13 APPENDIX V

This appendix presents a description of the AIMSUN model (network topology and traffic demand) used in this work. It is intended as a starting point before the implementation of dynamic traffic assignment.

13.1 AIMSUN MODEL DESCRIPTION

Microscopic traffic simulators are probably the most powerful and versatile traffic analysis tools. Their ability to reproduce a broad range of traffic conditions means that skilled users are constantly asking for new features and functionalities in the never-ending process of improving the reproduction of traffic phenomena that are increasingly complex. This demand for constant improvement reaches its zenith when ITS applications are involved. Consequently, AIMSUN is a continuously evolving traffic simulator, as is GETRAM, its supporting software modelling platform. AIMSUN (**A**dvanced **I**nteractive **M**icroscopic **S**imulator for **U**rban and Non-Urban **N**etworks; http://www.aimsun.com) is imbedded in GETRAM (**G**eneric **E**nvironment for **TR**affic **A**nalysis and **M**odelling), a simulation environment that is inspired by modern trends in the design of graphical user interfaces for traffic modelling (AIMSUN, 2002) (TEDI, 2002).

Microscopic traffic simulators are simulation tools that realistically emulate the flow of individual vehicles in a road network. Most of the currently existing microscopic traffic simulators rely on the family of car-following, lane-changing and gap-acceptance models to model vehicles' behaviour. For a comprehensive description of car-following models see Gabbard (1991). Microscopic traffic simulators are proven tools for aiding transport feasibility studies. This is not only due to their ability to capture the full dynamics of time-dependent traffic phenomena, but also because they are capable of using behavioural models that can account for drivers' reactions when exposed to Intelligent Transport Systems (ITS). GETRAM is a simulation environment that is built around a microscopic traffic simulator, AIMSUN. GETRAM provides the following features:

- The ability to accurately represent any road network geometry. An easy-to-use graphic user interface (TEDI) can use existing digital maps of the road network and allows the user to model any type of traffic facility.

- Detailed modelling of the behaviour of individual vehicles. This is achieved by employing sophisticated and proven car-following and lane-changing models that take into account both general and local phenomena that can influence a vehicle's behaviour.

- An explicit reproduction of traffic control plans, pre-timed and actuated, in accordance with Nema's standards as well as those defined by TRANSYT and SYNCHRO. Auxiliary interfacing tools that allow the simulator to work with almost any type of real-time or adaptive signal control systems, such as C-Regelaar, Balance, SCATS and UTOPIA, are also provided.

- Animated 2D and 3D output of the simulation runs. This highly desirable feature helps to analyse and understand the operation of the system being studied and can be a powerful way of gaining widespread acceptance for complex strategies.

Car-following and lane-changing models in AIMSUN have evolved from Gipps's seminal models (Gipps, 1981 and 1986). The way in which the car-following model was implemented in AIMSUN took into account the additional constraints on the breaking capabilities of vehicles, which are imposed in the classic safe-to-stop-distance hypothesis and in the analysis carried out by Mahut (Mahut, 2000). In the implementation, an attempt was also made to capture the empirical evidence that driver behaviour depends on local circumstances (i.e. the acceptance of speed limits on road sections, the influence of grades, friction with drivers in adjacent lanes, and so on). This is achieved in AIMSUN by means of model parameters whose values—calculated at each simulation step—depend on the current circumstances and conditions in each part of the road network.

The lane-changing process, which has also evolved from one of Gipps's models, is modelled as a decision-making process that emulates the driver's behaviour when he or she is considering whether to change lanes (as in the case of turning manoeuvres determined by the route), the desirability of the lane change (such as, for example, to overtake a slow vehicle) and the feasibility conditions for the lane change. A lane change also depends on the location of the vehicle on the road network. To achieve a more accurate representation of the driver's behaviour in the decision-making process, three different zones inside a section are considered, each of which corresponds to a different lane-changing motivation. The distance up to the end of the section characterises these zones and the next turning point. The zones are defined as follows:

- Zone 1 is the zone farthest from the next turning point. Lane-changing decisions are mainly governed by the traffic conditions of the lanes involved.

- Zone 2 is the intermediate zone. In this zone, vehicles look for a gap and may try to accept it without this affecting the behaviour of vehicles in the adjacent lanes.

