CORSIM USER MANUAL

VERSION 1.01

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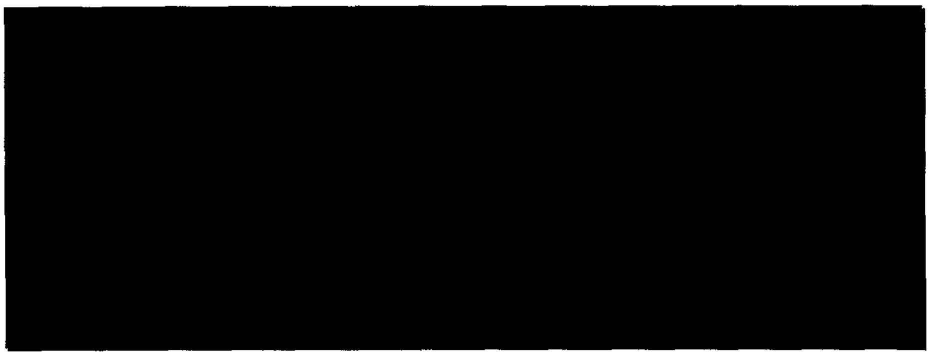
U.S. Department of Transportation
Federal Highway Administration

CORSIM
User Manual
Version 1 .O 1



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Introduction

In traffic engineering, the concept of traffic control is giving way to the broader philosophy of Transportation Systems Management (TSM), whose purpose is not to move vehicles, but to optimize the utilization of transportation resources to improve the movement of people and goods without impairing the community.

One of the most important analytical tools of traffic engineering is computer simulation. If a traffic system is simulated on a computer by means of a simulation model, it is possible to predict the effect of traffic control and TSM strategies on the system's operational performance, as expressed in terms of measures of effectiveness (MOEs), which include average vehicle speed, vehicle stops, delays, vehicle-hours of travel, vehicle-miles of travel, fuel consumption, and pollutant emissions. The MOEs provide insight into the effects of the applied strategy on the traffic stream, and they also provide the basis for optimizing that strategy.

Computer simulation is more practical than a field experiment for the following reasons:

> It is less costly.

> Results are obtained quickly.

> The data generated by simulation include several measures of effectiveness that cannot be easily obtained from field studies.

> The disruption of traffic operations, which often accompanies a field experiment, is completely avoided.

> Many schemes require significant physical changes to the facility, which are not acceptable for experimental purposes.

> Evaluation of the operational impact of future traffic demand must be conducted by using simulation or an equivalent analytical tool.

The availability of traffic simulation models greatly expands the opportunity for the development of new and innovative TSM concepts and designs. Planners and engineers are no longer restricted by the lack of a mechanism for testing ideas prior to field demonstration. Furthermore, because these models produce information that allows the designer to identify the weaknesses in concepts and design, they provide the basis for identifying the optimal form of the candidate approach. Finally, because the results generated by the model can form the basis for selecting the most effective candidate among competing concepts and designs, the eventual field demonstration will have a high probability of success.

The Role of the TRAF Models

Many TSM strategies affect the mode and route choice of trip-makers. To test the effect of TSM schemes on trip patterns, it is necessary to analyze an area that contains a substantial portion of the routes that the trip-makers may follow. There is a need, therefore, for a simulation model that is capable of representing traffic flow in large urban areas containing surface street networks and freeways and that has reasonable computer usage requirements. This concept of a single integrated simulation system that can provide the user with flexibility and ease of use and that can optimize the efficiency of all computations was conceived by the Federal Highway Administration (FHWA) in the mid- 1970s. FHWA has since supported a series of projects to implement this design and to develop the software for TRAF.

TRAF consists of an integrated set of simulation models that represent the traffic environment. Because the need for detail and precision usually varies from one portion of the network to another, it is necessary to provide the user with the flexibility to tailor the selection of simulation models according to his specific needs. The user can partition the analysis network into subnetworks, each of which is analyzed at a different level of detail. The interfacing of the various subnetworks is accomplished automatically by the software.

Each component model in TRAF is designed to represent traffic on a particular physical environment (urban streets or freeways) and at a specific level of simulation detail (microscopic or macroscopic). Microscopic simulation models represent movements of individual vehicles, which include the influences of driver behavior. The effects of very detailed strategies, such as relocating bus stations or changing parking restrictions, can be studied with such models. Less detailed strategies, such as changes in circulation patterns, can be studied with macroscopic simulation models, which can also be used to gauge the impact of very detailed strategies outside the boundaries of the area in which they are implemented.

The TRAF system also includes a traffic assignment program, which is designed to expand the applicability of traffic simulation modeling to transportation planners. The program internally translates the origin-and-destination data-which is readily available to the planning community-into a form suitable for use by the simulation models.

The Traffic Environment

The trafftc environment, which must be specified by the user to exercise the TRAF models, consists of the following:

- Topology of the roadway system (in the form of a link-node diagram)
- Geometrics of each roadway component
- Channelization of traffic (such as left, through, right, buses, and Carpools)
- Motorist behavior that determines the operational performance of vehicles in the system (such as acceleration, deceleration, and yellow-light response)
- Traffic control devices (stop, yield, signal timing, and detectorization)
- Traffic volumes entering the roadway system
- Turn movements or origin-and-destination data
- Transportation modes (cars, carpools, trucks, and buses)
- Specification of the bus system (routes, stations, and frequency of service).

To provide an efficient framework for defining these specifications, the physical environment is represented as a network comprised of nodes and unidirectional links. The links generally represent urban streets or freeway sections, and the nodes generally represent urban intersections or points at which a geometric property changes (such as a lane drop, a change in grade, or a major midblock traffic generator).

The TRAF System

TRAF is an integrated software system that consists of the following component models:

- NETSIM, a microscopic stochastic simulation model of urban traffic
- FRESIM, a microscopic stochastic simulation model of freeway traffic
- **NETFLO 1** (Level 1), a detailed macroscopic simulation model of urban traffic
- **NETFLO 2** (Level 2), a less detailed macroscopic simulation model of urban traffic
- **FREFLO,** a macroscopic simulation model of freeway traffic.

