



The author(s) shown below used Federal funding provided by the U.S. Department of Justice to prepare the following resource:

Document Title: Pursuit Technology Impact Assessment, Version 1.1

Author(s): Morgan Gaither, Mark Gabriele, Nancy Andersen Sean Healy, Vivian Hung

Document Number: 250549

Date Received: January 2017

Award Number: 2013-MU-CX-K111

This resource has not been published by the U.S. Department of Justice. This resource is being made publically available through the Office of Justice Programs' National Criminal Justice Reference Service.

Opinions or points of view expressed are those of the author(s) and do not necessarily reflect the official position or policies of the U.S. Department of Justice.

AOS-16-0787

January 2017

NIJ RT&E Center Project 14-5

PURSUIT TECHNOLOGY IMPACT ASSESSMENT

Final Report

Version 1.1

Morgan Gaither
Mark Gabriele
Nancy Andersen
Sean Healy
Vivian Hung

Prepared for:



Prepared by:

The Johns Hopkins University Applied Physics Laboratory
11100 Johns Hopkins Rd.
Laurel, MD 20723-6099

Task No.: FGSGJ

Contract No.: 2013-MU-CX-K111/115912

This project was supported by Award No. 2013-MU-CX-K111, awarded by the National Institute of Justice, Office of Justice Programs, U.S. Department of Justice. The opinions, findings, and conclusions or recommendations expressed in this publication/program/exhibition are those of the author(s) and do not necessarily reflect those of the Department of Justice.

CONTENTS

	<u>Page</u>
1. Introduction to the Pursuit Technology Impact Assessment	1
1.1 NIJ RT&E Center Overview.....	1
1.2 Pursuit Background and Assessment Tasking	1
2. Executive Summary and Key Findings.....	5
2.1 General Findings	5
2.2 StarChase-Specific Findings	6
3. StarChase Pursuit Management System	7
3.1 System Overview	7
3.2 Web-based Position Mapping and Tracking Report.....	11
3.3 Training.....	12
3.4 Installation and Maintenance	13
3.5 Noted System Attributes and Suggested Improvements.....	13
4. Impact Assessment Approach.....	15
4.1 StarChase Site Visit	15
4.2 End-User Site Visits.....	15
4.3 Police Pursuit Definition.....	15
4.4 Data Collection	16
4.5 Case Studies	17
4.6 Quantitative Data Analysis	19
4.7 Assumptions and Limitations	20
5. Case Study 1 – Urban Law Enforcement Agency	21
5.1 Case Study 1 – Agency and Location Overview	21
5.2 Case Study 1 – Pursuit Policy/StarChase CONOPS.....	21
5.3 Case Study 1 – StarChase Qualitative Data Summary	22
5.4 Case Study 1 – StarChase Quantitative Data Analysis Results	22
6. Case Study 2 – State/Rural Law Enforcement Agency	24
6.1 Case Study 2 – Agency and Location Overview	24
6.2 Case Study 2 – Pursuit Policy/StarChase CONOPS.....	24
6.3 Case Study 2 – StarChase Qualitative Data Summary	25
6.4 Case Study 2 – StarChase Quantitative Data Analysis Results	26

7.	Case Study 3 – Urban Law Enforcement Agency	27
7.1	Case Study 3 – Agency and Location Overview	27
7.2	Case Study 3 – Pursuit Policy/StarChase CONOPS.....	27
7.3	Case Study 3 – StarChase Qualitative Data Summary	28
7.4	Case Study 3 – StarChase Quantitative Data Analysis Results	29
8.	GPS Technology Legal Impact Assessment – Summary	31
9.	Conclusions.....	33
9.1	General Findings.....	33
9.2	StarChase-Specific Findings	34
10.	Recommendations.....	35
11.	Acronyms/Abbreviations	36
	Appendix A. Legal Impact Assessment – Further Reading.....	37

FIGURES

Figure 1: Launcher Installed in a Vehicle.....	8
Figure 2: Air Compressor Installed in a Vehicle	8
Figure 3: Console/Controller	9
Figure 4: Console/Controller and Installation within Different Vehicles.....	9
Figure 5: GPS Tracking Tags	11

TABLES

Table 1: Law Enforcement Agency Case Studies – Qualitative Criteria Comparison Summary	18
Table 2: Interpretation of Confidence Interval Limits	19
Table 3: Case Study 1 – Count Data and Probability Estimates for Apprehension.....	23
Table 4: Case Study 1 – 95% Confidence Interval*	23
Table 5: Case Study 2 – Count Data and Probability Estimate for Vehicle Recovery	26
Table 6: Case Study 2 – Count Data and Probability Estimate for Suspect Apprehension.....	26
Table 7: Case Study 2 – 95% Confidence Intervals *	26
Table 8: Case Study 3 – Count Data and Probability Estimate for Vehicle Recovery	29
Table 9: Case Study 3 – Count Data and Probability Estimate for Suspect Apprehension.....	29
Table 10: Case Study 3 – 95% Confidence Intervals *	30

ACKNOWLEDGMENTS

The assessment team would like to acknowledge the input, feedback, support, and other contributions of the participating law enforcement agencies, especially those agencies included as case studies in this assessment, and Dr. Sheldon Greenberg of the Johns Hopkins University.

1. INTRODUCTION TO THE PURSUIT TECHNOLOGY IMPACT ASSESSMENT

1.1 NIJ RT&E Center Overview

In 2014, the U.S. Department of Justice, National Institute of Justice (NIJ) selected two Johns Hopkins University (JHU) divisions — the Applied Physics Laboratory (APL) and the School of Education, Division of Public Safety Leadership — for a 5-year cooperative agreement to establish a National Criminal Justice Technology Research, Test, and Evaluation Center (NIJ RT&E Center).

The purpose of this center is to conduct focused RT&E activities to inform NIJ’s non-forensic technology research, test and evaluation efforts. It also conducts RT&E activities to support NIJ’s efforts to inform practitioners, policymakers, and researchers regarding technologies or technology-related issues for purposes of improving criminal justice policy and practice. The activities of this center vary from year to year depending on the needs of NIJ’s non-forensic technology RT&E efforts. The RT&E Center is staffed by JHU/APL and the JHU Division of Public Safety Leadership using a core management team and selected scientists and engineers who function as subject matter experts.

Under NIJ Cooperative Agreement Award No. 2013-MU-CX-K111, the NIJ RT&E Center was tasked to accomplish an independent assessment of StarChase, LLC’s (referred to hereafter as “StarChase”) remote vehicle tracking system and its impact on vehicle pursuits and public safety. A team consisting of former law enforcement personnel, system engineers, and data analysts conducted this impact assessment. It investigates how police operations are impacted by the use of the StarChase system. This assessment relies on both quantitative data and qualitative feedback from the end-user community.

1.2 Pursuit Background and Assessment Tasking

The assessment of a newly emerging technology to mitigate the dangers of police pursuits requires the understanding of the law enforcement profession and problem domain. This section provides the context for the assessment of a relatively new pursuit management technology that tags and tracks a fleeing vehicle.

The National Highway Traffic Safety Administration (NHTSA) defines police pursuits, pursuit terminations, and pursuit fatalities as follows:

A police pursuit is defined as an event initiated by a law enforcement officer operating an authorized motor vehicle giving notice to stop (either through the use of visual or audible emergency signals or a combination of emergency devices) to a motorist who the officer is attempting to apprehend, and that motorist fails to comply with the signal by either maintaining his/her speed or taking evasive action to elude the officer’s attempt to stop the motorist. A pursuit is terminated when the motorist stops, the attempt to apprehend is

discontinued by the officer, or at the direction of a competent authority. A police pursuit related death is defined as all fatalities recorded in a pursuit-related crash.¹

Fatalities related to police pursuits have drawn the attention of researchers in academia and in the medical community. In *Motor Vehicle Crash Deaths Related to Police Pursuits in the United States*², Dr. Fred Rivara states that “approximately 300 lives are lost each year in the United States from police pursuit related crashes and one third of these among innocent people, not being pursued by the police.” Using the publicly available Fatality Analysis Reporting System operated by NHTSA, “There were 260–365 police pursuits ending in a fatality annually in the United States for a total of 2654 crashes involving 3,965 vehicles and 3,146 fatalities during the nine year study period.” Rivara further characterizes the fatalities stating, “altogether 102 . . . of the fatalities were non-motorists [pedestrians or bicyclists], 40 were police officers, 946 . . . were occupants of vehicles uninvolved in the police pursuit, and three were unknown.”

In *Policing: Continuity and Change*³, Geoff Alpert, Roger Dunham, and Meghan Stroshine report that, “the vast majority of vehicle pursuits are initiated for minor criminal or traffic offences.” In the second edition of this text, Geoff Alpert et al. state, “40 percent of pursuits result in property damage from a motor vehicle crash, with damage costs to be over \$1,000,000 annually. Almost half of the pursuit crashes also result in physical injuries to the occupants of the fleeing vehicle, police officers or uninvolved third parties.” AELE law library research indicates that costs for these pursuit events are \$1.4Billion in court settlements alone⁴. This point is further underscored by recent news headlines which continue to identify ongoing liability for agencies. In 2015, USA Today published a series of articles related to the impact of and data reporting concerns with police pursuits.^{5,6,7}

Efforts to mitigate high-risk and unnecessary police pursuits have been addressed through policies, training, and technology. In the area of policy, Alpert found that, “Most agencies had written policies governing pursuit but many had been implemented in the 1970s. Of those that

¹ Definitions of Pursuits (In House Definitions) 2004. Washington DC: National Highway Safety Administration, U.S. Department of Transportation

² Rivara, Fred and C. D. Mack, “Motor Vehicle Crash Deaths Related to Police Pursuits in the United States,” *Injury Prevention* (2004); 10; 93–95

³ Alpert, G.P., Roger G. Dunham, and Meghan S. Stroshine, *Policing: Continuity and Change*, Long Grove, IL: Waveland Press, 1997

⁴ AELE Law Library, Case Summaries: Civil Liability of Law Enforcement Agencies & Personnel, “Pursuits – Law Enforcement,” <http://www.aele.org/law/Digests/civil111.html> (accessed December 10, 2014)

⁵ Thomas, Frank, “Feds Fail to Track Deadly Police Pursuits”. USA Today. (29 Sept. 2015) <http://www.usatoday.com/story/news/2015/09/29/nhtsa-police-high-speed-pursuit/72617864/>

⁶ Thomas, Frank, “FBI Vastly Understates Police Deaths in Chases”. USA Today. (26 Oct. 2015) <http://www.usatoday.com/story/news/2015/10/26/fbi-police-deaths-vehicle-pursuits-chases/74349056/>

⁷ Frank, Thomas. “Police Chase Deaths Up in 2014”, USA Today. (28 Dec. 2015), <http://www.usatoday.com/story/news/2015/12/23/police-chase-deaths-up-in-2014/77762174/>

had updated them, most had made them more restrictive to control”⁸. In the area of training, Alpert’s study found that, “There is a lack of initial and continuing training for law enforcement on the specific risk factors and benefits of pursuit driving. The survey of police recruits before and after academy training indicates that such education can have a major impact on attitudes.”

Several technologies are currently available for the law enforcement market to mitigate the risk of police pursuits including some widely adopted tools such as spike strips, OnStar Stolen Vehicle Slowdown (SVS), aerial vehicles, nets and barricades, and StarChase. Size and type of agency, budget, availability of training, and commitment are among the factors that influence the use of such tools.

Spike strips are intended to puncture the pursued vehicle’s tire(s). In *A Longitudinal Examination of Officer Deaths from Vehicle Pursuits*⁹, Johnson states that, “A national survey of 419 large police departments found that these spike strip devices were the anti-pursuit technology used most by these agencies, and were strongly supported by officers in the field.” While supported by the law enforcement community, deployment of spike strip devices is not without risk. The *Officer Down Memorial Page*¹⁰ lists officers struck and killed during the use of spike strip devices. The first death listed occurred in 1996 with 26 additional officers killed through October 2015.

“The technology known as Stolen Vehicle Slowdown (SVS) enables OnStar advisers, working in tandem with law enforcement agencies, to slow down stolen vehicles remotely”¹¹. The SVS technology was first designed to assist law enforcement in dealing with stolen vehicles.