- Zone 3 is the zone nearest to the next turning point. Vehicles are forced to reach their desired turning lanes; they may reduce their speed if necessary and even come to a complete halt to make the lane change possible. Vehicles in the adjacent lane may also modify their behaviour to create a gap that is sufficiently large for the lane-changing vehicle.

The length of the lane-changing zones is defined by two parameters, Distance Zone 1 and Distance Zone 2, whose values depend on the current traffic conditions on the road section at each simulation step. For a more detailed description, see Barceló et al., 1995, 1998), Barceló and Casas (2002) and AIMSUN (2002).

Vehicles are assigned to routes according to a route choice model (Barceló et al., 1995). Additionally, AIMSUN allows vehicles to change their chosen route from origin to destination according to variations in traffic conditions as they travel through the road network. This provides the basis of a heuristic for dynamic traffic assignment.

The recent evolution of the AIMSUN microscopic simulator has taken advantage of the state-of-the-art in the development of object-oriented simulators and graphical user interfaces, new trends in software design and the support tools that are suited to traffic modelling requirements (Banks, 1998). Meeting the basic requirements of a microscopic simulator implies building models as close to reality as possible. The closer the model is to reality, the more data-demanding it becomes. This has traditionally been the main barrier preventing wider use of microscopic simulation. The manual coding of geometric data, turning movements at intersections, timings and so on is not only cumbersome and time-consuming but also a potential source of errors. Microscopic simulators are also hard to debug if the appropriate tools are not available. These drawbacks have been partially overcome by equipping GETRAM/AIMSUN with the required user-friendliness in the form of the graphic traffic-network editor (TEDI), which can import the geometric background of the road network and draw the network model on top, as shown on the left in Figure 13.1.

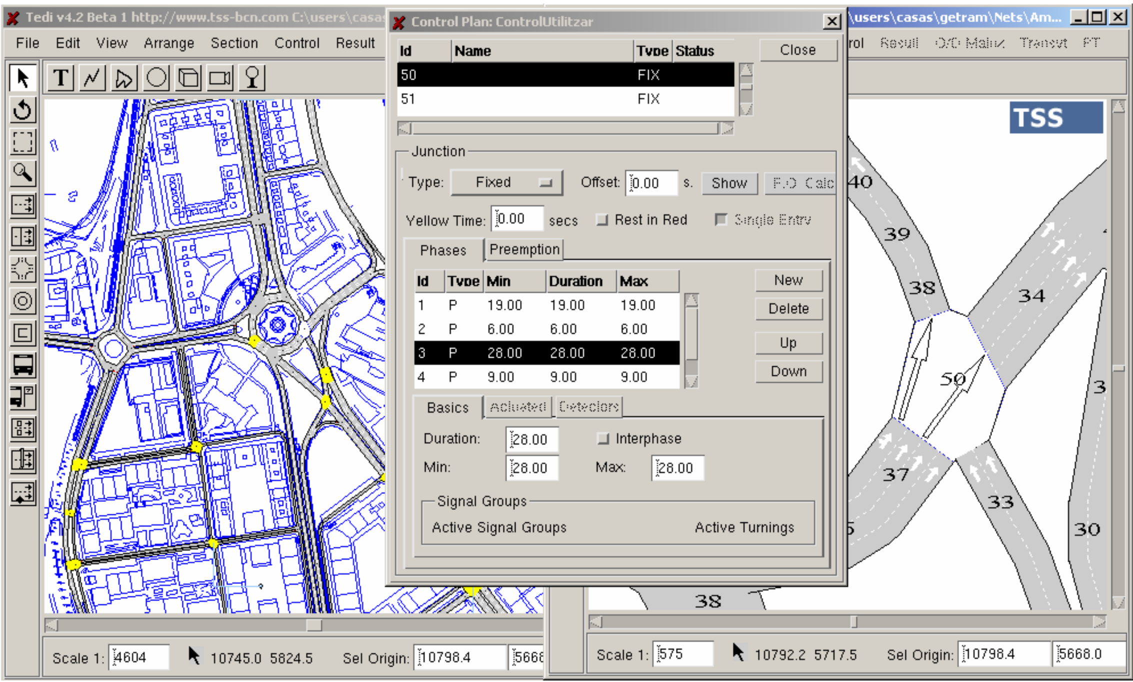

Figure 13.1. Example of GETRAM GUI for building microscopic simulation models

The background can be imported as a .dxf file, from a CAD or GIS system, or as any other graphic format, such as .jpg, .bmp and so on. All objects comprising the road model can be built with the graphic editor. Their attributes and parameters are defined and assigned values by means of window dialogs such as the one on the right in Figure 13.1, which shows the definition of the shared movements in a phase of a pre-timed signal control and the allocation of the timings. In short, this software environment for traffic modelling makes an easy task of the model-building process, ensures accurate geometry, prevents errors, provides powerful debugging tools and can be used to model any type of traffic-related facility.

