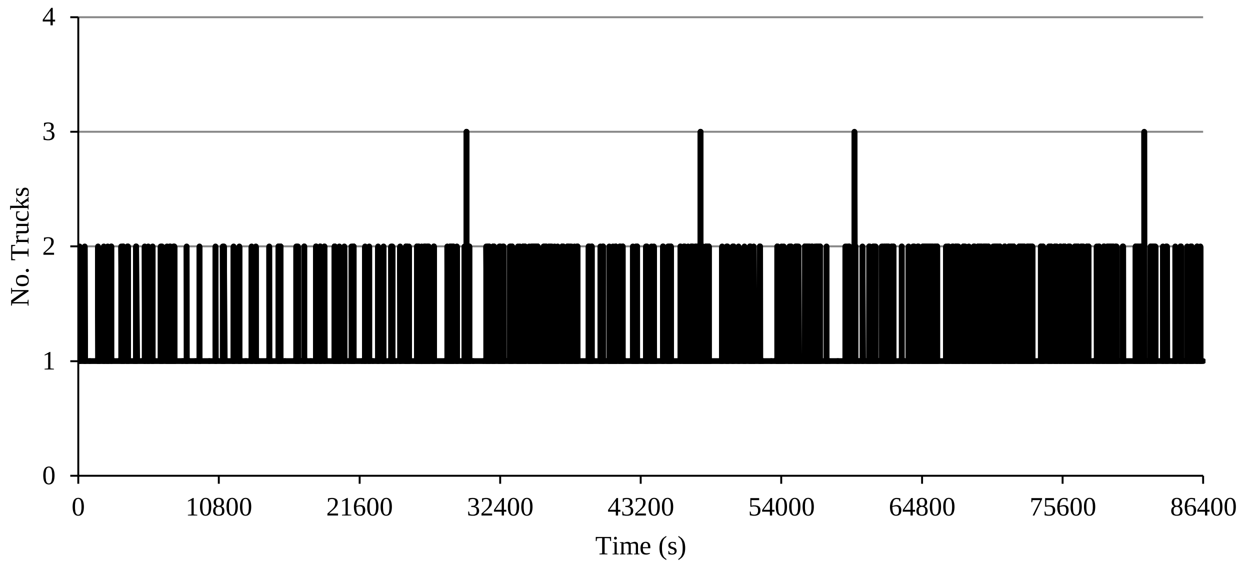
TIME (s)	NO. TRUCKS	EFFECTS		
14.02	1	0.00	0.00	53.91
14.12	1	42.69	20.14	47.51
14.22	1	142.05	60.68	140.34
14.32	1	270.07	91.41	121.14
14.42	1	403.98	79.35	157.27
14.52	1	535.21	98.94	183.67
14.62	1	631.70	153.09	200.96
14.72	1	637.24	195.08	161.72

The format is:

- Column 1: the current time. Note that time starts at the time of arrival of the first vehicle;
- Column 2: The number of trucks currently on the bridge;
- Columns 3+: The current value of each load effect is given, according to the order of the load effects in the bridge definition file.

This file can get extremely large, but for short runs (e.g. 1-day) it is very useful for checking and debugging output.

An example output is given showing the number of trucks on the bridge through the day. As can be seen, four 3-truck events occur on this 20 m bridge.

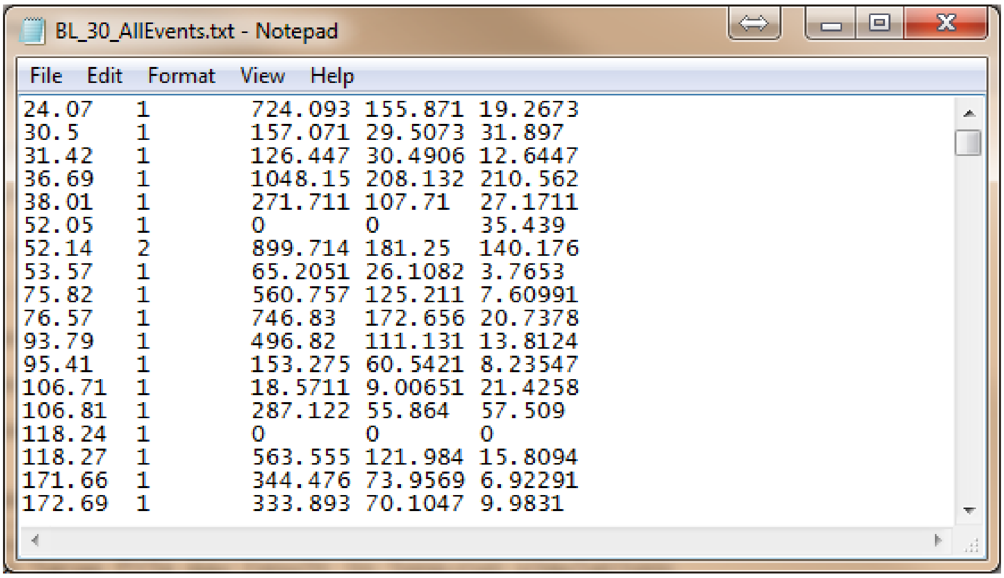


All Events File

If all loading events are selected to be output (Line 19 of `BTLSin.txt`), BTLS creates a single file for each bridge named:

```
BL_L_AllEvents.txt
```

Where *L* is the bridge length. The file gives the maximum of each calculated load effect recorded during each loading event to occur. A loading event is defined as the loading that occurs between two occasions of zero trucks on the bridge, or the departure or arrival of another vehicle. A sample output is:



24.07	1	724.093	155.871	19.2673
30.5	1	157.071	29.5073	31.897
31.42	1	126.447	30.4906	12.6447
36.69	1	1048.15	208.132	210.562
38.01	1	271.711	107.71	27.1711
52.05	1	0	0	35.439
52.14	2	899.714	181.25	140.176
53.57	1	65.2051	26.1082	3.7653
75.82	1	560.757	125.211	7.60991
76.57	1	746.83	172.656	20.7378
93.79	1	496.82	111.131	13.8124
95.41	1	153.275	60.5421	8.23547
106.71	1	18.5711	9.00651	21.4258
106.81	1	287.122	55.864	57.509
118.24	1	0	0	0
118.27	1	563.555	121.984	15.8094
171.66	1	344.476	73.9569	6.92291
172.69	1	333.893	70.1047	9.9831

The format is:

- Column 1: the starting time of the loading event.
- Column 2: The number of trucks in the event;
- Columns 3+: The maximum value of each load effect during the event.

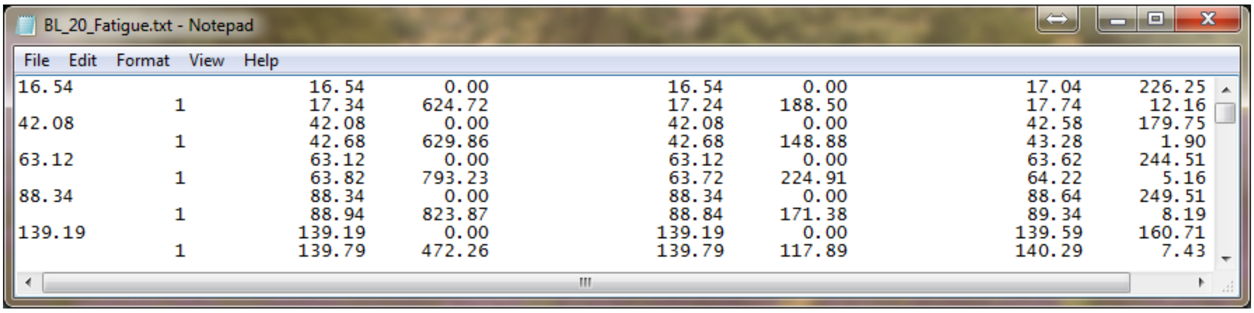
This file can get extremely large, but is useful for checking and debugging output.

Fatigue Events File

If fatigue events are selected to be output (Line 21 of `BTLSin.txt`), BTLS creates a single file for each bridge named:

`BL_L_Fatigue.txt`

Where *L* is the bridge length. The file gives the maximum and minimum values of each loading event (defined above) in chronological order. This is suitable for examination of fatigue cycles. A sample output is shown below:



BL_20_Fatigue.txt - Notepad

File Edit Format View Help

16.54		16.54	0.00	16.54	0.00	17.04	226.25
	1	17.34	624.72	17.24	188.50	17.74	12.16
42.08		42.08	0.00	42.08	0.00	42.58	179.75
	1	42.68	629.86	42.68	148.88	43.28	1.90
63.12		63.12	0.00	63.12	0.00	63.62	244.51
	1	63.82	793.23	63.72	224.91	64.22	5.16
88.34		88.34	0.00	88.34	0.00	88.64	249.51
	1	88.94	823.87	88.84	171.38	89.34	8.19
139.19		139.19	0.00	139.19	0.00	139.59	160.71
	1	139.79	472.26	139.79	117.89	140.29	7.43

The format is:

- Column 1 (Line 1): the starting time of the loading event;
- Column 2 (Line 2): The number of trucks in the event.

For each line, the subsequent columns are:

- Column 3: The time at which the value of load effect 1 is recorded;
- Column 4: the value of load effect 1.

Columns 5 & 6 give the time and value of load effect 2, and so on.

For example, this file shows that load effect 3 had a maximum value at 17.04 s, followed by a minimum at 17.74 s.

5.3 Vehicle Output

Traffic File

A traffic file can be output in any Program Mode if selected on Line 22 of BTLSin.txt. For Program Mode 2, this must be selected.

The file is named as specified on Line 23 of BTLSin.txt.

The program outputs vehicles in CASTOR format. An example of the program output for several trucks is given:

```
1001 1 1 2 0 12618155  54 43211 18 2743 27 0  0 0  0 0  0 0  0 0  0 0  0 0  0
1001 1 1 2 0 2 412133 137 67311 18 5441 6626 17 0  0 0  0 0  0 0  0 0  0 0  0
1001 1 1 2 0 2 598157  64 43211 18 3243 32 0  0 0  0 0  0 0  0 0  0 0  0 0  0
1001 1 1 2 0 44354134 336133511 18 7839 7040 6327 6327 63 0  0 0  0 0  0 0  0
1001 1 1 2 0 93062152 117 67311 18 3941 3926 39 0  0 0  0 0  0 0  0 0  0 0  0
1001 1 1 2 0101765131  97 44211 18 5344 44 0  0 0  0 0  0 0  0 0  0 0  0 0  0
```

Flow Statistics

For generated or read-in vehicle files, selecting this option will output files containing the flow rate and traffic stream composition. The files are named:

FlowData_D_L.txt

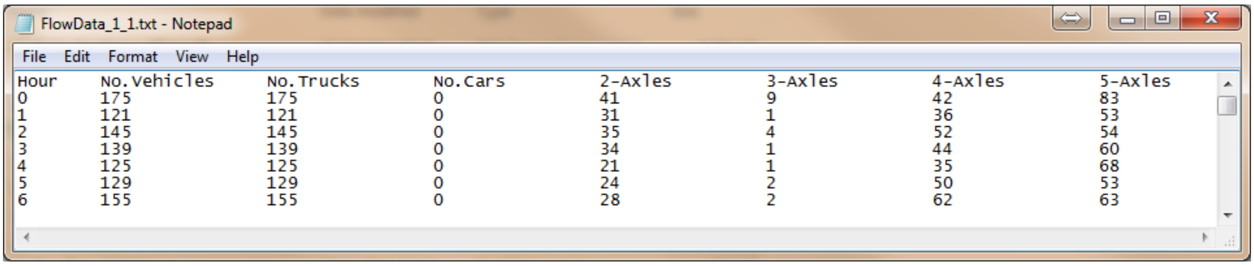
Where *D* is the direction number and *L* is the lane number corresponding to those in the Lane Flow Data definition file.