In his 1997 study, *Police Pursuits and Training*, Alpert states the following:

*Continued improvements in technology to slow or stop a vehicle may reduce risks in pursuits. The use of helicopters or fixed-wing airplanes, while expensive, already can allow law enforcement to monitor a fleeing suspect unobtrusively and alert ground units when he or she stops. The spike belt, a strip of spikes that slowly deflate a vehicle’s tire when run over, has been available for several years; nets and barricades are being developed to bring vehicles to a stop; and emerging technology promises remote-control devices to allow police to shut down a car’s electrical system. The data from this study show that a suspect who does not know he or she is being pursued will drive in a reasonably safe manner, and suspects who know they are being pursued and drive dangerously will slow down after the police terminate their pursuit.*¹²

⁸ Alpert, Geoffrey P., “Police Pursuit: Policies and Training,” Research in Brief, Washington D.C.: U.S. Department of Justice, National Institute of justice, May 1997, NCJ 164831

⁹ Johnson, Richard R., “A longitudinal examination of officer deaths from vehicle pursuits,” *International Journal of Police Science and Management* 15 (October 2013): 82

¹⁰ The Officer Down Memorial Page, <http://www.odmp.org/> (accessed October 9, 2015).

¹¹ Baker, George, “Halting Auto Theft in Its Tracks: OnStar’s Stolen Vehicle Slowdown Protocol,” *Police Chief Magazine* LXXV (October 2015) <http://www.policechiefmagazine.org/> (accessed October 9, 2015)

¹² Alpert, Geoffrey P., “Police Pursuit: Policies and Training,” Research in Brief, Washington D.C.: U.S. Department of Justice, National Institute of justice, May 1997, NCJ 164831

The pursuit technology developed by StarChase relies on Alpert's conclusions from a report to NIJ where he states, "Suspect's whose vehicles are tagged behave as if they are free from the police and slow down when the police stop chasing, in many cases within a minute".¹³

StarChase's technology, a commercial off-the-shelf system, is currently in use by several law enforcement agencies in the United States. The system contains a compressed-air launcher mounted behind the grille of a police vehicle. This launcher has a laser target capability and discharges an adhesive projectile/tag containing a global positioning system (GPS) module that then transmits coordinates back to law enforcement entities in real-time via a digital roadmap¹⁴. This study assesses the impact of this tagging and tracking technology.

¹³ Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, "Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology," Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.

¹⁴ StarChase, LLC. Web site: <http://www.starchase.com>. Accessed May 2014.

2. EXECUTIVE SUMMARY AND KEY FINDINGS

StarChase is a GPS-based system that provides a capability for tracking a fleeing vehicle at a distance by launching and attaching a GPS-tracking tag to a fleeing vehicle and providing real-time data on the vehicle's location. The impact assessment of StarChase by the NIJ RT&E Center does not include investigation or analysis of the technical specifications or performance of the system; rather it strives to describe how police operations are impacted by the use of the system.

To accomplish this, the NIJ RT&E Center focused on data available from end-user agencies. The impact of StarChase was difficult to assess comprehensively due to a number of factors including: inconsistent baseline and use data, varying agency pursuit policies, varying agency uses (including special cases), and limited deployments (the technology is relatively new to the market).

Ten end-user agencies were contacted and site visits were conducted with the three agencies that had the highest number of uses and associated data. These three agencies were in differing geographic locations and had varying pursuit policies. The analysis of their available StarChase use data along with qualitative feedback from the end-users (officers) formed the basis for the impact assessment, with each of the three agencies representing a single case study. While data were not consistent in type or quantity across these agencies, the assessment team was able to identify general findings and StarChase-specific findings.

2.1 General Findings

1. GPS-enabled pursuit technologies such as StarChase extend police flexibility by providing remote tracking capability when line-of-sight vehicle tracking becomes unfeasible.
2. Success or failure of a pursuit technology such as StarChase is related to the integration of the new technology into existing pursuit policies and practices.
3. A technology/system "champion" who advocates for its use aids in the successful adoption and integration of a new pursuit technology.
4. Law enforcement agencies that do not have a process in place for deploying and evaluating new technologies may lack the data required to comprehensively assess a technologies' impact and effectiveness.
5. Law enforcement agencies engaged in new technology deployment and evaluation would benefit from an end-to-end assessment process that includes the collection of comparable baseline data.

2.2 StarChase-Specific Findings

1. Implementation and use of StarChase varied among the end-user agencies. In some cases, use was consistent with the stated purpose of the system (e.g., tagging a vehicle during or prior to a pursuit and tracking the vehicle from a distance). In some cases, the agencies deployed the system with a different intended use or Concept of Operations (CONOPS).
2. In two of the three case studies presented, the data suggests that the use of StarChase, when properly¹⁵ deployed, had a positive impact on the pursuit outcome for apprehensions. In the other case study, apprehensions remained high whether the system was properly or improperly¹⁶ deployed.
3. End users' opinion of StarChase is that it is a helpful pursuit management tool, but that it is not a comprehensive solution for avoiding or successfully resolving all possible pursuit scenarios.

¹⁵ Tags adhered to the suspect vehicle and GPS tracking data was received.

¹⁶ Tags did not adhere to the suspect vehicle.

3. STARCHASE PURSUIT MANAGEMENT SYSTEM

3.1 System Overview

The content in this system description chapter is presented for informational purposes and was obtained from the system vendor, StarChase. This system description and any associated technical details and performance described were not assessed or evaluated by the assessment team, as any technical evaluation activities were outside of the scope of the impact assessment task. Further technical details may be obtained from the system vendor.

StarChase is a pursuit management tool that allows an officer to launch non-lethal GPS tracking tags via a compressed-air launcher from the front grille of a patrol vehicle, with the intent of affixing the adhesive-tipped tags to the aft portion of suspect vehicles.¹⁷ The system is capable of launching up to two tags in one load. The system provides an eye-safe green laser and elevation control to assist the officer with targeting the suspect vehicle, as well as readiness feedback to the officer that includes audible and visual cues. Once attached to the suspect vehicle, the tag broadcasts secure Web-based, real-time position mapping data to devices within the officer's vehicle, another officer's vehicle, and/or to the police communications center personnel. The officers then use mapping data during the pursuit to locate the suspect vehicles. Tracking occurs either while the officer continues to pursue at a close distance (i.e., maintaining visual contact), or while the officer monitors from a distance (i.e., purposeful or accidental loss of visual contact). These data are also archived for subsequent analyses.

The StarChase system consists of the following two components¹⁸:

- Launcher system and console/controller
- GPS tracking tags

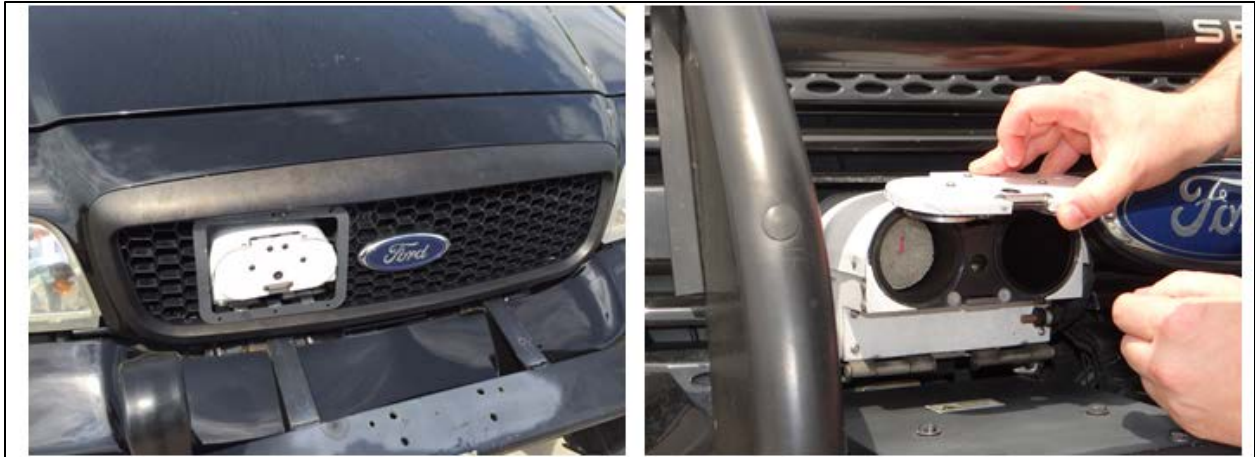
3.1.1 Launcher System and Console/Controller

The launcher system is comprised of a non-lethal, compressed air, dual barrel launcher capable of firing up to two active GPS tracking tags either separately over a period of time or in rapid succession. The launcher is installed in the vehicle grille, as shown in Figure 1. The air compressor is installed in the vehicle engine compartment, as shown in Figure 2. The system also includes an eye safe green laser and elevation control to assist the officer with targeting the suspect vehicle.

¹⁷ Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, "Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology," Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.

¹⁸ Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, "Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology," Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.

The software controls all the functions of the system through a microcontroller unit using a Can-Bus communications architecture. Internal processors control all launcher functions with safety and error checking communicated back to the officer via a series of light-emitting diodes (LEDs) displayed on the console/controller.



Source: Law Enforcement Agency Site Visit

Figure 1: Launcher Installed in a Vehicle



Source: Law Enforcement Agency Site Visit

Figure 2: Air Compressor Installed in a Vehicle

The console, shown in Figure 3, provides launcher readiness feedback to the officer that includes audible and visual cues. This allows the officer to keep his/her eyes up and forward on the target. The console has three green/red LED lights, with a set of LED indicators for both the driver- and passenger-side GPS tracking tags (i.e., left- and right-side tracking tags), which indicate the system status to the officer. The LED's include the following functions for each launcher barrel:

- P: Pressure Indicator. Green/ Red reports system's readiness
- S: Serial and GPS status. Green/ Red reports system's readiness
- T: Temperature: Indicates adhesive temperature, Green/ Red reports system's readiness



Source: Law Enforcement Agency Site Visit

Figure 3: Console/Controller

The console is located inside the vehicle cabin and is installed within the driver's reach and vision, examples of which are shown in Figure 4. A key fob is also available to operate the system remotely (i.e., if the officer is outside of the agency vehicle).



Source: Law Enforcement Agency Site Visit

Figure 4: Console/Controller and Installation within Different Vehicles

When the system is turned on, it takes approximately 10 seconds for the system to warm up; the actual time is based on the ambient temperature and how long it takes the heater to warm the adhesive. The system is then armed and ready to launch tags (i.e., there is no time delay associated with the launcher air pressure). For each initiation, the system remains armed for 3 minutes. If no user input is detected during this time, the system is automatically disarmed and locked, or the user can manually disarm the system prior to the 3 minutes.

The launcher operations include the following modes¹⁹:

- **Training Mode:** ON/OFF. Training mode ON is selected by the user(s) when using the system for officer training (with non-GPS tracking tags). Training mode OFF is selected by the user(s) when the system is in use for a pursuit with GPS-tracking tags. In this OFF configuration, the compressed air system is activated and tags are present in the launcher. The laser is in ON mode and is in a slow blink mode with no audible indicators.
- **Live Mode:** ON. Live mode ON is selected by the user(s) when they intend to use the system with GPS tracking tags. In this mode, the compressed air system is activated and the GPS tracking tags are present in the launcher. The laser is in ON mode and is in a slow blink mode with no audible indicators. The launcher door is unsecured. A “status check” GPS ping/signal is transmitted to the database once per hour.
- **Live Mode:** OFF. Live mode OFF is selected by the user(s) when officers do not intend to use the system. The compressed air system is deactivated and the GPS tracking tags are placed in standby mode. The laser is in OFF mode with no audible indicators. The launcher door is secured. A “status check” GPS ping/signal is transmitted to the database once per hour.
- **ARM Mode.** ARM mode is selected when officers intend to use the system to immediately tag a suspect vehicle with GPS tracking tags. The tags are placed in rapid update mode (i.e., 5 second GPS update rate), and the system is readied for FIRE mode. Audible and visible cues include a constant beeping accompanied by the green laser entering a fast (i.e., double time) blink mode. A GPS signal update is transmitted to the database once every 5 seconds. If no user input is detected, the system returns to Live Mode OFF after 3 minutes.
- **FIRE Mode.** FIRE mode is selected when officers intend to launch a GPS tracking or training tag. The system is ready to deploy. Audible and visible cues include a constant beeping accompanied by the green laser entering a very fast (i.e., triple time) blink mode.

