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RESEARCH IN BRIEF

Effects of Electronic Stability Control on the Pursuit Intervention Technique

By Tracy Burleson, Emma Covelli, Steve Westerberg and Mike Brady

As electronic stability control systems have been developing, questions have emerged among researchers and practitioners of law enforcement regarding the impact of these technologies on the use of pursuit intervention techniques.

To date, a few formal and informal studies have been conducted to examine the impact of the electronic stability control technology

About this study

on the Pursuit Intervention Technique (PIT). Some have been conducted using computer modeling of the vehicles and others have utilized physical vehicles and live application of the Pursuit Intervention Technique.

These studies have provided the groundwork for this current study, which seeks to further explore the various findings and questions developed from previous work.

This study was conducted in collaboration between the Portland Police Bureau Training Division, the Oregon Department of Public Safety Standards and Training, the Lake Oswego Police Department, the Oregon State Police, Marion County Sheriff's Office, and the Washington County Sheriff's Office. Many individual contributions were made to the development and execution of this study. Key personnel were:

Officer Tracy Burleson, Principal Investigator, Portland Police Bureau; ***Officer Mike Brady***, Lake Oswego Police Department; ***Lieutenant Steve Westerberg***, Department of Public Safety Standards and Training; ***Lieutenant Steve Thiessen*** (ret), Department of Public Safety Standards

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The Pursuit Intervention Technique (PIT) is a maneuver that has been successfully utilized by law enforcement agencies in the United States since the late 1980's.

While many different names for the maneuver exist (Precision Immobilization Technique, Pursuit Intervention Tactic, Tactical Vehicle Intervention), the maneuver is simply a forced-rotation of a moving vehicle.

As vehicle technology has been developing, such as electronic stability control (ESC) systems, questions have developed among researchers and practitioners of law enforcement regarding the impact of these technologies on the use of pursuit intervention techniques.

The PIT maneuver is designed to rotate a vehicle around the yaw axis. Electronic stability control technology is designed to analyze the condition of a vehicle in milliseconds and to implement measures to assist the driver in maintaining control of a vehicle. These ESC responses tend to prevent vehicles from rotating about the yaw axis as much as possible.

This study seeks to build upon previous formal and informal studies, which have examined the vehicle dynamics of electronic stability control systems on pursuit intervention techniques. Including gaining a more in-depth general understanding of the differences with conducting a PIT with ESC equipped vehicles, some specific questions of interest were:

- Does the PIT technique require more steering input or acceleration to push or spin the ESC vehicle?
- Is the pursuing vehicle more effective in a pre-yaw (steeper angle) position prior to making contact with the subject vehicle, as shown in computer simulation model reports?
- Will a PIT with an ESC equipped vehicle result in a "T" position of the two vehicles?
- At higher speeds, is the subject vehicle of the PIT going to correct and rotate to 360 degrees because of ESC?
- Can a car equipped with ESC PIT another car with ESC or will the pursuing vehicle correct to avoid completing the maneuver?

Methodology

A total of 183 physical Pursuit Intervention Technique runs were conducted during the course of this study utilizing various speeds (25 – 60mph) and vehicles (2005 and 2006 Ford Crown Victoria Police Interceptors, 2007 and 2008 Dodge Chargers, and a 2011 Chevrolet

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and Training; ***Sergeant John Clinton***, Portland Police Bureau; ***Sergeant Matt Stimmel***, Portland Police Bureau; ***Sergeant Willie Goff***, Portland Police Bureau; ***Officer Bob Pippen***, Portland Police Bureau; ***Officer Pete Taylor***, Portland Police Bureau; ***Mark Rose***, Videographer, Portland Police Bureau; ***Emma Covelli***, Analyst, Portland Police Bureau.

In addition, the following were a valuable resource of knowledge: ***Racelogic***; ***Mike Hendrickson***, Pennsylvania State University; ***Tony Scottie***, Vehicle Dynamics Institute; ***Donny Leader***, City of Portland Fleet; and various commercial and law enforcement vehicle representatives. Their willingness to share their knowledge and experience of vehicle testing is greatly appreciated and contributed to the success of this study.

This Pursuit Intervention Technique study, completed in 2015, was a cooperative effort with the purpose of studying the potential impact vehicle technologies such as Electronic Stability Control, Traction Control, and other vehicle control options may have on both police and subject vehicles during a PIT maneuver.

