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Development of an Adaptive Corridor Traffic Control Model

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PATH T.O. 5323

Development of an Adaptive Corridor Traffic Control Model

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PATH T.O. 5323

Development of an Adaptive Corridor Traffic Control Model

Abstract

This report documents work performed on PATH TO 5323. Due to an administrative mandate, the work performed and reported herein constitutes only the early stages of the multi-year project that was approved under PATH TO 5323, and subsequently divided into two distinct awards—TO 5323 and TO 6323. Moreover, a series of events during the early stages of the project substantially redirected the original effort. These factors led to a major redirection from the original project. The majority of the work performed under the revised TO 5323 was then to develop a methodology consistent with the new direction of the project, which is detailed in this report.

Under the revised direction, the objective of the project is to develop and implement a real-time adaptive control system for corridor management. The proposed control strategy is based on a mathematical representation that describes the behavior of the real-life processes (traffic flow in corridor networks and actuated controller operation). In formulating the optimal control problem, we have restricted our attention to control of only those parameters commonly found in modern actuated controllers (e.g., Type 170 and 2070 controllers). By doing this, we hope to ensure that the procedures developed herein can be implemented with minimal adaptation of existing field devices and the software that controls their operation.

Keywords: Adaptive signal control, corridor management, simulation

PATH T.O. 5323

Development of an Adaptive Corridor Traffic Control Model

Executive Summary

This report documents work performed on PATH TO 5323. Due to an administrative mandate, the work performed and reported herein constitutes only the early stages of the multi-year project that was approved under PATH TO 5323, and subsequently divided into two distinct awards—TO 5323 and TO 6323. The objective of the project is to develop and implement a real-time adaptive control system for corridor management. The work reported here is confined to presenting the methodological approach that will be followed in completing PATH TO 6323. The proposed control strategy is based on a mathematical representation that describes the behavior of the real-life processes (traffic flow in corridor networks and actuated controller operation). In formulating the optimal control problem, we have restricted our attention to control of only those parameters commonly found in modern actuated controllers (e.g., Type 170 and 2070 controllers). By doing this, we hope to ensure that the procedures developed herein can be implemented with minimal adaptation of existing field devices and the software that controls their operation.

In the approach taken herein, we first develop estimates of both the expected time required to dissipate any queue formed during the Red interval (minimum initial), as well as the time lapse between the termination of the phase minimum and a gap sufficiently large to invoke a gapout in terms of the gap (unit extension) setting of the controller. We then express the expected delay in terms of the minimum green, gap, maximum green settings of the full eight phases and the measured mean vehicle arrival rates on the approaches to the intersection. Based on the expression for expected delay, we formulate a nonlinear optimization problem for determination of gap settings that minimize the expected delay under gapout conditions.

We estimate upstream contributions to the target intersection from known controller parameter settings at the upstream intersections (a total of four) and readouts from the corresponding signal displays; depending on the expected travel time from the contributing intersection, these values may be drawn from a completed cycle or from an ongoing cycle of operation that commenced just prior to the forecast period for the target intersection. Dynamic turning fractions at the target intersection, which cannot be known *a priori*, are estimated based on a moving average model. In order to test and evaluate the intersection control model, the optimal control formulation is being developed as an API in Paramics.

We further propose a ramp control methodology that recognizes that, qwing to the proximity of the intersections to the respective ramp meters, the arrival pattern at the point of metering will be determined using platoon dispersion principles. The departure pattern will be determined as an output of the ramp control model, which has as its

control parameter the instantaneous metering headway, subject to certain installation parameters (e.g., queue override headway, merge queue override headway), and to controller operation protocol. The typical goal for efficient operations is to design a ramp control strategy that processes the maximum number of vehicles, while maintaining uncongested, or "high-speed," conditions on the freeway. In work conducted herein, we propose to represent the freeway traffic by the well-known triangular flow model, first "fitting" the triangular flow model to loop data for each section of the freeway in our corridor. Then, using the calibrated speed-flow-density models, we will specify freeway delay in terms of the mainline volumes (determined from loop stations at the entry boundary to the corridor) and the controlled discharge from the entry ramps within the corridor.

These procedures allow us to specify the total delay components in the corridor network—intersection delay, ramp delay, and freeway delay—in terms of a set of control variables (gap settings, maximum green settings, and ramp meter headway settings) that can be dynamically adjusted in response to detector inputs and known controller responses. Nominally, these adjustments will be guided by achieving some system optimal condition, e.g., minimization of total system delay, and achieved through solving the accompanying nonlinear optimization problem.

As mentioned, the scope of work for PATH TO 5323 is restricted to problem formulation to serve as background for work to be conducted under PATH TO 6323. The scope of the effort undertaken in PATH TO 6323 includes the development of the corridor adaptive control model and its testing and evaluation in a simulation environment. Prior to testing the complete model, separate tests will be conducted to evaluate the intersection control model on: 1) an isolated intersection, and 2) a network of intersections along an arterial. The complete model will be tested and evaluated on the Alton Parkway/I-405 corridor network.

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1. Background

This report documents work performed on PATH TO 5323. Due to an administrative mandate, the work performed and reported herein constitutes only the early stages of the multi-year project that was approved under PATH TO 5323, and subsequently divided into two distinct awards—TO 5323 and TO 6323.

Moreover, a series of events during the early stages of the project substantially redirected the original effort as follows:

1. Based on discussions with the Principal Investigator of TO-5322 at UCB, the Caltrans Project Manager, and Caltrans customers, a tentative agreement was reached to concentrate both studies on a common network (likely El Camino), rather than on the stretch of Pacific Coast Highway originally described in the RFP.

2. Based on preliminary discussions, a tentative agreement was reached to concentrate the study on the El Camino (San Mateo) site. The Irvine team then received partially coded Paramics network for the El Camino (San Mateo) site, reviewed and analyzed network for discrepancies, and began to sketch out network control strategy parameters/configuration.

3. However, at a “kickoff” meeting held on April 8, 2005, one quarter after the planned start of the project, a tentative decision was made to have the UCI team focus on the Irvine I-405 corridor network. As a result, we have revised the original effort relative to this site.

4. To help ensure that the product of the research would be useful to the customers, we then investigated the option of incorporating the adaptive control model as a bundled "service" of CTNET, which is a signal control software used by Caltrans and some of its local agency partners. This approach would ultimately enable the convergence of work being done on PATH TO-5322 and that on PATH TO-5323. The approach would also allow the integration of the adaptive control model to be incorporated as a module in the CARTESIUS implementation in CTNET.

5. Because of all of the changes/opportunities presented by these discussions with the Caltrans customers, a decision was made at a combined quarterly meeting (of PATH TO-5322 and TO-5323) to have the UCI team draft a detailed description of the newly proposed methodology for distribution to potential clients within Caltrans.

These factors have led to a major redirection from the original project and a slight delay in scheduling. The majority of the work performed under the revised TO 5323 was then to develop a methodology consistent with the new direction of the project, which is detailed in this report.

2. Introduction

Under the revised direction, the objective of the project is to develop and implement a real-time adaptive control system for corridor management. The proposed control strategy is based on a mathematical representation that describes the behavior of the real-life processes (traffic flow in corridor networks and actuated controller operation). In formulating the optimal control problem, we have restricted our attention to control of only those parameters commonly found in modern actuated controllers (e.g., Type 170 and 2070 controllers). By doing this, we hope to ensure that the procedures developed herein can be implemented with minimal adaptation of existing field devices and the software that controls their operation.