3.1.2 GPS Tracking Tags

The system is capable of launching up to two GPS tracking tags in one load. The locations of these tags within the launcher are referred to as the driver-side tag and the passenger-side tag, with the launcher being physically located on the passenger side of the vehicle grille. Figure 5 shows examples of the GPS tracking tags. The tags consist of a GPS tracking tag inside a “shell” casing. This shell has a hard sponge-like tip coated with an adhesive, enabling the tag to adhere to the target vehicles.

¹⁹ Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, “Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology,” Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.



Source: Law Enforcement Agency Site Visit

Figure 5: GPS Tracking Tags

The GPS tags are consumables that must be replaced after use. The tags, once deployed/used, are recovered and sent back to StarChase for either refurbishment or replacement.

3.2 Web-based Position Mapping and Tracking Report

Once a GPS tracking tag is launched and adheres to a vehicle, the tag broadcasts secure Web-based, real-time position mapping data to devices within the officer's vehicle, another officer's vehicle, and/or to the police communications center personnel. The GPS data are transmitted by the tag every 3 to 5 seconds, and these updates are used by the officers to locate the suspect vehicle(s). A sample screen shot of the mapping portal, and the associated tracking data in real time, can be found in the StarChase report²⁰.

The GPS tracking software sends an update every 3 to 5 seconds (as mentioned above) when deployed, and uses a longer update interval when armed prior to deployment. The database displays when the system is armed and then continues to send location data until the agency discontinues its use or the tag comes to a stop (either by a completed pursuit, or a failure of the tag to stick to the target vehicle).

These data are also securely archived in the StarChase tracking report for subsequent analyses. The tracking report includes the following information obtained from both the officers and the StarChase unit²¹:

²⁰ Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, "Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology," Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.

²¹ Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, "Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology," Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.

- Time and date of pursuit
- Duration of pursuit
- Distance of pursuit
- Type of area (e.g., congested, open highway); officer supplied information
- Vehicle speed after the tag is deployed; officer and suspect vehicle
- Minimum vehicle speed during the pursuit
- Maximum vehicle speed during the pursuit

3.3 Training

Initial StarChase training is typically conducted at the agency location by a StarChase representative and takes approximately 30–45 minutes. A “train the trainer model” can be used, or the training can be distributed per officer. Some agencies choose to send a representative to be trained at StarChase. This designee returns to the agency location to train the remaining officers who will be using the system. Initial training includes familiarization of StarChase and the tracking software, along with scenarios that include real-time pursuits and deployment of training tags for each user.

In-service training is typically conducted at the agency location by a StarChase representative or previously trained officers that use or have used the system and takes approximately 15–20 minutes. Some agencies incorporate this training into the start of shift roll call sessions and some hold special training sessions. Some agencies vary the frequency from only when needed (e.g., when officers take possession of a StarChase equipped vehicle) to multiple times per year (e.g., organized group training). In-service training may include a review of the tracking software, discussion of deployment techniques and best practices, as well as deployment of training tags for each user.

Whether during initial or follow-up training, officers indicated that training at speed, as opposed to being stationary, is important to successfully using the system, as it allows the end-user to practice judging the appropriate speed and distance for deploying the tag(s).

Agency personnel often review the deployment of StarChase tags. Feedback is provided either in a group setting or individually to each officer, in order to improve use of the system. This feedback facilitates the discussion of successful deployment techniques and best practices. Additionally, some agencies provide officers with a laminated training card obtained from StarChase, which serves as a reminder of the proper system operation and tactical procedures.

As noted by the law enforcement agency representatives that use StarChase, a key element in the successful implementation of the system is obtaining buy-in from supervisors and executives. Training for supervisors and police communications center personnel is typically coordinated by the agency, and emphasis is placed on knowledge of the approved StarChase policy. Some agencies are planning to conduct integrated StarChase training (i.e., combined officer, supervisor, and police communications center personnel) in the near future.

3.4 Installation and Maintenance

The StarChase system takes approximately 2 hours to install. Some agencies have StarChase representatives install the systems, and, after training, others have it installed using their own agency installation capability.

StarChase hardware maintenance is typically performed by the law enforcement agency and occasionally by StarChase representatives as necessary. StarChase representatives may visit the agency to facilitate system upgrades, conduct refresher training, and to address any additional officer requests.

As the GPS tags are consumables that must be either replaced or refurbished after use, at the time of this report, StarChase instituted a pre-determined unlimited data plan for the GPS tracking service associated with each tag. This data plan provides unlimited tag refurbishments/replacements and GPS tracking data for each of the installed StarChase systems.

3.5 Noted System Attributes and Suggested Improvements

Weather and other environmental conditions are known factors in the effectiveness of the StarChase system. StarChase cautions users to be aware of extreme temperature and excessive condensation and dirt when using the system due to interference with the tag adhesive effectiveness. However, officers noted that the tags sometimes adhere to the target vehicles in adverse weather conditions.

Some officers indicated that the GPS data tracking does not always function in inclement weather (e.g., heavy rain, heavy fog). This is an expected limitation of GPS technology due to signal strength being easily disrupted in these conditions.

Within one agency, it was noted by officers that extreme heat caused the original tag adhesive to slowly “melt” over time inside the system launcher units. Upon learning this, StarChase improved the adhesive, thereby reducing the effect. StarChase made additional improvements to the system resulting in a reduction of the launcher unit temperature by about 10 degrees Fahrenheit.

Some officers observed degradation of the adhesive over time due to factors such as moisture and dirt contamination, as some of the tags can remain in the units for extended periods without use. Agencies that have experienced this issue are implementing processes to rotate the tags after a deployment.

Some officers indicated that having the ability to override the laser sighting system would be beneficial. Some chose to override the aiming indicator out of concern that suspects might be able to anticipate that the system is in use when the laser is visible, particularly at night, and some chose to override the aiming indicator because they found they did not require the laser for targeting the suspect vehicles. During the course of this assessment, StarChase did introduce an on/off switch for the laser.

It was noted by officers that some had successfully used the system via the key fob feature while outside of their vehicle. All systems are installed with two (2) key fobs. This enables officers to place fobs in multiple locations within the vehicle (e.g., attached to the steering wheel, on their keychain). Additionally, officers also suggested that a hand held version of a tagging device could be more versatile, allowing tagging from any position relative to the suspect vehicle.

Since the StarChase systems are GPS-enabled and communicate wirelessly, they must be shut down properly (i.e., similar to a computer). One agency ensured this was possible by wiring the units to a separate battery, which allows the units to stay powered on, and when necessary, shut down properly.

Because the StarChase system sends a “status check” GPS ping/signal during non-use times, some agencies expressed an initial concern for officer safety. For example, those who take home vehicles could be at risk of having their home location obtained. After learning that the tag broadcasts secure mapping data, the officer concerns were alleviated.

The law enforcement agency representatives who were interviewed attributed most of the failed/missed tag deployments to user-error, but noted that in a few instances the failure/miss may have been due to a system failure (e.g., misaligned launcher, etc.) or maintenance issue.

One agency launched a large media campaign to inform the public of their use of the StarChase system, resulting in not only awareness of the technology but also providing unintended details about the system and potential defeat capabilities. The agency believes, in retrospect, that having multiple press releases and a large media campaign on the technology was a mistake in that many suspects have learned to remove and/or defeat the tags. Upon learning of this experience and to assist with public information guidance, StarChase has developed “agency talking points”. These talking points are shared with agencies so they can be best prepared to share information with their community while retaining tactical advantage’s over offenders.

All agencies consistently noted that the communications with StarChase personnel regarding concerns or suggested improvements have been met with timely and effective responses.

4. IMPACT ASSESSMENT APPROACH

4.1 StarChase Site Visit

The assessment team visited StarChase at the initiation of this task in February 2015. StarChase representatives provided the team with background information on the operational and design details of the system (see previous section 3), a system demonstration, and a copy of a previous StarChase evaluation report²². In addition to this background information, the vendor provided the assessment team with contact information for some of its end-user agencies. The assessment team used this contact information, in addition to other information gained independently, to begin communication efforts with system end-users.

4.2 End-User Site Visits

In initial police pursuit technologies research, it was determined that there are a limited number of law enforcement agencies across the United States that currently use the StarChase tagging and tracking technology. Based on the list of end-users provided by StarChase, as described above, the assessment team contacted these end-users via email exchanges and telephone interviews to discuss the assessment. Three agencies had a significant number of StarChase systems and were using them as a pursuit management tool. These three agencies were visited to collect details and data regarding how StarChase is used and its impact on pursuit outcomes.

As described later in section 4.5, and Table 1, the three agencies varied in size, geographical location, use of the system, and data collection practices.

Due to the sensitive nature of the data collected and the limited number of end-users, the information and analysis associated with the site visits are generalized and presented as a case study. All specific references to law enforcement agency and officer details have been removed to avoid any potential protected information issues or inadvertent advertisement of the agencies that employ the StarChase system.

4.3 Police Pursuit Definition

In talking with the various law enforcement agency representatives that have selected, acquired, and deployed StarChase as one of their police pursuit management tools, it became evident that the use of the system varies between agencies due to varying policy, crime, and environmental/location factors.

²² Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, "Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology," Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.

The definition of police pursuit is described previously in section 1.2. To expand on this police pursuit definition, it was realized from discussions with end-users that StarChase is used as a pursuit management tool in a wide range of police pursuit activities and operations including (but not limited) to the following:

- Stolen vehicles
- Eluding
- Evading
- Unlawful flight
- Driving under the influence
- Disturbances
- Narcotics
- Human trafficking
- Failure to yield
- Armed car-jacking
- Carrying concealed firearms
- Burglary
- Assisting the U.S. Customs and Border Protection (CBP)

4.4 Data Collection

The assessment team planned to gather quantitative and qualitative data from the StarChase end-user law enforcement agencies, including (but not limited to) the following:

- Costs associated with police pursuits with and without the use of StarChase (e.g., number of police personnel involved, number and severity of injuries, damage to police equipment)
- Data on StarChase use (e.g., number of launched tags per pursuit event, number of launched tags that adhered to the target)
- Costs associated with the StarChase life cycle (e.g., cost to purchase, costs to install and maintain, shelf life of the GPS tags, cost to modify police vehicles)
- Training requirements (e.g., number of police personnel trained, training hours, frequency of refresher training)
- Operator assessment of the system (e.g., ease of use, reliability, ergonomics, likelihood of subsequent purchases)

In interviewing the end-users, it became evident that StarChase data collection varies greatly across agencies. Some data are collected and stored by the vendor (i.e., StarChase) in the StarChase tracking report (e.g., time and date of pursuit, duration, type of area/environment,

speeds)²³. Some agencies documented only the successful use of StarChase. Others documented varying details of each use (e.g., the number of GPS tags launched per pursuit, apprehensions/arrests, collisions, injuries, cost damages). The approach to the quantitative data analysis is described below in section 4.6, with analysis results described in each case study.

4.5 Case Studies

Because of the variances in police pursuit definition, system use, and data collection practices, multi-agency comparison was not feasible. Therefore, the assessment was performed at an individual law enforcement agency level. Using this approach, case studies were identified and described pertaining to the different agency missions and specific StarChase usages. This case study approach was useful in that it allows a law enforcement agency, which may be considering acquiring this technology, to identify with a specific case study agency.

Table 1 shows a qualitative summary comparison of the specific agency case studies described within this report. Common criteria were identified for the case studies to provide a high-level comparison. These criteria include the following:

- Usage Environment – agency geographic area of responsibility
- Policy – specific agency-related StarChase use policy highlights
- Staff – the number and type of staff members supporting the agency
- Vehicles – number of agency vehicles that are equipped with StarChase
- Time of Day – agency shifts where StarChase is used
- Types of Crime – criminal activities typically occurring when StarChase is used
- Approach – agency pursuit tactics
- Success Definition – what constitutes a successful apprehension for that specific agency

Please note that while quantitative data were collected from each of the case study agencies, the results of the data analysis is not correlated to the specific agency attributes (e.g., location, policy). In other words, it would be inaccurate to assume that an agency similar to that described in a specific case study is likely to have similar quantitative results as those shown in this assessment.

