SUMMARY REPORT

I-84 FREEWAY TRAFFIC SURVEILLANCE AND CONTROL PROJECT

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INTRODUCTION

The Freeway System represents a major portion of the traffic-carrying capacity of the overall street network in Hartford. To meet present and future traffic demands, I-84 must operate safely and efficiently. Practical measures for simultaneously assuring maximum efficiency and minimum congestion and accident potential, must be implemented. Consequently, the Connecticut Highway Department in conjunction with the Civil Engineering Department of the University of Connecticut initiated a study to investigate the feasibility of a surveillance and control system for eastbound I-84.

OBJECTIVES

The specific objectives of the "I-84 Freeway Surveillance, Communication and Control" research project included:

1. The design and development of a digital computer simulation system for analyzing freeway traffic flow.

2. The evaluation of capacity and operating characteristics of I-84 from Sigourney Street to I-91. This evaluation will include an operational analysis using the "1965 Highway Capacity Manual".

3. A general evaluation and correlation of freeway operating characteristics with geometric and design features.

4. The design and installation of a surveillance and control system, including ramp-metering devices, speed-regulating devices, and weave-metering devices.

5. Evaluation and optimization of the surveillance and control system by closed-circuit-television monitoring and by simulation.

RESEARCH PERFORMED

Capacity Analysis

A capacity and operational analysis for all intersections adjacent to I-34 was completed for I-34, from Sigourney Street to I-91. This analysis provided an estimate of the maximum traffic volumes that could gain access to I-34 from the signalized intersections adjacent to I-34 on-ramps. Estimates of the potential traffic that would gain access to I-34 in the study area, as well as of traffic that was anticipated on mainline I-34, were needed for the simulation studies that were to follow.

Traffic Monitoring

A closed-circuit television system for making time-lapse studies was purchased in February 1967. However, the topography in the area of I-34 made it difficult to use the television equipment. This was due to the fact that viewing angles to traffic were skewed from all locations. In addition to this problem, mainline I-34 was not open to traffic so that there was only a very low volume of local traffic on the freeway. Because of these problems, traffic characteristics such as volume, speed and density were not monitored.

The ramp origins and destinations of the local traffic on I-84 were observed in February 1967. The field work was conducted by the Connecticut Highway Department, Bureau of Traffic, and the analysis was completed at the University of Connecticut.

Freeway Operations

A general evaluation of freeway operating characteristics was performed. This included subdividing the roadway into subsections having uniform capacity conditions. Stopping sight distances to all critical points and to all off-ramps were measured to determine substandard sections of roadway. This information was needed to insure proper placement of surveillance equipment.

On-Ramp Metering

A simulation program to determine waiting time of on-ramp vehicles was developed[6]. The program was written in Fortran IV to run on an IBM 7040 computer. It was used to determine the amount of time a vehicle waits (service time) in the first-in-line position. The intent of this work was to formulate one basic model to describe vehicle service times for waiting and for non-waiting on-ramp vehicles. This research effort indicated that vehicle service times do not follow

e basic frequency distributions and thus, there is no simple queueing model to describe ramp queueing and delay characteristics. A ramp-metering simulator could have been developed from the service time simulator, but this was not done due to time limitations on this phase of the research.

Freeway Simulator

The major portion of the research effort was devoted to the development of a freeway digital simulator[7]. The simulator was structured as a collection of subroutines under control of a main monitoring routine. It has the capability of simulating traffic flow along two miles of multi-lane highway with six on-ramps and six off-ramps.

Several of the routines of interest are:

1. The Hyper-Erlang vehicle generating model[1,2,3]. In general, a moving traffic stream is a combination of two different populations of vehicles. One population is made up of unconstrained vehicles with completely random spacings between them, and the other is made up of constrained vehicles with restricted inter-vehicle spacings. The former population can be described by an exponential, or Erlang (K=1) distribution; while the latter

population is described by an Erlang ($K \geq 1$) distribution. When the two distributions are intermixed they form a Hyper-Erlang distribution.

2. An acceleration model for vehicles whose movements are not constrained[5]. In the model, acceleration is expressed as a function of the drivers actual and desired speeds.

3. A model describing the deceleration of vehicles. This work, based on earlier research reported in Traffic Engineering Handbook (Third Edition), indicated that the rate of deceleration is not a constant independent of speed; rather it is a function of the current speed and the desired speed of the vehicle. The deceleration rates and speeds of passenger vehicles approaching a stop sign from 20 to 60 MPH were modeled.

4. A car-following model to describe driver-vehicle behavior for situations where the movement of the following vehicle is influenced by the lead vehicle. After reviewing many different car-following techniques elsewhere, it was realized that a more general car-following model was needed. A model was developed from the acceleration and deceleration models presented above. The basic premise of car-following was that vehicles in the traffic stream do not come in physical contact.

5. A lane change and weaving model to describe the interaction of merging on-ramp and off-ramp vehicles. The model was developed from the findings reported in the Nationwide Freeway Merging Study. The interaction involves driver decisions in maneuvering through the traffic stream.

Metering Concept

A proposal for the installation of surveillance, control, and metering equipment in the Ann Street on-ramp and I-91 southbound areas was prepared in March 1969(3). This proposal showed the equipment configuration that would be necessary to properly control traffic flow in the study area. Graphs showing the number of vehicles unable to made safe weaving and merging maneuvers on I-84 were depicted using simulation techniques. The proposal was presented to the Research Liaison Committee in April 1969 and received their approval.

An oral presentation was made before administrative heads of the Connecticut Highway Department in July 1969.

SUMMARY

The objectives of this research project were met by July 1969. The main effort was devoted to the development of a freeway digital simulation system capable of simulating two miles of freeway with six each of on-ramps and off-ramps. Many innovations were introduced in this portion of the research. These will be the subject of three papers being prepared for publication.

Based on the apparent feasibility for a traffic surveillance and control system, the Ann Street area of I-84, recommendations for the design of a surveillance, control and metering system were made in March 1969.

The ultimate decision as to disposition of the research results rests with the administrative officers of the Connecticut Highway Department.

PROJECT PAPERS

1. Chimini, L. A., Dawson, R. F., "The Hyperlang Probability Distribution -- A Generalized Traffic Headway Model", Highway Research Record 230.

2. Chimini, L. A., "The Hyperlang Headway Probability Model", University of Connecticut, Storrs, Connecticut, Master Thesis, June 1968.

3. Dawson, R. F., "The Hyperlang Probability Distribution - - A Generalized Traffic Headway Model", Fourth International Symposium on Traffic Flow Theory, Karlsruhe, Germany, June 1968.

4. Dawson, R. F., Perruccio, W. B., "I-84 Freeway Traffic Surveillance and Control Projects", (a proposal) March 1969.

5. Dawson, R. F., and Perruccio, W. B., "Acceleration Model for Non-Constrained Traffic Flow", University of Connecticut, unpublished.

6. Perruccio, W. B., "An Analysis of On-Ramp Service Times by Monte Carlo Simulation", University of Connecticut, Storrs, Connecticut, Master Thesis, June 1968.

7. Sinha, K. C., "The Development of a Digital Simulator for the Analysis of Freeway Traffic Phenomena", University of Connecticut, Storrs, Connecticut - Doctoral Thesis, September 1968.