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THESIS

**UNSTOPPABLE?
THE GAP BETWEEN PUBLIC SAFETY AND TRAFFIC
SAFETY IN THE AGE OF DRIVERLESS CARS**

by

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March 2017

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**UNSTOPPABLE?
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OF DRIVERLESS CARS**

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ABSTRACT

Autonomous vehicles (AVs) are already driving on some of the nation's streets and highways. AV technology is advancing quickly, and regulatory environments and market demands will result in its rapid diffusion throughout society. AVs are likely to dramatically reduce traffic collisions and motorist injuries, as long as those motorists become passengers only, not drivers, thus eliminating human error as a traffic safety hazard. With the traffic safety benefits of the AV, there will be little need for the traffic enforcement conducted by police and highway patrol agencies across the country today. Yet traffic stops are the most common form of face-to-face contact between police officers and citizens, and traffic enforcement has been a form of crime detection, deterrence and disruption in this country since the dawn of the automobile. This research examines the future of law enforcement in the age of the driverless automobile. It recommends that police and homeland security agencies engage with AV technology today so that they can innovate with that technology and find public safety substitutes for the traffic stop in a future where cars are unstoppable.

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LIST OF ACRONYMS AND ABBREVIATIONS

ABS	anti-lock brake system
ALPR	Automated License Plate Reader
AV	autonomous vehicle
BCG	Boston Consulting Group
BJS	Bureau of Justice Statistics
CHP	California Highway Patrol
CPS	cyber-physical systems
DMV	Department of Motor Vehicles
DOT	Department of Transportation
DTO	drug trafficking organization
DUI	driving under the influence
EPIC	El Paso Intelligence Center
FASTR	Future of Automotive Technology Research
HIDTA	High Intensity Drug Trafficking Area
IoT	Internet of things
LEA	law enforcement agency
NHTSA	National Highway Traffic Safety Administration
NPS	Naval Postgraduate School
PATH	Partners for Advanced Transportation Technology (Berkeley)
SAE	Society of Automotive Engineers
TSC	Terrorism Screening Center
V2I	vehicle-to-infrastructure
V2X	vehicles to everything
VII	vehicle-infrastructure integration

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EXECUTIVE SUMMARY

Autonomous vehicles (AVs) are already driving on some of the nation's streets and highways. This technology is advancing quickly and will likely diffuse rapidly throughout society. AVs are likely to reduce traffic collisions and prevent motorist deaths, but only if those motorists become passengers, not drivers, thus eliminating human error as a traffic safety hazard.

With the traffic safety benefits of the AV, there will be little need for the traffic enforcement conducted by police and highway patrol agencies across the country today. Yet traffic stops are the most common form of face-to-face contact between police officers and citizens, and traffic enforcement has been a form of crime detection, deterrence and disruption in this country since the dawn of the conventional automobile.¹ This research examines the rising use of AV technology and its effects on police use of traffic enforcement to disrupt crime and terrorism. In doing so, it asks the following questions:

- Once all cars drive themselves, what will the increase in traffic safety cost society in terms of public safety?
- What can public safety and homeland security policymakers do about it?

A. RESEARCH DESIGN

While AVs are not yet widely used, they are likely to become a disruptive innovation that will displace transportation industry jobs and eliminate the need for today's traffic enforcement model. This phenomenon's potential impact on public safety is not discussed in any known literature on AV technology, nor does it seem to be on the radar of police executives or public policymakers. The research addresses a potential gap in public safety that may be an unintended consequence of AVs' traffic safety advantages.

¹ Lynn Langton and Matthew Durose, *Police Behavior during Traffic and Street Stops, 2011* (NJC 242937) (Washington, DC: U.S. Department of Justice), 2, <http://www.bjs.gov/content/pub/pdf/pbtss11.pdf>.

To illustrate that gap, traffic stops are examined through the lens of existing literature, including Bureau of Justice Statistics data, sociological and demographic studies, police and legal journals, and relevant case law. The impact of traffic enforcement on crime and public safety is described using existing published articles, as well as traffic stop case studies and subsequent criminal investigations. Related effects are expressed using a diffusion-of-innovations model and examples of plausible future scenarios. Theories on innovation in organizations, including government, are applied as potential means to bridge the foreseen gap between traffic safety and public safety after AV technology diffusion. Among these are signals theory and “nowcasting,” tools that innovators use to “predict the present” by reading signs that the convergence of technology and culture will require pivots in organizational strategic planning.²

B. FINDINGS

While it is impossible to accurately predict the rate of AV diffusion or how quickly such diffusion will affect traffic enforcement strategies, there is consensus that AVs will represent a significant part of the automotive market within the next ten to twenty years.³ But from a nowcasting perspective, existing signals indicate that AV diffusion could happen much faster. These signals include: increased urbanization and associated traffic and parking congestion; permissive, even encouraging, regulatory environments such as Smart City initiatives; the popularity of vehicles with semiautonomous features; and the proliferation of disruptive innovations in transportation sectors such as Uber, Lyft and Zipcar.⁴

² Amy Webb, *The Signals are Talking* (New York: PublicAffairs, 2016); Hyunyoung Choi and Hal Varian, “Predicting the Present with Google Trends,” *Economic Record*, 88 (June, 2012): 2–9.

³ Cadie Thompson, “Elon Musk Has a Stunning Prediction for What Cars Will be Like 10 Years from Now,” *Business Insider*, February 13, 2017, <http://www.businessinsider.com/elon-musk-predicts-most-cars-will-be-driverless-in-10-years-2017-2>; “Autonomous Vehicle Adoption Study,” Boston Consulting Group (BCG), accessed February 14, 2017, <http://www.bcg.com/expertise/industries/automotive/autonomous-vehicle-adoption-study.aspx>.

⁴ Jeffrey Zients and John P. Holden, “American Innovation in Autonomous and Connected Vehicles,” the White House, December 7, 2015, <https://www.whitehouse.gov/blog/2015/12/07/american-innovation-autonomous-and-connected-vehicles>; Uber and Lyft are both taxi services coordinated by mobile technology with independently operated vehicles and contracted owner/drivers; Zipcar is an on-demand rental-car service cars are shared by many users via monthly membership and usage fees.

While the timetable for change remains uncertain, AVs will reduce the need for police to enforce traffic laws, leading to a diminished capacity for police to detect and deter crime in the same ways they do today. Criminals may imagine ways to capitalize on reduced enforcement, leading to less detection of previously undiscovered crimes and criminals; decreased interdiction of crimes involving vehicles, such as drug smuggling and human trafficking; and the potential for terrorists to weaponize vehicles that can drive themselves with very little risk of being stopped by the police. Further disruptive technologies will require law enforcement and homeland security agencies to innovate in order to ensure public safety with diminished traffic enforcement capacity.

C. ANALYSIS

In order to avoid being overwhelmed by criminal exploitation of AV technology, policymakers—with leadership and guidance from law enforcement agency (LEA) executives—must not take a wait-and-see approach. LEAs must not leave public safety issues raised by AV proliferation to regulatory agencies—such as departments of transportation or motor vehicles—but must take the lead in anticipating and responding to them. To develop effective strategies, LEAs will have to collaborate with AV technology companies in the present to anticipate future public safety risks. Such collaboration could serve the goals of LEAs as well as industry. Safer products are more marketable products, and companies that work with law enforcement for the benefit of public safety may have an advantage over those that do not. Such discussions could help police discover problems they did not know existed and solutions they did not know were needed.

Beyond new models of collaboration, new methods of policing and new types of police professionals may be required to keep future cities safe. Specifically, traffic agencies will have to pivot from traditional traffic enforcement to technology-based solutions to traffic safety and security. To do so, police professionals will have to imagine a different world—one without traffic enforcement as they know it—and envision how they want that world to look. In order to innovate on behalf of public safety, LEAs need to assert influence over, and adapt to, such a world starting now. They will also need to

overcome cultural inertia—a resistance to change that is inherent to government, and to which their agencies are not immune.

D. RECOMMENDATIONS

AV technology is no longer nascent—it is here. To follow are practices LEAs can employ today, as well as courses policymakers can set toward a long-term public safety strategy for dealing with the unstoppable cars of tomorrow.

1. Lead the Way

LEAs with traffic responsibilities should become the subject matter experts on the impact of AV technology on public safety. Policymakers should rely on such expertise to mitigate related public safety threats. Traffic enforcement agencies should continue to leverage their expertise and reputations on matters involving the AV by:

- Increasing their accident investigators’ and public information officers’ knowledge about AV technology.
- Joining industry groups to engage with AV manufacturers on public safety issues.
- Educating the public about semi- and fully autonomous technology.
- Continuously evaluating AV and associated technologies for potential threats to public safety, as well as innovative solutions to such threats.

2. Collect Data

LEAs and other public agencies should begin collecting data about how AVs are used and how semi- and fully autonomous technology affects public safety. Collection methods should be evaluated and sources appropriately modified as technology changes and AV usage increases. Data sources should include, but not be limited to:

- Traffic collision reports with check boxes that indicate levels of autonomy and whether autonomous features affected the outcome of the collision.
- Crime reports that indicate if and how an AV was used in the crime.
- Business licenses involving AV and related infrastructure technologies.
- AV registration records.

3. Incorporate Public Safety into Cyber-Physical Infrastructure

Public safety organizations must be integrated into the cyber-physical infrastructures of the future. As vehicles become increasingly connected to everything, the related data production could lead to safer vehicle operation and could be used to detect and solve crimes. LEAs should engage with transportation agencies and city planners to maximize public safety and crime control opportunities. AVs should meet prescribed requirements in order to operate within certain infrastructures. Such requirements might include:

- Scanners that evaluate vehicle sensor failure, software vulnerabilities, malware or hacks.
- Software that ensures AVs yield or stop to signals sent by police and other emergency vehicles.
- Electronic signatures that report vehicle registration information, commercial licensing and insurance status.
- Preservation of data collected by cyber-connected sensors and software, license plate reader cameras, GPS signals or other means in order to track vehicles' historical movements. Such data could have implications not just for solving known crimes or stopping crimes in progress, but for predictive policing methods associated with vehicles' patterns of criminal activity.

4. Legislate and Regulate

The legality for police to use data collected from infrastructure will depend on how well lawmakers understand the relationship of traffic enforcement on crime detection and deterrence. If police and policymakers pay attention to the AV's effect on this relationship early, they could create substitutes for the traffic stop as a crime-fighting tool. Now is the time to consider how public safety threats can be addressed through regulation, as companies will be eager to enter a burgeoning and lucrative market. Over the long term, AVs will change expectations of privacy on the highway, presenting policymakers with an opportunity to create a future that puts public safety first. Instead of judges deciding the legality of particular searches after the fact, legislators could consider

issues of privacy and security, debate them openly, and pass laws that give clear search and inspection guidelines to police.

5. Train and Hire for the Future

Police agencies today must begin training and hiring for an uncertain future. While AV diffusion will affect the way many departments do business, it is unclear how long the change will take or how dramatic it will be. In order to position themselves for the future, police agencies will have to increase their traffic enforcement officers' competencies. They must also become savvier about general law enforcement, especially as it relates to technology, as cyber-physical technology will become one of the crime-detection tools of tomorrow. Training considerations should include:

- High-tech accident investigation training to help determine fault in vehicles with semi- and fully autonomous capabilities.
- Advanced training in highway interdiction, including search and seizure training related to vehicle stops.
- Increased general law enforcement training for agencies with a traffic enforcement focus to prepare for a pivot toward more traditional policing roles.

Agencies should also consider hiring more law enforcement professionals for non-sworn positions that bring different skills to policing than uniformed officers—something that could become more relevant in a post-traffic enforcement environment. Such positions should be highly paid and respected within the agencies to ensure recruitment and retention of quality personnel with an interest in a long-term career. Existing positions that might be hired in increased numbers include:

- Crime analysts.
- Evidence and forensic technicians.
- Computer forensics technicians.
- Information and technology support staff.

Some new positions to consider creating include:

- Computer code programmers.

- Cyber-security technicians.
- Surveillance technicians.
- Technology company liaison officers or technicians.
- An agency futurist to advise LEA executives on emerging technology and its potential impact on the mission of the agency.

E. STOPPING THE UNSTOPPABLE

Historically, law enforcement has risen to challenges and adapted to new roles to meet those challenges. Traffic enforcement was one such challenge—a role that was never imagined by police in the years before the advent of the automobile. Prior to the 9/11 attacks, police did not consider themselves a bulwark against terrorism; yet, today, they are on the front line of the fight against it. In the years to come, the unstoppable AV will cause the role of traffic enforcement to change once again, but police will still be expected to fight crime and terrorism. Stopping the unstoppable will require innovation in crime detection and resistance to organizational inertia that denies such change is needed.

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PROLOGUE

Tell me what you know. Tell me what you don't know. Tell me what you think. Always distinguish which is which.

—Colin Powell

I am a California highway patrolman, and I know my job makes you safer. I know that driving is dangerous, and I know that people are fallible. I know these factors result in people getting killed on the highways I protect. I also know that criminals drive those highways, and I know how to find them. I know that, when I do my job well, less people die and more criminals go to jail. I also know that this may change someday.

I don't know what the future holds for my profession. Cars will drive themselves, but I don't know how soon. When they do, our highways are going to be safer than I can make them now. I know that will change my job, but I don't know how.

Today, I make the world safer by stopping people from doing wrong in their cars. No one likes it when I stop them, but most people want me out there because they know that driving is dangerous and that I make it safer. Most of the time, the stop is just for bad behavior—a heavy foot on a gas pedal, or a slow roll over a limit line—and I make the roads safer with a few lines scratched on a ticket or maybe just a friendly warning.

But, sometimes, there's more. Sometimes, after I stop people, I learn that they are up to something else. It might be something they just did, something they are planning to do, or something they are doing as we speak, but it is a crime, and I find out about it because I am out there doing my job. Even if they planned to hide from me, they made a mistake behind the wheel, and gave me a reason to meet them. And then they went to jail.

But if the bad people did not control the wheel—or if there were no wheel at all—I might never meet them. If their high-tech cars drove themselves, the cars would follow the rules, and might not give me a reason to stop them. Even if they did, I might have no reason to meet the people inside—to talk to them, to find out if they were doing something bad—because they were just along for the ride.

And if my stops weren't saving people from being injured or killed in traffic, you might not need me, or want me, to do my job anymore. You might not let me talk to you, and the laws may change so that you don't have to. I wouldn't be able to talk to the bad people either, which means I may never find them.

I think driverless cars are going to save a lot of lives, and I think that is good. But I also think there is space in this new, safer world for criminals to move more freely than they do today, to commit crimes we have not yet imagined. And I think we all need to do some thinking on that.

I have enough experience in police work to know that traffic enforcement is not the only way to catch bad people. Good beat cops make contacts that lead to arrests all the time on sidewalks, and in homes and businesses, throughout the country. Local, state and federal law enforcement and intelligence professionals collect information on crimes using a variety of investigative tools and techniques that will only improve with advances in technology. But even some of my colleagues from other agencies, who rib me about what it means to do "real police work," occasionally ask me to help them out with a traffic stop because they know it is a good way to learn about the bad people. When the bad people aren't driving anymore, we're going to need another way.

I have been doing this job for twenty-plus years. I have been a patrol officer, a detective sergeant and a field manager. I no longer make traffic stops as part of my daily job, and it is unlikely that I will ever stop an autonomous vehicle. I am no longer the future of California Highway Patrol, the law enforcement profession or the homeland security enterprise. There are new officers who will carry that honor and responsibility in an increasingly technological world. But I would like to help them make a plan.

The research that follows is about the unintended consequences of the autonomous vehicle on public safety, and it is my small way of contributing to a plan for our future. This contribution is not a treatise for the continuation of traffic enforcement as we know it, but an examination of how our world might change when it is less of a public safety imperative.

Most of what I have written in this examination is based on literature about traffic enforcement and autonomous vehicle technology, but some of it is based on my training, experience, and education as a law enforcement professional. I recognize that such a perspective can lead to researcher bias, which I have addressed through extensive research from a variety of sources, as well as through continual discussions with homeland security practitioners and academics from other fields. But I also believe that my professional experience affords me a more integrated and nuanced understanding of this research subject, and it is my hope that this work explains that subject in a way that connects to a broader audience than just public safety and homeland security professionals.

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I. PROBLEM SPACE

Initial research of autonomous vehicle (AV) technology suggests that future cars will completely drive themselves with no input from humans, and governments and consumers are in general agreement that AVs will benefit society.¹ Among these benefits is the fact that the vehicles will seldom crash or break traffic laws.² Most of the literature on the traffic safety advantages of AVs predicts an 80- to 90-percent reduction in traffic collisions, and a similar reduction in fatalities.³ However, such reductions are only likely to be realized if humans are removed from the equation, and completely autonomous cars drive our roadways.

1. Unintended Consequences

Because it is argued that AVs will revolutionize the field of traffic safety, they will likely reduce the budgets of law enforcement agencies (LEAs), which are currently funded for traffic enforcement.⁴ Perhaps just as importantly, AVs could diminish the practicality and effectiveness of the traffic stop as a general law enforcement tool. Without this resource, LEAs will have to develop new means to detect criminal activity to fill the void left by a reduction in traffic enforcement.

With a diminished ability to detect crime, patrol officers' ability to deter or disrupt criminal activity will likely suffer as well. As criminals, including terrorists, adopt AV technology, they will be able to move contraband, including weapons and improvised

¹ "Automated and Connected Vehicles," University of California, Berkeley, accessed March 1, 2016, <http://path.berkeley.edu/research/automated-and-connected-vehicles>.

² Keith Naughton, "Humans are Slamming into Driverless Cars and Exposing a Key Flaw," *Bloomberg Business*, December 18, 2015, <http://www.bloomberg.com/news/articles/2015-12-18/humans-are-slamming-into-driverless-cars-and-exposing-a-key-flaw>.

³ National Economic Council and Office of Science and Technology Policy, *A Strategy for American Innovation* (Washington, DC: The White House, 2015), 92–93, https://obamawhitehouse.archives.gov/sites/default/files/strategy_for_american_innovation_october_2015.pdf.

⁴ Chou Her, "Driverless Vehicles Could Hurt Law Enforcement and Public Budgets," *Journal of California Law Enforcement* 50, no. 1 (2016): 6–12.

explosives, in vehicles with little fear of detection.⁵ In fact, they will not even need to be in a car themselves, as AVs will be able to drive unoccupied. Furthermore, if officers *are* able to develop probable cause to stop an occupied AV, they might not be able to question the occupants, as early AV policy has determined that the software itself can be considered the “driver” of the vehicle.⁶ Though the “vehicle exception” to the Fourth Amendment’s warrant requirement would still apply, the probable cause required to search a vehicle would be difficult to establish if a police officer has little reason to question passengers whose license status, driving habits or sobriety are not relevant to the reason for the stop.

Another potential consequence of reduced traffic enforcement is the impact it will have on the patrol officer’s on-the-job training and experience. Traffic stops are mini-investigations, which involve interviewing and rapport-building skills that are essential to developing probable cause, as well as developing an officer’s intuition and confidence in his or her ability to detect criminal activity.⁷ This on-the-job training effect may be more valuable in smaller cities and rural areas where agencies do not have a foot patrol, public housing or public transit components.⁸

Beyond the loss of police interdiction of criminal activity, day-to-day positive interactions between police and the citizens they serve may also suffer with the reduction of traffic enforcement. Though no one likes it when a police cruiser’s red light is shined on them, most people who are stopped believe they deserve to be. Such public acceptance is truer for traffic stops than any other form of involuntarily police contact.⁹ Furthermore,

⁵ Though the use of the AV for smuggling is still speculative, drug trafficking in vehicles is common and drug trafficking organizations use innovative methods to move their contraband; “Drug Trafficking in New Jersey,” *Trends in Organized Crime* 7, no. 3 (Spring 2002): 62.

⁶ Kyle Field, “Google Self-Driving Cars Now Considered Drivers by NHTSA,” *Clean Technica*, February 16, 2016, <http://cleantechnica.com/2016/02/16/google-self-driving-cars-now-considered-drivers-nhtsa/>.

⁷ Charles F. Klahm and Rob Tillyer, “Rethinking the Measurement of Officer Experience and its Role in Traffic Stop Searches,” *Police Quarterly* 18, no. 4 (December 2015): 344–367.

⁸ Rob Tillyer and Charles Klahm IV, “Searching for Contraband: Assessing the Use of Discretion by Police Officers,” *Police Quarterly* 14, no. 2 (June 2011): 178–179.

⁹ Lynn Langton and Matthew Durose, *Police Behavior during Traffic and Street Stops, 2011* (NJC 242937) (Washington, DC: U.S. Department of Justice), 3, <http://www.bjs.gov/content/pub/pdf/pbtss11.pdf>.

the communication skills that police employ during such contacts are more often used to interact with essentially innocent citizens than with criminals. These frequent and routine interactions help to develop social skills that can be employed in more stressful public interactions such as a domestic disturbances or even physical altercations. The relatively low-risk and low-consequence contacts with the public during routine traffic stops provide repetitious training that helps officers learn conflict resolution skills that prepare them for potentially volatile interactions.¹⁰

2. The Traffic Safety–Public Safety Gap

As stated, most research that speculates about the potential impact of driverless cars highlights the traffic safety benefits such technology would bring. With over 32,000 traffic fatalities annually in the United States, any technology that would significantly reduce that number should be encouraged.¹¹ However, there is currently no research analyzing unintended public safety consequences that may result from a reduction in traffic enforcement. There has been speculation that state revenue might decrease due to a reduced number of registered vehicles—if AVs are used as ride-shares—and that traffic citation revenue for municipalities would decline because traffic laws would not be broken.¹² But no one is forecasting the effect that reduced traffic enforcement might have on criminal activity or what policymakers should be doing to ensure that increased traffic safety does not create an unforeseen gap in other public safety sectors.

3. Modeling the Problem

Public safety is the purpose behind traffic enforcement. The two are directly related. Traffic laws ensure people are safer in their vehicles in the same way construction codes ensure they are safer in buildings. Figure 1 models the direct relationship between public safety and traffic enforcement.

¹⁰ While the author recognizes that traffic stops are inherently dangerous, and no stop is truly “routine,” the interactions between the police and the public during traffic stops are more frequently cordial and professional than they are confrontational or life threatening.

¹¹ “Traffic Fatalities Fall in 2014, but Early Estimates Trending Higher,” National Highway Traffic Safety Administration (NHTSA), November 24, 2015, <http://www.nhtsa.gov/About+NHTSA/Press+Releases/2015/2014-traffic-deaths-drop-but-2015-trending-higher>.

¹² Her, “Driverless Vehicles.”

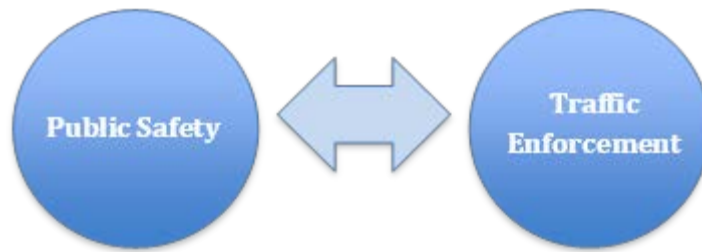


Figure 1. Model of the Direct Relationship between Public Safety and Traffic Enforcement

Because traffic laws are necessary for public safety, police officers are given broad discretion to enforce them. Unlike many other laws, people break traffic laws frequently and in open view, which gives officers reasonable suspicion to detain and question them. These contacts can lead to the discovery of information or evidence that may develop into probable cause to search a vehicle, make an arrest or both. The possibility that crimes might be detected through traffic enforcement can lead to crime deterrence, thus completing a cycle that affords traffic enforcement the ability to increase public safety beyond its primary intent of preventing traffic collisions. Figure 2 models the primary and secondary relationships between public safety and traffic enforcement.



Figure 2. Model of the Cyclical Primary and Secondary Relationships between Public Safety and Traffic Enforcement

The autonomous technology itself would ensure that vehicles are driven more safely than humans can drive them today. If, as predicted, AVs seldom violate traffic laws or become involved in collisions, traffic enforcement would lose its direct relationship with public safety. Figure 3 models this broken relationship.