TRAF and its support programs (which are discussed in the next chapter) interface with these models in a coherent, integrated system. NETSIM and FRESIM are discussed in this manual, while NETFLO 1, NETFLO 2, and FREFLO are discussed in the ***CORFLO User Manual.***

The naming system for these models is based on a combination of prefixes and suffixes and is depicted in figure 1-1. The prefixes NET and FRE indicate a surface street network and a freeway network, respectively, and the suffixes SIM and FLO indicate microscopic simulation and macroscopic simulation, respectively. The combination of NETSIM and FRESIM is named CORSIM, for corridor-microscopic simulation. The NETFLO 1, NETFLO 2, and FREFLO models are distributed as a group for use in analyzing transportation corridors, and the group is named CORFLO, for corridor-macroscopic simulation.

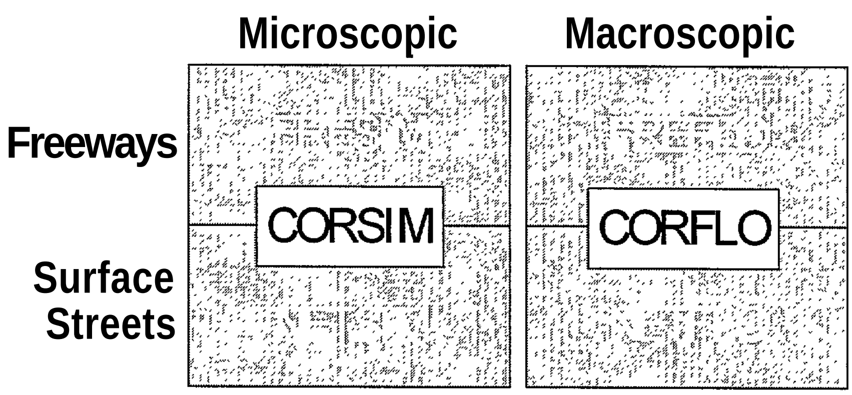

Figure 1-1. TRAF family of models.

The network that represents the traffic environment can be divided into subnetworks, which interface with one another. The user has total control over partitioning the analysis network into its component subnetworks. The choice of subnetwork configuration (and assigned simulation models) depends on many considerations, which include the following:

- The level of detail desired for the study
- The network topology
- The anticipated level of traffic congestion
- The extent of mass transit operations
- The detail of input available.

For urban networks-which require a high level of detailed analysis and for which available resources for data collection are ample-the user can select the most detailed urban simulation model, CORSIM. When some of the above conditions are absent, the user can conserve resources-and still obtain results of satisfactory quality-by using CORFLO.

Another consideration in model selection is the intent of the study. If the user is exploring traffic management concepts and wishes to identify those that are viable candidates for more detailed analysis in the future, the CORFLO model might be used to analyze the initial strategies. For the more detailed study, CORSIM would be used. The TRAF input format is designed to minimize the effort involved in changing from one subnetwork configuration and model assignment to another.

Another important feature of TRAF is that characteristics that change over time, such as signal timings and traffic volumes, can be represented by dividing the simulation into a sequence of user-specified time periods, during which the traffic flows, the traffic controls, and the geometry are held constant. Therefore, the morning rush hour might be simulated with one time period representing pre-rush hour, a second representing rush-hour timing, and a third representing the post-rush-hour flows. These time periods are further divided into time intervals, during which each of the simulation models is executed for its subnetwork in turn. This process facilitates TRAF's internal management of the simulation. For convenience, the time interval is usually specified as the most common signal cycle length.

Input Data

Because CORSIM simulates the traffic and traffic control conditions of a network over a period of time, the input must accommodate specifications that not only differ from one point on the network to another, but that might also change with time. Furthermore, the structure of the input stream must reflect the concept of network partitioning.

The time-varying portion of the simulation analysis is expressed as a sequence of "time periods" specified by the user; that is, the input data specified by the user for a certain time period remains in force unless changed in a subsequent time period. The user can specify up to 19 time periods and **must** specify the conditions that apply during each period. Therefore, the input stream consists of a sequence of "blocks" of data records, with each block defining the conditions that apply to one time period.

For the CORSIM model, which contains both the NETSIM and FRESIM models, the spatial extent of the traffic environment is defined as a set of "subnetworks," which reflect the concept of network partitioning. Each block of data records for a time period is subdivided into "sections" of data records. Some sections define conditions on particular subnetworks, while others provide inputs for the specifications that must be specified for the "global" network (such as bus routes).

Within each section, the input stream consists of a sequence of "record types," which are also called "cards" and "card types." Each record type contains a specific set of data items as well as an identification number.

CORSIM contains a thorough set of diagnostic tests for input, which are executed in the following sequence:

- Test that the structure of the input stream is correct, that all records are in proper sequence, and that no required records have been omitted.
- Test that each data item is valid and that its value lies within a "reasonable" range.
- Test that the set of data items on a record is internally consistent, with no missing items.
- Test that all the data items on the set of records belonging to one record type are consistent and that the set is complete.
- Test that the data **on all** record types of a particular classification are compatible and that the classification is completely defined. A classification describes an attribute of the traffic environment, such as network geometry, traffic operations, intersection control, and traffic demand. All the record types belonging to a classification are grouped together.
- Test that the data items of all classifications are compatible and completely define the network.

Whenever an error is detected in the tests outlined above, an error message is generated **(see Appendix A).** Each message contains sufficient information to allow the user to identify the cause and make any required changes.

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Two categories of messages are identified: "warning messages" and "fatal error messages." Warning messages identify unusual conditions that may or may not represent an error. Conditions that lead to warning messages will not prevent the simulation from running, but they may lead to an incorrect result, The legitimacy of such conditions should always be verified by the user. Fatal error messages identify conditions that will prevent the simulation from running.

Because of data interactions and the complexity of the diagnostic tests, the presence of a single error can generate a large number of messages. An effort has been made to restrict extensive output that reports numerous inconsistencies stemming from a single error. Therefore, several diagnostic tests are not performed until entire sections of the data are error free. For example, the logic checks that the geometric and traffic control specifications provide a means to discharge all traffic that might enter each link. On an urban subnetwork, this requires consistency between several different types of data:

- Turn movement data must identify the expected discharging movements from each link (Record Type 2 1).
- Geometric specifications must identify a receiving link for traffic executing each of these discharge movements (Record Type 11).
- Traffic control specifications for the link must provide some opportunity (sign or signal phase) to service traffic for each of these turn movements (Record Types 35 and 36 for pretimed controllers and Record Types 43-48 for actuated controllers).

Because of similar data interactions, many tests on traffic assignment data and bus transit operations are not performed until much of the data is error free.

