An Optimization Model Based Decision Support System for the Placement of Variable Message Signs for Enhanced Safety and Mobility

Submitted By: Sushma Srinivas, M.S.C.E.
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NEITE’s mission is to serve its members, the transportation profession, and the public by facilitating professional development and education, promoting the exchange of ideas, and enhancing the professional practice to provide safe efficient cost-effective and sustainable transportation solutions.

A Message from the New England Section President

JOSEPH A. HALLISEY, P.E., PTOE
Lead Civil/Traffic Engineer
Parsons Brinkerhoff

Dear NEITE Members:

It took too long but we’re finally into spring weather here in New England! First, congratulations to our 2015 recent graduates! We wish you success as you begin your professional careers and hope to see you soon at our ITE functions. It has been a busy time of year for events.

On March 26th, University of Massachusetts Amherst held its 16th Annual Technical Day combined with the Student Symposium. Three area schools participated in the event: UConn, UMass Lowell and UMass Amherst. It was a great opportunity for transportation professionals to interact with the students and share in their research. Congratulations to Ruth Bonsignore who received the Jane F. Garvey/UMass ITE Transportation Leadership Award. Also, congratulations to the dinner speaker, Professor Kevin Heaslips who received the Distinguished Alumni Award and UMass Student Chapter Vice President Craig Schneider who received the Student Service Award. The evening concluded with a fun transportation trivia competition with teams made up of students, professors and professionals. One question, surprisingly missed by one team, “Who is the current NEITE President?”

On April 8th NEITE had its annual joint meeting with the Connecticut Chapter in Manchester, Connecticut. CT ITE teamed with APA’s local chapter in organizing this well attended event. In the first session Matthew Roe from NACTO presented on the Urban Street Design Guide. He illustrated how streets can become public places for all users and how cities benefit from these transformations with a more business friendly environment. The second session led by University of Connecticut Professors Norman Garrick, Nicholas Lownes and Karthik Konduri shared their work on “New Research in Urban Transportation Systems”. This complemented the first session, discussing multimodal research, enhanced travel forecasting models and current transit oriented designs. The dinner keynote presentation by Hillary Isebrands discussed safe, efficient roadways and asked transportation professionals to think about reducing roadway fatalities in their designs. Congratulations to the 2015-2016 CT ITE Officers: President Kwesi Brown, Vice President Craig D. Yannes, Secretary/Treasurer Joe Rimiller, and Past President Mike Morehouse! And, congratulations to this year’s recipient of the CT ITE Scholarship, Radhameris Gomez of UMass Amherst! I want to thank the Connecticut Chapter for organizing an informative and lively day of learning and networking.

At the 2nd Section Board Meeting of the year the Executive Board reviewed the Treasurer’s Report, received updates on International’s initiatives from Ken Petragnia, on the District happenings from Joe Balskus, on the 2016 District Meeting in Portsmouth from Kevin Dandrade and Jeffrey Dirk, an informative breakdown of Section membership from Ian McKinnon, and the great work the Technical Committee is doing on updating the Section’s Traffic Calming Guidelines.

I had a great experience competing in the 119th running of the Boston Marathon on April 20th. The weather was not the best but it didn’t discourage the thousands of cheering fans that were lined along the entire course. That’s what makes this marathon the most special! After the race, wisely displaying my medal at a cozy Waltham establishment, the bartender told me my first Samuel Adams 26.2 was on the house!

Upcoming Events

Please try to attend these upcoming NEITE events:
• The District Annual Meeting will be held on May 13th – 15th in Albany, New York.
• The 16th Annual Thomas E. Desjardins Golf Tournament at Sandy Burr Country Club in Wayland, MA on June 3rd.
• The next NEITE Section Board Meeting on June 10th at the Village by the Sea in Wells, Maine.

Keep a look out for event flyers and check our website for updates http://neite.org/.

Thank you to all the Board, Committee Chairs and members for the great work you do in making NEITE a successful organization! If you have any questions or suggestions, please feel free to contact me at hallisey@pbworld.com or 860.815.0269.

Sincerely,
Joseph Hallisey, P.E., PTOE
New England Section President
New England Section Directory

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http://www.neite.org

ITE Upstate New York Section:
http://www.itenyupstate.org

ITE New York Metro Section:
http://ite-metsection.org

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American Society of Civil Engineers:
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http://www.ascenh.org

ASCE Vermont Chapter:
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ASCE Maine Chapter:
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ASCE Connecticut Chapter:
http://www.cscce.org

ASCE Rhode Island Chapter:
http://riascce.org

Urban Land Institute:
http://www.uli.org

MA Association of Consultant Planners:
http://www.macplan.org

The American Planning Association Northern New England Chapter:
http://www.mncapa.org

APA Massachusetts Chapter:
http://www.massapo.org

APA Connecticut Chapter:
http://www.ccopo.org

APA Rhode Island Chapter:
http://www.rhodeislandapo.org

On the Cover: Bright Spring Day at the intersection of Pleasant Street and State Street in Portsmouth, New Hampshire. Photo Source: Samuel W. Gregorio, P.E.