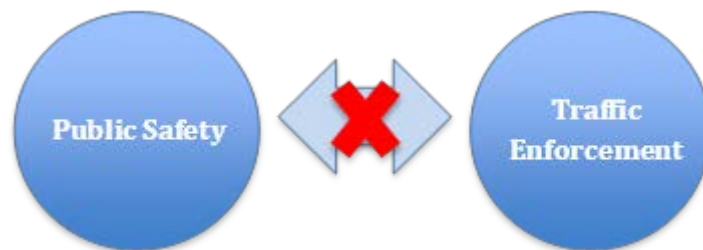


Figure 3. Model of the Broken Direct Relationship between Public Safety and Traffic Enforcement with AV Predominance

Beyond eliminating the need for today's level of traffic enforcement, this broken relationship would also reduce its acceptability as a police tactic, thus breaking the cycle that leads to its secondary public safety benefit of crime suppression. Reasonable suspicion to stop a vehicle would be an infrequent occurrence, and the legal authority to interview or detain a passenger in a vehicle would likely diminish, thus curtailing the capacity to develop probable cause to search or arrest. Officers' reduced capacity to make traffic stops and investigate potential crimes beyond the reasons for those stops will undoubtedly lead to less crime detection, which will reduce deterrence. Because the cycle can break at any phase, the secondary relationship between public safety and traffic enforcement would be virtually eliminated. Figure 4 models this broken relationship.

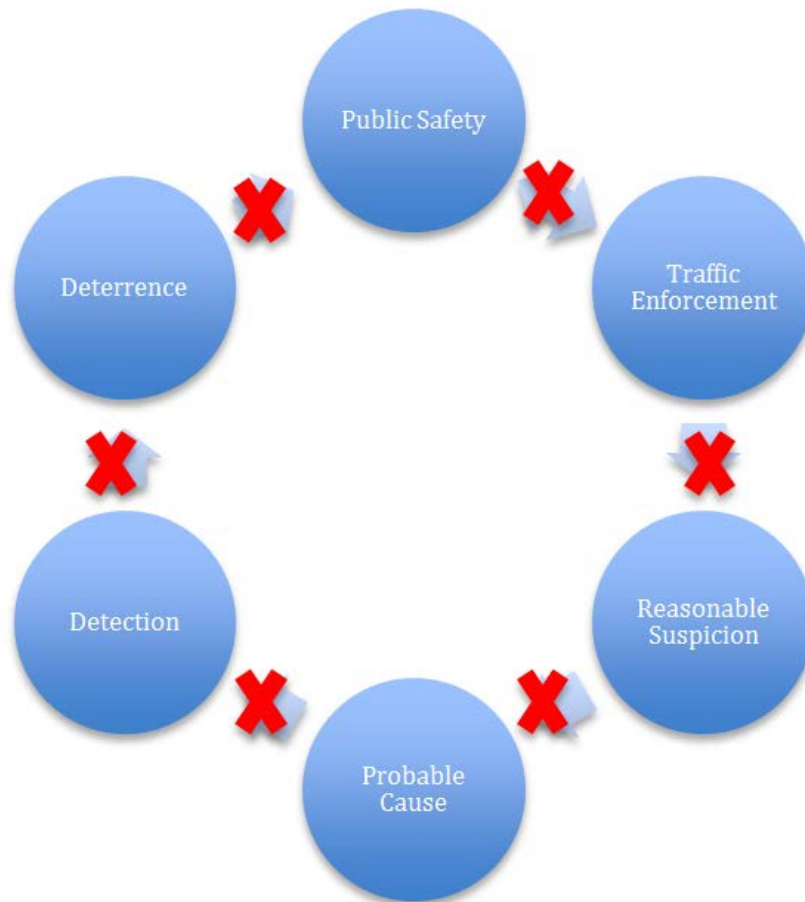


Figure 4. Model of the Broken Secondary Relationship between Public Safety and Traffic Enforcement with AV Predominance

B. RESEARCH QUESTIONS

This research examines the rise of AV technology use and its effects on police use of traffic enforcement as a tool to detect, deter and disrupt crime and terrorism. In doing so, it asks the following questions:

- Once all cars drive themselves, what will the increase in traffic safety cost society in terms of public safety?
- What can public safety and homeland security policymakers do about it?

C. LITERATURE REVIEW

This literature review consists of three parts. Section 1 examines literature relevant to the traffic stop as a public safety tool as well as the traffic safety factors that allow police to use this tool. Section 2 examines the current status and future development of AV technology and the policy discussions around its implementation on our highways. Section 3 surveys literature written about the challenges of innovation within organizations, with a focus on government institutions. The intent of the review is to familiarize the reader with current traffic enforcement practices, and then to introduce a vision of how AV technology may affect those practices. Once this vision is reached, it should serve as a backdrop for further exploration into the public safety implications of a future without traffic enforcement as we know it today. Highlighted against that backdrop are the organizational challenges that may contribute to a law enforcement lag in adapting to such a future.

1. Traffic Enforcement Stops

The United States Department of Justice's Bureau of Justice Statistics (BJS) compiles the most comprehensive national statistical data on traffic enforcement stops, or traffic stops. BJS publishes statistics on traffic stops every three years based on data collected from a Police-Public Contact Survey.¹³ This survey asks citizens about contacts with police in general, with the traffic stop included as the most common involuntary form of contact. Much of the BJS data focus on the demographics of the citizens who are

¹³ Langton and Durose, *Police Behavior*.

stopped, as well as their perceptions about the justification for the stop. While the statistics are fairly detailed, they are based solely on the opinions of the citizens surveyed. BJS does not compare the results of the survey with statistical data from LEAs, nor does it conduct surveys of law enforcement officers. This is significant because the absence of such data does not allow for insight into officers' motivations behind the traffic stops or subsequent vehicle searches.

The BJS data identifies the traffic stop as the most common type of interaction between police and the public, accounting for 42 percent of all contacts. Respondents felt that traffic stops were more legitimate than involuntary contacts initiated in public, outside of a vehicle.¹⁴ Approximately 3.5 percent of drivers stopped in 2011 had their person or vehicle searched during a traffic stop, and 1 percent were arrested.¹⁵

The relatively high level of police–public contacts and the subsequent searches and arrests arising out of traffic stops, combined with the high visibility of traffic enforcement patrols, have led to studies of traffic enforcement as a form of crime suppression. The National Highway Traffic Safety Administration (NHTSA) published a comprehensive summary of such studies, concluding that traffic enforcement is not just effective at reducing traffic collisions, but it is also “central to the core law enforcement functions of preventing crime and disorder.”¹⁶ There are other works on the subject of the traffic stop as a tool for general law enforcement, including a Naval Postgraduate School (NPS) thesis recommending targeted traffic enforcement deployments as a tool for hardening targets of terrorism.¹⁷

¹⁴ Ibid., 2.

¹⁵ Ibid., 7, 9.

¹⁶ Alexander Weiss, *Data-Driven Approaches to Crime and Traffic Safety (DDACTS): An Historical Overview* (Washington, DC: NHTSA, 2013), <https://www.nhtsa.gov/staticfiles/nti/pdf/809689.pdf>.

¹⁷ Mark W. Weiss, “Traffic Enforcement, Policing, and Crime Rates,” (PhD Dissertation, Walden University, 2016), <http://scholarworks.waldenu.edu/dissertations/2628>; Lawrence W. Sherman, “Policing for Crime Prevention,” in *Preventing Crime: What Works, What Doesn’t, What’s Promising*, chapter 8 (College Park, MD: University of Maryland, 1998), <https://www.ncjrs.gov/works/chapter8.htm>; Mark D. Thomas, “Deployment of State Traffic Law Enforcement Officers for Homeland Security” (master’s thesis, Naval Postgraduate School, 2006).

Perhaps not surprisingly, given the ubiquity of traffic stops and the search-and-seizure issues that arise from them, there is a vast amount of case law and legal analysis on the subject. The progression of case law has, in general, led to increased officer discretion. The legal standard for initiating a traffic stop is one of reasonable suspicion, which is a relatively low threshold.¹⁸ Once stopped, a vehicle can be searched much more easily than a residence, either through the driver's consent or based on probable cause. Because of the inherent mobility of vehicles, a "vehicle exception" to the Fourth Amendment allows an officer to search a vehicle based on probable cause without a search warrant.¹⁹ Beyond this search warrant exception, based upon probable cause, there are several other search theories that allow officers to search vehicles, including limited "frisks" for weapons, consensual searches, and inventories of the contents of impounded vehicles.²⁰

Given the broad level of officer discretion during vehicle stops and searches, much of the literature surrounding traffic stops focuses on concerns that such latitude can lead to racial profiling.²¹ Yet even studies that argue against officer discretion in traffic stops—such as a 2015 *UCLA Law Review Journal* article on the subject—recognize that limiting such discretion may negatively impact crime control and erode police legitimacy.²²

2. Autonomous Vehicle Technology

While AV technology is relatively nascent and completely "driverless" cars are still being tested, relevant literature points to a future in which vehicles will, indeed, drive themselves with little or no human input. It is also likely that there will be little

¹⁸ Terry v. Ohio, 392 U.S. 1 (1968).

¹⁹ Pennsylvania v. Labron, 518 U.S. 938, 940 (1996).

²⁰ Edward Hendrie, "The Motor Vehicle Exception," *FBI Law Enforcement Bulletin* 74, no. 8 (August 2005): 22, <http://search.proquest.com/docview/204133359?accountid=12702>.

²¹ Though the literature in this regard is vast, and the perception or actual existence of racial profiling is important to mention when examining policy issues related to traffic stops, such practices are not a focus of this literature review. The studies reviewed were chosen because they illustrate the pros and cons of officer discretion.

²² Jordan Blair Woods, "Decriminalization, Police Authority, and Routine Traffic Stops," *UCLA Law Review* 62, no. 3 (May 2015): 758.

interaction between the passengers of such vehicles and law enforcement. Because the technology is rapidly evolving, much of the literature review is based on potentially biased sources, including vehicle manufacturer or designer marketing publications and popular news stories. Only information that was consistent across multiple sources or supported by scholarly articles was used in this review.

Beginning with the claims of the manufacturers, it seems clear that most carmakers envision a future in which autonomous cars need no help from humans. Marketing material by Mercedes Benz, a company that already produces vehicles with advanced “assisted driving” functions, anticipates that “drivers” will be more akin to passengers who are completely oblivious to traffic; AV “drivers” may even be sleeping as the cars drive themselves down the road.²³ Technology magnate and Tesla CEO Elon Musk predicts that most vehicles will be autonomous within ten to fifteen years.²⁴

Literature produced by research firms and government agencies echoes these industry leaders’ forecasts. According to Partners for Advanced Transportation Technology (PATH), a transportation research program from the University of California at Berkeley, vehicle-to-vehicle (V2V) communication systems can make vehicles safer and more fuel efficient.²⁵ Similar technology has been tested in commercial trucks, which are able to drive within four to ten meters from each other as they go down the road in large “platoons” of other V2V-equipped trucks.²⁶

Future vehicles will not only talk to each other, but will also be connected to the transportation infrastructure itself, including traffic signals.²⁷ The United States Department of Transportation (DOT) expects that it will cost billions of dollars to establish this kind of vehicle-infrastructure integration (VII) technology. However, a

²³ “Mercedes-Benz on the Way to Autonomous and Accident-Free Driving,” accessed December 21, 2015, <https://www.mercedes-benz.com/en/mercedes-benz/innovation/mercedes-benz-on-the-way-to-autonomous-and-accident-free-driving/>.

²⁴ Christopher Morris, “Musk Talks about Tesla Submarine, Tesla Truck, Tesla Driverless Car,” ValueWalk, January 31, 2016, <http://www.valuewalk.com/2016/01/musk-talks-tesla-submarine-truck-car/>.

²⁵ “Automated and Connected Vehicles,” Berkeley.

²⁶ Ibid.

²⁷ Ibid.

2007 draft report on the costs and benefits of VII anticipated that the return on investment would be 2.8 to 1; a \$16.3 billion investment in vehicle and infrastructure upgrades could yield \$24.9 billion in benefits to society.²⁸ These estimates are based on the kind of VII technologies the report predicts can be implemented incrementally over the next forty years.

Yet vehicle-to-infrastructure (V2I) communication is already here. Amazon—a company interested in autonomy but that does not currently produce AVs—has recently patented a V2I system that would communicate with traffic management centers (TMCs) in order to improve a vehicle’s decision making while choosing lanes.²⁹ Audi is the first company to introduce a V2I-capable production car that can communicate with a TMC to indicate how long a traffic light will stay a certain color in order to better inform driving decisions.³⁰

The insurance industry has also published studies on semiautonomous features.³¹ This data is limited to insurance statistics and does not address all the advantages of autonomous vehicles suggested by the PATH and DOT studies, such as fuel economy and traffic congestion relief. However, the study determined that some features, such as forward collision avoidance systems with autonomous braking, resulted in fewer collisions.³²

In recent years, VII and AV technologies have become closely intertwined with the “Internet of things” (IoT)—the complex network of sensors in various devices, objects and even organic material that connects them to each other over existing Internet

²⁸ Sean Pierce and Ronald Mauri, *Vehicle-Infrastructure-Integration (VII) Initiative Benefit-Cost Analysis: Pre-testing Estimates* (Washington, DC: U.S. Department of Transportation, 2007), 1, [https://www.pcb.its.dot.gov/connected_vehicle/508/Library/Library-RRs-Institutional/VII%20BCA%20report%20draft%20\(3-30-07\).htm](https://www.pcb.its.dot.gov/connected_vehicle/508/Library/Library-RRs-Institutional/VII%20BCA%20report%20draft%20(3-30-07).htm).

²⁹ Andrew Krok, “Is Amazon Moving into the Autonomous Vehicle Industry?” CNET, January 18, 2017, <https://www.cnet.com/roadshow/news/is-amazon-moving-into-the-autonomous-vehicle-industry-too/>.

³⁰ Ibid.

³¹ Matthew Moore and David Zuby, “Collision Avoidance Features: Initial Results,” 23rd *International Conference on Enhanced Safety of Vehicles*, 2013, <http://www-nrd.nhtsa.dot.gov/Pdf/esv/esv23/23ESV-000126.pdf>.

³² Ibid.

infrastructure.³³ This integration between physical objects, infrastructure and communication technologies is part of a cyber-physical systems (CPS) environment that is likely to shape the design of future cities and highways.³⁴ Consequently, CPS technologies, including AVs, have received financial support from the White House over the last several years. Industry literature suggests that such support is not without merit, as predictions indicate the pace of diffusion of CPS technology is rising steeply. Gartner, a technology research firm, “forecasts that about one in five vehicles on the road worldwide will have some form of wireless network connection by 2020, amounting to more than 250 million connected vehicles.”³⁵

In December of 2015, the National Transportation Secretary announced the Smart City Challenge, which will award \$40 million to the American city that can best implement such technology on their streets.³⁶ This is in addition to the Smart Cities Initiative that the White House announced earlier in the year, which would invest \$160 million in federal research money toward advancing IoT technology to address a variety of urban issues, including \$42 million in connected vehicle pilot programs.³⁷ While the Trump administration’s plans to continue Smart City funding are not yet known, such investments were clearly part of President Obama’s agenda, and that agenda included removing humans from the driver’s seat. The Obama White House’s *Strategy for American Innovation* planned to double the federal investment in AV technology, which

³³ Wikipedia, s.v. “Internet of Things,” accessed February 3, 2016, https://en.wikipedia.org/wiki/Internet_of_Things.

³⁴ Cyber Physical Systems Public Working Group, *Framework for Cyber-Physical Systems, Release 0.8* (Gaithersburg, MD: National Institute of Standards and Technology, 2015).

³⁵ “Gartner Says by 2020, a Quarter Billion Connected Vehicles Will Enable New In-vehicle Services and Automated Driving Capabilities,” Gartner, January 26, 2016, <http://www.gartner.com/newsroom/id/2970017>.

³⁶ Jeffrey Zients and John P. Holden, “American Innovation in Autonomous and Connected Vehicles,” the White House, December 7, 2015, <https://www.whitehouse.gov/blog/2015/12/07/american-innovation-autonomous-and-connected-vehicles>.

³⁷ “FACT SHEET: Administration Announces New Smart Cities Initiative to Help Communities Tackle Local Challenges and Improve City Services,” the White House, September 14, 2015, <https://www.whitehouse.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help>.

the administration believed could lead to a 90-percent reduction in collisions caused by driver error.³⁸

According to an October 2015 report published by the University of Michigan Transportation Research Institute, the self-driving car is involved in twice as many collisions as conventional vehicles, but the human drivers of other vehicles are at fault.³⁹ Some 78 percent of these collisions occur when the AVs are traveling at low speeds or have come to a stop and a conventional vehicle rear-ends them.⁴⁰ While the AVs' actions might be appropriate and legal, they are often sudden or overly cautious, causing human drivers to fail to react in time to avoid a collision.⁴¹ AVs' actions are unpredictable to human drivers in part because the AVs are programmed to follow all traffic laws, all the time.⁴²

Perhaps the most comprehensive research literature on AV technology was conducted by the RAND Corporation in its 2014 *Autonomous Vehicle Technology: A Guide for Policymakers*. While this report analyzes many aspects of potential AV impact on society, including potential criminal acts such as terrorism and cybercrime, it makes no recommendations to policymakers. In fact, the report specifically warns against adopting policy at this early stage of AV development, instead recommending further research.⁴³

An NPS master's thesis by Doug Lyons suggests that policymakers and LEAs encourage AV technology because of its potential benefits to society.⁴⁴ Lyons's work draws a direct connection between the AV-related reduction of traffic collisions and the reduced need for traffic enforcement agencies, specifically the California Highway

³⁸ National Economic Council and Office of Science and Technology Policy, *American Innovation*.

³⁹ Brandon Schoettle and Michael Sivak, *A Preliminary Analysis of Real-World Crashes Involving Self-Driving Vehicles* (Ann Arbor: University of Michigan, 2015).

⁴⁰ Ibid.

⁴¹ Naughton, "Humans Slamming into Driverless Cars."

⁴² Ibid.

⁴³ James M. Anderson et al., *Autonomous Vehicle Technology: A Guide for Policymakers* (Santa Monica, CA: RAND, 2014).

⁴⁴ Doug Lyons, "Autonomous Vehicles: A Policy Roadmap for Law Enforcement" (master's thesis, Naval Postgraduate School, 2015).

Patrol (CHP). Lyons suggests that the CHP invest in more technological training to better prepare officers for future complex traffic collision investigations. He further suggests early input from the CHP on legislation and licensing issues surrounding the introduction of AVs onto the nation's roadways. However, he does not address gaps in public safety that may result from decreased traffic enforcement.

While much of the literature on AVs discusses the innovations behind the technology, there is very little yet written about innovative approaches by government agencies, including police forces, to innovate with it. Both the RAND report and Lyons's thesis touch upon AVs' vulnerabilities to hacking, but there is little written in AV technology literature about the government's plans to address AV cybersecurity threats.

However, the AV companies are calling themselves to action, having formed several coalition groups of industry partners to address cybersecurity issues.⁴⁵ In 2017 one such coalition—called Future of Automotive Security Technology Research (FASTR)—published a manifesto about the industry's responsibility to ensure that autonomous and connected vehicles are safe from cybersecurity threats.⁴⁶ The manifesto expands upon CPS, V2I and IoT connectivity by introducing the concept of V2X, or “vehicles to everything.” According to the manifesto, the implications of V2X communication—along with the rapid pace of adoption and diffusion of the technology—demands that the industry collectively has “the opportunity, and responsibility, to rearchitected [sic] the vehicle in such a way that cybersecurity is at its very foundation.”⁴⁷

The literature on AV security does not suggest that government agencies are seeking membership in groups like FASTR or that vehicle cyber security is on the radar of today's LEAs. And there is no literature discussing the gap between the traffic safety benefits of AVs and their effect on LEAs' ability to detect, deter and disrupt crime through traffic enforcement.

⁴⁵ Tom Spring, “Consortium Publishes Manifesto on Autonomous Vehicle Security,” Threatpost, February 8, 2017, <https://threatpost.com/consortium-publishes-manifesto-on-autonomous-vehicle-security/123621/>.

⁴⁶ “Our Manifesto,” Future of Automotive Security Technology Research (FASTR), accessed March 8, 2017, <https://fastr.org/about-us/what-is-fastr-a-manifesto/>.

⁴⁷ Ibid.

3. Innovation in Government as an Organization

Literature about innovation in organizations can be found in many forms, such as blogs and books; academic papers, theses and dissertations; business school studies; and government reports. They focus on a variety of topics—from business management to data collection—and span across several disciplines, beginning with the business world but eventually including modern homeland security and policing. This literature review surveys some of these sources to facilitate introducing innovation into discussions surrounding homeland security and public safety challenges. The review first provides a brief historical context and then explores a modern perspective. As the review surveys works on government organizations, including LEAs, it expands its focus to span failures in innovation and the influence of inertia.

After the industrial revolution, business models, management practices and economic theories struggled to keep pace with evolving technologies. This led to innovation becoming a key concept for managers of successful organizations, which is reflected in a scan of twentieth-century literature. In 1919, architect and steel industry magnate Frederick Winslow Taylor’s work on “scientific management” was a response to human inefficiencies that slowed the full potential of machine manufacturing.⁴⁸ Taylor’s concepts quantified work outputs in new ways, and his innovation led to a paradigm shift in management systems that increased a manager’s contribution to those outputs. In the 1930s, economist Joseph Schumpeter argued that businesses must innovate in order to further develop and become increasingly profitable.⁴⁹ Schumpeter believed innovation required organizational flexibility and a capacity for change.⁵⁰ He provided five key strategies for profitability, centered on innovation: launching new products, applying new production and sales tactics, opening new markets, seeking new supply sources, and restructuring of industries.⁵¹

⁴⁸ Frederick Winslow Taylor, *The Principles of Scientific Management* (New York: Harper and Brothers, 1919).

⁴⁹ Joseph A. Schumpeter, *The Theory of Economic Development* (Piscataway, NJ: Transaction Publishers, 1934).

⁵⁰ *Ibid.*, xxii.

⁵¹ *Ibid.*, 66.

Later in the twentieth century, Everett Rogers examined the rate at which technological innovations are adopted by various individuals, organizations and societies.⁵² Rogers developed a model for the diffusion of innovations, which Geoffrey Moore later expanded upon by suggesting that diffusion did not occur at a constant rate and that a “chasm” of incompatibility existed between early adoption of innovations and mainstream acceptance.⁵³ Malcolm Gladwell suggests that key people can help innovations cross the chasm, connecting innovations with new sectors of an organization or society until they reach a “tipping point,” at which time they spread like a virus.⁵⁴ The diffusion of innovations has been discussed and expanded upon in literature about business and social theory, and homeland security studies courses have included such writing in their curriculum.⁵⁵

In the twenty-first century, the exponential growth of computerized technology has made innovation even more central to the success of large organizations. Consequently, the majority of relevant literature on modern organizational innovation comes from writings on the topics of business management, economics and technology.⁵⁶

Harvard Business School Professor Clayton Christensen has written seven books on the subject, beginning with *The Innovator’s Dilemma: When New Technologies Cause Great Firms to Fail*. In the book, he defines technology and innovation as follows: “*technology ... means the processes by which an organization transforms labor, capital, materials, and information into products and services of great value. ... Innovation refers*

⁵² Everett Rogers, *Diffusion of Innovations* (New York: Free Press, 1995).

⁵³ Ibid., 262; Geoffrey Moore, *Crossing the Chasm* (New York: Harper Collins, 1999).

⁵⁴ Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference* (New York: Little, Brown and Company, 2000), 196–203.

⁵⁵ Harvard Business Review Press, *HBR’s 10 Must Reads on Innovation* (Boston: Harvard Business Review Press, 2013); Gladwell, *The Tipping Point*; John T. Gourville, *Note on Innovation Diffusion: Rogers’ Five Factors* (Boston: Harvard Business School, 2005)—The Naval Postgraduate School synthesized this reading on innovation diffusion theory into a curriculum for its Center for Homeland Security and Defense’s strategic planning course.