The results of this study are available for review and are not intended as a policy statement nor are they a recommendation for agencies to adopt, revise, or remove tactics from their operational policies.

Agencies are encouraged to review the findings in light of their mission and jurisdiction. ■

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Caprice PPV). The 2011 Chevy Caprice and the 2007 and 2008 Dodge Chargers were equipped with electronic stability control systems, while the Ford vehicles were not.

Racelogic Vbox high accuracy GPS data acquisition devices were used in each car to measure vehicle position, acceleration, braking, lateral acceleration, longitudinal acceleration, distance, time, speed, heading, slip angle, yaw rate and rotation of the vehicles[1]. The PIT's were filmed with cameras from inside and outside the vehicles and notations were taken from the drivers experiences with the vehicle characteristics after each PIT.

The main portion of this study utilizes ten runs with the 2006 Ford Crown Victoria Police Interceptor (CVPI) conducting a PIT on the 2005 Ford CPVI at each testing speed (25, 30, 35, 40, and 45mph) and ten runs with the 2006 Ford conducting a PIT on the 2011 Chevy Caprice at the same speeds (100 runs total). Several runs were conducted at each speed in order to assess reliability in the vehicles' responses and ensure accuracy in the results.

In addition to the main study, supplemental exploratory runs were conducted with the Ford Crown Victorias, Dodge Chargers, and the Chevy Caprice at additional speeds and various conditions (e.g. the ESC in performance mode, ESC on versus off, the driver in the subject car attempting to drive out of the PIT, etc.). Some observations from these runs are included in this paper after the main findings. The generalizability from these observations is less certain given the low number of repetitions.

Main study findings

Main differences between conducting a PIT on a car without ESC and a car with ESC

Secondary Impacts There was a greater issue with secondary impacts when conducting a PIT on the Chevy Caprice PPV (with ESC) than the Ford CVPI (without ESC).

- Eighteen secondary impacts were counted on the Caprice versus zero on the Ford. In addition, several secondary impacts were avoided with the Caprice runs due to the driver using braking, steering, and/or acceleration to avoid a crash.
- The severity of secondary impact increased at the higher speeds (40mph and 45mph). Especially at 45mph, the driver consistently had to apply braking, steering, and/or acceleration to avoid a crash (often in significant amounts).

Inconsistency in Vehicle Response In general, the reaction of the Caprice to the PIT was much less consistent than with the Ford.

- The Ford would PIT successfully every run in an overall reliable manner. The range in degree of rotation, yaw, and centerline deviation among PIT runs within a speed category with the Ford was fairly consistent.
- The Caprice had a successful PIT most runs, however, one at 25mph was not successful, one at 40mph was a hanging PIT (when the car slides off during the maneuver creating a wider arc rather than a tight spin but still has enough input to turn the car), and a few additional runs resulted in more of a slide than a spin. Among the higher speeds (35, 40, and 45mph),

[1] The Racelogic Vbox Mini was used in the subject vehicles. This device has a 10Hz GPS engine, internal and external GPS antenna with internal yaw rate sensor. The Racelogic Video Vbox Lite was used in the contacting vehicles to record GPS data at 10 times per second and film the subject car.

the Caprice had a wider range of outcomes particularly in terms of yaw (rotation) and centerline deviation (see *GRAPHS 1 & 2*). The ranges for these differences in measurement were approximately 1 to 4 times greater with the Caprice runs, compared to the Ford runs.

Additional caution may be warranted at higher speeds[2] At 45mph, the Chevy Caprice PPV had more consistent and greater issues with secondary impact.

