CHAPTER 1. INTRODUCTION

1.1 The Problem

Route 114, Montgomery County, Virginia also known as “Peppers Ferry Road”, is a two-lane rural road that connects the town of Christiansburg and the city of Radford (Figure 1-1). The busiest part of Route 114 is the 5-mile stretch that connects the New River Valley Mall and the Radford Army Ammunition plant. The entire Route.114, and especially the section located near the Christiansburg town limits, is accessible from a number of side roads and driveways.

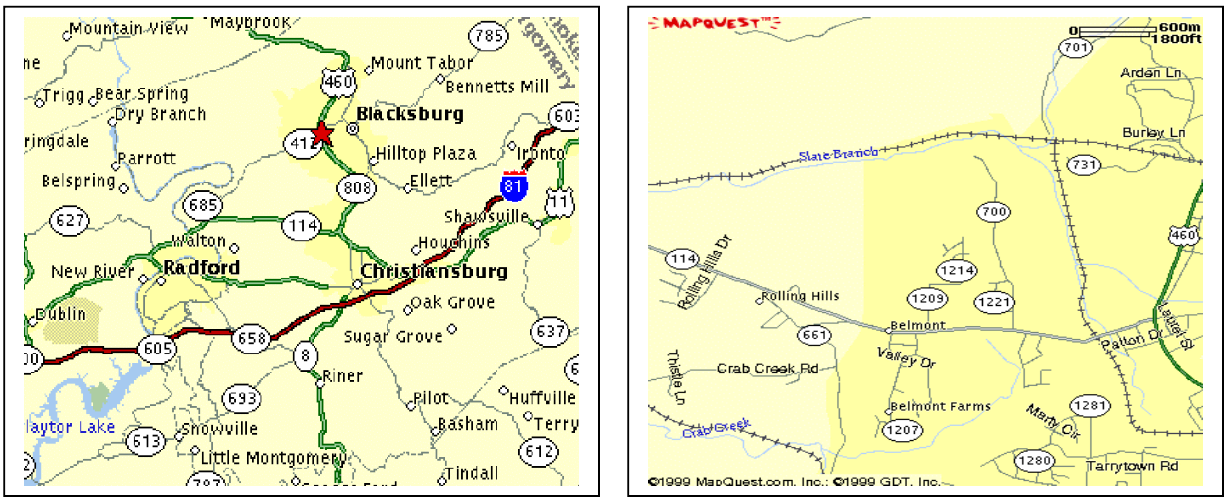

Figure 1-1. Peppers Ferry (Route 114) Location

This section is a two-lane road. Its pavement has a uniform with of approximately 29 ft., and the shoulder width varies, is around 4 ft. on each side (not uniform) and is partly paved. Pavement surface conditions are satisfactory, and yellow no-passing zone markings on the pavement are clearly visible .The geometry of the first few miles of Route114 consists of several consecutive vertical curves. One of these vertical curves, which is located between station points 110-140, has been the scene of several accidents.

The vertical curve which is the subject of this research, is located at 0.6 mile west of the Christiansburg town limit (about 2 miles from the road bifurcation with road 460), and in the near vicinity of the County Road 1286 (Rolling Hills Drive). The total length of this vertical curve is 850 ft. As figure 1-2 shows, the west side of the crest top has a 4.2 % slope, which extends over 425 ft. to the following sag vertical curve. Whereas the other side of the crest (eastside) has a sag curve extending approximately 325 feet with a slope varying from 0 % (horizontal) to 4.2 %. The average daily traffic volume on this section of the Route 114 is about 12,000 vehicles (field survey-Fall 2000) and has been steadily growing for the past years.