Model Integration

In a multiple-model network, each of the component models of CORSIM simulates a different subnetwork. The interfacing of adjoining subnetworks is accomplished by defining "interface nodes" (as shown in figure 2-l), which represent points at which vehicles leave one subnetwork and enter another. Nodes of this type are assigned special numbers to distinguish them from other nodes in the network. The terms "entry interface links," which receive traffic from the adjoining subnetworks, and "exit interface links," which carry traffic exiting the subnetwork to adjoining subnetworks, are used to describe links at the boundaries of the subnetworks. In addition to defining the subnetwork partitioning, the user must identify the duration of time known as the "time interval" (see Record Type 04). A subnetwork is simulated once over each time interval. During that time, vehicles scheduled to enter from adjacent subnetworks enter the current subnetwork at the appropriate time. All vehicle movements throughout the subnetwork are simulated over the course of the time interval. As vehicles reach adjacent subnetworks, their scheduled time to enter the next subnetwork is stored.

At the end of a time interval, the next subnetwork is simulated over the same time interval. This process is repeated for the next time interval until the requested duration of the run is completed.

Figure 2-l illustrates a multiple-model network in which a city's central business district is bordered by a freeway. The freeway sections can be modeled with FRESIM, while the urban subnetwork can be modeled with NETSIM. Other subnetworks will be processed in a similar manner. Once the user

identifies the appropriate subnetwork representation, all interfacing processes are handled internally by the model by the interface logic.

Appendix D contains the CORSIM sample dataset, which is included in the CORSIM package and represents a multiple-model network similar to figure 2- 1.

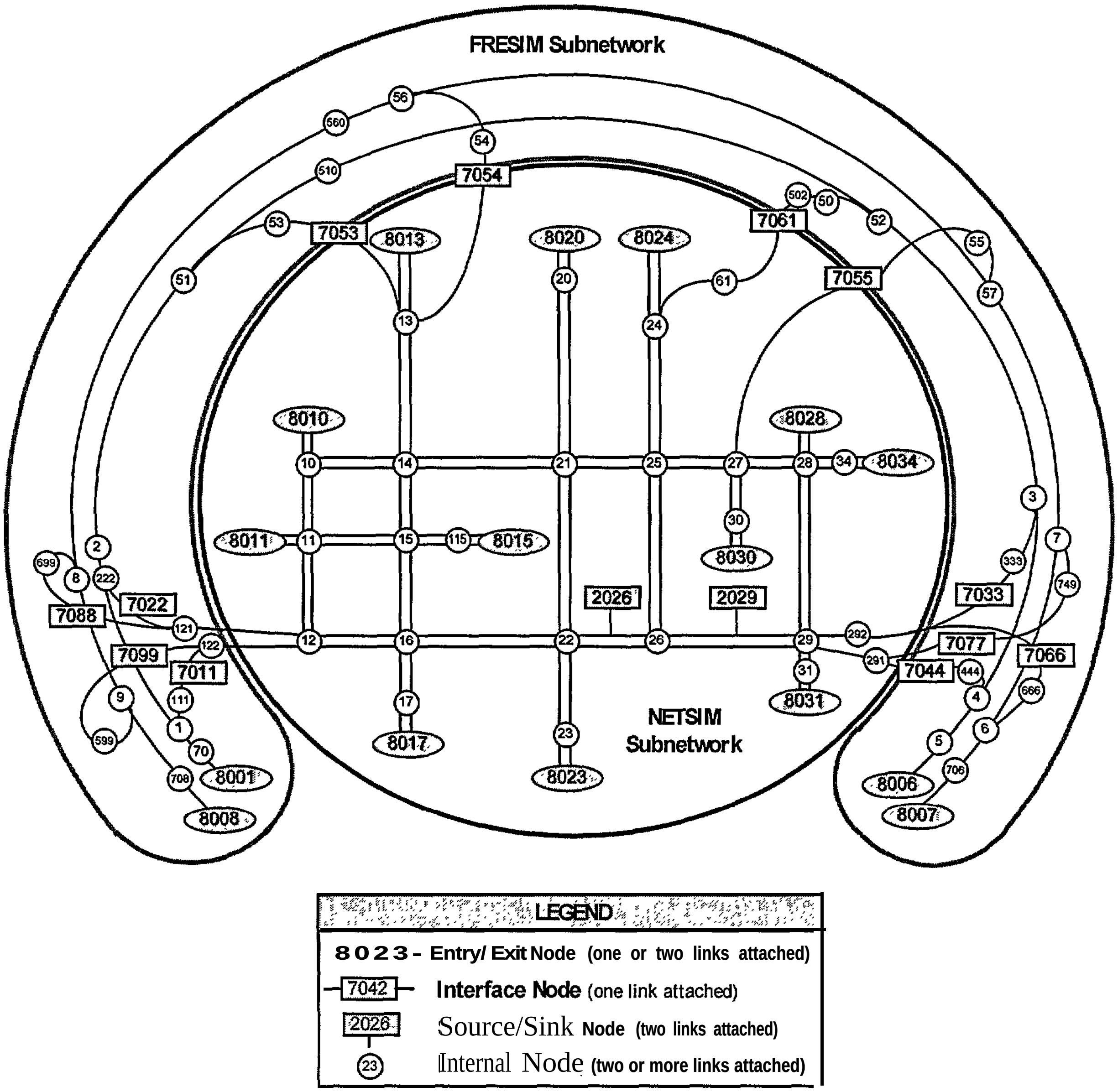


Figure 2-1. Multiple-model network.

Installation and System Requirements

For detailed instructions on installing any of the TRAF components, refer to the ***TSIS User Guide.***

The following hardware ensures that CORSIM and its supporting programs run correctly:

- Computer SO3 86/803 87 or higher
- Memory 640 K of conventional memory and 16 MB of extended memory, with 13.5 MB free at execution

The following hardware and software ensure that GTRAF-the optional postprocessing graphics package-performs properly:

- Monitor with EGA or higher resolution
- GSS*GKS device drivers (version 2.14 or higher)
- Mouse
- Printer

Simulation Models

NETSIM

NETSIM applies interval-based simulation to describe traffic operations. Each vehicle is a distinct object that is moved every second. Each variable control device (such as traffic signals) and each event are updated every second. In addition, each vehicle is identified by category (auto, car-pool, truck, or bus) and by type. Up to 16 different types of vehicles (with different operating and performance characteristics) can be specified, thus defining the four categories of the vehicle fleet. Furthermore, a “driver behavioral characteristic” (passive or aggressive) is assigned to each vehicle. Its kinematic properties (speed and acceleration) as well as its status (queued or free flowing) are determined. Turn movements are assigned stochastically, as are free-flow speeds, queue discharge headways, and other behavioral attributes. As a result, each vehicle’s behavior can be simulated in a manner reflecting real-world processes.

