1.3 Research Objective

This research project will focus on a solution package that can facilitate the following objectives:

1. A better delineation of the no-passing zone, in particular the “danger zone”, in which an accident is almost inevitable,
2. Discourage the drivers who has the potential to violate the no-passing zone,
3. Provide real-time detection and instantaneous intervention system, if there is a violation committed,
4. Find a low-cost and technology-intense system that can be installed in a time-saving manner, and can be adapted to any other location with similar geometry and/or conditions

Delineation of the no-passing zone (and the danger zone) will be accomplished by analyses of the vertical curve between mile points 103 and 112. Most important factor in this process is the determination of visibility of the vehicles to one another. There will be no system intervention where there is a clear sight of vehicles in each direction.

Another factor that will play a major role is the determination of the distance that will allow the driver to complete an overtaking maneuver (if possible). And the last element will be the safe and emergency stopping distances, derived under extreme conditions (wet surface), in case of a passing violation.
Discouraging the drivers who are attempting to make an overtake maneuver will be facilitated by giving them a warning signal and/or message that will be conveyed in real-time. Constant roadway detection and instantaneous intervention for any passing violation will work with the above warning system (actually intervention part will be the next step).

Such system will be designed as an Intelligent Transportation System (ITS) application, in order to accomplish the low-cost technology-intense nature of the entire project. This will also allow us to adapt such warning system to any other location with the same geometric and roadway conditions, and with a potential danger for accidents.

1.4 Organization of This Project

The following sequence is the methodology of this research project:

1. Study of the vertical curve location geometry,
2. Stopping and passing sight distances,
3. Distances for overtaking maneuvers at different speeds,
4. Curve lengths for stopping and passing sight distance,
5. Visibility and danger zone limit analyses,
6. Determination of the danger zone and no-sight zone around the vertical curve,
7. Design of a warning system suitable for installation at this location,
8. Study for available systems designed for collision avoidance and warning systems,

9. Developing the warning system algorithm,

10. Evaluation,

11. Conclusion.
Chapter-2

Vertical Curve Characteristics

2.1 Vertical Curve Location and Geometry

The vertical curve, which is the subject of this research project, is located on Rt.114, in Montgomery County, Virginia. The curve is located approximately 0.6 miles west of Christiansburg Corporate (Town) limits, and is a section of two-lane rural highway. This curve starts at milepoint 96.5, and ends at milepoint 112 (according to Virginia Department of Transportation Road Plan-Profile # A 2287-8 and A 2287-9, Figure I.2 and I.3).

As it can be seen in Figure XX, the eastern side (Christiansburg) of the vertical curve is 2.0% slope, tangent point starting at milepoint 96.5, and ending at milepoint 104.5. The length of eastern slope is 800 ft. horizontally. Western side (Radford) of the curve is a 4.6% slope, which starts at milepoint 111.5, and ends at milepoint 112. This section’s length is approximately 50 ft. The slopes are connected by a parabolic curve with a horizontal length of 700 ft. Vertical curve’s crest top is located at milepoint 106.5. Entire length of the crest vertical curve has a 30-ft. road width (24-ft. total marked lane width)
2.2 Stopping and Passing Sight Distances

2.2.1 Stopping Sight Distance

Stopping sight distances for this vertical curve is calculated based on the formula given on the “A Policy on Geometric Design of Highways and Street 1994” publication of AASHTO (see appendix A, and references section). As it is given on equation (A-2) on page 35, the stopping distance on a grade is a function of perception-reaction time, vehicle speed, friction between the vehicle’s tires and the road surface, and the percent measure of the grade.

In this research study, perception-reaction time is applied as 2.5 seconds (in most cases this figure is accepted as 2.0 second, but a higher value like 2.5 seconds is used here to ensure a longer distance for secure stopping). Friction coefficient (f) is based on the wet road surface conditions, and applied as 0.28 (friction coefficient has no dimension).

Based on the above, Table-I.1 shows stopping distances for different speeds on either 2.0% or 4.6% climbs. On Table-I.2 stopping distances are calculated for descending vehicles on the same slopes. In this study, an assumption is made for the speeds of two vehicles, each on opposite direction. Since the design speed on this section of Rt.114 is 55 mph, oncoming car’s speed is applied as 55 mph, and violator car’s (the car which is attempting to complete an overtake maneuver) speed is applied as 60 mph. Another assumption is made with regards to the exact location of each car, in the case of an head-on collision; based on the fact that all recent accidents occurred at or near the crest top,
the oncoming car, and the violator car will be on either side of the vertical curve (the possibility of two car being on the same slope (one is climbing, other descending) is out of consideration, because they would have clear sight of each other and violator would not attempt to an overtake maneuver).

From the Table-I.1, the required stopping distances for emergency stopping (car coming on opposite direction) can be extracted as below:

Situation #I
Obeying car travelling at 55 mph, on 2.0% slope (climb) > Stopping distance on wet surface = 540 ft.
Violating car travelling at 60 mph, on 4.6% slope (climb) > Stopping distance on wet surface = 590 ft.
Total distance required to stop = 1130 ft.

Situation #II
Obeying car travelling at 55 mph, on 4.6% slope (climb) > Stopping distance on wet surface = 513 ft.
Violating car travelling at 60 mph, on 2.0% slope (climb) > Stopping distance on wet surface = 622 ft.
Total distance required to stop = 1135 ft.
The total stopping distance given above should be considered as an emergency stopping distance which will prevent a head-on collision of the two opposing cars (it is assumed that two cars will come to a stop on the same lane with an extremely short distance between each other). Required length for the definition of danger zone on this vertical curve will be applied as 1150 ft.