For each hour of the simulation, the following statistics are collected for each lane:

- The number of vehicles in the hour
- The number of trucks;

- The number of cars;
- The number of 2-axle, 3-axle, 4-axle and 5-axle trucks in the hour.

This output allows direct comparison with the input given in the Lane Flow Definition file is generating traffic. A screenshot is shown below:


FlowData_1_1.txt - Notepad

File Edit Format View Help

Hour	No.Vehicles	No.Trucks	No.Cars	2-Axles	3-Axles	4-Axles	5-Axles
0	175	175	0	41	9	42	83
1	121	121	0	31	1	36	53
2	145	145	0	35	4	52	54
3	139	139	0	34	1	44	60
4	125	125	0	21	1	35	68
5	129	129	0	24	2	50	53
6	155	155	0	28	2	62	63

5.4 Block Maximum Files

If block maximum vehicle files are selected to be output (Line 26 of BTLSin.txt), BTLS can creates different types of file output.

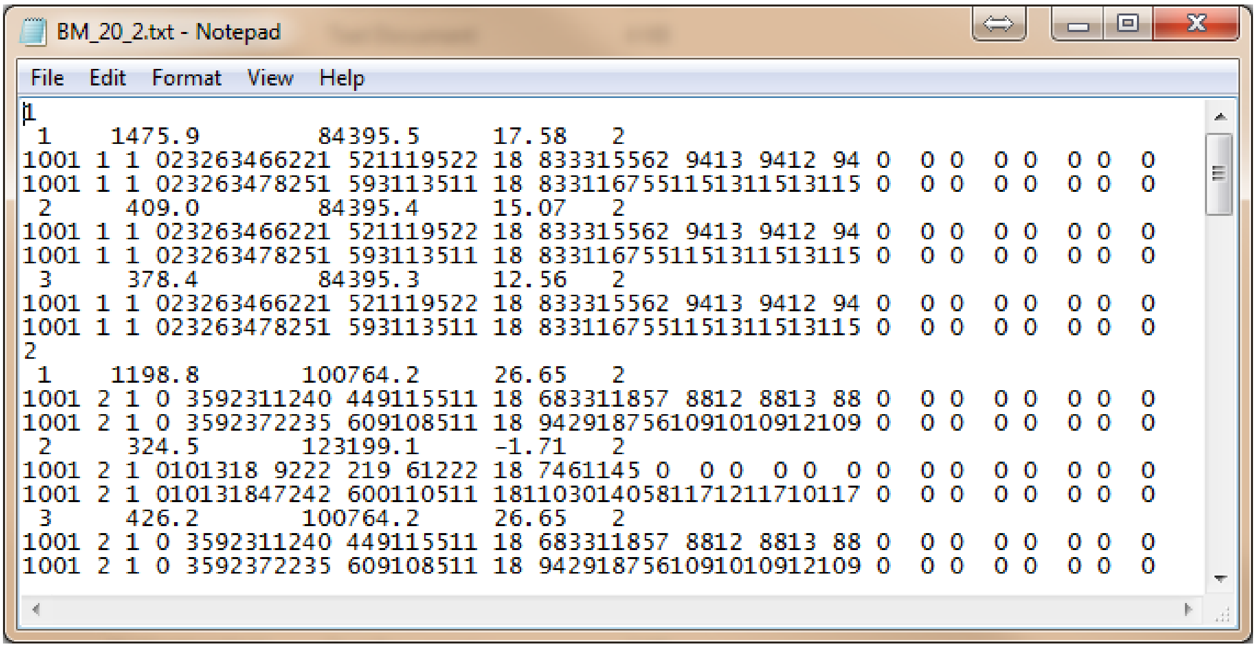
Output by Number of Trucks

This option is specified on Line 29 of BTLSin.txt. Output is given for each load effect of each bridge named:

BM_V_L_N.txt

Where *L* is the bridge length and *N* is the number of trucks comprising the loading events. In this manner a comprehensive breakdown of the causing of loading can be studied, suitable for application of the CDS method (Caprani et al 2008).

A sample output is shown:


BM_20_2.txt - Notepad
File Edit Format View Help

```
1
 1    1475.9         84395.5     17.58   2
1001 1 1 023263466221 521119522 18 833315562 9413 9412 94 0  0 0  0 0  0 0  0
1001 1 1 023263478251 593113511 18 8331167551151311513115 0  0 0  0 0  0 0  0
 2     409.0         84395.4     15.07   2
1001 1 1 023263466221 521119522 18 833315562 9413 9412 94 0  0 0  0 0  0 0  0
1001 1 1 023263478251 593113511 18 8331167551151311513115 0  0 0  0 0  0 0  0
 3     378.4         84395.3     12.56   2
1001 1 1 023263466221 521119522 18 833315562 9413 9412 94 0  0 0  0 0  0 0  0
1001 1 1 023263478251 593113511 18 8331167551151311513115 0  0 0  0 0  0 0  0
2
 1    1198.8        100764.2     26.65   2
1001 2 1 0 3592311240 449115511 18 683311857 8812 8813 88 0  0 0  0 0  0 0  0
1001 2 1 0 3592372235 609108511 18 9429187561091010912109 0  0 0  0 0  0 0  0
 2     324.5        123199.1     -1.71   2
1001 2 1 0101318 9222 219 61222 18 7461145 0  0 0  0 0  0 0  0 0  0 0  0 0  0
1001 2 1 010131847242 600110511 1811030140581171211710117 0  0 0  0 0  0 0  0
 3     426.2        100764.2     26.65   2
1001 2 1 0 3592311240 449115511 18 683311857 8812 8813 88 0  0 0  0 0  0 0  0
1001 2 1 0 3592372235 609108511 18 9429187561091010912109 0  0 0  0 0  0 0  0
```

