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Examining Instrumented Roadways for Speed-Related Problems

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Randolph Atkins was the contracting officer's representative on this project.

16. Abstract

The project evaluated efforts by law enforcement officers to reduce speeding on roadways. The researchers coordinated with the Stafford County, Virginia, Sheriff's Office to implement countermeasures on corridors with safety concerns where speed was a factor. Speed and enforcement data were collected to look at the impacts of the enforcement efforts. Data were collected using radar-based speed sensors placed on targeted roadways with speeding problems and shared with the Sheriff's Office. From this data the law enforcement officers were able to make decisions on where countermeasures would be applied and what countermeasures would be implemented.

The countermeasures or speed reduction activities included deputy presence with on-site enforcement, decoy cars, speed trailers with digital feedback signs, and changeable message signs. The Sheriff's Office also used social media to release public service announcements about the safety campaigns. Decoy cars proved to be the most successful activity that led to drivers reducing their speeds for more than a day. This was likely influenced by length of deployment time at a given location. Speed trailers and deputies on-site issuing citations were also effective. However, the effects seemed to be localized. In other words, speeds were reduced in the location of the speed enforcement activity but did not carry over to adjacent locations on the segment. Finally, this study found the number of speeders to be a statistically significant predictor of crashes, and showed that traffic volumes can increase without a concurrent increase in crashes if the increased volume is made up of non-speeders.

17. Key Words speeding, speed management, speed enforcement, speed reduction activities, non-speeders	**18. Distribution Statement** This document is available to the public from the DOT, BTS, National Transportation Library, Repository & Open Science Access Portal, https://rosap.ntl.bts.gov.

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Executive Summary

This project, sponsored by the National Highway Traffic Safety Administration, evaluated techniques by law enforcement officers to reduce speeding on roadways. The researchers coordinated closely with the Stafford County, Virginia, Sheriff's Office (SCSO) to implement countermeasures on corridors with safety concerns where speed was a factor. Several criteria were used in site selection, including willingness to participate, variety of roadway types for analysis, and a dedicated team of law enforcement who focuses on traffic safety.

After signing an agreement with the county, speed and enforcement data were collected as baseline data as well as to analyze the impacts of the enforcement efforts. SCSO received data collected from speed sensors placed on designated test and control road segments after baseline data collection. Using the data, law enforcement officers were able to make decisions on countermeasure type and location.

The various countermeasures or speed reduction activities (SRA) included deputy presence with on-site enforcement, decoy cars, speed trailers with digital feedback signs, and changeable message signs. The SCSO also used social media to release public service announcements about the safety campaigns. Researchers calculated success rates for each SRA, which were considered successful if they significantly lowered the hourly number of speeders at a given sensor before the SRA, and if that decrease was larger than a concurrent decrease in speeding observed at a control sensor.

Decoy cars proved to be the most successful activity that led to drivers reducing their speeds more than a day after the SRA. The decoy car's probability of successfully reducing the number of speeding drivers more than 1 day after the SRA, given average values for other variables, was 7.6 percent. Speed trailers and deputies on-site issuing citations were less effective (at 2.7 and 3.0 percent). These percentages represent the probability of successfully reducing the number of speeding drivers at any point more than 1 day (i.e., 3 days, 1 week, or 2 weeks) after implementing the SRAs. These effects were highly localized. With 1 mile between an SRA and a sensor, the estimated success rate is 3.8 percent, versus 2.8 percent at 2 miles, 2.0 percent at 3 miles, 0.7 percent at 6 miles, etc. In other words, the farther drivers are from an SRA, the less likely they are to reduce their speed in response to the SRA. The sheriff's office use of social media through Twitter did not seem to significantly reduce speeding at the time that an individual Tweet was posted; however, each additional Tweet seemed to show a slight but significant reduction of 0.2 percent in traffic speeds on the instrumented road segments.

Roadside sensors and data from the Virginia Department of Transportation (VDOT) aided in the collection of data on crashes, speeding and traffic density. The monthly number of crashes was then modelled as a function of the number of speeders and non-speeders. These two variables represented both the level of speeding and overall traffic density. While more volume of either type of driver (speeders and non-speeders) increases the opportunity for crashes and thus should increase the rate of crashes, only the number of speeders alone was found to be a statistically significant predictor of crashes; specifically, a 1-percent increase in speeders during a given month was associated with an 0.84-percent increase in crashes This implies that total volume can increase without yielding more crashes if the increased volume is composed of all non-speeders.

