Efforts to Evaluate the Feasibility of Using Video Image Processing Capabilities for the Automated Detection of TACT Driver Behaviors

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Abstract

North Carolina is considered to be a 'lead' state in efforts by the Federal Motor Carrier Safety Administration (FMCSA) to develop a 'model program' for truck safety in the United States. The TACT program (Ticketing Aggressive Cars and Trucks) is characterized by three major components: (a) education/outreach, (b) enhanced enforcement, and (c) evaluation. North Carolina is now in its second iteration of TACT. Efforts to evaluate the effectiveness of the TACT program have been hindered to this point by the absence of measures able to provide an accurate and reliable assessment of the impacts of TACT on operational driver behavior. It is recognized that the level of enforcement effort (and the resulting number of citations) alone is not a sufficient measure of program success.

Funding provided to ITRE under TACT II has provided improved measures of effectiveness (MOE's) – measures that reliably detect aggressive vehicle speeds, "following too close" events, and restricted lane compliance – using quantitative analysis methods developed using video image processing (VIP). The use of VIP via the Econolite Autoscope software suite has allowed the team to employ equipment in an unobtrusive manner to collect the various MOE's. The team further identified supplemental detection that will be procured and utilized for future research efforts.

Based upon the results of the current study, ITRE and the NCSHP TACT Program Office recommend the selective implementation of video image processing capabilities to augment the planned evaluation of TACT III efforts in CY2010.

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1. Introduction

North Carolina is a major trucking hub for the eastern United States, with many roadways operating upwards of 30% heavy vehicles during certain times of the day. In addition, North Carolina has a high density of paved roads – many of which are rural - compared to most other states. This combination of high truck volumes and availability of freeway and non-interstate roads makes North Carolina susceptible to many potentially risky crashes involving trucks. The Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA) have currently provided funding to more than sixteen states to implement a high-visibility enforcement program geared towards reducing unsafe driving behaviors of passenger and commercial vehicles *(1)*. This enforcement program, called "TACT – Ticketing Aggressive Cars and Trucks", was based on a demonstration project conducted in Washington State. The findings from this initial effort provided guidelines for implementing a successful program through examples and lessons learned which have been utilized by many of the sixteen TACT funded states since starting two years previous.

In March 2009, the Institute for Transportation Research and Education (ITRE) at North Carolina State University (NCSU), with support from the North Carolina State Highway Patrol (NCSHP), set out to provide additional measures of effectiveness that could be used to more directly evaluate TACT efforts. The evaluation efforts currently underway included qualitative surveys of 'jingles' that were aired over major radio stations. North Carolina's initial experience with TACT program implementation suggested the need to develop these additional evaluation methods, which would be able to provide more definitive and quantitative evidence of the ability of TACT treatments to effect desired changes in the spatial and temporal relationships between cars and large trucks under actual roadway conditions. The bottom line is that there has yet to be any 'hard' evidence for the effectiveness of the TACT program in terms of measurable effects upon actual driver 'behavior' as directly inferred from observations of their on-road performance – only suggestive evidence of an increased 'awareness' (through printed and electronic media) of the risks.

Of the sixteen currently funded TACT states, North Carolina is aggressively searching and implementing strategies that educate the driving public on the dangers of traveling in the close proximity of heavy vehicles, along with enforcing motorist non-compliance with laws put in place to promote safe movement of vehicles around heavy trucks. This first effort aims to develop methods to quantitatively evaluate TACT program efforts utilizing video and existing image processing software to automate the collection of objective measures of the spatial (lane volumes, vehicle classification, vehicle headways, lane change behavior, etc.) and temporal (speed-related) characteristics of traffic behavior in areas covered by TACT operations. This report describes those efforts conducted during this initial endeavor and proposes to further utilize the hardware and software algorithms for future evaluation of TACT enforcement waves to document any potential short and long term benefits of the program.

2. An Overview of TACT Evaluation Efforts in NC

North Carolina is considered to be a 'lead' state in efforts by the FMCSA to develop a 'model program' for truck safety in the United States. The TACT program is characterized by three major components: (a) education/outreach, (b) enhanced enforcement, and (c) evaluation. North Carolina has now completed its second iteration of TACT, which has primarily focused on the first two components of the program, with limited focus on evaluation. Efforts to evaluate the effectiveness of the TACT program have been hindered to this point by the absence of measures able to provide an accurate and reliable assessment of the impacts of TACT on operational driver behavior. It is recognized that the level of enforcement effort and the associated frequency of citations alone is not a sufficient measure of program success.

Over the past five months, ITRE has worked diligently to assess the feasibility of a camera-based evaluation methodology for providing a more operationally oriented evaluation of TACT effects on actual driver behavior. This work represents an extension of a preliminary, ITRE-funded effort judged by NCSHP to have significant potential for improving the evaluation component of the TACT program. North Carolina's initial experience with TACT program implementation suggested the need to develop additional evaluation methods . . . methods that would be able to provide more definitive and more quantitative evidence of the ability of TACT treatments to effect desired changes in the spatial and temporal relationships between cars and large trucks under actual roadway conditions.