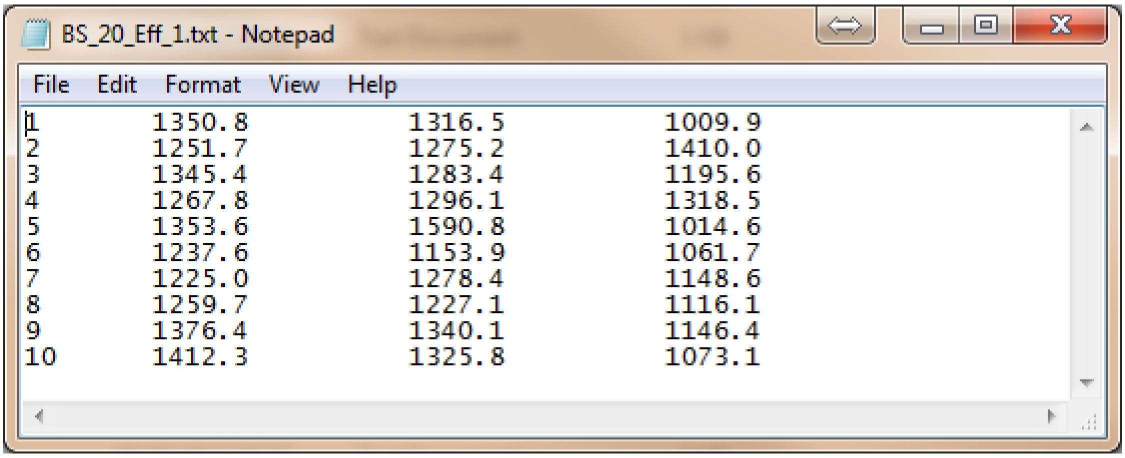
This file structure is termed a Loading Event File, and its structure explained later.

Summary Files

If block maximum summary files are selected to be output (Line 30 of BTLSin.txt), BTLS creates a file for each load effect of each bridge named:

`BM_S_L_Eff_E.txt`

Where *L* is the bridge length and *E* is the load effect number. The file gives the maximum load effect recorded during each block, broken down according to the number of trucks comprising the event. A sample output is:


BS_20_Eff_1.txt - Notepad

File Edit Format View Help

1	1350.8	1316.5	1009.9
2	1251.7	1275.2	1410.0
3	1345.4	1283.4	1195.6
4	1267.8	1296.1	1318.5
5	1353.6	1590.8	1014.6
6	1237.6	1153.9	1061.7
7	1225.0	1278.4	1148.6
8	1259.7	1227.1	1116.1
9	1376.4	1340.1	1146.4
10	1412.3	1325.8	1073.1

The format is:

- Column 1: The block index.
- Column 2: The block maximum 1-truck load effect;
- Columns 3: The block maximum 2-truck load effect
- Columns 4+: As appropriate, the block maximum 3-, 4-, … truck load effect.

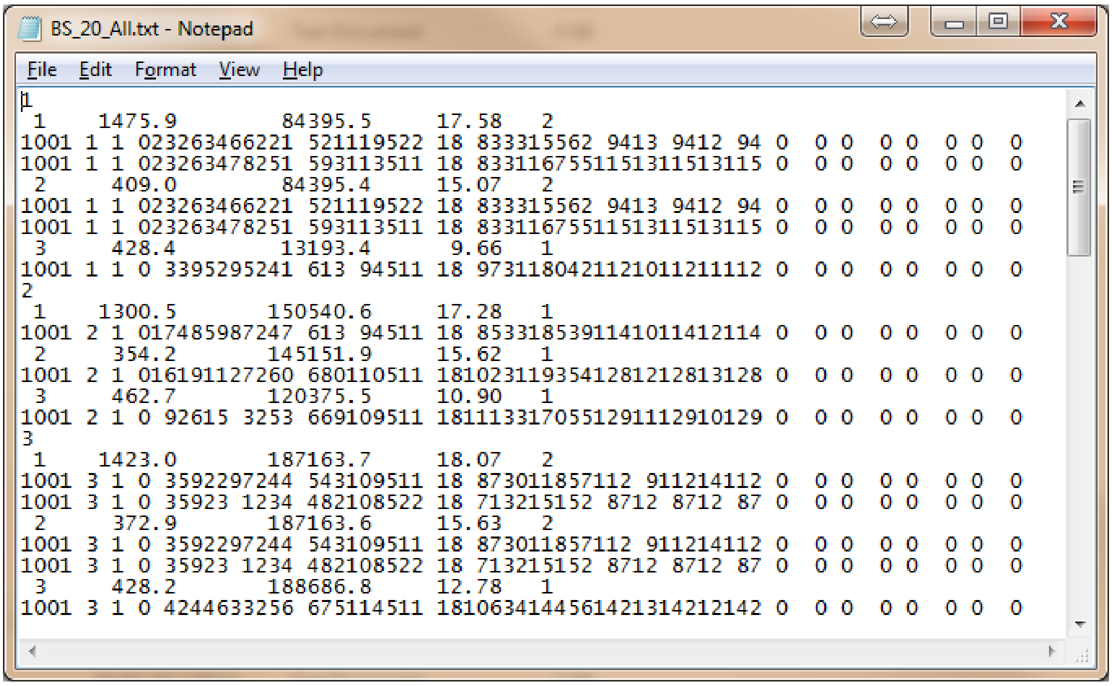
Taking the maximum across Columns 2+ gives the overall block maximum load effect.

