INTEGRATION© RELEASE 2.40 FOR WINDOWS: User's Guide – Volume II: Advanced Model Features

Technical Support:
E-mail: VTTI.INTEGRATION@GMAIL.COM

Model Development:
Hesham A. Rakha, Ph.D. P.Eng., F.IEEE
Samuel Reynolds Pritchard Professor of Engineering, Charles E. Via, Jr. Dept. of Civil and Environmental Engineering
Courtesy Professor, Bradley Department of Electrical and Computer Engineering
Director, Center for Sustainable Mobility at the Virginia Tech Transportation Institute
E-mail: hrakha@gmail.com

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Chapter 1:
Introduction

Volume II of the INTEGRATION Release 2.40 User's Guide is intended to compliment the fundamental modeling techniques described in Volume I. The content of Volume II is aimed at providing the reader with a further description of some additional and more advanced modeling features that are not discussed in Volume I.

It is strongly advised that the reader first review Volume I and become comfortable with the basic modeling features prior to examining the more advanced features discussed in Volume II, as this guide is written in a style that assumes the reader is familiar with the contents of Volume I.

1.1   Master Control File

Details of
sample file

The Master Control File can be coded in three possible formats, called Format I, II or III. Volume I of this manual only described Format I. Samples of Format I, II and III are provided in Table 1, Table 4, and Table 6. Descriptions of the format of these files are provided in Table 2, Table 5, and Table 7, respectively. This volume also describes additional input/output files that were not described in Volume I.

In addition, a number of additional features will be described. First, independent of format I, II or III, the user can also code the master file to skip any outputs at time 0, as indicated next. Second, the user can change the random number seed in order to investigate differences in results because of randomness.

Table 1: Sample Master Control File – Format I.

Line #	Input
1	QNET master file - format I
2	2700 900 300 1 0
3	qnet\
4	qnet\output\
5	qnet1.dat
6	qnet2.dat
7	qnet3.dat
8	qnet4.dat
9	qnet5.dat
10	none
11	none
12	none
13	none
14	qnet10.out
15	none
16	none
17	none
18	none
19	none
20	none
21	none
22	none
23	none
24	none
25	none
26	none
27	none
28	none
29	none
30	none
31	none
32	none
33	none

Table 2: Description of basic fields in Master Control File- Format I

Line	Field	Description
1	1	File title (up to 300 characters) The title will appear in formatted output and can serve to clearly identify the results.
2	1	Total simulation time (seconds) [real] ($x \geq 1$)
	2	Frequency of outputs (seconds) to Output File 10 [integer] ($0 \leq x \leq$ *simulation time*) If $x = 0$ then no output is written to File 10. If $0 < x \leq$ *simulation time* then output is written to File 10 at time zero and every x seconds.
	3	Frequency of outputs (seconds) to Output Files 12 - 14 [integer] ($0 \leq x \leq$ *simulation time*) Recommend initial value of $x = 0$
	4	Routing Option [integer] (1, 2 or 3) if x=1, the routing will based on a Dynamic Traffic Assignment if x=2, the routing will be based on the pre-2.40 routing format. If x=3, the routing will be based on an expanded format. (recommend setting x=1)
	5	End of simulation PAUSE flag [integer] if x=0 simulation will not be paused at the end of the simulation horizon. If x=1, simulation will be paused at the end of the simulation. (Recommend setting x=1)
3	1	Folder path for folder in which the input files are located. If the line is left blank, then the model assumes that the files are in the current folder.
4	1	Folder path for folder in which output files are to be placed. If the line is left blank, then the model assumes that the files are in the current folder. Note that path must be different that the folder of the input files.
5-9	1	Names of required input data files (Files 1 - 5)
10-13	1	The name `none` or `NONE` should appear in these fields.
14	1	Name of the required standard output file (File 10) If `none` or `NONE` is entered a default file called `default.u10` will be created.
15-27	1	Names of the optional input/output files (Files 11-22) The name `none` or `NONE` should appear if the optional file is not desired.

Table 3: Input/Output File Descriptions

File	Description	Type
1	Node characteristic file	Input
2	Link characteristic file	Input
3	Traffic signal timing file	Input
4	Origin-Destination demand file	Input
5	Incident and rubbernecking file	Input
6	Travel time file to be used in building trees – Average travel times and standard deviations	Input
7	Travel time file to be used in building trees – Expected future travel times	Input
8	External tree file	Input
9	External tree file	Input
10	Standard output file	Output
11	Link flow file for entire simulation based on microscopic modeling	Output
12	Link flow file based on microscopic modeling	Output
13	Minimum path tree output file for routing method 2	Output
14	Signal timing file	Output
15	Trip-based vehicle probe file	Output
16	Link and second-by-second vehicle probe file	Output
17	Link travel time file. This file is used for research purposes only.	Output
18	Minimum path tree output file	Output
19	Minimum path tree output file	Output
20	Lane striping customization file	Input
21	Detector location file	Input
22	Bus stop file	Input
23	Ramp metering configuration file	Input
24	Listing of vehicle departures	Output
25	Not used	NA
26	Individual vehicle path file	Output
27	Emission concentration file	Output
28	Summary output file	Output
29	Link flow file based on mesoscopic modeling	Output
30	Time-space file name	Output

Table 4: Sample Master Control File for the INET network – Format II

Line #	Input
1	QNET master file - format II
2	2700 900 300 2 0
3	150 0 0 0 0
4	0.05 0.0 0.0 0.0 0.0
5	qnet\
6	qnet\output\
7	qnet1.dat
8	qnet2.dat
9	qnet3.dat
10	qnet4.dat
11	qnet5.dat
12	none
13	none
14	none
15	none
16	qnet10.out
17	none
18	none
19	none
20	none
21	none
22	none
23	none
24	none
25	none
26	none
27	none
28	none
29	none
30	none
31	none
32	none
33	none
34	none
35	none

Table 5: Description of fields in Master Control File – Format II

Line	Field	Description
1	1	File title (up to 300 characters) The title will appear in formatted output and can serve to clearly identify the results.
2	1	Total simulation time (seconds) [real]. ($x \geq 1$)
	2	Frequency of outputs (seconds) to Output File 10 [integer]. ($0 \leq |x| \leq$ *simulation time*) If $x = 0$ then no output is written to File 10. If $x > 0$ then output is written to File 10 at time zero and every x seconds. If $x < 0$ then no output is written to File 10 at time zero, but such output is written at every $|x|$ seconds thereafter.
	3	Frequency of outputs (seconds) to Output Files 12 - 14 [integer]. ($0 \leq |x| \leq$ *simulation time*) If $x = 0$ then no output is written to Files 12-14. If $x > 0$ then output is written to the files at time zero and every x seconds. If $x < 0$ then no output is written to the files at time zero, but such output is written at every $|x|$ seconds thereafter.
	4	Master File Routing Format [integer]. For routing format II, $x = 2$
	5	Simulation termination [integer] If $x = 0$ then animation screen closes at end of regular simulation. If $x = 1$ then animation screen pauses just prior to end of simulation.
3	1-5	Frequency (seconds) at which driver classes 1 through 5 respectively, will re-compute their minimum paths [integer]. ($0 \leq |x| \leq$ *simulation time*) If $x = 0$ then minimum paths are only computed at time zero. If $x > 0$ then minimum paths are re-computed on average every x seconds based on current real-time link travel times. (Note that real-time link travel times are only available for links under surveillance) If $x < 0$ then minimum paths are re-computed every $|x|$ seconds using a macroscopic rate-based traffic assignment technique.
4	1-5	Amount of error introduced into the link travel time data, prior to the calculation of the minimum path trees [real] ($0.0 \leq |x| \leq 0.5$), where x equals COV (standard deviation/mean) of link travel time. If $x = 0$ then no error is introduced. If $x \geq 0$ then error is considered to be normally distributed. If $x \leq 0$ then error is considered to be log-normally distributed.
5	1	Folder path for folder in which the input files are located. If the line is left blank, then the model assumes that the files are in the current folder.
6	1	Folder path for folder in which output files are to be placed. If the line is left blank, then the model assumes that the files are in the current folder. Note that path must be different from the input subfolder.
7-11	1	Names of required input data files (Files 1 - 5)
12-15	1	The name `none` or NONE should appear in these fields.
16	1	Name of the required standard output file (File 10) The name `none` or NONE should appear if the optional file is not utilized, however, a default file called `default.u10` will be created.
17-35	1	Names of the optional input/output files (Files 11-29) The name `none` or NONE should appear if the optional output file is not desired.

Table 6: Sample Master Control File for the INET network – Format III

Line #	Input
1	QNET master file - Format III
2	2700 900 300 3 0
3	2 2 2 2 2
4	150 0 0 0 0
5	0 0 0 0 0
6	1 1 1 1 1
7	0 0 0 0 0
8	0 0 0 0 0
9	1 1 1 1 1
10	0.05 0.0 0.0 0.0 0.0
11	qnet\
12	qnet\output\
13	qnet1.dat
14	qnet2.dat
15	qnet3.dat
16	qnet4.dat
17	qnet5.dat
18	none
19	none
20	none
21	none
22	qnet10.out
23	none
24	none
25	none
26	none
27	none
28	none
29	none
30	none
31	none
32	none
33	none
34	none
35	none
36	none
37	none
38	none
39	none
40	none
41	none

Table 7: Description of fields in Master Control File – Format III

Line	Field	Description
1	1	File title (up to 300 characters) The title will appear in formatted output and can serve to clearly identify the results.
2	1	Total simulation time (seconds) [real]. ($x \geq 1$)
	2	Frequency of outputs (seconds) to Output File 10 [integer]. ($0 \leq |x| \leq$ *simulation time*) If $x = 0$ then no output is written to File 10. If $x > 0$ then output is written to File 10 at time zero and every x seconds. If $x < 0$ then no output is written to File 10 at time zero, but such output is written at every $|x|$ seconds thereafter.
	3	Frequency of outputs (seconds) to Output Files 12 - 14 [integer]. ($0 \leq |x| \leq$ *simulation time*) If $x = 0$ then no output is written to Files 12-14. If $x > 0$ then output is written to the files at time zero and every x seconds. If $x < 0$ then no output is written to the files at time zero, but such output is written at every $|x|$ seconds thereafter.
	4	Master File Routing Format [integer]. For routing format III, $x = 3$
	5	Simulation termination [integer] If $x = 0$ then animation screen closes at end of regular simulation. If $x = 1$ then animation screen pauses just prior to end of simulation.
3	1-5	Minimum Path Construction Method [integer] If $x = 1$, Macroscopic User Equilibrium – Method of Successive Averages, If $x = 2$, Microscopic Feedback for Sub-population, If $x = 3$, Microscopic Feedback for Individuals, If $x = 4$, Microscopic Dynamic Traffic Assignment, If $x = 5$, Macroscopic User Equilibrium – Franke-Wolfe Algorithm, If $x = 6$, External trees specified in File 8, If $x = 7$, External trees specified in File 9, If $x = 8$, Distance based traffic assignment, If $x = 9$, Eco-routing microscopic feedback for individuals.
4	1-5	Frequency (seconds) at which driver classes 1 through 5 respectively, will re-compute their minimum paths pre-trip [integer]. ($0 \leq x \leq$ *simulation time*) If $x = 0$ then minimum paths are only computed at time zero. If $x > 0$ then minimum paths are re-computed on average every x seconds.
5	1-5	Frequency (seconds) at which driver classes 1 through 5 respectively, will re-compute their minimum paths en-route [integer]. ($0 \leq x \leq$ *simulation time*) If $x = 0$ then minimum paths are only computed at time zero. If $x > 0$ then minimum paths are re-computed on average every x seconds.
6	1-5	Information source for driver classes 1 through 5 respectively [integer] If $x = 1$ then paths are updated based on real-time information If $x = 2$ then paths are updated based on data from File 6. If $x = 3$, then paths are updated based on data from File 7.
7	1-5	Update weight for real-time data base for vehicles of same type [integer]. ($0 \leq x \leq 100$) OBSOLETE
8	1-5	Update weight for real-time data base for vehicles of same type [integer]. ($0 \leq x \leq 100$) OBSOLETE
9	1-5	Travel time assumption for vehicles not under surveillance [integer]. If $x = 1$ then travel times are assumed to be at free-speed If $x = 2$ then travel times are assumed to be as listed in File 6. If $x = 3$, then travel times are assumed to be as listed in File 7.
10	1-5	Amount of error introduced into the link travel time data, prior to the calculation of the minimum path trees [real] ($0.0 \leq |x| \leq 0.5$), where x equals COV (standard deviation/mean) of link travel time. If $x = 0$ then no error is introduced. If $x \geq 0$ then error is considered to be normally distributed. If $x \leq 0$ then error is considered to be log-normally distributed.
11	1	Folder path for folder in which the input files are located. If the line is left blank, then the model assumes that the files are in the current folder.

12	1	Folder path for folder in which output files are to be placed. If the line is left blank, then the model assumes that the files are in the current folder. Note that path must be different from the input subfolder.
13-17	1	Names of required input data files (Files 1 - 5)
18-21	1	The name `none` or `NONE` should appear in these fields.
22	1	Name of the required standard output file (File 10) The name `none` or `NONE` should appear if the optional file is not utilized, however, a default file called `default.u10` will be created.
23-41	1	Names of the optional input/output files (Files 11-29) The name `none` or `NONE` should appear if the optional output file is not desired.

1.2   Omissions of Outputs at Time 0

File 10 Outputs at Time 0

It can be noted that in Field 2 on Line 2 the output frequency for File 10 is specified as a negative number. This implies that outputs of summary statistics will not be produced at time 0. Instead outputs will be produced in File 10 at output intervals equal to the absolute value of the entry in Field 2 on Line 2. If the value in this field is set to a positive value, as described in Volume I, summary statistics will also be produced at time 0.

Optional File Outputs at Time 0

The generation of any optional output files at time 0 can be controlled in a manner identical to that described above for the standard output file (File 10). Specifically, if the specified interval of output is a positive value, then initial outputs to the files will be produced at time zero. In addition, any subsequent outputs will be written at intervals equal to the stated value. However, if the specified output interval is a negative value, then outputs at time zero will not be produced and outputs to the files will be written only at intervals equal to the stated value.

The sample Master Control File entry of –1800 and -900 indicate that no summary statistics will be output to either File 10 or the optional output files at time 0. Instead, the first output to File 10 will be produced at time 1800 seconds, while the first output to any optional output files will be produced at time 900 seconds.

1.3   Alternate Traffic Assignment/Routing Methods

The INTEGRATION simulation model provides for 7 basic traffic assignment/ routing options:

Option 1:   Time-Dependent Method of Successive Averages (MSA)
Option 2:   Time-Dependent Sub-Population Feedback Assignment (SFA)
Option 3:   Time-Dependent Individual Feedback Assignment (IFA)
Option 4:   Time-Dependent Dynamic Traffic Assignment (DTA)
Option 5:   Time-Dependent Frank-Wolf Algorithm (FWA)
Option 6:   Time-Dependent External Routing 1 – File 8 (ER1)
Option 7:   Time-Dependent External Routing 2 – File 9 (ER2)
Option 8:   Distance Based Routing
Option 9:   Time-Dependent Sub-population Feedback Eco-Assignment (ECO-SFA)
Option 10:   Time-Dependent Individual Feedback Eco-Assignment (ECO-IFA)

Method 4: **Dynamic Traffic** **Assignment** **(DTA)**	The default traffic routing mechanism in INTEGRATION, as described in Volume I, involves the use of a Dynamic Traffic Assignment or DTA. This method computes the minimum path for every scheduled vehicle departure, in view of the link travel times anticipated in the network at the time the vehicle will reach these specific links. The anticipated travel time for each link is estimated based on anticipated link traffic volumes and queue sizes. While this procedure has become the default, it is referred to as Routing Option 4.
	The basic format of Routing Option 4 involves the execution of a complete Dynamic Traffic Assignment model prior to the simulation of the traffic. During this DTA, the routes of all vehicles are computed using the above procedure. Upon completion of this DTA, the actual simulation simply implements the routings computed as per the DTA.
Method 1: **Method of** **Successive** **Averages** **(MSA)**	An alternate routing mechanism involves the derivation of a time series of Method of Successive Averages (MSA) traffic assignments. Within this MSA, each time slice is evaluated in isolation of the conditions that prevail either prior or subsequent to the time slice in which the vehicle departs. Furthermore, each vehicle is considered to only affect travel times during the time slice in which the vehicle is scheduled to depart.
	The link travel times, upon which the route computations are based, are estimated based on the prevailing O-D pattern and an approximate macroscopic travel time relationship for each link. Multiple paths are computed in an iterative fashion, where the tree for each subsequent iteration, is based on the travel times estimated during the previous iteration. The weight assigned to each new tree is $1/N$ where N is the iteration number. In other words, the first tree is assigned a weight of 1.0, the second tree a weight of 0.5, and the third tree a weight of 0.333. As weights are added to each new tree, the weights on each previous tree is reduced proportionally.
Method 2: **Sub-population** **Feedback** **Assignment** **(SFA)**	Routing mechanism 2 involves the application of a Sub-population Feedback Assignment (SFA) mechanism. Specifically, all drivers of a specific type are divided into 5 sub populations each consisting of 20% of all drivers. The paths for each of these sub populations are then updated every *t* seconds during the simulation based on real-time measurements of the link travel times for that specific vehicle class. The value of *t* is a user-specified value. Furthermore, the minimum path updates of each vehicle sub population are staggered in time, in order to avoid having all vehicle sub populations update their paths at the same time. This results in 20% of the driver paths being updated every t/5 seconds.
Method 3: **Individual** **Feedback** **Assignment** **(IFTA)**	Routing mechanism 3 involves the application of the above feedback mechanism to individual drivers, rather than sub populations. It is referred to as an Individual Feedback Assignment (IFA). The main difference is that, while the paths under method 2 were always shared by at least 20% of the drivers, within method 3 all paths are customized to each individual driver and may therefore be unique relative to any other drivers.
	Given that paths can be computed for individuals, rather than sub populations, the path calculations are triggered based on a vehicle's departure rather than some average time interval as in method 2 (SFA). In other words, when paths are calculated for sub-populations in method 2, paths are recomputed for an entire sub-population at specified intervals in anticipation of their subsequent use when vehicles belonging to that sub-population actually depart. This means that paths may often be several seconds, if not minutes old, when a specific vehicle actually departs.

In contrast, for method 3, the path for a specific vehicle is computed at the time of departure of that vehicle. This implies that the paths are computed based on the most recent information that is available at this time of departure.