⁵⁶ Clayton M. Christensen, *The Innovator’s Dilemma: When New Technologies Cause Great Firms to Fail*, Kindle edition (Boston: Harvard Business School, 1997); Eric Ries, *The Lean Startup* (New York: Crown Business, 2011); Salim Ismail, Michael S. Malone, and Yuri Van Geest, *Exponential Organizations: Why New Organizations are Ten Times Better, Faster, and Cheaper Than Yours (and What to Do about it)*, Kindle edition (New York: Diversion Books, 2014); Amy Webb, *The Signals are Talking* (New York: PublicAffairs, 2016).

to a change in one of these technologies.”⁵⁷ Christensen draws a distinction between sustaining technologies—those that foster new product performance—and disruptive technologies, which generally underperform existing products but do the same job in novel ways for less money. Christensen’s “principles of disruptive innovation” provide a set of rules that guide managers of successful, well-run organizations to change some of the very strategies that made the company profitable in order to compete with new firms that bring disruptive technologies to market.⁵⁸ The “innovator’s dilemma” is essentially knowing how and when to do so.

In contrast to *The Innovators Dilemma*, Entrepreneur Eric Ries’s work, *The Lean Startup*, is a guidebook on how small, new companies can overcome barriers to entry into markets dominated by larger, more established organizations. Ries dispenses with complex business plans, instead basing strategy on validated learning and constant feedback in order to help an organization decide whether to hold the course—to persevere—or change its strategy—pivot—to reach its vision.⁵⁹ The speed with which the organization can learn, and the number of times it is able to pivot, before spending all of its capital are central to its profitability and success.⁶⁰

Organizational learning is a recurring theme in contemporary literature on technology and innovation. Futurist Amy Webb’s book, *The Signals Are Talking: Why Today’s Fringe is Tomorrow’s Mainstream*, discusses how to recognize “signals” that indicate how technology is converging with culture, providing an organizational methodology for charting the future using contemporary knowledge.⁶¹ This ability to “predict the present” has been called “nowcasting”—a term derived from meteorology

⁵⁷ Christensen, *Innovator’s Dilemma*, Kindle location 137.

⁵⁸ Ibid., 124.

⁵⁹ Applied to a startup, Ries defines validated learning as “the process of demonstrating empirically that a team has discovered valuable truths about a startup’s present and future business prospects.” Ries, *Lean Startup*, 38.

⁶⁰ Ibid.

⁶¹ Webb, *Signals Are Talking*.

and adapted to many disciplines, including homeland security studies.⁶² Another futurist, NPS Professor Rodrigo Nieto-Gomez, suggests nowcasting as a way for homeland security practitioners to collaborate with technology industries to increase the speed with which government policies respond to disruptive innovations in homeland security threats.⁶³ Nieto-Gomez offers nowcasting as a way to learn about “knowable unknowns.”⁶⁴

As technology has exploded across all sectors of society, the need for innovation in government organizations, including homeland security and police agencies, has become a policy imperative. In 2015 the White House’s National Economic Council and Office of Science and Technology Policy issued a report entitled *A Strategy for American Innovation*. The report recognizes government’s need to innovate and lays out a plan for adopting an innovation toolkit “to increase the effectiveness and agility of the government through improvements in its core processes, including people and culture, procurement, grant-making, digital services, performance management, and internal and external collaboration.”⁶⁵ In the law enforcement arena, industry think tanks and specific agencies have published strategies that stress the importance of innovation in technology and community engagement.⁶⁶

Yet, even as organizations’ strategies and vision statements tip their hats to innovation, much of the literature on innovation exists because of a prevailing consensus that organizations do not innovate well. Thus, literature on innovations often involves studying those who failed to do so—such as the Eastman Kodak company’s reluctance to

⁶² Hyunyoung Choi and Hal Varian, “Predicting the Present with Google Trends,” *Economic Record*, 88 (June, 2012): 2–9; Rodrigo Nieto-Gomez, “A Director of the Present? Nowcasting Homeland Security’s Challenges,” *Homeland Security Affairs* XIII (September 2016), <https://www.hsaj.org/articles/11952>.

⁶³ Nieto-Gomez, “Director of the Present.”

⁶⁴ Ibid.

⁶⁵ National Economic Council and Office of Science and Technology Policy, *American Innovation*, 109.

⁶⁶ President’s Task Force on 21st Century Policing, *Final Report of the President’s Task Force on 21st Century Policing* (Washington, DC: Office of Community Oriented Policing Services, 2015); J. A. Farrow, *California Highway Patrol Strategic Plan 2015–2019* (Sacramento, CA: California Highway Patrol, 2015).

embrace digital photography, or the U.S. Postal Service's inability to modernize.⁶⁷ Discussions on organizational and cultural inertia are a common literary trope, especially in the case of government. Former military leaders have written many books on their innovative attempts to overcome such inertia, and their examples are studied in courses and seminars for business, homeland security and law enforcement leadership.⁶⁸

In summary, the literature indicates that private companies and public agencies can learn from each other and from scholarship about innovative successes and failures. From the business and economic perspective, organizations suffer losses when they do not recognize disruptive innovation, and established organizations are slower to innovate than new ones. The entrepreneurial and futurist perspective indicates that organizations should encourage innovation and flexibility as a strategy, and that there are signs in the present that signal how and when to act on that strategy. Finally, the government perspective encourages adaptive change in doctrine while, in practice, cultural and organizational inertia hinders the ability to make such changes.

D. RESEARCH DESIGN

While AVs are relatively new and not yet widely used, they are likely to become a disruptive innovation that will not only displace many transportation industry jobs, but could also eliminate the need for today's traffic enforcement model. This phenomenon's potential impact on public safety is not discussed in any known literature on AV technology, nor does it seem to be on the radar of police executives or public policymakers. The research and recommendations in this section are designed to illustrate

⁶⁷ Chunka Mui, "How Kodak Failed," *Forbes*, January 18, 2012, <http://www.forbes.com/sites/chunkamui/2012/01/18/how-kodak-failed/#b27bbb9bd6ae>; Peter J. Coughlan, based upon an earlier case study titled "Kodak and the Digital Revolution" authored by Giovanni Gavetti, Rebecca Henderson, and Simona Giorgi, in "Kodak: Death by Digital?", (coursework case study, Naval Postgraduate School, 2015).

⁶⁸ This literature is part of the curriculum for the NPS master's program in National Security Studies (Homeland Security and Defense). See Robert Gates, *Duty: Memoirs of a Secretary at War* (New York: Vintage Books, 2015), 115–148; Stanley McChrystal et al., *Team of Teams*, Kindle edition (New York: Penguin, 2015); D. Michael Abrashoff, *It's Your Ship: Management Techniques from the Best Damn Ship in the Navy* (New York: Warner Books, 2002)—this book is read as part of the curriculums of the CHP's middle management course at the Sherman Block Supervisory Leadership Institute, a professional development program for law enforcement supervisors.

and address a potential gap in public safety that may be an unintended consequence of AVs' traffic safety advantages.

1. Sample Selection Process

Traffic enforcement and traffic stops are studied in a modern context to establish their significance to public safety, specifically crime deterrence, outside of traffic safety. While there are few comprehensive studies on traffic enforcement as a crime deterrent, statistical information surrounding traffic stops, as well as case studies of individual stops that have led to the discovery or prevention of other crimes, can shed light on their effectiveness as a crime-fighting tool.

Because AV technology is in its early stages, futures-forecasting methodologies, including environmental scanning of current literature and signals theory, are used to analyze the potentially negative impact AVs might have on public safety. A synthesis of extant literature and theories on innovation as they apply to government organizations, including police agencies, is applied in the final analysis in order to recommend action and areas of further study.

2. Study Limitations

This study does not address the abuse of traffic enforcement policies or related questions surrounding unchecked police discretion, racial profiling or revenue enhancement through traffic fines, though these topics may be briefly mentioned to better evaluate policy decision making.

The study does not delve deeply into the specifics of AV technology or related public policy if it does not impact public safety related to crime. Speculation about future AV technology is based on what seems probable given the research design.

3. Data Sources

Data sources on traffic stops come from existing literature, including legal journals and published case law, as well as relevant published statistics. AV technology data and information about its future impact come from academic sources whenever

possible, but are necessarily reliant on periodicals and industry publicity because the technology is in its nascent stages. Sources on innovation in organizations derive from disciplines including business management, economics, sociology, communications and futures forecasting.

4. Analytical Steps

The impact of traffic enforcement on crime and public safety is described using existing published articles, including some on traffic stops studies and subsequent criminal investigations. The impact of AV technology on traffic enforcement and its subsequent effects on public safety are examined using futures-forecasting methodologies, including environmental scanning and signals theory. These effects are expressed using a diffusion-of-innovations model and plausible future scenarios based on past traffic stops and forecasted AV technology, which presupposes a reduction in traffic enforcement.

Solutions to filling potential public safety gaps identified by these methodologies are explored using signals theory and nowcasting methods. When possible, solutions are sought through existing successful police policy and procedure, including traffic enforcement tactics, that can be applied to future scenarios.

5. Output

By painting a picture of a future world in which AVs have supplanted human-driven vehicles, this research develops plausible scenarios—including some fictional vignettes—that illustrate AV technology's unintended consequences upon crime and general public safety. An analysis of possible outcomes may help develop policies and technologies to fill the public safety gaps created by the absence of traffic enforcement on our roadways.

E. OVERVIEW OF CHAPTERS

While driverless cars will likely impact society in many ways, their impact on the nature of traffic enforcement may not be immediately evident or seem significant. To the contrary, the likelihood that the need for traffic enforcement—and the traffic stops that give such enforcement its teeth—would decrease as a byproduct of safer roads would seem an added benefit of AV technology.

The remaining chapters illustrate the gap between public safety—especially crime detection and deterrence—and traffic safety; they then go on to suggest ways in which to bridge that gap. Chapter II provides an overview of traffic enforcement, specifically the traffic stop, as a crime-fighting tool. Chapter III explores the future of AV technology and concludes that the technology will likely curtail or eliminate current traffic enforcement tactics and strategies. Chapter IV uses diffusion-of-innovations and signals theories to suggest that AVs will be widely adopted by consumers and that adoption will accelerate in the near future. The chapter also suggests that law enforcement may be slower to innovate in its responses to the technology. Chapter V envisions a plausible future in which AVs rise to prominence on society's highways, and imagines how criminals and terrorists might exploit them. Chapter VI recommends ways in which policymakers and police agencies can engage with AV technology in the present to shape how it impacts public safety in the future.

II. JUST A ROUTINE STOP

The best car safety device is a rear-view mirror with a cop in it.

—Dudley Moore

Many of us are familiar with the pang of anxiety that hits when a police cruiser pulls up behind us, even if we know our vehicle is road-ready and we are following all the traffic laws. Even though completely innocent, we might slow down. “What are they going to stop me for?” we ask ourselves, just before the cruiser drifts into the exit lane and disappears.

Yet, even though completely innocent, we might have slowed down. If we were wanted criminals, or were transporting something illegal, we would have worried even more. Perhaps we would have begun to rehearse a story and wonder if our contraband was hidden well enough. Herein lies the power of the traffic stop as a deterrent of unlawful behavior.

This chapter provides an overview of the traffic stop’s public safety significance and examines the legal concepts behind its use. It also illustrates the effectiveness of the traffic stop as a general law enforcement tool, specifically in terms of detection, deterrence and disruption of criminal activity.

A. PURPOSE AND ACCEPTABILITY OF TRAFFIC ENFORCEMENT

According to NHTSA, there were over 6 million police-reported traffic collisions in 2014, resulting in over 2.3 million injuries and 32,675 fatalities.⁶⁹ When compared to the number of aggravated assaults (741,291) and homicides (14,249), this figure illustrates the importance of traffic law enforcement as a public safety priority.⁷⁰

⁶⁹ NHTSA, *Summary of Motor Vehicle Crashes: 2014 Data* (Report No. DOT HS 812 263) (Washington, DC: NHTSA, 2016).

⁷⁰ “Uniform Crime Reporting: 2014 Crime in the United States—Aggravated Assault,” FBI, accessed July 11, 2016, <https://www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2014/crime-in-the-u.s.-2014/offenses-known-to-law-enforcement/aggravated-assault>.

Consequently, police departments throughout the country have units focusing on traffic safety in cities, and state patrols are either specifically chartered for traffic enforcement or take on traffic responsibilities as part of their missions.

Perhaps due to the public safety significance of traffic enforcement, the motoring public generally tolerates traffic stops more than other kinds of police contact. According to a 2011 Bureau of Justice Statistics study, there was a higher level of public acceptability and feelings of police legitimacy among persons stopped in a motor vehicle than those contacted by police on the street.⁷¹ Yet such acceptability would likely not exist if the traffic enforcement were used solely as a means to protect the public from crimes against persons or property, rather than to ensure traffic safety.

The California Highway Patrol (CHP) is the largest state police agency in the United States with a primary focus on traffic safety.⁷² CHP Commissioner Joseph Farrow describes the department's mission in his 2015–2019 strategic plan as follows:

The mission of the CHP is to provide the highest level of Safety, Service, and Security. Our ultimate purpose is to save lives and through strategic planning efforts, we can provide California's communities with education, enforcement, and support to decrease fatalities on the road.⁷³

Chapter one of the CHP's *Enforcement Policy Manual* reflects this primary mission by delineating the purpose of the traffic enforcement stop:

The primary purpose of the CHP is traffic safety and officers should enforce the California Vehicle Code (CVC) with the goal of ensuring and maximizing the safety of the thousands of motorists on California roads and highways every day. Officers shall not stop individuals for the primary purpose of drug interdiction unless they have probable cause or reasonable suspicion of drug-related activity. Officers must have specific and articulable facts to support their determination; a mere suspicion or "hunch" is not sufficient.⁷⁴

⁷¹ Langton and Durose, *Police Behavior*, 1.

⁷² "Uniform Crime Reporting: Table 76, Full-Time State Law Enforcement Employees, by State, 2014," FBI, accessed June 28, 2016, <https://www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2014/crime-in-the-u.s.-2014/tables/table-76>.

⁷³ Farrow, *California Highway Patrol Strategic Plan*, 3.

⁷⁴ California Highway Patrol (CHP), *Highway Patrol Manual 100.68—Enforcement Policy Manual* (Sacramento, CA: CHP, July 11, 2011), 4–5.

B. THE TRAFFIC STOP AS A GENERAL LAW ENFORCEMENT TOOL

Though the CHP's enforcement policy specifically addresses drug interdiction, its spirit applies to other types of investigatory stops. Yet, even within such parameters, crime suppression is an inherent consequence of vigorous traffic enforcement. In 2003 a beleaguered Oakland Police Department requested CHP assistance with "sideshow" activity—"random gatherings of people in vehicles displaying lawless behavior."⁷⁵ As part of this joint law enforcement effort, called Operation Impact, the CHP responded with a heavy traffic enforcement presence within the Oakland city limits and a "zero tolerance" policy for traffic violations.

According to a CHP report, Operation Impact resulted in sixty-nine days of deployment over a roughly two-year period. While it netted many traffic-related arrests and citations, it also resulted in 432 arrests for felony and misdemeanor offenses, nearly half as many as the driving under the influence (DUI) arrests made during the operation.⁷⁶ Additionally, twelve firearms were recovered and there were reportedly no homicides during the first eleven deployments.⁷⁷ Though traffic enforcement was but one part of a larger strategy to target rising crime rates in Oakland in 2003, there was a 23-percent drop in the homicide rate from 2003 to 2004.⁷⁸

The concept of directing traffic enforcement efforts toward the interdiction of other criminal activity is not without controversy. Operation Impact came under fire for harassment of Oakland citizens.⁷⁹ A Drug Enforcement Administration-sponsored initiative, called Operation Pipeline, trained traffic enforcement officers in drug

⁷⁵ J. A. Farrow, *2008 Herman Goldstein Award for Excellence in Problem Oriented Policing-Operation Impact* (Sacramento, CA: CHP, May 2008), i.

⁷⁶ *Ibid.*, 12. Note: One statistic in this report is flawed, but this appears to be an editorial error, as the number of stolen vehicles recovered during the operation was reflected as the same as the number of verbal warnings given: 2,357. This is far too high a number for stolen vehicles, but is a reasonable one for verbal warnings. There is no reason to believe other statistics were inaccurate.

⁷⁷ *Ibid.*, iii, 12.

⁷⁸ Henry K. Lee, "Oakland/Homicide Rate Plummeting/down 23% to Date, and Police Expect Decline to Continue," *SFGate*, December 29, 2004, <http://www.sfgate.com/bayarea/article/OAKLAND-Homicide-rate-plummeting-Down-23-to-2661165.php>.

⁷⁹ "Challenging Police Lockdowns of Oakland Neighborhoods," DataCenter, September 18, 2005, <http://www.datacenter.org/challenging-police-lockdown-of-oakland-neighborhoods/>.

interdiction techniques. The operation was vigorously attacked by civil liberties groups, including the American Civil Liberties Union (ACLU), which alleged it resulted in racial profiling.⁸⁰ Despite such controversy, the techniques introduced to traffic enforcement officers through Operation Pipeline are still being taught today, and are considered effective ways to combat crime, including terrorism. The El Paso Intelligence Center (EPIC) sponsored “Operation Pipeline Training” at the Midwest Counter Drug Training Center as recently as May of 2016. The course bulletin describes the training as follows:

This is the basic course of instruction for uniformed patrol officers, detectives, agents or investigators, covering the fundamental principles of criminal roadway interdiction of passenger and commercial motor vehicles. Topics covered: Passenger and Commercial Motor Vehicle Interdiction, Hidden Compartments, Officer Safety; Law—Search and Seizure; Intelligence Trends and Traffic; El Paso Intelligence Center (EPIC) Operations and Access.⁸¹

Similar courses have also been taught by former and current law enforcement officers who own private companies such as Desert Snow and the 4:20 Group. Such courses illustrate ways traffic enforcement can be leveraged to detect and deter other crimes. This leverage is possible largely because of the aforementioned acceptability of the traffic enforcement mission—saving lives on our highways—and because the courts have generally granted a great deal of discretion to officers conducting traffic stops.

⁸⁰ “DEA History 1980–1985,” Drug Enforcement Administration, accessed June 15, 2016, 54, <https://www.dea.gov/about/history/1980-1985.pdf>; David A. Harris, *Driving while Black: Racial Profiling on Our Nation’s Highways* (New York: American Civil Liberties Union, 1999). Note: Racial profiling by police is illegal. The examination of traffic enforcement procedures in this work applies to officers using legal means to target their stops, independent of race. Illegal practices are not being condoned or considered as viable, nor is any change of policies or laws regarding racial profiling being recommended.

⁸¹ “Operation Pipeline Training,” Midwest Counterdrug Training Center, accessed March 10, 2017, <http://www.counterdrugtraining.com/files/DDF/FLYER%20-%20PIPELINE.PDF>.

C. TRAFFIC STOPS AND POLICE SEARCHES

In order to make a traffic stop, an officer must establish probable cause for the stop, or at least be able to articulate a reasonable suspicion that a crime has occurred or may be occurring.⁸² Once a stop is made, officers have many tools at their disposal to detect further criminal activity.

The Fourth Amendment protects against *unreasonable* search and seizure. This protection requires that a sworn warrant be issued in order to search a person's property or seize items discovered therein.⁸³ Searches conducted with a valid warrant are considered "reasonable" by the courts, while all other searches are presumed "unreasonable," making it the burden of the prosecution to prove otherwise. Over the years, the courts have ruled on exceptions to the warrant requirement, which can then make certain warrantless searches "reasonable." Some of these exceptions particularly enhance officer discretion to search a vehicle during traffic stops. These include: consent searches, searches incident to arrest, "plain-view" searches, and—the one that is most unique to traffic enforcement—the "vehicle exception." The following sections briefly describe how each of these exceptions applies to contacts made during a traffic stop:

1. Consent Searches

An officer can simply ask a driver, registered owner or any passenger in a vehicle for permission to search areas or articles under that person's control. If granted, an officer may search without a warrant, and such a search will generally be deemed as "reasonable" in court. Seeking consent to search after stopping a person for a minor

⁸² *Black's Law Dictionary*, s.v. "Definitions of Probable Cause vs. Reasonable Suspicion," accessed July 30, 2016, <http://thelawdictionary.org/article/definitions-of-probable-cause-vs-reasonable-suspicion/>.

"Reasonable suspicion is a standard established by the Supreme Court in a 1968 case in which it ruled that police officers should be allowed stop and briefly detain a person if, based upon the officer's training and experience, there is reason to believe that the individual is engaging in criminal activity. The officer is given the opportunity to freeze the action by stepping in to investigate."

"Probable cause to search for evidence or to seize evidence requires that an officer is possessed of sufficient facts and circumstances as would lead a reasonable person to believe that evidence or contraband relating to criminal activity will be found in the location to be searched. As with an arrest, if an officer cannot articulate the facts forming the basis for probable cause, the search and seizure will not hold up in court."

⁸³ U.S. Const. Amend. IV.

traffic violation is controversial enough that some courts have ruled officers need reasonable suspicion before seeking consent, and some police departments have self-imposed this requirement as part of their enforcement policies.⁸⁴ Still, as long as it is freely given, consent is a powerful tool to officers who use due diligence to ferret out greater crimes than simple traffic infractions.

Even assuming reasonable suspicion must be established, obtaining consent during a traffic stop can be fairly straightforward. An officer establishes initial reasonable suspicion or probable cause to make a traffic stop for a violation of a traffic law. Upon contact with the driver, the officer asks routine questions. The answers to those questions, in combination with the driver's or passenger's behavior and a variety of other factors, are consistent with the *possibility* of criminal activity, thus establishing reasonable suspicion. A classic example is the stop made on a rented car along a known drug-smuggling route, where a driver and passenger are excessively nervous and give conflicting stories as to the reason for their trip. Each of these factors alone might not be suspicious, but an experienced officer may determine that, combined, they are *indicators* of criminal activity. However, they are still insufficient to establish probable cause to search the vehicle or make an arrest. Thus, the officer could ask for consent to search.

2. Searches Incident to Arrest

If a person is arrested during a traffic stop, an officer may search the vehicle for any evidence to prove the arresting offense.⁸⁵ This exception to the search warrant requirement is less controversial and even more straightforward than obtaining consent, though the scope, or parameters, of the search are more limited. A typical arrest may occur after an officer pulls a person over for weaving, and then discovers the driver is driving under the influence of alcohol. After arresting the subject, an officer could then search the passenger area for alcohol, as this could provide further evidence of the

⁸⁴ *New Jersey v. Carty*, 790 A.2d 903 (2002); CHP, *Highway Patrol General Order 100.91–Search and Seizure Policy* (Sacramento, CA: CHP, January 2014), 6.

⁸⁵ *Arizona v. Gant*, 556 U.S. 332 (2009). Prior to *Gant*, an officer could search the entire passenger area of a vehicle after arrest for weapons or contraband that may have been accessible to the person before the arrest. *Gant* prohibited such searches once the subject was removed from the vehicle.

offense. However, if the officer made the stop and discovered a driver was not under the influence of alcohol but merely driving on a suspended license, an arrest might still be made; in this instance a search would not be legal, as nothing in the vehicle could reasonably provide further evidence of the suspended license.

3. Plain-View Searches

If evidence is in “plain view,” or immediately visible to an officer conducting a traffic stop, it may be seized without a warrant.⁸⁶ The plain-view exception would also apply to any place an officer could legally be stationed—e.g., in a business investigating an alarm call, or in a home responding to a domestic violence incident—where evidence is plainly visible. For example: An officer sees a car roll through a stop sign and makes a traffic stop. Upon contacting the driver, the officer asks for license and registration. When the driver opens the glove box to retrieve registration, the officer sees a bag filled with a white powdery substance resembling cocaine “in plain view” in the glove box. The officer could then seize the suspected cocaine; if it is confirmed that the substance is indeed cocaine, the driver could then be arrested.

Because traffic stops are the most common form of police contact, these exceptions can give officers the discretion to look into private aspects of the average motorist’s life in ways not possible in that person’s home or business, or in most public places. Though such exceptions do apply to places other than automobiles, the frequency and general acceptance of the traffic stop makes their use in searching cars much more commonplace than other locations.

