CHAPTER 4
VEHICLE-TRAVEL SIMULATION

4.1 INTRODUCTION

The modeling of vehicle behavior along the highway implies the simulation of two main interactions: (a) vehicle-highway interaction, and (b) vehicle-vehicle interaction. This chapter explains how these phenomena are brought into model form.

4.2 VEHICLE-HIGHWAY INTERACTION

The results of the traffic experiments designed by the ICR Research made it possible to develop correlations on the basis of observed data between free speed and the physical characteristics of highways. These functional forms are used to develop distributions of free-speed means for each vehicle class, on each traffic lane. The distributions of free-speed means, together with such highway survey data as grade, type of surface, surface roughness and visibility will then become input data for the simulation model. A more detailed description of the interaction between a vehicle at free speed and the physical characteristics of the highways can be found in Swait (1976).

4.3 VEHICLE-VEHICLE INTERACTION

In most cases, the speed of a vehicle is limited by changes in the speed of various other vehicles. This limitation of free speed leads to queues of vehicles whenever overtaking is impossible or whenever visibility distance or the intervals between vehicles in the opposite lane are inadequate. Since the simulation process is nothing more than a simplified representation of the real world, certain assumptions with respect to interaction must be made, and certain rules developed. In the case of the MST, these assumptions are as follows:

1) There exists a minimum free headway, termed unrestrained headway (UNH), beyond which the presence of a vehicle does not alter the free speed of the vehicle coming behind. This headway is an input variable for the Model.

2) After having been generated, classified and the performance index established, the vehicle is introduced at the start of the section, at free speed. However, if, at the moment in which it advances to the first time increment, the vehicle's headway is below free headway and its speed greater than that of the immediately preceding vehicle, then a test is carried out to determine the possibility of performing an overtaking operation. Should it be impossible to overtake and should the vehicle's headway already be at the minimum level, the speed of the vehicle is made equal to that of the immediately preceding vehicle. If the headway is greater than the minimum but below free headway, the vehicle is decelerated and its initial speed is adjusted in such a way that, upon advancing, the vehicle in the process of deceleration cannot come nearer the preceding vehicle than the minimum headway interval. After having reached minimum headway, speed must be made equal to that of the preceding vehicle.

3) In the first version of the MST, a vehicle could not overtake another if its free speed were not at least 10 km/h greater than that of the vehicle to be overtaken, at the point in which overtaking was initiated. In the second version of the MST, this speed differential is given as an input parameter.

4) The vehicle may never exceed its free speed, even during an overtaking operation.

5) The vehicle may initiate an overtaking operation from any position in the queue, but the maximum number of vehicles that may be overtaken at a single time is only six.

6) Adequate visibility and sufficient space in the opposite traffic flow are necessary for the execution of an overtaking operation. At the same time, there must exist a headway that is equivalent to double the minimum headway between the vehicle to be overtaken and that immediately in front of it (Figure 4.1). Having begun the overtaking operation, this headway is maintained by the overtaking vehicle.

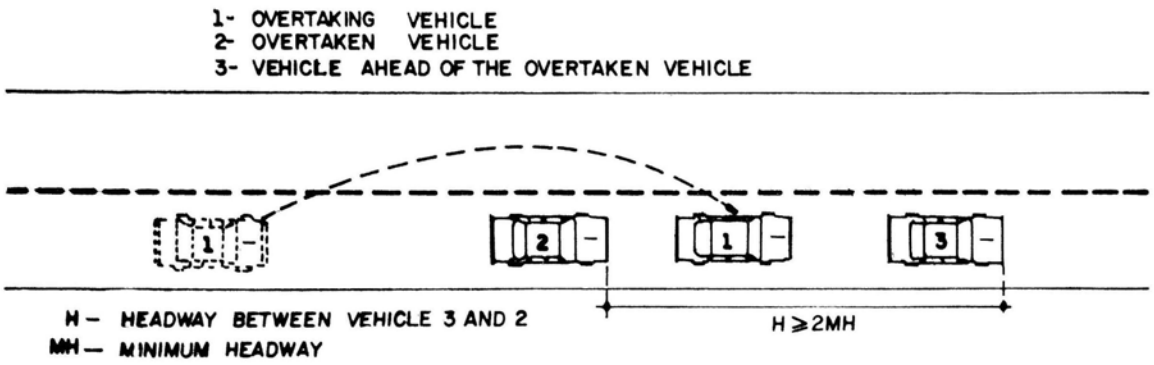

FIGURE 4.1 - REQUIRED HEADWAY BETWEEN VEHICLES FOR OVERTAKING TO BE POSSIBLE.

7) Overtaking is not permitted unless it can be completed within 30 seconds. The operation is considered completed when the overtaking vehicle is at a minimum headway in front of the vehicle overtaken. At this point in time, a vehicle on the opposite lane may be at the same distance, i.e., a zero safety margin is acceptable.

8) While being overtaken, a vehicle may only initiate its own overtaking operation after the overtaking vehicle has concluded its operation and attained a position in front of the last overtaken vehicle with a time interval equivalent to double the minimum headway.

Seven operating modes are utilized to describe the behavior of each vehicle:

- Mode 1: free-speed mode - the vehicle travels at a speed determined in the free-speed matrix;
- Mode 2: acceleration mode - the vehicle is accelerated from a speed lower than free speed (this can occur when an overtaking is completed);
- Mode 3: overtaking at free speed - the vehicle is capable of overtaking at free speed;
- Mode 4: overtaking with deceleration phase - the vehicle is initially hindered from overtaking by inadequate visibility or insufficient spacing in the opposite traffic flow, which requires deceleration before overtaking;

- Mode 5: deceleration mode - due to a insufficient speed differential, the vehicle is incapable of overtaking the vehicle in front and must decelerate;
- Mode 6: mode of follower-vehicle - the vehicle is incapable of overtaking and is forced to travel in a queue;
- Mode 7 to 12: vehicles in queue - these are equivalent to modes 1 to 6, the only difference being that they are applicable to vehicles while in a queue.

The assumption that a follower vehicle is forced to travel at the speed of the slower vehicle is valid only while the vehicle in front is at steady-state speed. For example, if the vehicle in front is in a acceleration phase on a negative grade, its speed will become greater than that of the vehicle coming behind it, at that given instant. Consequently, to maintain the headway at a constant value, the distance between the vehicles must be increased as the speed of both vehicles increases. The opposite occurs in the deceleration mode: the intervehicle space is reduced in order to compensate for the loss of speed and maintain the headway at a constant value.

4.4 *PROCESSING OF VEHICLES THROUGH THE SYSTEM*

To process the vehicles through the system, two computer files were assembled, one for the vehicles in the primary lane, and one for the vehicles in the opposite lane. In each file, each vehicle is identified by a single number. Its position relative to the vehicles in the same lane is easily identified, since each vehicle entry contains the number of the vehicle that is immediately in front, as well as that of the vehicle immediately behind.

The vehicles of each lane (primary and opposite) are processed alternatively at each time increment, which can be from one to nine seconds, at the discretion of the Model user.

With this description, the explanation of how the vehicles are simulated by the MST is concluded. The following chapter will show how to operate the MST.