Method 5: Frank-Wolf Algorithm (FWA)	Traffic assignment method 5 provides for a Frank-Wolf Algorithm (FWA). It is virtually identical Method 1 (MSA), except that the weights are optimized rather than set to a default of 1/N. In other words, while the first tree is still assigned a weight of 1.0, the weight on the second tree is optimized rather than set to a default of 0.5. Once the proportion of weights between trees 1 and 2 are set, they are locked in before the weight on the third tree is optimized next. As the weight is added to the third tree, the weights on each of the previous trees are reduced proportionally.
Method 6: External Routings 1 (ER1)	Traffic assignment method 6 provides the user one of two opportunities to specify External Routings (ER1). Specifically, if routing method 6 is specified, vehicles will be routed based on the paths specified in File 8, if present. The specified paths in File 8 can be multi-path and be time-dependent.
Method 7: External Routings 2 (ER2)	Traffic assignment method 7 provides the user with the second opportunity to specify External Routings (ER2). Specifically, if routing method 7 is specified, vehicles will be routed based on the paths specified in File 9, if present. The specified paths in File 9 can also be multi-path and time-dependent.
Method 9: Eco-routing	This traffic assignment is similar to method 2 except that the vehicles route themselves to minimize their fuel consumption as opposed to minimizing their travel times. Fuel consumption levels of various vehicles are stored in a database for each of the five vehicle classes. Subsequent vehicle class departures use the database for their routing decisions. It should be noted that only the fuel consumption experiences of the specific vehicle class is used in building routes for the same vehicle class.
Method 10: Eco-routing	This traffic assignment is similar to method 3 except that the vehicles route themselves to minimize their fuel consumption as opposed to minimizing their travel times. Fuel consumption levels of various vehicles are stored in a database for each of the five vehicle classes. Subsequent vehicle class departures use the database for their routing decisions. It should be noted that only the fuel consumption experiences of the specific vehicle class is used in building routes for the same vehicle class.
Sample Master File	The sample master file in Table 1.3a illustrates that:

      a.   Driver type 1 is routed using routing option 1,
      b.   Driver type 2 is routed using routing option 2,
      c.   Driver type 3 is routed using routing option 3,
      d.   Driver type 4 is routed using routing option 4, and
      e.   Driver type 5 is routed using routing option 5.

1.3 Pre-Trip Path Update Interval

Line 4 in master file formats II and III permits the specification of the pre-trip path update interval for a specific vehicle class. At present this option only is relevant to routing options 1 and 2. For routing options 3 and 4, this field should be set to 0.

Method 1	The interpretation of the pre-trip path update interval for routing option 1 can be best explained by considering a simulation run in which traffic is loaded onto the network for 7200 seconds (2 hours). If the routing update interval is also set to 7200, all of the individual departures between time 0 and 7200 seconds will be accumulated into an aggregate O-D departure demand for each O-D pair. The departure demand will be scaled by a factor of 0.5 to then yield an hourly departure rate. Based on this aggregate

O-D departure rate, a macroscopic equilibrium traffic assignment will be computed and all vehicles on the network between 0 and 3600 will be routed using the results of the macroscopic equilibrium traffic assignment.

If instead the pre-trip path update interval is set to, for example 900 seconds, then at time 0 all vehicle departures between time 0 and 900 seconds will be accumulated into an aggregate O-D demand. This aggregate O-D demand will be multiplied by a factor of 4.0 in order to yield an hourly rate. Subsequently, a macroscopic equilibrium traffic assignment will be performed, and all vehicles departing between time 0 and 900 will be routed in a manner consistent with the results of this macroscopic traffic assignment. At time 900 seconds, a similar macroscopic equilibrium traffic assignment will then be performed for all departures between time 900 and 1800 seconds. The results of this assignment will be utilized to set all routes for vehicles departing between time 900 and 1800 seconds.

It should be noted that all departures within a given time interval are, at least within the traffic assignment, considered to complete their trips within the given time interval. They are therefore also considered to not interact with any departures during the previous or the subsequent traffic assignment interval. Any variations in departure rates within a traffic assignment interval are also ignored. Finally, any queues accumulated at the end of one time interval are not carried over as additional demand for the next traffic assignment interval.

Method 2   The interpretation of the pre-trip update interval for routing option 2 will be described next using the same demand scenario that was described above. Specifically, if the update interval is 7200 seconds, paths for all sub-populations will be computed at the start of the simulation in order to bootstrap the traffic assignment process. Subsequently, 20% of all drivers will have their paths updated at time 1440 seconds, while another 20% of all drives will have their paths updated at time 2880 seconds. All other sub-populations will have their paths updated in a similar fashion until all drives will have their paths updated by time 7200 seconds.

Each update is based on the most recent link travel time data available at that time. Furthermore, the minimum path calculations consider only the travel times at that time, and do not reflect any forecasts into the future. It should also be noted that individual drivers can only utilize the most recent path available for their sub-population at the time of their departure.

If the pre-trip update frequency is set to 900 seconds, new sub-population paths will be computed at times 180, 1080, 1980, … , 180+900*n seconds, for 20% of the driver population. The next 20% of drivers will have their paths updated at time 360 seconds, and at all subsequent intervals equal to 360+900*n. Drivers departing at any time will have their paths computed based on the most recent path re-computation for that vehicle driver type and sub-population.

Methods 3/ 4   The selection of different pre-trip update intervals for methods 3 and 4 has no effect, for the following reasons. In the case of method 3, all paths are computed automatically at the specific vehicle's time of departure. In the case of method 4, paths are computed automatically for all vehicles prior to the start of the simulation.

Sample Master File   In the sample master file, pre-trip paths are updated every 600 seconds for driver types 1, 2 and 5. The use of methods 4 and 5 for driver types 4 and 5 obviates the need for a pre-trip update interval for them.

1.4   En-Route Path Update Interval

En-route update intervals can only specified on Line 5 using master file format III.

If the en-route path update interval is set to 0 for a specific driver type, all pre-trip paths are locked in for a specific driver type as soon as the vehicle departs its origin. For routing methods 2 and 3, en-route updates are permitted, as described next.

In contrast, for routing methods 1, 4, 5, 6 and 7 the paths are always locked in at the time of departure and can at present not be altered en-route. If a non-zero value of the update frequency is specified, then this value is ignored by the program.

Method 2

If the en-route update interval is set to 0, paths will be permanently locked in at the time of departure. For all update intervals greater than 0, the most recent pre-trip routing update for that driver type will be implemented for the remaining portion of a vehicle's en-route trip as soon the next en-route update is requested. En-route update requests at intervals, when pre-trip routings have not changed, have no effect.

In general, 4 types of en-route update intervals can be specified. If the en-route update interval is set to 0, then paths are locked in at the start of each vehicle's trip, and never changed once en-route. If the en-route update interval is longer than the pre-trip interval, the paths for en-route vehicles will be update but this update will be less frequent that for drivers who are just departing. If this en-route update interval is the same as the pre-trip interval, than paths are updated en-route as soon as they are recomputed for the pre-trip decision makers. Finally, if the en-route update interval is less than the pre-trip update interval, any updates occurring at times when there are no pre-trip updates will have no effect. En-route updates coinciding with pre-trip updates will take effect immediately en-route as well.

Lets consider a pre-trip update interval of say, 600 seconds. This implies that a vehicle departing at time 1790 seconds, in the absence of en-route updates, would have paths consistent with the traffic flow conditions at time 1200 seconds. This would be the case even though it actually spends most of its trip interacting with vehicles departing between time 1800 and 2400 seconds.

If the en-route path update interval is set instead to 120 seconds, each driver on the network (and belonging to that driver type) would have its path re-examined every 120 seconds. This would result in a re-examination at time 1800 seconds. Consequently, the path update at time 1800 seconds will be provided to a vehicle departing at time 1790 seconds, even though the conditions at time 1800 seconds were unknown at the vehicle's time of departure. A similar update would also occur at time 1920 seconds, at least for the remaining portion of the vehicle's trip.

Method 3

The use of an en-route update interval equal to 0 for routing method 3 results in all paths being locked in at the time of departure of each vehicle. If the update interval is greater than 0, then the remaining path for that specific vehicle will be reexamined exactly at the time the update interval is reached.

Sample Master File

Within the sample master file, the en-route update intervals for all driver types 1 to 4 are set to 300 seconds. The use of an update interval to driver type 5 is not applicable as it uses routing option 4.

1.5   Routing or Travel Time Information Source

Line 6 in the master file permits the specification of the source of the routing or travel time source. This line, at present, only applies to routing methods 2 and 3, as indicated next. In the case of routing methods 1, 4, and 5, all routes are computed based on internally generated travel time estimates from the pre-simulation Microscopic Traffic Assignment. In the case of routing methods 6 and 7, the paths are specified explicitly from an external source

Methods 2/3   In the case of routing methods 2 and 3, the routing information source flag also creates 3 alternatives. The most common one is alternative 2, which is activated by coding this field as 2. It causes the model to compute paths based on the most recent on-line measurement of link travel times for that driver type. If this flag is set to 2, then paths are computed based on the link travel times read in from File 6, if available. If this flag is set to alternative 3, then paths are computed based on the link travel times from File 7, if available.

Methods 1/4/5/6/7   As noted above, the use of this field is not relevant to routing methods 1, 4, 5, 6 or 7.

1.6   Travel Time Update Weighting

The entries on Lines 7 and 8 of the master file for Format III used to specify the weights to be utilized in computing on-line estimates of link travel times for methods 2 and 3. These fields are now obsolete.

1.7   Default Travel Time for Links with No Surveillance

Line 9 permits the specification of a default link travel time for links that are not under real-time surveillance. This line only is relevant to routing options 2 and 3.

Links not under Active Surveillance   Routing options 2 and 3 rely on the feedback of link travel times from vehicles that have just previously traversed the links they are now contemplating to use. Just real-time information is only available for links that are under active real-time surveillance, as indicated in File 2. When real-time surveillance is not available, the indication on Line 9 indicates what alternate travel time will be assumed.

Defaults other than the Link Free Speed   An entry of 1 in the fields of Line 9 indicates that link travel times, for links that are not under surveillance, will be considered to have a link travel time equal to the free speed for that link. In contrast, an entry of 2 will result in the link travel time being set to that which is listed in File 6, if available. Finally, an entry of 3 will result in the link travel times being set equal to those listed in File 7, if available.

1.8   Link Travel Time Error

Line 10 permits the coding of errors in link travel time measurement and/or perception. At present, such errors can be introduced for routing methods 1, 2 and 3. The coding of link errors for routing method 4 has no impact.

Method 1   Within routing method 1, the use of a non-zero error coefficient will result in the use of 5 iterations of the method of successive averages. Before each iteration, the link travel times that were obtained from the previous iteration will be modified in order for them to contain an error level that, on average, is equal to the value specified on Line 10. The errors that are introduced, for each subsequent iteration, are independent of those introduced in the previous iteration.

Method 2 In both the rate based and the default feedback oriented traffic assignment approach, the introduction of a positive coefficient of variation for perceived travel times (will result in a stochastic traffic assignment.

The network loading procedure will consider link travel time errors that are considered normally distributed. Conversely, if a negative coefficient of variation is provided, the link travel time errors are considered to follow a log-normal distribution.

1.9 Running in Batch Mode

The user may run a batch of files by creating a master file called "batch.int." A sample file and the format of the file is presented in Table 1.4a and 1.4b, respectively.

Table 8: Sample Batch Master Control File

```
INET Batch File
 10
 inet-1.int
 inet-2.int
 inet-3.int
 inet-4.int
 inet-5.int
 inet-6.int
 inet-7.int
 inet-8.int
 inet-9.int
 inet-10.int
```

Table 9: Description of Fields in Batch Master File

Line	Field	Description
1	1	File title (up to 40 characters)
		The title will appear in formatted output and can serve to clearly identify the results.
2	1	Number of runs to be included in batch [integer]
3+	1	Name of master control file for each run in batch

1.10 Running with Multiple Random Seeds

The user may run a scenario using a different random seed. The seed is computed as the decimal portion of the simulation time multiplied by 1000 (field 1 of line 2 in the master control file). For example, a simulation time of 3600.01 would result in an initial seed for the random number generator of 10 (0.01×1000). Running with different seeds results in different model outcomes due to the stochastic nature of traffic.

Chapter 2:
Introduction

2.1   File 1: Node Characteristics

There are two advanced features that can be invoked within the Node Characteristic File. The first is macro-zone clustering and the second is the presence of information availability indicators, such as a changeable message sign (CMS). A description of the fields contained within a generic node descriptor file may be found in Table 2.1.

Macro-zone clustering

Macro-zone clusters consist of two or more clustered destination zones, with one destination zone considered to be the macro-zone centroid. The macro-zone centroid acts as the initial routing destination for all vehicles bound for any of the destination defined within the cluster. When a vehicle reaches the boundary of the cluster, which is assumed to be located on a two-kilometer radius from the zone centroid, it is then routed to the actual destination within the cluster based on a minimum distance tree. In this process, it should be noted that any vehicle routed based on a minimum distance tree would no longer respect any link restrictions or turn prohibitions defined in the INTEGRATION input files.

Macro-zones provide the user with a mechanism for modeling larger traffic networks with reduced computational requirements. As such, this feature is useful in coding networks having a number of destination zones that exceeds the limit provided by the version of INTEGRATION that is being used.

The sample Node Descriptor File indicates that destination zones 8, 9 and 10 are clustered, with zone 9 serving as the macro-zone centroid. All of the other destination zones are not clustered and are associated with a unique macro-zone number, while origin zones and intermediate nodes have an entry of zero for the macro-zone cluster number.

Information availability indicator

Within the Master Control File, the routing mechanism of each vehicle class is defined. In the event that a particular vehicle has access to an information device, then the default routing mechanism may be temporarily replaced by an alternative routing mechanism of another vehicle class. For example, vehicles with routing mechanism type 1 may be temporarily transformed into vehicles with routing mechanism type 2. This transformation is initiated when a vehicle enters the upstream end of the link at the end of which the information providing device exists, and will be sustained for a time period of 180 seconds after the vehicle has departed this link. If this feature is utilized, a response vehicle class must be specified for each of the five possible vehicle classes. However, the existing routing characteristics of a given vehicle class may be maintained if no response is specified or if the original vehicle class is specified as the response vehicle class. It should also be noted that all non-routing characteristics for specific vehicle classes are maintained, even if the routing mechanism is transformed.

Once the response vehicle classes have been specified, the user must state, using a two digit number, the percentage of total vehicles that will respond to the information providing device. Values between 00 and 99 are considered valid, such that a vehicle compliance to the device of 100 percent is not available.

The sample Node Characteristic File indicates that an information availability indicator exists at node 115. This node is located on the eastbound portion of the

freeway, just upstream of the second interchange. Upon entering the link immediately upstream of this node (link 21), 50 percent of type 4 vehicles will inherit the routing characteristics of type 2 vehicles, while all other vehicle classes will maintain their current routing characteristics. These changes in routing characteristics will remain in effect, for each type 4 vehicles, for the first 180 seconds after node 115 is passed.

Table 10: Description of fields in Node Characteristic File (File 1)

Line	Field	Description
1	1	File title (up to 40 characters)
2	1	Number of nodes for which information is provided in the file [integer] ($2 \leq x \leq$ *max. number of nodes*)
	2	Scale factor applied to all x-coordinate values listed in the file [real] ($x > 0.0$) This factor can be used to convert coordinates from any unit system into another system, such as converting from mile to kilometers.
	3	Scale factor applied to all y-coordinate values listed in the file [real] ($x > 0.0$) This factor can be used to convert coordinates from any unit system into another system, such as converting from mile to kilometers.
3+	1	Unique node identification number [integer] ($1 \leq x \leq$ *max. node number*) Node numbers cannot be duplicated and should be consistent with those in Files 2 and 4.
	2	X coordinate of node location [real] ($x > 0.0$)
	3	Y coordinate of node location [real] ($x > 0.0$)

	4	Node type identifier [integer]
		($1 \leq x \leq 4$)
		      1 = both origin and destination zone
		      2 = destination zone only
		      3 = origin zone only
		      4 = intermediate node only

	5	Macro-zone cluster number [integer] ($|x| \leq$ *max. macro-zone number*) $x = 0$ for node type 3 or 4. $x > 0$ when zone is associated with another macro-zone cluster centroid -x (node type 1 or 2 only). $x < 0$ when zone is the centroid of macro-zone cluster x (node type 1 or 2 only).

	6	Information availability indicator [real]
		($0 \leq x < 55555.99$), where x is a seven digit number *abcde.zz* indicating vehicle class routing transformations in response to information providing devices, where:
		      a: vehicle class 1 response vehicle class [integer] ($1 \leq a \leq 5$)
		      b: vehicle class 2 response vehicle class [integer] ($1 \leq b \leq 5$)
		      c: vehicle class 3 response vehicle class [integer] ($1 \leq c \leq 5$)
		      d: vehicle class 4 response vehicle class [integer] ($1 \leq d \leq 5$)
		      e: vehicle class 5 response vehicle class [integer] ($1 \leq e \leq 5$)
		      zz: the percentage of vehicles that will respond [integer] ($00 \leq zz \leq 99$)
		If $x = 0$ then no information providing device exists at that node.

	7	Optional alpha-numeric descriptor of this node (maximum 40 characters)

2.2   File 2: Link Characteristics

The Link Characteristic File provides the user with an extensive range of advanced modeling options. These features include link specific output options, the coding of zone connectors, the placement of lane additions, the degree of variability in vehicle speeds, and the critical gap sizes for opposed movements. In addition, some options permit detailed turning movements to be specified at intersections, link use restrictions to be noted, and link surveillance levels to be set. This section also describes an advanced coding format that is indicated by a negative number of link entries in the file. This format allows you to code specific signalized movements, like for example advanced left turns and permissive left turns.

A sample Link Characteristic File for the INET network is provided in Table 2.3a, while a description of the fields contained within this file may be found in Table 2.3b.

Output options   Link specific outputs can be eliminated from Output Files 10, 11, and 12 if the link identification number in the file is made negative. In the sample Link Characteristic File, for example, links numbered 1 through 8 are identified with negative link numbers and thus output for these links will not be provided in the link-oriented output files.

Zone connectors   Zone connectors are typically used to represent a group of links that are required to connect an origin or destination zone with the actual road network. A link coded as a zone connector will behave as a regular link, except that minimum path calculations will consider an additional penalty of 3600 seconds in order to discourage use of these links mid-route. Consequently, links coded as zone connectors will only be considered by the routing algorithm when alternative regular links do not exist. A zone connector may be coded in File 2 by specifying a negative free speed for the link and can be identified graphically by a dashed shoulder/median line.

In the sample Link Characteristic File, links 1, 3, 4, and 7 are coded as zone connectors with a free speed of 60 km/h. These links join zones 17 and 19 to the network.

