



Homeland Security

FEDERAL LAW ENFORCEMENT TRAINING CENTERS

Training Research

Electronic Stability Control

and the Precision Immobilization Technique



TOP RIGHT: Screen shot of computer monitored driver controls with live views from camera mounts on vehicles during the ESC and the PIT testing. MAIN: The PIT as seen from inside the pursuit vehicle. LEFT: A FLETC driving instructor demonstrates the technique.

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Electronic Stability Control (ESC) and the Precision Immobilization Technique (PIT)

INTRODUCTION

ELECTRONIC STABILITY CONTROL (ESC) systems have been mandated by the Federal Motor Vehicle Safety Standards since the 2012 model year, but have been on the mass market as a vehicle option since 1988 (Lie, Tingvall, Kraft, & Kullgren, 2006). ESC systems vary by manufacturer and are marketed under different names, such as StabiliTrak™, Electronic Stability Program™, Dynamic Stability Program™, etc. ESC systems are designed to reduce vehicle yaw or rotation when placed in an out-of-control spin.

The ESC is an on-board safety system that automatically increases the stability of a vehicle during critical maneuvering situations by correcting understeering or oversteering errors. If the vehicle loses control (defined as when one wheel or more is moving faster or more slowly than calculated from the steering input and turning angle [yaw]), braking is applied to one or more wheels, and the engine power may be reduced (according to the manufacturer's design).

The Precision Immobilization Technique (PIT) maneuver has been used by law enforcement since the 1980s to disable a fleeing vehicle. PIT is also used in protective operations as a means to remove an aggressor vehicle from a motorcade or convoy. The PIT was developed by Bill Scott Raceway (BSR), Inc. out of Summit Point Raceway located in West Virginia, a training group that specializes in evasive driving and other highly specialized driving maneuvers (Peterson, 2006). PIT was introduced as a law enforcement technique by Fairfax County Police Department (VA) during the 1980s. The PIT maneuver consists of applying lateral pressure to the rear quarter panel of the fleeing Target vehicle resulting in a predictable spin-out action of the Target vehicle. The predictable spin-out action is one of the reasons the maneuver is considered a precision technique.

It was first noted by Zhou, Lu, and Peng (2008) in their simulated studies that the response of the vehicle equipped with ESC could make the PIT maneuver less effective. Further, at the 2015 Association of Law Enforcement Emergency Response Trainers (ALERT) conference, Portland Police Bureau released a research brief: *The Effects of Electronic Stability Control on the Pursuit Intervention Technique*. The Portland study had several interesting findings, such as:

- When conducting a PIT, secondary impacts were more common in Target vehicles with ESC than in vehicles without ESC (a secondary impact is when the force of the initial impact to the Target vehicle causes the Target vehicle to spin around and make a side collision with the PIT vehicle in a T-bone type collision).
- The severity of secondary impacts increased at higher speeds (45 mph and beyond).
- There were inconsistencies in the performance between vehicle makes in either configuration of the study (i.e. Ford versus Chevrolet, Dodge versus Chevrolet, PIT versus Target, etc.).
- There was no evidence an ESC equipped vehicle can correct and rotate to 360 degrees due to ESC.

The Portland study concluded additional research would be beneficial to the law enforcement community.

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Based upon the vehicle dynamics produced by ESC and multiple reports, the Driver and Marine Division (DMD) of the Federal Law Enforcement Training Centers (FLETC) was concerned that these developments could change the way the PIT maneuver was taught to students. The DMD developed a series of tests to determine whether vehicles equipped with ESC react differently to the PIT maneuver than those not equipped with ESC. Also, if vehicles equipped with ESC did react differently, can the PIT maneuver still be used safely, effectively, and predictably as a law enforcement technique?

METHODOLOGY

Several **Racelogic** DriftBoxes were purchased for data collection on the performance of the study vehicles. The DriftBox is a vehicle performance meter with the ability to measure several performance data points on a vehicle (see figure 1). A 10Hz GPS engine, coupled with sophisticated motion sensors will record vehicle performance characteristics such as drift angle, g-force, speed, distance, and acceleration. All parameters are recorded on a Secure Digital (SD) memory card ten times per second for later review and comparison.