The use of video detection methods for traffic surveillance and traffic management is well-documented. Video detection represents a cost effective alternative to the use of in-road detection devices (e.g., inductive loops). The ability to establish reconfigurable 'virtual detection loops' provides a level of flexibility beyond that associated with in-road detection methods. ITRE has applied experience in the use of camera-based detection both for traffic control purposes as well as for more 'experimental' applications. We describe below preliminary ITRE efforts (funded by the NC TACT program) which demonstrate the successful use of camera based methods to detection of critical TACT behaviors such as following too close, speeding, and compliance with lane restrictions.

Camera based methods, while limited to sampling from a fixed vantage point, have the advantage over previous officer-based detection methods in that they are continuously active and can simultaneously provide surveillance for all lanes within the camera's field of view. There is no camera 'down time' while an officer intercepts a vehicle for the purpose of issuing a citation. Camera based methods require little or no human monitoring beyond set up and calibration. And, to the extent that a camera based detection event can be used to trigger a visual message (e.g, via a variable message sign) to the offender(s), the opportunity exist for future methods for education and enforcement. Thus camera based detection can both serve as a performance measurement capability and as part of a real-time driver feedback 'treatment.' Although the use of camera based detection for dynamic messages is not a part of this initial TACT effort, it is hoped to be part of an overall treatment approach evaluated in future efforts.

3. Preliminary TACT Evaluation Efforts

The exploratory work conducted by ITRE, independent of MCSAP program funding, identified an ideal video detection test site for collecting pre-peak traffic data. The site, located at the Old Reedy Creek Road overpass on I-40 in the vicinity of Raleigh, NC (Figure 1), provides a good overhead vantage point of all freeway lanes with very limited vehicular access.

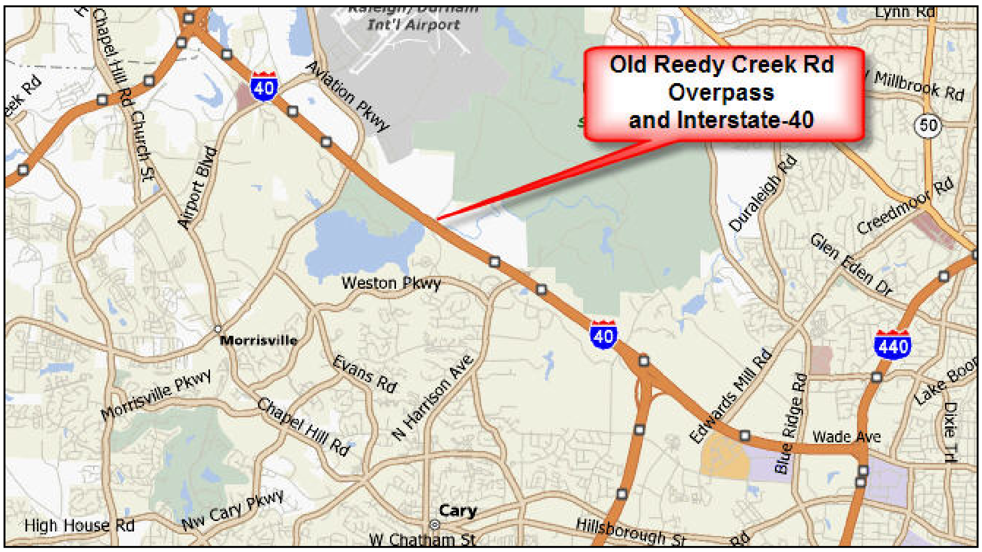


Figure 1. Pilot Data Collection Location – Old Reedy Creek Road – Raleigh, NC


Figure 2. Multiple Camera Views at Old Reedy Creek Road Overpass

In the initial effort approximately one hour of continuous video was recorded on each of three separate cameras positioned above the eastbound lanes of traffic on I-40. Figure 2 shows that three cameras were used to provide different viewing angles (e.g., looking straight down and at different oblique angles to the roadway below) to test the optimum camera configuration for video detection.

Using a commercially available video processing software product, Autoscope, virtual detection zones were created in each travel lane. The software uses a background image to determine if an object moves into specified zones (shown as detectors) causing a pixel change against this background image. This pilot effort quickly gauged the ability of Autoscope software to detect data and evaluate performance measures related to:

- **Volume:** Traffic volume will be utilized to evaluate the proportion of drivers not complying in a particular area (measures below) before, during, and after enforcement.
- **Following to Close – 'FTC'**: Trucks and cars in the close proximity of other vehicles is typically a sign of aggressive driving behavior, especially vehicles in the immediate proximity of trucks because of the sight distance issues and braking distance required to stop a heavy vehicle. To determine FTC events, the software must be able to accurately classify vehicle types and the time between two types of vehicles (known as the 'gap time') – see Figure 3.
- **Restricted Lane Compliance**: North Carolina, along with other states across the United States, has allowed the State Department of Transportation the ability to restrict trucks from utilizing inner-most lanes where safety may be an issue. If pavement marking or signs are installed to restrict use of certain lanes for safety reasons, it could be considered an aggressive maneuver if trucks do not comply. As with FTC events, classification of vehicles would need to be utilized.
- **Speed:** Speeding is directly related to aggressive driving behavior of all vehicle types, and is the leading cause of collisions in NC and the US. The evaluation of speeds before/during/after enforcement would likely show if an effect on driver behavior could be attributed to the enforcement efforts under TACT.
- **Aggressive Lane Change**: Another potential evaluation measure SHP would like to utilize is whether vehicles of all types are aggressively changing lanes. A combination of various detection parameters were utilized while exploring if Autoscope could accurately determine these events (Figure 4).