A typical advantage of an adaptive signal controller is that the cycle length, phase splits, and even the phase sequence, may vary from cycle to cycle, thus to satisfy current traffic demand pattern in a maximum degree; to some extent, actuated controllers are themselves “adaptive” in the sense that they vary these same outcomes, but do so subject to a set of predefined, fixed, parameters that do not “adapt” to current conditions. For the functionality of truly adaptive controllers, a set of on-line optimized phasing and timing parameters are needed.

Existing adaptive controls, such as SCOOT (Robertson and Bretherton, 1991), make incremental adjustments to the current signal plan for the next cycle, in response to the changing traffic demands. In another real-time network control, SCATS (Lowrie, 1992; Sims, 1979), the local-level intersection controller decides its timing parameters on the basis of the degree of saturation, and then incrementally adjusts to varying traffic conditions. The major drawback of these systems is that they are not proactive and therefore, cannot accommodate significant transients effectively. RHODES^{TM}, a real-time traffic-adaptive signal control system developed at the University of Arizona, uses a traffic flow arrivals algorithm - PREDICT (Head, 1995) to improve effectiveness when calculating online phase timings. In the PREDICT algorithm, detector information on approaches of every upstream intersection, together with the traffic state (arrival and queues), and control plan for the upstream signals are used to predict future traffic volume. It assumes that all surrounding upstream intersections have fixed-time signalized planning, an assumption that is violated in virtually every modern system.

In none of these previous systems do the embedded traffic flow prediction models fully utilize available detector information and control features. Consequently, their applicability is confined only to particular factors, and thus restricted in achieving comprehensively good performance. For any signalized intersection, at least three kinds of information—vehicle actuated detector information, signal timing plan and current signal phase information—can be exploited to infer a relatively rich body of information that can be used in adapting the operation of the signal controller to current, or expected, conditions. Here, we develop a traffic flow prediction model based on the actuated phase control strategy and other features, such as minimum green time, unit or vehicle extension and maximum green time, together with related detector information gleaned from actuated-signalized upstream intersections to estimate the future arrivals at downstream intersections. To better utilize all available information, our traffic flow prediction model is divided into an approach volume prediction and a corresponding turning proportion estimation. Based on the time of actuation in upstream detector of neighboring intersections, together with current signal state and control tactics of the neighboring intersections, the arrival pattern of vehicles is predicted. Then by using the exit/entry passage detector cycle/phase counts in the neighboring intersections, the turning percentage for each movement is estimated. As a result, the model can utilize instantaneous information that is currently available but not used, and thus assist fine-tuning intersection performance without any additional hardware investment.

The development and adoption of adaptive control procedures for signalized intersections have been hampered by two fundamental impediments to their successful implementation—those that are theoretically sound invariably have been specified in terms of parameters and control options that simply are not within the lexicon of control devices and typically involve complex mixed-integer-programming formulations that do not lend themselves to real-time solution, and those that do manipulate parameters employed in modern actuated control devices are based on highly simplified approximations and simplifications to both control response and traffic measurement. Consistent modeling of traffic signal operations inevitably includes some sort of conditional piece-wise functions in the mathematical representation. For example, such a representation is the basis of the dispersion-and-store model where the inflow to a link is dispersed and is subsequently stored at its end if the signal at the adjacent intersection is "Red," or the similar store-and-forward model where the inflow is assumed to travel at a constant travel time, a general relationship of the corresponding outflow discharge would be described by a function that is conditional on the signal indication and the prevailing traffic conditions. Specifically, the outflow is equal to zero if the signal is "Red," and equal to the minimum of the flow rate of the stored vehicles and the saturation flow rate if "Green." Within the context of a mathematical programming problem this function is represented by some sort of constraint(s).

Typically, this task has been approached either by considering specific aspects of the process behavior that narrow the applicability of the model and restrict the insight of the findings, or via its questionable manipulation in the solution procedure of the corresponding problem. For example, when designing optimal signal control strategies for surface street networks based on the store-and-forward model, Singh and Tamura (1974), D'Ans and Gazis (1976), and Papageorgiou (1995) assumed that oversaturated conditions prevail. The control variables are the green per cycle ratios given a cycle of fixed duration, so that the outflow discharge is calculated as the product of the saturation flow rate and the green per cycle ratio. In their formulations, traffic signal operation is not explicitly modeled, and the oversaturation assumption restricts the applicability of the control strategy that of a single-ring, 2-phase, fixed cycle controller. As another example, Chang *et al*. (1994) develop signal control strategies for mixed surface street/freeway networks by manipulating the outflow discharge function based on the values of the current state and the previously determined control variable, with the solution algorithm assigning the minimum of the two arguments to the link outflow. In other cases, the conditional piece-wise function is expressed in the form of minimum or maximum operators; see, e.g., Stephanedes and Chang (1993), and Ziliaskopoulos (2000).

Despite the theoretical consistency of optimal control formulations based on such piece-wise functions, the impracticality of their solution in real-time and their general inconsistency with the operation of existing control devices (e.g., by specifying control transition commands that cannot be understood by existing controller logic) have rendered their practical implementation virtually impossible. In the approach taken herein, we avoid this pitfall by formulating the optimal control problem for a signalized intersection in terms of parameters (phase maximums and gap settings) featured in any modern actuated controller, based on a theoretically consistent model of stochastic traffic flow.

3. Methodological Approach

3.1 Intersection Control Module

In the approach taken herein, we assume that the traffic arrival pattern can be represented as a queue with Poisson arrivals, and from queuing theory (e.g., Cox and Smith, 1961) first develop estimates of both the expected time required to dissipate any queue formed during the Red interval (minimum initial), as well as the time lapse between the termination of the phase minimum and a gap sufficiently large to invoke a gapout in terms of the gap (unit extension) setting of the controller. Assuming an expression for delay per cycle given by Darroch (1964), which is a generalization of the well-known Webster formulation, we then express the expected delay in terms of the minimum green, gap, maximum green settings of the full eight phases and the measured mean vehicle arrival rates on the approaches to the intersection. Based on the expression for expected delay, we formulate a nonlinear optimization problem for determination of gap settings that minimize the expected delay under gapout conditions. The solution procedure is also shown to identify those instances where gapout conditions do not arise. Based on maximum cycle length restrictions, we set phase maximums based on Webster's functions, accounting for any spillover from previous cycles of operation.

We similarly estimate upstream contributions to the target intersection from known controller parameter settings at the upstream intersections (a total of four) and readouts from the corresponding signal displays; depending on the expected travel time from the contributing intersection, these values may be drawn from a completed cycle or from an ongoing cycle of operation that commenced just prior to the forecast period for the target intersection. Dynamic turning fractions at the target intersection, which cannot be known *a priori*, are estimated based on a moving average model.

As specified, the outputs of the adaptive control model for intersection signalization are the product of a stochastic optimal control problem that returns dynamic values for the two parameters of actuated controllers (gap setting and maximum green setting) that control its responsiveness to stochastic fluctuations in traffic conditions (other parameters, e.g., minimum greens, yellow interval, clearance interval, phase sequencing, are determined principally in regard to safety and geometric considerations); contrasted to current controller operation, in which these parameters are static/preset, in our formulation they are dynamically set in response to estimates of demand.