Placement of lane drops and additions   Within the INTEGRATION model, lane drops and lane additions will occur by default on the right hand side of the roadway, both with respect to any lane flow continuity between consecutive links and the graphical presentation on the screen. However, there are circumstances in the field where lane drops or lane additions may occur on the left hand side of the roadway. The model is capable of representing such configurations, in terms of lane flow continuity logic, by specifying a negative number of lanes for the link on which the addition/drop occurs. If more than one lane addition occurs between consecutive links, only a single lane can be added to the left and all of the remaining lanes will be added to the right. Graphically, the model always displays lane drops or lane additions on the right.

Consider Figure 2.3a, which illustrates a common lane addition configuration of a 2-lane roadway expanding into a 3-lane section. Configuration I illustrates the lane mapping logic for a lane addition to the right. In this case, vehicles in lane *a* will be mapped onto lane *c*, while vehicle in lane *b* will be mapped onto lane *d*. The discretionary lane changing logic will dictate when lane *e* may begin to be utilized. Conversely, configuration II illustrates the lane mapping logic for a lane addition to the left. Vehicles in lane *a* will be mapped onto lane *d*, while vehicle in lane *b* will be mapped onto lane *e*. Lane *c* may begin to be utilized when the discretionary lane changing logic is activated.
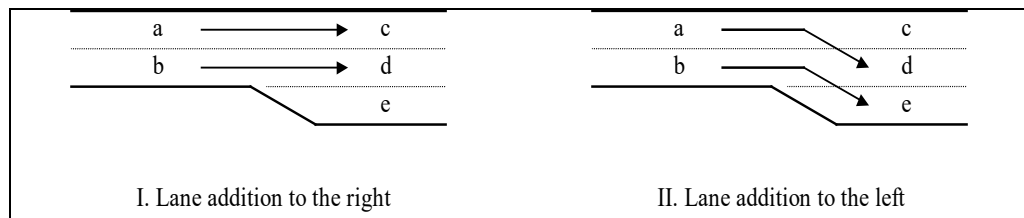
Figure 1: Impact of modeling lane additions to the left or right

In the sample Link Characteristic File, the eastbound approach to the detailed intersection (link 81) has a lane addition coded to left, as indicated by the negative number of lanes (-3.0). The westbound approach (link 88), however, has the lane addition coded to the default right.

Vehicle speed variability factor

The predicted average speed of vehicles is dictated by the prevailing traffic volume and speed-flow relationship. It is possible to model some variability in individual speeds from this average by specifying a speed variability factor, which is defined as the desired coefficient of variation (standard deviation/mean). This feature has the implicit impact of generating a random capacity headway. A positive value will distribute speeds and headways based on a normal distribution, while a negative value will distribute them based on a log-normal distribution.

In the sample Link Characteristic File, the speeds of vehicles on the eastbound freeway (links 31-35 for example) will be made to vary based on a normal distribution, that is characterized by a coefficient of variation of 5 percent.

Gap acceptance

Vehicles are often required to find acceptable gaps in an opposing flow, typically when attempting unprotected movements at either signalized or partially controlled intersections. The user has the option to specify up to two links that may oppose the current link, in which case the default gap size is assumed. Alternatively, all of the neighboring links may be set to represent an opposition to the current link and an acceptable base gap size may be specified. This feature is invoked by specifying the negative equivalent of the desired gap size (seconds) in the field of the first opposing link. It is recommended that this later option only be invoked if the number of opposing links exceeds two, as the internal computation of opposing flows tends to increase the associated processing time significantly.

The base gap size default to the model, if an opposing link is specified explicitly, is set to 4.5 seconds. In addition, if the number of opposing lanes for the vehicle to cross is limited to one, then 0.5 seconds will be subtracted to the acceptable gap for a right turn movement and 0.5 seconds will be added to the acceptable gap for a left turn movement. An additional 1.5 seconds is added for a stop sign. No additional time will be added to the basic gap size if a straight through movement is being attempted, but another 0.5 seconds will be added to the acceptable gap size for each additional lane the vehicle must cross in order to complete the maneuver. For example, if a vehicle must turn left across two lanes of opposing flow, the acceptable gap size will be 5.5 seconds, assuming a base gap size of 4.5 seconds.

It has been observed that drivers will typically accept a smaller gap size as their wait time increases. The INTEGRATION model incorporates this behavior by utilizing a linear decay function, which reduces the acceptable gap size from the computed maximum value to a value of zero over a period of 120 seconds. The decay process is initiated each time the speed of a waiting vehicle makes the transition from above the

speed-at-capacity to below this threshold value. The user has more flexibility to override the gap acceptance logic using the ops_gaps.dat file, as will be described later.

In the sample Link Characteristic File for the INET network, opposing links and gap acceptance are defined for the typical signalized intersection illustrated in Figure 1.2. In the default format, opposing links are specified for the eastbound and westbound approaches. For example, left turners from the eastbound approach (link 81) will be opposed by through traffic from the westbound approach (link 88), while right turners from the eastbound approach (link 81) will be opposed by through traffic from the southbound approach (link 125). Alternatively, an acceptable gap size is stated for the northbound and southbound approaches. For example, an acceptable base gap size of 6 seconds is specified for all approaches conflicting the northbound approach (link 142) and the southbound approach (link 125).

Right turn on red and protected left turns

Many jurisdictions permit vehicles to complete right turns on a red signal. This capability may be invoked by specifying a negative value for the signal number that controls the exit privileges for the link in question. Vehicles that complete this maneuver, and that are not blocked by a vehicle in front completing an alternative maneuver, will seek out an acceptable gap in the opposing traffic stream and merge only when an acceptable gap is found.

In addition, protected left turns may be modeled by specifying, in the link file, a negative value for the phase of the corresponding signal on which the link discharges. In this way, the opposing stream will have no impact until the protected phase ends, at which time left turning vehicles will be forced to seek out an acceptable gap in the opposing streams.

If either of the right turn on red (RTOR) or protected left turn features are utilized, it is recommended that a corresponding Lane Striping File be created that specifies the precise lanes from which the appropriate turning movements are permitted. The internal default lane allocation logic may not necessarily represent these movements in the precise manner occurring at each particular site.

In the sample Link Characteristic File, right-turns-on-red are permitted from all approaches (links 81, 88, 125, and 142) to the typical signalized intersection illustrated in Figure 1.2. This is indicated by the negative signal number. Also, a protected left turn phase has been coded for vehicles discharging on the eastbound approach (link 81) and the westbound approach (link 88). This is indicated by the negative value assigned to the first phase number in which these links discharge, namely -2. The value of the second phase number is positive, +3, indicating that during this phase, the straight through and right turn movements may both discharge and that any left turns must seek out acceptable gaps in the opposing movements.

Link prohibition indicator

The link prohibition feature impacts only the routing algorithm. It may be exploited, for example, in order to prevent trucks from traversing local streets within a network. Link prohibitions can be specified, with respect to each of the five vehicle classes, by utilizing a unique five digit number. A zero value for a given vehicle class digit will indicate that the vehicle class is not prohibited from the link, while a value of one will indicate that access to the link is prohibited for that particular vehicle class. The relative position of each digit within the sequence indicates the vehicle class affected.

For example, a prohibition indicator value of 11001 would indicate that, for the given link, vehicle classes 1, 2, and 5 are prohibited access, while vehicle classes 3 and 4 are not prohibited. It should also be noted that any leading zeros within the indicator value can be omitted. Consequently, for an input value of 111, for example, vehicle

classes 1 and 2 are permitted access to the link (two leading zeros), while vehicle classes 3, 4, and 5 are prohibited from gaining access. Similarly, a simple prohibition indicator value of 0 will indicate that all five vehicle classes are permitted access to the link.

The user may also consider using the optional Lane Striping File to specify prohibitions at a more detailed lane level, such as restricting a lane for HOV use only.

In the sample lane characteristic file, type 1 vehicles are banned from using the eastbound local street located south of the freeway facility (links 215, 217, 219, 221, 222, 223). This is indicated by a value of 10000 in the vehicle class prohibition indicator field for these six links. The impact of this particular series of link prohibitions becomes evident during the simulation when type 1 vehicles, some of which are coded as trucks, divert from the freeway due to an incident but are unable to use these local streets. For all other links within the network, no vehicle class link prohibitions exist.

Surveillance level indicator

The surveillance indicator for each link indicates the status of real-time surveillance with respect to each vehicle class. The value of this indicator impacts any feedback oriented routing algorithms. Specifically, if no real-time surveillance exists on a link, any vehicles that typically would choose their routes based on real-time data, will instead consider the free-speed link travel time in order to evaluate the merits of any candidate routes involving these links.

The 5-digit surveillance level indicator is also composed of a combination of binary values, where the location of each value within the sequence corresponds to a particular vehicle class. A digit value of zero indicates that no real time surveillance exists on the link with respect to that vehicle class, while a digit value of one indicates that surveillance does exist for that particular vehicle class. For example, an indicator value of 10010 indicates that, for the given link, vehicle classes 1 and 4 have access to real-time surveillance information, while vehicle classes 2, 3, and 5 do not. Leading zeros need not be specified in the indicator value, as they are assumed to exist.

Table 11: Description of fields in link characteristics file (advanced format)

Line	Field	Description
1	1	File title (maximum 40 characters)
2	1	Number of links listed in the file [integer]
		($x \leq$ -1 $\times$ *max. number of links*)
	2-6	Scale factors for link length, free-speed, saturation flow rate, speed at capacity, and jam density, respectively [real]
		($x > 0.0$)
3+	1	Unique link identification number [integer]
		($1 \leq |x| \leq$ *max. link number*)
		If $x < 0$ then link specific results will not be provided in output Files 10, 11, and 12 for the current link.
	2	Identification number of the node at the upstream end of the link [integer]
		($1 \leq x \leq$ *max. node number*)
		The node number must have been coded within File 1.
	3	Identification number of the node at the downstream end of the link [integer]
		($1 \leq x \leq$ *max. node number*)
		The node number must have been coded within File 1.
	4	Link length (km) [real]
		(*min. length* $\leq x \leq$ 6.000), where *min. length* = 0.010*number of lanes on the link
	5	Free speed on link (km/h) [real]
		($10.0 \leq |x| \leq 200.0$)
		If $x < 0$ then the corresponding link will act as a zone connector with a free speed of $|x|$.

6	Basic saturation flow rate per lane (vph) [real] ($100.0 \leq x \leq 10000.0$)
7	Number of lanes [real] ($1.0 \leq |x| \leq 7$) If $x < 0$ then the first lane addition or drop will be considered to occur to the left side of the road, as opposed to default right side of the road.
8	Vehicle speed coefficient of Variation [real] ($|x| \leq 0.25$), where x equals the COV (standard deviation/mean) of speed. If $0.0 \leq x \leq 0.25$ then speeds are considered to follow a normal distribution. If $0.0 \geq x \geq$ -0.25 then speeds are considered to follow a log-normal distribution.
9	Speed at capacity (km/h) [real] ($10.0 \leq x \leq$ *free speed*)
10	Jam density (veh/km/lane) [real] (*density at capacity* $\leq x \leq$ 5**density at capacity*), where *density at capacity* = saturation flow/speed at capacity.
11	Turn prohibition indicator [integer] ($0 \leq x \leq$ *max. link number*) If $x = 0$ then no turns are prohibited. If $x > 0$ then x is interpreted as the number of the link onto which turns from the present link are not permitted.
12	Simulation time at which the prohibition of Field 11 is activated [integer] ($x \geq 0$)
13	Simulation time at which the prohibition of Field 11 is deactivated [integer] ($x \geq 0$)
14	Link number of first link opposing current link [integer] ($0 \leq |x| \leq$ *max. link number*) If $x = 0$ then no links oppose the current link. If $x > 0$ then x is interpreted as the number of the first link which opposes the flow of the current link. If $x < 0$ then $|x|$ is interpreted as the critical gap (seconds) that is applied to all links conflicting with the discharge of vehicles at the downstream node.
15	Link number of second link opposing current link [integer] ($0 \leq |x| \leq$ *max. link number*) If $x = 0$ then no links oppose the current link or Field 14 has a negative value. If $x > 0$ then x is interpreted as the number of the second link which opposes the flow of the current link.
16	Number of the traffic signal which controls exit privileges of this link [integer] ($|x| \leq$ *max. signal number* or $x = 10001$ or 10002) If $x = 0$ then no signal controls exit privileges. If $x < 0$ then vehicles are permitted to complete a right turn on a red signal. If $x = 10001$ then a stop sign controls exit privileges. If $x = 10002$ than a yield sign controls exit privileges.
17	Number of the first phase of the above signal in which this link discharges [integer] ($1 \leq |x| \leq$ *max. number of phases*)

18	Discharge behavior for first phase [binary]
	($0 \leq x < 111$), where x is a three digit number *abc* indicating the discharge pattern by movement (0 prohibited and 1 is permitted), where:
	       a: indicator for left turn movement permissibility [binary]
	       b: indicator for through movement permissibility [binary]
	       c: indicator for right turn movement permissibility [binary]
	Example: 100: left turn only, 010: through only, 011: through and right turns

19	Number of the second phase of the above signal in which this link discharges [integer] ($1 \leq |x| \leq$ *max. number of phases*)
20	Discharge behavior for second phase [binary]
21	Number of the third phase of the above signal in which this link discharges [integer] ($1 \leq |x| \leq$ *max. number of phases*)
22	Discharge behavior for third phase [binary]

23	Number of the forth phase of the above signal in which this link discharges [integer] ($1 \leq |x| \leq$ *max. number of phases*)
24	Discharge behavior for forth phase [binary]

25	Vehicle class link prohibition indicator [integer]
	($0 \leq x < 11111$), where x is a five digit number *abcde* indicating any link use prohibitions by vehicle class (0 not prohibited or 1 prohibited), where:
	  a: vehicle class 1 permissibility [binary]
	  b: vehicle class 2 permissibility [binary]
	  c: vehicle class 3 permissibility [binary]
	  d: vehicle class 4 permissibility [binary]
	  e: vehicle class 5 permissibility [binary]
	Note, there are 31 (2^5-1) acceptable values of *abcde* (11111 not acceptable).

26	Surveillance level indicator [integer]
	($0 \leq x < 11111$), where x is a five digit number *abcde* indicating the status of link surveillance by vehicle class (0 no surveillance or 1 surveillance), where:
	  a: vehicle class 1 surveillance indicator [binary]
	  b: vehicle class 2 surveillance indicator [binary]
	  c: vehicle class 3 surveillance indicator [binary]
	  d: vehicle class 4 surveillance indicator [binary]
	  e: vehicle class 5 surveillance indicator [binary]
	If $x = 0$ then no real-time surveillance exists on this link for any vehicle class and all vehicles that choose their routes based on real-time data will use the free-speed time for this link.

27	Optional descriptive name of link [alpha-numeric]

2.3   File 3: Signal Timing Plans

This file includes one advanced feature, which is offset optimization. In order to activate the offset optimization feature you will need to provide a negative offset in Field 5 of the file. The negative offset number refers to the master signal within the clustered area. For example, if you wanted to coordinate traffic signals 1, 2, and 3 in a single cluster and signals 4, 5, and 6 in a different cluster with signal 1 serving as the master signal for the first cluster and signal 5 serving as the master signal for the second cluster you would include a "-1" in Field 5 for traffic signals 2 and 3 and a "-5" in Field 5 for traffic signals 4 and 6.

The offset optimization is done every cycle length by minimizing a performance index (combination of delay and stops) using a cyclic profile approach similar to TRANSYT-7F and SCOOT.

Table 12: Description of fields in Signal Timing Plan File (Advanced Format)

Line	Field	Description
1	1	File title (maximum 40 characters)
2	1	Number of traffic signals within the traffic network [integer] ($x \leq -1 \times$ *max. number of signals permitted*)
	2	Number of traffic signal plans provided in this file for each signal [integer] ($0 \leq x \leq 1000$)
	3	Duration of each signal timing plan (seconds) [integer] ($x \geq 60$, *where x is a multiple of 60*)
3	1	Signal plan number [integer] ($1 \leq x \leq$ *number of traffic signal plans specified*) Signal plans must be numbered sequentially in increasing order.

4+	1	The traffic signal number for which the remaining fields on this line apply [real]
		 ($1 \leq x \leq$ *max. signal number*)
		 Decimal portion indicates the vehicle classes that receive actuation (x.abcde). Where the five digit number *abcde* specifies the vehicle actuation flag (0 no actuation; 1 actuation), where:
		     a: vehicle class 1 actuation flag [binary]
		     b: vehicle class 2 actuation flag [binary]
		     c: vehicle class 3 actuation flag [binary]
		     d: vehicle class 4 actuation flag [binary]
		     e: vehicle class 5 actuation flag [binary]
		 Example 5.01001 results in traffic signal 5 being actuated by vehicle classes 2 and 5.

	2	Initial cycle length (seconds) that will be utilized in the simulation [real]
	3	Minimum cycle length (seconds) that will be permitted in the event that signal timing optimization is performed [real] ($0.0 \leq x \leq$ *max. cycle length*)
	4	Maximum cycle length (seconds) that will be permitted in the event that signal timing optimization is performed [real] ($x \geq$ *min. cycle length*)
	5	Offset reference signal. If offset is set to a negative value it indicates the master signal in the signal cluster
	6	Time in seconds, after the start of the current time plan, that the first phase of this signal begins. This time in normally referred to as the signal offset [integer]. This offset is used as a start point for offset optimization. ($0 \leq x \leq$ *cycle length*)
	7	Number of phases at this traffic signal [integer] ($2 \leq x \leq 8$)
For each of the phases specified in Field 6 the following four fields must be provided		
		Effective green time (seconds) of this phase [real] ($1.0 \leq x <$ *cycle time specified*)
		Minimum green time (seconds) of this phase [real]

		Maximum green time (seconds) of this phase [real]
		Green extension time (seconds) of phase [real]
		Effective lost time (seconds) of this phase [real]
		$(0.0 \leq x \leq 10.0)$
	8+5n	Frequency (seconds) at which the phase splits and cycle lengths of this signal will be optimized [integer]
		$(x \geq 0,$ *where x is a multiple of 60*$)$
	9+5n	Not used. Enter as 0.
	10+5n	Not used. Enter as 0.
	11+5n	Not used. Enter as 1.0.
	12+5n	Not used. Enter as 1.0.
	13+5n	Not used. Enter as 1.0.
	14+5n	Not used. Enter as 1.0.
	15+5n	Not used. Enter as 1.0.
	16+5n	Not used. Enter as 1.0
	17+5n	Not used. Enter as 0.