This initial ITRE funded pilot effort led the team to conclude that each of the measures had potential; however, accurate speeds would be problematic in the current video configuration. It was determined that supplemental in-road detection may need to be utilized if further evaluation does not yield accurate speeds.

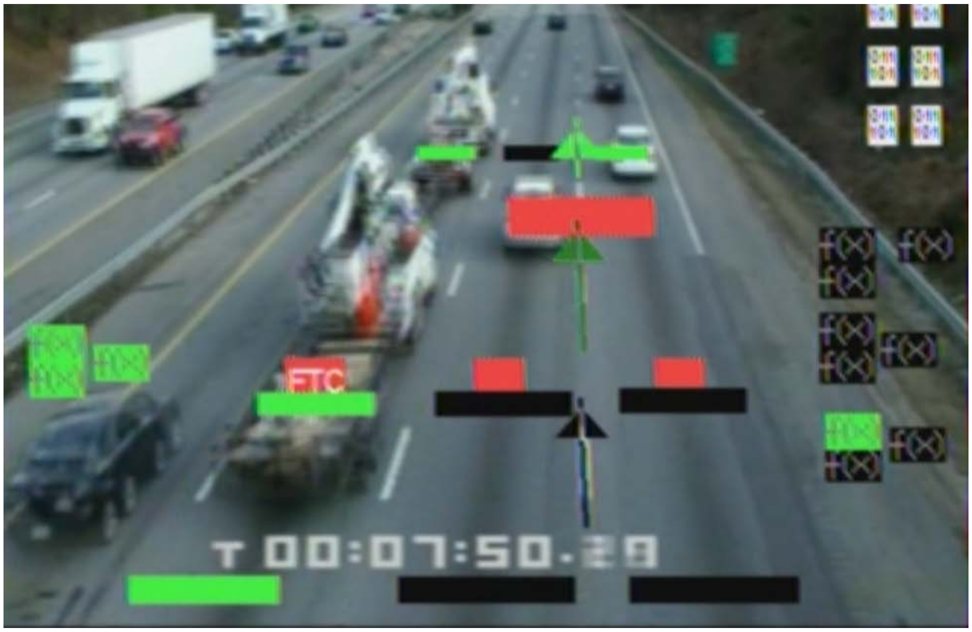


Figure 3. Example of following-too-Close event (FTC)

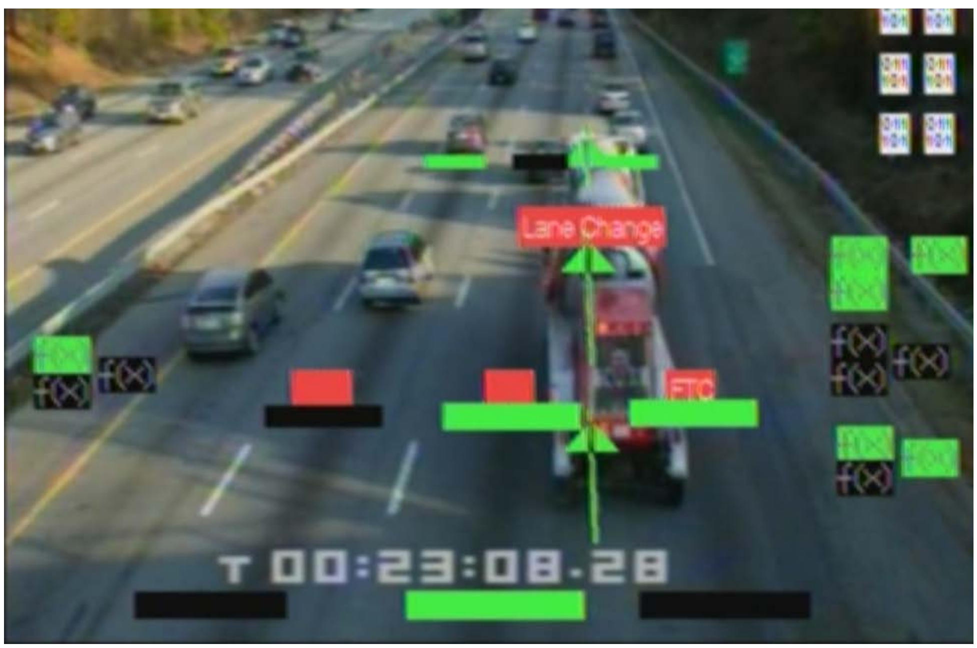


Figure 4. Autoscope view showing detection of lane change event

4. Current TACT Evaluation Efforts

In a continuation of the ITRE-funded pilot data collection efforts, funding was provided by NCSHP to further investigate the use of video and in-road detection methods from April – September 2009. This six month effort was necessary to substantiate the reliability of a video based system for evaluating future TACT enforcement waves in the spring of 2010. Findings from these efforts have yielded improved video algorithms for determining traffic volumes and speeds (Figure 5), FTC (Figure 6), and restricted lane compliance.