3.2 Testing and Evaluating the Intersection Control Model

In order to test and evaluate the intersection control model, the optimal control formulation will be developed as an API in Paramics. The test network will be drawn for a subsection of the so-called “Irvine Triangle” Paramics network (Figure 1) that has been extensively coded and calibrated as part of the Caltrans ATMS Testbed program.

Figure 1. Irvine Triangle Network

The specific subsection of interest will be a stretch of Alton Parkway that parallels I-405 freeway, and encompasses three freeway access ramps to northbound I-405: Jeffrey Road, Sand Canyon Avenue, and Irvine Center Drive (Figure 2).

Figure 2. Subsection of Application

A state-of-the-art Siemens ACTRA Central Traffic Control System and eighteen 2070NL intersection controllers with SE-PAC firmware has been installed along an 18-intersection adaptive control test-bed in the City of Irvine (COI) (Figure 3) that supplies real-time traffic data to the ATMS Testbed laboratories utilizing single mode fiber optic communication operating over 4 communication channels. The Eagle ACTRA system provides detection and adaptive control capabilities utilizing existing Ethernet communications.

The communications architecture for the system is designed to isolate the Testbed functions from the COI's traffic system, thus allowing researchers to interact with the traffic system without the possibility of disrupting normal city operations. Input Acquisition Software (IAS) was developed to enable transmission of all detector inputs and signal displays to the Testbed laboratories. As part of this project, that system is currently undergoing modification that will place the 2070 controllers under the CTNET management system.

In testing the optimal control model, we will simulate a variety of conditions on the freeway and arterial subsystems that will cover the range of demand from peak to non-peak, incident to non-incident, conditions. The results of these experiments will be evaluated against full-actuated, and coordinated actuated, operation (these models have already been coded as API functions within Paramics). In this particular phase of the evaluation, we will be interested only in the performance of the arterial subsystem, rather than in the combined performance of the freeway-arterial system—this latter aspect of the study will be addressed in subsequent testing.

Figure 3. Locations of Testbed 2070 Controller Installation

3.3 Ramp Meter Control Model

Owing to the proximity of the intersections to the respective ramp meters, the arrival pattern at the point of metering will be determined using platoon dispersion principles. The departure pattern will be determined as an output of the ramp control model, which will have as its control parameter the instantaneous metering headway, subject to certain installation parameters (e.g., queue override headway, merge queue override headway), and to controller operation protocol.

Caltrans Type 170 metering controllers comprise a number of control elements based on inductive loop detector data inputs. A typical freeway configuration is shown in Figure 4.

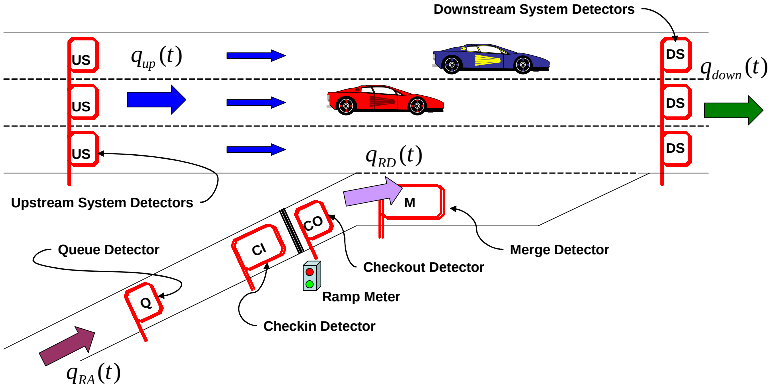

Figure 4. Typical Ramp Meter Configuration

Under current deployment, the headway component of the signal controller uses input from: 1) the upstream system detector control element, 2) the downstream system detector control element, 3) the queue detector control element, and 4) the merge detector control element. Basically, the upstream and downstream system detectors are used to calculate an appropriate metering headway based on conditions on the mainline freeway, while the queue and merge detectors are used to override the calculated headway based on conditions on the ramp.

A typical open-loop control operation is shown in Figure 5 below, in which the objective of the control is to keep the total demand downstream at a value that does not exceed the capacity downstream:

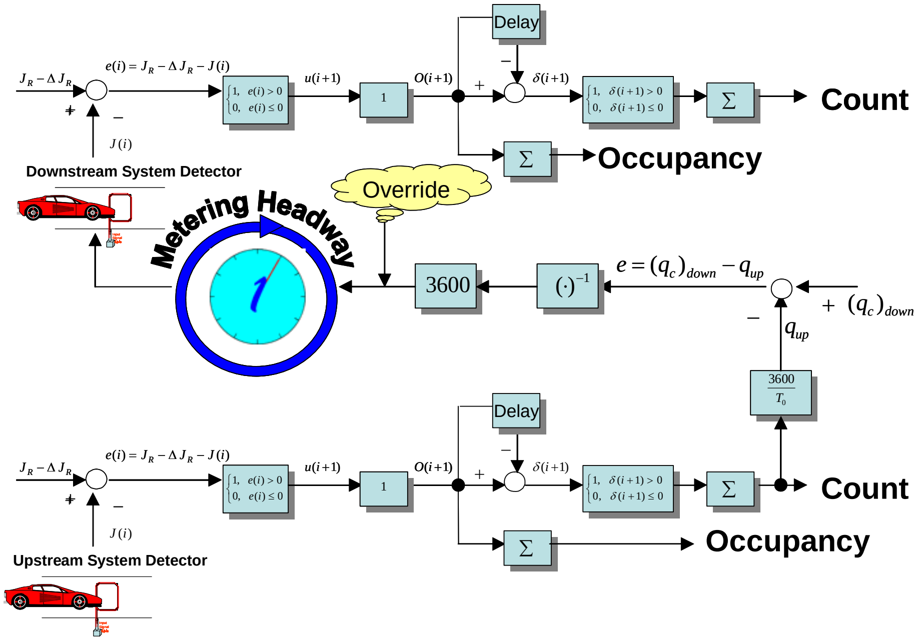

Figure 5. Typical Open-loop Ramp Metering Control

In this controller, the reference input is the downstream capacity, $(q_c)_{down}$, and the metering headway is computed as the headway corresponding to a ramp flow rate that would lead to the total downstream demand being less than or equal to capacity. Note that in this open loop design, the downstream detectors are not used; only the upstream flow rate (which is external to the control system) is utilized.

An example of a simple closed-loop control system is shown in Figure 6 in which the objective is to maintain the downstream speed at a certain prescribed level, $\dot{x}_{REF}$.