On the Back Cover: Turning on the HAWK Signal for the first time along Parker Street in Newton, MA. Photo Source: Kevin R. Dandrade, P.E., PTOE

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http://www.itenyupstate.org

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http://ite-metsection.org

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http://www.massapo.org

APA Connecticut Chapter:
http://www.ccopo.org

APA Rhode Island Chapter:
http://www.rhodeislandapo.org
Hello New England Section!

Where We Have Been
The snow is finally melted, construction season is underway, and we are full steam ahead as a Section. The first few months of the 2015 calendar year have been productive as the New England Section’s Executive Board has approved the budget, the Chronicle is well on its way to releasing four issues, and the planning has already begun on the 2016 Northeastern District Annual Meeting which will be held in Portsmouth, New Hampshire next May. For those who are interested in assisting with the 2016 Northeastern District Annual Meeting planning, please contact Meeting Co-Chairs Jeffrey S. Dirk, P.E., PTOE at jdirk@rdva.com or Kevin R. Dandrade, P.E., PTOE at kdandrade@theengineeringcorp.com.

Where We Are Now
In this quarterly issue, the New England Chronicle features the doctoral degree research of Sushma Srinivas, “An Optimization Model Based Decision Support System for the Placement of Variable Message Signs for Enhanced Safety and Mobility.” It is a testament to the New England Section that so many of our Student Chapter member are getting involved with Section activities such as at presenting at meetings or contributing here in the Chronicle.

Where We Are Going
As we inch closer to the half way point of 2016, it is time to start thinking down the road for the New England Chronicle and what it can bring to our Section beyond 2015. As my third and final year as Editor of your award winning Section publication reaches its terminus, the New England Section of ITE is looking for another dedicated member and/or company to be passed the torch. Any member or company who is interested should contact New England Section President Joseph A. Hallisey, P.E., PTOE at Hallisey@pbworld.com.

A Thank You to Our Sponsors
As always, I would like to thank all those New England companies and firms that have renewed their sponsorship of the New England Chronicle in our Section’s Professional Services Directory. Just in 2015, we have welcomed four new sponsoring firms to the Directory. The Chronicle will continue to reach out to the many New England companies and firms in hopes that we can assist in promoting the great engineers, planners, and vendors that make up our New England Section of the Institute of Transportation Engineers.

Contributions to the Section
I would again like to thank all contributors to the second issue of 2015. Behind the scenes, it takes many people across the Section’s membership to put together the award winner newsletter publication of your New England Section. I hope you enjoy the second issue of the 2015 calendar year.

Samuel White Gregorio, P.E.
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Please remember to visit the New England Section website at http://www.neite.org and our updated Section Directory for information on the New England Section.
An Optimization Model Based Decision Support System for the Placement of Variable Message Signs for Enhanced Safety and Mobility

SUSHMA SRINIVAS, M.S.C.E.
Doctoral Candidate and Graduate Research Assistant
University of Massachusetts Lowell

Introduction

Variable Message Signs (VMS) are being used for traffic warning, regulation, routing and management, and are intended to affect the behavior of drivers by providing real-time traffic-related information such as adverse weather conditions, special events and travel times [1]. Acceptable messages for display on VMS are detailed in the FHWA report by Dudek et al [2]. The objective of this study is to develop an optimization model for the placement of VMS on any given highway network. This methodology was used to develop a strategic plan for the placement of such equipment along the Interstate-95N (I-95N) network operated by MassDOT’s Highway Operations Center (HOC).

The performance of a HOC is largely being measured by how quickly and effectively it responds to incidents and congestion. A key factor affecting performance is the location of the VMS and Closed Circuit Video Equipment (CCVE). Ideally, a traffic network should be completely equipped, i.e., all links should have a VMS to inform drivers about upcoming traffic conditions downstream and allowing them, in a timely fashion, to choose an alternative route. This would require all segments to be monitored. When the entire state freeway network is considered, due to budget constraints as well as possible physical constraints, this is rarely possible or economical. Therefore, the goal is to develop a list of priorities for instrument placement on the state’s freeway network such that the benefits to drivers are maximized in terms of travel time, safety and convenience. This is achieved, primarily, by providing drivers with an opportunity to make informed decisions about route choices.