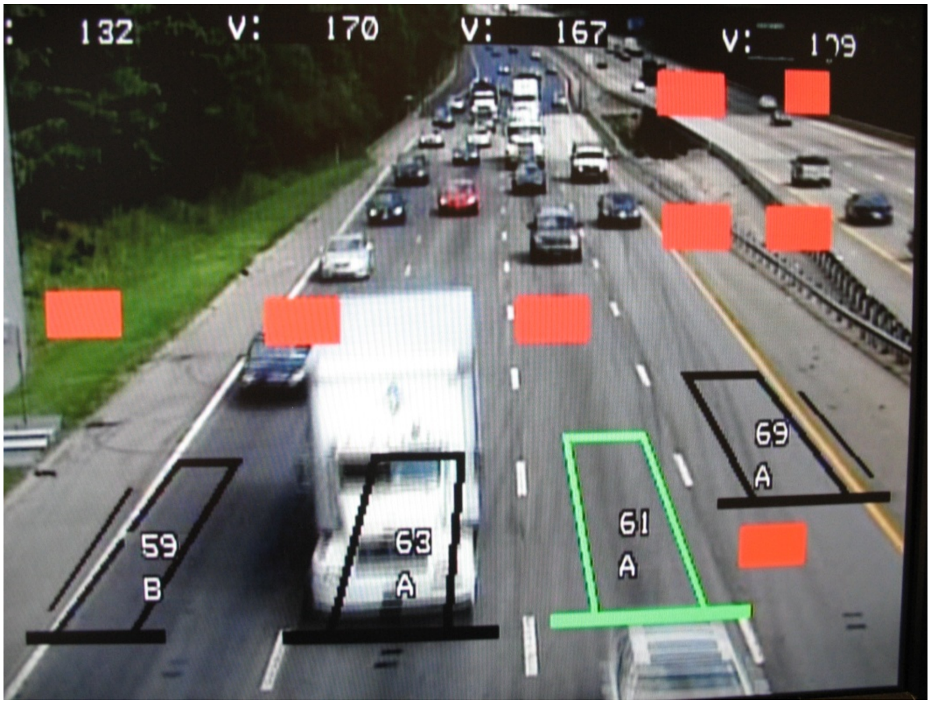


Figure 5. Autoscope view of virtual detectors. Example of speed and traffic volumes by lane.

Figure 6. Autoscope view of virtual detectors. Example of speed and traffic volumes by lane.

Speeds, which were considered to be problematic during our initial pilot project, have been refined considerably and appear to be fairly consistent. The initial issue appeared to be the need for vehicles to be approaching the camera instead of receding. Field calibration will be necessary prior to actual evaluation; however, this is a fairly simple task using a laser speed gun. Last, video algorithms were further explored for aggressive lane changing events; however, it was determined that the frequency of these events was so small over such a short segment that it would not be worthwhile to evaluate. Traffic volume and FTC events were further enhanced to provide more accurate measures.

In a recent meeting with the TACT oversight committee in September 2009, ITRE demonstrated the capabilities of the video-based system and received positive feedback on the potential of the current findings in evaluating the TACT program. A future field demonstration is in the planning stages for December 2009 prior to actually implementing the program in 2010.

4.1. Supplemental Equipment Needs

An additional component evaluated by the research was the use of in-road detection for supplementing future TACT efforts. The research team investigated various alternatives and weighed the benefits and disadvantages of each. Initially, the team had high hopes for using detection currently installed by NCDOT along sections of I-40. The map below shows the current location of detectors as well as the graphic user interface available for online monitoring of traffic performance (Figure 7).