13.1.1 NETWORK STRUCTURE

An AIMSUN traffic network model is composed of a set of sections (one-way links) that are connected to each other via nodes. Sections and nodes may be connected to centroids, which can be thought of as traffic sources or sinks. Figure 13.2 shows an example of a network model.

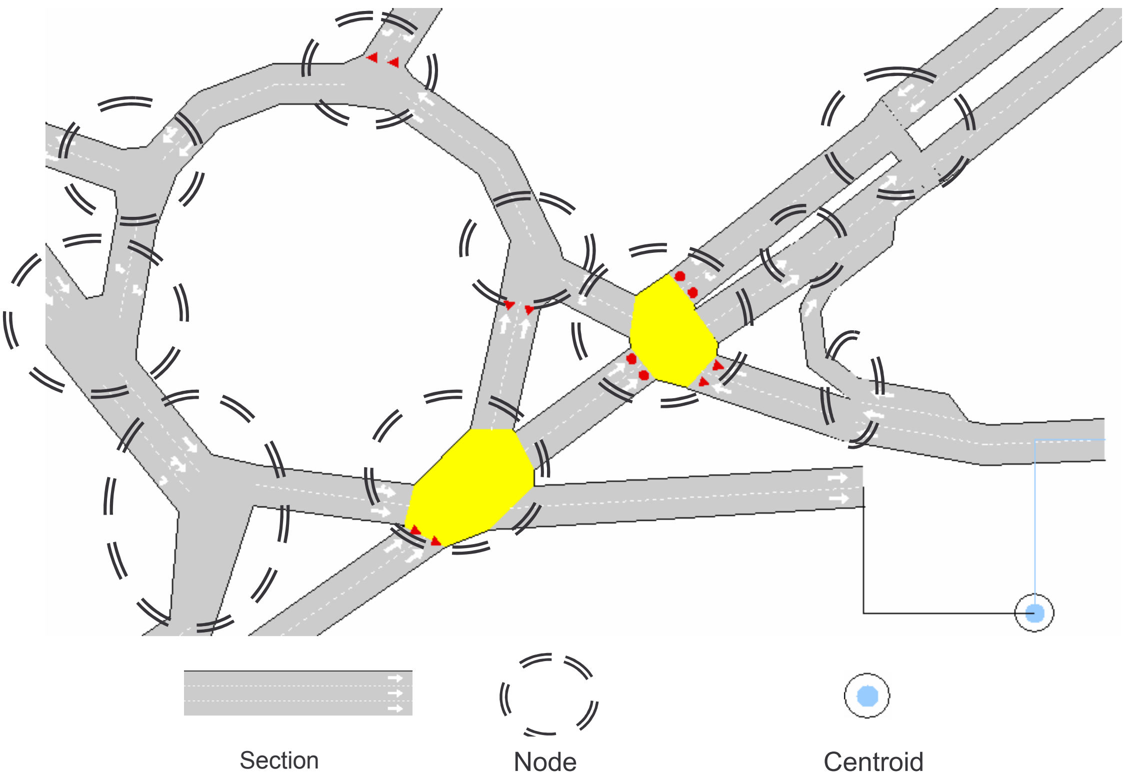

Figure 13.2. AIMSUN network model

13.1.1.1 SECTIONS

A section is a group of contiguous lanes in which vehicles move in the same direction. The partition of the traffic network into sections is usually governed by the physical boundaries of the area and the existence of turning movements. In an urban network, a section corresponds closely to the road from one junction to the next. In a freeway area, a section can be the part of the road between two ramps. Whatever the case may be, at the end of the section vehicles may have to take certain lanes to be able to turn into another section. However, since turnings occur in the transition between sections, they are modelled within the nodes, as explained hereafter.