Mixed Vehicle Output

This option is specified on Line 31 of `BTLSin.txt`. This form of output represents the conventional form in which the number of trucks comprising the event is not taken into account. Instead the maximum load effect recorded during the block is noted. One such file per bridge is output, named:

```
BM_V_L_All.txt
```

Where *L* is the bridge length. This file structure is a Loading Event File, explained later. A sample output showing 3 blocks is:



BS_20_All.txt - Notepad

File Edit Format View Help

```
1
 1     1475.9          84395.5      17.58    2
1001 1 1 023263466221 521119522 18 833315562 9413 9412 94 0  0 0  0 0  0 0  0
1001 1 1 023263478251 593113511 18 8331167551151311513115 0  0 0  0 0  0 0  0
 2      409.0          84395.4      15.07    2
1001 1 1 023263466221 521119522 18 833315562 9413 9412 94 0  0 0  0 0  0 0  0
1001 1 1 023263478251 593113511 18 8331167551151311513115 0  0 0  0 0  0 0  0
 3      428.4          13193.4       9.66    1
1001 1 1 0 3395295241 613 94511 18 9731180421121011211112 0  0 0  0 0  0 0  0
2
 1     1300.5         150540.6      17.28    1
1001 2 1 017485987247 613 94511 18 8533185391141011412114 0  0 0  0 0  0 0  0
 2      354.2         145151.9      15.62    1
1001 2 1 016191127260 680110511 1810231193541281212813128 0  0 0  0 0  0 0  0
 3      462.7         120375.5      10.90    1
1001 2 1 0 92615 3253 669109511 1811133170551291112910129 0  0 0  0 0  0 0  0
3
 1     1423.0         187163.7      18.07    2
1001 3 1 0 3592297244 543109511 18 873011857112 911214112 0  0 0  0 0  0 0  0
1001 3 1 0 35923 1234 482108522 18 713215152 8712 8712 87 0  0 0  0 0  0 0  0
 2      372.9         187163.6      15.63    2
1001 3 1 0 3592297244 543109511 18 873011857112 911214112 0  0 0  0 0  0 0  0
1001 3 1 0 35923 1234 482108522 18 713215152 8712 8712 87 0  0 0  0 0  0 0  0
 3      428.2         188686.8      12.78    1
1001 3 1 0 4244633256 675114511 1810634144561421314212142 0  0 0  0 0  0 0  0
```

As can be seen, there are a different number of trucks comprising the loading events that cause the maximum of each load effect in the block. Sometimes the same truck(s) loading event causes the maximum of 2 or more load effects, but in general different loading events cause the maximum of each load effect. This is because of the different shapes of the influence lines, and hence critical loading arrangements.

5.5 Peaks-Over-Threshold Files

If POT files are selected to be output (Line 33 of `BTLSin.txt`), BTLS can creates two types of file output.

Vehicle Files

This option is specified on Line 34 of `BTLSin.txt`. The vehicles comprising the loading event that is a peak are output in a Loading Event File structure. The files are named:

`PT_V_L_E.txt`

Where *L* is the bridge length and *E* is the load effect number. This file structure is a Loading Event File, explained later. A sample output showing 2 peaks is:

PT_V_30_1.txt - Notepad

File Edit Format View Help

```
1
 1    1202.7           651.6     23.56   1
1001 1 1 0 0105055236 556111511 18 84331165311910119151 19 0   0 0   0 0   0 0   0
 2     215.0           651.5     21.21   1
1001 1 1 0 0105055236 556111511 18 84331165311910119151 19 0   0 0   0 0   0 0   0
 3     170.3           651.1     11.78   1
1001 1 1 0 0105055236 556111511 18 84331165311910119151 19 0   0 0   0 0   0 0   0
2
 1    1206.6          1315.7     22.93   2
1001 1 1 0 0215456218 480105422 18 683115460129141 29 0  0 0   0 0   0 0   0 0   0
1001 1 1 0 0215477255 384114511 18 603311156 7114 7111 71 0   0 0   0 0   0 0   0
 2     249.9          1315.6     20.38   2
1001 1 1 0 0215456218 480105422 18 683115460129141 29 0  0 0   0 0   0 0   0 0   0
1001 1 1 0 0215477255 384114511 18 603311156 7114 7111 71 0   0 0   0 0   0 0   0
 3     134.6          1315.3     12.74   2
1001 1 1 0 0215456218 480105422 18 683115460129141 29 0  0 0   0 0   0 0   0 0   0
1001 1 1 0 0215477255 384114511 18 603311156 7114 7111 71 0   0 0   0 0   0 0   0
```

Note that the number of vehicles comprising the loading events are mixed and not separated out.