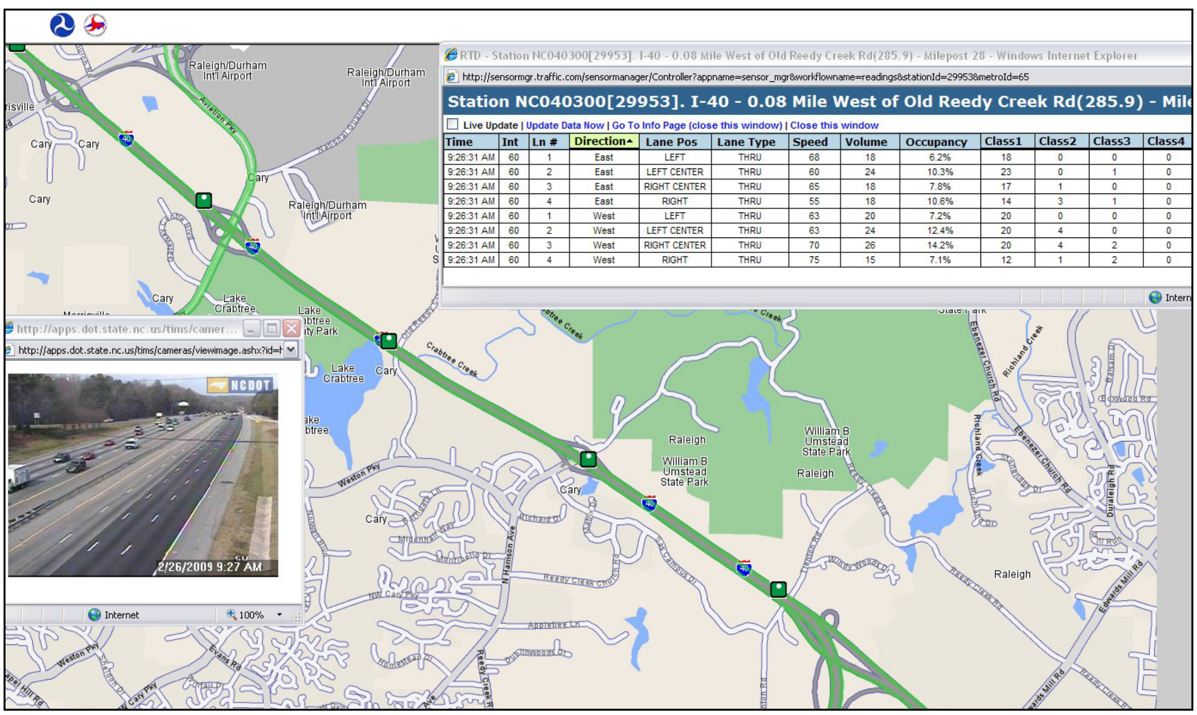


Figure 7. Traffic.com Graphical Interface via Internet

The detectors utilized by the system are multiple in-pavement sensors in each travel lane which allow access to detector data via the internet at traffic.com. Although the team had high hopes for utilizing this database of vehicle detections, the primary drawback was the inability of the team to acquire individual detector events since the program recorded data in 1-minute increments or greater. The team will continue to monitor NCDOT and traffic.com efforts for acquiring data on a 'by vehicle' basis; however, discussions at this time indicate that it will not be available for some time because it is very database intensive.

Following the investigation of NCDOT detection capabilities, the research team looked into acquiring detection of their own to supplement future evaluation efforts for 2010 and beyond. The detection devices considered were:

- *Numetrics HiStar* (nu-metrics.com/pages/nmproducts.html): HiStar's are a semi-permanent device that is mounted to the surface of the roadway; allowing for quicker installation than boring holes in the pavement. For a 4-lane roadway section, the system would require 8 detectors ($16,000) and a software suite for downloading data ($1,500) for a total cost of 17,500. Although easier to install, the system does not collect individual vehicle detections, but instead averages data in bins of 1+ minute increments. It is therefore associated with the same limitations as the existing NCDOT instrumentation.
- *Numetrics Groundhog* (nu-metrics.com/pages/nmproducts.html): This is the type of detection provided on the freeway currently to NCDOT through traffic.com (Figure 7). Although the equipment is the same as that currently installed in many locations along I-40, ITRE would be able to collect the data on a 'by vehicle' basis because the database would only require a maximum of one week's worth of detections. In discussions with the vendor, a 4-lane freeway section would require 8 detectors ($16,000), 1 local base unit ($5,000), and 1 wireless data management unit ($2,000) for a total cost of $23,000. This system would require the team to bore two separate holes in the pavement (thus requiring traffic control for a short period of time) for each lane detected, along with setting up equipment on the roadside to collect wireless video transmissions. Batteries in the detectors last approximately 7 years.
- *Sensys* (sensysnetworks.com): Sensys detectors are similar to Numetrics Groundhog detection devices in concept. The detectors already showed promise. A typical 4-lane freeway section would require 8 detectors ($8,000), a wireless access point ($3,000), a repeater to transmit the data to a controller at a safe location ($1,500), and 2 detector cards (1,500) for a total cost of $14,000. As with the Groundhog, the team would need to bore holes in the pavement requiring a short period of traffic control, and some minor equipment set up. Battery life was equivalent to that of the Groundhog. Individual vehicle detections are acquired at a signal controller instead of a separate software package.

- *Econolite Autoscope* (www.econolite.com): ITRE's initial efforts using video detection hardware and software proved initially to be problematic. Econolite vendors claim they can accurately detect speeds with their new camera system. A typical 4-lane freeway section would require 4 Solo-Terra cameras ($16,000) and 4 detector cars ($8,000) for a total cost of $24,000. The primary benefit of using video is that it is less obtrusive in that it does not require any set up in the traffic lanes. Initial problems were resolved with over the course of the effort.

Following ITRE's work in updating the video algorithm's to monitor the necessary MOE's, a final review of supplemental equipment necessary to conduct a proper evaluation of TACT was completed. The team evaluated the supplemental equipment needs based on necessity, ease of set up, and costs. First, the improved video algorithms showed that the current equipment already procured (from previous research efforts) did collect speed data accurately when the view was changed to allow vehicles to approach the camera. Therefore, ITRE procured additional camera equipment to supplement the small number of cameras 'in house' to properly outfit a 4-lane freeway section. Because the previously purchased equipment was used, the additional cameras were not as significant a cost as originally thought. In addition, the team still felt strongly that better vehicle count and classification data could be obtained by detectors installed in the lane, and opted to purchase Sensys detectors. This purchase was justified because the costs were reasonable and could be obtained in addition to Econolite's Autoscope hardware. Sensys detectors will be further evaluated during one 2010 enforcement wave to better understand its capabilities for future TACT evaluation. In addition, the availability of a raw data stream opens the possibility for the development of real-time conflict detection and output to a variable message sign or other device.