²³ Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, “Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology,” Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.

Table 1: Law Enforcement Agency Case Studies – Qualitative Criteria Comparison Summary

Criteria	Case Study 1	Case Study 2	Case Study 3
Usage Environment	<ul style="list-style-type: none"> Urban and suburban environment City of approximately 1 million citizens 	<ul style="list-style-type: none"> State-wide/highway (rural) environment with some urban and suburban use 	<ul style="list-style-type: none"> Urban environment City of nearly 250,000 citizens
Policy	<ul style="list-style-type: none"> Pursuit policy allows for pursuits to continue (even after deployment of StarChase) 	<ul style="list-style-type: none"> Pursuit policy allows for pursuits to continue (even after deployment of StarChase), also used preemptively 	<ul style="list-style-type: none"> Pursuit policy does not allow for pursuits to continue (even after deployment of StarChase), except for violent felonies (tag and continue to closely follow)
Staff	<ul style="list-style-type: none"> Approximately 2,500 sworn law enforcement and support personnel 	<ul style="list-style-type: none"> Approximately 1,200 sworn employees (state-wide) 	<ul style="list-style-type: none"> 550 sworn officers and over 200 civilian support staff
Vehicles	<ul style="list-style-type: none"> All StarChase equipped vehicles are shared (10 vehicles) 	<ul style="list-style-type: none"> All StarChase equipped vehicles are take-home (seven vehicles) K-9 unit (focused criminal unit, not traditional traffic violations) 	<ul style="list-style-type: none"> Almost all StarChase equipped vehicles are take-home (11 vehicles); one shared vehicle
Time of Day	<ul style="list-style-type: none"> All shifts 	<ul style="list-style-type: none"> All shifts 	<ul style="list-style-type: none"> All shifts
Types of Crimes	<ul style="list-style-type: none"> Stolen vehicles plus five other types of criminal behavior 	<ul style="list-style-type: none"> Stolen vehicles plus three other types of criminal behavior 	<ul style="list-style-type: none"> Stolen vehicles plus seven other types of criminal behavior; focus is stolen vehicles
Approach	<ul style="list-style-type: none"> Pursuing officers normally drop back significantly from the suspect vehicle once tag is deployed 	<ul style="list-style-type: none"> Pursuing officers tag the vehicle and back off, create a “bubble” to follow suspect(s) 	<ul style="list-style-type: none"> Undercover officers follow the vehicle from a safe distance, follow it, and then box it in
Success Definition	<ul style="list-style-type: none"> Apprehending the suspects 	<ul style="list-style-type: none"> Capturing the vehicle and contraband Apprehending the suspect(s) is secondary 	<ul style="list-style-type: none"> Capturing the vehicle and apprehending the suspect(s) Losing the suspect(s) is considered a failure (even if the vehicle is captured)

4.6 Quantitative Data Analysis

Each of the three end-user agencies provided quantitative data from which StarChase's impact on police pursuits could be assessed. The metric for assessing this impact is the probability estimate of a successful pursuit outcome, i.e., the vehicle and/or suspects were apprehended. In particular, the study team compared the successful outcome probability for two scenarios:

- Proper tag deployment – adheres to the suspect vehicle and the agency receives GPS tracking data
- Improper tag deployment – the tag is fired, but misses the vehicle, fails to adhere to the vehicle, or GPS tracking data is not received

If the probability of a successful outcome is greater for a proper tag deployment than for an improper tag deployment, this is an indication that the StarChase system has utility in terms of the pursuit outcome. Note that the analysis does not consider the case in which the StarChase system is not used at all. The study team did not receive such data from any of the case study agencies.

Since these probabilities are estimated from the data, one needs to determine whether the observed difference in probabilities is statistically significant. A statistically *significant* difference gives evidence that the two probabilities are different. This means that, in terms of usefulness in determining a successful pursuit outcome, there is a difference between a properly and improperly deployed StarChase tag. In contrast, a statistically *insignificant* difference indicates that the observed probability difference occurs purely by chance. This means that the pursuit outcome is independent of whether or not a tag is properly deployed.

The study team used the confidence interval to determine the significance of the probability difference. To better understand this, we introduce the notation $P_{A|PT}$ and $P_{A|IT}$ to signify the probabilities of apprehension for a proper and improper tag deployment, respectively. The difference is defined to be $\Delta P = P_{A|PT} - P_{A|IT}$. The confidence interval is denoted as $[\Delta P_L, \Delta P_U]$, where ΔP_L (deltaP_L) is the lower-limit bound and ΔP_U (deltaP_U) is the upper-limit bound. The interval ΔP has a confidence level of 95%, which means that it encompasses the true probability difference with a probability of 0.95. With this notation in mind, the statistical significance is determined according to Table 2.

Table 2: Interpretation of Confidence Interval Limits

Sign ($[\Delta P_L, \Delta P_U]$)	Interpretation
$[-, -]$	ΔP statistically significant ($P_{A IT} > P_{A PT}$): <ul style="list-style-type: none"> • Properly deployed tag has a negative impact on pursuit outcome
$[+, +]$	ΔP statistically significant ($P_{A PT} > P_{A IT}$): <ul style="list-style-type: none"> • Properly deployed tag has a positive impact on pursuit outcome
$[-, +]$	ΔP statistically insignificant: <ul style="list-style-type: none"> • Tag deployment makes no difference in pursuit outcome

The analysis that follows entails four important caveats.

1. The probability of apprehension (for either vehicle or suspect) is assumed to be constant for all of the pursuit events. An example of the probability *not* being constant is if, given a proper tag deployment, some officers are better than others are at apprehending the suspect at the conclusion of a pursuit.
2. The analysis does not account for other factors that might affect the apprehension probability, such as weather, driving conditions, and suspect behavior.
3. Improper tag deployment is not the same as not using StarChase at all. As a result, one should not assume the apprehension probabilities under these two conditions are similar. As an example, consider an improper deployment in which a tag is fired, strikes the suspect vehicle, but bounces or falls off. Upon hearing the tag strike his/her vehicle, the suspect might believe he/she is being tracked and alter his/her behavior. This behavior could be different than if StarChase was not used at all (and the suspect had no reason to think he/she was being tracked).
4. For some pursuits, a second StarChase tag was fired because the first one either missed the suspect vehicle or failed to adhere. In these cases, the status of the second tag was considered. If it adhered to the vehicle and GPS tracking data was received, the pursuit event was counted as having a proper tag deployment.

Because of the limited data provided by the case study agencies, the study team had to make these assumptions in order to proceed with the analysis. If the user agencies believe the caveats are substantially violated, then more detailed data is required. For instance, if one has reason to think the pursuit outcome depends on the experience of the law enforcement officer, each pursuit event should include the officer's experience, e.g., number of years on the job.

4.7 Assumptions and Limitations

- The StarChase system is a relatively new pursuit management technology that tags and tracks a fleeing vehicle. The technology has matured over the past several years, with Star Chase providing next generation system versions based on end-user feedback and StarChase internal research and development. As a result, the systems employed by the end-user agencies are of varying technology maturity.
- The analysis provided in this assessment is limited to qualitative and quantitative data available to the assessment team as provided by the end-user agencies.
- The quantitative analysis in this assessment does not account for factors that could affect the outcome of a pursuit other than those identified. Such factors might include weather, pursuit speed, and whether a suspect's driving behavior changes if he/she thinks his/her vehicle is tagged.
- This assessment is not intended to be a performance test or evaluation of the StarChase system.

5. CASE STUDY 1 – URBAN LAW ENFORCEMENT AGENCY

The agency in this case study employs the StarChase technology in a populated urban setting with some suburban terrain. This agency consists of just over 2,500 sworn law enforcement and support personnel who conduct police operations within a city of nearly a million citizens, as well as the local international airport, city parks and lakes, and municipal courts.

5.1 Case Study 1 – Agency and Location Overview

Use of StarChase was conducted by a group of six full-time officers who make up a Police Technology Unit. The unit is responsible for identifying potential new technologies for use within the department. This agency purchased 10 StarChase systems via a NIJ grant. The grant was used to pay for the initial hardware, installation, and training for the 10 units. While the initial acquisition costs were covered by the NIJ grant, the continual sustainment costs are now a regularly budgeted item paid for by the agency.

The agency consists of the main headquarters and three substations: North, South, and East. The 10 StarChase systems were originally placed in vehicles assigned to the North substation. During the initial deployment, only the patrol officers in the North substation were trained on the use of the system; no supervisors or other staff in this substation had StarChase training or experience. After this initial deployment, the StarChase system was not being utilized as often as anticipated. Based on this low level of activity, the vehicles were relocated to the East Substation where they are currently being utilized. As a result of lessons learned from the first deployment, supervisors and support staff, in addition to officers, were trained in the use of the StarChase system. Use of the system during this second deployment increased significantly. It was reported by the agency that this more successful second deployment resulted from including a broader scope of personnel in the training curriculum. StarChase data from both the North and East Substations were provided for analysis.

The East substation includes two day shifts (with one shift working at a time), three evening shifts (with two shifts working at a time), and two night shifts (with one shift working at a time), with approximately 10 officers per shift. StarChase is installed in shared vehicles and only officers trained in the use of the system are permitted to drive StarChase enabled vehicles. StarChase equipped vehicles were initially assigned to evening and night shifts only. Since the assessment team's site visit, day shift was added to the rotation and now uses the system as well. Data analyzed in this assessment includes information from all shifts.

5.2 Case Study 1 – Pursuit Policy/StarChase CONOPS

Pursuit policies of the agencies that employ StarChase as a tool influence how the system is used. For this agency, eluding (i.e., when a suspect does not pull over but continues to follow traffic laws) is a misdemeanor and is not considered a reason for pursuit; whereas evading (i.e., not pulling over and refusing to follow traffic rules) is a felony and is considered rationale for pursuit.

This agency incorporated specific language to address the use of StarChase into its existing pursuit policy. This system-specific policy allows for StarChase equipped vehicles to move

ahead of other police vehicles during a pursuit. Once the StarChase tag has been successfully deployed, pursuing vehicles should normally drop back significantly from the suspect vehicle. The decision to continue pursuing or monitor the vehicle from a distance is based on a variety of factors including but not limited to, severity of the offense committed, traffic conditions, speed, and weather. It was reported by the agency that the use of the StarChase system has contributed to positive outcomes by establishing the suspect vehicle's location when it otherwise might be lost.

In addition to use in pursuits, StarChase has been used by this agency preemptively on known stolen vehicles and on vehicles for known suspects with warrants.

5.3 Case Study 1 – StarChase Qualitative Data Summary

Summary of Case Study 1 agency, usage, and success criteria are listed below:

- Urban and suburban environment; city of approximately 1 million citizens
- Pursuit policy allows for pursuits to continue (even after deployment of StarChase)
- Approximately 2,500 sworn law enforcement and support personnel
- All StarChase equipped vehicles are shared (10 vehicles)
- All shifts
- Stolen vehicles plus five other types of criminal behavior
- Pursuing officers normally drop back significantly from the suspect vehicle once tag is deployed
- Success is defined as apprehending the suspects

The agency provided extensive insight into the use of the StarChase system in an urban and suburban environment, and several key observations were identified:

- The definition of pursuit and the approach for how StarChase is deployed may vary significantly based on the environment in which the system is being used.
- Policy and training were noted as key factors in the successful use of the system. In particular, training a broader scope of personnel was shown to greatly increase the use of system in the field.
- The agency confirmed its favorable opinion of the system and plans to continue its use.

5.4 Case Study 1 – StarChase Quantitative Data Analysis Results

The data set provided by the agency of Case Study 1 consists of a set of 46 pursuit events involving the StarChase system. This set was collected over a period of almost 30 months, from May 2013 through October 2015. The outcome of each event (i.e., suspect apprehension) was recorded as was the deployment status of the StarChase tag. These data and the probability estimates are summarized in Table 3.