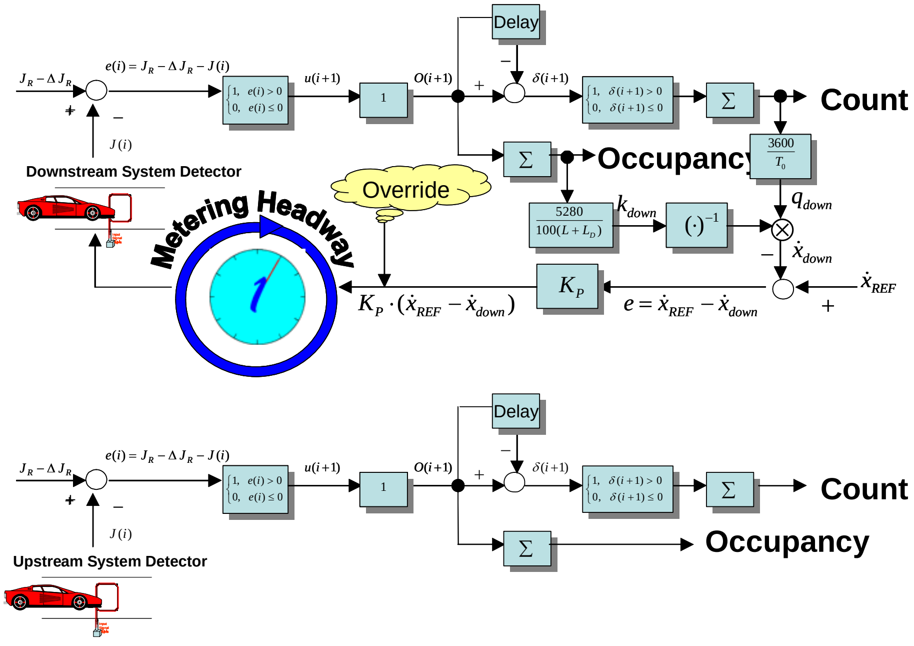

Figure 6. Typical Closed-loop Ramp Metering Control

In this controller, the count and occupancy from the downstream system detectors are used to compute an estimate of the downstream speed, which is then compared to the input reference speed; a proportional control is then used to calculate the ramp metering headway. In this application the upstream system detectors are not used.

In neither of these typical installations is systemwide performance an explicit consideration in the setting of parameters under which ramp meter controllers operate. In the work presented here, we formulate the ramp control element of our real-time adaptive control corridor model under assumptions of stochastic queuing, with demand input determined from the output of the associated intersection discharge model, and with output determined in accordance with minimizing the delay to the combined corridor system, comprised of: intersection delay, ramp delay, and freeway delay.

3.4 Freeway Model

It is well-known that there is an inherent relationship among the speed (and, correspondingly, delay), flow, and density of traffic on a freeway (often referred to as the "fundamental diagram of traffic flow"). Less well-known is the exact form of this relationship. For analytical formulations, such as ours, it is nonetheless necessary to impose a mathematically tractable relationship. Although a number of such relationships have been proposed, based on their mathematical simplicity (see, e.g., Greenshield's linear model), few of these compare favorably to observed data; most of these models predict a gradual decrease in speed (linear, in the case of Greenshield's model) as traffic density increases. In fact, our experience suggests that speed remains relatively constant until we reach a point where there are sufficient numbers of vehicles to cause interference in the traffic stream, resulting in the need or desire among drivers to change lanes, accelerate and brake. At this point, we know that things can quickly deteriorate to "stop-and-go" conditions, i.e., congestion, with a precipitous drop in speed. That is, what we expect to see in the way of a relationship between speed and density is something like that shown in the figure below.

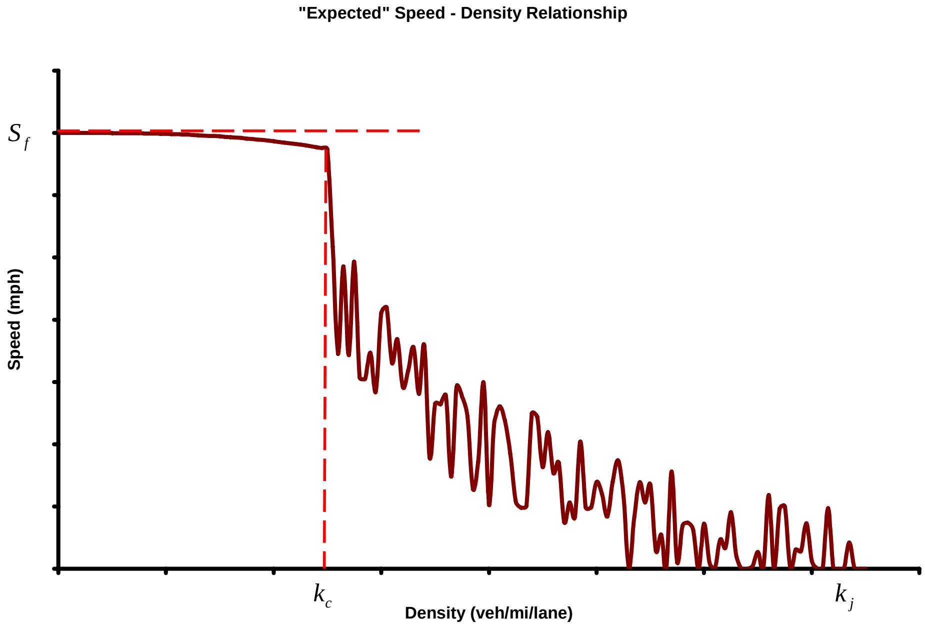

Figure 7. Expected Speed-Density Relationship

This figure depicts a speed – density relationship in which speed remains relatively constant at a value equal to the free-flow speed until we reach capacity, and then speed decreases somewhat unstably from that point to stop-and-go conditions. Is what we intuitively expect borne out by data drawn from the field? Indeed it is! Plotted below are data drawn from an interior lane of a four-lane section of I-405 in Irvine, California. Note the similarities between our intuitive expectations and the "real-world" experience.