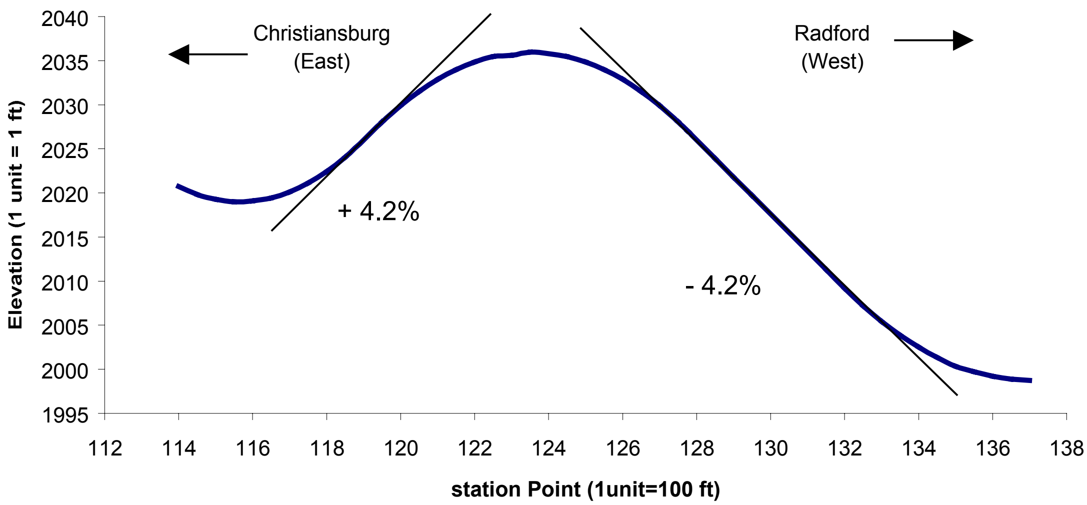

Figure 1-2. Road Vertical Profile

In approximately seven years, from January1994 and to November 2000, eleven fatal crashes occurred on the identified section of Route 114 resulting in a total of 12 deaths and 29 injuries. Five of these crashes occurred on the stretch described above. All these crashes were head-on collisions. These fatal accidents, except for one, all occurred between the half-mile and one-mile mileposts west of the Christiansburg limit. In addition, 167 other crashes occurred on that road resulting in 181 injuries (no fatalities). The statistics show that most of the fatal crashes were caused by violators who crossed the solid yellow line at high speeds to pass the vehicles in front of them and collided with an opposing vehicle that was traveling in the opposing lane.

Two main factors contributing in such severe crashes were found to be:

1. The geometry of the study section of Route 114, where almost all accidents took place, has a positive grade of 4.2 % on the west and east sides of the curve. That may reduce the climbing speed and the performance of some smaller vehicles and heavy vehicles, and thus degrades the following vehicle's climbing performance. In addition, the three consecutive vertical curves reduce the visibility and increase the sight distance required for safe passing.
2. In spite of the two solid yellow line markings and the "No Passing" signs that prohibit passing maneuvers, it seems that many drivers attempt to make an overtake maneuver on these crests without having a clear visibility of the opposing traffic and sufficient passing distance.

1.2 Problem Statement

The problem in this case, is that there is a high probability for severe accidents to occur when a passing driver, especially non resident drivers, violates the double yellow line restriction without having enough passing distance on this low visibility roadway link.

1.3 What To Do: Upgrade the facility or introduce safety improvement devices?

A debate took place on what would be the "best" solution for the problem of illegal passing. For instance, some were arguing whether a major investment should be made to upgrade the facility by receiving a major widening (4 lanes instead of 2) in order to allow for legal pass without jeopardizing the traffic coming in the other direction. However, this solution in addition to its high costs is not justified in term of the level of traffic demand at least for the near future. Actually VDOT has a long-term plan for this road that encompasses such kind of infrastructure improvements. But till that horizon is reached, a safety-oriented improvement was found to be a more cost-effective way to solve this problem in the short-term.

Other suggestions included building concrete New Jersey barriers in the middle of the road as a physical obstacle to passing. This proposal, however, which appeared to be effective and reasonable, poses several requirements such as the barrier needs a room of at least six feet in the middle of the road (including minimum lateral clearance). This solution implies widening the existing pavement and involves a significant amount of civil works, additional costs, traffic interruptions and introducing safety measures. In addition the barrier would require numerous openings in order to ensure access to driveways along the roadway. This poses another safety problem about the end treatment of those rigid concrete barrier segments where standards call for installing impact attenuator to absorb the collision energy at those end points. Such devices require additional spaces and costs to that alternative.

Based on the above discussion it seems that a surveillance tool could be installed to detect and warn the violators, similar to the red-light running at signalized intersections. A camera could be installed to enforce the law and capture the ID of violating vehicles. In other words, The Intelligent Transportation systems (ITS) could play a major role here in achieving the same objective in a much shorter time, and at a relatively much lower costs and without disturbing traffic during installation and maintenance.

