SIMULATION AND DISPLAY OF FOUR INTER-RELATED VEHICULAR TRAFFIC INTERSECTIONS

Harry H. Goode and Wendell C. True
University of Michigan
Ann Arbor, Michigan

(Summary prepared by E. A. Weiss)

A traffic engineer is able to handle single intersections with a reasonable assurance of success. However, if he is concerned with the relationship among two or more intersections he is without an adequate tool for the solution of the problem. This paper concerns the development of such a computational tool.

Reference 1 described the development of a "reasonable" mathematical model of a single intersection, programming of the model for a digital computer, and subsequent runs on a computer to test it for consistency.

This paper extends this one intersection model to a model containing four intersections. In the cross block there are four incoming lanes. Each lane consists of 35 possible car positions. With each lane is associated four paths within the intersection and one "exit" position. One of the four paths lying within the intersection is followed by right-turning cars, one by cars going straight ahead, and two by cars turning left.

There is an exit box in each "straight ahead" path out of the cross block. This exit box consists of the first two points that are attained by a car leaving the intersection on the straight ahead path. Right and left turners into the exit box are also deposited in it as they leave the intersection. These exit boxes allow the programming of the computer to arrange for the connection of any given cross block with any other cross blocks.

For each cross block there now corresponds a storage register to each lane, to each intersection path, and to each exit box- 24 in all, since there are four lanes, sixteen paths, and four exit boxes. Four cross blocks, interconnected, make up the model.

When a car reaches point one of any lane, the light is checked. If it is red or in the last ten quarterseconds of the amber period, the car remains at point one. If it is green or in the first 15 quarterseconds of the amber period, the computer examines the turn register. If a right turn is indicated, the right turn path is considered. If it is empty, the car proceeds; otherwise the car remains at point one. If a left turn is indicated, the left turn path is examined. If it is empty, the car proceeds; otherwise it remains at point one. The same procedure is followed if a straight path is indicated.

The rules of this model are applied in the following order. First the four intersections are worked on, then the lanes are worked on starting at point 35 and progressing up the lane to point one. Then the appropriate exit boxes are connected to their lanes. Having done this, the unconnected exit boxes are attended to. Next, the lights are examined and changed if necessary. This brings up the next quarter of a second which repeats the routine.

The computer used in connection with the one intersection model was the MIDAC. For the four intersection case an IBM 704 was used.

In order to allow the traffic engineer to examine the traffic flow without forcing him to consider the reduced amount of information provided by the use of single measures of effectiveness such as average delay, etc., it is desirable to have the computer situation at every moment fed out to an oscilloscope which would represent the positions of cars in their proper geographical location. The four intersection model was so arranged that every quarter of a second of problem time the contents of the computer were scanned and points on an oscilloscope intensified at locations corresponding to those of cars within the computer model. In addition, the scope was made to paint the bounding lines of the four intersections, resulting in frames of film. The resulting film provided an animated cartoon-like version of the flow of traffic within the computer.

The actual results on the IBM 704 used half of the available computer speed to do four intersections of problem time. Probably the computer could do about eight to ten intersections at a real time rate. However, since a film can be made, and since scaling time is no obstacle, even if the computer takes ten or twenty times real time, no difficulties are envisioned in producing for the traffic engineer a version of what real traffic flow would look like. Moreover, ten intersections in any city, with attention being paid to the important intersections, is a fair representation of the flow of traffic during the busy periods at essential points. The model thus far indicates that at this level of sophistication, a reasonably adequate real time version of traffic flow can be produced.

To date the most important point in the development of a computational tool, that is, an experiment to verify the comparability of the computer model and real traffic flow, has not been forthcoming. No support has thus far been available for such a comparison.

The authors have now undertaken the development of an expanded model with characteristics different from the one described above at the following points:

1. They will represent two lanes of traffic flowing in the same direction, in which a car in one lane may attempt the passing of the car in front by going over into the next lane, speeding up, and then pulling back into the original lane.

2. Each car will be given a character (bus, passenger, truck, etc.) on a random number (but fixed average) basis.

3. The desired speed will be assigned on a distributed basis (average $\underline{a}$ miles per hour, ranging from $\underline{a} - k$ to $\underline{a} + h$ with known probabilities) and subsequently carried with the car.

4. By increasing the number car spaces in a lane car movement will be smoother (although it is not objectionably jerky at present).

REFERENCE

1. Goode, H. H., Pollmar, C. H., and Wright, J. B., "The Use of a Digital Computer to Model a Signalized Intersection," Proceedings of Highway Research Board, vol. 35, 1956, pp. 548 - 557.