Fig. 1

Also, several **Racelogic** VBox Pro vehicle video systems were installed on both the PIT and Target vehicles. The VBox records GPS logging at 10Hz/20Hz, has four 580L and 420L bullet cameras, an internal tank circuit for reliable recording, and logs directly to a SD card (see figure 2). For this study the cameras were placed on the front windshield, the rear window, the driver's side window and the ESC warning light area.



Fig. 2

See figure 3 for the internal set-up of the equipment inside one of the test vehicles.

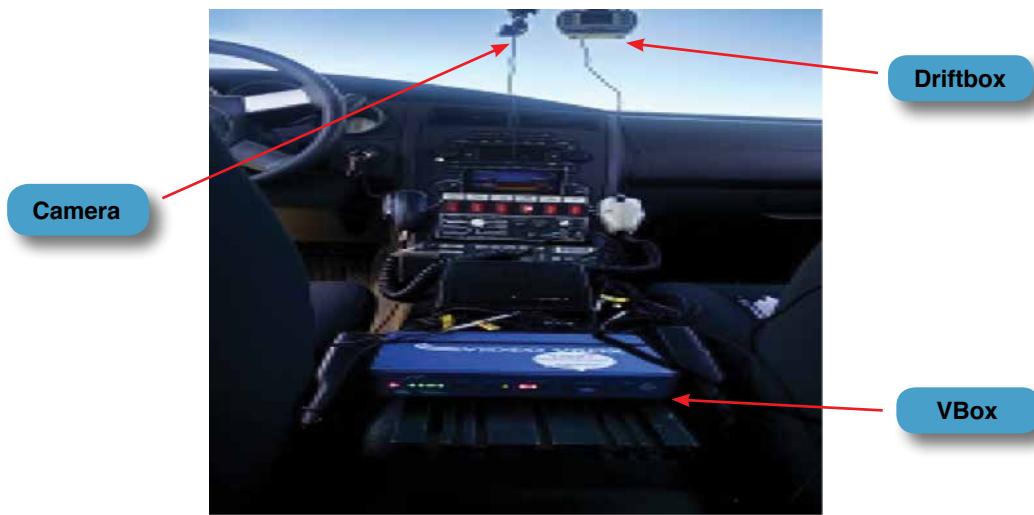


Fig. 3

Vehicles used for the study were:

- Two 2007 Dodge Chargers Rear Wheel Drive (RWD) (ESC)
- One 2013 Ford Police Interceptor (PI) Sedan All Wheel Drive (AWD) (ESC)
- One 2005 Ford Crown Victoria RWD (non-ESC)

(NOTE: This study was restricted by the available vehicles that are used to teach the PIT maneuver at the FLETC. Due to the high level of wear-and-tear on the PIT vehicles, most PIT vehicles used at the FLETC are towards the end of their use as a training platform. The 2013 Ford had been involved in a vehicle rollover causing it to be moved to the PIT fleet sooner than normal.)

The location of the study took place on DMD Range 8 at the FLETC, Glynco, GA campus (see fig 4). Range 8 is 1.5 mile asphalt road course. Data collection took place July through September 2016.