Generally speaking, there are not many legitimate reasons for police to contact people in their homes, much less enter uninvited. Imagine the public uproar if officers, absent the belief that a crime was occurring, made it a habit to knock on doors and ask for consent to search. Yet the fact that motorists routinely break traffic laws provides many opportunities for officers to contact people in their cars, and these exceptions provide further opportunities to enter and search those cars.

⁸⁶ *FindLaw Legal Dictionary*, s.v. “Plain View,” accessed July 30, 2016, <http://dictionary.findlaw.com/definition/plain-view.html>.

4. The Vehicle Exception

Perhaps the most powerful tool officers can use to search vehicles is known as the “vehicle exception” to the search warrant requirement. Unlike other exceptions that can also be used to search homes, the vehicle exception applies only to automobile. This exception essentially allows officers to search areas of a vehicle without a warrant as long as they can reasonably articulate probable cause to believe evidence or contraband exists in those areas.

Building on the cocaine-in-the-glove box scenario used previously, the vehicle exception would allow an officer to further search the car for more cocaine or any other evidence that would link the driver to the cocaine. This is permissible simply because the officer has probable cause to believe that there might be such evidence in the car. Were the same circumstances to occur in a house, an officer could still seize evidence in plain view, but he or she would need to “freeze the residence”—or secure the location while officers stood guard over it—before writing a search warrant, which would then need to be signed by a judge in order to permit a search for further evidence. This warrant would need to lay a foundation that outlined the officer’s training and experience to substantiate why the officer felt more evidence or contraband existed, and it would have to specifically articulate why evidence would be located in particular locations within the residence. Furthermore, if evidence were in plain view through the open door of a residence, an officer would also have to procure a warrant before seizing it.⁸⁷ Under the vehicle exception, an officer could not only seize such evidence without a warrant, but he or she would likely have sufficient probable cause to search the vehicle further. In essence, if the probable cause to search a vehicle exists, it does not have to be vetted by the courts for the search to be legal.

The vehicle exception to the warrant requirement affords a great amount of officer discretion to search. The courts have repeatedly upheld its legality, citing the inherent

⁸⁷ *Steele v. United States*, 267 U.S. 498 (1925).

mobility of cars, the heavy regulation of vehicle equipment and registration requirements, and the relative lowered expectation of motorist privacy as justification.⁸⁸

5. Storage and Impound Authority

In addition to the frequency of contacts and the broad search discretion afforded to officers while enforcing traffic laws, storage and impound authorities offer additional opportunities to detect criminal activity while conducting traffic enforcement or accident investigation duties. There are a variety of reasons for police to store or impound (henceforth the terms will be used interchangeably) vehicles—e.g., upon arresting a driver, to remove an illegally parked vehicle, or to clear a roadway of a wrecked or disabled vehicle. When police store a vehicle, they must conduct a thorough inventory of the vehicle’s contents and condition before turning it over to a tow truck driver. Such inventories are not deemed unreasonable searches by the courts but rather part of police officers’ duties as community “caretakers.”⁸⁹ The purpose of a vehicle inventory is to protect the vehicle owner’s property as well as to protect police against false claims that they have damaged, lost or stolen property.

Although inventories cannot function as pretexts to search vehicles, they still provide police with a legal opportunity to look inside them. If contraband is located during a vehicle inventory, it may be seized under the plain-view exception. Furthermore, under the vehicle exception, finding such contraband might establish enough probable cause to continue to search areas that were beyond the scope of a simple inventory.

An example of this progression—from a traffic stop, to a vehicle inventory, to a search—might transpire as follows: An officer stops a vehicle for running a stop sign and determines the driver has a suspended license. In California, for example, the driver would not be taken into physical custody for such an offense; the driver simply signs a

⁸⁸ *Carroll v. United States*, 267 U.S. 132 (1925)—A prohibition-era case involving a search for liquor with a vehicle, *Carroll* allowed for the search without a warrant, as long as probable cause could be established and an exigent circumstance existed that might allow for removal of the vehicle before a warrant could be obtained; *California v. Carney*, 471 U.S. 386, 390–391 (1985)—*Carney* introduced concepts of inherent mobility and lower expectations of privacy because of regulation as justification a warrantless search of a motor home while being operated on a highway.

⁸⁹ *South Dakota v. Opperman*, 428 U.S. 364 (1976).

citation and then leaves. However, the offense gives the officer the authority to impound the driver's vehicle.⁹⁰ During the course of a vehicle inventory, the officer locates cocaine in the vehicle's glove box—a location the officer would normally search during an inventory. Once the officer finds the cocaine, sufficient probable cause exists to search inside body panels, engine parts, tires, or virtually anywhere that cocaine is likely to be hidden, even though such locations could not be searched under the auspices of a vehicle inventory.

D. THE PRETEXT STOP AND OFFICER DISCRETION

The previous examples of exceptions to the Fourth Amendment's search warrant requirement provide snapshots of how a traffic violation could lead to the discovery of contraband or evidence of a crime. While useful for general law enforcement purposes, such discoveries are essentially byproducts of a traffic enforcement mission. A weapon in plain view on the seat of a car might indicate to an officer that crime is afoot, but the intent of the stop is usually to enforce a traffic law and nothing more. The discovery of greater crimes is often a random consequence of such intent. Indeed, the "randomness" of traffic enforcement's contribution to crime detection is a great part of its significance to crime deterrence and public safety in general.

However, beyond their traffic enforcement purpose, traffic stops can be targeted toward specific law enforcement goals, and these goals can legally have nothing to do with traffic safety, as long as an officer observes a violation of a traffic law. Such stops are known as pretext stops, and the courts have repeatedly upheld them. The most significant judicial decision on the issue came down in 1996, via the United States Supreme Court, in *Whren v. United States*. The circumstances in *Whren* involved vice officers in an unmarked vehicle patrolling a "high drug area," when they observed the occupants of a Nissan Pathfinder displaying suspicious behavior. When the driver, Whren, failed to signal, the officers pulled him over; upon contacting him, they found crack cocaine in his hands. The Supreme Court decided that the traffic violation was

⁹⁰ California Vehicle Code, div. 11, sec. 22651(p) (1959).

sufficient probable cause to stop the driver, even though the officers' initial interest was piqued by the possibility of drug trafficking activity. The decision read as follows:

Here the District Court found that the officers had probable cause to believe that petitioners had violated the traffic code. That rendered the stop reasonable under the Fourth Amendment, the evidence thereby discovered admissible, and the upholding of the convictions by the Court of Appeals for the District of Columbia Circuit correct. The judgment is Affirmed.⁹¹

By allowing officers to stop any vehicle for any traffic violation regardless of their true investigative purpose, *Whren* effectively grants police one of their most effective discretionary law enforcement tools. Beyond the specific example in *Whren* itself—vice officers patrolling a “high drug” area in order to discover narcotics trafficking—the pretext stop can be used in a variety of ways. Though deployed for traffic safety purposes, traffic enforcement officers in known drug trafficking corridors across the country use pretext stops to catch smugglers of contraband. Officers learn how to recognize “criminal indicators” of narcotics trafficking during traffic enforcement duties in courses like “Desert Snow” or “Operation Pipeline.” The discretion to stop a vehicle on a pretext and then develop probable cause to search is part of the dynamic that makes highway drug interdiction possible.

There are other instances when such discretion, including the discretion for a pretext stop, has a greater public safety purpose than traffic safety alone. Without delving deeply into the specific benefits and pitfalls of each, a few simple, but frequently used, examples follow.

As part of a larger case, traffic officers might stop and identify, or potentially search and arrest, occupants of vehicles who leave a residence of a drug dealer who is under investigation. The stop essentially stands on its own merits. Thus, the arrest or evidence achieved by the stop has less chance of compromising the ongoing investigation, without ignoring a potential threat to public safety presented by the newly discovered crime. Similarly, with information obtained by a confidential source—such as a citizen informant or a court-sanctioned electronic involved in criminal activity—

⁹¹ *Whren v. United States*, U.S. 517, no. 95-5841 (1996), 806.

officers might stop a vehicle for a traffic violation and develop independent probable cause to further investigate.

Pretext stops can be used for more overt public safety applications as well. Similar to the strategy employed in Oakland’s “Operation Impact,” traffic officers might be deployed to a neighborhood that has experienced an uptick in violent crime. These officers could stop vehicles for any traffic violation with the intent of detecting or deterring such crimes, rather than in response to any specific traffic safety problem in the area.

Examples such as these illustrate how the pretext stop can be used to target specific crimes and the individuals who commit them. However, the discretion afforded to officers by the Court’s decision is a constant source of criticism by civil rights advocates. While such criticisms are not a focus of this examination, they are important to recognize, as subsequent chapters discuss the AV’s potential to reduce the need for traffic enforcement. Such a reduction might also have an impact on officers’ discretion, including their discretion to make a pretext stop. This might be viewed as a positive consequence of the AV to those who believe such discretion is too broad.

Yet, even those who seek to curtail police discretion on traffic stops—including discretion to employ pretext stops, as well as to leverage the Fourth Amendment exceptions to vehicle searches—recognize that traffic enforcement has a legitimate crime suppression purpose that must be balanced with any police reform efforts.⁹²

⁹² Woods, “Decriminalization,” 32. Woods’s article argues that even when traffic violations are decriminalized regarding sanctions imposed by the courts, such decriminalization does limit police discretion and authority from a social-control perspective. Woods acknowledges “potential disadvantages of making crime-control efforts harder in traffic settings,” suggesting further study to compare such a loss with the potential gains in police legitimacy that he suggests might come from limiting police discretion on traffic stops.

E. THE TRAFFIC STOP AS CRIME DETECTOR AND DETERRENT

Compared to those made under pretext, a far greater number of traffic stops are conducted with the express intent of enforcing traffic laws in order to enhance traffic safety. Yet either intent can lead officers to the discovery of more serious crimes. A person need look no further than their daily news sources to find examples of how felonious crimes are discovered on what is often described as “a routine traffic stop.”⁹³

In 2015, domestic highway enforcement operations coordinated through the High Intensity Drug Trafficking Area (HIDTA) program resulted in the seizure of approximately ten tons of marijuana, 526 kilograms of heroin and 1,788 kilograms of cocaine.⁹⁴ In addition to the interdiction of these and a variety of other illicit drugs, HIDTA reports that its highway enforcement program resulted in 13,614 arrests, 978 illegal firearms seizures and the forfeiture of over \$54 million in cash associated with drug trafficking.⁹⁵ Such seizures are but a small part of the contraband that moves across our country’s highways, but they result in fewer drugs and guns—and their associated harm—in our neighborhoods.

There are many examples of notorious criminals who were apprehended during traffic stops. These range from the arrest of serial killers like Ted Bundy—whose propensity to speed in stolen cars led to multiple arrests—to terrorists, including Oklahoma City bomber Timothy McVeigh.⁹⁶ McVeigh had just set off 5,000 pounds of explosives in a Ryder truck he had parked in front of the Alfred P. Murrah Federal Building in Oklahoma City—killing 168 people, including 19 children—when he was

⁹³ “KZOO Traffic Stop Leads to Drug and Weapons Arrests,” WWMT, November 14, 2016, <http://wwmt.com/news/local/kzoo-traffic-stop-leads-to-drug-and-weapons-arrests>; “\$500,000 of Marijuana Seized During Traffic Stop in Pocatello,” *Idaho State Journal*, November 13, 2016, http://idahostatejournal.com/members/of-marijuana-seized-during-traffic-stop-near-pocatello/article_42389d59-336c-5d68-996a-c48683d21085.html; “Traffic Stop Results in Warrant/narcotics Arrest,” *Mohave Valley Daily News*, November 15, 2016, http://www.mohavedailynews.com/news/traffic-stop-results-in-warrant-narcotics-arrest/article_611cfc6c-ab08-11e6-932b-6fcb6ccf7856.html.

⁹⁴ High Intensity Drug Trafficking Area (HIDTA), “2015 Domestic Highway Enforcement Outputs,” (statistical report, March 3, 2016).

⁹⁵ *Ibid.*

⁹⁶ Dean Scoville, “Killer Stops: Alert Traffic Officers Have Caught Some of America’s Worst Fiends, Terrorists and Psychos,” *Police: The Law Enforcement Magazine*, June 1, 2006, <http://www.policemag.com/channel/patrol/articles/2006/06/killer-stops.aspx>.

stopped on Interstate 35 near Perry, Oklahoma, in his yellow Mercury.⁹⁷ Oklahoma Highway Patrol Trooper Charlie Hanger knew nothing about McVeigh's terrorist act when Hanger pulled the Mercury over because it did not have a license plate.⁹⁸ During the stop, Hanger arrested McVeigh after discovering he was carrying a concealed and loaded .45-caliber pistol.⁹⁹ After the FBI connected this arrest to the bombing, evidence located on McVeigh's person and in the Mercury was used to help prove his guilt.¹⁰⁰ At the time of the traffic stop, Hanger did not think the Murrah explosion had been an act of terrorism, something he thought would not happen in America's heartland.¹⁰¹

In the Bundy and McVeigh cases, the connection to their larger crimes was not discovered until days after their initial arrests for less serious offenses. Traffic enforcement did not prevent their heinous acts, but it led to their arrests and resulted in evidence collected against them. But there are many other examples of traffic stops that led to the discovery of criminal plots before they occurred, including plots of terrorism.

One example of such a discovery resulted from the stop and subsequent arrest of Yu Kikumura, a member of a terrorist organization called the Japanese Red Army. New Jersey State Trooper Robert Cieplensky observed Kikumura at the Vince Lombardi service area off the New Jersey Turnpike. Kikumura looked disheveled and was acting suspiciously, making several trips between his car and the service area's restaurant.¹⁰² Trooper Cieplensky continued to watch Kikumura as the man got in his car and drove away in an unsafe manner, which justified a traffic stop. During the stop, Trooper Cieplensky noticed cans of gunpowder in plain view in the back seat, which warranted probable cause to search Kikumura's person and vehicle for firearms. The search

⁹⁷ "The Oklahoma City Bombing, 20 Years Later," FBI, accessed February 28, 2016, <https://stories.fbi.gov/oklahoma-bombing/>.

⁹⁸ Kim Morava, "Trooper Who Arrested Timothy McVeigh Shares Story," *Shawnee News-Star*, February 25, 2009, <http://www.news-star.com/article/20090225/NEWS/302259941>.

⁹⁹ *Ibid.*

¹⁰⁰ "Oklahoma City Bombing," FBI; Morava, "Trooper Who Arrested Timothy McVeigh."

¹⁰¹ Morava, "Trooper Who Arrested Timothy McVeigh."

¹⁰² *United States V. Kikumura*, 698 F. Supp. 546 (D.N.J.) (1988).

discovered that Kikumura was in possession of bomb-making materials.¹⁰³ He was arrested and later convicted of plotting to explode the bomb in conjunction with another Red Army attack in Naples, Italy.¹⁰⁴ The Naples attack did happen, resulting in the death of five people at a USO club, but Trooper Cieplensky's arrest prevented Kikumura from simultaneously bombing his suspected target, a Navy recruiting facility in Manhattan.¹⁰⁵ During Kikumura's court proceedings, a motion to suppress evidence determined that Trooper Cieplensky's traffic stop, search and arrest of Kikumura were lawful.¹⁰⁶

It would be unrealistic to overstate the traffic stop's power to detect crime or terrorism. There is no doubt that many criminals are let go on traffic stops with nothing worse than a ticket, while greater crimes went undetected by officers who either failed to notice them or were not presented sufficient probable cause to delve deeply enough to discover them. Three of the 9/11 hijackers—Mohamed Atta, Hani Hanjour and Ziad Jarrah—were stopped individually for traffic violations in the days and months leading up to the attacks.¹⁰⁷ All three were released on their promises to appear in court or pay a fine. Atta, who piloted a jet into the World Trade Center, was let go on a traffic stop in April of 2001.¹⁰⁸ After he failed to pay the fine, a bench warrant was issued for his arrest, but the warrant was not in the system by the time he was stopped and released for another traffic violation in July.¹⁰⁹

Had they transpired differently, these stops eventually could have led to a discovery of the hijackers' plot. In fact, in the post-9/11 law enforcement environment where information—including intelligence about watch-listed terrorists—is more

¹⁰³ Ibid.

¹⁰⁴ Robert Hanley, "U.S. Links Man with 3 Bombs to a Terror Plot," *New York Times*, February 4, 1989, <http://www.nytimes.com/1989/02/04/nyregion/us-links-man-with-3-bombs-to-a-terror-plot.html>.

¹⁰⁵ Ibid.

¹⁰⁶ Hanley, "Man with 3 Bombs."

¹⁰⁷ Susan Condiati, "Another Hijacker Was Stopped for Traffic Violation," CNN, January 9, 2002, <http://edition.cnn.com/2002/US/01/09/inv.hijacker.traffic.stops/>.

¹⁰⁸ National Commission on Terrorist Attacks Upon the United States, *The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks Upon the United States*, Kindle edition (New York: Norton, 2004), 231.

¹⁰⁹ Condiati, "Another Hijacker."

efficiently shared, it is likely that one of hijackers would have been detained. Jarrah was on a CIA watch list at the time he was stopped, but such information was not available to the trooper who ran Jarrah's information through police databases.¹¹⁰ Today, a routine run of Jarrah's name through the FBI's National Crime Information Center would have prompted the trooper to contact the Bureau's Terrorism Screening Center (TSC) for more information. From there, the FBI and other LEAs could have investigated further and perhaps connected the dots with other intelligence to lead to the discovery of the plot.¹¹¹ While the TSC keeps precise numbers of law enforcement sensitive, it attributes traffic stops as a significant source of "domestic encounters" with watch-listed subjects.¹¹² The frequency of traffic violations and the opportunities for routine questioning make such encounters a logical byproduct of traffic stops.

Counterterrorism is a small but important part of traffic enforcement's public safety benefit. Whether working organized anti-crime operations like Oakland's Operation Impact, highway interdiction efforts like Operation Pipeline, or routine patrol in local neighborhoods, successful traffic enforcement efforts can, in fact, deter crime—the crime of terrorism is no exception.

One of the principles of counterterrorism is to harden targets so terrorists believe the risks of a failed attack outweigh the potential gains of success. Such hardening can be accomplished by posting personnel, surveillance equipment or physical barriers in and around critical infrastructure, tourist attractions, stadiums or city centers. Traffic enforcement is not generally one of the strategies used to deter terrorists, but the fact that it is ever-present on the roads around targets can have a similar effect, and it has been suggested that traffic officers be deployed strategically to add an additional layer of protection against terrorism.¹¹³

¹¹⁰ "Keeping Watch: Inside the Terrorist Screening Center," FBI, accessed August 5, 2016, <https://archives.fbi.gov/archives/news/stories/2007/august/tsc083107>.

¹¹¹ Ibid.

¹¹² Shaun Waterman, "U.S. Says Officials Encounter Watch-Listed Terror Suspects 50 Times a Day," United Press International, September 24, 2008, <http://www.upi.com/US-says-officials-encounter-watch-listed-terror-suspects-50-times-a-day/62421222287869/>.

¹¹³ Thomas, "State Traffic Law Enforcement Officers."

This chapter has discussed how traffic enforcement can be used as a crime-fighting tool that enhances public safety beyond its purpose of reducing traffic collisions. In summary, if criminals, including terrorists, require a vehicle to commit their crimes, there is always a possibility that they may be stopped by police for a simple traffic violation, and they must plan accordingly to avoid detection.

But what if they knew they could not be stopped?

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III. IS THE AUTONOMOUS VEHICLE UNSTOPPABLE?

What we usually consider as impossible are simply engineering problems
... there's no law of physics preventing them.

—Michio Kaku, physicist¹¹⁴

This chapter explores the future of AV technology through the lenses of existing scholarly literature, technology industry articles, marketing material and public policy reports. This scan of the current environment suggests a future in which AV technology is supported by public policy and deeply interconnected with all aspects of society. The chapter concludes that AV technology is likely to eventually curtail or eliminate current traffic enforcement tactics and strategies. The conclusion is based on research that suggests the technology will comply with extant and future vehicle safety regulations; that vehicles will operate safely within existing traffic laws; and that the technology will be reliable, failsafe and relatively secure from malicious cyber-intrusion.

A. LEGAL COMPLIANCE

A survey of the current regulatory environment and an evaluation of AV technology strongly suggest that driverless vehicles will meet or exceed today's safety standards and will operate much more safely than human drivers.

1. Vehicle Regulation—Will AVs Be Permitted on Our Highways?

Though AV technology regulation is in its early stages, the national policy has thus far supported rapid adoption.¹¹⁵ Throughout 2016, the White House continued to show financial support and set policy guidelines that balance public safety with

¹¹⁴ Michio Kaku, BrainyQuote, accessed February 3, 2017, <https://www.brainyquote.com/quotes/quotes/m/michiokaku574548.html>.

¹¹⁵ At the time of this writing, the Trump administration is transitioning into the presidency. There is very little information regarding the administration's posture on AV technology, though it is generally against government regulation writ large; Zients and Holden, "American Innovation"; Barack Obama, "Barack Obama: Self Driving, Yes, but Also Safe," *Pittsburgh Post-Gazette*, September 19, 2016, <http://www.post-gazette.com/opinion/Op-Ed/2016/09/19/Barack-Obama-Self-driving-yes-but-also-safe/stories/201609200027>.

profitability and rapid adoption. These guidelines are meant to provide a framework for uniformity in regulations from individual states while encouraging technological innovation from AV manufacturers.

Though not always in lockstep with federal guidelines, individual states are also trending toward wider adoption. For example, California—the third state to allow self-driving technology on its roads—changed its position on permitting testing of cars without steering wheels or control pedals.¹¹⁶ Initially, the California Department of Motor Vehicles (DMV) proposed regulations that would require specially licensed drivers in test vehicles to be “capable of taking immediate control in the event of an autonomous technology failure or other emergency.”¹¹⁷ This resulted in immediate reprisals from AV developers, most notably Google, which has been testing self-driving cars in its hometown of Mountain View, California, since 2009. California has since relaxed its regulations, though they are still more restrictive than current federal ones.¹¹⁸

Like California, most states’ regulations on AVs are still in flux, or non-existent. Since 2012, thirty-four states have considered AV legislation in some form, while others—like Texas, where Google began testing in 2015—have permitted operation on its highways without changing existing laws.¹¹⁹ In 2016, Pennsylvania allowed Uber to use AVs for its taxi services in Pittsburgh.¹²⁰ Though these AVs are currently equipped with

¹¹⁶ Heather Kelly, “Self-driving Cars Now Legal in California,” CNN, October 30, 2012, <http://www.cnn.com/2012/09/25/tech/innovation/self-driving-car-california/>; “Express Terms: Title 13, Division 1, Chapter 1 Article 3.7—Autonomous Vehicles,” California Department of Motor Vehicles, accessed March 10, 2017, 17, 27, https://www.dmv.ca.gov/portal/wcm/connect/211897ae-c58a-4f28-a2b7-03cbe213e51d/avexpressterms_93016.pdf?MOD=AJPERES.

¹¹⁷ “California Department of Motor Vehicles: Summary of Draft Autonomous Vehicles Deployment Regulations,” California Department of Motor Vehicles, December 16, 2015, 2, <https://www.dmv.ca.gov/portal/wcm/connect/dbcf0f21-4085-47a1-889f-3b8a64eaa1ff/AVRegulationsSummary.pdf?MOD=AJPERES>.

¹¹⁸ Jack Loughran, “Californian Driverless Testing Proposals Anger Google and Automakers,” *Engineering and Technology*, October 20, 2016, <https://eandt.theiet.org/content/articles/2016/10/californian-driverless-testing-proposals-anger-google-and-automakers/>.

¹¹⁹ “Autonomous/Self-Driving Vehicles Legislation,” National Conference of State Legislatures (NCSL), December 12, 2016, <http://www.ncsl.org/research/transportation/autonomous-vehicles-legislation.aspx>; Paul J. Weber and Justin Pritchard, “Texas Welcomes Google Self-Driving Cars,” *Claims Journal*, November 20, 2016, <http://www.claimsjournal.com/news/southcentral/2015/11/20/267141.htm>.