Entrances, exits and the right and left sides of a section are defined according to the movement of vehicles, as shown in Figure 13.3.

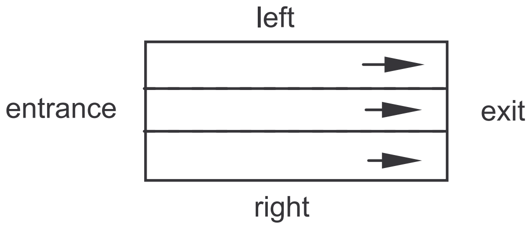

Figure 13.3. Notation used in sections

The lanes in a section are classified as main lanes or side lanes. In a main lane, vehicles can enter from other sections and exit to other sections: a main lane is both an entrance and exit lane. A side lane is positioned either on the right or the left side of the section, and is either an entrance or an exit lane (see Figure 13.4). In an urban area, side lanes model turns starting at the end of a section before a junction (see Figure 13.5). In a freeway area, side lanes are used to model entrance and exit ramps, acceleration and deceleration lanes and lane gains and losses, as will be seen later when the concept of the node is introduced. While a section cannot exist without one or more main lanes, side lanes are optional. A section cannot have more than one side lane per side.

Figure 13.4. Types of side lanes

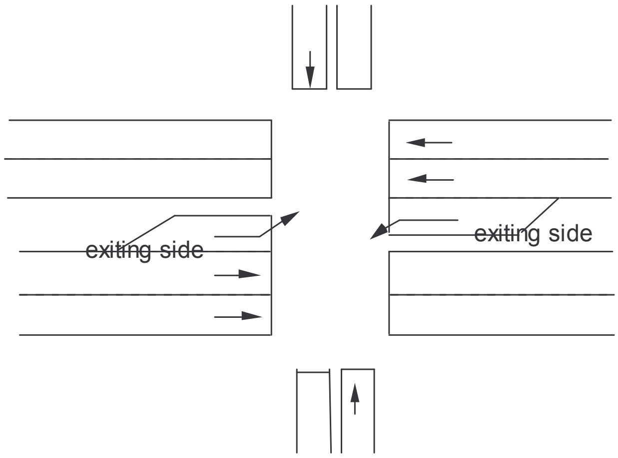

Figure 13.5. Side lanes used for left turnings at a junction

Besides the section identifier and name, the lane information (solid lanes, reserved lanes, etc.) and the equipment (VMS, detectors and meterings), the attributes of a section are the following (see Figure 13.6):

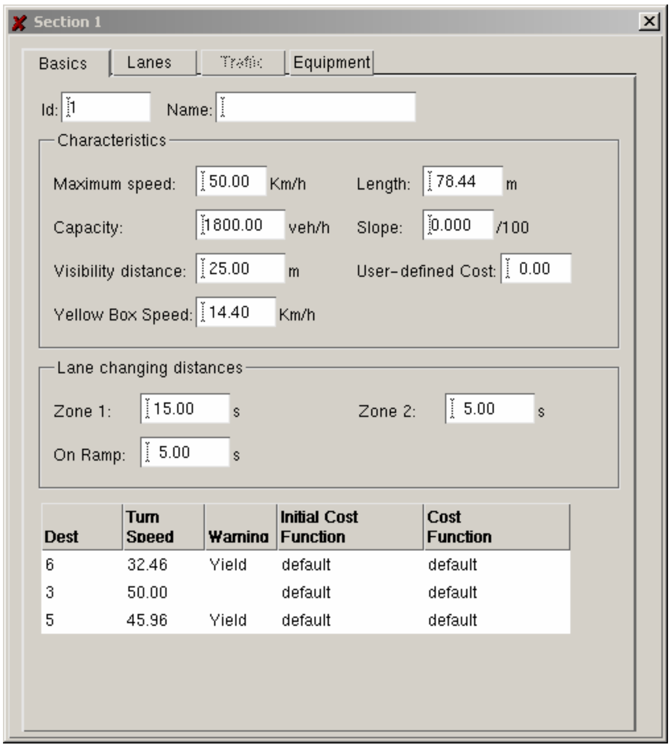

Figure 13.6. Section attributes

- Section Characteristics
    - Maximum speed: the speed limit for that section.
    - Theoretical capacity, in vehicle/hour.