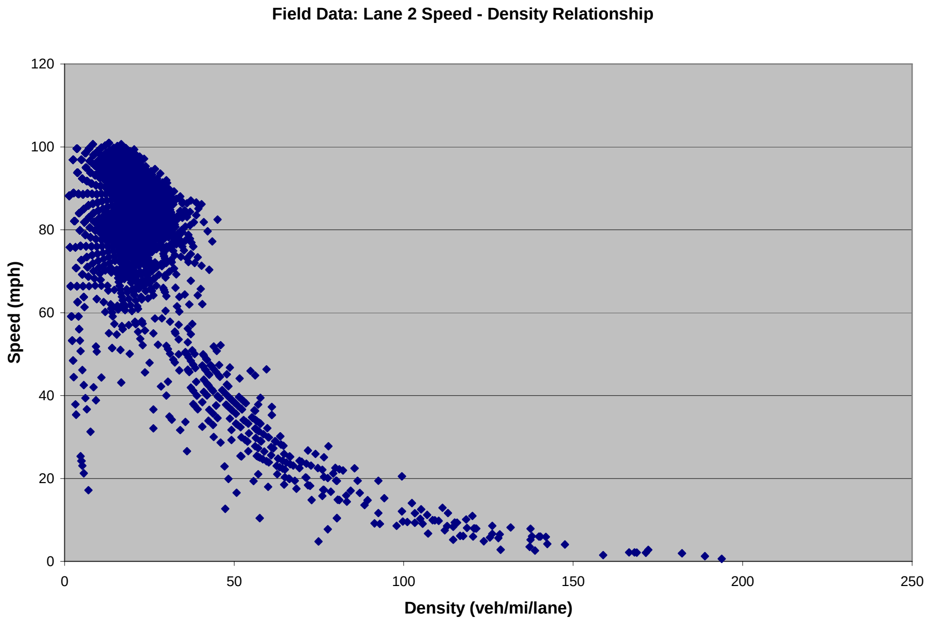

Figure 8a. I-405 Lane 2 Speed-Density Field Data

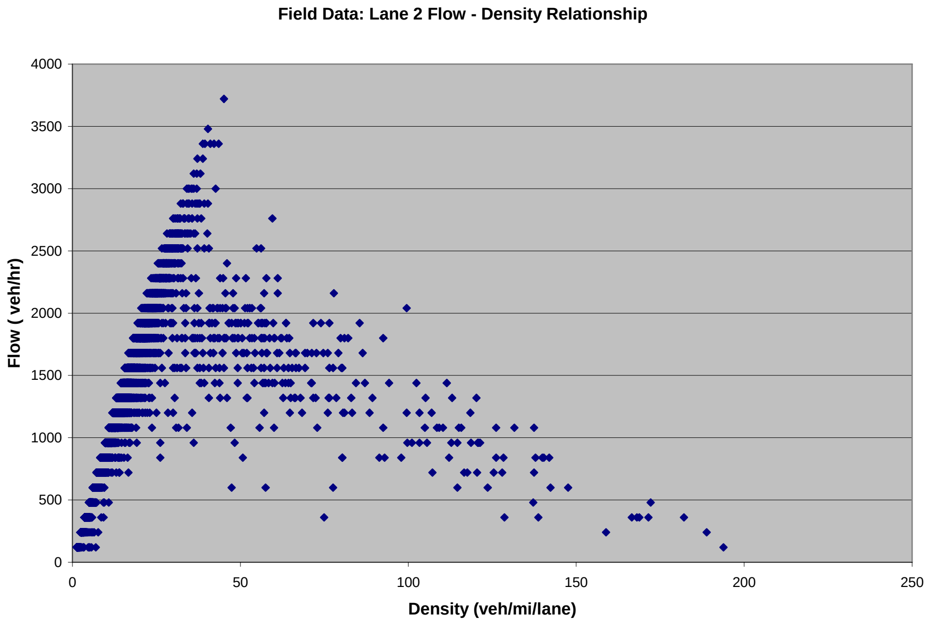

Figure 8b. I-405 Lane 2 Flow-Density Field Data

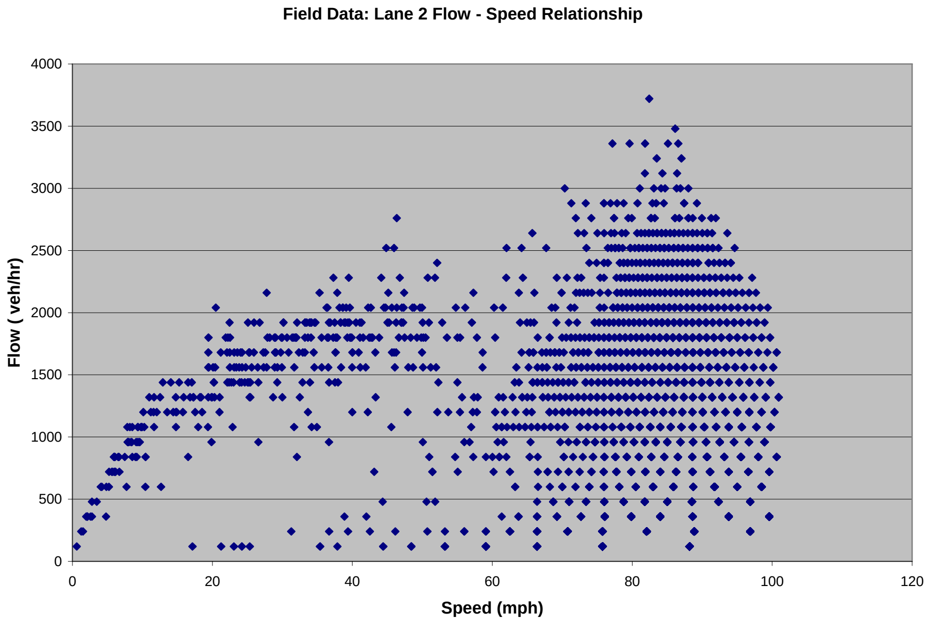

Figure 8c. I-405 Lane 2 Flow-Speed Field Data

Of course, there is considerable variation in any real-world data. Some of this variation is "smoothed" when we aggregate the data over the four lanes of the freeway section, as is shown below.

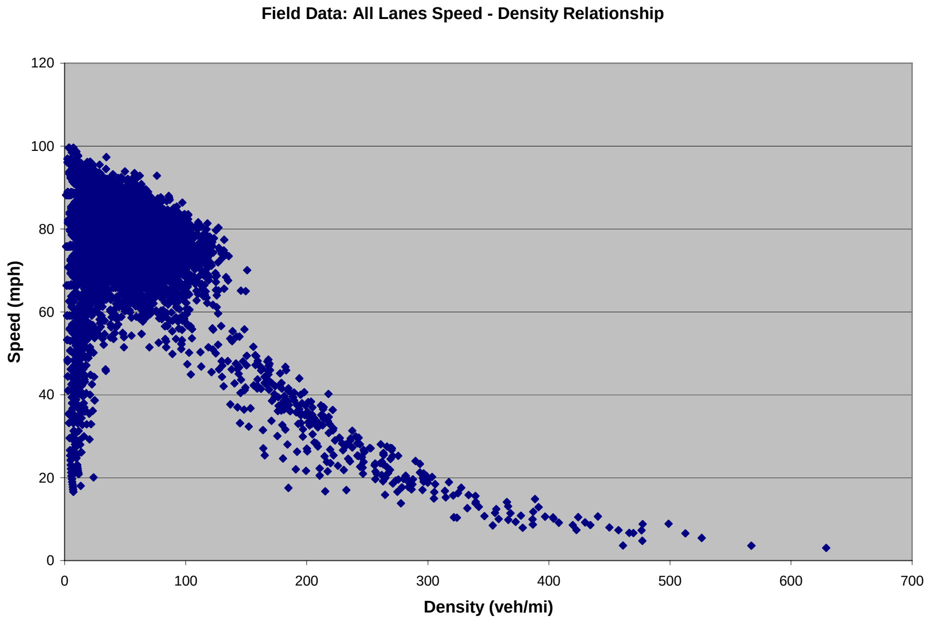

Figure 9a. I-405 Composite Speed-Density Field Data

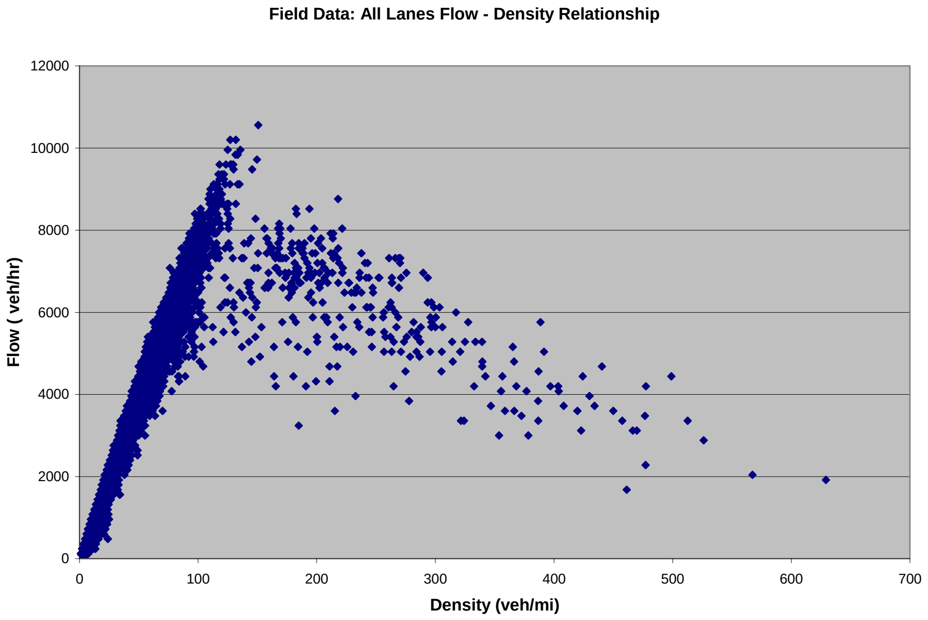
Field Data: All Lanes Flow - Density Relationship