2.4 File 4: Origin-Destination Traffic Demands

Within the Origin-Destination (O-D) Traffic Demand File, the user has access to a number of modeling features beyond those listed in Volume I. These features include the ability to load only departures within a specified time period, to specify the color of each simulated vehicle class, to modify the scope of any vehicle probe output, and to invoke explicit vehicle acceleration constraints. A description of the fields contained within this file is provided in Table 2.5.

Departures within a time interval

In Volume I it was shown how the user may restrict the network demand pattern by specifying a specific start and end O-D pair number in line 2 of the O-D file. An option within the model also exists that enables the user to restrict the demand pattern on the basis of a time interval. This feature is invoked by specifying negative values for the fields normally reserved for indicating the first and last O-D pair to be loaded by the model. The absolute value of these negative numbers will correspond to the start and end times for the vehicle loading that is to occur. If the O-D start and end times stated for individual O-D pairs straddle the specified departure time interval, only those departures occurring within the interval will be loaded. Any vehicles that are generated outside of the specified range will not be loaded. For example, values of -900 and -1800 will cause only those vehicles with O-D start times greater than or equal to 900 seconds, and less than or equal to 1800 seconds, to be generated.

Within the sample O-D Traffic Demand File, for example, only the vehicles loaded during the time interval from 1800 to 3600 seconds would be generated when the user specified two negative values, equal in absolute value to the desired time frame boundaries, in the first and last O-D pair loading fields, respectively.

Vehicle class color control

Throughout the simulation, vehicles of all types are represented by default in one of four colors; either green, blue, amber, or red. These speed-sensitive presentation color are set based on the traffic conditions the vehicle is experiencing. The user may also wish to assign vehicle colors with respect to vehicle class in order to better track the routing behavior of a specific vehicle class. However, the assigned color of each vehicle class will not be sensitive to speed and will be maintained throughout the simulation. This feature may be invoked by specifying a negative value for the fraction of the demand for the driver class for which vehicles are to be presented in a distinctive color. The speed independent color convention adopted for each vehicles type is presented in Table 2.4 below.

Table 13: INTEGRATION'S coloring convention by vehicle class

Vehicle class	Color	
1	Cyan	(low intensity)
2	Magenta	(low intensity)
3	Grey	
4	Cyan	(high intensity)
5	Magenta	(high intensity)

In the sample O-D Traffic Demand File, a coloring convention for O-D pair 1 has been assigned for vehicle class 5, as indicated by the negative fraction of the demand (-0.2). Vehicles of type 5 may be viewed as HOV that have exclusive use of the median lane on the eastbound freeway. The second O-D pair, which also utilizes an assigned vehicle coloring convention, is intended to represent truck demand, as indicated by

the negative fraction of demand for vehicle class 1 (-1.0) and larger passenger car equivalency factor (-3.0).

The O-D pairs numbered 4 through 15 provide approach traffic to the detailed signalized intersection located in the northwest corner of the network. The required maneuver of each approach vehicle can be identified by the color of the vehicle, as determined by the coloring convention assigned to each vehicle class. Type 1 vehicles will proceed straight through the intersection and will appear cyan in color. Type 2 vehicles will turn left at the intersection and will appear magenta in color. Finally, type 3 vehicles will complete a right turn at the intersection and will appear grey in color.

Acceleration constraints

Vehicle acceleration is typically a function of numerous factors, including driver aggressiveness, road surface conditions and grade, engine size, vehicle mass, and current vehicle speed. Therefore, vehicles such as heavily loaded trucks or buses are not able to accelerate as quickly as a normal passenger car. Vehicle acceleration rates are typically also greater at lower speeds, since the impact of wind resistance is less than at higher speeds.

The default logic within INTEGRATION models all vehicles with having constrained acceleration capabilities. In the sample O-D Traffic Demand File, all vehicles operate with constrained acceleration behavior.

To enable the selection of a different vehicle type one would have to use the advanced O-D demand feature that allows the user to include information about the number of passengers on the vehicle and the vehicle type from a total of 15 vehicle types.

Table 14: Description of fields in O-D Traffic Demand File (advanced file 4 format)

Line	Field	Description
1	1	File title (maximum 40 characters)
2	1	Number of O-D demands to be read [integer]. If this entry is negative it uses this advanced format. ($x \leq -1 \times$ *max. number of O-D pairs*)
	2	The number of the first O-D pair loading to be utilized by the model [integer] ($0 \leq x \leq$ *max. O-D number specified*) If $x < 0$ then vehicle loading will commence at time $|x|$ (seconds). If $x = 0$ then x is set to be 1.
	3	The number of the last O-D pair loading to be utilized by the model [integer] ($0 \leq x \leq$ *max. O-D number specified*) If $x < 0$ then vehicle loading will terminate at time $|x|$ (seconds). If $x = 0$ then x is set to be *max. O-D number specified*.
	4	Global O-D demand scaling factor [real]. ($x > 0.0$) For example, if x equals 2.0 then all listed departure rates are assumed to be double their listed values.
	5	Vehicle Class 1 O-D demand scaling factor [real]. ($x > 0.0$). For example if x equals 2.0 then all listed departure rates of vehicle class 1 are assumed to be double their listed values.
	6	Vehicle Class 2 O-D demand scaling factor [real]. ($x > 0.0$). For example if x equals 2.0 then all listed departure rates of vehicle class 2 are assumed to be double their listed values.
	7	Vehicle Class 3 O-D demand scaling factor [real]. ($x > 0.0$). For example if x equals 2.0 then all listed departure rates of vehicle class 3 are assumed to be double their listed values.

	8	Vehicle Class 4 O-D demand scaling factor [real]. ($x > 0.0$). For example if x equals 2.0 then all listed departure rates of vehicle class 4 are assumed to be double their listed values.
	9	Vehicle Class 5 O-D demand scaling factor [real]. ($x > 0.0$). For example if x equals 2.0 then all listed departure rates of vehicle class 5 are assumed to be double their listed values.
3+	1	O-D line identification number [integer] ($1 \leq x \leq$ *number of O-D pairs specified*)
	2	Origin zone identification number [integer] ($1 \leq x \leq$ *max. zone number*)
	3	Destination zone identification number [integer] ($1 \leq x \leq$ *max. zone number*)
	4	Departure rate (vph) for given O-D [real]
	5	The fraction of the vehicle headway that is random [real] ($0.0 \leq x \leq 1.0$)
	6	Time (seconds) at which specified O-D demand begins [integer] ($x \geq 0$)
	7	Time (seconds) at which specified O-D demand ends [integer] ($0 \leq x \leq$ start of O-D demand)
	8-12	The fraction of the demand that is to be of driver class *i* [real] ($0.0 \leq |x_i| \leq 1.0$) where $\sum_{i=1}^{5} |x_i| = 1.0$ If $x < 0.0$ then vehicles of type *i* will appear with a distinctive color (speed independent) throughout the simulation.
	13	The fraction (or percentage) of the total demand that will act as vehicle probes for the purposes of generating output for optional Output Files 15 and/or 16 [real]. The use of fraction or percentage changes the type of output. ($|x| \leq 200$) If 0.0<x<1.0 then record types 1 and 2 are written to File 15 and record type 11 is written to file 16 if the file names are specified in the master control file. If -1.0<x<0.0 then only record types 1 and 2 are written to File 15 and $|x|$ represents the proportion of vehicles that act as probes. If 100≥x>1.0 then the entry represents the percentage of the O-D demand that acts as probes and record type 21 is generated in file 16. If 200≥x>100 then the entry minus 100 represents the percentage of the O-D demand that acts as probes and the time-space file is created (default: timespac.out).
	14	The length-based passenger car equivalency for all vehicles of this O-D demand [real] ($0.5 \leq x \leq 10.0$) (acceleration of vehicles is always constrained).
	15	Vehicle occupancy in terms of number of passengers in the vehicle. This parameter is used to compute the passenger delay.

		16	Vehicle type. One of 25 vehicle types:
			ORNL composite vehicle: average of 5 LDVs and 3 LDTs
			LDV1 composite vehicle:
			LDV2 composite vehicle:
			LDV3 composite vehicle:
			LDV4 composite vehicle:
			LDV5 composite vehicle:
			LDT1 composite vehicle:
			LDT2 composite vehicle:
			HE1: High emitter vehicle 1
			HE2: High emitter vehicle 2
			HE3: High emitter vehicle 3
			HE4: High emitter vehicle 4
			Chevrolet Corsica
			Oldsmobile Ninety Eight
			Oldsmobile Cutlass Supreme
			Geo Prizm
			Subaru Legacy
			Mercury Villager
			Jeep Grand Cherokee
			Chevy Pickup
			Toyota Celica
			Light Truck (100 lb/hp)
			Medium Truck (200 lb/hp)
			Heavy Truck (300 lb/hp)
			Bus
			The user may specify the vehicle type in conjunction with file veh_parameters.dat. The format of the file is described later in this manual.

2.5 File 5: Incident Characteristics

Two forms of the Incident File can be utilized by the INTEGRATION model. The file form is distinguished by the sign of the number of incident descriptor records that are to be read. A positive value indicates that the file is of format 1, while a negative value indicates that the file is of format 2.

Format 1   File format 1 enables the user to specify, for a given link, the equivalent number of lanes to be blocked by the incident and the duration of this incident. The lane blockage, for type 1 incidents, is modeled as a capacity reduction equivalent to the value of the number of lanes blocked divided by the total number of lanes as specified in File 2. The incident is assumed to occur on the upstream end of the link and occupy a length of approximately 250 m. A description of the fields contained within the file may be found in Table 2.6.

The sample Format I Incident File indicates that a total of two incidents occur during the simulation period. The first incident occurs on the eastbound freeway (link 31) from time period 200 seconds to 840 seconds. The incident blocks 1.0 lanes, which represents a capacity reduction of 33 percent, and will occur on the downstream end of the link. The second incident occurs on a westbound arterial (link 108), from time period 600 seconds to 1000 seconds, and blocks 0.8 lanes. This lane blockage represents a capacity reduction of 40 percent.

Format 2   A second type of Incident File, Format II, provides more flexibility to the user in terms of incident location and length, but is more restrictive in terms of the extent of the particular lane blockage. A description of the fields contained within the file may be found in Table 2.6.

The user must specify a lane blockage indicator, a value composed of a number of digits equal to the number of lanes on the link. For each lane, a binary value must be stated indicating whether the lane is blocked or available. A component value of 0 indicates that the lane is accessible, while a component value of 1 indicates that the lane is completely blocked. The position of each binary digit within the sequence of the indicator value corresponds to the lane number, which are numbered from the median to the shoulder. For example, an lane blockage indicator of 01 on a 2-lane link indicates that the median lane is accessible, but that the shoulder lane is blocked.

In the sample Format II Incident File, the same two incidents are modeled that were described in the type 1 file. The first incident blocks the shoulder lane starting 100 m from the upstream end of link 31 and is 150 m in length, as indicated by the incident end location of 250 m. The second incident blocks the median lane starting at a location 450 m from the upstream end of link 108, and is only 20 m in length.

Table 15: Description of fields in Incident File (Format II)

Line	Field	Description
1	1	File title (maximum 40 characters)
2	1	Number of incident descriptor records to be read [integer]
		($x \leq 0$, $|x| \leq$ *max. number of incidents permitted*)
3+	1	Incident record number [integer]
		($1 \leq x \leq$ *max. incident number*)
	2	Identification number of the link in which the incident will occur [integer]
		($1 \leq x \leq$ *max. link number*)
	3	Distance along the link (km), measured from the upstream end, where the incident starts [real]
		($0 < x \leq$ *length of link*)

4	Distance along the link (km), measured from the upstream end, where the incident ends [real] (*incident start point < x ≤ length of link*)
5	Simulation time (seconds) at which incident is to begin [integer]
6	Simulation time (seconds) at which the incident is to end [integer]
7	Lane blockage indicator [binary] (*x ≥ 0*) An *n* digit number indicating the status of each of the *n* lanes on the link (0 accessible or 1 blocked), coding the lanes from median to shoulder.

CHAPTER 3
Overview of Optional Input Data Files

Chapter 3 of this document describes in some detail the optional input data files that have been introduced in this model release. These files include a Lane Striping File, a Detector Location File, and a screen capture frequency file. Each of these will be described next.

3.1 File 6: External Average Travel Times and Standard Deviations

3.2 File 7: External Travel Time File

3.3 File 8: External Tree File

File 8 allows the user to specify an external tree files for up to 5 vehicle classes to be utilized within the simulation. The use of such a file allows the user to specify the routes of a specific or number of vehicle classes. This feature can be utilized for the modeling of transit routes. It should be noted that in order to utilize this feature the routing type of the vehicle should be specified as type 6.

The file allows the user to include up to 25 trees (5 trees for each of the 5 vehicle classes). The model assumes that the first 5 trees are associated with vehicle class 1, while the second 5 trees are associated with vehicle class 2, etc.

Table 16: Description of fields in optional External Tree File

Line	Field	Description
1	1	File title (up to 40 characters long).
2	1	Number of periods [integer].
	2	Duration of each period [integer].
	3	Number of origins [integer].
	4	Maximum origin number [integer].
	5	Maximum destination zone number [integer].
	6	Number of links [integer].
	7	Maximum link number [integer].
3	1	Current period number [integer].
	2	Number of trees for each vehicle class [integer]. *(0 < x < 6)*
	3	
4	1	Tree number for the current period [integer]. This batch is repeated for all periods.
	2	Tree weight for the current period and tree [real]. This batch is repeated for all periods.
5+	1	Trip origin [integer]. This batch of entries is repeated for all origin zones.
	2+	First link on tree from trip origin zone to first 15 trip destination zones [integer]. If additional zones are required additional zones can be included in a subsequent line. A maximum of 30 destination zones are permitted in the file.
6+	1	Link number of current link [integer]. This batch of entries is repeated for all links in the network.

	2+	Next link on tree from current link number to first 15 trip destination zones [integer]. If additional zones are required additional zones can be included in a subsequent line. A maximum of 30 destination zones are permitted in the file.

3.4 File 9: External Tree File

Similar to File 8, File 9 allows the user to specify an external tree file to be used by the different vehicle classes. The routing method should be specified as 9 in the master control file in order to use this feature.

3.5 File 20: Lane Striping

The optional Lane Striping File enables the user to specify lane restrictions for turning movements at intersections and/or lane prohibitions by vehicle class. For example, at an intersection with a three lane approach, the user may specify a dedicated left turn, a dedicated straight through, and a separate right turn lane for each movement. Similarly, the user may restrict access to a given lane, within a link, to only a specific vehicle class, such as HOV or trucks for example. The user may be compelled to code trivial lane allocation values on links where more complicated link use prohibitions exist, or vice versa, by utilizing the Lane Striping File for only one of the file's intended purposes.

If utilized, the name of the Lane Striping File should be stated on the appropriate line of the master file and the optional file should be located in the same subfolder as all of the other standard input files. If the file is not specified, the model will internally compute a default lane allocation for turning movements and assume that all vehicle classes are permitted to use all available lanes. A description of the file format may be found in Table 17.

File organization   The optional Lane Striping File defines the permitted left turn, straight through, and right turn movements by lane, and also permits lane restrictions to be specified by vehicle class. It should be noted that lanes are listed consecutively from left to right, starting from the median lane and ending at the shoulder lane. A maximum of seven lanes may be coded per link.

In order to specify lane permissions for turning movements from a link, a three digit integer can be specified for each lane. The integer is composed of a series of zeros or ones, where a zero value indicates that a movement is not permitted and a value of one indicates a permitted movement. The leading digit corresponds to the left turn movement, the second digit corresponds to the straight through movement, and the final digit corresponds to the right turn movement. Although a total of eight combinations of zeros and ones are possible, the combination 000, indicating that no movements are permitted, is not admissible. On links with multiple lanes, unreasonable movements such as right turns from the median lane or left turns from the shoulder lane are permitted, but should be avoided in the coding process.

There are five potential vehicle classes for which the user may define unique characteristics, including the permissibility to use certain lanes. For each lane within the link, the user may provide a five digit number which indicates lane permission/prohibition of each vehicle class. Again, a series of zeros and ones are utilized to define this number, where a zero corresponds to a permitted use and a one corresponds to a prohibited use. The relative position within the five digit number corresponds to the vehicle class. For example, the leading digit indicates lane use

prohibition status for vehicle class 1. Entries such as 11111, which ban all vehicles from a lane, are not valid.

Details of sample file

In the sample Lane Striping File, specific lane allocations are provided for 17 links within the INET network, as illustrated in Table 18. Record numbers 1 through 13 are relevant to the lane use prohibitions on the eastbound freeway, while record numbers 14 through 17 pertain the lane striping at a typical signalized intersection.

The eastbound freeway facility is composed of either 3 or 4-lane segments, and the median lane of all these segments is coded for use by vehicle class 5 (HOV for example) only. The 3-lane segments correspond to the primary mainline, while the 4-lane sections represent portions of the freeway with an additional 1-lane acceleration or deceleration lane. Although not necessary from a lane allocation perspective, those primary mainline segments of the freeway (links 15, 19, 23, 27, 31, 33, 35) are coded as permitting all 3 lanes for through movements only, as indicated by the 010 value in Fields 4, 5, and 6. This somewhat obvious lane allocation coding is required, however, since lane restrictions with respect to vehicle class are to be stipulated in Fields 7, 8, and 9. In these fields, lane 1 has lane use prohibitions on vehicle classes 1 through 4, but permits use by vehicle class 5. This is indicated by the value 11110 in Field 7. Lanes 2 and 3 have no lane use prohibitions, as indicated by the value 00000 in Fields 8 and 9.

For those freeway segments that contain deceleration lanes to off-ramps (links 17, 25, and 32), the 4 lanes must be striped to permit the required straight through and diverge movements, although the model's internal logic would likely compute identical lane allocations. The lane use prohibition sequence described for the 3-lane segments remain applicable to the 4-lane segment, with the exception that an additional lane use prohibition value of 00000 has been added for the shoulder lane. Finally, for those freeway segments containing acceleration lanes from on-ramps (links 21, 29, and 34), all lanes are coded as through lanes and lane use prohibitions only apply to the median lane for vehicle classes 1 through 4.

The detailed signalized intersection requires a detailed lane striping scheme in order to ensure that the desired movements are permissible. These lane striping requirements are specified in records 14 through 17.

The northbound approach (link 142) and the southbound approach (link 125) contain 2 lanes for which allocations are made. Lane 1, the median lane, permits left turn and straight through movements to be completed, as indicated by the value 110 in Field 4. Lane 2, the shoulder lane, is coded as a shared through and right turn lane, as indicated by the value 011 in Field 6. The trivial lane use prohibition with respect to vehicle class is required in Fields 7 and 8.