Each time a vehicle is moved, its position (both lateral and longitudinal) on the link and its relationship to other vehicles nearby are recalculated, as are its speed, acceleration, and status. Actuated signal control and interaction between cars and buses are explicitly modeled.

Vehicles are moved according to car-following logic, response to traffic control devices, and response to other demands. For example, buses must service passengers at bus stops (stations); therefore, their movements differ from those of private vehicles. Congestion can result in queues that extend throughout the length of a link and block the upstream intersection, thus impeding traffic flow. In addition, pedestrian traffic can delay turning vehicles at intersections.

The following list summarizes the major features of the NETSIM simulation model. Most of these microscopic treatments are transparent to the user, whose prime concern is the description of traffic operations provided by the model:

- Fleet Components (buses, carpools, cars, and trucks)
- Load Factor (the number of passengers/vehicle)
- Turn Movement
- Bus Operations (paths, flow volumes, stations, dwell times, and routes)
- HOV Lanes (buses, Carpools, or both)
- Queue Discharge Distribution
- Detailed Approach Geometry
- Stop and Yield Signs
- Pretimed Signal Control
- Signal Ring-actuated Control
- Dual Ring-actuated Control
- Number of Lanes per Approach (a maximum of 7)
- Incidents and Temporary Events

FRESIM

FRESIM is a microscopic freeway simulation model that models each vehicle as a separate entity. The behavior of each vehicle is represented in the model through interaction with its surrounding environment, which includes the freeway geometry and other vehicles.

The FRESIM model is a considerably enhanced and reprogrammed version of its predecessor, the INTRAS model. The enhancements include improvements to the geometric representation as well as the operational capabilities of the INTRAS model. As a result, FRESIM simulates more complex freeway geometrics and provides a more realistic representation of traffic behavior than INTRAS. These enhancements have also resulted in a more flexible and user-friendly model.

The FRESIM model is capable of simulating most of the prevailing freeway geometrics, which include the following:

- One to five through-lane freeway mainlines, with one- to three-lane ramps and one- to three-lane inter-freeway connectors
- Variations in grade, radius of curvature, and superelevation on the freeway
- Lane additions and lane drops anywhere on the freeway
- Freeway blockage incidents
- Work zones through the use of the blockage incident capability of the model
- Auxiliary lanes, which are used by traffic to begin or end the lane-changing process or to enter or exit the freeway.

The model also provides realistic simulation of operational features, which include the following:

- A comprehensive lane-changing model
- Clock-time and traffic-responsive ramp metering
- Comprehensive representation of the freeway surveillance system
- Representation of six different vehicle types, including two types of passenger cars and four types of trucks, each having its own performance capabilities
- Heavy vehicle movement, which may be biased or restricted to certain lanes
- Differences in driver habits, which are modeled by defining 10 different driver types, ranging from timid drivers to aggressive drivers
- Vehicles' reaction to upcoming geometric changes; the user can specify warning signs to influence the lane-changing behavior of vehicles approaching a lane drop, incident, or off-ramp.

Although FRESIM is the most powerful and detailed freeway simulation model developed thus far by FHWA, it has some limitations that may restrict its application for certain freeway operations studies.

For instance, there is no direct capability for representing HOV operations, and there is no direct modeling of the effect of reduced lane width.

Traffic Assignment

Traffic assignment supports the use of the simulation programs as part of CORSIM, but it is not a simulation program in itself. The traffic assignment model interfaces with the NETSIM component of CORSIM only and uses conventional traffic assignment techniques, along with user equilibrium and system optimization capabilities. The purpose of including a traffic assignment model in CORSIM is to extend the potential user group for this program to include planners and traffic engineers.

The planner usually has sufficient information available to produce a table of origin-and-destination volumes that represent traffic demands over an area for a specified period of time. For this information to be useful as input in a simulation program, it must first be transformed into link-specific turn percentages. The mechanism for performing this transformation is the traffic assignment model.

The interfacing logic is designed to perform data manipulation internally, thus freeing the user to focus attention on providing the origin-and-destination table. This logic will read and check the data and then perform the necessary data organization to provide the traffic assignment program with its data requirements. Subsequently, it will create turn percentages and entry volumes for input into one or more of the specified component simulation programs. At that point, the simulation analysis can run.

TRAF Support Programs

There are three major support programs for TRAF:

1 **TSIS,** which is the integrated traffic software system that supports the execution of the various TRAF simulation models and support programs

2 **TRAFEdit,** which aids in the creation of datasets for running TRAF

3 **GTRAF,** which displays the output data graphically.

TSIS is a set of utility programs that provide menu-driven access to the TRAF family of traffic engineering tools. TSIS can invoke the TRAF models and support programs, and it comes with an "install" utility. TSIS and the TRAF programs are available from the PC-TRANS and McTrans software distribution centers. TSIS is described in detail in the *TSIS User Guide.*

TRAFEdit is an interactive data editor used to create and modify input data for the TRAF system, and the user typically invokes the program from within TSIS. TRAFEdit is a menu-driven system that has two component editors:

1 **Smart Edit,** which is designed to facilitate the creation of large datasets simulating many links and nodes

2 **Quick Edit,** which is designed to quickly make the numerous "debugging" changes that are required when developing a TRAF dataset. These changes are often triggered by

examination of the GTRAF outputs that show discrepancies between what the simulation is doing and what is observed in the “real” network.

TRAFEdit is described in detail in *the TRAFEdit User Guide*.

GTRAF is the interactive display postprocessor for the NETSIM simulation model, and it supports static and animated displays of traffic information and statistics from NETSIM. [FHWA is currently developing the FRESIM postprocessor graphics package.] When setting up the run, the user must specify (on Record Type 05) that graphics output is desired. The animated displays present an aerial view of the traffic in a network. GTRAF is suitable for traffic operations analysis as well as the presentation of "before and after" studies to convince the audience of the utility of the simulation results.