¹²⁰ Signe Brewster, “Uber Starts Self-Driving Car Pickups in Pittsburgh,” *Tech Crunch*, September 14, 2016, <https://techcrunch.com/2016/09/14/1386711/>.

steering wheels and control pedals and staffed by a “driver” who can take control in an emergency, they are an important evolution as AVs transition from the testing phase to real-world application.¹²¹

2. Real-World Application—Will AVs Operate Safely and within the Law?

While much of the discussion in this chapter predicts where AV technology is going, it has already been in use in some capacity for years. Thus, existing data indicate whether or not fully autonomous cars will, in fact, operate more safely, and within the law. For the most part, the data suggest that they will.

NHTSA has adopted the Society of Automotive Engineers (SAE) International’s six levels of autonomous driving, and all but the most sophisticated level are already commercially available or being tested on the nation’s highways.¹²² The SAE International defines vehicles with no autonomous driving features as “level zero.”¹²³ Level one features some semiautonomous functions that manage either speed or steering, but not both, automatically.¹²⁴ Here, the human is essentially still monitoring the driving environment; the vehicle is not driving itself. Level-two systems achieve “partial automation.”¹²⁵ Because the system itself can detect data from its driving environment, it can employ collision avoidance, automatic braking and lane-centering functions in combination to react to changing driving conditions. This level of automation allows a driver limited freedom to take his or her hands and feet off of the vehicle’s controls.¹²⁶ Level three, or “conditional automation,” increases the driver’s freedom to allow the car to drive itself most of the time, but requires the driver to stay vigilant enough to monitor

¹²¹ Ibid.

¹²² Hope Reese, “Updated: Autonomous Driving Levels 0 to 5: Understanding the Differences,” Tech Republic, January 20, 2016, <http://www.techrepublic.com/article/autonomous-driving-levels-0-to-5-understanding-the-differences/>.

¹²³ “Automated Driving: Levels of Driving Automation are Defined in New SAE International Standard J3016,” SAE International, accessed March 10, 2017, <http://www.sae.org/misc/pdfs/automated-driving.pdf>.

¹²⁴ Ibid.

¹²⁵ Ibid.

¹²⁶ Reese, “Autonomous Driving Levels.”

the driving environment in the event the vehicle cannot handle an unsafe condition.¹²⁷ In level four “high automation” is achieved—a vehicle could drive itself safely in every condition it encounters in the “operational domain” for which it is programmed.¹²⁸ Level five achieves “full automation,” enabling a car to drive itself better than a human could in every possible scenario, including off-road conditions.¹²⁹ Figure 5 provides a quick reference to the SAE International levels of vehicle automation.

¹²⁷ Ibid.

¹²⁸ Ibid.

¹²⁹ SAE International, “Automated Driving”; Reese, “Autonomous Driving Levels.”

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the <i>driving mode</i> -specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the <i>driving mode</i> -specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	System	Human driver	Human driver	Some driving modes
Automated driving system (“system”) monitors the driving environment						
3	Conditional Automation	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the dynamic driving task with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i>	System	System	Human driver	Some driving modes
4	High Automation	the <i>driving mode</i> -specific performance by an automated driving system of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i>	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i>	System	System	System	All driving modes

Figure 5. SAE International’s Levels of Driving Automation¹³⁴

¹³⁴ Source: SAE International, “Automated Driving.”

The data indicate that AVs are operating more safely than human drivers in most driving environments, and that they will continue to adapt and improve as more data are collected. To varying degrees, level-one and level-two systems have been available options on production vehicles for many years.¹³⁵ Insurance data suggest that some features of these systems—such as forward collision warning with autonomous braking—have significantly decreased collision claims.¹³⁶

Tesla Autopilot currently employs sophisticated level-two technology, which is poised to reach level three.¹³⁷ Google has logged over 2.3 million miles on its level-three and level-four vehicles.¹³⁸ In a 2017 report to the California DMV, Google’s car required 124 disengagements—instances in which a human driver had to take over from an AV during testing on public roads—out of 635,868 miles traveled, a 75 percent reduction from the prior year.¹³⁹ Outside of test environments, Uber has been operating level-three AVs, which it claims require minimal human intervention, in Pittsburgh for several months since September of 2016.¹⁴⁰

Each of these companies has experienced setbacks in their vehicles’ technology. A semiautonomous Tesla was involved in a fatal accident while being operated in Autopilot mode; level-three Google AVs have had higher-than-average collision rates, though only one in which the vehicle was “at fault,” and highly automated Ubers have

¹³⁵ Moore and Zuby, “Collision Avoidance Features.”

¹³⁶ *Ibid.*, 7.

¹³⁷ Fred Lambert, “Tesla’s Software Timeline for ‘Enhanced Autopilot’ Transition Means ‘Full Self-driving Capability’ as Early as Next Year,” *Electrek*, October 20, 2016, <https://electrek.co/2016/10/20/tesla-enhanced-autopilot-full-self-driving-capability/>.

¹³⁸ Google’s AV program has operated under several company divisions, including Google, Google X, Alphabet, and Waymo. For clarity, all references to AVs from any of these divisions will be referred to as Google. “Google Self-Driving Car Project Monthly Report: October 2016,” accessed March 10, 2017, <https://static.googleusercontent.com/media/www.google.com/en/selfdrivingcar/files/reports/report-1016.pdf>.

¹³⁹ Waymo, “Report on Autonomous Mode Disengagements for Waymo Self-driving Vehicles in California: December 2016,” California Department of Motor Vehicles, January 5, 2017, https://www.dmv.ca.gov/portal/wcm/connect/946b3502-c959-4e3b-b119-91319c27788f/GoogleAutoWaymo_disengage_report_2016.pdf?MOD=AJPERES.

¹⁴⁰ Mike Isaac, “Uber Expands Self-driving Car Service to San Francisco. D.M.V. Says It’s Illegal,” *New York Times*, December 14, 2016, http://www.nytimes.com/2016/12/14/technology/uber-self-driving-car-san-francisco.html?_r=0.

reportedly committed traffic infractions and caused fender benders in Pittsburgh. The California DMV revoked the registration on Uber AVs after the company introduced them to San Francisco streets without applying for testing permits.¹⁴¹ Yet, despite technological failures and regulation setbacks, AV technology is rolling on, and the industry is continually learning.

Every vehicle operated by these companies and others in the industry is a data source that will undoubtedly move level-three and level-four AV technology toward level-five vehicles that operate more safely than human drivers in every condition. Having achieved his goal of proliferating electric vehicle use with the much-anticipated Model 3, Musk's vision for "Tesla's Master Plan, Part Deux" is to "develop a self-driving capability that is 10x safer than manual via massive fleet learning."¹⁴² Musk believes full autonomy is nothing more than a software issue for its existing fleet of Model S cars equipped with Autopilot, and the company plans to equip all of the less expensive Model 3s with hardware that will allow them to be upgraded to AVs.¹⁴³

Although Tesla leads the industry in terms of data collection—Autopilot-equipped cars collect data in "shadow mode" even when customers are not using the option, resulting in over a billion miles of real-world data—other AV developers are also on the brink of full autonomy.¹⁴⁴ Musk predicts his company will achieve that goal by 2017, while the industry at large believes 2020 to be a more realistic timeframe.¹⁴⁵

¹⁴¹ Jordan Golson, "Tesla Driver Killed in Crash with Autopilot Active, NHTSA Investigating," *The Verge*, June 30, 2016, <http://www.theverge.com/2016/6/30/12072408/tesla-autopilot-car-crash-death-autonomous-model-s>; Naughton, "Humans Slamming into Driverless Cars"; "Google Self-driving Car Project Monthly Report," Google; M. J. Slaby, "Three Months of Self-driving Cars in Pittsburgh: A Look Back," *The Incline*, December 12, 2016, <https://theincline.com/2016/12/12/three-months-of-self-driving-cars-in-pittsburgh-a-look-back/>; Rich McCormick, "Uber Forced to Remove Self-driving Cars from San Francisco Roads," *The Verge*, December 21, 2016, <http://www.theverge.com/2016/12/21/14049070/uber-san-francisco-self-driving-removed-registration-revoked>.

¹⁴² Elon Musk, "Master Plan, Part Deux," Tesla, July 20, 2016, <https://www.tesla.com/blog/master-plan-part-deux>.

¹⁴³ Levi Tillemann and Colin McCormick, "Will the Tesla Model 3 Be the First Truly Self-driving Car?" *New Yorker*, April 14, 2016, <http://www.newyorker.com/business/currency/will-the-tesla-model-3-be-the-first-truly-self-driving-car>.

¹⁴⁴ Dana Hull, "The Tesla Advantage: 1.3 Billion Miles of Data," *Bloomberg*, December 20, 2016, <https://www.bloomberg.com/news/articles/2016-12-20/the-tesla-advantage-1-3-billion-miles-of-data>.

¹⁴⁵ *Ibid.*

In the meantime, AVs have already shown that their programming affords them the ability to better obey traffic laws and operate more safely than human drivers.¹⁴⁶ In fact, many in the AV industry believe that the removal of human drivers is necessary for the vehicles to reach their real potential to not only save lives, but also to make those lives better.

B. SAFETY, RELIABILITY AND CYBER-PHYSICAL INTEGRATION

Level-three autonomy—which requires human vigilance and possible intervention under some driving conditions—is considered a gray area for vehicle safety applications. Despite a fatality involving a Tesla operated in Autopilot mode, Musk feels partial autonomy “is already significantly safer than a person driving by themselves and it would therefore be morally reprehensible to delay release simply for fear of bad press or some mercantile calculation of legal liability.”¹⁴⁷ But other industry leaders want to hold out until they can release level-four vehicles, as they see the human factor as potentially dangerous.¹⁴⁸ AVs’ safety, reliability and interoperability likely will improve as human intervention decreases and the technology integrates more into other systems across multiple levels of society.

AVs currently operate independently, using onboard sensor technology to interpret their environment and maneuver through it safely. Telematics, or the data transfer from AVs to the world around them, will be central to their technology.¹⁴⁹ Telematics will allow AVs to communicate with each other and their surroundings as part of “smart transportation” systems.¹⁵⁰ It is predicted that this CPS technology will share data across multiple platforms from sensors in the AVs themselves, as well as countless other systems that might impact them. CPS connectivity paths are predicted to include not only V2V and V2I communications, but also person-to-machine, machine-to-machine

¹⁴⁶ Schoettle and Sivak, *Crashes Involving Self-driving Vehicles*, 14–18; Naughton, “Humans Slamming into Driverless Cars.”

¹⁴⁷ Musk, “Master Plan, Part Deux.”

¹⁴⁸ Reese, “Autonomous Driving Levels.”

¹⁴⁹ Anderson et al., *Autonomous Vehicle Technology*, 75.

¹⁵⁰ Cyber Physical Systems Public Working Group, *Framework for Cyber-Physical Systems*, 28–29.

and connections. This technology will allow machines to form ad hoc relationships that could not only coordinate travel in traffic, but also integrate traffic systems with weather forecasts, maintenance schedules and a variety of other systems, including emergency services.¹⁵¹ As part of this system, the AVs will constantly provide updates, via telematics, on the “way of the world” as they receive new sensory data, which will allow the system to send real-time traffic information to other AVs and the rest of the system.¹⁵²

In their report for RAND, Anderson et al. consider, “ultrareliability ... a prerequisite for vehicles that are fully autonomous.”¹⁵³ The report goes on to posit that V2V communication and cyber-physical integration might reach such high safety levels. Vehicles could learn about traffic conditions and road hazards before actually encountering them, and AVs that experience sensor malfunctions could gather data from surrounding vehicles in order to maneuver safely to the side of the road.¹⁵⁴

Development of AV and CPS technologies is likely to dramatically increase the safety of future streets and highways, but such increases will become more dependent on traffic engineering than on traffic enforcement. The data produced by such interconnected and interdependent systems could potentially detect, deter or disrupt crime and terrorism, but only if law enforcement and intelligence agencies are permitted to access it. Such permission may not be immediately available unless police and homeland security agencies make policymakers aware that reduced traffic enforcement may leave a gap in public safety. And, even then, policymakers may not respond until that gap results in a dramatic increase in crime or presents a vulnerability that is exploited by terrorists.

¹⁵¹ Ibid., 30, 200.

¹⁵² Anderson et al., *Autonomous Vehicle Technology*, 75.

¹⁵³ Ibid., 58–59.

¹⁵⁴ Ibid., 78.

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IV. UNSTOPPABLE, PART DEUX: DIFFUSION OF THE AV

I want it NOW!

—Veruca Salt, *Willy Wonka and the Chocolate Factory*

This chapter continues on the theme of AVs’ “unstoppable” nature, using diffusion of innovations and signals theories to suggest they will be increasingly adopted by consumers as AVs integrate into society.

A. DIFFUSION OF INNOVATIONS AND CROSSING THE CHASM

Rogers’s diffusion of innovations model theorizes that when innovators create a technology, it is adopted at a slow rate by a relative few early on, but then diffuses more rapidly as it becomes more widely adopted.¹⁵⁵ Moore suggests that a gap, or “chasm,” exists between the early adopters and the early majority, and innovations that fall into the chasm essentially die there.¹⁵⁶ But if the innovation is sufficiently appealing and a company applies appropriate marketing strategies to reach the early majority, Moore suggests the chasm can be crossed and adoption rates can increase dramatically.¹⁵⁷ Figure 6 illustrates Rogers’s diffusion of innovations with Moore’s chasm.

¹⁵⁵ Rogers, *Diffusion of Innovations*.

¹⁵⁶ Moore, *Crossing the Chasm*.

¹⁵⁷ *Ibid.*

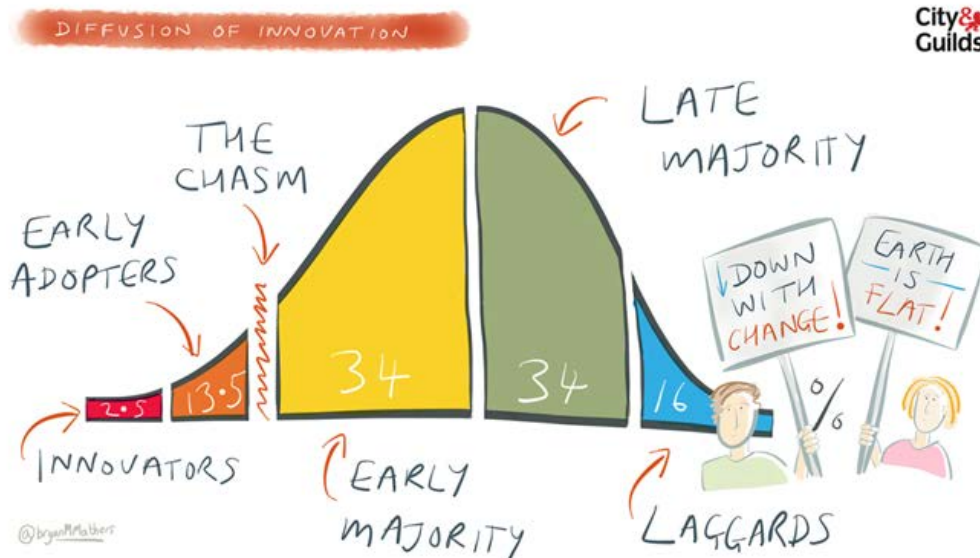


Figure 6. Diffusion of Innovations with Moore's Chasm¹⁵⁸

While Moore's chasm does not apply to every innovation, it does fit "disruptive" innovations—generally, inferior technologies that depart from established ones, but achieve desired outcomes in novel ways at a lower cost.¹⁵⁹ While AVs will certainly be disruptive in the sense that they will dramatically change society, the technology is simply sustaining because it offers better performance than previous iterations.¹⁶⁰ Cars with autonomous features are already in use, so it may not be difficult for users to cross the chasm and purchase full autonomy. In fact, the introduction of semiautonomous features—such as Tesla Autopilot—and V2I technology—such as Audi's traffic light management system—could play into today's innovators' plans for diffusion of the AV.

¹⁵⁸ Source: Bryan M. Mathers, "Diffusion of Innovation," accessed March 15, 2017, <http://bryanmmathers.com/diffusion-of-innovation-2/>.

¹⁵⁹ Christensen, *Innovator's Dilemma*, Kindle location 185.

¹⁶⁰ Ibid. For example, the telephone was a disruptive innovation to the telegraph—even as its initial reliability and universality was inferior—while the push-button telephone was a sustaining innovation from those with a rotary dial.

For example, Tesla's initial plan for introducing electric vehicle technology to the wider market was outlined in Musk's 2006 "Secret Tesla Motors Master Plan," which began by introducing a novel but expensive electric sports car, the Tesla Roadster. In the plan, Musk outlines how he would cross the chasm to rapidly diffuse his innovative vehicles:

Almost any new technology initially has high unit cost before it can be optimized and this is no less true for electric cars. The strategy of Tesla is to enter at the high end of the market, where customers are prepared to pay a premium, and then drive down market as fast as possible to higher unit volume and lower prices with each successive model.¹⁶¹

By targeting wealthy early adopters, Tesla was able to gain both investment capital and a small but influential customer base, which resulted in the introduction of the more-widely adopted Tesla S and X models. This innovation began as a diffusion of electric vehicle technology, but has become one of vehicle autonomy as newer versions of these models are already equipped with software-upgradable Autopilot hardware. Preorder deposits for the Tesla Model 3—expected to hit dealerships sometime in 2018—are estimated in excess of 400,000, and Musk has made it clear that full autonomy for the Model 3 is part of his "Master Plan, Part Deux."

Musk has also forecast that nearly all newly built vehicles will be fully autonomous within ten years, and AVs will have their most significant impact on society in twenty to twenty-five years as current traditional vehicles reach the end of their lifespans.¹⁶² Other predictions are more conservative. The Boston Consulting Group (BCG) conducted a study based on current trends surrounding self-driving technology, concluding that 2017 will be the beginning of a two-decade period of growth resulting in mass adoption.¹⁶³ By 2035, BCG predicts annual worldwide sales of fully autonomous vehicles to reach 12 million annually, and that 25 percent of all vehicles sold will have

¹⁶¹ Elon Musk, "The Secret Tesla Motors Master Plan (just between You and Me)," Tesla, August 2, 2006, <https://www.tesla.com/blog/secret-tesla-motors-master-plan-just-between-you-and-me>.

¹⁶² Cadie Thompson, "Elon Musk Has a Stunning Prediction for What Cars Will be Like 10 Years from Now," *Business Insider*, February 13, 2017, <http://www.businessinsider.com/elon-musk-predicts-most-cars-will-be-driverless-in-10-years-2017-2>.

¹⁶³ "Autonomous Vehicle Adoption Study," Boston Consulting Group (BCG), accessed February 14, 2017, <http://www.bcg.com/expertise/industries/automotive/autonomous-vehicle-adoption-study.aspx>.

autonomous features.¹⁶⁴ While such numbers are significant to global markets, depending on the size of the United States' share of that market, BCG's predicted rate of diffusion may not have a dramatic effect on traffic safety.

Semi-autonomy is susceptible to human fallibility; cars with full autonomy cannot operate to their potential on roads driven simultaneously by human drivers. Traffic enforcement will still be needed, and criminals may not immediately be able to hide below the surface of an ocean of unstoppable self-driving cars. But there are signals today that indicate a faster pace of diffusion, which could cause AVs to leap across Moore's chasm and become rapidly adopted by U.S. society.

B. SIGNALS THEORY: THE ROADSIGNS FOR ADOPTION

There is little available data to estimate the public's confidence in AV technology; most AVs have only operated as test vehicles to which the general public has little direct access. But, by applying Webb's signals theory and Nieto-Gomez's nowcasting methodology, there are many converging indicators, or signals, that presently indicate AVs' rapid proliferation in the future.¹⁶⁵ These signals include: increased urbanization, and associated traffic and parking congestion; permissive, even encouraging, regulatory environments such as Smart City initiatives; the popularity of vehicles with semiautonomous features; and the proliferation of disruptive innovations in transportation sectors, such as Uber, Lyft and Zipcar.¹⁶⁶ These signals, and others, are converging with technology and culture in subtle ways that could result in AV technology crossing the diffusion of innovations chasm and spreading rapidly throughout society.

¹⁶⁴ Ibid.

¹⁶⁵ Refer to the literature review, Chapter I, Section C3.

¹⁶⁶ Uber and Lyft are both taxi services coordinated by mobile technology with independently operated vehicles and contracted owners/drivers. Zipcar is an on-demand rental car service for which cars are shared by many users via monthly membership and usage fees; Zients and Holden, "American Innovation."

1. First Signal: Urbanization and Traffic—A Quest for Solutions

A major signal that U.S. citizens may be ready to adopt AVs comes with the traffic congestion and associated parking problems that have grown with urbanization.¹⁶⁷ Census statistics since 2010 have shown a general trend of increased populations in cities with over 50,000 residents, due mainly to migration rather than increased birthrates.¹⁶⁸ Greater metropolitan areas surrounding larger cities have seen a similar population increase.¹⁶⁹ While such larger coastal cities as New York and San Francisco are experiencing population growth, urbanization is increasing throughout America's heartland in places like, Texas, Colorado, and Iowa.¹⁷⁰

Urbanization has contributed to increased traffic, with corresponding losses in time, fuel and productivity for drivers.¹⁷¹ Traffic congestion, limited parking space and increased pollution are challenges that come with increased urbanization. Many cities, large and small, are looking toward new technologies, including AVs, to meet these challenges.

2. Second Signal: Smart Cities Ahead

Another signal of impending AV popularity is the success of the 2015 Smart City Challenge. This program incentivized mid-sized U.S. cities to compete for federal funding by leveraging technology to improve transportation networks and civic infrastructure.¹⁷² Seventy-eight cities competed in the challenge, each proposing its own unique program for improving citizens' lives. Under the Obama administration, the Smart City Challenge

¹⁶⁷ Lucy Wescott, "More Americans Moving to Cities, Reversing the Suburban Exodus," *Atlantic*, March 27, 2014, <https://www.theatlantic.com/national/archive/2014/03/more-americans-moving-to-cities-reversing-the-suburban-exodus/359714/>.

¹⁶⁸ *Ibid.*; "Five of the Nation's Eleven Fastest-Growing Cities are in Texas, Census Bureau Reports," May 19, 2016, <https://www.census.gov/newsroom/press-releases/2016/cb16-81.html>.

¹⁶⁹ "Fastest-Growing Cities," United States Census Bureau.

¹⁷⁰ *Ibid.*

¹⁷¹ Thomas C. Frohlich and Samuel Stebbins, "10 Cities with the Worst Traffic," *24/7 Wall Street*, August 28, 2015, <http://247wallst.com/special-report/2015/08/28/10-cities-with-the-worst-traffic/>.

¹⁷² "U.S. Department of Transportation Announces Columbus as Winner of Unprecedented \$40 Million Smart City Challenge," June 23, 2016, <https://www.transportation.gov/briefing-room/us-department-transportation-announces-columbus-winner-unprecedented-40-million-smart>.

program awarded \$40 million to the City of Columbus, Ohio, which promised to “become the country’s first city to fully integrate innovative technologies—self-driving cars, connected vehicles, and smart sensors—into their transportation network.”¹⁷³ Among other transportation innovations, Columbus will be introducing self-driving buses as part of its plan.¹⁷⁴

It is difficult to predict if the White House will fund future Smart Cities, but such funding is not central to their success—competing cities raised \$500 million in private sponsorship, \$10 million of which went to Columbus.¹⁷⁵ Should Columbus and other Smart Cities deliver on their promises, they will serve as a transportation model for other cities and smaller towns to follow.

3. Third Signal: Semi-autonomy as a New Baseline for Vehicle Safety

Urbanization and infrastructure issues aside, traffic safety continues to be one of the main drivers for government support of AV technology. Thus, the safety benefits of current semiautonomous technology may be another signal that full autonomy will soon follow. As mentioned previously, insurance data suggests that some semiautonomous features have reduced the number of vehicle accidents, and fully autonomous cars are predicted to reduce fatal accidents by up to 90 percent.¹⁷⁶

Historically, when safety features that enter markets as innovative options on new vehicles prove significant, they become regulated as mandatory equipment by transportation authorities. The time between technology integration and regulation varies, but early consumer popularity can accelerate the decision to regulate. Before a given option becomes regulated as standard vehicle safety equipment, a sufficient number of equipped vehicles must operate on the highways for a sufficient amount of time to create

¹⁷³ “Smart Columbus: We are the Smart City,” City of Columbus, accessed February 2, 2017, <https://www.columbus.gov/smartcolumbus/>.