In terms of the eastbound approach (link 81) and the westbound approach (link 88), each contains 3 lanes for which allocations can be made. Lane 1 is coded as a dedicated left turn lane, as indicated by the value 100 in Field 4, while lane 2 is coded as a dedicated through lane, as indicated by the value 010 in Field 5. Lastly, the value 011 in Field 6 indicates that lane 3 is coded as a shared through and right turn lane. Fields 7, 8, and 9 have no lane use prohibitions with respect to vehicle class.

Table 17: Description of fields in optional Lane Striping File

Line	Field	Description
1	1	File title

2	1	Number of records defined in the file [integer]
		($0 < x \leq$ *max. number of links in network*)
3	1	Record number identification [integer]
		($0 < x \leq$ *max. number of records in file*)
	2	Link number on which permission/prohibition exists [integer]
		($0 < x \leq$ *max. link number in network*)
	3	Number of lanes *n* on current link, as stated in File 2 [integer]
		($0 < n \leq$ *maximum number of permissible lanes*)
		Note, lanes are numbered consecutively from 1 to *n* from the median lane to the shoulder lane.
	4+	For each lane *n*, a three digit number *xyz* indicating permitted movements starting from the leftmost lane
		(0 prohibited or 1 permissible) [integer], where:
		x: left turn permission [binary]
		y: straight through permission [binary]
		z: right turn permission [binary]
		Note, there are 7 (2^3-1) acceptable values of *xyz* (000 not acceptable)
	4+*n*+	For each lane *n*, a five digit number *abcde* indicating lane use prohibition by vehicle class (0 permitted or 1 prohibited) [integer] where:
		a: vehicle class 1 prohibition [binary]
		b: vehicle class 2 prohibition [binary]
		c: vehicle class 3 prohibition [binary]
		d: vehicle class 4 prohibition [binary]
		e: vehicle class 5 prohibition [binary]
		Note, there are 31 (2^5-1) acceptable values of *abcde* (11111 not acceptable)

Table 18: Sample Lane Striping File

```
INET Lane Striping File
 17
  1    15   3    010   010   010           11110   00000   00000
  2    17   4    010   010   010   001     11110   00000   00000   00000
  3    19   3    010   010   010           11110   00000   00000
  4    21   4    010   010   010   010     11110   00000   00000   00000
  5    23   3    010   010   010           11110   00000   00000
  6    25   4    010   010   010   001     11110   00000   00000   00000
  7    27   3    010   010   010           11110   00000   00000
  8    29   4    010   010   010   010     11110   00000   00000   00000
  9    31   3    010   010   010           11110   00000   00000
 10    32   4    010   010   010   001     11110   00000   00000   00000
 11    33   3    010   010   010           11110   00000   00000
 12    34   4    010   010   010   010     11110   00000   00000   00000
 13    35   3    010   010   010           11110   00000   00000
 14   142   2    110   011                 00000   00000
 15    88   3    100   010   011           00000   00000   00000
 16   125   2    110   011                 00000   00000
 17    81   3    100   010   011           00000   00000   00000
```

3.6 File 21: Detector Location

The optional Detector Location File permits measurements of volume, speed and occupancy, to be recorded at a user specified frequency, at a fixed point on a link and provides a simulated data stream very similar to that provided if actual loops had been installed in the field.

The INTEGRATION model utilizes a combination polling frequency and effective detection length in order to compute the speed, volume and occupancy measurements recorded at each station. The recorded time mean speed is computed by averaging the speed of all those vehicles that activate the detector during a particular polling interval. The recorded volume is computed by dividing the number of activations recorded during the polling interval by the duration of the polling interval. Finally, the recorded occupancy is computed as a function of a derived density (volume/speed) and the prevailing effective detection length.

If utilized, the name of the Detector Location File should be stated on the appropriate line in the master file, and the file should be located in the same subfolder as the other input files.

File organization

The optional detector definition file provides the number, location, and type of all loop detectors that exist on the network. These detectors may be placed at any point along a link and multiple detectors may be located on the same link. The user may wish to adopt a labeling convention for each detector station and enter the label after the last input field for that station.

At present, two types of detector stations exist. Output data from a type 1 detector is summarized at a link or section level, while output data from a type 10 detector is provided on an individual lane basis. The details of each type of output file are described in Chapter 4 of this document.

The user may specify the interval of generation for the detector output files. This causes a file, called detector.out, to be created in the specified output subfolder, whenever File 21 is specified in the master file.

Details of file

The fields contained within this file are described in Table 3.2b.

Detector stations 1 through 4, specified as type 10 detectors, are located on the eastbound freeway and are positioned 600 m from the upstream end of the specified links (links 15, 23, 31, and 35). These detectors have an effective detection zone length of 5 m and are polled every 20 seconds. Each station is also labeled in order to aid the coding process, but such labeling is optional. A similar group of detectors are located on the westbound freeway (links 10, 14, 22, and 30), except that these detectors are defined as type 1 detectors.

Table 19: Description of fields in optional Detector Location File

Line	Field	Description
1	1	File title
2	1	Number of loop detector stations defined in file [integer] ($0 \leq x \leq$ *max. detector station permitted*)
	2	Time series interval of detector output (sec) [integer] Currently, *x* must equal 0 ($x = 0$) and a single output file is produced in the specified output folder.

3+	1	Detector station identification number [integer] (0 ≤ *x* ≤ *max. detector station permitted*) Note, these numbers must be sequential
	2	Detector type [integer] (*x* = 1 or *x* = 10) If *x* =1 then data are output on a station basis. If *x* = 10 then data are output on an individual lane basis
	3	Link number on which detector station exists [integer] (0 < *x* ≤ *max. link number in network*)
	4	Detector station position measured as distance (km) from **upstream** end of link [real] (0 < *x* ≤ *length of link*)
	5	Effective detection length (km) of detector station [real] (0 < *x* ≤ 0.050) Typically, *x* = 0.005
	6	Polling frequency in seconds [integer] (0 < *x* ≤ 300)
	7	Optional detector station name [alpha-numeric]

3.7 File 22: Bus Stop Location

The optional Bus Stop Location File forces pre-specified vehicle classes to stop at a specific location for a user-defined duration. Currently, all vehicle defined vehicle classes will stop at a bus stop. The model can currently model a maximum of 20 bus stops in a network with a maximum of 5 bus stops on a link.

File organization

Table 20: Example illustration of Bus Location File

```
Bus Location File
2
1       1       0.475   2       70      0.5     00001   0.010
2       3       0.475   2       70      0.5     00001   0.010
```

Table 21: Description of fields in optional Bus Location File

Line	Field	Description
1	1	File title
2	1	Number of bus stops [integer]. (0 ≤ *x* ≤ 20)
3+	1	Bus stop sequence number [integer]. (0 ≤ *x* ≤ 20)
	2	Link number on which bus stop is located [integer]. (0 ≤ *x* ≤ *maximum link number*)
	3	Location of bus stop from upstream end of link (km) [real].
	4	Lane on which bus stop is located [integer]. Lanes are numbered in ascending order from median to shoulder lane.
	5	Mean loading time in seconds.
	6	Loading time Coefficient of Variation (COV) in seconds [real].

	7	Vehicle classes that stop at bus stop [binary].
		For each bus stop, a five digit number *abcde* indicating vehicle classes that are affected by the bus stop (0 do not respond to stop or 1 respond to stop) [integer] where:
		a: vehicle class 1 bus stop response [binary]
		b: vehicle class 2 bus stop response [binary]
		c: vehicle class 3 bus stop response [binary]
		d: vehicle class 4 bus stop response [binary]
		e: vehicle class 5 bus stop response [binary]
		Note, there are 31 (2^5-1) acceptable values of *abcde* (11111 not acceptable)
	8	Length of bus stop loading area in kilometers [real].

3.8 File 23: Adaptive Ramp Metering File

File 23 allows the user to input parameters to be used in applying an adaptive ramp metering algorithm. This file must be coded in conjunction with the loop detector file (file 21).

File organization

The organization of the file is specified in

Table 22: Sample the Optional Ramp Metering File

```
Sample Ramp Metering File
  1  20
  1  3  1  0  600  300  2  2  1  2  3  4  5  6  7  8
```

Table 23: Description of Fields in the Optional Ramp Metering File

Line	Field	Description
1	1	File title
2	1	Number of ramp meters [integer]. (0 ≤ *x* ≤ *max. number of ramp meters*)
	2	Ramp metering optimization frequency (s) [integer]. *(20 ≤ x ≤ 900)*
3+	1	Ramp meter number
	2	Link number on which ramp meter is located
	3	Control strategy flag (1 = occupancy , 2 = speed, 3 = volume)
	4	Next upstream meter from which help can be requested
	5	Starting value of ramp metering rate
	6	Minimum permitted ramp metering rate
	7	Green pulse duration - 1 vehicle
	8	Threshold - 2 vehicles / pulse - up
	9	Queue spill back detector 1
	10	Queue spill back detector 2
	11	Check-in detector
	12	Check-out detector
	13	Merge detector
	14	Upstream main-line detector
	15	Downstream main-line detector
	16	Downstream merge detector

3.8 Lnkgrade.dat: Link Grade File

File organization

The file has to be named "lnkgrade.dat" and must be located in the input folder (defined in the Master Control File) for it to be used. The format of the file is summarized in Tables 3.4a and 3.4b.

Table 24: Sample optional Link Grade File

```
Grade File
  8
  1   0.00
  2   0.00
  3   0.02
  4   0.02
  5   0.04
  6   0.04
  7   0.06
  8   0.06
```

Table 25: Description of fields in optional Link Grade File

Line	Field	Description
1	1	File title
2	1	Number of grades defined in file [integer]. ($0 \leq x \leq$ *max. number of links*)
3+	1	Link number [integer]. ($0 \leq x \leq$ *max. number of links*)
	2	Link grade (e.g. 0.02 means an upgrade of 2 percent) [real]. *($-0.10 \leq x \leq 0.10$)*

3.9 veh_parameters.dat: Vehicle Characteristics File

The file has to be named "veh_parameters.dat" and must be located in the input folder (defined in the Master Control File) for it to be used.

The model computes the maximum acceleration from the residual force by computing the maximum tractive force the aerodynamic, rolling and grade resistance forces. The tractive force is computed as the minimum of the tractive force (Equation 3.4.1) and the maximum force sustained between the wheel and the road surface (Equation 3.4.2). The aerodynamic, rolling, and grade resistance forces are computed using Equation 3.4.3, 3.4.4, and 3.4.5, respectively.

$$F_t = 3600 h f_p \frac{P}{V} \qquad [3.4.1]$$

$$F_{\max} = 9.8066 \, W_{t_a} \mu \qquad [3.4.2]$$

$$R_a = c_1 C_d C_h A V^2 \qquad [3.4.3]$$

$$R_r = 9.8066 C_r (c_2 V + c_3) \frac{W}{1000} \qquad [3.4.4]$$

$$R_g = 9.8066 W i \qquad [3.4.5]$$

Where:
 P: engine power (kW)
 V: speed (km/h)
 η: transmission efficiency
 f_p: drive pedal input [0, 1]
 F_{max} : maximum tractive force (N)

W_{ta} :   vehicle weight on tractive axle (kg)

μ : friction coefficient

R_a :   air drag resistance (N)

c_1:   coefficient that accounts for air density and units conversion (c_1 = 0.047285)

C_d :   air drag coefficient

A :   frontal area (m²)

V :   speed (km/h)

C_h :   altitude coefficient

H: altitude (m)

R_r :   rolling resistance (N)

C_r :   rolling coefficient

c_2, c_3: rolling resistance constants

W :   vehicle weight (kg)

V :   speed (km/h)

R_g :   grade resistance (N)

W :   vehicle weight (kg)

i :   grade magnitude

Table 26-1: veh_parameters.dat file format

Line	Field	Description
1	1	File description
2	1	Number of vehicle types defined [integer]
	2	Energy model to be used (0: VT-Micro, 1 VTCPXM)
	3	VTCPXM link cost updating mode (0: use VTCPFM 8 varibales to compute the link cost, 1: update the link cost using feedback from vehicles)
3+	1	Vehicle type number [integer]. (0 ≤ *x* ≤ *max. number of vehicle types (25 types)*)(Only the first 5 vehicle types will be considered at this point (i.e x=1,2,3,4,5), therefore a maximum of 5 input lines will be used)
	2	Type of the engine for this car type 1: Gas(done), 2: Diesel (done), 3: Full electric (done), (has only one motor) 4: Plug-in hybrid serial (under development), (has one gas engine and one electric motor working in serial) 5: plug-in hybrid parallel (under development), (has one gas engine and one electric motor working in parallel). 6: hybrid (From the paper: a simple hybrid electric fuel consumption model for transportation applications).
	3	Vehicle weight (kg)
	4	Vehicle length (meters)
	5	Proportion of mass on tractive axle (e.g. 0.40 is equivalent to 40 percent)
	6	Coefficient of friction
	7	Vehicle gas/diesel engine power (KWatts)
	8	Maximum battery energy for eclectic motor (KWatts)
	9	Transmission efficiency
	10	Drag coefficient
	11	Frontal area (m²)
	12	Rolling coefficient
	13	First rolling resistance constant
	14	Second rolling resistance constant
	15	Driver pedal input [0, 1]. For example, a value of 0.6 would reflect a depressing of the gas pedal of 60% which results in a throttle level of 60%.
	16	Gr1 – Truck gear parameter (default = 1164)

	17	Gr2 – Truck gear parameter (default = -0.75)
	18	Battery efficiency for electric vehicles.
	19	Minimum state of charge for electric vehicles.
	20	Maximum state of charge for electric vehicles.
	21	Initial State of Charge
	22	Electric motor efficiency for eclectic vehicles.
	23	Regenerative efficiency for eclectic vehicles.
	24	Switching buffer between gas engine and electric motor in Plug-in hybrid serial cars
	25	Battery capacity (KWH) for electric vehicles
	26	Energy consumed by auxiliaries (KW)
	27	The VTCPFM model parameter Alph0. This will be the same as Alph0 for Hybrid
	28	The VTCPFM model parameter Alph1. This will be the same as Alph1 for Hybrid
	29	The VTCPFM model parameter Alph2. This will be the same as Alph2 for Hybrid
	30	Hybrid vehicle Parameter Alph3 (coefficient of velocity)

Table 26-2: Sample VT-CPFM parameter file (For illustrative purposes only – this might give you wrong results)

```
Veh Parameters
1  1    1
3 3 1196 4.8 0.6 0.5 82 80 0.8 0.34 2.73 1.75 0.0328 4.575 1 0.92 0.2 0.95 0.85 1.0 0.0 80 0.7 0.0 1.0 0.0
```

Table 26: Description of fields in optional Vehicle Characteristic File

Line	Field	Description
1	1	File title
2	1	Number of vehicles defined in file [integer]
		($0 \leq x \leq$ *max. number of vehicle classes*)
3+	1	Vehicle type number [integer].
		($0 \leq x \leq$ *max. number of vehicle types (20 types)*)
	2	Vehicle weight (kg)
	3	Vehicle length (meters)
	4	Proportion of mass on tractive axle (e.g. 0.40 is equivalent to 40 percent)
	5	Coefficient of friction
	6	Vehicle power (Kwatt)
	7	Transmission efficiency
	8	Drag coefficient
	9	Frontal area (m^2)
	10	Rolling coefficient
	11	First rolling resistance constant
	12	Second rolling resistance constant
	13	Driver pedal input [0, 1]. For example a value of 0.6 would reflect a depressing of the gas pedal of 60% which results in a throttle level of 60%.

3.10 Fuelemis.dat: Vehicle Specific Fuel/Emission Factors

The "fuelemis.dat" file allows the user to override the default vehicle type specific fuel consumption and emission factors. These factors permit the instantaneous fuel consumption and emission rates each second on the basis of its current instantaneous speed and acceleration (Rakha et al., 2000 and Ahn et al., 2001). These models were developed using data that were collected on a chasis dynamometer at the Oak Ridge

National Labs (ORNL) and by the Environmental Protection Agency (EPA). The models use instantaneous speed and acceleration levels as independent variables, as demonstrated in Equation 3.10.1. The derivation of the model parameters is described in the literature (Ahn et al., 2001 and Rakha et al., 2003) and also provided in Volume III of the User's Guide.

$$\ln(MOE_e) = \begin{cases} \displaystyle\sum_{i=0}^{3}\sum_{j=0}^{3}(L_{i,j}^{e} \times s^{i} \times a^{j}) & \text{for } a \geq 0 \\ \displaystyle\sum_{i=0}^{3}\sum_{j=0}^{3}(M_{i,j}^{e} \times s^{i} \times a^{j}) & \text{for } a < 0 \end{cases} \qquad [3.10.1]$$

where:

MOE_e	Instantaneous fuel consumption or emission rate (ml/s or mg/s)
$L^{e}_{i,j}$	Model regression coefficient for MOE "e" at speed power "i" and acceleration power "j" for positive accelerations
$M^{e}_{i,j}$	Model regression coefficient for MOE "e" at speed power "i" and acceleration power "j" for negative accelerations
s	Instantaneous Speed (km/h)
a	Instantaneous acceleration (km/h/s)