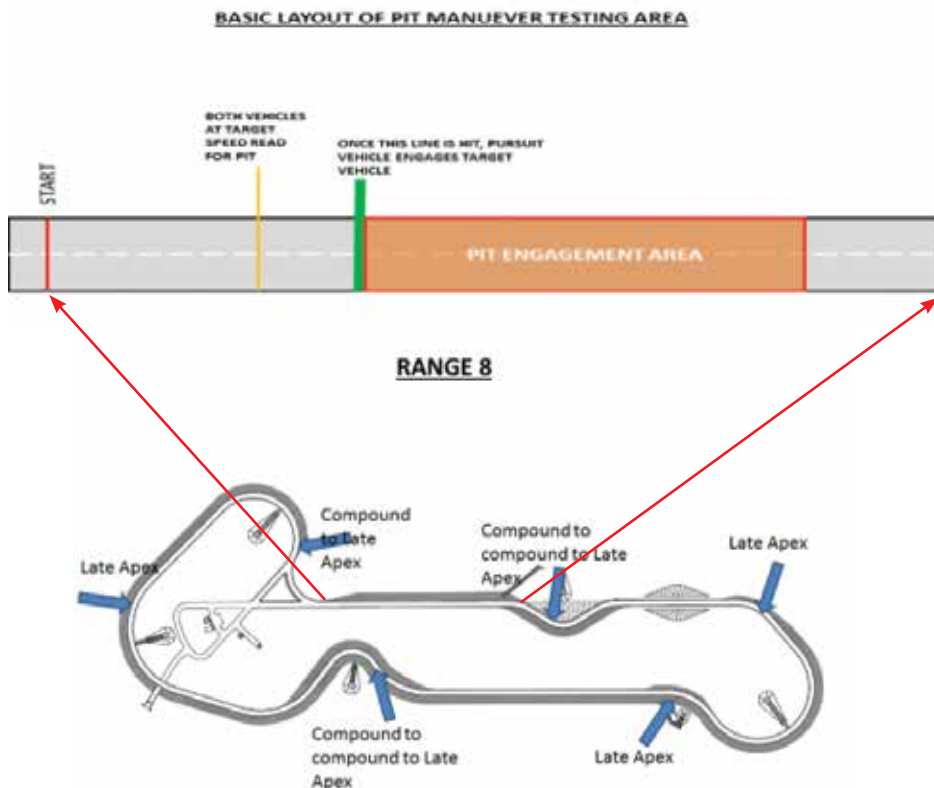


Fig. 4

RESEARCH PROTOCOL

Strict protocols were maintained for proper data collection. There were 10 runs for each run series of data collection. Separate SD data cards were used for each vehicle and each run series. Data sheets recorded the vehicle, driver, time, date, temperature, and humidity.

Though the DriftBox collects numerous data points regarding the performance of a vehicle, for this study only acceleration position, steering wheel angle, brake, centerline deviation, lateral acceleration, and yaw rate were collected. These data points were collected because they have the largest impact on how the PIT maneuver is taught to FLETC students. ESC remained in the default ON mode in both the PIT and TARGET vehicle during testing; in most vehicles the ESC can be turned off.

The 25 mph and 35 mph speeds were used because those speeds correspond to the FLETC lesson plan for teaching the PIT maneuver to students. Fifty-five mph was chosen as the top speed for run-off and safety considerations for the available space in the engagement zone. While target speeds at FLETC may approach 55 mph for demonstration purposes, it is limited to instructors only. Students do not PIT a target at those speeds in training.

Originally, positive and negative PITs were part of the research plan, however, due to the unique characteristics of each vehicle data readings proved to be inconsistent (explanation will be in the results portion of this report). For consistency and ease of data analysis, PITs were conducted on the Target vehicle's driver's side.

Data Collection Research Plan

Vehicle	Data Collection Series 1 Driver's Side (25 mph)	Data Collection Series 2 Driver's Side (35 mph)	Data Collection Series 3 Driver's Side (55 mph)
PIT 2013 Ford Police Interceptor (ESC)	Accelerator Position Steering Wheel Angle Brake	Accelerator Position Steering Wheel Angle Brake	Accelerator Position Steering Wheel Angle Brake
Target 2007 Dodge Charger (ESC)	Centerline Deviation Lateral Acceleration Yaw Rate	Centerline Deviation Lateral Acceleration Yaw Rate	Centerline Deviation Lateral Acceleration Yaw Rate
Target 2005 Ford Crown Victoria (no ESC)	Centerline Deviation Lateral Acceleration Yaw Rate	Centerline Deviation Lateral Acceleration Yaw Rate	Centerline Deviation Lateral Acceleration Yaw Rate

EXPLANATION OF TERMS

PIT vehicle – for this study the PIT vehicle is the pursuing or law enforcement vehicle.