¹⁷⁴ Ibid.

¹⁷⁵ The Obama administration is no longer in office, and it is uncertain if the current administration will be supportive of such programs; “Smart Columbus,” City of Columbus; “Columbus as Winner,” DOT.

¹⁷⁶ Moore and Zuby, “Collision Avoidance Features,” 7; National Economic Council and Office of Science and Technology Policy, *Strategy for American Innovation*, 92–93.

enough data for evaluation.¹⁷⁷ For example, Volvo first introduced three-point seatbelts to the car market in 1954, but it took NHTSA twenty years to make them mandatory in the front seats—and later the rear—of cars sold in the United States.¹⁷⁸ The four-wheel anti-lock brake system (ABS) was first introduced as standard equipment in 1985.¹⁷⁹ Though four-wheel ABS was not required equipment on U.S. light vehicles as part of mandated electronic stability control feature until 2011, consumers adopted the option at a much faster rate, with a majority of vehicles being so equipped by 1994.¹⁸⁰ A similar relationship between consumer adoption and government regulation has been true of other safety features such as passenger compartment airbags and backup cameras.¹⁸¹

Thus, the safety benefit of semi- and fully autonomous technology is a potential signal that indicates the possibility of rapid consumer adoption and the potential for regulation that mandates autonomy as a standard traffic safety feature of the future.

4. Fourth Signal: Online Taxis and Vehicle Ownership—A Paradigm Shift

The online taxi service Uber has already been discussed as an early adopter of AV technology. But the ubiquity of Uber users—and those of its main competitor, Lyft—is perhaps an even more significant signal that AVs will be adopted at a faster pace than society may expect. At least in urban areas, traditional car ownership is waning.¹⁸² Smartphone technology has made it increasingly easier to call up a taxi on demand,

¹⁷⁷ Charles J. Kahane and Jennifer N. Dang, *The Long-Term Effect of ABS in Passenger Cars and LTVs* (DOT HS 811 182) (Washington, DC: NHTSA, 2009), 5, <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811182>.

¹⁷⁸ “America on the Move—Corporate Innovations,” Smithsonian Institute of American History, accessed February 3, 2017, http://amhistory.si.edu/onthemove/themes/story_86_19.html.

¹⁷⁹ Kahane and Dang, *ABS in Passenger Cars and LTVs*, 5.

¹⁸⁰ National Center for Statistics and Analysis, *FMVS No. 126: Electronic Stability Control Systems* (Washington, DC: U.S. Department of Transportation, 2007); Kahane and Dang, *ABS in Passenger Cars and LTVs*, 5.

¹⁸¹ “1998: Federal Legislation Makes Airbags Mandatory,” History.com, accessed February 3, 2017, <http://www.history.com/this-day-in-history/federal-legislation-makes-airbags-mandatory>.

¹⁸² Mark Rogowski, “Zipcar, Uber and the Beginning of Trouble for the Auto Industry,” *Forbes*, February 8, 2014, <http://www.forbes.com/sites/markrogowsky/2014/02/08/viral-marketing-car-sharing-apps-are-beginning-to-infect-auto-sales/#4bee1e031255>; Chris Woodyard, “NHTSA to Require Backup Cameras on All Vehicles,” *USA Today*, March 31, 2014, <http://www.usatoday.com/story/money/cars/2014/03/31/nhtsa-rear-view-cameras/7114531/>.

and—again, at least in urban areas—using such services is quicker and easier than driving and parking one’s own vehicle. For those who need a car for multiple trips over the course of one or several days, subscription rideshare companies like Zipcar afford urbanites the ability to use a vehicle on demand without having to pay for maintenance, parking or other expenses of ownership while the vehicle is not in use.¹⁸³

Such established innovations in on-demand vehicle services have paved the way for new ones. Following the example of peer-to-peer vacation real estate rental applications like Airbnb, companies like Turo are now leveraging technology to facilitate peer-to-peer vehicle rentals.¹⁸⁴ In fact, Tesla names peer-to-peer rentals of its autonomous vehicles as part of its eventual business plan.¹⁸⁵

Even consumers who want cars at their curbsides or in their garages all the time do not necessarily want to own them. At least one-third of new vehicles in the United States are being leased rather than bought.¹⁸⁶ Leases by millennials are on the rise, which an Edmunds analyst suggested might correlate to this generation’s familiarity with subscription services such as Netflix or their smartphone plans, which are continually negotiable and upgradable.¹⁸⁷ In 2017, Cadillac introduced another option to ownership with its Book program, which affords a month-to-month subscription to its luxury cars without any further commitment or responsibility for maintenance, repairs or registration.¹⁸⁸

Scholarly research and industry journalism have suggested that future AVs will be used mainly in a communal capacity, such as a taxi or rideshare; indeed, companies like Google and Uber have banked on such models, and present signals support these

¹⁸³ Ibid.

¹⁸⁴ Rick Broida, “Rent Private Cars for Cheap with Turo,” CNet, February 22, 2016, <https://www.cnet.com/how-to/rent-private-cars-for-cheap-with-turo/>.

¹⁸⁵ Musk, “Master Plan, Part Deux.”

¹⁸⁶ Greg Gardner, “Report: More New Cars Leased than Ever,” *USA Today*, March 4, 2016, <http://www.usatoday.com/story/money/cars/2016/03/03/report-more-new-cars-leased-than-ever/81286732/>.

¹⁸⁷ Alessandra Malito, “Why Millennials Like to Lease Cars,” *MarketWatch*, October 8, 2016, <http://www.marketwatch.com/story/why-millennials-like-to-lease-cars-2016-09-29>.

¹⁸⁸ “Book by Cadillac,” accessed February 5, 2017, <https://www.bookbycadillac.com/#group1>.

predictions.¹⁸⁹ These signals also indicate that those already familiar with car ownership alternatives will have little trouble adjusting to such services evolving toward driverless technologies.

5. More Signals on the Horizon

There are other signals—some more obvious than others—that AV technology may jump Moore’s chasm and rapidly diffuse across society. Webb’s and Nieto-Gomez’s methodologies—reading signals to nowcast the potential success and proliferation of a given innovation—suggest that the convergence of signals matters. In the case of the AV, proliferation may be influenced by the convergence of distracted-driving vehicle accidents caused by smartphones and the infotainment and mobile business potential of AV technology.¹⁹⁰ Or it may be a drop in new vehicle sales converging with the next generation of car buyers, who are not applying for drivers’ licenses by the time they come of age.¹⁹¹

Yet it may not be necessary to predict which of these signals is the most significant; they could combine to push AVs over Gladwell’s “tipping point” and accelerate proliferation dramatically.¹⁹² There is, however, one area where the signals are disturbingly silent, and that is in the response of police and traffic enforcement agencies. Most have given little indication that they are even reading the signals, much less sending any of their own, in order to shape the future of driverless technology.

¹⁸⁹ Anderson et al., *Autonomous Vehicle Technology*, 18; Musk, “Master Plan, Part Deux.”

¹⁹⁰ NHTSA, *Traffic Safety Facts: Distracted Driving 2013* (Washington, DC: NHTSA, 2015), 4, https://www.distraction.gov/downloads/pdfs/Distracted_Driving_2013_Research_note.pdf; Anderson et al., *Autonomous Vehicle Technology*, 26, 76.

¹⁹¹ Marianne Lavelle, “U.S. Teenagers Are Driving Much Less: 4 Theories about Why,” *National Geographic*, December 18, 2013, <http://news.nationalgeographic.com/news/energy/2013/12/131217-four-theories-why-teens-drive-less-today/>.

¹⁹² Refer to the literature review, Chapter I, Section C3.

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V. IMAGINING THE WORST

Think left and think right and think low and think high. Oh the thinks you
can think up if only you try!

—Dr. Seuss

Using the Greek myth of Promethean Fire as a framework, this chapter asks the reader to imagine the AV's positive and negative effects on society's future. This exercise in imagination begins by painting a picture of how vehicles capable of driving themselves might look and behave, as well as how they might be used in more diverse ways than cars and trucks are today. Imagining such changes in the nature and behavior of vehicles could lead to imagining how society might change with them. While many effects of such changes will be positive—safer highways, more mobility and increased productivity—there may be negatives, including driving certain transportation professions into obsolescence. As discussed in previous chapters, the profession of traffic enforcement officer may join the ranks of the obsolete, and this chapter culminates with some plausible scenarios describing what a world without traffic cops might look like. The scenarios are illustrated by three fictional vignettes—told in two parts—that posit the Promethean duality of the AV in society.

A. PROMETHEAN FIRE

In Greek mythology, Prometheus was the titan who dared to defy the gods by stealing fire and delivering it to mortals. He taught man how to use the fire to kiln-dry clay and forge metals, thereby introducing them to the benefits of technology. But, as to be expected when dealing with the capricious gods, the results were mixed. Through an unwitting agent, Pandora, the gods channeled humankind's innocent curiosity toward the release of its baser evils, thus turning Prometheus's gift into a mixed blessing. To be sure, mortals were better off; they could now warm themselves, cook their food and keep predators at bay. But Prometheus's gift also came with unintended consequences: the new users accidentally burned down their own villages, crops and the forests that

surrounded them. Once mortals understood the destructive power of their new gift, they forged weapons and otherwise used fire to destroy each other's villages, burn the crops of their enemies and clear forests to build more villages, ensuring that the destruction would continue endlessly. Thus the gift of technology was also a curse on the society that it helped to create.¹⁹³

B. THE GIFT: ROADS WITHOUT DRIVERS, VEHICLES WITHOUT LIMITS

The streets and highways of the future will likely look very different from today's; AV technology will not just remove human drivers from vehicles, but will transform how they look and act in ways that we have yet to imagine. Even in the near term, some level-four and level-five autonomous vehicles are not likely to have steering wheels, as is already the case with some of Google's test fleet.¹⁹⁴ Without the need for forward controls, or even forward window glass, vehicle configurations could change dramatically, with passenger and cargo compartments that are tailored to the particular use of a given vehicle. Through telematics, vehicles will "speak" to each other and the cyber-physical infrastructure of our cities and towns, allowing them to maneuver and interact in ways that are not possible for human drivers.¹⁹⁵

Many vehicles might still be privately owned, but the possibility of increased rideshares, rentals, sublets and taxi services will likely create new markets, just as the smartphone did a decade ago. AVs might be strictly utilitarian for routine rides around town, or highly customizable as rolling offices, sleeping chambers or personal delivery services.¹⁹⁶ They are likely to cut down on highway congestion and the need for city parking space, but increased ridership and the demand for yet-to-be-discovered services

¹⁹³ An early comparison of Promethean Fire with twentieth-century technology can be found in R. M. Salter and P. T. Van Dyke, *The Price of Fire: The Application Technology to the Improvement of Man's Environment* (Santa Monica, CA: RAND, 1972).

¹⁹⁴ Reese, "Autonomous Driving Levels"; Field, "Google Self-Driving Cars."

¹⁹⁵ Anderson et al., *Autonomous Vehicle Technology*, 75; Cyber Physical Systems Public Working Group, *Framework for Cyber-Physical Systems*, 28–29.

¹⁹⁶ Liz Stinson, "IDEO Imagines the Wild Future of Self-Driving Cars," *Wired*, November 18, 2014, <https://www.wired.com/2014/11/ideo-imagines-self-driving-cars/>.

could actually increase the number of miles they drive each year.¹⁹⁷ Even with more cars plying the streets and highways, though, the roads of tomorrow are likely to be safer than today's, and they are consequently likely to have fewer police cruisers patrolling them.

The sections that follow introduce three short, fictional vignettes that help illustrate the promise of a world in which vehicles drive themselves.

1. First Vignette: Crosstown Traffic

Gus's eValet app caused his throw-phone to vibrate, telling him the eValet "RoundTown" pod-van was a minute away.¹⁹⁸ He grabbed the trash from the kitchen as a diversion, then walked toward the front door. In his other hand was a small, heavy plasticized box which read "RoundTown.com" across its shiny sides.

"Eh, Gustavito, where are you going?" asked his grandmother from the living room when she heard the door open.

"Just taking out the garbage, out, Abuelita," Gus responded, tucking the RoundTown box close to his chest and out of her sight.

Abuelita was incredulous, but thought that maybe her grandson's apartment fever might have driven him to lend a hand for once. "Okay, but not past the curb. You know the rules. Mister Ramirez will call me if your thing goes off."

She was right. Gus was on probation and his ankle bracelet would alert his PO if he went any further than the sidewalk outside their brownstone apartment.

As he made it to the bottom of the short flight of steps, Gus dumped the trash and the throw-phone into the garbage can, and looked around briefly—more out of habit than necessity—before inserting the package into a drop slot on the side of the RoundTown van, which had already parked itself curbside. The slot hissed closed. The throw-phone's vibration resonated inside the garbage can, buzzing eValet's pickup confirmation. The pod-van accelerated away, quickly and silently. The vehicle's ad

¹⁹⁷ Anderson et al., *Autonomous Vehicle Technology*, 18.

¹⁹⁸ The RoundTown described in this vignette is inspired by the Cody self-driving delivery truck. See Stinson, "IDEO Imagines the Wild Future of Self-Driving Cars."

banner lit up its entire exterior, 3D images of the latest Call of Duty movie fluttering across its front, back and sides. The video explosions and gunfire blasts were incongruous with the pod's dull shape and pragmatic purpose. Gus looked around again before heading back into Abuelita's apartment.

To be continued...

2. Second Vignette: Long Haul¹⁹⁹

PB18473 was three feet off the vestigial Mansfield bar²⁰⁰ of the tractor-trailer in front of it, FL29346. The autonomous semi-trailers were each pulling triples in a long convoy of similarly spaced big-rig AVs hurtling down the interstate at 100 miles per hour. PB18473 was loaded with cargo around its engine compartment, and its triples were just as packed. Its telematics sent maintenance, licensing, cargo and destination records to the highway inspection facility ahead, but it was not signaled to enter. PB18473 continued toward its destination without interrupting the flow of the convoy, each truck communicating with the next to maintain its speed and distance. Commerce was uninterrupted, schedules were maintained, and—as it was a diesel unit, not electric—the environment was better off—staying in the convoy saved on fuel. PB18473 was doing its job the way it was programmed to do it, and it could go on for miles.

To be continued...

¹⁹⁹ This vignette envisions a future involving a fully autonomous truck. While the capabilities of this truck, PB18473, exceed those of today's AV technology, they are plausible in the near future. See California PATH, <http://www.path.berkeley.edu/>; Agence France-Presse, "Convoy of Self-driving Trucks Completes First European Cross-border Trip," *Guardian*, April 7, 2016, <https://www.theguardian.com/technology/2016/apr/07/convoy-self-driving-trucks-completes-first-european-cross-border-trip>.

²⁰⁰ Properly known as an under-ride guard, a Mansfield bar is a steel bar mounted beneath the rear edge of a semi-trailer to prevent passenger cars from plowing under trailers during a rear-end collision. The bar was named after the actress Jayne Mansfield, who was decapitated in such a collision before the bars were mandated by law. Such safety features might become redundant on future highways if humans no longer drive on them.

3. Third Vignette: *Emily's Commute*²⁰¹

Emily shifted baby Beatrix in her arms a bit as she hurried her six-year-old, Jax, through the sliding door of the RoomGo AV. Jax's infotainment lit up in the wall as soon as he had buckled himself into his rear-facing seat. Emily's desk and monitor folded out of the equipment wall as her chair swiveled to her app's pre-programed location. Beatrix's recumbent safety seat slid on its floor rail and rose up beside the desk. Emily snapped the baby in, then buckled herself to the desk chair. The RoomGo began to drive as soon as the last belt clicked.

"Good morning, Emily and Beatrix. Jax, did you remember your lunch this time?" chimed a voice through the RoomGo's speaker system.

"AI-mee, I told you, Mom forgot it, not me!" the little man answered indignantly.

Emily wasn't listening. Her news feed had just lit up the forward wall screen, and the sound feed was piping through her chair speakers. AI-mee was set not to override Emily's chair sound with congenial chatter, just the important stuff. As Emily began to work, she caught a waft of lingering incense aroma in the vehicle. She would have to vet her lease-sharers better in the future. No more head and neck masseuses. Even if they didn't use the same interior configuration, sandalwood gets into the upholstery—and stays there! She would have to send the RoomGo back to its garage for another extra interior detail after it dropped her and the kids off. Problem was, she had promised Chloe she would send it by to pick up some catering equipment across town before it went into sublet mode for the early afternoon around-town crowd. Besides, the masseuse should be on the hook for the cost of the detail!

To be continued...

²⁰¹ Literature on plausible AV configurations suggest workspace configurations and infotainment systems that can increase productivity of commuters and entertain passengers while the vehicles do the driving. See Stinson, "IDEO Imagines the Wild Future of Self-Driving Cars,"; Anderson et al., *Autonomous Vehicle Technology*, 18.

C. UNINTENDED CONSEQUENCES

The previous section's opening vignettes show a glimpse of AV technology's benefits, as intended by innovators and policymakers. Conversely, this section examines some of the costs innovators and policymakers may not have considered. Using the lessons learned from the myth of Promethean fire, this section suggests some plausible unintended consequences that might come with the predicted benefits of AV technology. At this stage of development, the costs and benefits cannot be forecast with complete certainty. But, given that AVs will reduce the need for police to enforce traffic laws, the first unintended consequence is likely to be a diminished capacity for police to detect and deter crime in the same ways they do today. Once criminals catch onto this curtailment in traffic enforcement, they will capitalize on it. Just as the ancient Greeks quickly learned how to pivot the technology of fire toward the destruction of their enemies, so might criminals and terrorists pivot the technology of the AV. The following subsections present plausible scenarios, moving from the technology's unintended consequences to its deliberate usurpation for crime.

1. Decreased Detection or Discovery of Crime and Criminals

Traffic enforcement can lead to the discovery of crimes and criminals that were previously unknown to law enforcement at all.²⁰² For example, a man arrested for drunk driving might have child pornography in his car that is discovered while an officer conducts a storage inventory of the vehicle. Other criminals, like Ted Bundy, whose crimes were known but whose identity was not, go to great lengths to avoid detection while committing their crimes, yet are caught because of a simple traffic violation. Some traffic stops lead to the arrest of identified criminals who were wanted by police—perhaps even being actively searched for—but could not be located until their license was run through police databases during a traffic stop. In all of these scenarios, the discovery of the criminals and evidence of their crimes, or both, are fortuitous results of a traffic stop unrelated to the greater crimes.

²⁰² Richard Simon, "Traffic Stops—Tickets to Surprises," *LA Times*, May 15, 1995, http://articles.latimes.com/1995-05-15/local/me-841_1_routine-traffic-stops.

According to the CHP's own statistical database, its officers made 7,705 felony arrests while on patrol in 2015.²⁰³ Given the nature of the CHP's primary mission as a traffic enforcement agency, it is likely this number would drop significantly if the need for such enforcement was curtailed by the emergence of the AV.²⁰⁴

2. Increased Contraband Trafficking

Drug runners, human traffickers and other criminals already move contraband on our streets and highways with regularity.²⁰⁵ According to a U.S. Department of Justice report, forty-two times more drug contraband in 2010 was smuggled in motor vehicles than by sea or land.²⁰⁶ Even with traffic enforcement—both targeted and random—in full effect on our highways, far more of this contraband reaches its destination than is intercepted.²⁰⁷ Still, in order to avoid detection and arrest, criminals must be increasingly innovative. Innovation is especially common among drug trafficking organizations (DTOs), which move large quantities of drugs with regularity. They use surrogates, or “mules,” to drive contraband-loaded vehicles.²⁰⁸ Mules—who sometimes are selected because they have an innocent appearance, valid driver's license and no criminal record—seldom know the identity of the real drug traffickers.²⁰⁹ Rental vehicles are often used to further obscure the identities of true drug dealers.²¹⁰ Loads can be hidden in vehicles in a variety of novel ways—welded into body panels, stuffed into tires, or tucked

²⁰³ California Highway Patrol, “Commander's Year to Date Summary Report,” (Field Support Section, January 8, 2016).

²⁰⁴ Farrow, *California Highway Patrol Strategic Plan*, 3.

²⁰⁵ Bret Helman and Brad Heath, “How Riverside County Became America's Drug Pipeline,” *Desert Sun*, November 11, 2015, http://www.desertsun.com/story/news/crime_courts/2015/11/11/riverside-county-drug-trafficking/75232146/.

²⁰⁶ U. S. Department of Justice, *National Drug Threat Assessment 2010* (Product No. 2010-Q0317-001) (Washington, DC: U.S. Department of Justice, 2010), 19.

²⁰⁷ Helman and Heath, “America's Drug Pipeline.”

²⁰⁸ John Moore, “Experts Say Drug Mules are Easy to Find, Hard to Catch,” NBC, May 30, 2013, <http://usnews.nbcnews.com/news/2013/05/30/18589533-experts-say-drug-mules-are-easy-to-find-hard-to-catch>.

²⁰⁹ Ibid.

²¹⁰ Department of Justice, *National Drug Threat Assessment*, 21, 23.

into compartments called “traps,” which can be opened remotely but are undetectable when closed.²¹¹

These efforts to avoid detection take resources that make smuggling a complex and risky business. Using an AV instead of a mule would significantly lower a trafficker’s risk. In fact, it is likely that DTOs, and even less sophisticated smugglers, will be among the first to use them with regularity.²¹² They will be able to simply load the car—which might not even have windows or seats—program it for a destination and press “go.” It could drive to its destination with virtually no chance of being stopped by police, who might not even be patrolling the highways at all. If the AV were somehow intercepted, it would have nothing to tell investigators about the person or organization that sent it, other than whatever data could be gleaned from its navigation system, which might have been hacked to destroy such data.

According to HIDTA, the contraband seizures and arrests made through their member LEAs’ 2015 domestic highway interdiction efforts resulted in the identification, dismantlement or disruption of 140 DTOs.²¹³ While it is difficult to quantify the significance of this impact on the drug trade as a whole, it is plausible to speculate that DTOs might proliferate if they are able to move contraband with less risk of detection.

3. Weaponization

Perhaps the worst-case scenario for the nefarious use of AVs would be to fashion them into weapons. In a time when terrorism on domestic soil is of increasing concern to police and other homeland security professionals, the use of the AV as a “smart bomb” is not at all a stretch of the imagination; it is a rational concern.

A RAND study suggests that criminals or terrorists could hack AV software to take over a vehicle—or multiple vehicles—in order to carry out their plots, and homeland

²¹¹ Ibid., 23; Paul Clinton, “Hidden Drugs in Vehicle ‘Traps,’” *Police: The Law Enforcement Magazine*, July 6, 2010, <http://www.policemag.com/channel/gangs/articles/2010/07/hiding-drugs-in-vehicle-traps.aspx>.

²¹² Marc Goodman, “How Technology Makes Us Vulnerable,” CNN, July 29, 2012, <http://www.cnn.com/2012/07/29/opinion/goodman-ted-crime/>; Lyons, “Autonomous Vehicles,” 4.

²¹³ HIDTA, “2015 Domestic Highway Enforcement Outputs.”

security professionals are already preparing for the possibility.²¹⁴ The related implications are perhaps worse than the typical smart-bomb scenario one might imagine: a terrorist could not only use a vehicle loaded with explosives to carry out an attack, but could also use a vehicle that belonged to or was rented by someone else. A car could be intercepted, for example, while it was picking up dry cleaning for its owner. It could be directed by the hacker to drive to a location where explosives could be secreted upon it, and it could be days or weeks before it is used for the intended attack. Perhaps the owner would be onboard at the time, thus adding to the frightening nature of the attack, while also—at least initially—confusing investigators, who might waste many precious resources investigating a hapless passenger.

While all of the scenarios described in this section could play out right under the noses of today’s traffic enforcement officers, the fact that there will likely be fewer such officers on the roads of tomorrow make the nefarious use of AV technology all the more plausible.