The objective of the optimization function developed is to maximize the benefits of installing VMS on a freeway segment (hereafter also referred to as link) subject to the budget constraint. Several studies have attempted to assess the benefits of the placement of ITS devices such as VMS and CCVE on a network [3-9]. Clearly, it is difficult to measure directly the benefits associated with these devices over their lifetime. This study adopts surrogate measures for the evaluation of the benefits accruing to motorists. The methodology uses a mathematical function to quantify benefits comprising of the following four components: Accident proneness of a link, diversion opportunity, total capacity of a directional link and Average Annual Daily Traffic (AADT) on each link. Each one of these measures addresses a different aspect of the benefits associated with the installation of the ITS elements. By combining them into a mathematical function, one can obtain an overall measure of the reduction in cumulative delay due to demand reduction. Once this is obtained, the reduction in delay is monetized as a function of the accident proneness and benefits are quantified.

The calculated benefits, costs and available VMS data on the freeway network is then input into the benefit maximization optimization function and the links that need to be instrumented are obtained. These results may be utilized by the HOC to prioritize the instrumentation of links on a freeway network based on available resources.

Background

An early reference to the problem of optimizing VMS locations in a road network is given in [3]. Their location optimization objective is to reduce potential vehicle delay due to diversion of traffic to alternate routes in response to incident information provided by the VMS. They utilize a simple deterministic queuing model to perform before and after studies of utilizing VMS in a linear freeway network. However, consideration of issues such as congestion on alternative routes, oversaturation, incidents on individual links and dependency of diversion rates on potential savings is not included in their model.

The MUTCD [4] and several state DOTs [5] have their own guidelines. The use of VMS for diversion was studied also by Belz & Gärder [6] in Maine. They provided various recommendations for improving the utility of VMSs and stressed the need for automatic information relay to Traffic Management Centers and to increase inter agency cooperation in terms of information exchange for efficient diversion and traffic management.

The use of VMS as a tool in influencing route choice of drivers and the network wide benefits of VMS in terms of safety and comfort during driving was measured by Kran et al [7]. Their study showed that the use of VMS had a positive effect on network performance in the freeway network of Amsterdam. They observed reduction in total congestion and reduction in the variation in average speed leading to more reliable travel time and homogenous traffic flow.

Several mathematical models have been proposed in the literature for optimally locating VMSs on highways. Fu et al [8] proposed a mathematical model that recognized VMS location as a planning problem taking into account both current and future needs over multiple time periods and different traffic distributions by explicitly considering incident characteristics variations across links over time. The study used a random probability distribution to model incidents on the roadway.

Huynh et al [9] proposed a simulation based heuristic approach for finding near-optimal locations for portable VMS signs on a traffic network to divert traffic to alternate paths when an incident occurs on a network so that the effect of the incident on the network is minimized. In another study, a two-stage stochastic program with recourse approach was adopted by Huynh et al [10] to determine the locations of permanent VMS systems in a vehicular traffic network in conjunction with Advanced Traveler Information Systems (ATIS). They employed a Tabu search algorithm combined with dynamic traffic simulation and assignment approaches to determine optimal VMS locations. A neural network model for placement of VMS was proposed in [11].

Several State DOT’s have published the methodology adopted by them in placing VMS/CCVE’s. This is shown in Table 1 VMS Placement Guidelines for Selected States.
Conducted a review of the mandate for
required input data was minimal. Underwood
national agencies and local agencies since the
parameters was developed by Lindley [14].

A variety of procedures
quantifiable benefits. A variety of procedures
Benefit Estimation is a challenging process.

Evaluation of Benefits of Variable Message

Table 1: VMS Placement Guidelines for Selected States

Continued from Page 5

However, all the above mentioned studies
and guidelines [12],[13] do not provide
specific information for a system-wide
network based priority location strategy for
these technologies. The study presented in
this paper develops a ranking based
prioritization list utilizing actual and surrogate
congestion, volume and crash measures from
the Massachusetts highway network. The
results of this study provide the HOC with a
strategy to procure and place VMS hardware
in locations deemed necessary to support
customer service, public safety and incident
management.

Evaluation of Benefits of Variable Message Signs

Benefit Estimation is a challenging process.
There are quantifiable benefits and non-
quantifiable benefits. A variety of procedures
and criteria have been employed in past
studies. A computerized methodology to
quantify urban freeway congestion
parameters was developed by Lindley [14].
He stated that the model could be utilized by
national agencies and local agencies since the
required input data was minimal. Underwood
[15] conducted a review of the mandate for
evaluation of Intelligent Vehicle-Highway
Systems (IVHS) in the U.S. and North America.