Target vehicle – for this study the Target vehicle is the fleeing or suspect's vehicle.

Positive PIT – is a PIT where the Target vehicle is outside of the PIT vehicle in a turn.

Negative PIT – is a where the Target vehicle is inside of the PIT vehicle in a turn.

The following terms used from collection sensors from the DriftBox data collection for this study are defined below:

For the Target Vehicle

Centerline Deviation (in feet) - Is the ability to track in a straight line under the influence of external conditions such as side wind susceptibility, road camber, suspension geometry errors, deviation under brake test, and deviation during lane change test. By knowing the heading of "straight ahead," the software can determine any deviation from the reference line.

Lateral Acceleration - Lateral acceleration acts on a vehicle sideways to the direction of travel. For example, it is noticeable as centrifugal force moves a vehicle to the outside of a curve when cornering.

Yaw - The yaw rate is the degrees per second that a vehicle is rotating about its vertical axis.

For the PIT Vehicle

Steering Wheel Angle - Measures the steering wheel position angle and the rate of turn in degrees.

Accelerator Pedal - Describes the amount of acceleration input given to the pedal in percentages.

Brake Pedal - Describes the amount of brake input given to the pedal in percentages.

DATA ANALYSIS

Data was collected from both the VBOX and DriftBox. Data was analyzed with VBox Tools software and exported into SPSS and Microsoft Excel for analysis.

RESULTS

PIT Vehicle Data

A noteworthy difference was found on the PIT vehicle's steering wheel angle between PITting a vehicle with ESC and the Target vehicle without ESC (see Fig. 5). For the PIT maneuver to maintain precision and predictability, greater steering input is required when the Target is equipped with ESC.

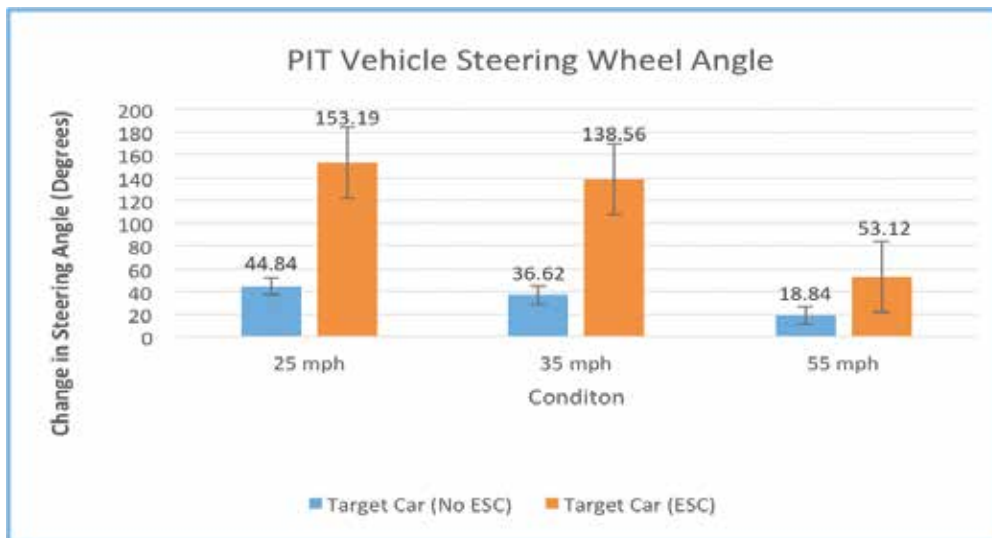


Fig. 5. PIT Vehicle Change in Steering Wheel Angle

There was also a noteworthy difference found on the PIT vehicle's accelerator pedal between PITting the Target vehicle with ESC and without ESC (see Fig. 6). These findings show additional throttle input is required to consistently successfully PIT the Target vehicle equipped with ESC.