Furthermore, AV diffusion is not happening in a vacuum; it coincides with other technological advancements with similar Promethean portent. Corporations, cops and criminals already have access to drones that can extend their eyes, ears and delivery systems; encrypted communications that can keep both sides from detecting each other’s actions; and 3D printers that can be used to create virtually anything, including drugs and firearms.²¹⁵ The challenge for LEAs and policymakers is to police and regulate such technologies in ways that encourage their legal use, while deterring criminals and terrorists who would use such innovations to do harm. AV diffusion makes this challenge

²¹⁴ Anderson et al., *Autonomous Vehicle Technology*, 70–71; Dustin Volz and Jonathan Oatis, “DOJ Studying if Self-driving Cars Pose ‘Terrorist Threat,’” *VentureBeat*, September 9, 2016, <http://venturebeat.com/2016/09/09/doj-studying-if-self-driving-cars-pose-terrorist-threat/>.

²¹⁵ Margi Murphy and Christina Mercer, “22 Companies Using Drones Right Now: Amazon, Asda, the BBC and More—Here’s How Drones Are Being Used in 2017,” *Techworld*, February 22, 2017, <http://www.techworld.com/picture-gallery/personal-tech/best-uses-of-drones-in-business-3605145-3605145/>; Robinson Meyer, “3-D Printed Drugs are Here,” *Atlantic*, August 19, 2015, <https://www.theatlantic.com/technology/archive/2015/08/3d-printing-pills-spritam-drug-industry/401177/>; Andy Greenberg, “Someone (Mostly) 3-D Printed a Working Semi-automatic Gun,” *Wired*, February 3, 2016, <https://www.wired.com/2016/02/someone-mostly-3-d-printed-a-working-semi-automatic-gun/>.

more complicated by taking the deterrence tool provided by the traffic stop out of the LEA toolbox.

D. THE CURSE: ROADS WITHOUT DRIVERS, VEHICLES WITHOUT LIMITS

The conclusions to this chapter's three vignettes further illustrate what "could be" in a world dominated by AVs. The first shows how AV evolution could lead to cities where crime goes unchecked without the random disruption of traffic enforcement. The second counters this vision by showing how innovative law enforcement agencies could leverage AV and CPS technologies to improve public safety, while the third envisions how innovations by criminals or terrorists could make the curse of Promethean fire a reality, using AV technology for the most nefarious purposes.

1. First Vignette: Crosstown Traffic Conclusion

The RoundTown rolled into the projects at around the time the kids were coming home from school. Children flowed off of driverless buses, met by parents who tracked their schedules to the minute. George was talking on his personal cell to a customer as he walked down the street to meet his little cousin at the bus stop. His other phone, a throwaway, burped in his pocket—the package from Gus had arrived. He ended the call with his customer and checked the AV's location on the app.

The RoundTown found him rather quickly, but passed once because it couldn't stop where the buses had blocked the curb. George didn't want to miss this package, which would trigger the car to send out a drone delivery. Paying for it wasn't an issue on a stolen credit account, but drones in the projects still attracted attention, so he trotted up to the next corner. When the pod-van calculated that the target would be close enough to meet without altering its schedule, it stopped and waited for George and his throw-phone to meet it at the intersection. As soon as George was within three feet, the drop slot hissed open, the package dropped, and George pulled it out. The pod-van, announced, "Package delivered, Mr. Smith. Thanks for making eValet part of your day!"

As the RoundTown drove off, its ad banner displaying the latest Lego movie to all the kids and parents walking home, George couldn't help but feel like a real original gangster. When his uncle told stories about getting

guns across town, he always talked about getting the right ride, maybe having a girlfriend drive it and hoping she wouldn't talk if she got stopped. Now, you could just have a youngster with a clean phone pack the thing up and send it in the damned RoundTown mail. It was like Amazon for gangsters. And the cops weren't on you unless they were already on you, which meant you already screwed up somewhere. George walked back toward his cousin's bus stop, tossing the throw-phone into a gutter drain. He wanted to get home quick. He had work to do.

2. Second Vignette: Long Haul Conclusion

PB18473's CPU was not shut down completely, as the highway commercial enforcement team's technician needed to scan its contents to find data about source of the truck and trailer's load. But the truck's telematics were shut down, cutting it off from the outside world and keeping it from communicating with other vehicles, the highway infrastructure and its controllers to the south.

Agent Jackson had caught this case, and he felt like it had wings. The trafficking interdiction algorithms had worked. A variety of criminal indicators—picked up on scanners at different points of PB18473's route—had determined the rig was worth inspection. Its source city information had been hacked, but the fact that it had stopped in one town for an entire day after already being loaded with the recycled plastic it carried was suspicious enough. In the old days, an informant or surveillance team would have had to know about that delay. Today, it was mostly automated analytics. When PB18473 was ordered into the inspection facility, the hack was found rather quickly, giving the interdiction agents and technicians free rein to tear the truck apart. They dug 2,000 kilos of black-tar heroin out of some avocado crates, the source city was discovered, and Jackson had himself a case. When the system works, it really works, Jackson thought to himself. It was nice to be ahead of the bad guys for a change.

3. Third Vignette,: *Emily's Commute Conclusion*²¹⁶

Emily was engrossed in her work, but Jax knew something was wrong. Despite his obsession with the Pink Monkey 2100 interactive animation on his monitor, he knew he should be at school by now. "Hey, Mom, why isn't AI-mee stopping?" he asked.

Emily nearly waived him quiet, as she was dictating an email to a client and monitoring two accounts on her screen, but she snapped to when she saw the time—8:15. Jax was supposed to be at school at five after.

"AI-mee, exterior view, please," she said—as a role model for Jax, she tended to be cordial to her AI. Her wall screen changed from news to video of the city outside, which was whizzing by at a fair clip. Emily, who generally left the route up to the RoomGo, saw that they were well past Jax's school and had even passed her own office building.

"All screens, now!" she snapped, cordiality gone. She was going to be way late, and Jax had a field trip today. When the screens lit up all around, it was as if the RoomGo were encased entirely in clear windows, with full visibility of the surrounding scenery and traffic displayed in crisp video along all four walls. There were several other RoomGos around her, but not many other vehicles could be seen. "AI-mee, take me to the office."

"Changing route to your office, Emily," the speakers chimed. But the RoomGo did not slow or change course.

"AI-mee, office, now!"

"I'm sorry, Emily, I didn't understand what you said there."

"Office, damn it!"

No response.

They rolled passed intersections where other RoomGos were stopped, with traffic queued up behind them for blocks. She saw emergency lights among the stuck cars, which she imagined belonged to the city's Rapid Response

²¹⁶ Literature suggests AVs could be susceptible to hacking and used to carry out crimes, including acts of terrorism. Anderson et al., *Autonomous Vehicle Technology*, 70–71; Volz and Oatis, "DOJ Studying Self-driving Cars."

Police, but she had never dealt with them before, so she wasn't sure. She saw some neighborhood safety officers in their yellow vests on the sidewalks. They just watched as dozens of RoomGos rolled by. The vehicles all seemed to be headed toward City Center. There was a demonstration there today—something political. Emily seemed to remember that thousands were supposed to be there. She hit the door button, but she knew it wouldn't work while they were rolling.

This was some kind of hack. It had happened before, but early on, before she subscribed to RoomGo. She had seen it on the news. It had been harmless—techies making a point—and the system was way safer now. She just held on, hoping this was just another prank.

E. PARALLEL TECHNOLOGY

While there is admittedly an element of drama to these imagined scenarios, there are ample precedents of criminals and terrorists leveraging technology to get the upper hand on law enforcement and homeland security practitioners. Police, border agents and even the United States Coast Guard have not been able to keep up with international drug smugglers who have employed sophisticated semi- and fully submersible vessels to transport drugs into the United States.²¹⁷ Drones have been used to smuggle drugs and other contraband into prisons.²¹⁸ Criminals have exploited the Internet to commit a variety of crimes, including identity theft, sex trafficking and the sexual exploitation of minors.²¹⁹ Terrorist groups—especially ISIS—have been online for years, using commercially available computer and cellular phone technology for encrypted

²¹⁷ Donald Davis, “The Submersible Threat to Homeland Security,” (master’s thesis, Naval Postgraduate School, 2013).

²¹⁸ Randy Ludlow, “Mansfield Prison Drone Drug Drop Not the First in Ohio this Year,” *Columbus Dispatch*, August 14, 2015, <http://www.dispatch.com/content/stories/local/2015/08/14/drone-drug-drop-ohio-prison.html>.

²¹⁹ “Identity Theft and Cybercrime,” Insurance Information Institute, accessed January 31, 2017, <http://www.iii.org/fact-statistic/identity-theft-and-cybercrime>; Eileen M. Alexy, Ann W. Burgess, and Timothy Baker, “Internet Offenders Traders, Travelers, and Combination Trader-Travelers,” *Journal of Interpersonal Violence* 20, no. 7 (July 2005), doi: 10.1177/0886260505276091; Mark D. Wallace, “Social Media Has Become a Radicalization Pipeline. It’s Got to Stop,” *USA Today*, January 25, 2016, <http://www.usatoday.com/story/opinion/2016/01/25/remove-terrorists-youtube-social-media-column/78939982/>.

communications within their organizations, and as a means to coordinate attacks, recruit new members and spread their messages of fear and intimidation.²²⁰

The Internet itself has led to myriad innovations and business opportunities, and criminals and terrorists have historically been quick to exploit them. For example, Bitcoin—a virtual currency that allows for anonymous money transactions through the use of block chain technology—has been used by criminal organizations to purchase drugs; its potential for financing jihadists is a real concern for homeland security professionals.²²¹

In the case of Bitcoin, the FBI partnered with cryptographers in the fields of computer science, economics and forensics to disrupt the online crypto-currency marketplace, Silk Road.²²² Silk Road sprang up shortly after the advent of Bitcoin, and was brazenly operating a virtual black market. According to *Science Magazine*:

By 2013, millions of dollars' worth of Bitcoins were being swapped for illegal drugs and stolen identity data on Silk Road. Like a black market version of Amazon, it provided a sophisticated platform for buyers and sellers, including Bitcoin escrow accounts, a buyer feedback forum, and even a vendor reputation system. The merchandise was sent mostly through the normal postal system—the buyer sent the seller the mailing address as an encrypted message—and the site even provided helpful tips, such as how to vacuum-pack drugs.²²³

As untouchable as Silk Road's operation seemed in 2013, by the next year the FBI was making arrests and getting prosecutions.²²⁴ The work of innovative investigators—who

²²⁰ "Jordanian Pilot's 'Obscene' Burning Death by ISIS Sparks Outrage in Mideast," CBS, February 4, 2015, <http://www.cbsnews.com/news/jordanian-pilots-obscene-burning-death-by-isis-sparks-outrage-in-mideast/>; Julia Glum, "ISIS on the Internet: 7 Apps the Islamic State Group Uses for Recruitment, News and More," *International Business Times*, August 10, 2016, <http://www.ibtimes.com/isis-Internet-7-apps-islamic-state-group-uses-recruitment-news-more-2399849>.

²²¹ A block chain is public ledger of transactions that tracks when Bitcoins have been moved from one account to another, while keeping the actual owners of the accounts anonymous. *Investopedia*, s.v. "Blockchain," accessed January 31, 2017, <http://www.investopedia.com/terms/1/51-attack.asp>; John Bohannon, "Why Criminals Can't Hide Behind Bitcoin," *Science*, March 9, 2016, <http://www.science.org/news/2016/03/why-criminals-cant-hide-behind-bitcoin>; Aaron Brantly, "Financing Terror Bit by Bit," Combating Terrorism Center at West Point, October 31, 2014, <https://www.ctc.usma.edu/posts/financing-terror-bit-by-bit>.

²²² Bohannon, "Why Criminals Can't Hide Behind Bitcoin."

²²³ Ibid.

²²⁴ Ibid.

recognized early on that Bitcoin was a disruptive and dangerous tool in the wrong hands—resulted in novel collaborations that have helped to innovate forensic investigations of block chain technology and related black market strategies.

Yet collaboration between tech industries and law enforcement is hardly the norm. The Silk Road investigation was not a result of cooperation between Bitcoin, itself, and authorities, but rather of partnerships with other private sector individuals who were willing to help reveal the hidden users of the virtual currency. It may stand to reason that cooperating with the police could serve against the business interests of a company that provides anonymity protection services to its users. But there are other examples in which tech companies have not cooperated with authorities, even when those companies' products were not tailored to criminals and were instrumental to solving crimes. Apple, for example, refused to assist the FBI in cracking the encryption on an iPhone 5c belonging to the San Bernardino shooting suspect Sayed Farook.²²⁵ This case was arguably not about civil liberties or privacy issues as much as it was about smartphone security. But Apple had a business interest—and, in the opinion of CEO Tim Cook, an ethical obligation—to ensure that iPhone encryption remained sound.²²⁶ In the company's view, creating a "backdoor" to its encryption would create a vulnerability that future hackers could exploit. After the FBI took legal action, a federal judge ordered Apple to crack its own code, but the company refused. The encryption was eventually hacked by a third party—possibly Cellebrite, an Israeli firm that markets cell phone analytic equipment to law enforcement—and the FBI's case against Apple was dropped.²²⁷

The success of the Silk Road investigation resulted from police partnerships with academia and the tech community, who shared a common goal of decrypting a potentially

²²⁵ Don Reisinger, "Apple and the FBI Could be Headed for Another Locked iPhone Battle," *Fortune*, October 7, 2016, <http://fortune.com/2016/10/07/apple-iphone-dahir-adan/>.

²²⁶ Tim Cook, "A Message to Our Customers," Apple, February 16, 2016, <http://www.apple.com/customer-letter/>.

²²⁷ Jeff Stone, "The FBI and Cellebrite, the Israeli Company Reportedly hacking The iPhone, Are Old Friends with \$2 Million Worth of Memories," *International Business Times*, March 23, 2016, <http://www.ibtimes.com/fbi-cellebrite-israeli-company-reportedly-hacking-iphone-are-old-friends-2-million-2342283>.

adverse technology. Conversely, the Farook investigation was a fight between two giants of their industries, Apple and the FBI, which may have adversely affected future opportunities for collaboration. Indeed, even though the FBI was working a legitimate investigation, its adversarial stance in the case strongly divided public opinion over their right to demand Apple's help, which appeared to some as a power grab for future privacy infringement.²²⁸ While Tim Cook stated that his company has cooperated in the past, such public battles are not conducive to cooperation, and the FBI found itself poised against Apple in a similar case a few months later.²²⁹ Furthermore, the technology used by the authorities to get the data they needed was obtained through a company that marketed to law enforcement, not from tech industry or academic actors sympathetic to the government's cause. It stands to reason police will seldom be on the cutting edge of technology created by private industry, and most agencies are not in a position to pay the estimated \$1 million it cost the FBI to have a private company crack Apple's code.²³⁰

Conversely, public-private partnerships from within the industry are likely to lead to better results when it comes to technological challenges confronting law enforcement. As in the case of Bitcoin, approaching the industry while a problem is developing and sharing common concerns might lead to collaborative solutions. It is not clear how much dialogue went on between the FBI and Apple in the years leading up to the iPhone's seemingly impenetrable encryption, but there is time for local law enforcement agencies to collaborate with AV companies within their jurisdictions today. By discussing potential public safety issues associated with AVs before they arise, LEAs and developers could work together on mutually beneficial solutions. The support of traffic agencies during the early AV technology development could help companies with regulatory challenges and improve their safety, which would only serve to enhance consumer confidence. At the same time, engaging with the producers of the technology about public safety problems could lead to solutions not evident from an LEA

²²⁸ Ibid.

²²⁹ Cook, "A Message to Our Customers."

²³⁰ Reisinger, "Apple and the FBI."

perspective. Failing to engage early could lead to after-the-fact accusations and expensive legal battles once the technology has already been put to use by criminals or terrorists.

F. FIGHTING FIRE WITH WHAT?

This chapter purposely emphasizes AV technology's costs over its benefits to illustrate potential unintended consequences. It paints a picture of AVs exploited by criminals and terrorists in ways yet to be imagined, with fewer police on patrol to stop them. To make its point, the illustration imagines AVs as Promethean fire used for nefarious purposes unintended by those who brought them into the world. But comparisons to current technologies, such as virtual currency and smartphone encryption, show that opportunities for high-tech crime can also lead to opportunities for innovative crime fighting using the very same technology—a case of fire being fought with fire.

Unfortunately, such examples show organizations that were able to rally resources and funding to combat criminal use of technologies that increased the need for law enforcement. Furthermore, the misuse of technologies such as virtual currency and data encryption was readily predicted by law enforcement and homeland security agencies and, consequently, acted upon quickly. By comparison, the somewhat predictable misuse of AV technology—such as for weaponization—may not be its most dangerous aspect. Instead, it is the AV's intended purpose—providing safe and reliable transportation—that makes the technology a more complex threat, with implications that are difficult to predict and thus even more difficult to counter. If the AV changes society for the better, as many feel it will, its success could lead to a reduced number of police on the streets with a reduced capacity to detect or deter crime through traffic enforcement. Thus, in the case of the AV, it is not a question of fighting fire with fire so much as a question of what to fight the fire with—or if it should be fought at all.

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VI. CONCLUSION

No serious futurist deals in prediction. These are left for television oracles and newspaper astrologers.

—Alvin Toffler, futurist

This final chapter suggests mitigation strategies for the unintended cost of reduced capacity for crime deterrence and interdiction through traffic enforcement. It begins by recommending that policymakers and police agencies make concerted efforts to better understand the impacts of AV technology in the present in order to influence a better future. The recommendations require imagination and innovation on the part of public safety practitioners, but do not call for dramatic departures from current twenty-first-century policing best practices. The chapter concludes by suggesting ways to track data in order to create a feedback loop for validated learning and provide information for future study.²³¹

A. IMAGINATION, INNOVATION AND INERTIA

The previous chapter required an exercise in imagination to envision what the AVs of the future might look like and what criminals and terrorists might do with them. But AVs are not just a thing of the future; cars have been driving themselves for years, and they are getting better at doing so with every passing mile. What they become in the future is likely to be limited more by imagination than by technology; historically, companies like Tesla, Google and Uber have not lacked imagination. Unfortunately, neither have criminals or terrorist organizations.

On the other hand, U.S. government agencies, specifically those involved in homeland security, have been accused of lacking the imagination and foresight required to counter crime and terrorism. The *9/11 Commission Report* claimed that a failure in imagination was one of the reasons the 9/11 terrorist attacks succeeded.²³² The report

²³¹ Refer to the literature review, Chapter I, Section C3; Ries, *Lean Startup*.

²³² National Commission on Terrorist Attacks Upon the United States, *9/11 Commission Report*, 339.

said the failure was not due to an inability to envision an aircraft being used as a weapon—there were indicators of such a tactic’s plausibility—but to aviation security’s lack of preparation for this possibility.²³³ Despite various signs that al Qaeda was a threat overseas, terrorism was not on the minds of most Americans.²³⁴ Instead of analyzing possible vulnerabilities in the nation’s air defenses, the intelligence community passed information on to the Federal Aviation Administration. The agencies responsible for protecting the country from surprise attacks—namely those working in intelligence and defense—relegated this responsibility to a largely regulatory agency instead of engaging with the possibility of a domestic attack head-on.²³⁵

Similarly, there is already enough known about AV technology to suggest its plausible exploitation by criminals and terrorists. And, as previous chapters suggest, the future of the technology may lead to a decreased capacity for police to counter such exploitation through criminal interdiction methods historically available through traffic enforcement. In order to avoid a failure of imagination, policymakers—with leadership and guidance from their LEA executives—must not take a wait-and-see approach toward the diffusion of AV technology and innovation. Instead, LEAs must understand that they cannot leave public safety issues raised by AV proliferation to regulatory agencies—such as DOTs or DMVs—but must take the lead in anticipating and responding to them.

Keeping the traffic safety–public safety gap in mind, LEAs must understand diffusion concepts to better gauge the speed at which AVs might rise in their jurisdictions, and then adjust strategies and allocate resources to ensure they keep up with it. At first, diffusion may not be consistent among varied geographical, socioeconomic or regulatory environments. LEAs must, therefore, monitor AV diffusion on a local level to identify innovators, early adopters and key promoters that will take the technology across Moore’s chasm and on to the early majority of adopters.²³⁶

²³³ Ibid., 343–344.

²³⁴ Ibid., 340.

²³⁵ Ibid., 347.

²³⁶ Refer to the literature review, Chapter I, Section C3, and Chapter IV, Section A, for Everett’s diffusion of innovations and Moore’s chasm.

Once such innovators are identified, it is important for LEAs to take an active role in engaging with them not just in a regulatory capacity—though early regulation may be necessary—but in collaborative efforts to ensure that products are safe and resistant to criminal exploitation. At first blush, this may seem a tall order; but such collaboration could serve the goals of LEAs as well as industry. Safer products are more marketable products, and companies that show they can work with law enforcement for the benefit of public safety may have an advantage. On the part of the police, such discussions could lead to discovery of problems they did not know existed as well as solutions they did not know were needed.²³⁷

Early discussions between LEAs and tech companies could identify ways to mitigate privacy and data security concerns before criminals exploit AV technology. Sustained dialogue and feedback between police executives and business leaders may reduce the likelihood of adversarial clashes like the one the FBI and Apple experienced in the Farook iPhone case.

Beyond new models of collaboration, LEAs have to accept that new methods of policing and new types of police professionals may be required to keep the streets and cities of the future safe. Much like automated fire alarms and sprinkler systems required firefighters to pivot to their now-ubiquitous role as emergency medical responders, traffic agencies will have to pivot from traditional traffic enforcement to technology-based solutions to traffic safety and security.²³⁸ To do so, it is again necessary for police professionals to imagine a different world—one without traffic enforcement as they know it—and to envision how they want that world to look. It is important to accept that, in order to innovate on behalf of public safety, LEAs must assert influence over, and adapt to, such a world starting now. Police and highway patrol departments will need to overcome cultural inertia—a resistance to change that is inherent to government, and to which their agencies are not immune.

²³⁷ Refer to the literature review, Chapter I, Section C3; Nieto-Gomez, “Director of the Present.”

²³⁸ Fred S. McChesney, “So Many Professional Firefighters, so Few Fires,” *Lebanon Voice*, June 26, 2016, <http://www.thelebanonvoice.com/so-many-professional-firefighters-so-few-fires-cms-5976>.

B. A WAY FORWARD

Overcoming inertia is an example of Christensen’s innovator’s dilemma: current strategies—including traffic enforcement—are working, thus making it difficult to know how and when to change them.²³⁹ Fortunately, there are courses of action to begin today—as well as existing strategies that will continue to work in the future—that can better maintain LEAs’ capacity to ensure public safety despite a reduced need for traffic enforcement.

1. Mind the Gap

A simple phrase, “Mind the gap,” was coined in 1968 as a campaign for the London Underground subway system to remind riders of an ever-present danger right in front of them—the gap between a stopped train and a curved platform at the tube stop.²⁴⁰ The phrase was short enough to paint on small signs and to play over the relatively unsophisticated public address systems of the time, but so ubiquitous it became evocative of London’s culture to travelers worldwide, and it has been adopted in different forms by many countries.

This research has illustrated another public safety gap. On one side of that gap is a much safer world in which the leading causes of death in the United States—fatal traffic accidents—are virtually eliminated thanks to AV technology. On the other side of that gap is a reduced capacity for LEAs throughout the country to detect, deter and disrupt criminal activity, including terrorism. If nothing else, this research should raise awareness among law enforcement executives and policymakers to “mind the gap” between the AV’s traffic safety benefits and the potential public safety consequences of reduced traffic enforcement.

Minding the gap will require constant evaluation of existing policies and procedures in order to deploy police resources appropriately as traffic patterns and the nature of traffic enforcement changes with the emergence and diffusion of AV

²³⁹ Refer to the literature review, Chapter I, Section C3; Christensen, *Innovator’s Dilemma*.

²⁴⁰ “Mind the Gap,” British Rail, accessed February 25, 2016, <http://www.britishrail.com/mind-the-gap>.

technology. While it is impossible to predict exactly how fast diffusion will happen or how it will change society, LEAs must not take a passive, “wait-and-see” approach to the technology. They must innovate with it and resist political, bureaucratic and cultural inertia in order to adapt to the technology.