Figure 9b. I-405 Composite Flow-Density Field Data

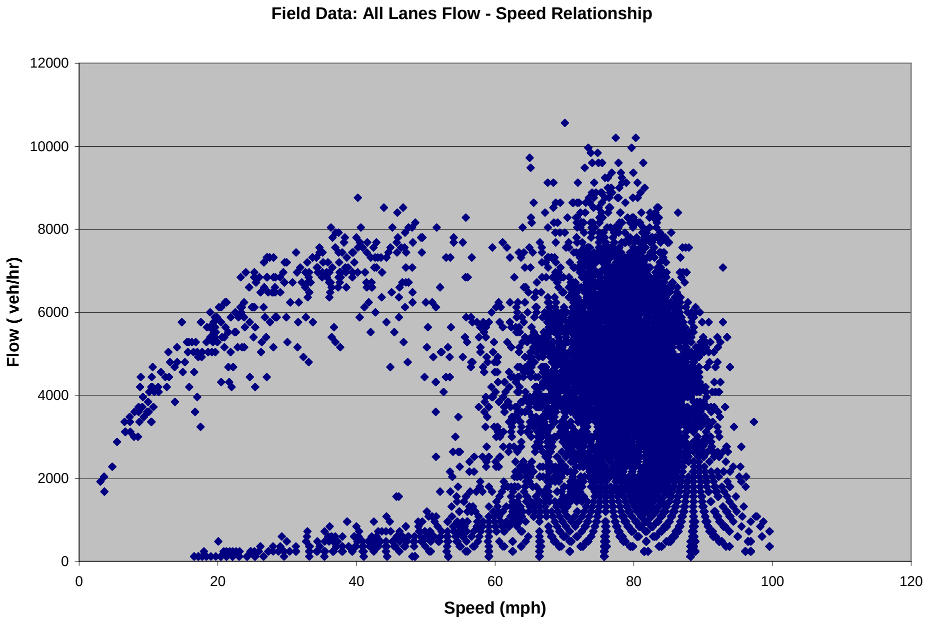
Field Data: All Lanes Flow - Speed Relationship

Figure 9c. I-405 Composite Flow-Speed Field Data

The flow – density picture above suggests an underlying theoretical model of the form shown below (in red) would give results that closely approximate conditions observed in the field. Such a theoretical model would have the attractive feature of being (piecewise) linear (but not smooth, i.e., not having continuous derivatives). Unlike the Greenshield formulation, the linearity here would be in the flow – density relationship, rather than in the speed – density relationship.

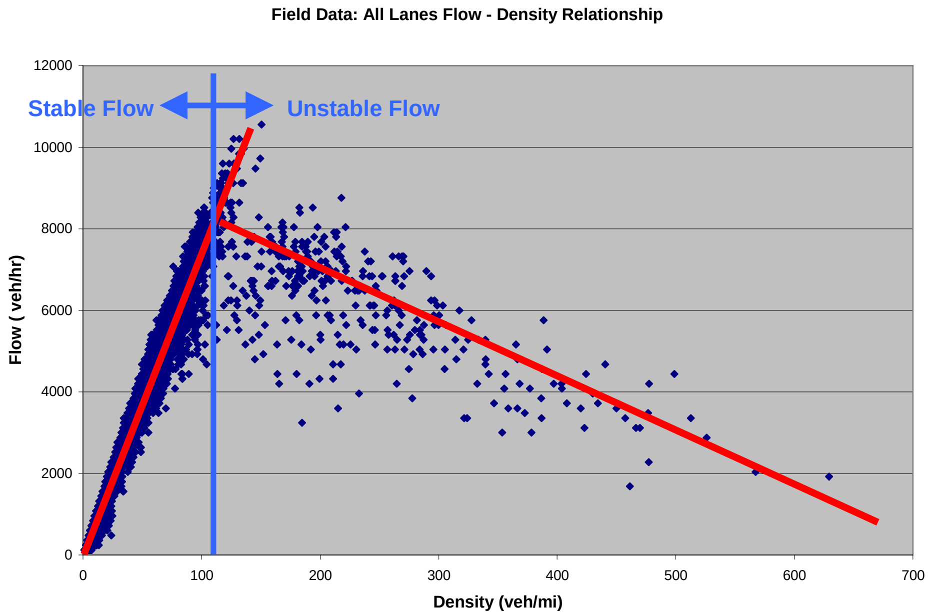

Figure 10. Triangular Model Flow-Density Relationship

Such a model was first proposed by Gordon Newell (of UC Bekeley). Known as the “triangular” flow – density relationship, it has the mathematical form:

$$q = \begin{cases} S_f \cdot k \ ; \ k \le k_c \\ q_c \cdot \left(1 - \dfrac{k - k_c}{k_j - k_c}\right) \ ; \ k_j \le k \le k_c \end{cases}$$

Since $q = k \cdot \dot{x} \Rightarrow \dot{x} = q/k$, The equations above imply the following speed – density relationship for the “triangular” flow – density relationship:

$$\dot{x} = \begin{cases} S_f \ ; \ k \le k_c \\ \dfrac{S_f}{\dfrac{k_j}{k_c} - 1} \cdot \left(\dfrac{k_j}{k} - 1\right) \ ; \ k_j \le k \le k_c \end{cases}$$

How closely does the “triangular” flow model replicate field conditions? Below, we superimpose the model results for $S_f = 80$ mph, $q_c = 2{,}300$ veh/hr/lane , and $k_j = 211$ veh/mi/lane. (Ordinarily, we would use a formal statistical analysis, such as "least squares regression" to find the best fit, but here we simply pick some values that seem to fit the data.)