Table 3: Case Study 1 – Count Data and Probability Estimates for Apprehension

Tag deployment	Num. Tag Deployments	Num. Apprehensions	Prob. of Apprehension
Proper	28	27	$P_{A PT} = 0.96$
Improper	18	18	$P_{A IT} = 1.00$

The probability $P_{A|PT}$ is estimated as the proportion of proper tagging events that lead to an apprehension; in this case $27/28 = 0.96$. $P_{A|IT}$ is similarly defined. Although the observed difference appears to be in favor of an improper tag deployment, the confidence interval level $[-, +]$ as defined from Table 2 indicates that there is no statistically significant difference between proper or improper tag deployments in terms of apprehension probability, as shown in Table 4.

Table 4: Case Study 1 – 95% Confidence Interval*

ΔP	95% Confidence Interval
$0.96 - 1.00 = -0.04$	$[-0.16, 0.18]$

*Because the improper tagging deployments resulted in a perfect apprehension rate, i.e., 18/18, the study team calculated the confidence interval using an implementation of Fisher's exact test. See M.P. Fay, *Exact Conditional Tests and Confidence Intervals for 2x2 tables*, Feb. 2015. The software implementation is in the R Statistical Computing package: exact2X2, ver. 1.4.1, Feb 2015.

In other words, the available data suggest that the probability of a successful pursuit outcome is independent of whether or not the tag is properly deployed.

These results may be related to environmental or unidentified factors (e.g., the suspect heard the tag hit the vehicle and pulled over, even though the tag did not adhere properly). Another hypothesis for these results is that with the use of StarChase, some agency CONOPS may allow vehicles to escape visual contact for periods, providing an opportunity for occupants to flee the vehicle and evade capture, while other agency CONOPS may allow for no escape of visual contact and therefore increase the likelihood that both the vehicle and occupant are recovered. The assessment team did not test these hypotheses for this or other case studies.

6. CASE STUDY 2 – STATE/RURAL LAW ENFORCEMENT AGENCY

The agency in this case study often employs the StarChase technology in a rural setting. The span of use covers miles of interstate highway and open, rugged, and sparsely populated terrain, with some use in an urban city environment. This agency consists of over 1,500 employees and is a state level law enforcement agency working in close partnership with other agencies (including CBP) to protect the public. It is also a service organization providing a broad range of scientific, technical, operational, and regulatory services to the state’s citizens and the criminal justice community.

6.1 Case Study 2 – Agency and Location Overview

Seven StarChase units were purchased by this agency via a Homeland Security Operation Stonegarden grant with the aim of reducing risk in police pursuits. The initial grant funding purchased the StarChase units and a number of replacement tags. These seven StarChase units were initially spread across several districts in the southern portion of the state, and were being used in a limited capacity due to a lack of buy-in by senior level officers. Over the last 3 years, the K-9 District Commander consolidated the StarChase units and transferred them to seven K-9 officers under its jurisdiction. While grant funding purchased the hardware and initial GPS tags, further maintenance and sustainment costs are paid for by the agency.

The Commander’s K-9 District is comprised of 23 K-9 officers across the state with seven of these containing StarChase units. All seven units are take-home vehicles. Shifts for these officers vary with the majority being in the daytime. While organizationally under one command, these units are distributed geographically across the southern part of the state. The K-9 officers do not have routine patrol responsibilities; they are primarily a criminal interdiction unit focused on crimes related to U.S. border security, including narcotics and human trafficking. It is because of these reasons (i.e., southern border location and job responsibilities) that the StarChase units were located to the K-9 District.

6.2 Case Study 2 – Pursuit Policy/StarChase CONOPS

Pursuit policies of the agencies that employ StarChase as a tool influence how the system is used. For this agency, unlawful flight is considered rationale for pursuit. The officers do not initiate pursuits for minor traffic infractions and do not need permission to initiate a pursuit. Officers can request a StarChase equipped vehicle to join a pursuit in progress.

Officers who use StarChase follow a District StarChase policy. This policy was developed as a result of employing StarChase as a pursuit tool and allows the officers to use StarChase at their discretion. While no permission is required to initiate a pursuit or use StarChase, police communications center personnel always notify supervisors when a pursuit is in progress. Due to the agency’s implementation of a distracted driving policy in the autumn of 2014, the GPS monitoring of the StarChase tags can be accomplished by an officer involved in a pursuit (if that officer stops his/her vehicle), or, in some cases, by the police communications center personnel. These personnel are instructed only to relay information and do not have permission to direct resources.

The often rural location of the majority of this agency's K-9 unit pursuits affords the officers the opportunity to back off from the suspect and follow the vehicle from a distance after tagging them. While pursuit locations vary, their highway and more rural pursuit locations often result in apprehension of suspect(s), their vehicle(s), and any contraband or evidence.

After a pursuit where StarChase is used, the K-9 District Commander requests that the involved officer fill out a deployment checklist (i.e., a form created by the Commander in order to describe the StarChase deployment details). This information is used for post deployment data analysis, as well as to obtain replacement tags. A copy of this deployment checklist was provided to the assessment team.

6.3 Case Study 2 – StarChase Qualitative Data Summary

Summary of Case Study 2 agency, usage, and success criteria are listed below:

- State-wide/highway (rural) environment with some urban and suburban use
- Pursuit policy allows for pursuits to continue (even after deployment of StarChase), also used preemptively
- Approximately 1,200 sworn employees (statewide)
- All StarChase equipped vehicles are take-home (seven vehicles); K-9 unit (focused criminal unit, not traditional traffic violations)
- All shifts
- Stolen vehicles plus three other types of criminal behavior
- Pursuing officers tag the vehicle and back off, create a “bubble” to follow suspect(s)
- Success is defined as capturing the vehicle and contraband; apprehending the suspect(s) is secondary

The agency provided extensive insight into the use of the StarChase system in a rural highway-based environment, and several key observations are identified:

- The definition of pursuit and the approach for how StarChase is deployed may vary significantly based on the environment in which the system is being used.
- Policy and training were noted as key factors in the successful use of the system. In particular, “buy-in” on these elements from higher level officers was shown to greatly increase the use of system in the field.
- The agency confirmed its favorable opinion of the system and plans to continue its use.

6.4 Case Study 2 – StarChase Quantitative Data Analysis Results

The data provided by the agency of Case Study 2 consists of a set of 35 pursuit events involving the StarChase system. This set was collected over a period of nearly three years, from April 2012 through March 2015. Twenty-three of these records are labeled *Successful Tags*, meaning that the StarChase tag was properly deployed. The remaining 12 records are labeled *Unsuccessful Tags*, indicating an improper deployment. The outcomes of all of the 35 pursuits are recorded. Each outcome is further labeled to indicate whether the vehicle was retrieved and whether one or more suspects were apprehended.²⁴ The pertinent data and probability estimates for vehicle and suspect apprehension are summarized in Table 5 and Table 6, respectively.

Table 5: Case Study 2 – Count Data and Probability Estimate for Vehicle Recovery

Tag Status	Tags Deployed	Vehicle Recoveries	Prob. of Recovery
Proper	23	22	$P_{A PT} = 0.96$
Improper	12	7	$P_{A IT} = 0.58$

Table 6: Case Study 2 – Count Data and Probability Estimate for Suspect Apprehension

Tag Status	Tags Deployed	Suspect Apprehensions	Prob. of Apprehension
Proper	23	18	$P_{A PT} = 0.78$
Improper	12	4	$P_{A IT} = 0.33$

The probability of apprehension $P_{A|PT}$ for the suspect is estimated as the proportion of proper tagging events that lead to an apprehension; in this case $22/23 = 0.96$. The probability of vehicle recovery is defined in a similar way. Table 7 shows the ΔP 95% confidence intervals.

Table 7: Case Study 2 – 95% Confidence Intervals*

Apprehension	ΔP	95% Confidence Interval
Vehicle	$0.96 - 0.58 = 0.38$	[0.11, 0.70]
Suspect	$0.78 - 0.33 = 0.45$	[0.12, 0.64]

*The confidence intervals were calculated using the score method. See A. Agresti, *Categorical Data Analysis 3rd Ed.*, Wiley, 2013 and references therein.

Note that in both cases the lower and upper limits of the intervals are greater than 0.00 (positive). This is evidence that the difference in probabilities is both statistically significant and in favor of proper tag deployment. In other words, the available data suggests that a properly deployed tag improves the probability of a successful pursuit outcome.

²⁴ In some cases, the suspect vehicle contained multiple riders. For the purposes of this study, if at least one of the riders was apprehended, the pursuit outcome is considered successful.

7. CASE STUDY 3 – URBAN LAW ENFORCEMENT AGENCY

The agency in this case study employs the StarChase technology in a populated urban setting. The span of use covers mainly city streets and populated urban and some suburban terrain. This agency consists of 550 sworn officers and just over 200 civilian support staff who conduct police operations within a city of nearly 250,000 citizens.

7.1 Case Study 3 – Agency and Location Overview

Twelve StarChase units were purchased by this agency via a Bureau of Justice Assistance (BJA), Justice Assistance Grant (JAG) Program. The initial grant funding was used to purchase the StarChase units and the first year of tracking data and a number of tags. The 12 units were installed in take home vehicles, except for one shared vehicle, which is used for patrol. While grant funding purchased the hardware and initial GPS tags, maintenance and sustainment costs are paid by the agency. Yearly funding for the 12 units (e.g., maintenance, data, and tags) is now included as a line item in the agency's annual operating budget.

This agency uses the StarChase units during all shifts. One of the StarChase units is installed in an unmarked vehicle dedicated to a detective with the task of searching for stolen vehicles. Ten of the StarChase units are installed in marked and unmarked vehicles used by officers with the tasks of searching for drug dealers, car thieves, and violent felons. The remaining StarChase unit is installed in a marked patrol vehicle and is shared by officers on patrol.

7.2 Case Study 3 – Pursuit Policy/StarChase CONOPS

Pursuit policies of the agencies that employ StarChase as a tool influence how the system is used. This agency's "Pursuit of a Vehicle or Boat" policy states the following:

- "Whenever an officer attempts to perform a vehicle stop and the operator of the suspect vehicle indicates by their actions an intent to elude or evade apprehension, the officer must determine if there is reasonable cause to believe the person(s) in the vehicle has committed or is committing a violent felony as defined by this order."
- "Pursuits ARE NOT PERMITTED unless necessary to apprehend persons who have committed or are committing a VIOLENT FELONY."
- "The Pursuit SHALL BE TERMINATED if the hazards created by the pursuit outweigh the necessity for immediate apprehension of the suspect."

There are policy sections describing the use (or restriction) of pursuit techniques and technologies/tools. The policy was specifically expanded and modified state the circumstances when StarChase may be used (e.g., wanted felon, probable cause for involvement in felony offense, attempt to flee and elude a traffic stop, reported stolen vehicle) and circumstances when StarChase may not be used (e.g., warrant required by law and not obtained prior to deployment, general investigative tracking, etc.).

If an officer witnesses a violent felony that was just committed, the officer can deploy a tag. If the suspect flees, the officer can follow for a limited duration to attempt to deploy a tag and track

the suspect. This agency's policy does not allow the officer to continue following for an extended distance; therefore, the time window for tagging the suspect vehicle is short.

When the decision to use StarChase is made, the policy outlines that the officer deploying the device immediately notifies a supervisor and communicates if the tag successfully attaches to the vehicle. The deploying officer requests tracking assistance from another officer, or communications personnel trained in using the StarChase Web-based tracking system, to track the tagged vehicle. If tracking assistance is not available, the deploying officer will track the tagged vehicle. After a pursuit, the policy states that a deployment form be filled out and turned in to the Research and Planning Unit along with the used tag for replacement.

Officers indicated that capturing the stolen vehicle, in addition to apprehending the suspect(s), is a key factor in determining the success of their pursuits. They consider the pursuit a failure if they do not apprehend the suspect along with capturing the vehicle.

When using StarChase, an officer will tag a suspect vehicle, track it with the GPS tag data, and then allow some distance to develop between the officer and suspect. The officer does not completely back off, but continues to follow at a safe distance. Concurrently, a surveillance team of unmarked police vehicles tracks the tagged vehicle via the GPS data, as well as visually, and boxes it in once it stops. If the tag misses, the surveillance units are still deployed and they will visually track the suspect vehicle without the GPS tag data.

