Emergency Vehicle-to-Vehicle Communication

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Introduction

Vehicle-to-vehicle communication can be used to improve the safety and efficiency of emergency response. Such communication, with driver compliance to guidance, can ease driver stress associated with trying to accommodate an approaching emergency vehicle but encountering roadside obstacles or limited space to maneuver to the right or being unsure of the intended path of the emergency vehicle. The communication can also aid emergency vehicle turning movements, particularly right turns, by clearing the right lane rather than the left. Through this project, a prototype of the emergency vehicle-to-passenger vehicle communication will be developed and tested on the test bed in Northern Virginia. Prior to prototyping and testing, the research team will collect and analyze video data from both freeways and arterials, develop algorithms to determine the optimal behavior for the passenger vehicles (e.g., "move left," "move right," "stay where you are") and to route the emergency vehicle through congestion, and test the algorithms with unique simulation code. The simulation and algorithms will be connected with signal pre-emption to further facilitate emergency vehicle movement and identify the effect of signal pre-emption on the optimal behavior.

Problem Statement

Emergency vehicles must often navigate through congested conditions to reach the people requesting assistance and/or to bring them to hospitals for treatment. While these vehicles may travel on shoulders, against traffic, or proceed through red-lights, these are risky situations for which the emergency vehicle driver will be held liable if a crash occurs. Other vehicles on the road are supposed to slow down and pull over to the right to facilitate the emergency vehicle's travel; however, not every driver does so. In some situations, there is little room for them to pull to the right as traffic may be gridlocked or shoulders may not be present or have obstructions. On arterials, the emergency vehicle may need to turn right but find it difficult to do so because of the drivers on the right. Vehicle-to-vehicle communication can help alert vehicles to the presence of an emergency vehicle and with information about the emergency vehicle's desired maneuvers, the other vehicles can be better directed to accommodate the emergency vehicle. This cooperative behavior will make emergency vehicle travel safer and allow police and first responders to reach those in need faster. Further benefits may be obtained by signal pre-emption.

Research Objectives

1. Determine the best behavior for passenger vehicles in order to facilitate the emergency vehicle's movement. In this initial study, passenger vehicle "behavior" is simplified to moving right, moving left, and staying where it is.
2. Determine the best path for the emergency vehicle through traffic. Since the maneuvering is in a small section of the network, the overall emergency vehicle path from origin to destination is considered given. With respect to this objective, the "path" pertains to the path through traffic within the localized section.
3. Develop a message prototype for the personal vehicles. In this initial study, the prototype will be designed for communication between an emergency vehicle and passenger vehicles.
4. Test the prototype in the field on the Northern Virginia test bed.
5. Determine the conditions under which signal pre-emption can provide additional benefits in speeding the emergency vehicle's passage and how pre-emption affects the optimal movements of the passenger vehicles and emergency vehicle. Due to the additional complexity and heavy congestion in the Northern Virginia area, this objective will be handled in the lab in this initial study rather than in the field.

Collecting and Analyzing Video

First, video will be captured from traffic cameras on freeways and arterials (below images) and supplemented with field video recordings as needed. These sources represent the higher (or system) level. The system level corresponds to the controller perspective, which can "see the bigger picture" and determine how to make the vehicles work synergistically, especially in cases where local and global ideal behavior do not match.

The videos will capture a variety of infrastructure configurations and congestion conditions. Greater emphasis is placed on congested conditions since these are anticipated to be the most difficult for emergency vehicles to maneuver through. Light congestion on arterials has a larger sample size than a particular freeway configuration with light congestion due to possible confusion about the intended movement of the emergency vehicle at the intersection. Consistency of the analysis results, or lack thereof, will determine whether additional samples are needed.

The videos are expected to show limitations on particular passenger vehicle movements. These barriers are important to identify for the individual level and act as constraints at the system level. If the barriers for a passenger vehicle on a particular approach cannot be overcome, it may be more appropriate for the emergency vehicles to use the adjacent lanes in a contraflow method.