Summary Files

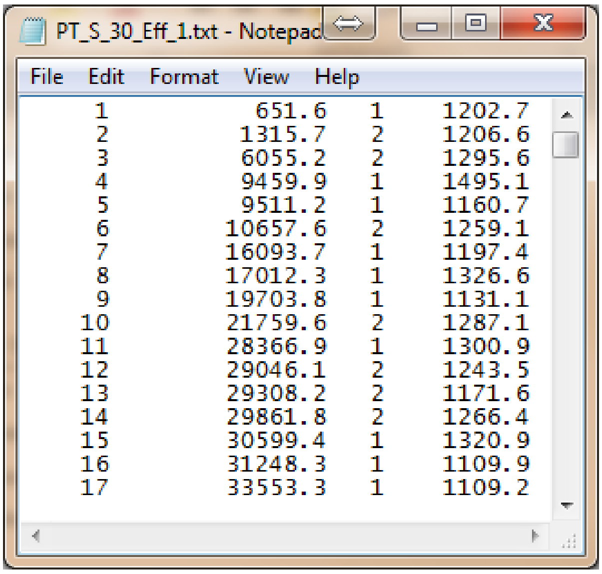
This option is specified on Line 35 of BTLSin.txt. The vehicles comprising the loading event that is a peak are output in a Loading Event File structure. The files are named:

    PT_S_L_Eff_E.txt

Where *L* is the bridge length and *E* is the load effect number. Each row of data in this file corresponds to a recorded peak. For each peak, the following data is ouput:

- The peak number;
- The time at which the peak occurred;
- The number of truck sin the event;
- The peak load effect value.

A screenshot of such a file is shown below.



1	651.6	1	1202.7
2	1315.7	2	1206.6
3	6055.2	2	1295.6
4	9459.9	1	1495.1
5	9511.2	1	1160.7
6	10657.6	2	1259.1
7	16093.7	1	1197.4
8	17012.3	1	1326.6
9	19703.8	1	1131.1
10	21759.6	2	1287.1
11	28366.9	1	1300.9
12	29046.1	2	1243.5
13	29308.2	2	1171.6
14	29861.8	2	1266.4
15	30599.4	1	1320.9
16	31248.3	1	1109.9
17	33553.3	1	1109.2

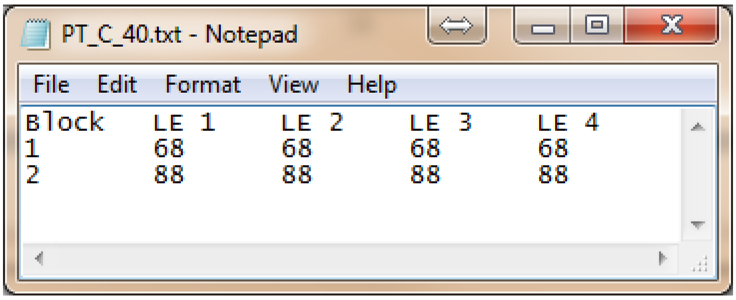
Note that since there is not much memory required to store peak information, the buffer size defined on Line 36 of BTLSin.txt should be large to prevent frequent disk writing which is slow.

Counter Files

This option is specified on Line 35 of BTLSin.txt. The number of peaks over the specified threshold occurring in each counter interval (defined on Lines XX of BTLSin.txt) is output for each load effect. The files are named:

PT_C_L.txt

Where *L* is the bridge length. Each row of data in this file corresponds to a counter interval, and for each block and load effect the number of peaks is given. A screenshot of such a file is shown below.



If the POT output buffer size (Line 36 of BTLSin.txt) is such that an output occurs during a counter interval, then the interval will have two rows (the number of peaks before output, and number after output) and the total number of peaks will be the sum of the two results. Again, since there is not much memory required to store peak information, the buffer size defined on should be large to prevent frequent disk writing which is slow.

5.6 Load Effect Statistics Output

BTLS can output some useful summary statistics of the calculated load effects. The statistics currently supported are:

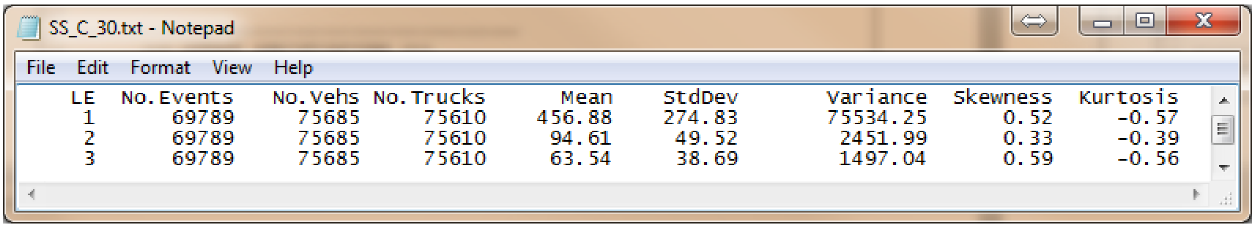
- Events count;
- The number of vehicles recorded;
- The number of trucks recorded
- The minimum load effect value;
- The maximum load effect value;
- The mean load effect value;
- The standard deviation of load effect;
- The load effect variance;
- The load effect skewness;
- The load effect kurtosis.

Cumulative Statistics

For this output, the statistics are accumulated throughout the full length of the simulation. The files are named:

```
SS_C_L.txt
```

Where *L* is the bridge length. In this file, each row corresponds to a load effect. A sample screenshot is:



SS_C_30.txt - Notepad

File Edit Format View Help

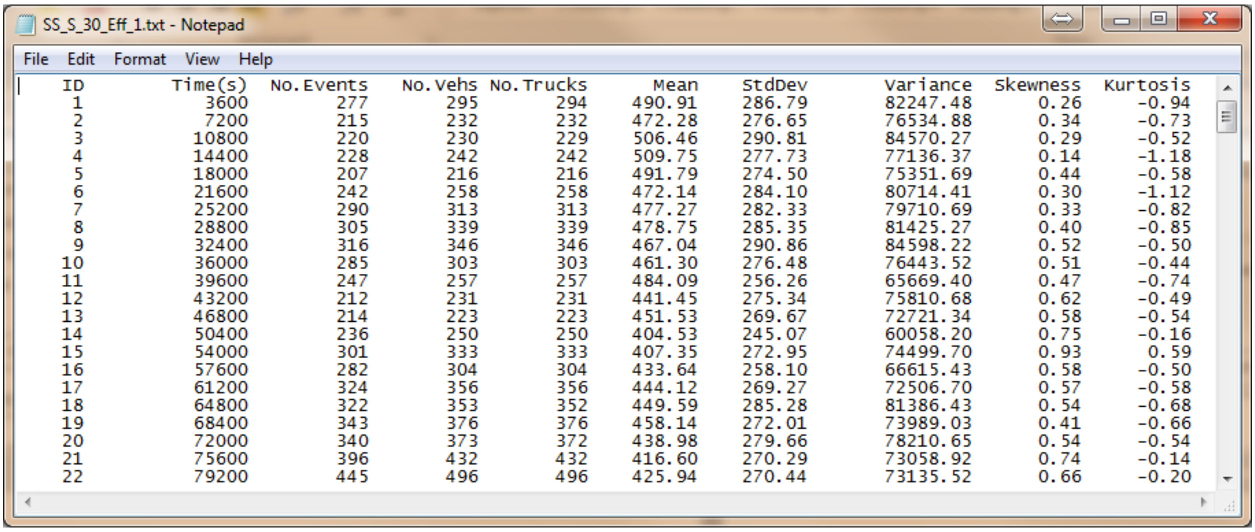
LE	No.Events	No.Vehs	No.Trucks	Mean	StdDev	Variance	Skewness	Kurtosis
1	69789	75685	75610	456.88	274.83	75534.25	0.52	-0.57
2	69789	75685	75610	94.61	49.52	2451.99	0.33	-0.39
3	69789	75685	75610	63.54	38.69	1497.04	0.59	-0.56

Interval Statistics

For intervals of specified duration (Line 40 of `BTLSin.txt`), the statistics are recorded and written to disk when the buffer size is exceeded (Line 41 of `BTLSin.txt`). This buffer size should be quite large since not much memory is needed to store statistics. The files are named:

`SS_S_L_Eff_E.txt`

Where *L* is the bridge length and *E* is the load effect number. A sample output is shown below. The interval number and time are also given.



SS_S_30_Eff_1.txt - Notepad

File Edit Format View Help

ID	Time(s)	No.Events	No.Vehs	No.Trucks	Mean	StdDev	Variance	Skewness	Kurtosis
1	3600	277	295	294	490.91	286.79	82247.48	0.26	-0.94
2	7200	215	232	232	472.28	276.65	76534.88	0.34	-0.73
3	10800	220	230	229	506.46	290.81	84570.27	0.29	-0.52
4	14400	228	242	242	509.75	277.73	77136.37	0.14	-1.18
5	18000	207	216	216	491.79	274.50	75351.69	0.44	-0.58
6	21600	242	258	258	472.14	284.10	80714.41	0.30	-1.12
7	25200	290	313	313	477.27	282.33	79710.69	0.33	-0.82
8	28800	305	339	339	478.75	285.35	81425.27	0.40	-0.85
9	32400	316	346	346	467.04	290.86	84598.22	0.52	-0.50
10	36000	285	303	303	461.30	276.48	76443.52	0.51	-0.44
11	39600	247	257	257	484.09	256.26	65669.40	0.47	-0.74
12	43200	212	231	231	441.45	275.34	75810.68	0.62	-0.49
13	46800	214	223	223	451.53	269.67	72721.34	0.58	-0.54
14	50400	236	250	250	404.53	245.07	60058.20	0.75	-0.16
15	54000	301	333	333	407.35	272.95	74499.70	0.93	0.59
16	57600	282	304	304	433.64	258.10	66615.43	0.58	-0.50
17	61200	324	356	356	444.12	269.27	72506.70	0.57	-0.58
18	64800	322	353	352	449.59	285.28	81386.43	0.54	-0.68
19	68400	343	376	376	458.14	272.01	73989.03	0.41	-0.66
20	72000	340	373	372	438.98	279.66	78210.65	0.54	-0.54
21	75600	396	432	432	416.60	270.29	73058.92	0.74	-0.14
22	79200	445	496	496	425.94	270.44	73135.52	0.66	-0.20

5.7 Loading Event File Structure

This file structure contains all information relating to the event. An example is shown below (from the Block Maximum Vehicle Files, Out by Number of Trucks screenshot).

Line	Data
1	1
2	1 1475.9 84395.5 17.58 2
3	1001 1 1 023263466221 521119522 18 833315562 9413 9412 94 0 0 0 0 0 0 0 0
4	1001 1 1 023263478251 593113511 18 83311675511513115 13115 0 0 0 0 0 0 0 0
5	2 409.0 84395.4 15.07 2
6	1001 1 1 023263466221 521119522 18 833315562 9413 9412 94 0 0 0 0 0 0 0 0
7	1001 1 1 023263478251 593113511 18 83311675511513115 13115 0 0 0 0 0 0 0 0
8	3 378.4 84395.3 12.56 2
9	1001 1 1 023263466221 521119522 18 833315562 9413 9412 94 0 0 0 0 0 0 0 0
10	1001 1 1 023263478251 593113511 18 83311675511513115 13115 0 0 0 0 0 0 0 0
11	2
12	1 1198.8 100764.2 26.65 2
13	1001 2 1 0 3592311240 449115511 18 683311857 8812 8813 88 0 0 0 0 0 0 0 0
14	1001 2 1 0 3592372235 609108511 18 942918756109101 0912109 0 0 0 0 0 0 0 0
15	2 324.5 123199.1 -1.71 2
16	1001 2 1 0101318 9222 219 61222 18 7461145 0 0 0 0 0 0 0 0 0 0 0 0 0 0
17	1001 2 1 010131847242 600110511 181103014058117121 1710117 0 0 0 0 0 0 0 0
18	3 426.2 100764.2 26.65 2
19	1001 2 1 0 3592311240 449115511 18 683311857 8812 8813 88 0 0 0 0 0 0 0 0
20	1001 2 1 0 3592372235 609108511 18 942918756109101 0912109 0 0 0 0 0 0 0 0

Each line is explained as follows.