- Visibility distance, in meters, which is used when there is a yield or give-way sign at the end of the section.
- Length of the section, in meters.
- Yellow box speed: a parameter used in the yellow box model for vehicles approaching the junction through this section.
- Slope: units represent percentage, which is the height corresponding to a length of 100 meters.
- User-defined section cost: any cost expressed in terms of time (i.e. an economic cost, such as toll pricing) associated with the section that can be used in any user-defined link cost function (see Section 3.2.1.2).

- Lane-changing distances used in the lane-changing model
  - Zone 1: distance zone 1, in seconds.
  - Zone 2: distance zone 2, in seconds.
  - On Ramp: distance on ramp, in seconds.
- Turning Information: a list containing the identifiers of the sections onto which a vehicle can turn from the current section, the turning speed, the sign (yield or stop), if any, the initial cost function and the corresponding cost function names (see Sections 3.2.1.2.2 and 3.2.1.2.3).

13.1.1.2 NODES

A node is a point or an area in the network where vehicles change their direction and/or disperse. Hence, a node has one or more origin sections and one or more destination sections. We differentiate between two types of node: *join nodes* (joins) and *junction nodes*. The difference between them is that, while in a junction there is a space between the origin and destination sections, in the join node there is no space between these two sections. In a join node, the number of origin lanes equals the number of destination lanes. Junction nodes are often found on arterials and streets; join nodes, on roads and highways.

13.1.1.2.1 JOIN NODES

Because, as explained above, the origin lanes of a turning are directly connected to the destination lanes, when a join is completed, the number of origin lanes equals the number of destination lanes.

Joins are often found in freeway areas (see Figure 13.7) to model bifurcations (A), exit ramps (B), mergings (C) and entrance ramps (D).

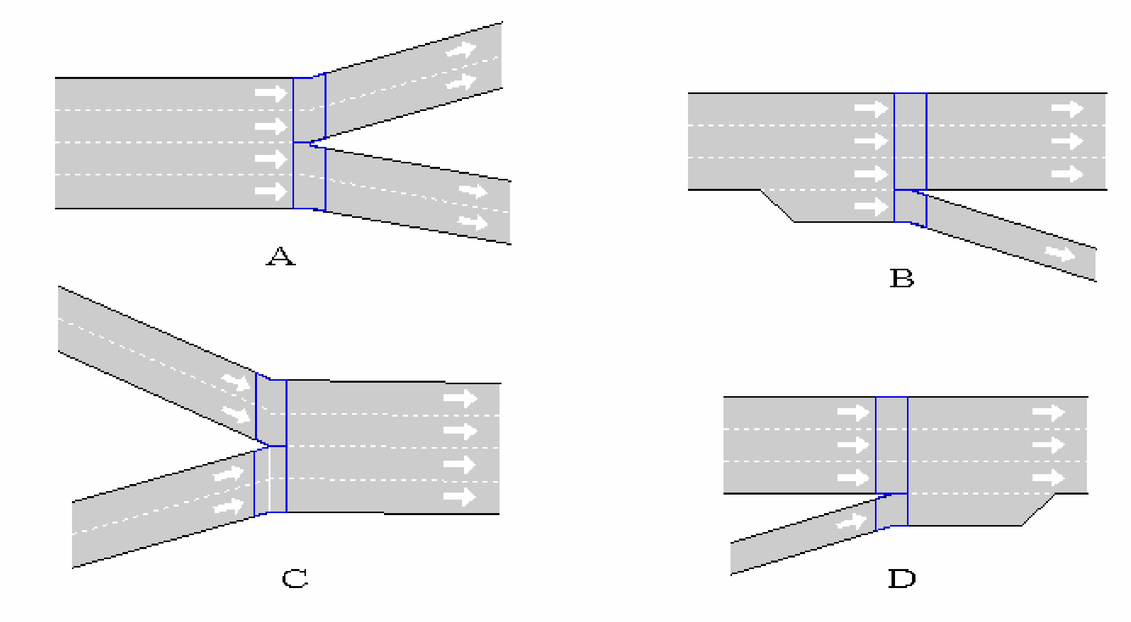

Figure 13.7. Examples of joins

13.1.1.2.2 JUNCTIONS

As stated above, a junction is a type of node in which there is a space between the origin and destination sections (see Figure 13.8).