Table 27: Sample optional fuel/emission file

```
ORNL Sample Emission File
    1
    1  1  1   -7.760530393    0.246597062    -0.010272227    0.000447337
    1  1  2    0.029242311    0.005779789    -0.000364834   -3.00192E-05
    1  1  3   -0.000245012   -1.82735E-05    -1.10528E-05    2.00290E-06
    1  1  4    1.20198E-06   -1.19337E-07     1.17559E-07   -1.69228E-08
    1  1  1   -7.760530393   -0.043729954    -0.012637630   -0.000620671
    1  1  2    0.029410910    0.009308791     0.001354880    1.61464E-05
    1  1  3   -0.000242520   -7.87193E-05    -1.59767E-05   -5.48188E-07
    1  1  4    1.18533E-06    3.73188E-07     8.98978E-08    4.34815E-09
    1  2  1   -0.896114000    0.067322841     0.034821589   -0.002252582
    1  2  2    0.036990562    0.008482395    -0.005270407    0.000380776
    1  2  3   -0.000481718   -0.000380729     0.000261438   -1.46307E-05
    1  2  4    2.77788E-06    3.36421E-06    -1.58987E-06    9.74021E-09
    1  2  1   -0.896114000   -0.129234118    -0.007979082   -0.000531355
    1  2  2    0.030521839    0.020706412     0.002834651    0.000142791
    1  2  3   -0.000308964   -0.000367104    -3.94717E-05   -6.91521E-07
    1  2  4    1.70533E-06    1.74315E-06     1.54649E-07   -1.98924E-09
    1  3  1    0.517454000    0.297481071     0.022577638   -0.001891533
    1  3  2    0.095860682   -0.017789525    -0.000475343    7.93283E-05
    1  3  3   -0.001327217    0.000261136     0.000142101   -4.41631E-06
    1  3  4    6.78121E-06   -5.09081E-07    -6.78320E-07   -1.14584E-07
    1  3  1    0.517454000   -0.050334468     0.024590889    0.004358323
    1  3  2    0.089658983    0.020638307     2.99398E-05   -0.000319383
    1  3  3   -0.001145327   -0.000292927     2.59003E-05    8.15052E-06
    1  3  4    5.59134E-06    1.15888E-06    -2.01170E-07   -4.56383E-08
    1  4  1   -1.146050000    0.400009150    -0.051503992    0.003797448
    1  4  2    0.023653035    0.024776101     0.001571358   -0.000282133
    1  4  3    0.000133718   -9.53714E-05    -0.000119337    8.97909E-06
    1  4  4   -5.22272E-07   -6.86362E-07     7.44957E-07   -3.42151E-08
    1  4  1   -1.146050000    0.132088449    -0.002895293   -0.001518374
    1  4  2    0.025180448    0.015391730     0.008088405    0.000774658
    1  4  3    9.55131E-05   -0.000110510    -0.000119337   -1.25316E-05
    1  4  4   -2.60379E-07    5.58057E-07     5.68933E-07    5.72922E-08
    1  5  1    6.651745279    0.066680000     0.021170000   -0.002430000
    1  5  2    0.029840000    0.012180000    -0.003470000    0.000375400
    1  5  3   -0.000275680   -0.000172110     0.000096690   -0.000012690
    1  5  4    0.000001420    0.000001000    -8.36282E-07    1.09630E-07
    1  5  1    6.651745279    0.076240000     0.025480000    0.002980000
    1  5  2    0.027910000    0.007610000     0.000423370   -0.000105760
    1  5  3   -0.000236940   -0.000001130     0.000026480    0.000005320
    1  5  4    0.000001250   -3.42452E-07    -2.48140E-07   -4.09308E-08
    1  6  1   -100000000.0    0.000000000     0.000000000    0.000000000,
    1  6  2    0.000000000    0.000000000     0.000000000    0.000000000,
    1  6  3    0.000000000    0.000000000     0.000000000    0.000000000,
    1  6  4    0.000000000    0.000000000     0.000000000    0.000000000,
    1  6  1   -100000000.0    0.000000000     0.000000000    0.000000000,
    1  6  2    0.000000000    0.000000000     0.000000000    0.000000000,
    1  6  3    0.000000000    0.000000000     0.000000000    0.000000000,
    1  6  4    0.000000000    0.000000000     0.000000000    0.000000000/
```

Table 28: Description of fields in optional fuel/emission file

Line	Field	Description
1	1	File title
2	1	Number vehicle entries [integer] ($1 \leq x \leq 25$)
3	1	Vehicle type number (ranges from 1 to 25)

	2	Fuel consumption or emission type:
		1. Fuel consumption coefficients
		2. HC Emission coefficients
		3. CO Emission coefficients
		4. NO_x Emission coefficients
		5. CO_2 Emission coefficients
		6. PM Emission coefficients
	3	Speed level (ranges from 1 to 4)
	4	Coefficient for acceleration factor 1 (Acceleration power 0)
	5	Coefficient for acceleration factor 2 (Acceleration power 1)
	6	Coefficient for acceleration factor 3 (Acceleration power 2)
	7	Coefficient for acceleration factor 4 (Acceleration power 3)

3.11 Lanebias.dat: Lane Bias File

The file 'lanebias.dat' is an optional file that biases vehicles to change lanes within a specified distance of a downstream link. The parameters included in the file will override the lane bias internal to the model.

The bias is only effective on the upstream link (field 2). Once the vehicle leaves the link the bias factor is no longer effective. Consequently, if the user wants to maintain a bias over a number of links, a separate line is required for each of the links.

The bias is achieved by reducing the perceived speed in the lanes other than the biased lane. The user has control the reduction factor of perceived speed. We recommend a factor of 2.0, which results in a perceived speed that is half the actual speed. A factor of 2.0 entices vehicles to use the desired lane at low volumes; however, it has a minor effect at high volumes. If the user would like a more aggressive lane allocation a higher factor should be utilized.

The distance at which the lane bias occurs is measured from the downstream end of the downstream link towards the upstream link. The location is varied randomly across the different vehicles in order to ensure that not all lane-changing occurs at the same location.

File organization

Table 29: Sample optional Lane Bias File

```
Lane Bias File
  1
  1  1   01111   100   13   1.0   2.0
```

Table 30: Description of fields in optional Lane Bias File

Line	Field	Description
1	1	File title
2	1	Number of lane bias entries [integer]
		$(0 \leq x \leq$ *max. number of links*$)$
3+	1	Lane bias number [integer]
		$(0 \leq x \leq$ *max. number of links*$)$
	2	Link number at which vehicles respond to bias
		$(0 \leq x \leq$ *max. number of links*$)$

3	Vehicle classes affected by bias [binary: *abcde*]. A "1" indicates the vehicle class responds to the bias while a "0" indicates that the vehicle does not respond to the bias.
	    a : vehicle class 1
	    b : vehicle class 2
	    c : vehicle class 3
	    d : vehicle class 4
	    e : vehicle class 5

4	Lane bias indicators [binary: for a 3-lane link *xyz*]. A binary number for each lane indicates whether the lane involves a bias. A "1" indicates that the lane has a bias while a "0" indicates that a lane does not have a bias.
	    x : lane 3 bias indicator
	    y : lane 2 bias indicator
	    z : lane 1 bias indicator
	Lanes are numbered in ascending order from the shoulder lane to the median lane.

5	The downstream link for which vehicles heading for will respond to the bias.
6	The length from the downstream link that vehicles will respond to the lane bias [km]. ($0 \leq x \leq 10.0$) If the length is less than the distance between the downstream end of the link number identified in field 2 and thedownstream link number identified in field 5, the bias will have no impact.
7	Speed reduction factor. ($1.0 \leq x \leq 10.0$). This divisive factor reduces the perceived speed in lanes other than the biased lane. For example a factor of 2.0 results in a perceived speed of 0.5 the actual speed in all other lanes except the biased lane.

3.12 Lanechange.dat: Lane Change Customization File

The file 'lanechange.dat' is an optional file that can be utilized to alter the default lane change parameters that are incorporated within the INTEGRATION software. Alteration of the lane change parameters should be made with caution given that the INTEGRATION default parameters were selected after significant experimentation. The lane change customization file is not link specific; instead it is a global file.

Table 31 illustrates a sample input file using the INTEGRATION default parameter values, while Table 32 provides a brief description of each of the input parameters. A more detailed description of the input parameters are provided.

The hardwall location factor identifies the location at which vehicles are unable to proceed closer to the diverge section. For example a factor of 10 means that vehicles will come to a complete stop at a distance equal to 10 times the jam density headway upstream the diverge section for each single lane change maneuver. The softwall location factor identifies the location at which the vehicle recognizes the need to change lanes in order to exit at a diverge section. The location of the softwall is the product of the hardwall and softwall factors with the jam density headway. The default value is 100 (10x10) times the jam density headway.

The logic reduces the number of unnecessary lane changes by incorporating an inertia factor that increases the attractiveness of the lane that the vehicle is traveling in, as demonstrated in the following equation. The attractiveness of the current lane is achieved using three factors, a relative speed factor, an absolute speed factor, and a maximum inertia threshold. The use of a relative factor encourages vehicles to make more lane changes at low speeds in order to minimize queue lengths at a signalized intersection. The use of the vehicle length equivalency factor ensures that trucks make less lane changes than passenger cars.

$$I = \min(uf_3 + f_4, f_5)\sqrt{pcu}$$

Where:

I = Inertia to remain in current lane which is added to the actual speed to compute the driver perceived speed of the current lane (km/h).

u = Vehicle speed (km/h)

f_3 = Relative inertia factor (unitless)

f_4 = Absolute inertia factor (km/h)

f_5 = Absolute inertia factor (km/h)

pcu = Vehicle length equivalency factor (e.g. a factor of 3.0 indicates that the length of the vehicle is equivalent to the length of 3 passenger cars).

The INTEGRATION model also biases travel towards the median lane for passenger cars when they travel outside the influence area of merge and diverge sections. In addition, the model biases trucks towards use of the shoulder lane by altering the perceived speeds across the different lanes, as demonstrated in the perceived speed equation.

$$\tilde{u}_i = u_i + \left(\frac{n}{2} - \text{ABS}\left(\frac{n-1}{2} + 1 - i \right) \right)\left(u_i f_7 + f_8 \right) + \left(\frac{7-i}{n} \right)^2 (pcu - 1)$$

Where:

$\tilde{u}_i$ = Perceived speed in lane "i" (km/h).

u_i = Actual speed in lane "i" (km/h)

n = Number of lanes on roadway section

f_7 = Relative speed factor (unitless)

f_8 = Absolute speed factor (km/h)

pcu = Vehicle length equivalency factor (e.g. a factor of 3.0 indicates that the length of the vehicle is equivalent to the length of 3 passenger cars).

File organization

Table 31: Sample optional Lane Change customization File

```
Lane Change Customization File
  10  10   0.2   5  10   2.0   0.01   1.0   0.5   0.5
```

Table 32: Description of fields in optional Lane Bias File

Line	Field	Description
1	1	File title
2+	1	Hardwall location factor [real]] $(5 \le x \le 15)$
	2	Softwall location factor [real] $(5 \le x \le 15)$
	3	Relative inertia to remain in current lane [real] $(0.0 \le x \le 0.5)$
	4	Absolute inertia to remain in current lane (km/h) [real] $(0 \le x \le 15)$
	5	Maximum inertia for lane (km/h) [real] $(5 \le x \le 25)$

	6	Average lane change duration (s) [real]
		(1.0 ≤ x ≤ 5.0)
	7	Relative lane change bias factor [real]
		(0.0 ≤ x ≤ 0.05)
	8	Absolute lane change bias factor [real]
		(0.0 ≤ x ≤ 2.0)
	9	Required but not used
	10	Required but not used

3.13 Tollplaz.dat: Toll File

The file 'Tollplaz.dat' is an optional file that permits the specification of driver value of time and tolls on specific links. This file, if it is to be used, should be present in the same input folder as all of the other input files.

File organization

Table 33: Description of fields in optional Toll File

Line	Field	Description
1	1	File title
2	1-5	Mean value of time for vehicle class 1 to 5 in $/hr [real]
		(0 ≤ x ≤ 100.0)
3	1-5	Coefficient of Variation of value of time [real]
		(0 ≤ x ≤ 1.0)
4	1	Number of links with tolls on them [integer]
		(0 ≤ x ≤ maximum number of links in File 2)
5+	1	First link toll entry [integer]
		(0 < x ≤ *max. link number in network*)
	2	Link with toll on it [integer]
		(1 < x ≤ *max. link number in network*)
	3	Toll type [integer]
		(*x= 1*)
	4	Toll start time in seconds [integer]
		(0 ≤ x ≤ toll end time)
	5	Toll end time in seconds [integer]
		(toll start time < x ≤ simulation time)
	6-10	Toll rate for vehicle class 1 to 5 in $ [real]

3.14 Biasfact.dat: Link Travel Time Bias Factor

The file 'biasfact.dat' is an optional file that permits the user to set link specific bias factors that are incorporated within the minimum path tree algorithm. Two factors are available, an additive factor and a multiplicative factor. The format of the file is illustrated in Figure 3.8.

$TT_i = TT_i \times TTF_2 + TTF_1$ for all links i

Where:

TT_i : Travel time on link "i",

TTF_1: Additive travel time factor (default value = 0.0 seconds), and

TTF_2: Mulitplicative travel time factor (default value = 1.0).

File
organization

Table 34: Description of fields in optional Link Travel Time Bias Factor file

Line	Field	Description
1	1	File title
2	1	Number of bias factors included in the file.
3+	1	Link number [integer] (1 < *x* ≤ *max. link number in network*)
	2	Additive to be included to the travel time function [seconds]. Default is 0.0 seconds.
	3	Multiplicative factor to be included to the travel time function [fraction]. Default value is 1.0.

3.15 Ops_gaps.dat: Link Travel Time Bias Factor

The file 'ops_gaps.dat' is an optional file that permits the user to set link specific gap acceptance critical gaps. The format is described in Table 35.

Table 35: Description of fields in optional opposing gaps file

Line	Field	Description
1	1	File title
2	1	Number of opposing gap entries included in the file.
	2	Base opposing gap size (seconds)
	3	Decay time for decay function (seconds)
	4	Coefficient of variation for stochastic gap acceptance
3+	1	Link number [integer]. (1 < *x* ≤ *max. link number in network*)
	2	First opposing link number
	3	First link critical gap size (seconds)
	4	Second opposing link number
	5	Second link critical gap size (seconds)
	6	Third opposing link number
	7	Third link critical gap size (seconds)
	8	Forth opposing link number
	9	Forth link critical gap size (seconds)
	10	Fifth opposing link number
	11	Fifth link critical gap size (seconds)

3.16 Mxvehspd.dat: Maximum Vehicle Speed File

The file 'mxvehspd.dat' is an optional file that permits the user to set vehicle class maximum speed. The format is described in Table 36.

Table 36: Description of fields in optional maximum vehicle speed file

Line	Field	Description
1	1	File title
2	1	Maximum speed for vehicle class 1 (km/h)
	2	Maximum speed for vehicle class 2 (km/h)
	3	Maximum speed for vehicle class 3 (km/h)
	4	Maximum speed for vehicle class 4 (km/h)
	5	Maximum speed for vehicle class 5 (km/h)

3.17 LnkLOS.dat: Link Level of Service File

The file 'LnkLOS.dat' is an optional file that permits the user to identify links to be considered in generating Level of Service (LOS) measures of effectiveness using the Highway Capacity Manual (HCM) procedures. The format of this file, which is described in Table 37, allows the user to generate LOS measures at user defined intervals and output to file 10. The frequency output to file 10 is defined in the master control file. A sample LOS file is presented in Table 38.

Freeway roadway LOS criteria are set based on the roadway density, as formulated in the HCM procedures. The procedures consider 6 LOS's based on an average lane density, as demonstrated in Table 39. A weighted average density is computed for a sequence of links defined within an LOS category using Equation 3.9.1.

The LOS for arterial roadways is defined based on the average delay incurred by vehicles approaching a traffic signal or stop sign using the HCM procedures. Specifically, the average delay for an approach is computed as the sum of delays across all links that are defined in an approach. Subsequently, an average delay for the entire intersection is computed as the volume weighted average delay across all approaches, as defined in Equation 3.9.2. The delay for each category is compared against the thresholds defined in Table 40 to estimate the intersection LOS. Delay is computed as the additional travel time relative to free-speed travel on a roadway segment.

$$k = \frac{1}{N}\sum_{i=1}^{N}\frac{q_i}{u_i}$$ [3.9.1]

Where:
k = Weighted average density (veh/km/lane)
q_i = Flow rate along roadway segment "i" (veh/h)
u_i = Speed of traffic stream along roadway segment "i" (km/h)
N = Number of roadway segments under consideration

$$d = \frac{\sum_{i=1}^{N}\left(t_i - t_i^f\right)}{\sum_{i=1}^{N}C_i}$$ [3.9.2]

Where:
d = Weighted average delay (s/veh)
t_i = Travel time along roadway approach "i" (s)
t_i^f = Free-speed travel time along approach "i" (s)
C_i = Number of vehicles traversing approach "i" over the analysis period (veh)
N = Number of approaches under consideration

Using the sample LOS file in Table 38 we observe that for freeway links the file only requires indicating the number of links to be grouped, while the arterial links require a list of approaches and the links that constitute the approach. This allows the user to include a long enough roadway section for computing the delay upstream of a traffic signal. The results of the analysis are printed in the standard file 10.

Table 37: Description of fields in optional LOS file

Line	Field	Description
1	1	File title
2	1	Number of entries
3	1	LOS category number
	2	LOS type (1: Freeway roadway, 2: Arterial roadway)
	For freeway roadways:	
	3	Number of links grouped within an LOS category
	4+	Links to be considered in the LOS category
	For signalized roadways:	
	3	Number of approaches grouped within an LOS category
	4+	Number of links grouped within an approach and their corresponding link numbers

Table 38: Sample LnkLOS.dat File

```
LOS  Sample File
15
1    1    2    1    2
2    1    1    3
3    1    3    4    5        6
4    1    1    7
5    1    2    8    9
6    1    2    11   12
7    1    1    13
8    1    3    14   15       16
9    1    1    17
10   1    2    18   19
11   2    3    1    36       2       33      34      2       54      55
12   2    1    2    54       55
13   2    1    2    33       34
14   2    1    1    36
15   2    3    1    26       2       23      24      2       44      45
```

Table 39: LOS criteria for freeway roadways

LOS	Maximum Density (pc/mile)
A	10
B	20
C	28
D	35
E	≤43
F	>43

Table 40: LOS criteria for arterial roadways

LOS	Maximum Delay (s/veh)
A	≤ 10
B	10 < x ≤ 20
C	20 < x ≤ 35
D	35 < x ≤ 55
E	55 < x ≤ 80
F	> 80

3.18 cms_lag.dat: CMS Lag Time File

The file 'cms_lag.dat' is an optional file that permits the user to input a CMS lag time for the various CMS's, as demonstrated in Table 41 and Table 42.

Table 41: Description of fields in optional CMS lag file

Line	Field	Description
1	1	File title
2	1	Number of entries
3	1	Node number
	2	Lag time (s). [Default is 60s]

Table 42: Sample cms_lag.dat File

```
LOS Sample File
2
5    300
10   600
```

3.19 (A) Ecodrive.dat: Eco-Cooperative Adaptive Cruise Control

The file 'ecodrive.dat' is an optional file that defines the settings of the eco-cooperative adaptive cruise control (Eco-CACC) algorithm. This file, if to be used, should be placed in the same input folder as all of the other input files. The format of the file is illustrated in Table 43 and Table 44 shows a sample input file.

The Eco-CACC algorithm utilizes vehicle-to-signal communication technology to control the movement of probe vehicles traversing intersections to minimize their fuel consumption levels. Applying this algorithm, each probe vehicle is provided with a target speed profile to minimize its fuel consumption while proceeding through a signalized intersection. Once the vehicle passes through the intersection, its acceleration behavior to approach its desired speed is also controlled. The two stages are incorporated to minimize the vehicle's fuel consumption rate.