Line 1:

The index of the current block (if block maximum output), or the index of the particular loading event in legacy files.

Line 2:

This is the load effect information line with 5 fields of data separated by tabs:

- Field 1: The load effect number;

- Field 2: The value of the load effect;
- Field 3: The time at which this load effect was found in seconds;
- Field 4: The distance of the first axle of the first truck on the bridge relative to the bridge datum, at the time of the crossing event maximum effect being reached. This allows one to sketch the positions of the trucks at the time of the load effect.
- Field 5: The number of trucks comprising the event.

Line 3-4:

These lines provide the truck data string in CASTOR format for later processing.

Line 5+:

The format of lines 2-4 continues for each of the effects calculated. Line 11 then provides the information for the start of the second block or loading event, and the format repeats itself.

6. Appendices

6.1 Appendix 1 – Traffic File Formats

CASTOR File Format

In the table below, the Format column gives the storage type of the data. IX refers to an integer of X number of digits, including leading or trailing zeros.

Record	Unit	Format
Head		I4
Day		I2
Month		I2
Year		I2
Hour		I2
Minute		I2
Second		I2
Second/100		I2
Speed	dm/s	I3
Gross Vehicle Weight - GVW	kg/100	I4
Length	dm	I3
Number of Axles		I1
Direction		I1
Lane		I1
Transverse Location In Lane	dm	I3
Weight Axle 1	kg/100	I3
Spacing Axle 1 - Axle 2	dm	I2
Weight Axle 2	kg/100	I3
Spacing Axle 2 - Axle 3	dm	I2
⋮	⋮	⋮
Spacing Axle 8 - Axle 9	dm	I2
Weight Axle 9	kg/100	I3

BeDIT File Format

This file format is similar to CASTOR except that the maximum number of axles possible is 20, the axle spacings are given by a three digit number, and the direction is zero-based.

Record	Unit	Format
Head		I4
Day		I2
Month		I2
Year		I2
Hour		I2
Minute		I2
Second		I2
Second/100		I2
Speed	dm/s	I3
Gross Vehicle Weight - GVW	kg/100	I4
Length	dm	I3
Number of Axles		I2
Direction (zero-based)		I1
Lane		I1
Transverse Location In Lane	dm	I3
Weight Axle 1	kg/100	I3
Spacing Axle 1 - Axle 2	dm	I3
Weight Axle 2	kg/100	I3
Spacing Axle 2 - Axle 3	dm	I3
⋮	⋮	⋮
Spacing Axle 19 - Axle 20	dm	I3
Weight Axle 20	kg/100	I3

DITIS File Format

This file format is similar to BeDIT except that the wheel track width (i.e. transverse width of the vehicle, wheel-to-wheel) is included for each axle; the transverse positon units are cm; and the direction is one-based. This is for use with influence surfaces. Further, the year is a four-digit number.

Field	Record	Unit	Format	Start
1	Head		I4	1
2	Day		I2	5
3	Month		I2	7
4	Year		I4	9
5	Hour		I2	13
6	Minute		I2	15
7	Second		I2	17
8	Second/100		I2	19
9	Speed	dm/s	I3	21
10	Gross Vehicle Weight - GVW	kg/100	I4	24
11	Length	dm	I3	28
12	Number of Axles		I2	31
13	Direction (1 or 2)		I1	33
14	Lane		I1	34
15	Transverse Location In Lane	cm	I3	35
16	Weight Axle 1	kg/100	I3	38
17	Track Width Axle 1	cm	I3	41
18	Spacing Axle 1 - Axle 2	dm	I3	44
19	Weight Axle 2	kg/100	I3	47
20	Track Width Axle 2	cm	I3	50
21	Spacing Axle 2 - Axle 3	dm	I3	53
⋮	⋮	⋮	⋮	⋮
72	Spacing Axle 19 - Axle 20	dm	I3	206
73	Weight Axle 20	kg/100	I3	209
74	Track Width Axle 20	cm	I3	212

6.2 Appendix 2 – References

- Caprani, C.C. (2005), *Probabilistic Analysis of Highway Bridge Traffic Loading*, PhD Thesis, School of Architecture, Landscape and Civil Engineering, University College Dublin, Ireland. http://www.colincaprani.com/research/phd-dissertation/
- Caprani, C.C. (2012), 'Calibration of a congestion load model for highway bridges using traffic microsimulation', *Structural Engineering International*, 22(3), August, in print.
- Caprani, C.C., OBrien, E.J. and McLachlan, G.J. (2008), 'Characteristic traffic load effects from a mixture of loading events on short to medium span bridges', *Structural Safety*, Vol. 30(5), September, pp. 394-404. 10.1016/j.strusafe.2006.11.006
- Grave, S.A.J. (2001), *Modelling of Site-Specific Traffic Loading on Short to Medium Span Bridges*, Ph.D. Thesis, Department of Civil Engineering, Trinity College Dublin.
- OBrien, E.J. and Caprani, C.C. (2005), 'Headway modelling for traffic load assessment of short- to medium-span bridges', *The Structural Engineer*, Vol 83, No. 16, August, pp. 33-36. http://www.istructe.org/thestructuralengineer/HC/Abstract.asp?PID=5494