As an extension of this study, an evaluation
framework useful for IVHS was presented in
[16]. Each component of IVHS described in
their study involved challenges involving
public private benefits, new product
functions, market penetration, abundant data
generation, human interaction, etc. Thill &
Rogova [17] presented the design and
development of a library of modeling tools
called the ITS Options Analysis Model
(ITSOAM) for evaluating the benefits of ITS
deployment elements within a benefit-cost
framework. ITSOAM was designed as a sketch
-planning tool for the state of New York which
would aid in the economic assessment of
expected user and operational benefits
imputable to ITS elements in specific

Continued on Page 8

breakdown of incident duration

As shown in Figure 1 Reduction of Cumulative
Delay due to Diversion, the overall duration of
an incident, from beginning to end, can be
divided into several smaller periods that are
briefly defined below based on the definitions
given in the Cambridge Systematics report
[18]:

- **Detection time** ($t_d$): this is the time
between the occurrence of the incident
occurrence until the time that agencies
become aware of the incident.

- **Dispatch time** ($t_r$): this is the time
between the notification of the
response units about the incident and
the assignment of the most appropriate
emergency vehicle. If a service vehicle is
available, then $t_r = 0$. Otherwise, $t_r$
equals the waiting time until a service
vehicle becomes available. Dispatch
time will be affected by the type of the
dispatching policy, the number of
available emergency vehicles and the
prevailing traffic conditions, etc.

- **Travel time** ($t_t$): this is the time
between the allocation of service
vehicles and the arrival of the service
vehicles at the incident site. Travel time
depends on the traffic conditions, and
the distance between the assigned
emergency service location and the
incident location.

- **Clearance time** ($t_c$): this is the time
between the arrival of the emergency
vehicles and the time the incident is
fully cleared.

Mathematical Formulation for Benefit
Estimation

\[ B_i = \delta_i A_{i+1} \quad \text{(Eq 1)} \]

Where,

- $B_i = \$ value of Benefit on each link;
- $\delta_i = \text{Total Benefit for all vehicles in the link in } \$;\n- $\delta_i(V_i D_i C_i) = \text{is a coefficient that is a function of } V_i D_i C_i;\n- A_i = \text{Accident Proneness of a link;}\n- D_i = \% \text{Diversion of traffic;}\n- C_i = \text{Capacity of the link;}\n- V_i = \text{Average Annual Daily Traffic (AADT) on the link.}\n
The accident proneness of a link $A_i$ is
determined by assuming that incidents follow
Poisson distribution with unchanging
coefficient in time. A Chi-Square test is
As always, the Continuing Education Committee needs your feedback and fresh ideas for training opportunities that are innovative and that would draw significant interest to the Section membership. Most importantly, training opportunities that would serve you, the New England Section membership in the upcoming meetings and gatherings.

If you have ideas for training sessions that would benefit the membership the most and have a high interest level, whether a half-day or full-day or training, please contact:

Jason M. DeGray, P.E., PTOE
jdegray@gpinet.com

Applications for the future October 1st to 31st, 2015 computer-based exams of Professional Traffic Operations Engineer (PTOE) and Professional Transportation Planner (PTP) are due August 12th, 2015.

Please note that applications received after the deadline will require an additional $75 late fee to process the application in addition to the application and examination fee that must accompany the application. TPCB will try to accommodate late applications but there is no guarantee they will be able to do so.

For a list of available exam cities, please visit:

### Section Calendar

**May 2015**

Northeastern District Annual Meeting
May 13th-15th, 2015
Albany Hilton Hotel
Albany, New York

**June 2015**

Desjardins Memorial Golf Tournament
June 3rd, 2015
Sandy Burr Country Club
Wayland, Massachusetts

Joint NH / ME Chapter Meeting
June 10th, 2015
Village by the Sea
Wells, Maine

**August 2015**

ITE International Annual Meeting
August 2nd-5th, 2015
Diplomat Resort & Spa
Hollywood, Florida

### Why Sponsor and Place an Advertisement:

- The New England Chronicle reaches more than 700 ITE professional and student members within the New England Section and many other transportation professionals around the northeastern U.S.,
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- Advertisement / Sponsorships run for one (1) calendar year. That includes posting in the next four (4) New England Chronicle newsletters and one (1) year posting on the New England Section website.