This agency's standard pursuit procedure, with or without StarChase or any other technology/tool, is that an officer identifies a suspect vehicle, communicates with a surveillance team, and the surveillance team visually tracks and captures/apprehends the vehicle/suspect. If StarChase GPS tagging data are available, it provides additional information for the surveillance team to track the suspect vehicle and ultimately apprehend the vehicle/suspect.

7.3 Case Study 3 – StarChase Qualitative Data Summary

Summary of Case Study 3 agency, usage, and success criteria are listed below:

- Urban environment; city of nearly 250,000 citizens
- Pursuit policy does not allow for pursuits to continue (even after deployment of StarChase), except for violent felonies (tag and continue to closely follow)
- 550 sworn officers and over 200 civilian support staff
- Almost all StarChase equipped vehicles are take-home (11 vehicles); one shared vehicle
- All shifts
- Stolen vehicles plus seven other types of criminal behavior; focus is stolen vehicles
- Undercover officers follow the vehicle from a safe distance, follow it, and then box it in
- Success is defined as capturing the vehicle and apprehending the suspect(s); losing the suspect(s) is considered a failure (even if the vehicle is captured)

This agency provided extensive insight into the use of the StarChase system in an urban and congested environment, and several key observations are identified below:

- The definition of pursuit and the approach for how StarChase is deployed may vary significantly based on the environment in which the system is being used.
- The agency confirmed its favorable opinion of the system and plans on to continue its use.

7.4 Case Study 3 – StarChase Quantitative Data Analysis Results

The data provided by the agency of Case Study 3 consists of a set of ninety-two pursuit events involving the StarChase System. This set was collected over a period of almost 16 months, from October 2013 through February 2015. Each pursuit record contains the tag-status fields ‘MISSED’, ‘ATTACHED’, and ‘TRACK.’ For several pursuits, the tag either missed the suspect vehicle (‘MISSED’ = ‘Y’), struck the vehicle but failed to adhere (‘ATTACH’ = ‘NO’) or the GPS tracking data was not received (‘TRACK’ = ‘NO’). There are 51 of these improper tag deployments.

The outcomes of all 92 pursuits are recorded. Each outcome is further labeled to indicate whether the vehicle was retrieved and whether one or more suspects were apprehended. The pertinent data and probability estimates for vehicle and suspect apprehension are summarized in Table 8 and Table 9, respectively.

Table 8: Case Study 3 – Count Data and Probability Estimate for Vehicle Recovery

Tag Status	Tags Deployed	Vehicle Recoveries	Prob. of Recovery
Proper	41	38	$P_{A PT} = 0.93$
Improper	51	22	$P_{A IT} = 0.43$

Table 9: Case Study 3 – Count Data and Probability Estimate for Suspect Apprehension

Tag Status	Tags Deployed	Suspect Apprehensions	Prob. of Apprehension
Proper	41	25	$P_{A PT} = 0.61$
Improper	51	15	$P_{A IT} = 0.29$

The probability of apprehension $P_{A|PT}$ for the suspect is estimated as the proportion of proper tagging events that lead to an apprehension; in this case $25/41 = 0.61$. The probability of vehicle recovery is defined in a similar way. Table 10 shows the ΔP 95% confidence intervals.

Table 10: Case Study 3 – 95% Confidence Intervals*

Apprehension	ΔP	95% Confidence Interval
Vehicle	$0.93 - 0.43 = 0.50$	[0.12, 0.49]
Suspect	$0.61 - 0.29 = 0.32$	[0.33, 0.63]

*The confidence intervals were calculated using the score method. See A. Agresti, *Categorical Data Analysis 3rd Ed.*, Wiley, 2013 and references therein.

Note that in both cases the lower and upper limits of the intervals are greater than 0.00 (positive). This is evidence that the difference in probabilities is both statistically significant and in favor of proper tag deployment. In other words, the available data suggests that a properly deployed tag improves the probability of a successful pursuit outcome.

8. GPS TECHNOLOGY LEGAL IMPACT ASSESSMENT – SUMMARY

As police agencies purchase pursuit management technologies and develop policies for their use, it is important for them to consider legal mandates and implications. The following is a brief legal impact assessment to provide information for those agencies seeking to purchase and deploy GPS-enabled technologies. While this legal impact assessment mentions the StarChase system specifically, this information is applicable to any GPS-enabled technology that might be used for tagging and/or tracking activities.

The StarChase system's essential function is that of deploying a GPS device to a vehicle in order to facilitate tracking that vehicle during a pursuit. For this and any other GPS device in use by law enforcement agencies, legal considerations, particularly those concerning the Fourth Amendment, unreasonable search and seizure, should be reviewed.

The StarChase tag, the key component of the StarChase system, is a GPS tracking device designed to stick to (tag) and track a vehicle that flees or may flee from the police. The StarChase tag is used by police officers during exigent circumstances—an exception to the Fourth Amendment warrant requirement—in current accepted CONOPS. Under exigent circumstances, police officers may deploy the StarChase tag without a warrant if a person's life or safety is threatened, a suspect's escape is imminent, or evidence is about to be removed or destroyed.²⁵ It is important to keep in mind that exigent circumstances can only be used during "hot pursuit." If the police were to end a pursuit and then track the suspect's vehicle for hours or days after the chase, then the exigent circumstances exception to the Fourth Amendment may no longer apply.

If no warrant exceptions apply, then the Fourth Amendment of the U.S. Constitution protects personal privacy by prohibiting unreasonable searches. The latest Supreme Court decision held that installing a GPS device on a vehicle constitutes a search.²⁶ A subsequent lower federal court decision further clarified that a warrant is needed to install a GPS device on a vehicle.²⁷ While it may be unconstitutional to use a warrantless GPS tracking device under normal circumstances, it may be constitutional under exigent circumstances (e.g., when a license plate reader identifies a vehicle as stolen, the vehicle is tagged with a GPS device and followed). For further details on applicable federal and state ruling, please see Appendix A.

As indicated by the two federal decisions mentioned above, purpose and duration of the GPS use are two key factors to consider when using the StarChase tag. Without a valid warrant and if exigent circumstances and probable cause are not present, police officers should NOT:

- Attach a GPS device to collect evidence in anticipation of a future crime; or
- Attach a GPS device to a suspect's car for an extended period of time.²⁸

²⁵ See definition of exigent circumstances in *Warden v. Hayden*, 87 S. Ct. 850 (1967).

²⁶ *U.S. v. Jones*, 132 S. Ct. 945 (2012).

²⁷ *U.S. v. Katzin*, 769 F.3d. 163 (2014).

²⁸ *Id.* (determining that a GPS device attached to suspect's vehicle without a valid warrant for 2 days was unconstitutional).

Specific rulings outlining other exact uses or special use cases of GPS technology are lacking until other cases are brought to and tested in court. Until then, law enforcement agencies should consider the existence of probable cause and exigent circumstances in addition to the purpose and duration of a pursuit when developing policy pertaining to the use of a GPS device, including the StarChase tag.

9. CONCLUSIONS

The StarChase pursuit technology is a GPS-based system that provides a capability for tracking a fleeing vehicle at a distance by launching (and attaching) a GPS tracking tag to a fleeing vehicle (or one that may flee) and providing real-time data on the vehicle's location. The impact assessment of this system did not include any investigation or analysis into the technical specifications or performance of the system, rather the intent was to determine its effect on police pursuit policies and outcomes. The impact of the StarChase system was difficult to assess comprehensively due to a number of factors including inconsistent baseline and use data, varying agency pursuit policies, varying agency uses (including special cases), and limited deployments (the technology is relatively new to the market). As mentioned previously, the pursuit technology developed by StarChase relies on Alpert's conclusions from a report to NIJ where he states, "Suspect's whose vehicles are tagged behave as if they are free from the police and slow down when the police stop chasing, in many cases within a minute".²⁹ The StarChase system is a tool for providing additional pursuit-related capabilities, and its effectiveness is directly related to pursuit policy and technology implementation CONOPS decisions by each law enforcement agency.

In addition to the specific quantitative and qualitative information given above in each case study, several key findings were identified:

9.1 General Findings

1. GPS-enabled pursuit technologies such as StarChase extend police flexibility by providing remote tracking capability when line-of-sight vehicle tracking becomes unfeasible.
2. Success or failure of a pursuit technology such as StarChase is related to the integration of the new technology into existing pursuit policies and practices.
3. A technology/system "champion" who advocates for its use aids in the successful adoption and integration of a new pursuit technology.
4. Law enforcement agencies that do not have a process in place for deploying and evaluating new technologies may lack the data required to comprehensively assess a technologies' impact and effectiveness.
5. Law enforcement agencies engaged in new technology deployment and evaluation would benefit from an end-to-end assessment process that includes the collection of comparable baseline data.

²⁹ Fischbach, Trevor A., Keo Hadsdy, and Amanda McCall, "Pursuit Management: Fleeing Vehicle Tagging and Tracking Technology," Final Report to the National Institute of Justice, Grant Number 2010-IJ-CX-K022, September 2015, NCJ 249156, available at <http://www.ncjrs.gov>.

9.2 StarChase-Specific Findings

1. Implementation and use of StarChase varied among the end-user agencies. In some cases, use was consistent with the stated purpose of the system (e.g., tagging a vehicle during or prior to a pursuit and tracking the vehicle from a distance). In some cases, the agencies deployed the system with a different intended use or CONOPS.
2. In two of the three case studies presented, the data suggests that the use of StarChase, when properly³⁰ deployed, had a positive impact on the pursuit outcome for apprehensions. In the other case study, apprehensions remained high whether the system was properly or improperly³¹ deployed.
3. End users' opinion of StarChase is that it is a helpful pursuit management tool, but that it is not a comprehensive solution for avoiding or successfully resolving all possible pursuit scenarios.

³⁰ Tags adhered to the suspect vehicle and GPS tracking data was received.

³¹ Tags did not adhere to the suspect vehicle.

10. RECOMMENDATIONS

Given the findings above, the assessment team recommends the following:

- Any agency or institution providing grant funding (or other funding) for the purchase and/or development of pursuit management technologies should establish both baseline and deployment data requirements and expectations for end-users prior to providing the associated funding.
- Any law enforcement agency intending to implement a new pursuit management technology (including a technology such as StarChase) should examine the technology's capabilities and policy implications prior to deployment.
- Any law enforcement agency intending to implement a new pursuit management technology should do so in a way that allows for a temporary or phased approach and evaluation period.
- Operational evaluation of new pursuit management technology should be conducted and should include evaluation of the new system with a focus on performance, lifecycle costs, operational conditions, and policy implications.
- Any law enforcement agency intending to implement a new pursuit management technology should establish baseline pursuit-related metrics (and collect the associated baseline data) that allow for quantitative impact assessment comparisons before and after the technology has been integrated and deployed (e.g., number of pursuit apprehensions before and after, cost of property damage before and after). Note: the types and amount of data collected and analyzed may vary depending on what is important to the agency.

11. ACRONYMS/ABBREVIATIONS

APL	(Johns Hopkins University) Applied Physics Laboratory
CONOPS	Concept of Operations
CBP	Customs and Border Protection
GPS	Global Positioning System
JAG	Justice Assistance Grant
JHU	Johns Hopkins University
LED	Light-Emitting Diode
NHTSA	National Highway Traffic Safety Administration
NIJ	National Institute of Justice
RT&E	Research, Test and Evaluation
SVS	Stolen Vehicle Slowdown

APPENDIX A. LEGAL IMPACT ASSESSMENT – FURTHER READING

A.1 Legal Implications of Using StarChase

This section will provide legal information and general analysis on the use of the StarChase tag as it may be applicable to the Fourth Amendment. It is not designed to provide a comprehensive picture of the law as applied to a specific situation. As such, it does not constitute legal advice. It is intended as a guide for consideration as policy is developed. Furthermore, government counsel will want to ensure that further research accounts for changes in the law after the date of this document.

A.2 Fourth Amendment Background

A.2.1 Search and Seizures

The Fourth Amendment provides, in relevant part, that “[t]he right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated” except where there is a search warrant based on probable cause.³² A vehicle is an “effect” as that term is used in the Amendment.³³ As such, vehicles are also protected under the Fourth Amendment. A warrant shall be issued based upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.³⁴ Accordingly, the Fourth Amendment only prohibits “unreasonable” searches and seizures.

What Constitutes a Search?