4.2. Autoscope Detector Configurations

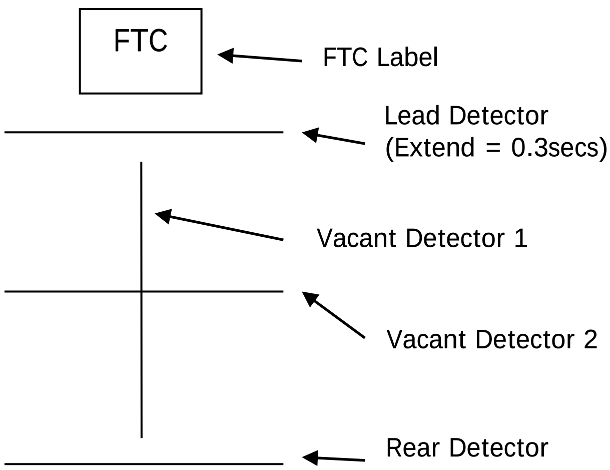
This section is intended to provide the reader with information on each of the MOE algorithms that were developed using Econolite's Autoscope software suite. The controller logic is provided along with a basic description of how the logic is utilized to provide the necessary information for future evaluation.

4.2.1. Following to Close - FTC

The FTC configuration developed using the Autoscope detection system identifies events where one vehicle (truck or car) is following another vehicle too closely. The "FTC" (Following Too Closely) label is turned on and off by the following algorithm, shown as logic statements below. A screen shot of an FTC event can be seen in Figure 6 along with the associated detectors shown below in Figure 8.

4.2.1.1. “FTC” Logic Statement

IF Rear Detector = **ON** THEN
    IF Vacant Detector 1= **OFF** THEN
        IF Vacant Detector 2 = **OFF** THEN
            IF Lead Detector = **ON** THEN
                FTC Label = **ON**
            END IF
        END IF
    END IF
END IF



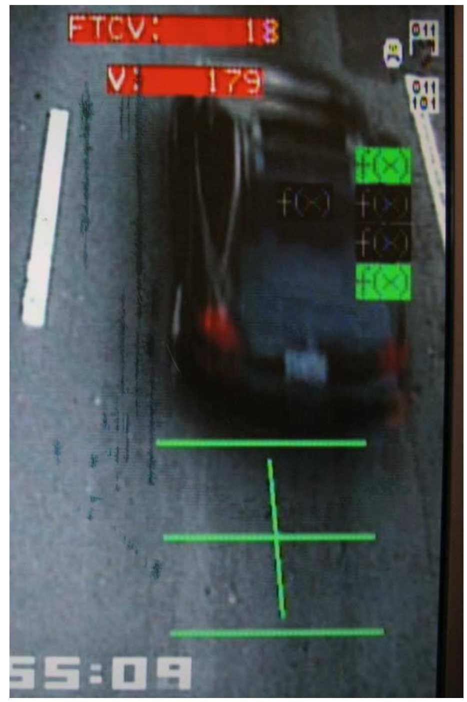


Figure 8. FTC Detector Labels and w/ Associated Screen Shot

4.2.1.2. “FTC” Description

This algorithm was developed and applied on an eastbound section of I-40 at the Old Reedy Creek Road Bridge with traffic receding from the bridge (Figure 6). When a vehicle is on the Lead Detector within 0.3 seconds of a vehicle crossing over the Rear Detector, that second vehicle is following the first vehicle too closely, which will turn on the “FTC” label. Since the lead and rear detectors are so closely spaced, a 0.3-second extend time is placed on the lead detector allowing the vehicle to continue to call the detector for 0.3 seconds after leaving the zone. The 0.3 seconds is the minimum gap between two following vehicles that cannot be exceeded or the FTC label will come on. This temporal parameter can be calibrated by the user to reflect a higher or lower FTC threshold. The two Vacant Detectors between the Rear and Lead Detector are used to ensure that a single vehicle on both the Rear and Lead Detectors isn’t signaling the FTC label to turn on.

4.2.2. Vehicle Speed

This algorithm represents the current configuration of the Autoscope detection system developed to track the running speeds of vehicles in each lane of a stretch of highway. The speed bins (divided into 5 mph bins) will appear as a label popping up on the screen the appropriate speed "Label" when the following logic is true. A screen shot of the speed detector set up can be seen in Figure 5 along with the associated detectors shown below in Figure 9.