In figure 2-2, which shows one screen of an animation, the arrows represent the signal controls for the corresponding approaches to the intersection. The rectangles represent cars, trucks, and buses, which are displayed in color. They change color depending on whether they are through, left-turning, or right-turning vehicles. Other graphical displays allow the user to show the link-node structure of the network, traffic volumes, control parameters, and bus routes. A detailed link display depicts all of the data about a particular link in a one-screen view so that the information can be examined in detail.

GTRAF is described in detail in the *TRAF Graphics User Guide.*

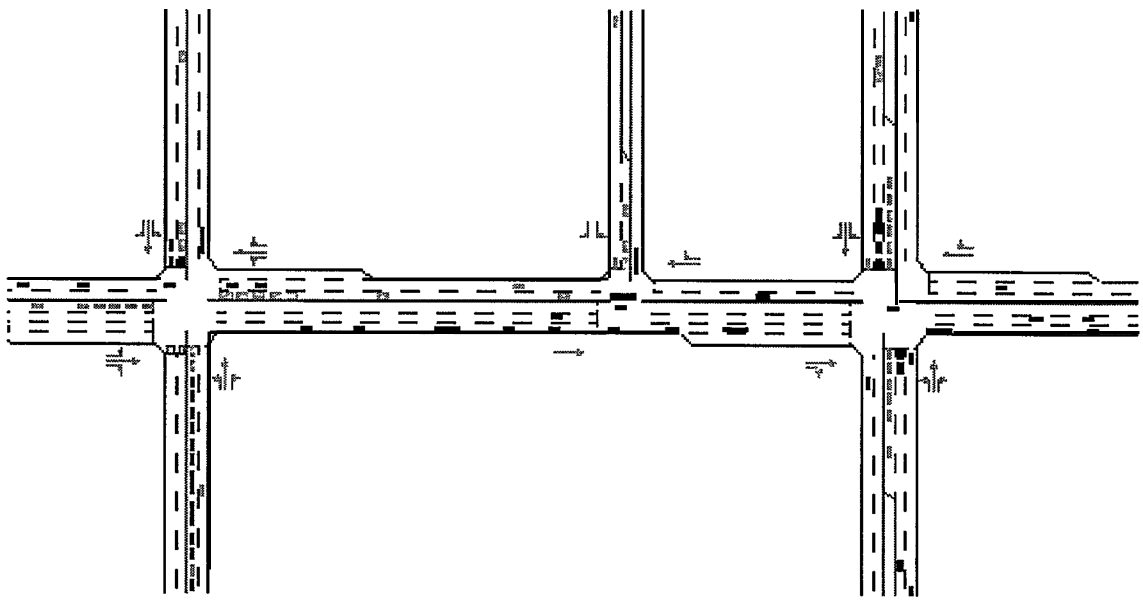


Figure 2-2. Animated network display of traffic flow.

Data Structure

Traffic models are a mathematical representation of the real world. Traffic simulation models are representations of the time-varying processes in traffic flow, and they require accurate descriptions of the characteristics of the vehicles, the street system, and the traffic control system. These characteristics vary over the physical network and over time. The characteristics that vary over space include the following:

- Traffic geometry (such as the number of lanes and turning pockets)
- Types of links (such as surface streets or freeways)
- Elements of traffic behavior (such as gap acceptance).

The characteristics that vary over time include the following:

- Traffic volumes
- Turn movements
- Traffic regulations
- Signal timing.

Input Stream

The input for CORSIM is arranged to facilitate the description of the variation in data. The input stream begins with a dataset that provides a basic description of the run being made (run control data), and it is followed by a dataset that is divided into time periods, each of which has model-specific data for each type of traffic network that is being simulated (model data). Each dataset is divided into a series of SO-column records. The first time period is unique because it contains the data that does not vary from time period to time period. At the end of the model data for the first time period is global network data that is applied to all subnetwork data. This global data describes traffic assignment [origin-destination (O-D) data], bus operations, and other data that applies to all subnetworks.

FIGURE 3-1. CORSIM data structure.

TABLE 3-1. Run Control data required to set up CORSIM simulation runs.

[ ] Required.

DATA STRUCTURE

Table 3-2 indicates whether each of the remaining record types is required or optional. When there is only one defining symbol for a model, it applies to Time Periods 1-19. When there are two defining symbols for a model, the first applies to Time Period 1, and the second applies to Time Periods 2-19.

TABLE 3-2. CORSIM record types. (Pages 3-4 to 3-6)

TABLE 3-3, Required record types in FRESIM for point processing, on-line and off-line incident detection, and MOE estimation

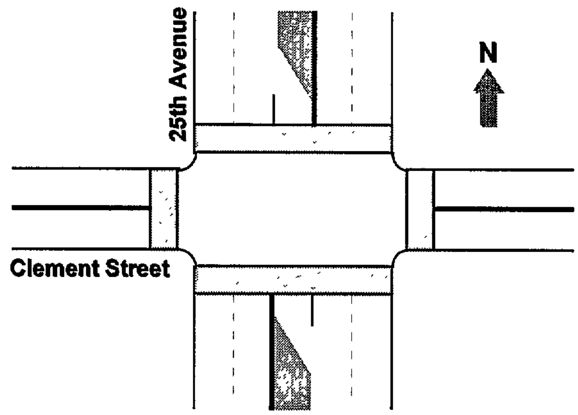
TABLE 3-4. Minimum coding requirements for the CORSIM models

TABLE 3-5. Size limitations of CORSIM network characteristics.

PAGES 3-4 to 3-9

Network Description

The first step in defining a dataset for CORSIM is describing the geometrics of the network. CORSIM uses the concept of links and nodes: Links are one-directional segments of streets or freeways, and nodes are usually the intersection of two or more links. Initially, the user must obtain geometric pictures of the network, such as aerial photographs or maps. A basic drawing of the geometry of a single intersection is shown in figure 4-l.