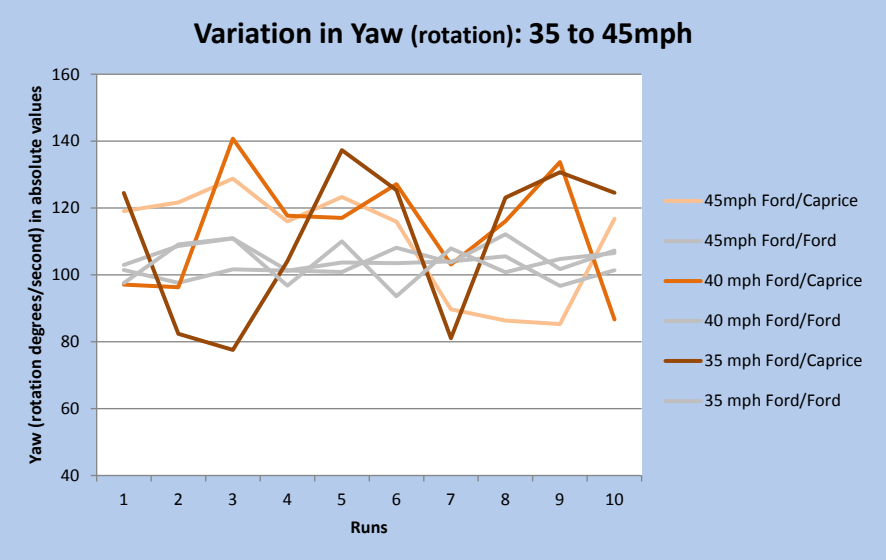
- The contact driver on the Caprice runs had to use a significant amount of extra steering, braking, and/or acceleration to avoid contact (on all 10 runs).
- The average centerline deviation and length of PIT appear to be significantly lower on the Caprice at this speed, compared to the Ford (particularly the centerline deviation, see *GRAPH 3*).

Does the PIT technique require more steering input or acceleration to push or spin the ESC vehicle?

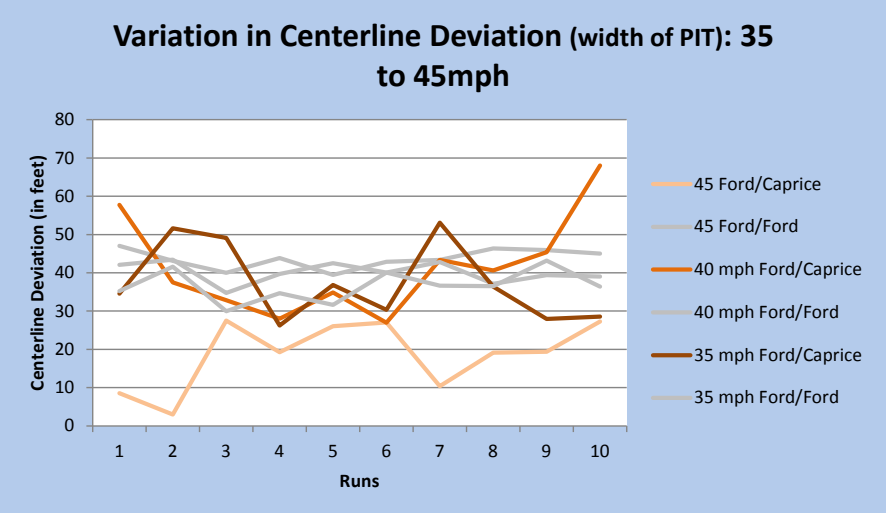
Steering The study did not find that extra steering was needed to PIT the Chevy Caprice PPV (an ESC equipped vehicle; see *GRAPH 4*).

- Out of the 50 runs with the Caprice, the driver reported only a small amount of extra steering (going into the PIT) on four runs (35 and 45mph) and a lot of extra steering on one of the runs (30mph)[3]. Given the small percentage of the time extra steering was used and the high

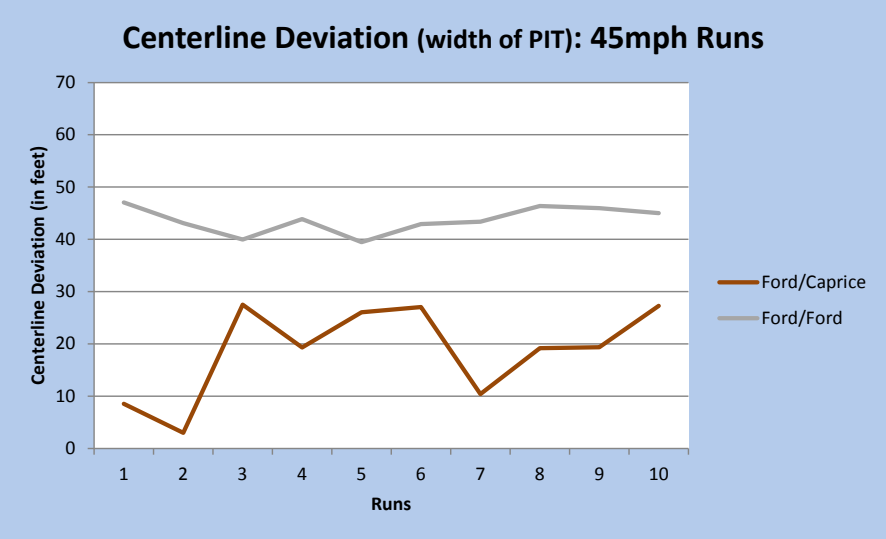
[2] In addition to the main study, a few additional runs were conducted at 50 and 55mph. The average yaw, centerline deviation, and length of spin measures were lower on the runs with the Caprice compared to the Ford. However, given the variability in the vehicle responses, particularly with the Caprice, further tests should be conducted prior to full interpretation.