The link location indicator (field 4) defines the location of the controlled link in the network. If the value is 1, the link is at the upstream of the intersection. The eco-speed control system slows down the speed of probe vehicles on the link to avoid complete stop ahead of the intersection. If the value is -1, the link is at the downstream, where the probe vehicles' accelerations are restricted to minimize fuel consumption levels.

The distance to signal (field 7) defines the location where the Eco-CACC algorithm is activated. This should be the link upstream of the intersection. This distance is defined as the distance between the start of the link and the intersection.

Table 43: Description of *ecodrive.dat* control file fields

Line	Field	Description
1	1	File description
2	1	Number of links where the vehicles will apply the eco-speed control algorithm [integer]
	2	Format of the input file [integer] 1: eco-speed control without the consideration of queues; 2: eco-speed control with the consideration of queues
3+	1	Line number
	2	Link number *nl* (0<x<max link number)
	3	Probe vehicle class: *abcde;* where 1 indicates the class of vehicles is controlled; 0, otherwise.

		a: vehicle class 1
		b: vehicle class 2
		c: vehicle class 3
		d: vehicle class 4
		e: vehicle class 5
	4	Link location indicator [integer]
		1: upstream of the signal
		-1: downstream of the signal
	5	Signal number [integer]
		(0<x<max signal number)
	6	Phase number that vehicle on link *nl* can go through the signal [integer], set as 1
	7	Distance to the signal where the eco-speed control algorithm is activated (meter)
	8	Updating frequency for the vehicle class 1 (second)
	9	Updating frequency for the vehicle class 2 (second)
	10	Updating frequency for the vehicle class 3 (second)
	11	Updating frequency for the vehicle class 4 (second)
	12	Updating frequency for the vehicle class 5 (second)
	13	Detector number at the start point of the controlled link
		(only applied for upstream link, and only used when eco-speed control considers queues)
	14	Length of the downstream control segment (meter)
		(only applied for the upstream link)

Table 44: Sample *ecodrive.dat* file

```
Sample Eco-drive File
2  2
1  4  11111   1  1  1  200  1.0  1.0  1.0  1.0  1.0  3  200
2  5  11111  -1  1  1  200  1.0  1.0  1.0  1.0  1.0  3  200
```

3.19 (B) multi_objective_eco_routing.dat: Multi Objective Eco-routing

The file 'multi_objective_eco_routing.dat' is an optional file that defines the settings of the multi-objective eco-routing. The objective is to minimize the trip time and the fuel consumed given input parameters. This file, if to be used, should be placed in the same input folder as all of the other input files. The format of the file is illustrated in Table 45 and Table 46Table 43 shows a sample input file.

$$Link_{Cost} = (1 - \alpha) * Travel\_time\_on\_link + toll\_penalty$$
$$+ \alpha\ fuel\_consumed\_per\_link * \frac{Cost\_factor}{Value\_of\_Time}$$

Table 45: multi_objective_eco_routing.dat file format

Line	Field	Description
1	1	File description
2	1	Alpha [real] unit less
	2	Value of time (energy) mean value for the normal distribution
	3	Value of time (energy) coefficient of variation (for the normal distribution), the returned value of time has units of dollars/hour
	4	Cost of fuel (dollars/liters)
	5	Cost of Energy (dollars/ (kw/h))

Table 46: Sample eco routing parameter file (For illustrative purposes only – this might give you wrong results)

```
Eco Routing Parameters for Conventional and Electric Vehicles
0.5 10.0 0.1 0.5 0.008
```

3.20 Eco-Cooperative Adaptive Cruise Control for Multiple Intersections: ecaccms.dat

The file 'ecaccms.dat' is an optional file which defines the settings of the Eco-Cooperative Adaptive Cruise Control (Eco-CACC) algorithm for multiple intersections. This file, if it is to be used, should be presented in the same input folder as all of the other input files. The format of the file is illustrated in **Table 46**, and **Table 47** shows a sample eco-speed control input file. Note that the advanced formatted of link characteristics is required here, since the discharge behavior for each signal phase is needed as the input for the algorithm.

The Eco-CACC algorithm utilizes the vehicle-to-signal communication technology and control probe vehicles passing more than one intersection to minimize the fuel consumption levels. Applying this algorithm, each probe vehicle is provided with a target speed profile to approach its downstream intersection with the consideration of vehicle queues and the signal timings of further downstream intersections. Once it passes the intersection, it accelerates to a steady speed to cruise to the next intersection. These two operations are incorporated to minimize its fuel consumption level.

The algorithm control probe vehicles on the specified links defined in the table 1. It is able to control more than one link at the upstream of the intersection, as well as more than one link at downstream. For each controlled link, its distance to the intersection shall be clarified (field 3). If the link is at the upstream of the intersection, the distance is measured from the end of the link to the intersection, and the algorithm will accelerate or decelerate the probe vehicles to a target speed and to cruise to the intersection. If the link is at the downstream of the intersection, the distance is measured for the intersection to the start of the link. The algorithm will accelerate the probe vehicles back to the road speed limit.

In order to use the option of 'control with the consideration of Queues', the input of File 21 with detector location information is needed. The detector shall be installed at the immediate upstream link of the intersection. It detects traffic volume entering the intersection, which is applied to estimate vehicle queue length ahead of the intersection.

Table 46: Description of fields in the Eco-CACC multiple intersections control file

Line	Field	Description
1	1	File description
2	1	Number of links where the vehicles will apply the Eco-CACC algorithm [integer]
	2	Format of the input file [integer] 1: control without the consideration of Queues; 2: control with the consideration of Queues
3+	1	Line number
	2	Link number, nl (0<x<max link number)
	3	Distance to the intersection N>0: from the end of the link to the downstream intersection N<0: from the upstream intersection to the start of the link
	4	Updating interval (seconds)
	5	Number of intersections controlled, N

		>1: control more than one intersections;
		1: only one downstream intersection;
		-1: the link is the downstream link where vehicles will accelerate back to road speed limit.
		$n = 1,2,\cdots,|N|$
	6n	Signal number, sig
		If $N > 0$
		n=1: the immediate downstream of the link nl (first intersection)
		n>1: the neighbors of the first intersection
		If N<0
		n=1: the immediate upstream intersection of the link nl
	6n+1	The immediate upstream link number of the intersection sig
	6n+2	The immediate downstream link number of the intersection sig
	6n+3	The detector number installed on the immediate upstream link of the intersection sig
	6n+4	The control length of the immediate downstream link of the intersection sig
	6n+5	The distance between the two consecutive intersection (meter)
		If $|N| = 1$ or it is the first intersection, the distance is 0.

Table 47: Sample eco-speed control file

Eco-drive multiple intersections file												
4	1											
1	1	00100	0	1	2	1	1	15	1	200	0	2
	2	3	2	200	1000							
2	15	00100	500	1	1	2	2	3	2	200	0	
3	2	00100	0	1	1	2	2	3	2	200	0	
4	3	00100	0	1	-1	2	2	3	2	200	0	

3.21 VT-CPFM.dat: VT-CPFM Parameter File

The VT-CPFM.dat file is an optimal file that defines the parameters of the VT-CPFM model, and the deceleration rate of each vehicle type when the Eco-CACC algorithm is applied. In the VT-CPFM model, there are totally 25 types of passenger cars, and each type of vehicles has the same parameters, which has been well calibrated. Table 48 illustrates the description of the input file, and Table 49 shows a sample input file.

Table 47: VT-CPFM.dat file format

Line	Field	Description
1	1	File description
2	1	Number of vehicle types defined [integer]
	2	Format of the input file [integer]. Not used
3+	1	Line Number
	2	Vehicle type
	3	The first coefficient of the VT-CPFM model α_0
	4	The second coefficient of the VT-CPFM model α_1
	5	The third coefficient of the VT-CPFM model α_2
	6	The deceleration level used in the Eco-CACC algorithm (m/s^2)

Table 49: Sample VT-CPFM parameter file

```
VT-CPFM Parameters
25      1
1       1       0.000341        0.0000583       0.00000100      2.0
```

```
2       2       0.000303       0.0000541       0.00000100       2.0
3       3       0.000271       0.0000769       0.00000100       2.0
4       4       0.000393       0.0000000       0.00000662       2.0
5       5       0.000379       0.0000704       0.00000100       2.0
6       6       0.000384       0.0000544       0.00000100       2.0
7       7       0.000432       0.0000569       0.00000100       2.0
8       8       0.000468       0.0000461       0.00000100       2.0
9       9       0.000416       0.0000408       0.00000100       2.0
10      10      0.000517       0.0000431       0.00000100       2.0
11      11      0.000489       0.0000429       0.00000100       2.0
12      12      0.000445       0.0000476       0.00000100       2.0
13      13      0.000793       0.0000224       0.00000100       2.0
14      14      0.000647       0.0000433       0.00000100       2.0
15      15      0.000642       0.0000401       0.00000100       2.0
```

3.22 divc_input.dat: Distributed Intersection Vehicle Control System File

The file "divc_input.dat" is an optional file that permits the user to activate the distributed intersection vehicle control system to allow connected or autonomous vehicles to pass intersection without signals. This file, if it is to be used, should be presented in the same input folder as all of the other input files. The format of the file is illustrated in **Table 50**, and **Table 51** shows one sample input files.

The distributed intersection vehicle control (DIVC) system is designed to allocate time slots for connected and autonomous vehicles to pass intersections without regulating by signals. The system requires all vehicles equipped with wireless communications, and they are able to coordinate with each other to search the best time to pass the intersection to minimize travel delay. This system is a fundamental platform to develop a fully connected and autonomous vehicle system in the near future.

Upstream and downstream links: The links are defined to identify the approaches of one intersection (up to 12 approaches). The priority of vehicles passing the intersection is given based on the approaches.

Passing time of movements: The passing time of the movements (up to 3) is defined to set the weight for different movements (left, right and through). Generally, the passing time of left- or right-turn is larger than the through traffic.

Table 50: Description of the file 'divc_input.dat'

Line 1	Column #	Definition
1		File title
2	1	Number of intersections controlled by the DIVC system
	2	Flag indicating whether the DIVC system is applied 1: activated; 0: not
3+	1	Line identification number
	2 - 5	Upstream link numbers of the intersection 2: West, 3: South, 4: East, 5: North
	6 - 9	Downstream link number of the intersection 6: West, 7: South, 8: East, 9: North
	10 - 13	Passing time for different movements (seconds) 10: Left turn, 11: Right turn, 12: Through
	14	Updating interval of the DIVC system (second)

Table 51: Sample DIVC system input file

```
Distributed intersection vehicle control system
```

```
1      1
1      2       14     6      10     7      11     3      15     1      1
       1      10
```

3.23 Optimal Signal control with Q-Learning: input_qlsig.dat

The file "input_qlsig.dat" is an optional file that permits the user to apply the Q-learning algorithm to find the signal phasing and timing plan to reduce stop delay of individual vehicles and improve capacities of the intersection. This file, if it is to be used, should be presented in the same input folder as all of the other input files. The format of the file is illustrated in **Tabe 52**, and **Table 53** shows a sample input file. The control algorithm applies Nash Bargaining solutions for multiple game players, i.e., the optimal signal timing plan to minimize the payoffs (queue length) of each phase.

Table 52: Description of fields in the file for optimal signal control with Q-learning

Line	Field	Description
1	1	File description
2	1	Number of controlled signals [integer]
	2	Format of weaving section control [integer] 0: no applicable; 1: applicable
3+	1	Line number [integer]
	2	Signal number sig
	3	Total number, n1, of links associate with the signal sig
	4 – 3+n1	Detector number at the beginning of the associated link
	4+n1 – 3+2n1	Number of lanes for the through traffic on the associate link
	4+2nl	Number, n2, of phases of the signal sig
	5+2n1 – 4+2nl+n2	The bargaining base point of each phase
	5+2n1 – 4+2nl+2n2	The weight of the payoff of each phase
	5+2nl+2n2	Updating interval (second)

Table 53: Sample of 'input_shql.dat'

```
Q-Learning Signal Control file
1    1
1    1    4    1    2    3    4    1    1    1    1    2    -20    -20    1    1    15
```

3.24 Speed Harmonization file: shcontrol.dat

The file "shcontrol.dat" is an optional file that permits the user to activate speed harmonization algorithm to prevent capacity drop at bottlenecks and increase their discharge rates. This file, if it is to be used, should be presented in the same input folder as all of the other input files. The format of the file is illustrated in **Table 54**, and **Table 55** and **56** shows two sample input files with different formats.

The speed harmonization (SH) algorithm is designed to prevent the onset or mitigate capacity drop at bottlenecks. The algorithm provides advisory speed limits for probe vehicles, so that

the inflow to bottlenecks is restricted, and the capacity drop caused by road congestion is dissipated. The increased bottleneck capacity also improves the overall network performance.

Format: The format of the speed harmonization algorithm (Line 2, Field 2) indicates whether a predictive algorithm is applied. If the value is 1, constant on- and off-ramp flow rates between the SH zone and the bottleneck are applied to estimated the target flow rate of the SH zone. If the value is 2, a linear regression model is introduced to predict the on- and off-ramp flow rates based on their locations.

Desired Flow Rate: The desired flow rate for the controlled link (Field 7) defines the optimal exiting flow rate of the SH zone to maintain the maximum bottleneck discharge rate. The value is determined by the bottleneck capacity without traffic breakdown and the total flow entering and leaving the freeway between the SH zone and the bottleneck.

Desired Density: The desired density at the upstream of the bottleneck (Field 9) is the density at the capacity of the link at the upstream of the bottleneck. This value is applied to determine whether capacity drop occurs at the bottleneck.

Table 54: Description of the file 'shcontrol.dat'

Line	Field	Definition
1		File title
2	1	Number of links in the speed harmonization zone
	2	Flag indicating whether the speed harmonization algorithm is applied 1: speed harm 5; 2: speed harm 6; 0: not
	3	Smoothing factor for the input data
	4	Factor to control acceleration rates
	5	Smoothing factor for the advisory speed limit
3+	1	Link line identification number
	2	Link number that applies the speed harmonization algorithm
	3	Vehicle classes controlled by the SH algorithm (abcde) a: vehicle class 1 b: vehicle class 2 c: vehicle class 3 d: vehicle class 4 e: vehicle class 5
	4	Time that the SH algorithm is activated (second)
	5	Time that the SH algorithm is terminated (second)
	6	Updating interval of the advisory speed limit (second)
	7	Desired flow rate for the controlled link (vph)
	8	Coefficient of the bottleneck capacity β_0, $0 < \beta_0 \leq 1$
	9	Desired density at the upstream of the bottleneck (veh/km)
	10	Maximum speed changes during each updating interval (km/hr)
	11	Detector number of the controlled link
	12	Detector number at the upstream of the bottleneck
	13	The number of efficient lanes to account the occupancy at the upstream of bottleneck Positive: from shoulder to median Negative: from median to shoulder
	14	Exponential smoothing factor, α
	15	Distance from the bottleneck to the controlled link (meter)
	16	Minimum advisory speed limit (km/hr)
	17	Number of on- and off-ramps between the bottleneck and the controlled link, n
	18 — 18+n-1	Detector number at on- or off-ramp
	17+n — 17+2n-1	Flag indicating on- and off-ramps 1: on-ramp -1: off-ramp
	18+2n — 18+3n-1	Distance from the on- or off-ramp to the controlled link

Table 55: Sample speed harmonization input file: format 1 (with prediction of off-ramp flow rates)

```
speed harmonization input file:
3      2      0.75    0.5    0.1
1      91     111     3600   18000   30      4200    0.6   23.7    10
       28     10      -3     0.5     741.785 20      2     22      4      -
1      -1     325     741
2      81     111     3600   18000   30      4200    0.6   23.7    10
       25     10      -3     0.5     616.785 20      2     22      4      -
1      -1     200     616
3      82     111     3600   18000   30      4200    0.6   23.7    10
       16     10      -3     0.5     416     20      2     22      4      -
1      -1     10      416
```

Table 56: Sample speed harmonization input file: format 2 (with constant off-ramp flow rates)

```
speed harmonization input file:
3      2      0.75    0.5    0.1
1      91     111     1200   18000   30      5100    0.6   23.7    8
       27     10      -3     0.5     10.0    40      0
2      81     111     1200   18000   30      5100    0.6   23.7    8
       16     10      -3     0.5     10.0    40      0
3      82     111     1200   18000   30      5100    0.6   23.7    8
       16     10      -3     0.5     10.0    40      0
```

3.25 Dynamic Speed Control File: spd_ctrl.dat

If the spd_ctrl.dat file exists in the input folder, INTEGRATION will read it and change the link free flow speed based on the configurations in the file.

The speed control file spd_ctrl.dat specifies the link number, change factor, the start and the end time. During that specified interval, the free flow speed of the specified link will be changed to the original free flow speed multiplied by the change factor. After the end time, it will be returned to the original value. The spd_cntl file should not have overlapped intervals for the same link.

Table 57: The fields in the spd_ctrl.dat file

Line	Field	Description
1	1	File title
2	1	Number of speed control descriptor records to be read [integer]. (0 ≤ x ≤2000)
3+	1	The speed control record number [integer]. (1 ≤ x ≤ 2000)
	2	Identification number of the link for which the free flow speed will be changed [integer]. (1 ≤ x ≤ max. link number)
	3	The speed control factor α. The new free flow speed = α * original free flow speed of the link
	4	Start time. When this record become active.
	5	End time. When the speed will be restored to its original value.

Table 58: Sample of the spd_ctrl.dat file

Merge_Control				
2				
1	3	0.1	100	1500
2	5	0.1	500	1000

Chapter 4:
Unlabeled Output Statistics

4.1   File 11: Average Traffic Conditions

File 11 provides a summary of the average traffic conditions that were experienced during the entire simulation run. Total counts are typically computed for the entire simulation run, while rates are computed as total counts divided by the duration of the simulation. A description of the fields contained within this file can be found in Table 4.1.