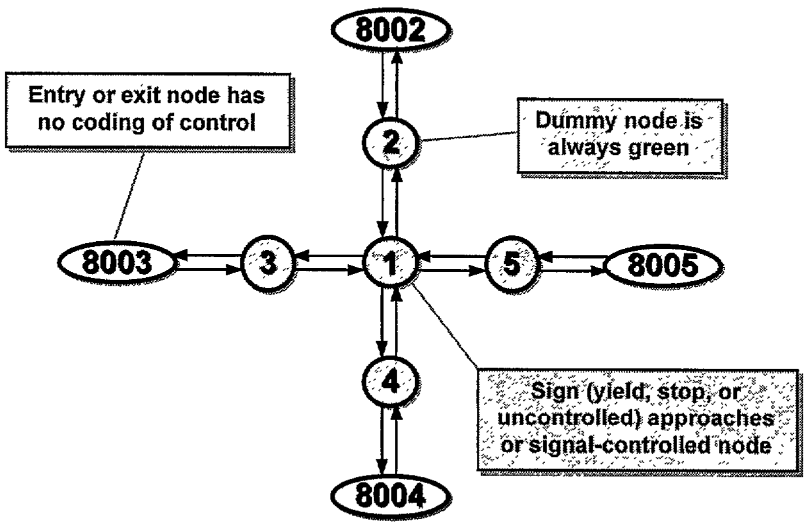


Figure 4-1. Intersection layout converted to a link-node diagram.

Each link represents one direction of a street, and links are defined in terms of the nodes at each end. For entry and exit links, a dummy node is placed between the entry or exit node and the internal node, which allows for the collection of statistics on the traffic approaching and exiting the nodes on the periphery of the network.

Links are controlled by the nodes at their downstream end. For entry and exit links, a dummy node between the entry or exit node and the internal node should be controlled by a perpetual green. There is **no** control specified for the entry, exit, and interface nodes, and there is **no** control specified for the internal centroid nodes (Record Type 5 1).

Data Record Types

This section provides an overview of the various blocks of data records that are used to input data in CORSIM.

Run control data

Run control data consists of six record types:

❶ **Record Type 00** provides the title for the run.

❷ **Record Type 01** provides the name of the person performing the run, the date of the run, the name of the organization involved, and the run identification number.

❸ **Record Type** 02 provides data on whether one or more models are to be run, whether traffic assignment is to be performed, how long an initialization period is needed, and whether fuel consumption and emissions data should be output. This record alsotells TRAF which model to execute first and what random number seeds to use.

❹ **Record Type** 03 is the time period specification record that informs TRAF how many time periods will be simulated as well as the duration of each time period. These time periods are used to divide the simulation into segments with similar characteristics, such as pre-rush hour, rush hour, and post-rush hour.

❺ **Record Type** 04 specifies how each of the time intervals is divided into a group of time intervals, which are used by the TRAF program to control the modeling process of each model.

❻ **Record Type** 05 is the final record in the block of run control data records, and it specifies the types of output desired by the user. The frequency of both cumulative and intermediate output is specified. Graphical output for animated and static displays of NETSIM can also be requested.

Reports and output specifications

Reports and outputs are controlled with several data records. **Record Type 03** specifies whether fuel consumption and emissions data should be output. **Record Type** 05 specifies the frequency of both cumulative and intermediate output and whether data for viewing graphical output will be created. **Record Type** 90 allows aggregation of links as a group for data collection and reporting purposes for NETSIM and FRESIM. Up to 1,000 links can be contained within a maximum of 100 sections.

Link names

Link names can be specified on **Record Type** 10, but they can be specified only for the NETSIM model. This block of data records appears at the beginning of the NETSIM data records for Time Period 1only. Links cannot be renamed in subsequent time periods.

Link description

Networks in TRAF consist of one-directional links. In the case of a two-way street, each block would consist of two one-directional links. Links are defined by their upstream and downstream node numbers. Entry links, exit links, interface links, and internal links have different kinds of node numbering. The link geometrics for NETSIM are coded on **Record Type 11.** Link records describe the number of lanes and their length, channelization (left turn only or buses only), and link-specific traffic behavior (such as free-flow speed).

Turn movement descriptions describe how traffic leaves each link to approach other links. Turn movements for NETSIM are described on **Record Type 21. Record Type 22** can be used to define conditional turn movements in NETSIM.

Traffic parameters

Traffic parameters provide TRAF with a description of how traffic behaves, and they can be specified by a variety of record types. These parameters are input into the data file in Time Period1. However, they are processed **before** any simulation modeling occurs. Examples of traffic parameters include the response to gaps in traffic for turning vehicles, the distribution of the desired free-flow speed, and vehicle types. This block of data records appears at the beginning of Time Period 1 only.

For NETSIM, **Record Types 140 and 141** modify the turn calibration data, spillback, and vehicle length, while **Record Types 142 and 143** modify the acceptable gaps for turning vehicles pulling out onto a main street at stop signs. **Record Type 144** describes vehicle response to yellow signals. Gaps in oncoming traffic that are acceptable for vehicles turning onto a side street across traffic are described on **Record Type 145. Record Type** 146 describes how pedestrian flows interact and impede traffic. Variation of free-flow speed around the user-specified free-flow speed is modified for NETSIM by **Record Type** 147. Short-term events vary according to a distribution that may be modified by **Record Type 148.** Start-up lost time and queue discharge headway at traffic signals vary according to distributions that may be changed by **Record Type 149.** The length of time that buses “dwell” at bus stops varies according to distributions that are modified by **Record Type 150.**

Bus operations

Bus operations in a network are described in terms of bus routes, stations, and flow rates. Each route is assigned a “route number,” which is then used to identify the route station stops, flow rates, and release offsets. The bus route is the geometric path of nodes that the bus traverses as it travels through the network. The bus-route station stops are the sequence of bus stations (bus stops) that the bus services as it passes through the network. The bus flow rate is the mean headway for buses that service a particular route number. The bus stations are defined in terms of the link they are on, the distance from the downstream node, and their capacity (in numbers of buses). The average dwell time buses spend at stations is also specified.

Buses operate at a fixed frequency in TRAF. Bus stop locations are defined on **Record Type 185.** The average time each bus stops (dwells) at a station, along with the percentage of buses that do not stop, is defined on **Record Type 186** (see also Record Type 150 under “Traffic parameters”). The route of each bus traveling through the network is defined by the series of nodes it traverses and the bus stops it stops at between the nodes. The nodes are defined on **Record Type 187,** while the bus stops on each route are defined on **Record Type 188.** The routes can traverse the interface nodes between subnetworks so that a route may cover NETSIM and FRESIM streets and highways. However, bus stops cannot be specified on a FRESIM link. If Record Type 187 is present to define bus routes, then bus station records (Type 185), bus-route station stop records (Type 1 SS), and bus flow rate records (Type 189) must also be present as a group to fully define the bus operations. If a bus route traverses a network without stopping, then the bus station and bus route record types may be omitted.