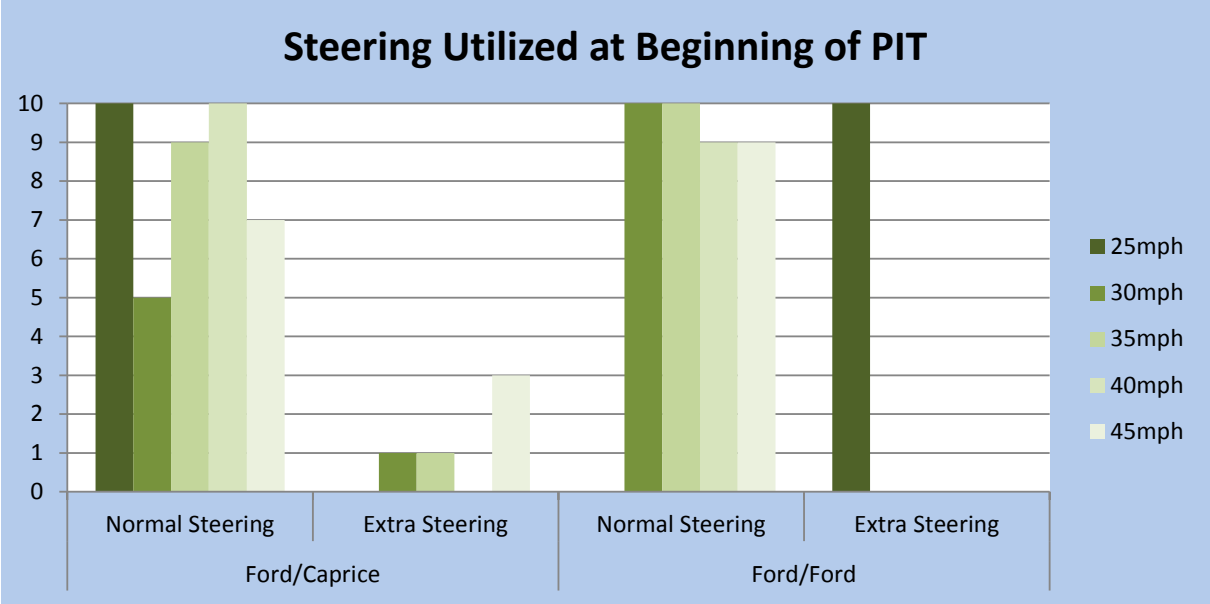
GRAPH 1



GRAPH 2



GRAPH 3



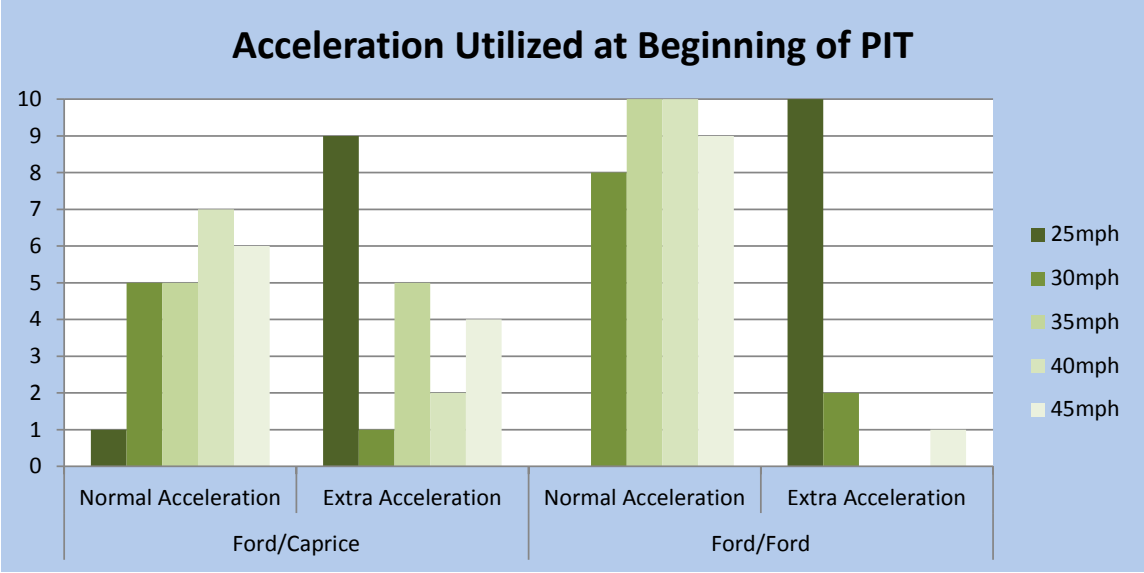
GRAPH 4

percentage of times the PIT was successful without extra steering, the findings support that extra steering is not necessary in order to PIT the Caprice successfully.

- One caveat is it is possible that during a particular PIT, a driver may find that extra steering is helpful to PIT the Caprice (given the variation in responses of the Caprice). Future testing would be needed to verify whether or not this is true.

Acceleration The study did not find that extra acceleration was needed in general to PIT the Chevy Caprice PPV (an ESC equipped vehicle).

- Extra acceleration with the Caprice runs was more common than extra steering. The driver reported a small amount of extra acceleration on 17 runs (some at every speed however, 9 of them were at speed 25 mph which shows no difference than conducting a PIT with the Ford) and a lot of extra acceleration on 4 runs (30 and 35mph)[4]. This finding is less conclusive, although it still shows extra acceleration (given the accuracy of the driver's estimation) is not a necessity in general to PIT the Caprice, particularly in high amounts.
- Further testing on this factor may be of value for more specificity.



[3] Four additional runs were missing confirmation on this variable.

[4] Five additional runs were missing confirmation on this variable.

Is the contact vehicle more effective in a pre-yaw (steeper angle) position prior to making contact with the subject vehicle, as shown in computer simulation model reports?

The study did not directly test this hypothesis by comparing runs utilizing a pre-yaw position and a standard position. There may be value in conducting such a study utilizing real vehicles.

The study found it was not necessary for a contact vehicle to approach a subject vehicle equipped with ESC at an angle during the beginning of a PIT. All runs in the main study were conducted with the standard vehicle positioning.

Observations from additional exploratory runs

As mentioned in the methodology section, additional individual runs were conducted utilizing additional vehicles, speeds, and conditions. Further repetition of runs under these circumstances should be done prior to determining the generalizability of these observations. However, these observations may be useful for guiding future research.