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- The cost of a one year business card size advertisement in the New England Chronicle’s Professional Services Directory is $100 per year, payable to the New England Section of ITE.
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Chronicle Editor
sggregorio@theengineeringcorp.com

### Just Over the Horizon

May 2015

Northeastern District Annual Meeting
May 13th-15th, 2015
Albany Hilton Hotel
Albany, New York

June 2015

Desjardins Memorial Golf Tournament
June 3rd, 2015
Sandy Burr Country Club
Wayland, Massachusetts

Joint NH / ME Chapter Meeting
June 10th, 2015
Village by the Sea
Wells, Maine

August 2015

ITE International Annual Meeting
August 2nd-5th, 2015
Diplomat Resort & Spa
Hollywood, Florida

Please send all calendar announcements, including the name of event, the contact person, event location and date to the New England Section webmaster Ian A. McKinnon, E.I.T. and Chronicle Editor, Samuel W. Gregorio, P.E. at:
Ian.McKinnon@tetratech.com and sgregorio@theengineeringcorp.com

As always, the Continuing Education Committee needs your feedback and fresh ideas for training opportunities that are innovative and that would draw significant interest to the Section membership. Most importantly, training opportunities that would serve you, the New England Section membership in the upcoming meetings and gatherings.

If you have ideas for training sessions that would benefit the membership the most and have a high interest level, whether a half-day or full-day or training, please contact:

Jason M. DeGray, P.E., PTOE
jdegray@gpinet.com
applied and the accident proneness of the link is determined.

The cost of a permanent VMS ranges from $28k-$136 and the cost of a portable VMS ranges from $16-$21k [19]. In addition to this maintenance costs are considered. Benefit comes in the form of time saved from shorter travel times and increased safety. 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% [20]. The algorithm to estimate benefits is as follows.

Algorithm for Benefit Estimation

- **Calculate Accident Proneness of Each Link:** The accident proneness of a link $A_i$ is determined by assuming that incidents follow Poisson distribution with unchanging coefficient in time. A Chi-Square test is applied and the accident proneness of the link is determined.

- **Identify Capacity Flow Rate for Each Link:** Capacity flow rate has the units: passenger cars/hour/lane abbreviated as pc/hr/ln. Interstate 95 has three lanes in most sections and four lanes in a few sections. Assuming $C = 2000$ pc/hr/ln; the capacity flow rate of each link is obtained by using the formula:

$$C = \text{No. of lanes} \times 2000 \text{ pc/hr} \quad (\text{Eq 2})$$

Making the final units of $C = \text{pc/hr}$

- **Identify Arrival Rate for Each Link:** Arrival rate per link has the units: passenger cars/hour abbreviated as pc/hr. The Average Annual Daily Traffic (AADT) available through the Massachusetts Department of Transportation (MassDOT) website [21]. The AADT values for each link for the year 2010 is used. The year 2010 is the latest year for which data was made available by MassDOT.

- **Incident Detection, Response and Clearance Times:** The incident detection, response and clearance times are obtained for three different incident categories namely, Property Damage (PD), Injury (IN) and Fatal Crashes (FC).

  **Property Damage**
  * Incident Detection Time: 5 minutes
  * Incident Response Time: 8.5 minutes
  * Incident Clearance Time: 20 minutes 

  **Injury**
  * Incident Detection Time: 5 minutes
  * Incident Response Time: 8.5 minutes
  * Incident Clearance Time: 90 minutes
  * Partial Capacity Flow Rate: 0% (Capacity Flow Rate)

  **Fatal Crash**
  * Incident Detection Time: 5 minutes
  * Incident Response Time: 8.5 minutes
  * Incident Clearance Time: 30 minutes
  * Partial Capacity Flow Rate: 20% (Capacity Flow Rate)

- **Reduction in Arrivals due to Traffic Management**

  Four cases are calculated:
  
  - 0% Diversion: Reduction in Arrival Rate = $1 + V_i$
  - 20% Diversion: Reduction in Arrival Rate = $0.8 + V_i$
  - 60% Diversion: Reduction in Arrival Rate = $0.4 + V_i$
  - 80% Diversion: Reduction in Arrival Rate = $0.2 + V_i$

  Diversion Begins: 13.5 mins after incident occurs

  A total of 3 incident scenarios x 4 diversion opportunity values = 12 cases are calculated for each link. With the above data, reduction of cumulative delay due to diversion and cumulative delay with demand reduction is calculated for each directional link of the north bound direction of I-95.

- **Calculate $\delta_i$:** $\delta_i$ is calculated for each link by utilizing the reduction in cumulative delay and multiplying the delay value with a $\delta$ constant.