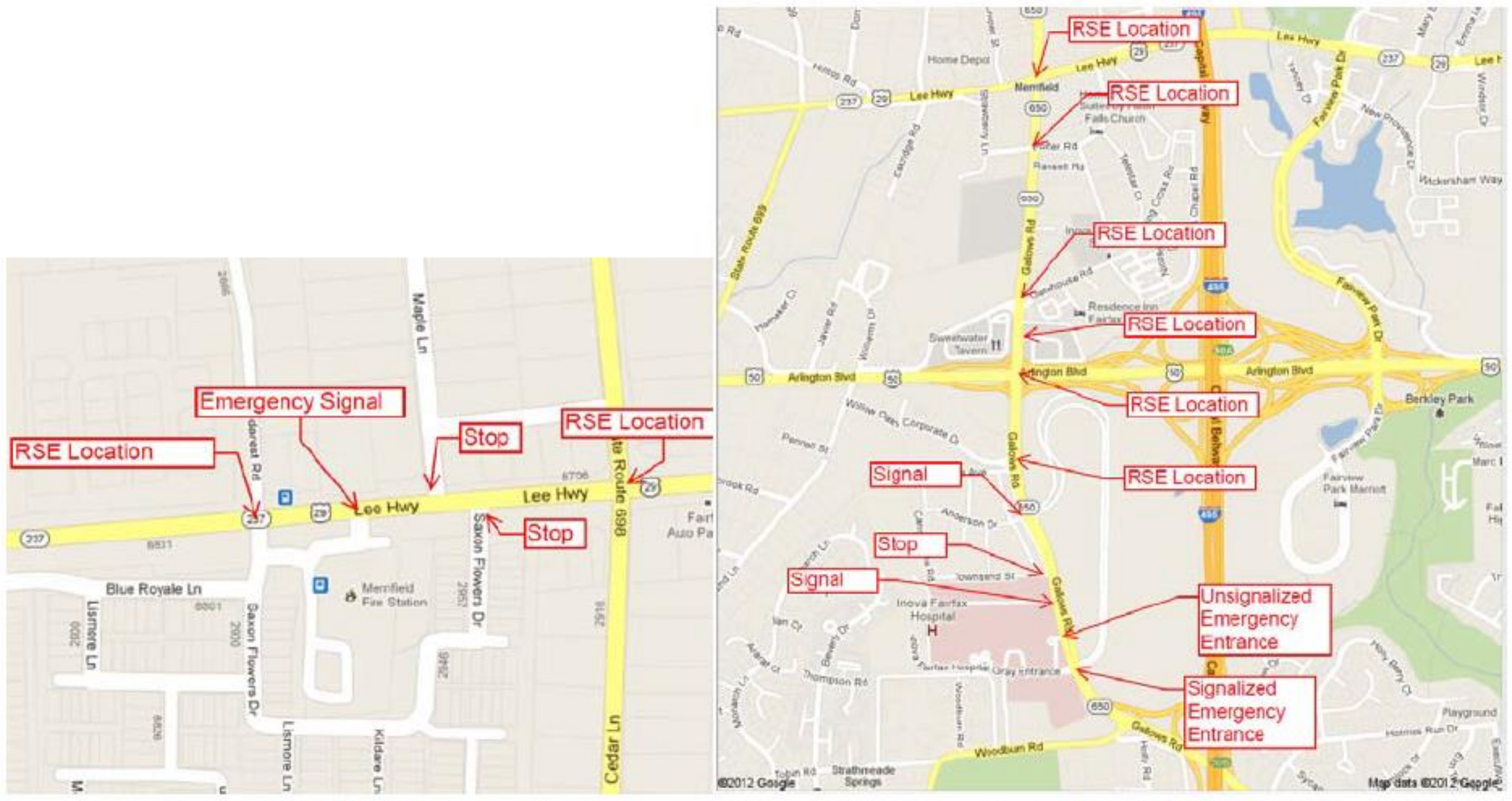
(a) Sample Arterial Video (b) Sample Freeway Video

Sample Traffic Video Captures

For each video, the appropriate movement of the passenger vehicles (or stay) will be determined in conjunction with (real or hypothetical) emergency vehicle movements. At each intersection, each potential movement for the emergency vehicle will be investigated. Ideally, some of the videos will capture interactions of passenger vehicles and emergency vehicles, but the traffic camera video may have to be supplemented with field video. For each video that includes these interactions, the passenger vehicles' behavior will be closely analyzed for (1) whether the vehicle makes an attempt to facilitate the emergency vehicle's passage, (2) whether surrounding vehicles make/fail to make similar attempts, (3) whether actions/lack of action seem to impede the emergency vehicle's progress, and (4) what traffic and infrastructure conditions are present in each case.

Table 1 System Level Minimum Video Sample Sizes

Traffic Conditions	Freeway			Arterial	
	Right shoulder only	Left shoulder only	Both shoulders	Separated turn lane	Un-separated turn lane
Heavy Congestion	30	30	30	30	30
Medium Congestion	25	25	25	25	25
Light Congestion	5	5	5	15	15



(a) Area near Merrifield Fire Station (b) Area near Inova Fairfax Hospital

Field Test Network Segments

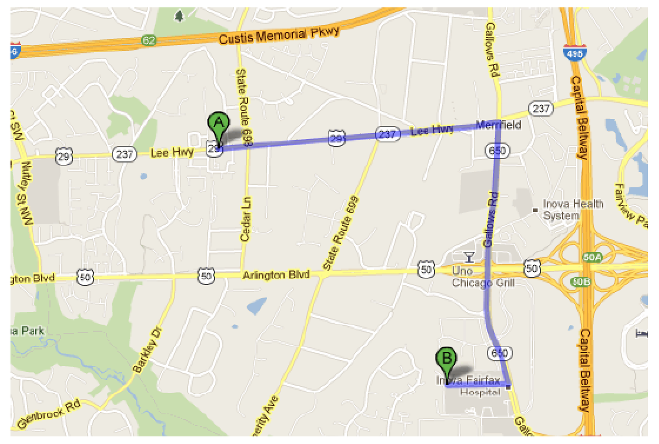
Field Testing Prototypes

Each driver follows the prescribed route shown below in the figure on the left, and be given two messages. One will involve text and one will be auditory. The order will be randomly selected per trial.

Based on the pre-test, the timing of the messaging will be such that there is a safe option to execute the requested maneuver without interfering with traffic that is not part of the study.

For instance, by the fire station on Rt 29, an option exists for vehicles to move into the left turn lane or the right side of the road, as shown in the figure below on the right. Along Gallows Road, some sections are limited to movement to the right, while others have a two way turn lane on the left and commercial parking lots on the right.

The field testing will start during off-peak periods. Once any modifications are made based on the off-peak testing, peak period testing will be performed as well. Specific items that will be evaluated include: (1) time spent reading message, (2) time to begin responding (e.g., begin slowing, looking in the correct direction), (3) time to execute the maneuver, (4) success in executing the maneuver, (5) speed of the maneuver, and (6) distance to other vehicles.



Field Test Route

Maneuvering Section of Route 29

CVI UTC

MORGAN STATE UNIVERSITY

VirginiaTech Transportation Institute

University of Virginia