4.2.2.1. "Vehicle Speed" Logic Statement

```
IF Vehicle > 60mph Speed Alarm = ON THEN
    IF Vehicle > 65mph Speed Alarm = OFF THEN
        IF Vehicle > 70mph Speed Alarm = OFF THEN
            IF Vehicle > 75mph Speed Alarm = OFF THEN
                61-65 Label:= ON
            END IF
        END IF
    END IF
END IF
--------
IF Vehicle > 65mph Speed Alarm = ON THEN
    IF Vehicle > 70mph Speed Alarm = OFF THEN
        IF Vehicle > 75mph Speed Alarm = OFF THEN
            66-70 Label:= ON
        END IF
    END IF
END IF
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IF Vehicle > 70mph Speed Alarm = ON THEN
    IF Vehicle > 75mph Speed Alarm = OFF THEN
        71-75 Label = ON
    END IF
END IF
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IF Vehicle > 75mph Speed Alarm = ON THEN
    76+ Label:= ON
END IF
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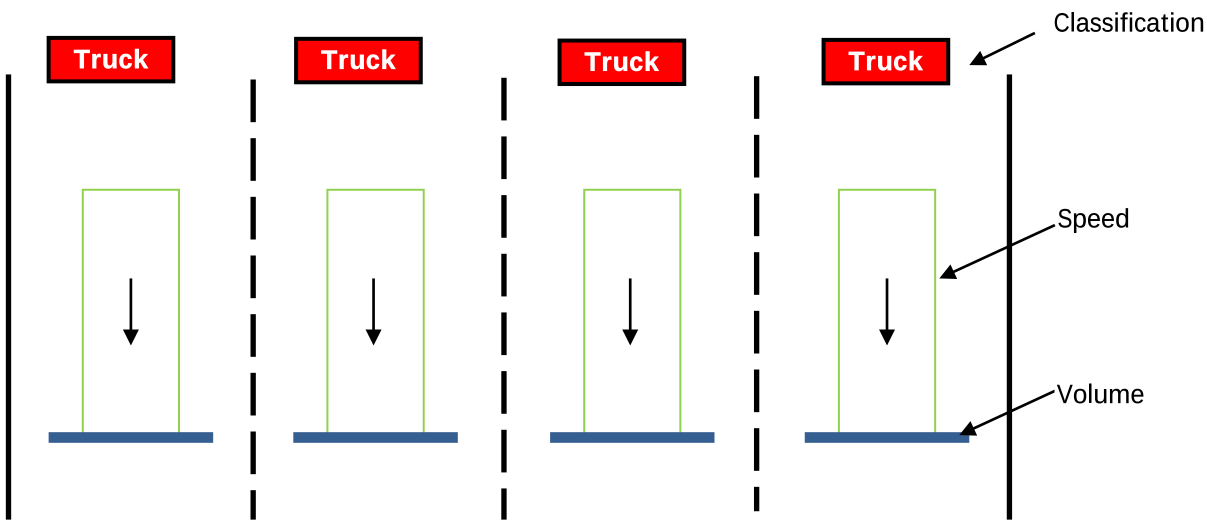

Figure 9. Speed, Classification, and Volume Detector Labels

4.2.2.2. "Vehicle Speed" Description

This algorithm was developed and applied on a westbound section of I-40 at the Old Reedy Creek Road Bridge with the traffic approaching the bridge (Figure 5). When a vehicle enters and leaves the speed detection zone, the speed of the vehicle is calculated. It is displayed on top of the speed detector as the vehicle leaves the detector. However, this algorithm is used in order to place each vehicle's speed in a speed bin that has a range of five miles per hour. If the speed of the vehicle is greater than 60 mph, but not greater than 65, 70, and 75 mph, the label "61-65" appears. If a vehicle is traveling at a speed greater than 65 mph, but not greater than 70 and 75 mph, the label "66-70" appears. Likewise, if a vehicle is going faster than 70 mph, but not faster than 75, the "71-75" label appears. Last, if the vehicle is going over 75 mph, the "76+" label appears. Vehicle speeds can be used for determining when spillback is occurring from upstream congestion. With a buildup of traffic comes a decrease in average speed. As average speed decreases, the gap time becomes shorter for a vehicle following another vehicle too closely, which means the detector "extend" should be decreased from 0.3 seconds to some threshold value that is smaller (to the nearest 1/10th second). Also, the danger of a serious collision is greatly decreased at slower speeds because drivers can react and come to a stop with little trouble. Therefore, speed bins will also be utilized to determine when FTC data should no longer be collected.

4.2.3. Vehicle Classification

This algorithm represents the current configuration of the Autoscope detection system developed to distinguish between trucks and cars in each lane of a stretch of highway. The "Truck" label is associated with a detector function called an "Alarm" when the following logic is true. A screen shot of the vehicle classification set up can be seen in Figure 5 along with the associated detectors shown in Figure 9.

4.2.3.1. “Vehicle Class” Logic Statement

IF Truck Alarm = **ON** THEN
    Truck Label = **ON**
END IF

4.2.3.2. “Vehicle Class” Description

This algorithm was developed and applied on a westbound section of I-40 at the Old Reedy Creek Road Bridge with the traffic approaching the bridge. When a vehicle enters and exits the speed detector zone, one quantity that is calculated is the vehicle length. The length is not displayed, but a classification based on the length of the vehicle can be displayed using an “alarm”, which turns on when a vehicle longer than a specified length passes through the speed detector. In this case, if a vehicle is calculated to be longer than 50 feet long, it is considered a truck. It is worth noting that a speed detector must be at least 50 feet long in order to obtain an accurate length. By using this algorithm to label each truck that travels along this corridor while the camera is running, the number of trucks in each lane can be accurately counted. This will also serve as a means to enforce against trucks traveling in the restricted lane.

4.2.4. Traffic Volume

Traffic volume is done through pre-programmed “count” detectors that are placed perpendicularly across each lane. A screen shot of the vehicle count detector set up can be seen in Figure 5 along with the associated detectors shown in Figure 9.Traffic volumes are utilized to calculate percentages for basic data as well as each of the MOE’s. For instance, traffic counts can be utilized to provide information on the density of traffic or the percentage of heavy vehicles in the overall traffic stream. For analyzing MOE’s, following could be calculated:

- the percentage of FTC events per lane (or across all lanes) can be easily calculated as the number of FTC events divided by the total traffic per lane (or across all lanes),
- the percentage of drivers exceeding a given speed over some time period
- the percentage of trucks in the restricted truck lane.

5. Recommendations

- Based upon the additional evaluation efforts conducted by ITRE, it is the consensus of ITRE and the NCSHP TACT program office that video image processing represents a feasible method for the automated detection of all of the targeted TACT driver behaviors other than driver lane changing. The detection of driver lane changing behavior remains beyond the capability of the current equipment. Since the video image processing capabilities under evaluation also produce a video tape record of traffic operations, it is possible to manually detect lane change behavior from direct observation of the video record.