Because the study was observational and based on the SCSO selections of activity, it was not possible to implement a controlled experiment in which the execution of SRAs was predetermined. Future researchers may want to assess variances in concentrated enforcement efforts and evaluate a larger number of speed reduction activities. In addition, while the research team placed enough sensors for the required data collection, a higher concentration of sensors might provide more information about the length of the impact of SRAs on traffic speeds.

Introduction

NHTSA categorizes speeding as a risky driving behavior[1] with an array of negative effects. A higher speed increases the amount of stopping distance when a driver realizes there is a safety risk, increases crash severity, and decreases the effectiveness of occupant protection equipment. These are significant consequences, but there is none more severe than the loss of life. In 2020there were 38,824 traffic fatalities. Of those, 11,258 (29%) resulted from crashes where at least one driver was speeding (National Center for Statistics and Analysis, 2022). Even with such severe consequences, drivers admit that speeding is a common behavior. According to the 2020 Traffic Safety Culture Index (AAA Foundation for Traffic Safety, 2021), 91 percent of surveyed drivers disapproved of driving over the posted speed limit by more than 10 mph on residential streets, yet 28.8 percent reported having done so in the last 30 days. Similarly, 83.5 percent disapproved of driving over the posted speed limit by 15 mph on a freeway, though 45.1 percent reported having done so in the last 30 days.

Law enforcement agencies (LEAs) play critical roles in reducing speeding and the prevalence of speeding-related fatalities. LEAs use a variety of tactics to mitigate speeding including traffic citations, speed feedback trailers, and decoy vehicles. However, agencies are increasingly faced with limited resources and pressure to focus on public safety issues outside of traffic and speed enforcement. Therefore, it is essential that LEAs be able to make strategic decisions on which speed management strategies to use as well as the best times and locations for deployment. Using data-driven approaches to resource management can help LEAs make strategic decisions and achieve the desired outcome given the available resources.

For example, using speed, crash, and roadway data can help LEAs identify locations with higher frequencies of speeding and a history of speed-related crashes. This knowledge can then be used to plan for the placement of resources, such as officer enforcement, speed feedback trailers, and decoy vehicles, so they will have the most impact on reducing speeding.

As part of NHTSA's continuing efforts to eliminate speeding on the nation's roadways, this research project examined LEA use of traffic speed data to plan resource allocation to optimize traffic speed reductions. This approach to traffic speed management is expected to aid law enforcement officials and program planners in determining the most cost-effective use of their resources to manage traffic speeds and reduce speeding-related crashes. To accomplish the project's objective, the research team partnered with the SCSO, a medium-sized county with a dedicated traffic law enforcement division. Researchers collected speed and enforcement data on selected roadway segments and performed an independent analysis of traffic speeds and enforcement levels to examine the relationship of speeding, traffic volume, and crashes and to determine optimum enforcement levels for reducing speeding and speed-related crashes.

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[1]For more information about risky driving behaviors, visit www.nhtsa.gov/risky-driving.

Methodology

Selection of Law Enforcement Agency Partner

To ensure the research results are applicable to other jurisdictions after completion of the study, the research team developed a list of required and ideal characteristics for the city or county where the project would be performed. In addition, supplemental data that could assist with the final selection of a jurisdictional partner was included in the list of considerations. Table 1 lists the characteristics and data that the team used while researching candidate locations.