But first, LEAs must heed signals of diffusion in their individual jurisdictions as well as signals nationwide that indicate diffusion is at a tipping point toward accelerated proliferation of AVs on their highways. As further innovations in AVs develop, LEAs must innovate with them, using existing resources and influence to engage with the technology companies to ensure such development is as safe as possible. At the same time, LEAs must establish feedback loops within their organizations and through external sources—including technology companies—to make validated decisions about when to stay the course, or persevere, and when to change course, or pivot.²⁴¹

Deciding what form that pivot takes—or whether to pivot at all—does not have to be based solely on the signals read today; there is time for further study. AVs are developing quickly, but traffic cops will not disappear overnight. Establishing a validated learning process today will help form strategies for future data collection and industry engagement, which will continue to inform policymakers’ decisions in the future.

2. Read the Signals

Institutional learning in law enforcement tends to be based on historical data—the number of crimes or traffic accidents in a given area, for example, or the number of vehicle searches that discovered contraband. Furthermore, much of that data are collected and reported by the LEAs themselves. While there is certainly value in historical, self-generated data, such information may not provide an agency with the kinds of learning it needs to keep up with a disruptive and rapidly evolving technology such as the AV. Instead, a validated learning approach must be adopted—one that recognizes the value of recent or real-time data, from a variety of sources, and how such data affects an agency’s operations.

²⁴¹ Refer to the literature review, Chapter I, Section C3; Ries, *Lean Startup*.

In the startup world, business leaders only act upon information beneficial to future growth; other information is ignored.²⁴² While this is not a perfect model for law enforcement—LEAs do not grow in the sense that companies do—these concepts of learning, in real-time from varied sources, and making flexible strategies based on that learning could help LEAs stay relevant and effective. And relevance might become more of an issue over the long term if the diffusion of AVs leads to reduced law enforcement resources formerly dedicated to traffic safety and enforcement.

In order to stay relevant and implement validated learning principles, LEAs must read and interpret the signals around them to gain knowledge they either do not have, or did not know they needed.²⁴³ Signals could include changes in culture or innovations in technology. The way external signals interact with each other and with historical internal agency data can help inform how an agency should apply existing strategies or develop new ones to best achieve its objectives.

For example, Uber usage in a given jurisdiction could be a signal for traffic enforcement agency consideration. Hypothetically, if Uber usage were high in the city's downtown area, and that data correlated with a reduced number of DUI arrests, the agency might adjust how and where it deploys its traffic enforcement officers. But a recent nationwide study indicates that Uber has not, in fact, reduced instances of drunk driving, and law enforcement data supports that drunk driving collisions have increased in cities like San Francisco, where Uber drivers are ubiquitous.²⁴⁴ Uber could be a viable part of a drunk driving reduction strategy, yet LEAs are not collecting data on Uber usage to develop or implement such a strategy. Without such data, traffic enforcement agencies cannot offer more than an opinion based on anecdotal information—as opposed to factual analysis—about Uber regulation to policymakers in their cities and states. Perhaps most

²⁴² Ries, *Lean Startup*, 49.

²⁴³ Refer to the literature review, Chapter I, Section C3; Webb, *The Signals are Talking*; Nieto-Gomez, "Director of the Present."

²⁴⁴ Heather Kelly, "Uber Doesn't Decrease Drunk Driving, Study Says," CNN, July 29, 2016, <http://money.cnn.com/2016/07/29/technology/uber-drunk-driving/>; "Program 10 Statistical Summary Data—Beats 1–799 Total of Current Year vs. Previous Three Years, Command: 335 San Francisco, Report Period: December 2016 Calendar Year," (internal report, CHP Management Information System, January 9, 2017).

importantly, such data collection could form a starting point for interaction between the agencies and Uber executives in order to work toward mutually beneficial strategies that ensure public safety while allowing for company growth.

Currently, Uber is using its vast data analysis capabilities for its own purposes: to detect and deter competitors, and to avoid detection by LEAs in cities where Uber drivers are operating despite legal prohibitions against them.²⁴⁵ Uber's Greyball software was invented to target people who violated their terms of service, but it has also been adopted to detect authorities who are known to hail a car and then cite the driver for operating illegally.²⁴⁶ Among the data collected were the user's location and credit card information, which could be tied to police station locations or police credit unions.²⁴⁷ It is unknown if a better relationship between Uber and law enforcement would dissuade Uber from using Greyball in such a way. However, the software's capabilities are an example of why dialogue with such companies might be important to policing of the future.

Uber is on the cutting edge of present and future driverless technology, and it is already using data to detect certain behavior, a signal of the potential for data collection AVs will make possible. By paying attention to such signals, which are relevant to traffic safety today, LEAs can create feedback loops for validated learning opportunities that might have greater implications for public safety in the future.

3. Endeavor to Persevere

Learning how to adapt policing to potentially disruptive innovations such as the AV does not necessarily require immediate or dramatic reengineering of today's law enforcement strategies, even among traffic enforcement agencies such as the CHP. Instead, departments should consciously decide if they should persevere—capitalizing on current practices that could positively influence the AV's impact on public safety—while remaining vigilant for signals that indicate it is time to pivot their resources. Current LEA

²⁴⁵ Mike Isaac, "How Uber Deceives the Authorities Worldwide," *New York Times*, March 3, 2017, https://www.nytimes.com/2017/03/03/technology/uber-greyball-program-evade-authorities.html?_r=0.

²⁴⁶ Ibid.

²⁴⁷ Ibid.

practices that could bridge the public safety gap presented by AV technology include: community engagement, predictive policing and—even if random crime detection through traffic stops decreases—criminal interdiction through targeted traffic enforcement.

Engaging communities and enhancing public trust have become central strategic themes in modern policing. The President’s Task Force on 21st Century Policing emphasized the importance of such strategies throughout its six “pillars of policing”; similarly, one of CHP’s strategic plan goals is to “enhance public trust through community outreach and partnerships.”²⁴⁸ Likewise, engaging with future technology is also an identified strategy in both documents. Yet neither the President’s Task Force nor the CHP suggests ways to meld these two strategic objectives. Community engagement focuses on churches, schools and other community groups, but does not discuss engagement with the companies that are bringing potentially life-changing technology like the AV to today’s streets. Furthermore, the focus on technology is more on its internal potential—if police officers should wear cameras, or how to leverage social media, for example—but gives only cursory attention to external technologies that might significantly impact public safety.²⁴⁹

In order to best read and understand signals about emerging technology and how it will affect public safety, LEAs must broaden their community outreach programs to engage and build trust with technology companies. LEAs should also leverage existing community contacts to learn how they are interacting with technology in the present and what they desire from technologies of the future. Such engagement will help LEAs decide how to best interact with or influence such technology based on validated learning and continuous feedback. In the case of AV technology, such learning will help establish police—especially those who specialize in traffic enforcement—as the subject-matter

²⁴⁸ President’s Task Force on 21st Century Policing, *Final Report*; Farrow, *California Highway Patrol Strategic Plan*, 18.

²⁴⁹ For example, the fifth goal of the CHP’s 2015–2019 strategic plan is to “Identify and Respond to Evolving Law Enforcement Needs,” but, unlike the first four goals in the plan, there are no metrics or deadlines on accomplishing its performance objectives. Farrow, *California Highway Patrol Strategic Plan*, 23.

experts on how that technology might impact public safety. Such expertise will position LEAs to advise lawmakers on how to regulate AV—and associated CPS—technology in order to mitigate potential public safety costs.

Beyond looking for ways to engage with the community on technological issues, LEAs should be alert for new opportunities to leverage technology for detection, deterrence, and disruption of crime through extant and future predictive policing methods.²⁵⁰ Technology is already being used in this regard, but its application is inconsistent throughout the country. Automated license plate readers (ALPRs), for example, are deployed in various capacities in many cities and highways.²⁵¹ Yet their effective application as a crime detection and deterrence tool varies among different jurisdictions. For example, California law limits the CHP's retention of ALPR data to sixty days, except in incidents where specific data are used as evidence for a felonious crime.²⁵² Such laws are designed to protect the motoring public's rights of privacy, but enhancing data collection on the nation's city streets and interstates may become more important over time as the AV displaces traditional traffic enforcement tactics.

As AV and CPS technologies evolve, opportunities for data collection could afford LEAs many new ways to predict crimes that might be afoot, as well as to solve those already committed. In keeping with sound public trust in policing principles, policies that govern the use of such data must be implemented and subject to public

²⁵⁰ Predictive policing tries to harness the power of information, geospatial technologies and evidence-based intervention models to reduce crime and improve public safety. "Predictive Policing," National Institute of Justice, accessed February 11, 2017, <https://www.nij.gov/topics/law-enforcement/strategies/predictive-policing/Pages/welcome.aspx>.

²⁵¹ ALPR systems consist of digital cameras, with infrared capability, feeding into computers loaded with recognition software, which can capture large numbers of photographs of vehicle license plates and translate them into characters then store them in a database or instantly compare them to numbers already stored in the database. This allows law enforcement to identify stolen or otherwise wanted vehicles instantly, while also compiling a database for future reference, which can be used to locate where and when a plate was last scanned. David J. Roberts and Meghan Casanova, *Automated License Plate Recognition (ALPR) Systems: Policy and Operational Guidance for Law Enforcement* (Washington, DC: US Department of Justice, 2012).

²⁵² California Vehicle Code, sec. 2413.

review in order to balance issues of security with transparency and accountability.²⁵³ In light of the potential reduced capacity for traffic enforcement to detect crime, it will become increasingly important for LEAs to engage with the public about predictive policing technologies and evaluate how to apply them to AV and CPS technologies.

While the need for traditional traffic enforcement might eventually diminish, traffic cops will still be necessary in the near term. As the number of AVs on the streets and highways increases over time, there will be a transition period during which human drivers and AVs interact. This period will not only have unpredictable effects on traffic safety—as fallible humans and yet-imperfect algorithms find equilibrium on the nation’s highways—but will also offer opportunities for police to interact with and learn about AV technology. Traffic officers should be trained about the technology and provided a means to collect data that track the technology’s impact on traffic safety—similar to the way cellular phone usage by drivers is collected today.²⁵⁴

LEAs should continue to deploy traffic officers for their primary purpose of ensuring traffic safety, but should also use targeted traffic enforcement to interdict criminals and terrorists. Twenty first-century policing best practices of community engagement and procedural justice should be kept at the forefront of such efforts, and validated learning should inform traffic enforcement goals and performance objectives. As AVs become more prevalent in society, traffic enforcement units could become data collection hubs for such learning, which could lead to knowing the unknowns about the AV’s impact on public safety outside the bounds of traffic safety alone.

At the very least, LEAs need to increase their institutional knowledge about AVs so they can remain relevant to the national discourse on traffic safety and broader issues of public safety. Companies like Tesla, Google and Uber are shaping the future of

²⁵³ In the United Kingdom—a country with a citizenry that is much more tolerant of surveillance and predictive policing techniques than the United States—surveillance methods, including the use of ALPRs, are formally prescribed in national policies that apply to both public and private organizations. “In the Picture: A Data Protection Code of Practice for Surveillance Cameras and Personal Information,” Information Commissioner’s Office, May 21, 2015, <https://ico.org.uk/media/1542/cctv-code-of-practice.pdf>.

²⁵⁴ For example, page 2 of the CHP 555, *Traffic Collision Report*, has series of check boxes that indicated if a driver was using cell phone at the time of a collision and whether it was handheld or hands-free.

transportation, but they should not be left to do so alone. While regulation can stifle creative innovation, it is still necessary to keep society safe from the unintended consequences of any technology. When it comes to transportation technology with the high level of CPS integration expected to follow the AV, law enforcement and homeland security professionals need to pay particular attention. And while it may still be too early to predict the exact course of such technology, there are enough present predictive signals that could result in meaningful discussions with groups like FASTR about a safer future. FASTR seeks to “enable innovation in automotive security.”²⁵⁵ If this is truly the group’s goal, then working with law enforcement may lead to knowledge discoveries that industry professionals would not have thought of, making perseverance a solid strategy for LEAs to deal with the emergence of the AV, as their historical expertise remains relevant.

4. Prepare to Pivot

Perseverance with tried-and-true law enforcement strategies, including traditional traffic enforcement, could very well serve LEAs best as AVs enter the market and proliferate on the highways. As semi- and fully autonomous vehicles mix with human drivers, traffic accidents could increase in the near term, which may give traffic enforcement agencies new opportunities to apply old strategies. But there may be a tipping point at which AVs diffuse rapidly, and LEAs must redirect resources from traditional traffic enforcement toward yet-undiscovered innovative law enforcement techniques. Agencies with traffic safety responsibilities will have to pivot dramatically in order to stay relevant.

In his NPS thesis, Lyons suggests the CHP should train existing officers about emerging technologies, and also create new technology professional positions within the department. The technology professionals would investigate collisions involving high-tech vehicles, as well as detect, deter and disrupt cyber-crimes that exploit that

²⁵⁵ Refer to the literature review, Chapter I, Section C2; “Our Manifesto,” FASTR.

technology.²⁵⁶ He calls on the CHP to pivot now in order to maintain relevance as a public safety agency of the future, stating:

If the CHP fails to think about the possibilities and then fails to shift its operations when they arrive, the CHP could become obsolete and California could form a new agency to rise to the occasion.²⁵⁷

Lyons's thesis focuses specifically on his own agency, and the AV's potential effects on its traffic enforcement mission. He encourages adoption of AV technology because of its life-saving benefits, and he makes recommendations for how his department can pivot to maximize those benefits. But the gap between those benefits and the loss of a crime detection tool like the traffic stop should be important across all levels of law enforcement, and to the policymakers who will pass laws to fill that gap.

The tools to replace the traffic stop with other means of criminal interdiction will not be as simple as firefighters' historical shift to emergency medical responders, which is a mere shift from one life-saving mission to another. The law permits police officers to make traffic stops—based on reasonable suspicion or probable cause—because such enforcement saves lives by reducing errant drivers' collisions; without a traffic safety focus, traffic enforcement serves no purpose. The fact that traffic stops detect and deter criminal activity beyond traffic violations is incidental to their primary purpose. Unlike firefighters shifting their mission from saving lives in one manner to saving them in another, traffic cops shifting their mission from saving lives to solely interdicting crime would require a major overhaul of the justice system that would likely be deemed unconstitutional.

There is nothing in current jurisprudence to suggest traffic stops would or should be permitted to interdict crime absent their primary purpose of saving lives. But there are existing solutions—such as highway surveillance cameras and ALPRs—that would not only augment current crime suppression on the highways, but might begin to fill the public safety gaps that widen as AVs make motorists unstoppable. The CPS environments in which AVs will operate will result in more technological solutions to

²⁵⁶ Lyons, "Autonomous Vehicles," 78–80.

²⁵⁷ *Ibid.*, 84.

crime detection, especially if LEAs establish an early influence on how such technologies are implemented in their jurisdictions. Furthermore, if LEAs can help policymakers understand that a new public safety paradigm might arise as AVs negate the need for traffic enforcement—reducing police capacity to interdict crime in vehicles—AV regulatory laws might be considered in a different light. Expectations of privacy may change in publically operated AVs, and search authority could be legislated in certain situations, thereby building crime deterrence into the very licensing of commercially operated AVs. In this way, crime would not be detected, deterred and disrupted as a byproduct of traffic safety, but public safety and crime reduction for its own sake could become the basis for such interdiction.

If LEAs continue to “mind the gap” the AV creates on the public safety landscape; monitor signals to continuously learn how that landscape is changing; and use that learning to persevere or pivot their strategies, there is a positive way forward. To find it, LEAs must be prepared to challenge policymakers to pay attention to the gap, and perhaps more importantly, challenge their own culture to lead the way forward through innovation rather than become mired by inertia.

C. RECOMMENDATIONS

AV technology is no longer nascent—it is here. The comprehensive RAND report *Autonomous Vehicle Technology: A Guide for Policymakers* was released in 2014. Since then, AVs have evolved from experiments in a few Silicon Valley towns to commercially operated Ubers on the streets of Pittsburg. New Teslas are equipped with semi-autonomous hardware that could be turned into level-four autonomy with little more than a software upgrade. The RAND report appropriately recommended that “aggressive policymaker intervention” on AV technology was premature at the time it was published.²⁵⁸ But policymaking on the AV has now begun, and it is time for law enforcement to engage with both those who bring the technology and those who regulate it. The following subsections recommend practices LEAs can employ today, as well as

²⁵⁸ Andersen et al., *Autonomous Vehicle Technology*, xxiv.

courses policymakers can set toward a long-term public safety strategy for dealing with the unstoppable cars of tomorrow.

1. Lead the Way

LEAs with traffic responsibilities should become the subject-matter experts on AV technology's impact on public safety. Policymakers should rely on such expertise in order to mitigate public safety threats that might arise from misuse of that technology. Traffic enforcement agencies like the CHP have expertise in traffic safety issues and a history of recommending policies and practices that save lives. Beyond simply enforcing traffic laws, these agencies have traditionally educated the public about traffic safety issues such as the dangers of drunk driving or the importance of wearing seatbelts. Traffic enforcement agencies should continue to leverage their expertise and reputations on matters involving the AV by:

- Increasing their accident investigators' and public information officers' knowledge about AV technology.
- Joining groups like FASTR to engage with AV manufacturers on public safety issues.
- Educating the public about semi- and fully autonomous technology.
- Continuously evaluating AV and CPS technologies for potential threats to public safety, as well as innovative solutions to such threats.

2. Collect Data

LEAs and other public agencies should begin collecting data about how AVs are used and how semi- and fully autonomous technology affects public safety. Such collection might initially only apply to vehicle ownership and collision data, but could later be relevant to crime statistics as AVs proliferate. Data could stem from a variety of sources already available to police agencies, with some modification to collect relevant AV information. Collection methods should be evaluated and sources appropriately modified as technology changes and AV usage increases. Data sources should include, but not be limited to:

- Traffic collision reports with check boxes that indicate levels of autonomy and if autonomous features affected the outcome of the collision.
- Crime reports that indicate if and how an AV was used in the crime.
- Business licenses involving AV and CPS technologies.
- AV registration records.

3. Incorporate Public Safety into CPS Infrastructure

Public safety organizations must be integrated into the cyber-physical infrastructures of the future. As vehicles become increasingly connected to everything (V2X), large amounts of data will be produced that could not only lead to safer vehicle operation, but could be used to detect and solve crimes. LEAs should engage with transportation agencies and city planners so that public safety and crime control opportunities are maximized as these infrastructures are being built. Project funding should be allotted to integrate of law enforcement databases, communication centers and traffic management centers into the cyber-physical infrastructure. Furthermore, the AVs themselves—especially those operated commercially—should meet prescribed requirements in order to operate within certain infrastructures. Such requirements might include:

- Scanners that evaluate vehicle sensor failure, software vulnerabilities, malware or hacks.
- Software that ensures AVs yield or stop to signals sent by police and other emergency vehicles.
- Electronic signatures that report vehicle registration information, commercial licensing and insurance status.
- Preservation of data collected by V2I sensors and software, ALPR cameras, GPS signals or other means in order to track historical movements of vehicles. Such data could have implications not just for solving known crimes or stopping crimes in progress, but for predictive policing methods associated with patterns of criminal activity in vehicles.

4. Legislate and Regulate

The legality for police to collect and use data from infrastructure will depend on how well lawmakers “mind the gap,” or understand the relationship between traffic enforcement and crime detection and deterrence. If police and policymakers pay attention to the gap early, they could create substitutes for the traffic stop as a crime-fighting tool. Current legislation, such as California’s prohibition on long-term storage of ALPR data, might be modified with the recognition that fewer police will be on patrol in the years to come.

It is too early to know exactly what laws and regulations will be required as AV use increases. Yet now is the time to consider how public safety threats can be addressed through regulation, as companies will be eager to comply in order to enter a burgeoning and lucrative market. For example, as a licensing provision, commercially operated AVs might require onboard cameras or tracking software which could be accessed by law enforcement.

Over the long term, AVs will change expectations of privacy on the highway. Personal ownership of AVs is predicted to decrease, and vehicles will become commonly used for a variety of services not yet imagined. It is quite likely that more vehicles than not will operate without people on board. This changing dynamic will undoubtedly affect police search authority, the legality of which will often be decided in the courts. Such decisions will be based on specific police actions and could have significant impacts on public safety, for the better or worse. This changing legal environment presents an opportunity for policymakers to envision and create a future that puts public safety first by passing laws that give clear guidance on how police can detect and interdict crime. Instead of judges deciding the legality of particular searches after the fact, legislators could consider issues of privacy and security, debate them openly, and pass laws that give clear search and inspection guidelines to police.

5. Train and Hire for the Future

Police agencies today must begin training and hiring for an uncertain future. While AV diffusion will affect the way many departments do business, it is unclear how long the change will take or how dramatic it will be. In order to position themselves for the future, police agencies will have to increase the competencies of their traffic enforcement officers, as this is where the agencies derive their credibility as advisors on traffic safety and AV policy. But they must also become savvier about general law enforcement, especially as it relates to technology; CPS technology will become one of the crime detection tools of the future.

Training considerations should include:

- High-tech accident investigation training to help determine fault in vehicles with semi- and fully autonomous capabilities.
- Advanced training in highway interdiction, including search and seizure training related to vehicle stops.
- Increased general law enforcement training for agencies with a traffic enforcement focus to prepare for a pivot toward more traditional policing roles.

Agencies should also consider hiring more law enforcement professionals for non-sworn positions that bring different skills to policing than uniformed officers—something that could become more relevant in a post-traffic enforcement environment. Such positions should be highly paid and respected within the agencies to ensure recruitment and retention of quality personnel with an interest in a long-term career.

Some existing positions that might be hired in increased numbers include:

- Crime analysts.
- Evidence and forensic technicians.
- Computer forensics technicians.
- Information and technology support staff.

Some new positions to consider creating include:

- Computer code programmers.
- Cyber-security technicians.
- Surveillance technicians.
- Technology company liaison officers or technicians.
- An agency futurist to advise LEA executives on emerging technology and its potential impact on the agency's mission.

D. STOPPING THE UNSTOPPABLE

Historically, law enforcement has risen to many challenges and adapted to new roles to meet those challenges. Traffic enforcement was one such challenge—a role that was never imagined by police in the years before the advent of the automobile. Prior to the 9/11 attacks, police did not consider themselves a bulwark against terrorism, yet today they are on the front line of the fight against it. In the years to come, the unstoppable AV will cause the role of traffic enforcement to change once again, but police will still be expected to fight crime and terrorism. Stopping the unstoppable will require innovation in crime detection and resistance to organizational inertia that would deny such change is needed.

EPILOGUE

If you dislike change, you're going to dislike irrelevance even more.

—General Eric Shinseki

I am a highway patrolman, and the last person in my profession has already been born. After today, if a kid wants to grow up and serve to keep you safe in your community, she won't do it the same way I did. She won't have to worry about you crashing a car because you are texting or falling asleep at the wheel. There won't be a wheel in those cars and, sometimes—maybe most of the time—there won't be a person either. But cars will still be driving around our cities, along our highways and across our borders—maybe more cars than ever before. They won't look or act the same way they did when I could stop them, but they will keep driving. And she won't be stopping them at all, at least not for the reasons I did. She probably won't get a chance to look inside them, at least not in person. Yet you will feel safe in them, and you won't miss someone like me asking you questions because you rolled a stop sign or were in too much of a hurry to get to work.

But that girl will still have a job to do when she grows up. She'll have to find the bad people, and she's going to have to work harder, and smarter, than I did to do it. Because people aren't going to change, even if the cars do. The bad people are still going to do bad things with those cars—maybe even more than they do now. They're going to know that she can't find them the same way I can today, and they're going to take advantage of her, of all of us. So she's got to think of new ways to catch them.

We can't wait—I can't wait—for her to figure it out all by herself. It's not fair to put her in that spot, and we don't have to. We know what we need to know right now to start giving her an edge. We know these cars are here, and we need to pay attention. We know they are going to change the world, and we need to be part of that change. Driverless cars are coming with or without us, and we need to talk to the people who build them. While they train their engineers to make them safer for our roads, we need to train our cops to keep them safer for our communities. And we can learn from each other

about how to do both. We need to work together on this to make sure that, when that little girl grows up, she knows how to keep us all safer.

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