Depending on the control policy applied, there are three types of junctions: without signals, fixed controlled, and demand-responsive controlled. Turnings occur within a junction and the user can specify give-ways between them. Imposing give-ways can solve conflicts between turnings that may arise in junctions without signals. In signalled junctions, a sequence of stages is designed to avoid conflicts, although give-ways can also be specified.

13.1.1.2.3 TURNINGS

Vehicles turn to get from one section to the next. Turnings occur within a node, be it a joint node or a junction. In the case of a joint node, there is a direct connection between the two sections, from certain lanes in the origin section to certain other lanes in the destination section—origin and destination lanes are given by the node geometry. In a junction, on the other hand, vehicles first enter the junction area before entering the destination section (by any of its entrance lanes), as shown in Figure 13.8.

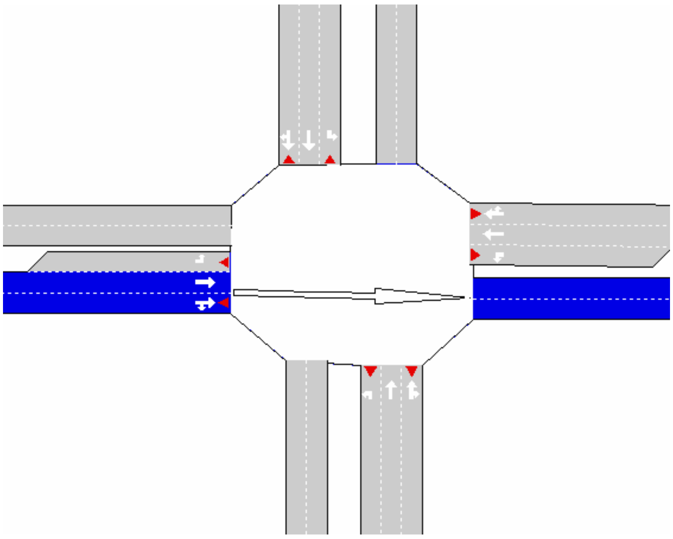

Figure 13.8. Example of a turning in a junction

13.1.1.3 Centroids

The centroids located in a network represent the origins and destinations. Each centroid is linked to the network through one or more connections. A connection is a virtual entity that the vehicles use to jump to/from the centroid to/from the entry/exit sections, as shown in Figure 13.9).

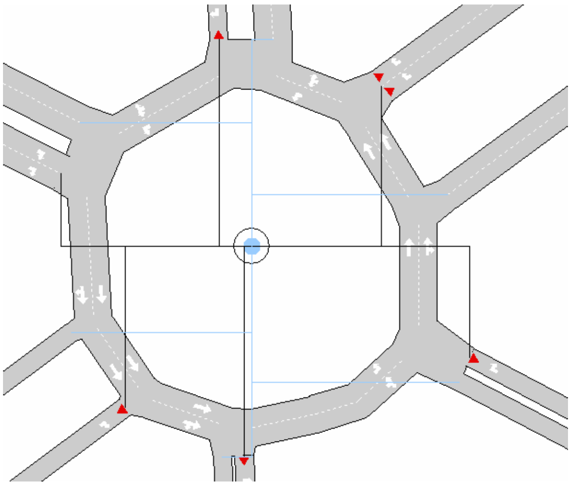

Figure 13.9. Example of a centroid and its connectors

The attributes that define a centroid are the following (see Figure 13.10):

- Centroid identifier and name
- Use Origin Percentages indicates how the vehicles are going to be distributed among the sections connected to the centroid when they enter the network. If this attribute is active, then the entrance section will be selected randomly according to the percentages defined

(see Section 3.2.2.6). Otherwise, the best entrance section will be selected in terms of path cost.