  FHWA has translated the average 20-minute lane blockage into a monetary figure to show how freeway incidents directly affect the national economy. If one lane of a three-lane freeway is blocked for 20 minutes – assuming the freeway is running at capacity – the delay caused to motorists will exceed 1,200 vehicle hours. At the FHWA-assigned value of $4.00 per hour for each vehicle hour of delay the cost of the incident due to the delay alone is approximately $5,000.00. The FHWA handbook on

* Incident Clearance Time: 20 minutes
* Partial Capacity Flow Rate: 75% (Capacity Flow Rate)
incident management also states that “for every minute a freeway lane is blocked due to an incident, this results in four (4) minutes of travel delay time”. Therefore, applying the same logic, the travel time savings due to reduced volume may be considered as $16.00 [22]. The assumed value of $16.00 per hour for each vehicle hour of delay is used.

\[ \delta_i = \text{Reduction in Cumulative Delay Value} \times (\text{Fixed benefit $16 /veh/hr}) \]  

(Eq 3)

Substituting the value of Equation 3 in Equation 1, we get the total monetary value of benefits using both the safety and mobility criteria.

VMS Location Problem & Solution

Methodology

Placement of VMS

The placement of VMS should always be in advance of a decision point such as an interchange or travel plaza, where motorists will be able to read, comprehend and react to any message displayed, see Figure 2. VMS placed too near the decision point may exacerbate bottlenecks and reduce the opportunity for motorists to react. Conversely, VMS placed too far in advance of a decision point may reduce the effectiveness of the message. In general, VMS should be deployed at a minimum of one mile in advance of the decision point [13].

The expected benefits of VMS usage include reduced delays caused by incidents, construction, or other recurrent and non-recurring congestion, as well as reduction of secondary incidents. The assumption is that drivers will make informed decisions based on the information provided by the signs such as diverting to an alternative route. VMS can also help alleviate drivers’ stress and better manage their time, for e.g. one can call in advance if he/she is going to be late for work based on the information from the signs [23]. Therefore, a basic advantage of VMSs is the improvement of the overall safety and mobility on the network.

VMS Location Problem

Definition

The VMS-location problem can be loosely 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” [8]. Theoretically, the benefits from VMS can be maximized, if the whole network of roads is instrumented with VMS. However, as seen in Figure 3 because marginal costs keep reducing, at a certain point the costs of installing and maintaining the VMS will outweigh the benefits of the installation.

The practical decision model proposed will be solved by only requiring the user to input AADT, volume to capacity ratio (v/c), number of lanes, road type, accident proneness, diversion opportunity and proximity of current ITS equipment for the state freeway network. With this data inputted optimal location of VMS will be modeled.

The following section describes the optimization model for the placement of VMS.

Development of the Decision Support

Optimization Model

The goal of the cost and benefit model is to maximize benefit while having a fixed yearly cost. Once a yearly cost is established, the maximum benefit is determined by establishing an individual benefit for every possible segment a VMS could be located at.

Since VMSs lose effectiveness when located in close proximity to each other the reduced-benefit-factor \( R \) due to the proximity of other VMSs is considered.

The selection of the locations for the placement of VMSs is formulated as a mixed integer linear program that will serve as the decision support model for agencies responsible for installation and operation of VMSs. A simple case study network to test the effectiveness of the proposed objective function was solved using the IBM ILOG CPLEX Optimizer [24].

Decision Variable:

\[ d_i = \begin{cases} 0 & \text{if the link will not be instrumented} \\ 1 & \text{if the link will be instrumented} \end{cases} \]

Objective:

\[ \text{Maximize } \sum_i (B_i - C_i) \cdot d_i - R(d_{i-1}, d_{i+1}) \cdot d_i \]

Where,

\( B_i \): is the benefit of installing a VMS on link \( i \);

\( d_i \): is the binary variable \((0,1)\) indicating the decision to install a VMS on directional link \( i \);

With,

\( d_i = 0 \): VMS will not be installed on segment \( i \);

\( d_i = 1 \): VMS will be installed on segment \( i \);

\( R(d_{i-1}, d_{i+1}) \): is the reduced-benefit-factor due to the possible installation of VMSs on the previous and following links.

Constraints:

Constraint 1: Check whether the link under consideration is instrumented or not.

Constraint 2: Total Benefit of instrumenting links > Total Cost of instrumenting links.

Constraint 3: Has the Annual budget been reached.

Constraint 4: Presence of VMS on preceding and succeeding links.
The methodology of the optimization process is shown in Figure 4.