Under the Fourth Amendment, a search occurs when a government employee or agent violates an individual’s reasonable expectation of privacy. This is a two-pronged test: 1) the person subject to search expects privacy in the thing searched, and 2) that expectation is reasonable.³⁵

Examples of a Search (Need a warrant)

- Inside of a home is a protected area.
- Thermal imaging - Where the government uses a thermal imaging device that is not in general public use to explore details of the home that would previously have been unknowable without physical intrusion.³⁶
- Checkpoints for visible illegal drugs – Courts have ruled that specialized purpose of drug interdiction violates the Fourth Amendment.³⁷

³² U.S. Const. Amend. IV.

³³ *U.S. v. Chadwick*, 433 U.S. 1, 12 (1977).

³⁴ U.S. Const. Amend. IV.

³⁵ *Katz v. U.S.*, 1967.

³⁶ *Kyllo v. U.S.*, 2001.

Examples of NOT a Search (Do NOT need a warrant)

- View from outside into a home.
- Open fields doctrine – permits police officers to enter and search a field without a warrant even if the field is highly secluded, not accessible from any public point, and posted with no-trespassing signs.³⁸
- Aerial searches through naked-eye observation of a fenced backyard from 1000 feet.³⁹
- Dog sniff of closed luggage or at traffic stops.⁴⁰
- Sobriety checkpoints.⁴¹

What Constitutes a “Reasonable” Search?

All searches and seizures under the Fourth Amendment must be reasonable. No excessive force shall be used. However, it was recently confirmed in a Supreme Court case that a police officer who places a fleeing motorist at risk of serious injury or death when attempting to terminate a dangerous high-speed car chase that threatens the lives of innocent bystanders does not violate the Fourth Amendment.⁴²

Overall, the reasonableness standard is construed upon the totality of circumstances on a case-by-case basis. If an individual has a reasonable expectation of privacy, then the focus turns to the governmental techniques used to obtain tangible things or information.⁴³ The reasonableness requirement can be satisfied with a warrant.

Warrantless searches and seizures are presumed to be unreasonable unless they fall within a few exceptions. The court will try to balance the degree of intrusion on the individual’s right to privacy and the need to promote government interests and special needs. The court will examine the totality of the circumstances using an objective assessment to determine if the search or seizure was justified.

Exclusionary Rule

Evidence gathered in violation of the Fourth Amendment is subject to the exclusionary rule, which provides that a criminal defendant may exclude from admission at trial any evidence obtained pursuant to an unlawful search. However, there is no constitutional right to have the

³⁷ *City of Indianapolis v. Edmond*, 121 S. Ct. 447 (2000).

³⁸ *Oliver v. U.S.*, 105 S. Ct. 150 (1984).

³⁹ *California v. Ciraolo*, 106 S. Ct. 3320 (1986).

⁴⁰ *Illinois v. Caballes*, 125 S. Ct. 834 (2005).

⁴¹ *Michigan v. Sitz*, 110 S. Ct. 2481 (1990).

⁴² *Plumhoff v. Rickard*, 134 S. Ct. 2012 (2014).

⁴³ What constitutes a search within the meaning of the Fourth Amendment. May 2015, accessed online at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1602051.

evidentiary fruits of an illegal search or seizure suppressed at trial.⁴⁴ Instead, the exclusionary rule is a judicially created means of deterring governmental violations of and thereby compelling respect for the Fourth Amendment.⁴⁵

Good Faith Exception

Furthermore, even when the Government violates the Fourth Amendment, evidence obtained in violation of the Fourth Amendment will not be suppressed when the good faith exception to the exclusionary rule applies.⁴⁶ The good faith exception to the exclusionary rule applies when particular facts of a case indicate that law enforcement officers acted with an objectively reasonable good-faith belief that their conduct was lawful or when their conduct involved only simple, isolated negligence.⁴⁷ Therefore the courts must objectively ascertain whether a reasonably well-trained police officer would have known that the search was illegal in light of all the circumstances.

C.2.2 Exceptions to the Warrant Requirement

Searches conducted absent a warrant are per se unreasonable under the Fourth Amendment, subject to certain exceptions. Without a warrant, the burden is on the government to prove the applicability of an exception. This burden of proof on the government requires only a preponderance of the evidence, a lower requirement as contrasted to “beyond a reasonable doubt,” which is the more severe test of evidence. Exceptions relevant to the StarChase system are described below.

Exigent Circumstances

Exigent circumstances allow police officers to conduct a warrantless search if there is imminent public danger to life or property, evidence is likely to be destroyed, or a suspect may escape in the time that it would take to obtain a warrant.⁴⁸ A common example of exigent circumstances is the hot pursuit of a fleeing felon.

Automobile Exception

The US Supreme Court has stated individuals have a reduced expectation of privacy in vehicles because vehicles are “readily mobile.” If the police have reasonable suspicion (e.g., failing to use a turn signal, seatbelt violation, etc.) that a crime has been committed, they can initiate a traffic stop. If the initial traffic stop is valid and the police develop additional probable cause to believe that a crime has been committed, the vehicle can be searched without a warrant.

⁴⁴ *Davis v. U.S.*, 131 S. Ct. 2419, 180 L. Ed. 2d 285 (2011).

⁴⁵ *Herring v. U.S.*, 555 U.S. 135, 139, 129 S. Ct. 695, 172 L. Ed. 2d 496 (2009).

⁴⁶ *See, e.g., U.S. v. Leon*, 468 U.S. 897, 920-26, 104 S. Ct. 3405, 82 L. Ed. 2d 677 (1984) (refusing to exclude fruits of unreasonable search because officer acted with objective good faith on later invalidated warrant).

⁴⁷ *Id.* at 909.

⁴⁸ *Warden v. Hayden*, 87 S. Ct. 850 (1967)

Similarly, the automobile exception applies to mobile homes.⁴⁹ As previously ruled, a mobile home is an automobile. The court applied the automobile exception because it is mobile, and like automobiles, there is significantly less protection for automobiles on public roads. There is reduced expectation of privacy and mobile homes are subject to a range of police regulation inapplicable to fixed dwellings.

It is important to note that courts have held that the automobile exception permits police officers to search a car without a warrant if they have reason to believe it contains contraband. The exception does not authorize police officers to install a tracking device on a vehicle without the approval of a neutral magistrate (i.e., obtaining a warrant.⁵⁰)

Plain View Doctrine

Where police officers have a legitimate, lawful reason to be in a place (e.g., warrant or exception to the warrant requirement), the police may seize evidence that is in plain view so long as the incriminating character of the evidence is immediately apparent and the officer has a lawful right of access to the object itself.⁵¹

Checkpoint Exception

Sobriety checkpoints where cars are stopped for a brief period of time to see if driver is intoxicated are constitutional.⁵² The court ruled that the balance of state's interest in preventing drunk driving and the degree of intrusion upon motorists who are briefly stopped weighs in favor of the state program. The courts ruled in favor of public safety.

A driver who “peels off” before a checkpoint does not create reasonable suspicion to stop the car. However, police officers can follow the car to monitor for reasonable suspicion (e.g., any traffic violations). For example, once the driver is pulled over for failure to signal, the police officer may be able to smell alcohol or detect other signs of drunkenness if present.

Searches Incident to an Arrest

It has been well established that police can search a person at time of lawful arrest.⁵³ The court held that upon a lawful arrest, police officers have basis for a search. However, a search incident to a lawful arrest is limited to the suspect's person and the area within which he could reach for a weapon or evidence. The search incident to arrest is not just an exception to the warrant requirement, but it is also an exception to the probable cause requirement. This means that the mere fact of an arrest in and of itself is sufficient to justify the subsequent search. Police officers do not need probable cause to take the next step to conduct a full search.

⁴⁹ *California v. Carney*, 105 S. Ct. 2066 (1985).

⁵⁰ *U.S. v. Maynard*, 615 F.3d 544.

⁵¹ *Horton v. California*, 110 S. Ct. 2301 (1990).

⁵² *Michigan v. Sitz*, 110 S. Ct. 2481 (1990).

⁵³ *Chimel v. California*, 89 S. Ct. 2034 (1969).

It is important to note that officers may not conduct a full search of a car and driver when the police elect to issue a citation instead of making a custodial arrest.⁵⁴ There must be an actual arrest to justify the search.

A.3 Relevant Federal Cases

While the StarChase technology has yet to be tested in court, relevant federal cases are reviewed below.

U.S. v. Jones (2012) – GPS is a Search

In *U.S. v. Jones*, defendant Antoine Jones came under suspicion of trafficking narcotics and was made the target of an investigation.⁵⁵ The government was issued a warrant, authorizing installation of an electronic tracking device to Jones' vehicle for 10 days. On the 11th day, agents installed a warrantless GPS tracking device to the undercarriage of Jones' vehicle while it was parked in a public parking lot. The government then used the GPS to track the vehicle's movements for the next 28 days, which then led to the multiple-count indictment of Jones for drug-related charges.

The Supreme Court held that the installation of a GPS tracking device constitutes a search triggering Fourth Amendment protections. The Court ruled that the police officers trespassed upon Jones' property when officers attached a GPS device to the undercarriage of the defendant's Jeep. This amounted to a search under the Fourth Amendment because "[t]he Government physically occupied private property for the purpose of obtaining information."⁵⁶

In *Jones*, GPS monitoring "generates a precise, comprehensive record of a person's public movements that reflects a wealth of detail about her familial, political, professional, religious, and sexual associations."⁵⁷ As such, otherwise constitutional monitoring of public movements becomes unconstitutional when, in its totality, it reveals private information about the person.⁵⁸

However the Supreme Court did not reach the issue of whether law enforcement's use of a GPS device without a warrant is presumptively unreasonable.⁵⁹ This issue is later decided in the *U.S. v. Katzin* case at a lower federal court.

U.S. v. Katzin (2014) – Warrant Needed to Install GPS; Evidence Admitted

In *U.S. v. Katzin*, without a warrant, police officers attached a GPS device onto the undercarriage of burglary suspect Katzin's van while it was parked on a public street.⁶⁰ Two days later,

⁵⁴ *Knowles v. Iowa*, 119 S. Ct. 484 (1998).

⁵⁵ 132 S. Ct. 945 (2012).

⁵⁶ *Id.*

⁵⁷ *Id.* at 955.

⁵⁸ *Id.*

⁵⁹ *Id.* at 954.

⁶⁰ 769 F.3d. 163 (2014).

information from the GPS device allowed police to connect the vehicle to a burglary that occurred shortly beforehand. Police officers stopped the van and found the burglarized merchandise inside. Katzin and his alleged accomplices were criminally charged, with much of the evidence against them coming from the seizure of the contents of the van.⁶¹

Katzin argued that pursuant to *Jones*, the warrantless installation and monitoring of the GPS device violated their Fourth Amendment rights. The U.S. Court of Appeals for the Third Circuit unanimously held that law enforcement officers must have a valid warrant before installing GPS devices on a suspect's vehicle.⁶²

The government argued that under the automobile exception, a warrant was not needed to conduct search of an automobile, and that the exception applied to GPS searches as well. However, the Third Circuit rejected this argument, finding that the automobile exception only allows warrantless searches of any part of a vehicle that may conceal evidence where there is probable cause to believe that the vehicle contains evidence of a crime.⁶³ Under the automobile exception, police officers who have probable cause to believe evidence is in a vehicle at that moment in time are permitted to search it without a warrant; but police officers would not be justified in acting on that probable cause weeks or months later.⁶⁴

In *Katzin*, police officers did not believe that the vehicle presently contained evidence of a crime—only that its location *might lead* to evidence of a crime. This is a far more pervasive search than the nominal investigation of a vehicle's interior, to which the Third Circuit held is beyond the scope of the automobile exception.

Despite the lack of a valid warrant in this case, the Third Circuit held that the evidence should not be suppressed under the U.S. Supreme Court's more general good faith test; the evidence should not have been suppressed because the agents acted with a good faith belief in the lawfulness of their conduct under the Fourth Amendment was "objectively reasonable."⁶⁵

Analysis

Similar to the two aforementioned cases, the GPS device component of the StarChase system (the tag) will attach to the suspect's vehicle. Although the GPS was attached to the vehicle's undercarriage in both *Jones* and *Katzin*, a physical intrusion has occurred by law enforcement onto private property. The location of the attached GPS device may be irrelevant.