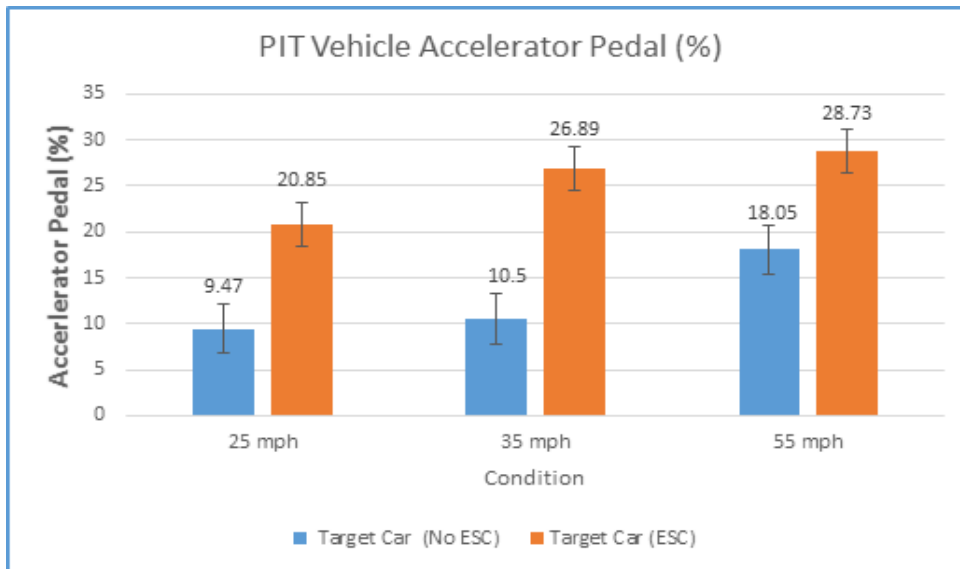


Fig. 6. PIT Vehicle Accelerator Pedal

There was also a noteworthy difference found on the PIT vehicle’s brake pedal between PITting a vehicle with ESC and a vehicle without ESC (see Fig. 7). Significant braking was required during the follow-through to avoid secondary impact with the Target equipped with ESC. It should be noted that many times the brake lights came on the Target vehicle when the driver was not pressing the brakes. This caused the PIT drivers to back off on the PIT maneuver. Further research found that in some of the model vehicles used the brake lights come on when ESC is activated, even though the brakes were not applied. Additionally, the ESC activation light would occasionally come on in the PIT vehicle when making contact with the Target vehicle.