TRAF computes measures of effectiveness for buses on a route-specific basis. The delays and stops for buses are also included in the overall MOEs computed by TRAF.

Sign and signal control

Stop and yield signs (which are available in NETSIM) are specified on **Record Types 35 and 36.** Record Type 35 defines the upstream node of each approach to the intersection, while Record Type 36 defines whether the approach is controlled by a yield sign or stop sign or is uncontrolled. The model cannot simulate all-way stops.

Pretimed signals are also specified on Record Types 35 and 36. Record Type 35 defines the upstream node of each approach to the intersection, the number of signal intervals, and the duration of each interval. Record Type 36 defines the control facing each approach on each phase, such as green, amber, red, or arrow indications. Signal transition from one timing plan to another is available for pretimed signals in NETSIM, but **is** not available for actuated signals.

For actuated control in NETSIM, **Record Type** 43 defines the approaches **and** referenced links. Actuated coordination in NETSIM is controlled by **Record Type** 44, which defines the time when permissive periods begin and end and when force-offs occur. **Record Type 45** defines the traffic movements that are permitted during each phase, which are defined in terms of left, through, right, and diagonal, rather than in terms of signal indications. **Record Type** 46 defines detector characteristics, location, and type. Phase operations are described on **Record Type** 47. Operational characteristics include maximum green time or maximum extension as well as vehicle extension or gap reduction time. Extensions of the phase timing for pedestrians are specified on **Record Type** 48. Actuated timing plans cannot be modified between time periods and remain constant for the duration of the run.

Intersection simulation

The detailed modeling of intersections has been added in this version. In previous versions, left-turners waiting for a gap in opposing traffic would stop and wait at the stop line of a link. With the new intersection logic, left-turn vehicles will proceed into the intersection but stop before conflicting with opposing traffic. These vehicles will wait in the middle of the intersection until there is a gap available for the left turn.

The intersection logic also allows blockages within an intersection to be modeled. Additionally, with the intersection logic, vehicles react to conflict with other vehicles in the intersection. The type and number of these vehicle conflicts within an intersection are tabulated and given in the output file. The fuel consumed and pollutants emitted within the intersection are also given. Intersections to be modeled with the intersection logic are referred to as micronodes. A flag on **Record Type** 36 **or** 43 designates a node as a micronode. Up to 20 intersections can be modeled as micronodes. **[This feature has been temporarily suspended in this version of CORSIM.]**

Traffic volumes and vehicle occupancy

Traffic volumes entering from outside the network are defined on **Record Type** 50. Traffic volumes leaving the network are not defined; they are the result of turn movements onto exit links. Traffic volumes entering or leaving the network from within the network are defined on **Record Type 51.** They are called source/sink volumes and occur on internal links. They are used to represent the behavior of minor traffic sources, such as parking lots and gas stations. Vehicle occupancy (the number of people per vehicle) is entered on **Record Type 52.**

Incidents, events, and parking maneuvers

NETSIM has both short- and long-term interruptions to traffic (known as “events”). Short-term events are short-duration events that take place in the curb lane. Long-term events are longer-duration interruptions to traffic for any regular (nonpocket) lane. Interruptions to traffic by parking maneuvers also occur in NETSIM and are specified on Record **Type** 56. Parking activity **can** vary from time period to time period, but only on links with parking.

Vehicle characteristics

Record Type 58 defines the vehicle types for NETSIM. The length, acceleration, speed, and discharge headways are defined, as are the various vehicle types in the vehicle fleet.

Fuel consumption and pollutant emissions

Detailed vehicle characteristics for fuel consumption and pollutant emissions can be optionally specified. **Record Type** 60 specifies the data tables for NETSIM. The fuel consumption rates can be specified for autos, trucks, and buses. Only one rate of HC emissions, CO emissions, and NOx emissions is set for all types of vehicles.

Urban interchanges

Multilevel urban interchanges can be modeled in NETSIM. In previous versions, interchanges could be modeled roughly, but the user was required to enter turn percentages for each link within the interchange. To further assist in the coding of interchanges, an option of entering travel demand patterns (i.e., origin-destination information) through an interchange instead of turn percentages for each link has been added in this version. Information on interchanges is entered on **Record Types 95 and 96.**

To allow for more realistic representation of interchanges in the graphics, the capability of having curved links and grade separations has been added. Information for these options is entered on **Record Type 196.** Node coordinates can be entered on **Record Type 195** in units of feet or meters. Any information on Record Type 195 will override any coordinates entered on Record Types 36 and 43.

Traffic assignment

Traffic assignment of O-D data is possible for the NETSIM model, but not the FRESIM model. Specification of the traffic assignment parameters for FHWA's (BPR's) or Davidson's functions and their related factors is entered on **Record Type** 175. Specification of the trip table, in the form of origin-and-destination nodes, is entered on **Record Type** 176. Sources and/or destinations (sinks) of traffic that are internal to the network can be specified on Record **Type 177.**

When traffic assignment is requested, all record types relating to entry volumes and turn movements should be left out of the dataset; the volumes and percentages will be determined by the traffic assignment results. When using traffic assignment, Record Types 22, 50, and 5 1 should not appear in the dataset. Entries 7-l 1 can be used on Record Type 2 1 to define prohibited turn movements, but Entries 3-6 should be left blank.

Although traffic assignment models are not categorized as simulation models, they represent an essential interface between travel demand and actual traffic flows. Assignment models can serve two purposes: to convert O-D trip tables into actual network loadings for processing by simulation models and to evaluate demand responses to operational changes.

In the TRAF system, two optimization techniques are used in the equilibrium traffic assignment model: the user's optimal assignment and the system's optimal assignment. The criterion for determining when user equilibrium has been reached is that no driver can reduce his journey time (or impedance) by choosing a new route. The criterion for the system's optimization is the minimum total cost of the entire network. Results of the traffic assignment model will interface with other TRAF simulation models.

A given origin-destination demand matrix is assigned over the specified network. The results of the traffic assignment are then transformed into link-specific turn percentages as required by the simulation models, which commence operation following the assignment process.

The impedance function employed by the traffic assignment model is the FHWA formula and modified Davidson's queuing functions that relate link travel time to link volume and link characteristics (capacity and free-flow travel time). Traffic assignment is performed on a transformed path network that represents the specified turn movements in the original network. The algorithm that is used is a Frank-Wolfe decomposition variation that generates all-or-nothing traffic assignments at each iteration using the link impedances produced by the previous iteration.