Conclusions
The study aims to bridge the gap between complex mathematical models and industry practices in providing optimal locations for placement of Variable Message Signs. The study uses both mobility and safety criteria such as accident proneness of a link, volume, diversion opportunity and reduction in cumulative delay due to diversion to quantify benefits of VMS on each link. An optimization model is coded in IBM ILOG CPLEX optimizer and the decision to instrument a link or not is obtained. The decision to instrument a link with VMS is subject to the annual budget, preexisting VMS and benefit to cost ratio constraints. A priority list can be generated based on the results to prioritize VMS installations. These results may be used as a Decision Support System for Traffic management Centers and Traffic Operations Centers to better allocate and manage their financial resources.

References
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My motivation to run for vice president of ITE is very straightforward. I have been a member for over 40 years, and I see our organization needing a major makeover to be in line with the thinking of mainstream, younger generation members. As a business owner of one of the largest transportation and traffic engineering firms in southern California, and as an experienced public policymaker (currently a City Council member of Diamond Bar, CA), I have the business acumen, leadership, and management skill to lead that effort. Furthermore, we need to keep pace and engage with the latest movements in our field as we have in the past, such as green transportation and active transportation. These are the reasons I have decided to run. I can make a difference for the better.

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Candidates for 2016 International Vice-President

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Ms. Sushma Srinivas is a doctoral candidate specializing in Facilities Allocation, Intelligent Transportation Systems, Traffic Engineering and Optimization at the University of Massachusetts Lowell. She actively collaborates with the Massachusetts Department of Transportation on several of their research projects. In addition to being recognized for her previous contribution to Transportation Engineering, she was awarded the 2014 Helene Overly Graduate Scholarship by the Women’s Transportation Seminar (WTS).

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Continued from Page 10


Would You Like to Contribute to the New England Chronicle?

Would you like to contribute to an award winning New England Chronicle newsletter? The New England Chronicle’s Editor Staff at TEC, Inc. is seeking members (both professionals and students) who are interested to write both short and feature articles for publication in the upcoming New England Chronicle issues. Both short and feature articles should be about technical topics, professional matters, innovative projects, and cutting-edge solutions that affect transportation engineering and planning.

Typically short article would consist of 1,000 to 2,500 words and feature articles would consist of 2,000 to 4,000 words. Each article should include a head shot and bio of all participating authors. Further details for each article submission can be given upon request.

For more information on how you can become a New England Chronicle contributor contact the New England Chronicle Editor: Samuel W. Gregorio, P.E. at sgregorio@theengineeringcorp.com.
On April 8, 2015, the Connecticut Chapter of the Institute of Transportation Engineers, in conjunction with the Connecticut Chapter of the American Planning Association, hosted its Annual Spring Meeting at Manchester Country Club in Manchester, CT.

Matthew Roe of the National Association of City Transportation Officials offered a technical session on ‘Design Guidance for Real Streets’ while Norman Garrick, Nicholas Lownes, and Karthik Kondui of the University of Connecticut discussed ‘New Research in Urban Transportation Systems.’ This year’s keynote presentation was provided by Hillary Isebrands of the Federal Highway Administration, who discussed ‘Planning and Designing for Safe, Efficient, and Smart Roadways’.

Ranjit Bhave, Norman Garrick, Michael Morehouse, and Sofia Nirschberg were recognized for their dedication to the transportation industry and participation in ITE CT. The 2015 ITE Connecticut Chapter Student Scholarship was awarded to Radhameris Gomez of UMass Amherst and results of the 2015 officer elections were announced.

A total of 85 professionals participated in the technical sessions and/or dinner.
Employment Opportunities

CLD Consulting Engineers, Inc.

Part-Time Civil Engineering / Traffic Engineer (Mid-Level)
Manchester, New Hampshire

We have an immediate opening for a Civil Engineer to join of traffic engineering team at our Manchester, NH facility. The selected candidate will be working with senior staff on private and public projects in conjunction with our traffic, site, municipal and highway groups. Provide coordination of various traffic data collection efforts, develop/execute scopes of work to complete traffic impact/corridor studies, signal design and associated analyses of various intersection lane configuration, including roundabouts, and prepare simulation modeling to show clients existing/anticipated operations. Conduct peer review and/or prepare traffic impact studies for private, municipal and state clients and provide oral and written presentation of findings. The CLD traffic team works in conjunction with a variety of disciplines (structures, highway, municipal, site development, survey, planning and environmental, etc). The diversity and complexity of projects is touted as a unique benefit of working in this group.

Successful candidate will have a BSCE with transportation/traffic concentration, MS preferred and 2-4 years traffic engineering experience, EIT required, PE preferred IMSA certification desirable. Candidates with 4-7 years should have signal design experience and a PE. Looking for a pro with experience in: Data collection (turning movement counts, ATRs, sight distance, signal operations); Strong knowledge of HCS, Synchro, SimTraffic software; working knowledge of AutoCad Civil 3D and Microstation and roadway design experience; Possess strong analytical and communication skills and be able to present findings to clients and public in public hearing settings both orally and in writing. Ability to work in both team setting and/or individual assignments. Self-starter with a desire to learn more about traffic/transportation engineering in a busy interdisciplinary firm.