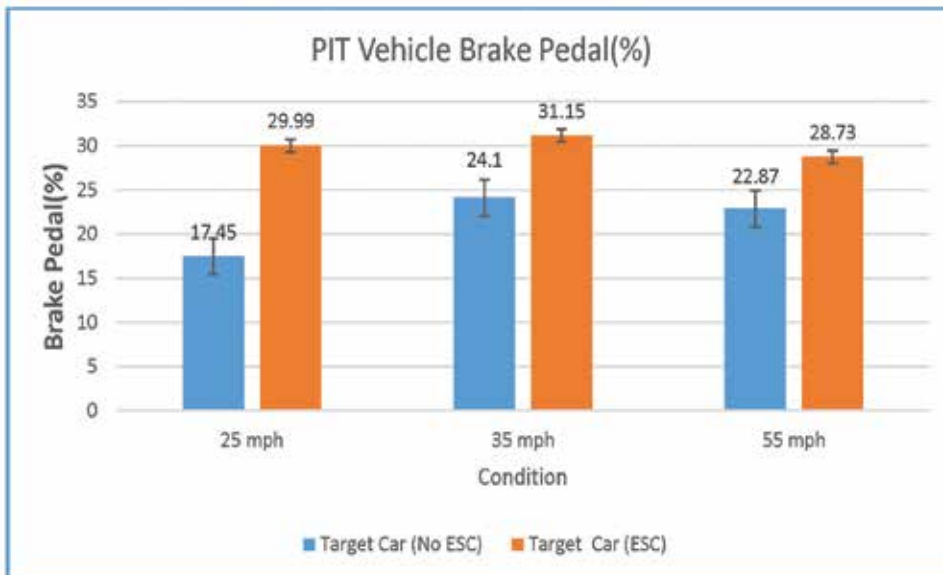


Fig. 7. PIT Vehicle Brake Pedal

Target Vehicle Data

Centerline deviation (CLD) was used to measure the distance the Target vehicle rotated during the PIT in feet. A noteworthy difference was found regarding the centerline deviation in the Target vehicle once pitted between the ESC Target and the Non-ESC Target (see Fig. 8). This shows the Target vehicle is not going to travel as far as a vehicle not equipped with ESC. Officers PITting a Target vehicle should be prepared for an ESC equipped Target coming to rest closer to the PIT vehicle. The PIT vehicle officer needs to be cognizant that a suspect's vehicle will be closer than a Non-ESC vehicle, thus reducing the officer's reactionary gap. Anecdotal information found that many times when a Non-ESC vehicle spins out, the vehicle's engine stalls out. This research found ESC vehicles' engine did not stall out.

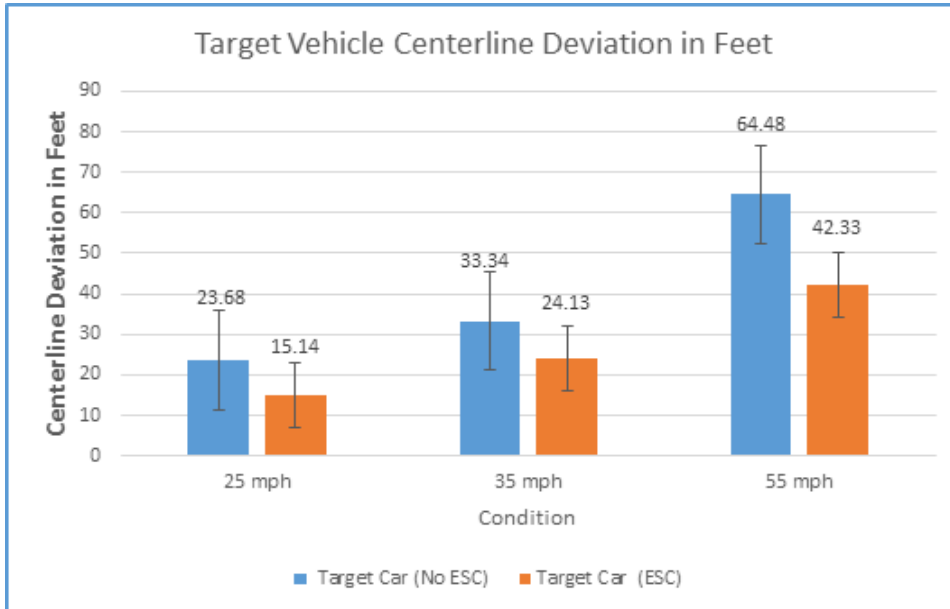


Fig. 8. Target Vehicle Centerline Deviation

A noteworthy difference was found regarding the lateral acceleration in the Target vehicle once pitted between the ESC Target and the Non-ESC Target (see Fig. 9). These results show how the ESC automatically intervenes in the ESC equipped vehicle.