For each iteration, a minimum path tree is constructed for each specified origin node to all other network nodes, using a label-correcting algorithm. The network cost function is evaluated at the end of each iteration, and a line search is conducted for the improved link flows that minimize the cost function. The iterative procedure terminates when convergence is attained or when a prespecified upper bound on the number of iterations is reached.

Graphics

Detailed graphical outputs are available in NETSIM. To obtain these outputs, the locations of all nodes must be specified relative to each other. **Record Type 195** specifies the x and y coordinates of each node. To depict the links more realistically, their shape as well as their length must be specified. **Record Type 196** provides link geometric data that describes link curvature and overpass/underpass relationships.

Data delimiters

Each set of model data is terminated by either **Record Type 170** or **Record Type 210.** Within a time period, the datasets are separated by Record Type 170. Each time period ends with a Record Type 2 10, which indicates whether it is followed by additional time period data or is the last data record in the input stream.

Recent Enhancements

Intralink lane changing

In previous versions of CORSIM, vehicles could only change lanes when entering a new link. To more realistically model lane-changing behavior, intralink lane changing has been added to the simulation logic. In this version, vehicles will know their next turn movement and will try to change into an appropriate lane for that turn movement as they travel along the network. The decision to make a lane change is based on the motivation, the advantage, and the urgency of changing lanes. Another important feature of the intralink lane changing logic is the consideration of the cooperation of drivers to vehicles attempting to make a lane change. No additional inputs are required for the intralink lane-changing logic. However, parameters such as duration of lane change, deceleration rate during lane change, unacceptable headway, and driver cooperation can be altered from the default values on **Record Type 81** in NETSIM and on **Record Type** 70 in FRESIM.

Even with intralink lane changes, CORSIM sometimes failed to move a vehicle to an appropriate lane in time, which often caused stopped vehicles to block traffic during simulation. That type of lane changing is unrealistic, and the resulting blockages by lane-changers inaccurately represented real-world traffic flow. To address that problem, the intralink lane-changing logic in CORSIM has been enhanced to allow stopped vehicles that are attempting to change lanes to force a lane-change gap to open when necessary.

When a vehicle has to make a mandatory lane change, it attempts to do so when it moves within the influence of the object (such as the stop line at which a'tum movement will be made or a blockage). The distance within which an object influences a vehicle can now be revised by the user. That distance is stochastic, and the default mean value is 300 feet, which is varied by a distribution based on the driver type of a vehicle. **Record Type 152** has been implemented in CORSIM to allow users to change that distribution.

Lane alignment

In the previous surface-street simulation logic in CORSIM, all vehicles selected their candidate lanes without considering the second consecutive turn movements. Such a treatment has led to unnecessary mandatory vehicle lane changes, thereby creating a deficiency in CORSIM's microscopic simulation. Furthermore, that logic ignored a key issue of drivers' familiarity with the roadway because of the one-turn-movement assumption. To address that problem, the candidate lane selection and the look ahead capability in CORSIM have been enhanced to eliminate that modeling deficiency.

Record Type 153 was created to allow users to specify the drivers' familiarity with their network; that is, the user can specify the percentage of drivers who are familiar with the roadways. Such drivers know their next two turn movements, whereas those who are unfamiliar with the roadways know only their next turn movement. Unnecessary mandatory lane changes usually exist when drivers are not familiar with the roadways in the network. Candidate lanes, which are based on lane channelizations, have been restructured by considering all of the combinations of turn movements on a link and its receiving links. That structure provides a more realistic modeling of real-world traffic.

Shared turn lanes

Shared lane logic has been added to CORSIM to model traffic more realistically. Previous versions of CORSIM would only allow the leftmost and rightmost lanes to service more than one turn movement. With the new shared lane logic, all lanes can accommodate more than one turn movement. New codes were added to Record Type 11 to specify lane channelizations. The new codes allow all possible lane channelizations to be modeled as long as the paths of conflicting movements do not cross (e.g., a lane servicing left turns cannot be to the right of a lane servicing through traffic).

Actuated control features

The following actuated control features have been added to this version of CORSIM: left-turn extension, lag left-mm hold, conditional service, and simultaneous gapout.

Left-turn extension allows time not required to serve pedestrians for a through phase to be added to the opposing left-turn phase. The left turn is extended only in the absence of pedestrian demand for the opposing through phase; otherwise, the pedestrian phases (i.e., walk and don't walk) will be served for the through phase. Left-turn extension for a phase is specified on Record Type 44.

Lag left-turn hold will hold a lagging left turn until its force-off. This allows the green band in coordinated systems with lagging lefts to be maintained. Lag left-turn hold is entered for a phase on Record Type 47.

Conditional service allows a phase to be serviced twice during a cycle even when there is a call to serve conflicting demand. This feature is useful with heavy left turns that require leading and lagging phasing. Conditional **service** for a phase is specified on Record Type 47.

Simultaneous gapout requires both phases to gapout or maxout before a barrier of dual-ring operation is crossed. Without the simultaneous gapout feature, a barrier will be crossed if one phase gaps out and the other maxes out. Simultaneous gapout will prohibit this situation. Simultaneous gapout for a phase is specified on Record Type 47.

Real-time traffic adaptive control features

The CORSIM software has been enhanced to represent the operation of real-time traffic adaptive control algorithms. These enhancements include the implementation of detector logic and the introduction of new logic to represent changes in traffic volumes and turn movements on a minute-by-minute basis. These features will enable the model to realistically represent the rapidly changing traffic conditions that are considered by real-time traffic control policies.

The new logic transfers detector surveillance data to an external real-time traffic control algorithm and receives signal control decisions from the algorithm. New entries on Record Type 02 define the frequency and type of information to be sent between CORSIM and the control algorithm.

Sub-time period variation in entry volumes and turn movements

The CORSIM software has been enhanced to allow users to specify changes in entry volumes and turn movements as frequently as every minute. Each time period can be subdivided into a series of sub-time periods. Within each sub-time period, interpolation techniques are employed to vary volumes and turn movements every minute. This feature works in conjunction with the new Real-Time Traffic Adaptive Control features.

The user can specify up to 15 variations in turn movements for each time period. Sub-time period information for turn movements is entered on **Record Type** 23. The user can specify up to 16 variations in volume for each time period. Sub-time period information for entry and source/sink volumes is entered on **Record Type** 53. Sub-time period parameters are specified in new entries on Record Type 02.