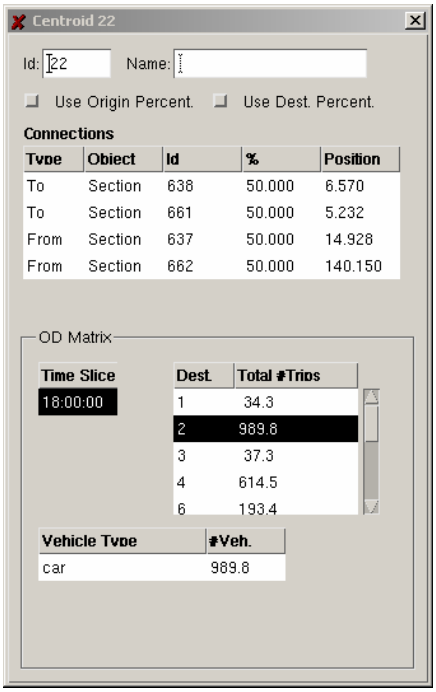

Figure 13.10. Centroid attributes

- Use Destination Percentages indicates how the vehicles are going to be distributed among the sections connected from the centroid when they exit the network. If this attribute is active, then the exit section will be selected randomly according to the percentages defined (see Section 3.2.2.6). Otherwise, the best exit section will be selected in terms of path cost.

- Connection information. The following data is provided for each connection:

    - Type of connection: a connection 'to' means from the centroid to the object (this is an 'origin'). A connection 'from' means from the object to the centroid (this is a 'destination').

    - Type of object: section or node.

    - Object identifier: identifier number of the section or node.

    - Percentage: percentage of vehicles generated/attracted by this centroid that will use this connection to enter/exit the network, only if the 'Use Origin/Destination Percentages' option has been selected.

    - Position in the object where the physical connection has been made.

- The demand data from the OD matrix for this centroid.

13.1.2 TRAFFIC DEMAND

The traffic conditions to be simulated could be defined by an OD matrix, which gives the number of trips from every origin centroid to every destination centroid, for each time slice and for each vehicle type. Vehicles are generated at each origin centroid and input into the network via the sections connected as ‘TO’ this source centroid. Then, vehicles are distributed along the network following the shortest paths between origin and destination centroids. Finally, vehicles exit the network via the objects connected as ‘FROM’ the destination or sink centroid.

13.1.2.1 VEHICLE TYPE PARAMETERS

These parameters are defined by vehicle type (e.g. car, bus, lorry, etc.). It is possible to define not only the mean values for the attributes of each vehicle type but also the deviation, minimum and maximum values. The particular characteristics of each vehicle are sampled from a truncated normal distribution. The attributes that characterise a vehicle type are the following:

- Name.
- Length, in meters, for this type of vehicle.
- Width, in meters, for this type of vehicle.
- Maximum desired speed in km/h, which this type of vehicle can travel at, at any point in the network.
- Maximum acceleration, in m/s^2, that the vehicle can achieve under any circumstances, as used in Gipps’s car-following model.
- Normal deceleration, in m/s^2, that the vehicle can perform under normal conditions, as used in Gipps’s car-following model.
- Maximum deceleration is the most severe braking, in m/s^2, that a vehicle can apply under special circumstances, such as emergency braking.
- Speed acceptance ($\theta \geq 0$) can be interpreted as the ‘level of goodness’ of the drivers or the degree of acceptance of speed limits. $\theta \geq 1$ means that the vehicle will take as its maximum speed for a section a value greater than the speed limit, while $\theta \leq 1$ means that the vehicle will use a lower speed limit.
- Minimum distance between vehicles is the distance, in meters, that a vehicle keeps between itself and the preceding vehicle when stopped.
- Maximum give-way time. When a vehicle is in a give-way situation, for example at a yield or stop sign at a junction or on an on-ramp in a freeway, it applies either the

normal gap-acceptance model or a lane-changing model in order to cross or merge with traffic respectively. When a vehicle has been at a standstill for more than this give-way time (in seconds), it will become more aggressive and will reduce the acceptance margins. This period is also used in the lane-changing model as the time that a vehicle will accept being at a standstill while waiting for a gap to be created in the desired turning lane before giving up and continuing ahead.

- Guided vehicles. This is the percentage of vehicles that are guided in the network.

- Guidance acceptance parameter ($0 \le \lambda \le 1$) gives the level of compliance of this vehicle type with the guidance indications, such as information given through variable messages signs or particular vehicle guidance systems. This parameter represents the probability of a vehicle following a recommendation. The modelling of drivers' reactions to guidance is explained in greater detail later on.

- Fuel consumption and pollution emission parameters. For details, refer to AIMSUN (2002) and TEDI (2002).