Qualified candidates will have a Civil Engineering degree, PE licensure (preferably in ME or NH), and previous transportation/traffic classroom/work experience. A valid driver’s license, references and the ability to work in both office and field settings. Communication is a key ingredient to success at CLD. All qualified candidates should have exceptional communication skills with attention to detail in documentation and follow through, innovative problem solving, great team skills, reliability, and technical excellence are also characteristics of a successful CLD team member. For more information please read the detailed listings below.

Interested candidates should visit http://www.cldengineers.com/Careers.html and please send your resume and letter of interest to:

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### Employment Opportunities

#### Vermont Agency of Transportation

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The Policy and Planning Section for the Vermont Agency of Transportation (VTrans) has an exciting opportunity in Montpelier, VT for an experienced transportation planning professional accustomed to working in a fast-paced, innovative environment.

You will collaborate with colleagues at VTrans, and other state, federal, regional and municipal agencies to create and evaluate policy options and prepare planning documents that address the most pressing transportation issues facing the state and inform Agency investments, activities and legislation. We are looking for an effective communicator with demonstrated technical skills in transportation planning, engineering and/or policy analysis.

Responsibilities include preparing and managing planning projects and special studies pertaining to highway, rail, air, bicycle & pedestrian, public transportation and freight movement. Other topics could include transportation funding, economic and demographic analyses, climate change, energy, land use and development of asset management and prioritization processes. You will also prepare discretionary grant applications in support of highway, rail, transit, and aviation projects.

Preferred qualifications include: Expert knowledge of transportation planning principles and practices and theory; and of federal transportation state and metropolitan planning requirements and procedures; and, of the principles of land use planning; Expert knowledge of the local, national and international social, economic, demographic, industrial and other factors affecting the State’s transportation system; Considerable knowledge of state DOT programs and procedures, including the project development process and of the structure and interaction among federal, state, regional, and local organizations involved in planning and project delivery; Considerable knowledge of transportation planning tools and methods, particularly Geographic Information Systems (GIS) applications, applied statistics, development and application of spreadsheet and database models, and transportation modeling; Ability to design and conduct quantitative and qualitative studies, perform complex statistical research, and analyze results; Ability to work collaboratively and communicate effectively, both orally and in writing, with a wide variety of audiences. Excellent written and verbal communication skills; and Ability to prepare grant applications.


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#### Green International Affiliates

**Transportation Engineer**  
Westford, Massachusetts

Green International Affiliates, Inc. (Green), a multi-disciplined civil engineering firm providing transportation planning and engineering services, has opportunities for Transportation Engineers with 0 to 5 years experience in transportation planning and traffic engineering. Located conveniently off I-495 in Westford, MA, the firm currently serve the six New England states with a wide range of projects for both public and private clients.

The successful candidate should have experience in performing traffic operational analyses using SYNCHRO, SimTraffic, HCS, SIDRA, etc. The Candidate should also be experienced in conducting safety studies, traffic signal operations and design, AutoCAD and be familiar with the MUTCD. Excellent writing and speaking skills are essential as the selected candidate will be responsible for preparing study and design reports for clients, interacting with public review boards and clients and assisting on proposals.

Green offers competitive and comprehensive benefits including health, dental, life and disability insurance, FSAs, profit sharing and professional development.

Interested candidates should send a letter of interest with resume and references to Human Resources, Green International Affiliates, Inc., 239 Littleton Road, Westford, MA 01886 or email to info@greennatl.com.
The New England Chronicle is interested in short articles on innovative projects and cutting-edge solutions.

Please send articles, listings (ITE and other relevant), graphics and photographs to the Editor: Samuel W. Gregorio, P.E. at sgregorio@theengineeringcorp.com

The New England Section Chronicle staff thanks you and we hope you enjoy the issue.

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Special Thanks to:
Claire Choquette - Ocean State Signal Co.
Lisa A. Rutherford - Ocean State Signal Co.

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REMINDERS

Those members of the New England Section that have not updated your personal and/or business contact information recently should visit the ITE website and do so. An updated contact directory allows the Section to properly send information emails, election information, and other details such as the NEITE calendar.

http://www.ite.org

For those members of the New England Section that would like to be included on the Section email list for Google Groups, please contact Samuel W. Gregorio, P.E. at TEC, Inc.

sgregorio@theengineeringcorp.com