Will PIT with ESC result in a "T" position of the vehicles?

The main study did not support that conducting a PIT with an ESC equipped vehicle will necessarily result in a "T" position of the contact and subject vehicles.

However, during the exploratory runs, two PITs were conducted with the 2006 Ford CVPI as the contact car and the 2008 Dodge Charger as the subject car. In these cases, the Ford did collide into the driver-side rear door of the Dodge immediately after attempting to PIT, resulting in a near "T" position.

According to the manufacturer, the sensitivity of the ESC settings on the 2008 law enforcement version of the Dodge Charger was set particularly high.

It would appear the outcome of a "T" position with cars equipped with ESC is possible, depending on the sensitivity of the ESC setting.

The ESC settings on each of the vehicles involved in our study were obviously slightly different. This can be attributed to the differences in programming by each manufacturer, the natural evolution of the technology, and continuing data being received by the manufacturers from customers with regard to the needs of ESC in operational contexts. The 2008 Dodge Charger we used in testing reacted quite differently than the other ESC-equipped vehicles with the ESC interventions. The 2008 Dodge Charger ESC programming activated sooner and more dramatically than the other vehicles we used in this study.

An aspect of this particular study that needs further consideration is the reality that police package versions of the vehicles are different than civilian versions of the same platforms and thus any ESC activations in a civilian model may have slightly different outcomes than those we obtained in testing.

The 2008 Dodge Charger had a setting that was specific to the model year only and was not used in years prior or after, or on civilian versions. Further research into range of ESC settings among civilian and law enforcement vehicles may be of value.

At higher speeds, is the subject vehicle of the PIT going to correct and rotate to 360 degrees because of ESC?

This study did not show evidence that an ESC equipped vehicle will continue to correct a vehicle around further than non ESC equipped vehicles.