- The video image processing methodology also permits accurate determination of vehicle class, vehicle volumes by lane, individual vehicle speeds. The ability to collect and quantify operational traffic conditions is extremely valuable in determining extent to which the likelihood of risky driver behaviors is a function of traffic volume and speed conditions, the rate of change of such conditions, etc (for example at the onset of queue development when lane-to-lane volumes and speeds are rapidly changing). If such were found to be the case, perhaps the ability to 'warn' those in the traffic stream that such conditions were developing could reduce the turbulence that normally might occur.

6. Future Research

- **Establish a Research Focus on Rural Road (2-lane undivided) enforcement methods for the manual and automated detection of risky heavy truck and passenger vehicle risky (driver) behaviors**

  Procure and evaluate on a prototype basis handheld laser based speed detection equipment having a capability to detect and provide a measurable (data and video) record of following too close. If effective, work through enforcement channels to get such equipment on the 'approved' list. Work with the judicial component to expedite the use of such data as 'evidence' that can lead to both a high level of prosecution as well as measurable changes in actual on-road behaviors. The hand-held laser with vehicle following distance readout capability could be used to provide a mobile enforcement capability where in-pavement sensors might not be available or feasible.

- **Longitudinal Integration of video Based on In-Pavement Detection**

  The methods proposed for implementation in TACT III constitute 'spot' samples of driver behavior. More continuous longitudinal measures of such behaviors would be preferable. The means to collect more longitudinal data using in-pavement or roadside sensors is possible along much of I-40 in the immediate Raleigh-Durham area. These routes/locations experience a high degree of congestion during peak periods. Research is needed to explore the potential value of augmenting the existing traffic.com detector environment with video-detection capabilities. To do so represents both measurement and system integration challenges. The obvious value of doing so is that it holds the potential for more active means of traffic control than present methods which focus more of incident detection and management.

- **Effective Data Mining of IVBSS Heavy Truck and Passenger Vehicle Database**

A third area of recommended research involves the ‘mining’ of the IVBSS database from the standpoint of gaining a better understanding of the operational likelihood of occurrence of the type of risky behaviors being addressed by TACT. The In-Vehicle Based Safety System (IVBSS) onboard systems provide continuous vehicle and driver data. Of particular interest to TACT would be data from the forward looking crash avoidance system from the standpoint of following too close as well as data from the side looking lane departure systems (inadvertent lane changes or poor lane control can be as potential dangerous in the car-vehicle environment as aggressive lane changing). We would propose that ITRE conduct this work in coordination with the University of Michigan Transportation Research Institute (UMTRI) the lead for the IVBSS heavy truck work. It should be remembered that the IVBSS work involves both heavy truck and passenger vehicle components. To the extent that it is the passenger vehicle that is more often at fault in truck-involved crashes, continuous data on PV operations represents a valuable source of data to address TACT car-truck interactions.

- **Research on the Effectiveness of Providing Real Time Driver Feedback on the Risky Spatial and Temporal Components of Traffic Operation**

There is evidence from the M25 Controlled Motorway and Active Traffic Management (ATM) efforts in the UK that lane-by-lane control of vehicle speeds can be used to increase safety and traffic flow under motorway (i.e., similar to US Interstate) conditions. In the US we have the ability on certain corridors (like I-40 in the Raleigh-Durham, NC area) to collect such data in real time and to use it for more effective traffic control. In a traffic environment involving a high percentage of trucks, part of this improved traffic control capability should address the dynamic relationship between car and truck operations (ala TACT). It is recommended that ITRE establish a collaborative working relationship with the NCDOT and its traffic.com ‘partner’ to develop a operational testbed environment for conducting this type of research.

- **Continued Research on Effective Media Approaches to Increase Driver Awareness of TACT Risky Behaviors**

It is recommended that ITRE and the MCE component of the NCSHP continue to develop and thoroughly evaluate risk based media messages and delivery systems toward the goal of developing high measurable levels of driver awareness and reported behavior change.