However, the questions that need to be answered now are: what ITS system will perform the identified functions? What are its components? How it works? And what is its cost?

1.4 Problem Solving Approach

The deployment consists of a surveillance system made up of several video cameras installed on the designated section to detect the presence and the direction of the violating vehicle in the wrong side of the two-lane road. After the detection is completed and verified, it activates an early warning system to the driver so that he or she can be discouraged and respond to the warning and take the appropriate action to avoid a possible head-on collision.

Such a system is an intelligent transportation system (ITS) component known as video detection deployed here in a new application of to detect the violating cars in a no-passing zone and activate a warning message device to make the driver abort his or her risky passing maneuver.

Also in the ITS area, there were some suggestions about installing displays to enable drivers to see whether there is traffic coming in the other direction and make a ‘safe’ passing maneuver. The main drawback of this approach, however, is that it indirectly encourages the potential violators to cross the yellow line whenever they feel ‘safe’ to commit illegal passing. Others suggested warning not only the violator but also the driver coming in the opposite direction. However, it was found that such a measure would pose some legal and financial liabilities on the owner of the system (VDOT here) in case wrong reactions of the coming driver happened to result in damages in property or human casualties.

1.5 Research Objectives

The main objective of this research is to design a warning system by installing an affordable and efficient system on the vertical crest curve, capable of performing the following two main functions:

1. Detect violating vehicles that attempt to cross into the opposing direction.
2. Warn the violating drivers in order to discourage them from continuing their maneuvers.

Other “by-products” or secondary objectives are:

1. Identify those violators through license plate recordings, and warn repeat violators by mail.
2. Collect data on vehicle volumes and speeds.
3. Monitor, in general, the roadway that would help for other type of traffic management practices such as: identifying driving code violators (high speeding for instance) and incident management.

1.6 Significance of The Work

Several studies have been conducted on the crash types and rates, and suggested countermeasures to minimize the occurrence or the severity of such types of crashes.

However, a lot of these studies have focused on those types of crashes constituting the main share of the total accidents such as rear-end, road departure and intersection collisions. Meanwhile, NHTSA research program- as we will see in chapter 2 - is putting more efforts on developing collision avoidance systems for these types.

The head-on collisions are only about 3% of total number of crashes. Even though, that would amount to more than 180,000 crashes in 1998, a number justifying the necessity to find appropriate countermeasures and solutions.

Moreover, the majority of studies dealing with lack or low visibility- caused crashes emphasizes on environmental causes (nighttime and weather conditions), whereas visibility problems at intersections and horizontal curves are the most addressed geometric causes.

ITS collision avoidance is problem driven. Therefore the significance of this research arises from the type of problem we are proposing to solve, particularly:

1- Deploying an Intelligent Transportation System to overcome the problem of accidents caused by violation and lack of visibility at vertical crest curves.

2- Proposing a new Advanced Rural Transportation System (ARTS) application aiming at reducing the number of crashes under specific conditions of roadway, vehicles and driver behavior.

3- Exploring the relationship between the parameters dealing with this specific type of problem. A special simulation program was written and developed in order to explain the phenomena of crashes and crash avoidance under varying conditions of those parameters.

4- The proposed system combines warning and enforcement as complementary functions in the same application.

5- It is a self-functioning infrastructure-based system that could perform all its tasks and document them without referring to a control center. However, this system could be accessed by a control center and even developed to perform complementary functions such as incident management and mayday.

6- Deploying video detection for new application, which is distinguishing illegal passing violation on two-lane rural road link.

1.7 Dissertation Layout

The remaining chapters of this dissertation are organized as follow: Chapter 2 presents comprehensive literature review of previous studies related to this research. Chapter 3 presents the methodology adopted to design, implement and evaluate the proposed solution. Chapter 4 deals with data collection surveys and analysis. Chapter 5 approaches the geometric aspects of the problem and determines the boundary of the project. Chapter 6 focuses on system architecture and sub-system functions. Chapter 7 develops detailed design of the various subsystems components. Chapter 8 illustrates in details the methodology of the system simulation. Chapter 9 evaluates the performance of the system by conducting a comparative analysis between "with" and "without" the system cases, including a sensitivity analysis and a benefit-cost analysis. Finally, chapter 10 summarizes the findings of this dissertation and recommends further research.