- The subject vehicles with ESC in this study did not rotate 360 degrees on their own. There was one run with the Caprice where the driver of the Caprice intentionally and successfully added steering to facilitate the car turning 360 degrees. The average degree of rotation on all other runs with ESC equipped subject vehicles was approximately 184 degrees.
- The subject vehicles without ESC in this study did not rotate 360 degrees on their own either, with the exception of one PIT on the 2005 Ford at 60mph.

Can a car equipped with ESC PIT another car with ESC or will the pursuing vehicle correct to avoid completing the maneuver?

During this study, some exploratory runs were conducted with the 2007 and 2008 Dodge Chargers conducting a PIT on the 2011 Caprice.

- Eleven runs were completed with the 2007 Dodge Charger conducting a PIT on the 2011 Caprice. Minimal data was collected on these runs. From the data available, it would appear only four of these runs had a successful PIT. Three runs noted that the car slipped off, two noted that the PIT was missed, and two additional runs show data indicating an

[5] In this study the 2008 Dodge Charger could not PIT the 2011 Chevy Caprice PPV with Stabilitrak but could successfully PIT the 2005 Ford CVPI without ESC.

unsuccessful PIT.

- Four runs were completed with the 2008 Dodge Charger conducting a PIT on the 2011 Caprice (around 30mph). All four runs were unsuccessful PITs. The drivers noted heavy ESC engagement. The steering on the Dodge Charger was resistant and the officer car could not turn into the subject vehicle.[5]

Further exploration into this question may be valuable. Some of the exploratory findings also included being able to drive out of a PIT successfully with an ESC equipped vehicle. Using the 2006 Ford CVPI to PIT the 2011 Chevy Caprice with Stabilitrak (the subject vehicle) the 2011 Caprice was moved to 43 degrees during the first PIT and then to 35 degrees in the second PIT.

The driver of the Caprice was able to use acceleration and steer in the direction desired to counter the PIT and continue driving. Once the Caprice pulled away and reduced the matching speed contact between the vehicles, the ESC quickly corrected the vehicle in the direction it was steering and then full acceleration was given back to the throttle and the Caprice successfully drove out of the PIT both times.[6] ■

Study References

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CONCLUSION

In sum, this study supports that there are differences between conducting a PIT on a car with electronic stability control (ESC) compared to one without. During the main portion of the study, the subject car with ESC (2011 Chevy Caprice) did not pose a serious safety risk to the people in either vehicle.

The most prominent differences found were a greater occurrence of secondary impacts and less consistency in vehicle responses, such as whether the car would PIT successfully, the rotation of the car, and the width of the PIT.

At many of the speeds, the car with ESC had a larger range of outcomes compared to the car without ESC, which had a significantly greater amount of consistency in vehicle responses.

Overall, the study found that utilizing extra steering or acceleration was not a necessity for conducting a successful PIT on the car with ESC.

The findings indicate that the PIT maneuver is still very much a finesse technique, and this may be even more the case with cars equipped with ESC.

This study did not find using aggressive steering or acceleration to be necessary and in some cases it may lead to more secondary contact situations. Too much acceleration can also move the contact car up into the side of the subject vehicle, increasing the likelihood of contact at the doors.

Drivers of the contact vehicles need to be ready to tap the brakes to allow separation of PIT's with ESC equipped vehicles. At higher speeds (such as 45mph), the driver may need to utilize braking and steering immediately after a PIT to avoid contact.

The findings also indicate that further systematic research into the interactions of electronic stability control systems on pursuit intervention techniques would be of value to ensure effective technique and safety as vehicle technology evolves.

Although this particular study did not thoroughly explore the impact of various ESC settings, the exploratory vehicle runs did reveal that the sensitivity of the setting can make a difference in how vehicles respond to the PIT.

Further research into the range of ESC settings used by manufacturers and the impact of various ESC setting on the PIT maneuver may be beneficial for law enforcement and car manufacturers. ■

[6] The same exercise was repeated using the 2006 Ford CVPI to PIT a non-ESC equipped 2005 Ford CVPI. The 2005 Ford CVPI was able to separate from the matching speed input but the slide was so abrupt and counter steering wasn't enough to straighten the 2005 Ford CVPI which slid to the left and then hard to the right all the way across the roadway, almost into a collision with the 2005 Ford CVPI, the pursuing or contacting vehicle. The non ESC vehicle was unsuccessful in driving out of the PIT.