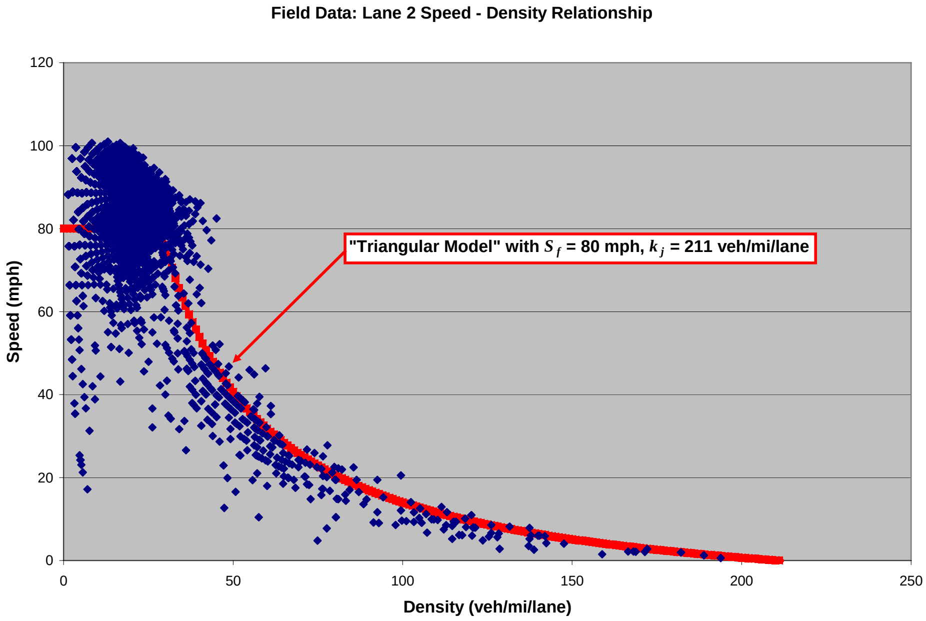

Figure 11a. Correspondence between Triangular Model and I-405 Lane 2 Speed-Density Field Data

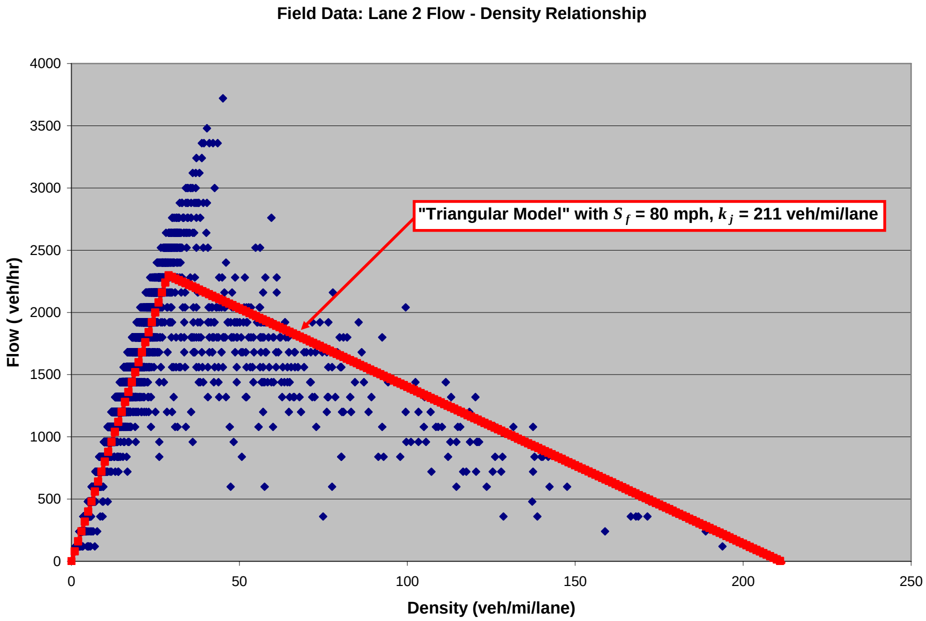

Figure 11b. Correspondence between Triangular Model and I-405 Lane 2 Flow-Density Field Data

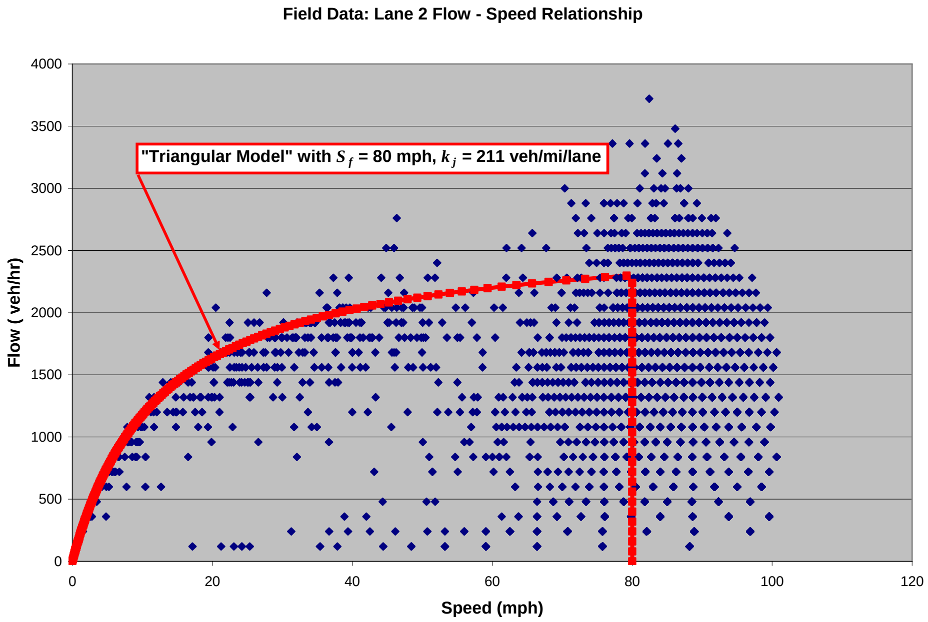

Figure 11c. Correspondence between Triangular Model and I-405 Lane 2 Flow-Speed Field Data

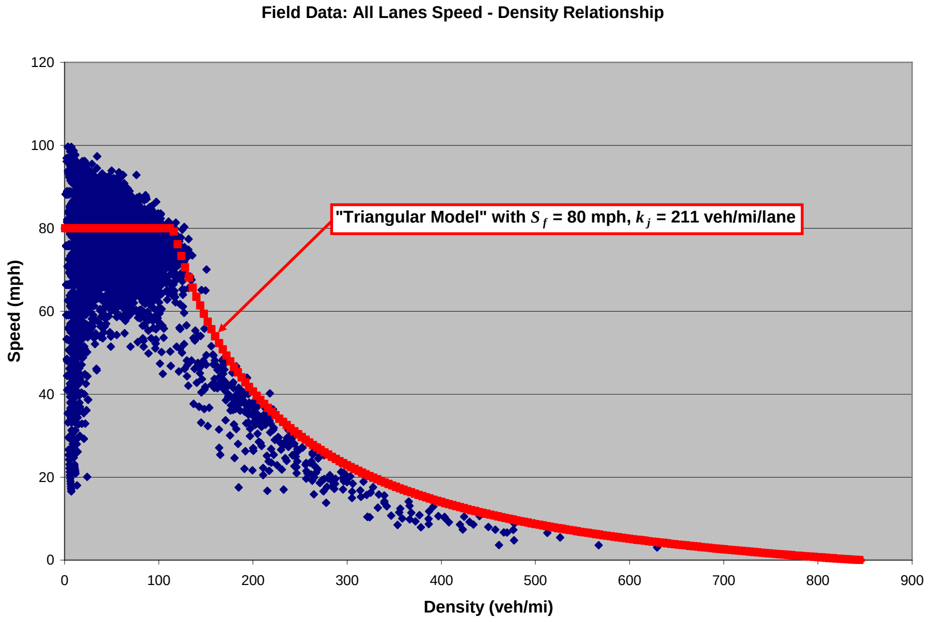

Figure 12a. Correspondence between Triangular Model and I-405 Composite Speed-Density Field Data