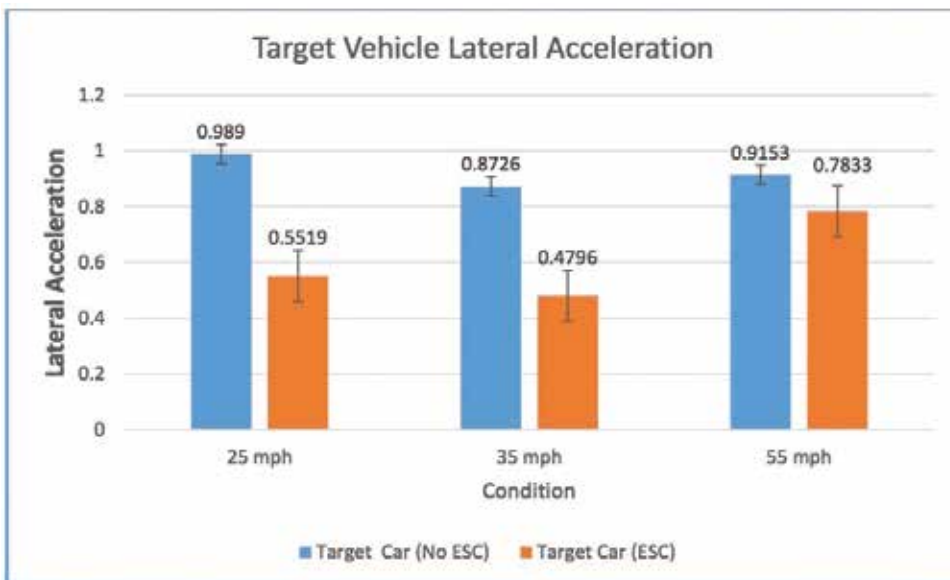


Fig. 9. Target Vehicle Lateral Acceleration

Though the yaw rate data was collected, the data was inconsistent. However, there were some trends noted that suggests an ESC equipped Target vehicle had an increased yaw rate in degrees per second

versus a Non-ESC Target vehicle.

Positive PIT Data

When the Target vehicle was equipped with ESC, the PIT vehicle had to use additional steering input. The additional steering input caused a tendency of the PIT vehicle to drop tires off the road (8 out of 9 times).

Negative PIT Data

When the Non-ESC Target vehicle was PITted in a negative turn, 15 of 15 PITs were successful. When the ESC Target vehicle was PITted in a negative turn, only 32 of 64 attempts were successful. This 50% success rate of the ESC Target vehicle only tells part of the story. Success varied greatly depending on the combination of the Target and PIT vehicles. The Dodge Charger was only successful PITting the Ford PI three out of 19 times (16% successful) while the Ford PI was successful 12 out of 15 times (80%) on the Dodge. Using the Ford Crown Victoria (Non-ESC) to Target the ESC vehicles was mildly successful pitting in 17 out of 30 attempts (56%). The Crown Victoria was more successful on the Dodge (66%) than on the Ford PI (46%) but showing a much smaller range than seen with the ESC vehicle targeting the other ESC vehicle. These data show there were obvious manufacture differences between vehicle companies.

DISCUSSION

These findings demonstrate the driver of a PIT vehicle will have to increase steering input, acceleration, and braking to successfully PIT a Target vehicle equipped with ESC versus a Non-ESC vehicle. Further, the PIT vehicle driver will have to be cognizant the Target vehicle will also respond differently by not spinning out as far and could cause a secondary impact versus a Target that does not have ESC. The Target vehicle with ESC could also come to rest much closer to the PIT vehicle thus reducing an officer's reactionary gap.

These findings will necessitate a change in the PIT curriculum, and how the PIT maneuver is taught at the FLETC. Findings showed that:

- The "sweet spot" is reduced in both Target and PIT vehicles.
- Instructors need to emphasize to driving students to have sound four corner awareness in the PIT vehicle. In addition, instructors need to actively coach their students regarding both brake light activation in the Target vehicle along with ESC light activation in their vehicle.
- Instructors need to make their students aware that they may hear and feel the vehicle perform differently when ESC activates, this will hopefully reduce student anxiety or errors.

Modern day motor vehicles are becoming safer every year. Yet, some of these safety factors are impacting the way the PIT maneuver is conducted. This research project was restricted by the vehicles (year, make, model) which were used by this study. Every year manufacturers are continuing to update their vehicles safety features, both for the Target vehicles and the Police (PIT) vehicles, complicating the PIT maneuver. As these changes are made, future studies will need to continue on the PIT maneuver.

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The Precision Immobilization Technique Step by Step



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