Table 48: Description of fields in Output File 11

Line	Field	Description
1	1	File title.
2	1	Number of time periods for which link flows are provided.
	2	Duration of each time period (seconds).
	3	Number of links in the network.
	4	Maximum link identification number.
3	1	Simulation time defining the end of the current time period (seconds).
	2	Observation period number:
4 to 4+nl-1 nl= number of links in the network	1	Link identification number.
	2	Link length (km).
	3	Link base capacity (vph): Computed as the product of the basic saturation flow rate and the number of lanes.
	4	Link total flow (vph): Sum of all vehicles for all vehicle classes divided by duration of simulation.
	5-9	Link flow by vehicle class (vph): Sum of all vehicles by class divided by the duration of the simulation.
	10	Link free-speed travel time (seconds): Estimate travel time when vehicle is virtually empty.
	11	Average link travel time for all vehicles (seconds): Sum of all travel times of vehicles, who traveled link, divided by the number of vehicles that completed the link.
	12-16	Average link travel time by vehicle class (seconds): Sum of all travel times of vehicles of a given type, who traveled the link, divided by the number of vehicles of that type who completed the link.
	17 - 21	Average toll collected on the link by vehicle class (dollars): Sum of all tolls collected for a vehicle class, divided by the total number of vehicles of that class who completed the link.
	22	Average number of vehicles on the link (vehicles): Sum of number of vehicles on link during each second, divided by the number of seconds of simulation.
	23	Average number of queued vehicles on the link (vehicles): Sum of vehicles in queue on link during each second, divided by the number of seconds of simulation.
	24	Average number of stops per vehicle on the link (stops/vehicle): Both complete and partial stops are recorded, where a change in speed from the free-speed to zero is considered a complete stop.
	25	Total fuel consumption on the link (L): Computed as the total volume of fuel consumed by all vehicles traversing the link.
	26	Total HC emissions on the link (g): Computed as the total amount of hydrocarbon (HC) produced by all vehicles traversing the link.

	27	Total CO emissions on the link (g): Computed as the total amount of carbon monoxide (CO) produced by all vehicles traversing the link.
	28	Total NO_x emissions on the link (g): Computed as the total amount of nitrous oxide (NO_x) produced by all vehicles traversing the link.
	29	Total CO_2 emissions on the link (g):
	30	Total PM emissions on the link (g)
	31	Total number of expected crashes on the link (crashes$\times 10^{-6}$).
	32	Total expected crashes on the link with injury as the highest injury level (crashes$\times 10^{-6}$).
	33	Total number of expected fatal crashes on the link (crashes$\times 10^{-6}$).
	34	Total number of crashes on the link for which the maximum damage was low (crashes$\times 10^{-6}$).
	35	Total number of crashes on the link for which the maximum damage was moderate (crashes$\times 10^{-6}$).
	36	Total number of crashes on the link for which the maximum damage was high (crashes$\times 10^{-6}$).
4+nl	1	Turning movement section header.
5+nl	1	Simulation time (seconds).
	2	Maximum link identification number.
6+nl to end	1	Link identification number.
	2	Average link left-turn flow over entire simulation for vehicle class 1 (vph).
	3	Average link through flow over entire simulation for vehicle class 1 (vph).
	4	Average link right-turn flow over entire simulation for vehicle class 1 (vph).
	5	Average link total flow over entire simulation for vehicle class 1 (vph).
	6-21	Average link directional flow movements for other vehicle classes (vph).

4.2   File 12: Time Series of Traffic Conditions

File 12 produces a time series of traffic conditions, similar in structure to File 11. The main difference is that this output is produced at intervals, as specified by the user in Field 3 on Line 2 of the master file. The field descriptions for File 12 are identical to those for File 11, except for the fact that turning movement counts are not provided. A detailed description of the fields contained within this file can be found in Table 4.2.

Table 49: Description of fields in Output File 12

Line	Field	Description
1	1	File title.
2	1	Number of time periods for which link flows are provided.
	2	Duration of each time period (seconds).
	3	Number of links in the network.
	4	Maximum link identification number.
3	1	Simulation time defining the end of the current time period (seconds).
	2	Observation period number:
4+	1	Link identification number.
	2	Link length (km).
	3	Link base capacity (veh/h): Computed as the product of the basic saturation flow rate and the number of lanes.
	4	Link total flow (vph): Sum of all vehicles for all vehicle classes divided by duration of simulation.
	5-9	Link flow by vehicle class (vph): Sum of all vehicles by class divided by the duration of the simulation.
	10	Link free-speed travel time (seconds): Estimate travel time when vehicle is virtually empty.

11	Average link travel time for all vehicles (seconds): Sum of all travel times of vehicles, who traveled link, divided by the number of vehicles that completed the link.
12-16	Average link travel time by vehicle class (seconds): Sum of all travel times of vehicles of a given type, who traveled the link, divided by the number of vehicles of that class who completed the link.
17 - 21	Average toll collected on the link by vehicle class (dollars): Sum of all tolls collected for a vehicle class, divided by the total number of vehicles of that type who completed the link.
22	Average number of vehicles on the link (vehicles): Sum of number of vehicles on link during each second, divided by the number of seconds of simulation.
23	Average number of queued vehicles on the link (vehicles): Sum of vehicles in queue on link during each second, divided by the number of seconds of simulation.
24	Average number of stops per vehicle on the link (stops/vehicle): Both complete and partial stops are recorded, where a change in speed from the free-speed to zero is considered a complete stop.
25	Total fuel consumption on the link (L): Computed as the total volume of fuel consumed by all vehicles traversing the link.
26	Total HC emission on the link (g): Computed as the total amount of hydrocarbon (HC) produced by all vehicles traversing the link.
27	Total CO emission on the link (g): Computed as the total amount of carbon monoxide (CO) produced by all vehicles traversing the link.
28	Total NO_x emission on the link (g): Computed as the total amount of nitrous oxide (NO_x) produced by all vehicles traversing the link.
29	Total CO_2 emissions on the link (g)
30	Total PM emissions on the link (g)
31	Total number of expected crashes on the link (crashes$\times 10^{-6}$).
32	Total expected crashes on the link with injury as the highest injury level (crashes$\times 10^{-6}$).
33	Total number of expected fatal crashes on the link (crashes$\times 10^{-6}$).
34	Total number of crashes on the link with low damages (crashes$\times 10^{-6}$).
35	Total number of crashes on the link with moderate damages (crashes$\times 10^{-6}$).
36	Total number of crashes on the link with high damages (crashes$\times 10^{-6}$).

4.3   File 13: Minimum Path Tree

File 13 produces a listing of the most recent minimum path tree calculations for driver class 1. Only one tree is produced per time period, although more than one path may have been used during the simulation. Trees are output at intervals specified in Field 3 of Line 2 in the Master Control File. A general description of the fields that comprise this file is provided in Table 4.3.

File structure   Each minimum path tree (one per time period) is defined within File 13 using two data blocks. The first block of data indicates which link a given vehicle should first enter if it leaves a particular origin zone, while the second block indicates which link this vehicle should take next as it completes travel on a previous link. The precise structure for the two data blocks will vary depending on the number of destination zones coded within the network.

If the maximum destination zone number is less than 15, then each data line is initiated by either an origin zone identification number (block 1) or a link identification number (block 2). Subsequent fields on the data line will represent the link number to be taken

next, from either the current origin zone (block 1) or link (block 2), in order to reach the corresponding destination zone.

However, if the maximum destination zone number exceeds 15, the structure for File 13 is the same as indicated above, except that a new line is utilized for each new set of 15 destination zones, in both block 1 and 2 data. For example, if there were 35 possible destinations, the first line for each destination would list the trip origin zone or current link number, as well as the links that are to be taken to reach destinations 1 to 15. On the second line the origin number / current link number would not be repeated, but the links to be taken to reach destinations 16 to 30 will be listed. Finally, on the third line, the current origin/link is again not repeated, but the links to be taken to reach destinations 31 to 35 are listed.

In both blocks of data, a zero indicates that there is no possible movement at that node that will lead to the given destination. Any other number refers to the link that should be taken, at each origin/link terminus, in order to be on the minimum path that leads to each destination zone. However, in the link data, an entry of -1 indicates that the current link is the last one on the driver's path towards that particular destination.

Table 50: Description of fields in Output File 13

Line	Field	Description
1	1	File title
2	1	Number of periods for which trees are provided [integer] Regardless of this value, only the first tree will be utilized.
	2	Duration of each time period in seconds [integer] Regardless of this value, the first tree will be utilized for the entire simulation.
	3	Number of origins in the network [integer]
	4	Maximum origin identification number [integer]
	5	Maximum destination zone identification number [integer]
	6	Number of links in the network [integer]
	7	Maximum link identification number [integer]
3	1	Period number [integer]
	2	Number of trees in the current period [integer]
4	1	Tree number within current time period [integer]
	2	Proportion of demand using current tree ($0.0 \leq$ weight ≤ 1.0) [real].
5-11	1	Origin zone identification number
	2+	Link to be taken at current origin zone to get to destination *j* where *j* is the column number. A maximum of 15 destinations are permitted on each line. If there are more than 15 destination in a network a new line should be utilized for each new set of 15 destinations. The node or link number representing the current position is **not** repeated for these additional lines.
12+	1	Link identification number
	2+	Next link to be taken to get to destination *j-1* where *j* is the column number

4.4   File 14: Time Series of Signal Plans

File 14 contains a time series of signal timing plans. This file has the same format as File 3, and allows the user to confirm fixed time plans or to check the structure of any optimized plans. The signal timings in File 14 are produced at intervals as specified in Field 3 on Line 2 in the master file.

4.5   Files 15 and 16: Trip and Link Level Probe Statistics

File 15 provides a vehicle probe listing which chronicles the trip arrival and departure statistics of vehicles which were coded as probes in the O-D Traffic Demand File. At present only 1 type of record is produced in File 15, namely record type 1. Specifically, Record type 1 is generated when a vehicle completes its trip. Record type 1 is only generated if the vehicle probe proportion for a given O-D pair is non-zero (ranges from 0.0 to 1.0), and a valid output file name is placed on the appropriate line in the Master Control File. A description of the fields that exist within the output file for record type 1 is provided in Table 51.

Table 51: Description of fields in Output File 15.

Line	Field	Description
1	1	Name of master file producing output
-	1	Record type indicator. 1 = probe report generated upon arrival of vehicle at destination
	2	Simulation time at which record produced (seconds)
	3	Vehicle ID number
	4	Vehicle class (1 to 5)
	5	Link Number of vehicle's last link during trip
	6	Vehicle origin zone number
	7	Vehicle destination zone number
	8	Time at which vehicle was scheduled to depart its origin zone (seconds)
	9	Time at which vehicle actually departed from its origin zone (seconds)
	10	Elapsed time (seconds) for entire trip
	11	Total delay (seconds).
	12	Stopped delay (seconds).
	13	Number of cumulative stops (stops).
	14	Distance covered (km).
	15	Average speed (km/h).
	16	Fuel used by vehicle (L).
	17	Amount of hydrocarbon produced by this vehicle (grams).
	18	Amount of carbon monoxide produced by this vehicle (grams).
	19	Amount of nitrous oxide produced by this vehicle (grams).
	20	Amount of CO_2 produced by this vehicle (grams).
	21	Amount of PM produced by this vehicle (grams).
	22	Total number of expected crashes (crashes x 10e-6).
	23	Total expected crashes: injury was the highest injury level (crashesx10e-6).
	24	Total number of expected fatal crashes (crashes x 10e-6).
	25	Total number of crashes: maximum damage was low (crashes x 10e-6).
	26	Total number of crashes: maximum damage was moderate (crashes x 10e-6).
	27	Total number of crashes: maximum damage was high (crashes x 10e-6).
	28	Total toll paid during trip (dollars).
	29	Total acceleration noise during trip (m^2/s^4).

File 16 provides a vehicle probe listing which chronicles the completion of each link a vehicle probe traverses. At present two types of records are produced, namely record

type 11 and 21. Record type 11 is produced only once for each link and generated at the time the vehicle departs the link. Record type 21, in contrast, is produced every second the vehicle is on the link. To generate record type 11 the vehicle probe proportion for a given O-D pair should be non-zero and range from 0.0 to 1.0. Alternatively, to generate a record type 21 the probe proportion should be greater than 1.0 and less than 100.0 (i.e. the value is input as percentage). In both cases a file name has to exist in the appropriate line in the Master Control File.

In addition to file 16 the probe vehicles can generate the time-space file to create time space diagrams. To generate this file the percentage probes should be 100.xx where "xx" is the proportion of probes (e.g. 100.40 will result in a 40% vehicle probe population). The format of the time-space output file is provided in Table 54.

The number of general characteristics of record types 11 and 21 is similar to record type 2, except that the information provided applies to the link or the previous second on that link, rather than the entire trip. The resulting differences are noted in Table 4.4 in each case. It should be noted that record types 21 have an additional field which is the lane on which the vehicle is located on the current link. Lane numbering starts from 1 on the median lane and increases towards the shoulder lane.

The relationship between the above records is as follows. A sum of all of the MOE's for a given link on record type 21 should sum up to the MOE report on record type

Table 52: Description of fields in Output File 16 file 11.

Line	Field	Description
1	1	Name of master file producing output
-	1	11= probe report generated upon completion of a link (percent probes in File 4 ranges from 0.0 to 1.0).
	2	Simulation time at which record produced (seconds)
	3	Vehicle ID number
	4	Vehicle class (1 to 5)
	5	Current link number
	6	Current lane number (numbering from median to shoulder lane in ascending order)
	7	Next link
	8	Lane number in next link (numbering from median to shoulder lane in ascending order)
	9	Vehicle origin zone number
	10	Vehicle destination zone number
	11	Time at which vehicle was scheduled to depart its origin zone (seconds)
	12	Time at which vehicle actually departed from its origin zone (seconds)
	13	Elapsed time (seconds) for most recent link
	14	Total delay (seconds).
	15	Stopped delay (seconds).
	16	Number of cumulative stops (stops).
	17	Distance covered (km).
	18	Average speed (km/h).
	19	Instantaneous speed when vehicle leaves link (km/h)
	20	Fuel used by vehicle (L).
	21	Amount of hydrocarbon produced by this vehicle (grams).
	22	Amount of carbon monoxide produced by this vehicle (grams).
	23	Amount of nitrous oxide produced by this vehicle (grams).
	24	Amount of CO_2 produced by this vehicle (grams).
	25	Amount of PM produced by this vehicle (grams).
	26	Energy Used by the Vehcile (kW)
	27	Total number of expected crashes (crashes x 10e-6).
	28	Total expected crashes: injury was the highest injury level (crashesx10e-6).

	29	Total number of expected fatal crashes (crashes x 10e-6).
	30	Total number of crashes: maximum damage was low (crashes x 10e-6).
	31	Total number of crashes: maximum damage was moderate (crashes x 10e-6).
	32	Total number of crashes: maximum damage was high (crashes x 10e-6).
	33	Total toll paid during trip (dollars).
	34	Total acceleration noise during trip (m^2/s^4).

Table 53: Description of fields in Output Files 16 format 21.

Line	Field	Description
1	1	Name of master file producing output
-	1	21 = probe report generated every second.
	2	Simulation time at which record produced (seconds)
	3	Vehicle ID number
	4	Vehicle class (1 to 5)
	5	Vehicle type (1 through 25)
	6	Current link number
	7	Current lane number (numbering from median to shoulder lane in ascending order)
	8	Vehicle origin zone number
	9	Vehicle destination zone number
	10	Time at which vehicle was scheduled to depart its origin zone (seconds)
	11	Time at which vehicle actually departed from its origin zone (seconds)
	12	Elapsed time (seconds)
	13	Total delay (seconds)
	14	Stopped delay (seconds)
	15	Number of cumulative stops (stops)
	16	Distance covered (km)
	17	Spacing between vehicle and vehicle ahead of it (m)
	18	Instantaneous speed (km/h)
	19	Instantaneous acceleration (m/s^2)
	20	Fuel used by vehicle (L)
	21	Energy Rate (in kW)
	22	Amount of hydrocarbon produced by this vehicle (grams)
	23	Amount of carbon monoxide produced by this vehicle (grams)
	24	Amount of nitrous oxide produced by this vehicle (grams)
	25	Amount of CO_2 produced by this vehicle (grams)
	26	Amount of PM produced by this vehicle (grams)
	27	Total number of expected crashes (crashes x 10e-6)
	28	Total expected crashes: injury was the highest injury level (crashesx10e-6)
	29	Total number of expected fatal crashes (crashes x 10e-6)
	30	Total number of crashes: maximum damage was low (crashes x 10e-6)
	31	Total number of crashes: maximum damage was moderate (crashes x 10e-6)
	32	Total number of crashes: maximum damage was high (crashes x 10e-6)
	33	Total toll paid during trip (dollars)
	34	Total acceleration noise during trip (m^2/s^4)

Table 54: Description of fields in Time-space Output File

Line	Field	Description
1+	1	Time (s)
	2	Vehicle ID number
	3	Vehicle class (1 to 5)
	4	Vehicle type (1 to 25)
	5	Cumulative distance traveled from origin (m)

	6	Link number
	7	Current lane number (numbering from median to shoulder lane in ascending order)
	8	Cumulative distance traveled on current link (m)
	9	Vehicle speed (km/h)
	10	Vehicle spacing (m)

4.6   File 17: Forecast Time Series of Link Statistics

Output File 17 contains a time series of link statistics in the same format as Output File 12. These statistics will only be written to File 17 if a valid file name is provided on the appropriate line in the Master Control File. It should also be noted, that Fields 7 through 17 will only contain zeros as these values are not relevant for a macroscopic assignment as opposed to microscopic simulation.

4.7   File 18: Time Series of Multiple Path Trees

Output File 18 contains a time series of multiple path trees in the same format as File 13. These path trees result from the utilization of the internal equilibrium assignment option. These equilibrium trees are written to File 18 if a valid file name is provided on the appropriate line in the Master Control File.

4.8   File 19: Time Series of Path Trees

Output File 19 contains a time series of path trees in the same format as File 13. These path trees represent the routes that are computed when the minimum paths toward each micro-destination zone are computed on the basis of distance only.

4.9   Detector Output File

When the optional detector location input file is utilized by the model, the output file DETECTOR.OUT is created in the specified output folder. This file may contain data generated by two different detector types. Type 1 detector data is provided on a section basis, while type 10 detector data is provided on a lane basis. A description of the fields contained within the detector output file is provided in Table 4.11.

Table 55: Description of fields in `DETECTOR.OUT` file

Line	Field	Description
1	1	File title
2	1	Simulation time (seconds) at start of interval
	2	Interval number.
	3	Duration of interval (seconds).
		For detector type 1
3+	1	Simulation time (seconds) when detectors were polled
	2	Detector station identification number
	3	Detector station type
	4	Section speed measured during the previous polling interval (km/h)
	5	Section volume measured during previous polling interval (vph)
	6	Average lane volume measured during previous polling interval (vphpl)
	7	Section occupancy measured during the previous polling interval ($\% \times 10$)

	8	Detector activation flag 0 = no vehicles passed detector during previous polling interval 1 = at least one vehicle passed detector during previous polling interval
3+		***For detector type 10***
	1	Simulation time (seconds) when detectors were polled
	2	Detector station identification number
	3	Detector station type
	4	Lane number - note lanes are numbered consecutively from 1 in the median lane, increasing to the shoulder lane.
	5	Lane volume measured during previous polling interval (vphpl)
	6	Lane speed measured during the previous polling interval (km/h)
	7	Lane occupancy measured during the previous polling interval ($\% \times 10$)