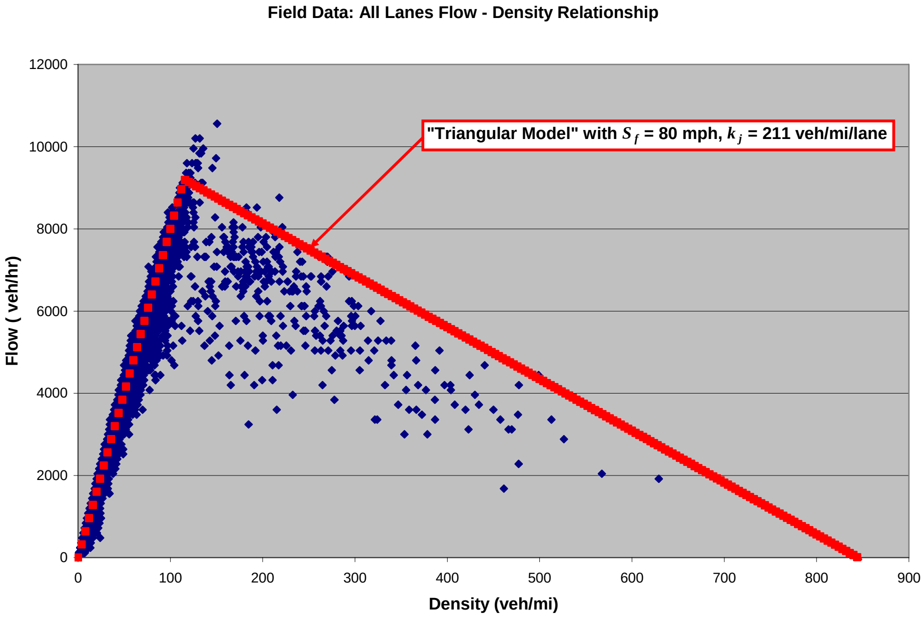

Figure 12b. Correspondence between Triangular Model and I-405 Composite Flow-Density Field Data

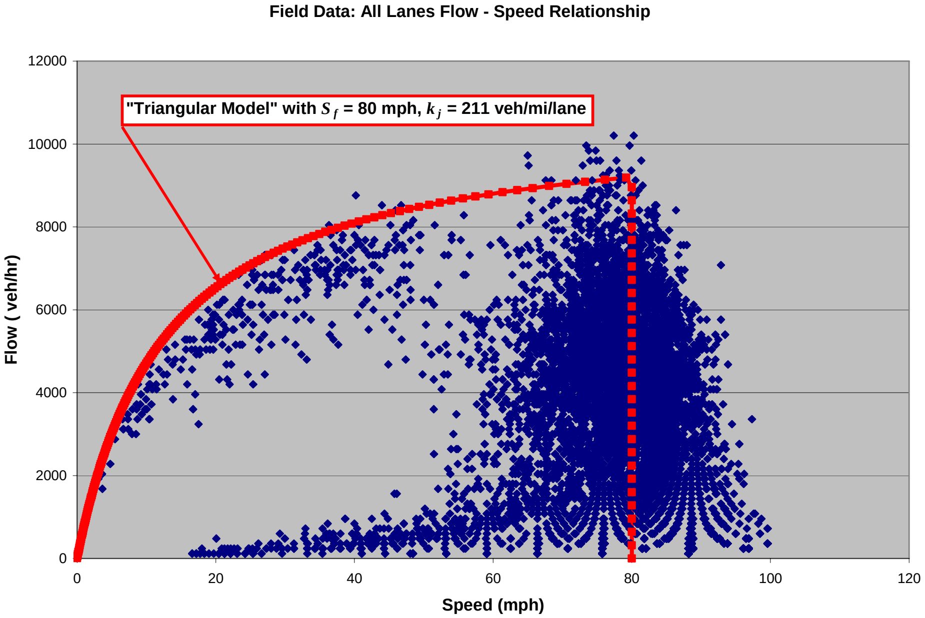

Figure 12c. Correspondence between Triangular Model and I-405 Composite Flow-Speed Field Data

The typical goal for efficient operations is to design a ramp control strategy that processes the maximum number of vehicles, while maintaining uncongested, or "high-speed," conditions. In work conducted herein, we will first "fit" the triangular flow model to loop data for each section of the freeway in our corridor. Then, using the calibrated speed-flow-density models, we will specify freeway delay in terms of the mainline volumes (determined from loop stations at the entry boundary to the corridor) and the controlled discharge from the entry ramps within the corridor.

3.5 Optimal Corridor Control Formulation

The procedures outlined in Sections 3.1, 3.3, and 3.4 above specify the total delay components in the corridor network—intersection delay, ramp delay, and freeway delay—in terms of a set of control variables (gap settings, maximum green settings, and ramp meter headway settings) that can be dynamically adjusted in response to detector inputs and known controller responses. Nominally, these adjustments would be guided by achieving some system optimal condition, e.g., minimization of total system delay, and achieved through solving the accompanying nonlinear optimization problem. For practical application, it is important to recognize that, in most cases, the arterial and freeway/ramp subsystems reside under different jurisdictional control. (For example, in the corridor used as the test network, the arterial/intersection components are under control of the COI, while the freeway/ramp components are under the control of Caltrans District 12.) We thus specify the system objective as a multi-objective minimization function—minimization of freeway/ramp delay and minimization of arterial signal delay—and develop solutions for optimal control that specify the efficient frontier; i.e., the set of non-dominated control options. In this way, we not only preserve the autonomy of the individual operating agencies, but also are able to present a set of global solutions that translate directly into the recommended set of options for use in CARTESIUS applications.

3.6 Path to Deployment

The ultimate goal of this project is to deploy a prototype of the optimal corridor control system in a real-world setting for evaluation and testing. It is primarily because of this overriding goal that we have specified the adaptive control procedures solely in terms of those parameters common to existing signal control devices (e.g., Type 170, Type 2070, and NEMA controllers), and utilize only those data provided by inductance loop detectors. As a result, upon successful completion of the adaptive control protocol, its deployment in the field is restricted only by the ability to communicate parameter value updates to the field devices at regular intervals.

To facilitate deployment, our development work is being conducted on a corridor network for which we have at least limited authority to conduct tests involving closed-loop control. On the arterial, we have installed a system of Type 2070 controllers at all signalized intersections that operate independently from the local COI system. Work is currently underway to place management of these controllers under CTNET; a secondary system based on state-of-the-art Siemens ACTRA Central Traffic Control System with custom-designed Input Acquisition Software is in place as a backup, should the CTNET configuration prove problematic. Software has been developed, and laboratory tested, that permits real-time adaptive control of Caltrans District 12 ramp meters in the study area (a feature not currently possible under Caltrans District 12 ATMS). We have established real-time communication with these control devices and also receive real-time raw data streams from loop detectors within the study area. We have memoranda of understanding with both the COI and Caltrans District 12 that permit the research team to conduct closed-loop control experiments in the study area.

The scope of the effort undertaken in PATH TO 6323 includes the development of the corridor adaptive control model and its testing and evaluation in a simulation environment. Prior to testing the complete model, separate tests will be conducted to evaluate the intersection control model on: 1) an isolated intersection, and 2) a network of intersections along an arterial. The complete model will be tested and evaluated on the Alton Parkway/I-405 corridor network. Although actual deployment is beyond the scope of the current effort, pending the results of the evaluation of the simulated network, it is envisioned that the adaptive control system will be incorporated as a service within the CARTESIUS deployment under CTNET (in separate, complementary PATH/Caltrans projects).

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