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ITS EQUIPMENT PLACEMENT FOR SAFETY AND MOBILITY

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This study develops a Decision Support Model (DSM) for the optimal placement of Intelligent Transportation Systems (ITS) equipment, such as Variable Message Signs (VMS) and Closed Circuit Video Equipment (CCVE), on a state highway network. Development of the model is motivated by the need of Traffic Management Centers (TMCs) to install or replace traveler information systems in the network under their jurisdiction. A mathematical programming model is formulated to maximize the net benefit of the installation subject to budget constraints. Benefits and costs are calculated on an annual basis and the model can be utilized as part of the annual element in the state transportation planning process (STIP). The model is powered by the IBM ILOG CPLEX Optimization Studio.

The following results were obtained in this study:

1. Development of a mathematical model to quantify benefits and costs of installation of Intelligent Transportation Systems devices such as VMS and CCVE.
2. A Decision Support Model to prioritize locations where ITS devices need to be placed based on a net benefit maximization criterion subject to an annual budgetary constraint.

Following is a more detailed description of the methodological developments in this study:

<u>Definition of the VMS Location Problem</u>

VMS installations are capital assets that require significant investments. If used inappropriately, the effectiveness of the installation diminishes. The objective of a VMS location solution approach is to ensure long-term system optimal performance. The VMS-location problem can be defined as follows: "Given a road network consisting of a set of road segments or links, identify a subset of links for installing a given number of VMS so that the total benefit that could be obtained from these installed VMS is maximized. The effectiveness of VMS, however, depends on how many VMS are installed and where the VMS are located in the network." (Dudek *et al.*, 2006).

<u>Development of an Optimization-based Decision Support Model for Placement of Variable Message Signs on a Freeway System</u>

The goal of the decision support model is to optimize the placement of VMS and related equipment subject to a budgetary constraint. Benefits and costs are determined for each potential location and the total net benefit is maximized, acc. to the following objective function:

$$Maximize\ Net\ Benefit = \sum_i \{(B_i - C_i) - R_i\} \cdot d_i$$

Where,

B_i is the benefit of installing a VMS on link i;
C_i is the cost of installing a VMS on link i;
R_i is the reduced benefit due to pre-installed or planned VMS installations;
d_i is a binary variable (0, 1) indicating the decision to install a VMS on directional link i;

$$d_i = \begin{cases} 0 \ if\ the\ link\ will\ not\ be\ instrumented \\ 1\ if\ the\ link\ will\ be\ instrumented \end{cases}$$

Benefits are estimated by the travel time savings obtained due to diversion, as seen in Figure 1 below. The light grey shaded triangle provides travel time savings accrued by drivers due to the information provided by the VMS. This value of travel time savings in then applied for all incidents occurring on the link. Recent studies indicate that traveler information can be very effective during periods of non-recurring congestion caused by unexpected events such as incidents. In addition to this, drivers who are able to monitor, evaluate, and adjust their travel behavior reduce their carbon footprint by 20%.

Costs include capital and maintenance costs which are annualized based on the expected economic life. VMS may lose some effectiveness when located in close proximity to each other (e.g., on adjacent links) and therefore a reduced-benefit-function R_i is included in the formulation. This function is specific for each location.

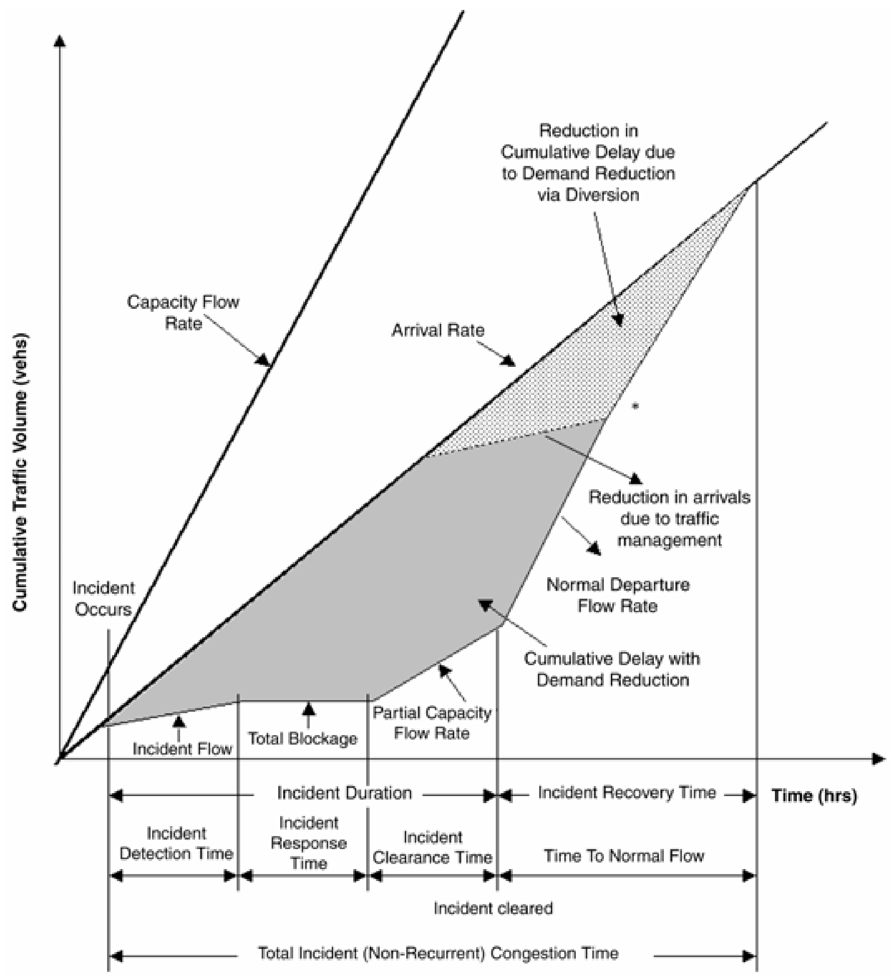

FIGURE 1 Reduction of cumulative delay due to diversion.
Source: Cambridge Systematics Report, 1990

A copy of a more extensive Final Report can be obtained by contacting the PI or co-PIs listed above.