Since the StarChase tag is a GPS tracker that attaches to the back of a suspect's vehicle, a physical intrusion on the driver's private property occurs. Thus a police officer conducts a search when he deploys the StarChase tag.

⁶¹ *Id.* at 168.

⁶² *Id.* at 169.

⁶³ *Id.* at 196.

⁶⁴ *Id.* at 205.

⁶⁵ *Id.* at 173.

Furthermore, pursuant to *Katzin*, a warrant or an exception to the warrant requirement is needed to deploy the StarChase tag on to a suspect's vehicle.

A.4 Relevant State Cases

Arizona

State of Arizona v. Mitchell (2014) – GPS Search without a Warrant is Illegal; Evidence Suppressed

In *Arizona v. Mitchell*, defendant Mitchell became the target of a drug investigation after an informant provided information about methamphetamine purchase.⁶⁶ A Sheriff's deputy attached a GPS device to the undercarriage of a car that Mitchell has been observed driving without the car owner's consent and without a warrant.⁶⁷ The GPS remained on the car for 25 days and provided the Deputy with constant updates from the GPS device with regard to the speed and location of the vehicle. This information led to Mitchell's indictment on several drug-related charges.

Mitchell appealed his conviction in trial court, arguing that the warrantless installation and use of the GPS device to track his movements while driving the vehicle was an unlawful search. The State argued that Mitchell lacked standing to challenge the installation of the device because he was not in possession of the vehicle at the time the device was installed, that he was not the owner of the vehicle, and he was not the exclusive driver.

Here, the Court of Appeals of Arizona held that Mitchell had standing to challenge the installation of the device because Mitchell was in lawful possession of the vehicle when the GPS device was used to track and record his movements. Furthermore, the Court of Appeals held that the trial court should have suppressed all evidence obtained from the GPS surveillance of the vehicle. The warrantless installation, continued presence, and monitoring of Mitchell's movements constituted an unlawful search under the Fourth Amendment to which no exception to the exclusionary rule applied.

Unlike the *Katzin* case where evidence was admitted despite a warrantless GPS search, here, all evidence obtained from the GPS surveillance was suppressed despite applicability of the good-faith exception. The Court reasoned that there are "no controlling Arizona or United States Supreme Court decisions authorizing the type of warrantless GPS tracking engaged in here, or that authorized law enforcement agents to attach a tracking device to private property without permission from the property's owner."⁶⁸ Consequently, the Court found that the good-faith exception to the warrant requirement is inapplicable and that the evidence should have been excluded.

⁶⁶ 234 Ariz. 410 (2014).

⁶⁷ *Id.* at 413.

⁶⁸ *Id.* at 420.

New York

New York v. Weaver (2009) – GPS Search without a Warrant is Illegal; Evidence Suppressed

In *New York v. Weaver*, a police officer placed a GPS device inside the bumper of defendant's street-parked van.⁶⁹ The GPS remained on the van for 65 days and surveillance was conducted nonstop without a warrant. The device's battery required replacement during the monitoring period, which resulted in another nocturnal visit by the police officer to the van's undercarriage. The defendant was eventually charged with burglary crimes. It is unclear why defendant was placed under electronic surveillance.

The court here held that the search was illegal because it was executed without a warrant and without justification under any exception to the warrant requirement.⁷⁰ Although residual privacy expectation is small in the vehicle, it was at least adequate to support the claim that defendant's constitutional right to be free of unreasonable searches and seizures was violated. Furthermore the massive invasion of privacy entailed by the prolonged use of the GPS device was inconsistent with even the slightest expectation of privacy.⁷¹ The court found that the GPS readings were not a mere enhancement of human sensory capacity. The warrantless installation of the GPS on defendant's vehicle violated his privacy expectation under the New York Constitution. As such, defendant's motion to suppress the GPS evidence was granted.

The ruling of this case occurred before the *Jones* case, and as such, the court relied upon the New York State Constitution. Under the New York Constitution, in the absence of exigent circumstances, the installation and use of a GPS device to monitor an individual's whereabouts require a warrant supported by probable cause. Here, the court pointed out that exigent circumstances did not exist and that there was no reason for the GPS placement other than a hunch or curiosity. Here, similar to *Arizona v. Mitchell*, GPS evidence was suppressed.

Washington

State v. Jackson (2003) – GPS Search with a Warrant is Legal; Evidence Admitted

In *State v. Jackson*, defendant reported the disappearance of his daughter.⁷² Upon investigation, investigators became suspicious that Jackson was involved with the disappearance and obtained a warrant to search his home and impound his cars. They then obtained a second 10-day warrant to attach GPS devices to the vehicles while they were impounded. They then returned the vehicles, but did not tell Jackson about the GPS devices. Investigators obtained a third warrant and added 10 more days to his surveillance. GPS data revealed the location of the dead daughter along with further evidence connecting Jackson to the murder.

⁶⁹ 12 N.Y. 3d 433 (2009)

⁷⁰ *Id.* at 445.

⁷¹ *Id.* at 443.

⁷² 150 Wash 2d 251 (2003).

The Washington Supreme Court noted that the use of a GPS device was not merely an augmentation of an officer's senses, but allowed the government to access an enormous amount of additional information, including a person's associations and activities.⁷³ The nature and extent of information obtained was relevant when considering whether an expectation of privacy is reasonable.⁷⁴

Consequently, the court held that a warrantless GPS is a violation of Article 1, Section 7 of the Washington State Constitution. Citizens of this State have a right to be free from the type of governmental intrusion that occurs when a GPS device is attached to a citizen's vehicle, regardless of reduced privacy expectations due to advances in technology and that a warrant was needed before such a device could be installed.⁷⁵ Here, GPS evidence was admitted since warrants were properly obtained.

Analysis

Courts take widely differing approaches to the use of GPS devices, but they all focus on the search prong of the Fourth Amendment. Although there are no state-specific regulations that apply directly to GPS tracking devices as it applies to StarChase, there are case laws that comply with the *Jones* case.

The ruling in *Arizona v. Mitchell* closely follows the ruling of *Jones*. In both cases, a warrantless GPS installation on a vehicle constitutes an unlawful search under the Fourth Amendment. Similarly in *New York v. Weaver*, the GPS attachment was illegal because it was executed without a warrant and without justification under any exception to the warrant requirement.

It is important to note that only the Supreme Court can issue proclamations of federal law that bind state courts. Decisions of lower federal courts, whether on issues of federal or state law, are only persuasive and not binding authority.⁷⁶ As such, the *Jones* ruling is binding and the *Katzin* ruling is only persuasive authority. Although states courts do not have to abide by the ruling in *Katzin*, many do follow this warrant requirement. As seen in *Arizona v. Mitchell* and in *New York v. Weaver*, a GPS search without a warrant was held illegal.

However, evidence obtained from both warrantless GPS was suppressed wherein the evidence in *Katzin* was admitted. Until *Katzin* is confirmed in the Supreme Court, states have discretion to deviate from that ruling and can bar evidence from being admitted, despite the good-faith exception.

A.5 Important Factors for Consideration

This section details a few factors for consideration as an agency considers developing pursuit policies for a StarChase deployment.

⁷³ *Id.* at 261.

⁷⁴ *Id.*

⁷⁵ *Id.* at 264.

⁷⁶ *People v. Leonard*, 40 Cal. 4th 1370, 1416 (2007) (Ninth Circuit decisions do not bind Supreme Court of California).

Existence of Exigent Circumstances

Pursuant to *Katzin*, a police officer should obtain a warrant prior to using StarChase. While it may be unconstitutional to use a warrantless GPS tracking device such as StarChase under normal circumstances, it may be constitutional under exigent circumstances. An exigent circumstance may exist if: 1) a person's life or safety is threatened; 2) a suspect's escape is imminent; or 3) evidence is about to be removed or destroyed.⁷⁷ As an exception to the warrant requirement, officers may engage in a search that would otherwise violate the Fourth Amendment when there is a sufficient exigency warranting the search.⁷⁸

However, it is important to note that an otherwise valid use of the StarChase tag may become unconstitutional if the police were to end pursuit and then track the suspect's vehicle for hours or days after the chase. The search would no longer fall into the exigent circumstances exception.

Purpose of GPS – Future vs. Current Evidence

As ruled in *Katzin*, the Third Circuit recognized that the Fourth Amendment does not permit law enforcement officers to leave behind an “ever-watchful electronic sentinel in order to collect future evidence” without a valid warrant. Police officers may not attach a GPS device to secure evidence that may exist in the *future*.⁷⁹ This ruling is implemented to protect individuals from the fearful watch of the Orwellian “big brother” government.

However, this is in contrast to the StarChase tag where officers believe the automobile *currently* contain evidence of a crime (e.g., suspects and evidence of illegal goods) during a high-speed pursuit. This distinction has not been tested in court, and as such, GPS use with a present and current purpose may pass the requirements of the Fourth Amendment.

Duration of Attached GPS

Similarly, another factor to consider is the duration of the attached GPS device. In *Jones*, the GPS was attached to the suspect's car for 28 days. The court explicitly ruled that it is a trespass on Jones' property. Similarly, the GPS used in *Katzin* was on the suspect's vehicle for 2 days, in *Mitchell* for 25 days, and in *Weaver* for 65 days. All four courts have ruled that this extended duration constitutes a search.

Conversely during high-speed pursuit, intrusion of the StarChase tag on the suspect's vehicle is limited in time and extent. The search lasts only as long as the pursuit does, gathering information solely for that purpose. Similar to the purpose of the GPS, duration of the attached GPS has not been tested in court. There is no bright-line rule or case law indicating how long a GPS tracking device can be installed as to not implicate the Fourth Amendment. As such, a shorter duration of an attached GPS may pass the requirements of the Fourth Amendment. Like

⁷⁷ *Warden v. Hayden*, 87 S. Ct. 850 (1967).

⁷⁸ *U.S. v. Santana*, 427 U.S. 38, 42-43 (1976).

⁷⁹ *Katzin*, 732 F.3d at 205.

the analysis of exigent circumstances, a GPS tracking device used only during a high-speed pursuit may pass the requirements of the Fourth Amendment.

Evidence Obtained via Warrantless GPS Search May Be Suppressed

As indicated in *Mitchell* and *Weaver*, a warrantless GPS search led to suppression of the obtained evidence in court despite the good-faith exception. As policy for the StarChase tag is being developed, it is important to keep in mind that decisions in lower federal courts are not binding on state courts. States have discretion to apply or dismiss the good-faith exception. As such, evidence obtained via a warrantless GPS search may run the risk of being suppressed in court.

Fleeing and Eluding from Police Officer

It is important to note that fleeing and eluding from police officers, without other supporting factors, does not create probable cause.⁸⁰ The court has ruled that flight from police is sufficient to support a finding of reasonable suspicion, but does not extend to probable cause. The court held that in a high-crime area known for drug dealing, when a man holding an opaque bag on the sidewalk with several others gathered around him fled at the mere sight of police, the flight created probable cause. Mere fleeing from police did not automatically create probable cause; instead, the flight's relation to probable cause must "be assessed in context with all of the circumstances surrounding it."⁸¹ And in this case, the court found that the totality of the circumstances (e.g., high-crime area for drug dealing and opaque bag on sidewalk) was enough to create probable cause.

As applied to the StarChase technology, mere flight from police officers does not amount to probable cause. A warrant or an exception to the warrant requirement is needed to deploy the StarChase tag onto a vehicle that flees simply at the sight of police officers.

A.6 Conclusion

The courts have grappled with issues of GPS technology in the recent years. As it currently stands, installation of a GPS device on a vehicle constitutes a search. And if Katzin is correct (i.e., if the decision is not overturned by the Supreme Court), then a warrant is needed to install a GPS device on a vehicle unless a valid warrant exception applies.

As technological advances continue to evolve, protections afforded by the Fourth Amendment will continue to be tested. More specific ruling delineating specific use of GPS technology is still unknown until it is tested in court (e.g., length of time the GPS may be attached). Until then, the existence of exigent circumstances, purpose, and duration of StarChase tags are very important factors to consider when developing law enforcement policies.

⁸⁰ *Illinois v. Wardlow*, 528 U.S. 119 (2000).

⁸¹ *Id.*