Table 1. Site selection considerations

Required Characteristics
• The city/county has speed-related crash problems on roadways that have been studied for the appropriateness of the roadway posted speed limit. • The city/county includes a variety of road types requiring speed management efforts. • The city/county is willing to work with NHTSA and the project team to conduct the study. • The city/county has an analyst whose duties include traffic data and crashes. • Seasonal weather issues are not a major issue for traffic and data collection. • The city/county has earned media. • The city/county is committed to making an effort to reduce speed-related traffic problems.
Ideal Characteristics
• The site has at least some existing data that can be used for the identification of corridors where speed-related traffic problems exist. • The site has established coordination between the transportation agency and the law enforcement agency (perhaps through an established liaison). • The site has a person who is already assigned to track and save records of media attention in the jurisdiction. • The site has one law enforcement agency (as opposed to one jurisdiction with two or more towns with separate law enforcement) that would be responsible for coordinating with the project team. • The site's corresponding law enforcement agency has a section or division that is tasked to assist with targeted traffic enforcement efforts jurisdiction-wide or at a minimum has a person responsible for coordinating jurisdiction-wide traffic enforcement efforts.
Other Data as Available
• Total roadway mileage in the jurisdiction. • Roadway mileage by functional classification (arterial, collector, local street, etc.). • Roadway mileage by number of lanes. • Roadway mileage by posted speed limit. • Roadway mileage by terrain time (level, rolling, mountainous). • Total number of law enforcement officers. • Number of law enforcement officers assigned primarily to traffic enforcement. • Approximate percentage of time regular patrol officers engage in traffic enforcement activities.

First, the list of potential jurisdictions was narrowed to Virginia as most jurisdictions in the State have only one law enforcement agency as opposed to one jurisdiction with two or more towns and separate law enforcement agencies. Limiting the candidates to ones with a single law enforcement agency simplified both the data collection and transfer process as well as coordination and documentation of enforcement activities. Additionally, selecting a site in Virginia improved the Virginia-based research team's access to field equipment for installation and maintenance and allowed more time to focus on data collection and analysis.

Then the research team identified those Virginia jurisdictions in medium-sized cities or counties. For the results to be applicable to other jurisdictions after completion of the study, the research team focused on jurisdictions that had varieties of roadway types and a combinations of urban, suburban, and rural portions to the roadway network. Each jurisdiction under consideration was researched to determine their characteristics and available data according to the selection criteria in Table 1. These criteria let the research team filter the list of study locations to the following seven potential jurisdictions.

- Chesterfield County
- Henrico County
- Loudoun County
- Prince William County
- Stafford County
- City of Chesapeake
- City of Virginia Beach

The research team not only needed to identify a jurisdiction willing and able to participate in the project, but that jurisdiction also needed to have speed-related crash problems on roadways that have been studied and have appropriately set posted speed limits. To that end, the research team conducted a preliminary review of crash data[2] from each jurisdiction to understand the numbers and rates of speed-related crashes (total, per vehicle million miles traveled, and per 1,000 residents), percentages of speed-related crashes, numbers of fatal speed-related crashes, and the presence of any corridors with clusters of speed-related crashes. Table 2 summarizes this.

Table 2. Preliminary analysis summary

Jurisdiction	Average Number of Speed-Related Crashes per Year	Average Percent of All Crashes Related to Speed	Average Percent of Fatal Crashes related to Speed	Average Number of Speed-Related Crashes per 1,000 Residents	Average Number of Speed-Related Crashes per 1 Million VMT
Chesterfield County	474	9%	9%	1.4	0.16
Henrico County	333	6%	15%	1.0	0.11
Loudoun County	344	10%	35%	1.0	0.16
Prince William County	555	10%	34%	1.3	0.20
Stafford County	278	14%	54%	2.0	0.20

[2] Crash data from the Virginia Department of Motor Vehicles (DMV) Traffic Records Electronic Data System (TREDS) completed this preliminary analysis.

Jurisdiction	Average Number of Speed-Related Crashes per Year	Average Percent of All Crashes Related to Speed	Average Percent of Fatal Crashes related to Speed	Average Number of Speed-Related Crashes per 1,000 Residents	Average Number of Speed-Related Crashes per 1 Million VMT
City of Chesapeake	253	10%	18%	1.1	0.10
City of Virginia Beach	551	9%	30%	1.2	0.20
Analysis of time period from January 2012 to December 2014					

Using these five measures, the preliminary analysis showed that Stafford County had the most significant speed-related crash problem out of the seven potential study locations. As a final step, researchers compared the characteristics of each potential site. Table 3 summarizes the results of those comparisons.

Table 3. Site selection criteria

Characteristic	Chesterfield County	Henrico County	Loudoun County	Prince William County	Stafford County	City of Chesapeake	City of Virginia Beach
A variety of road types requiring speed management efforts.	✓	✓	✓	✓	✓	✓	✓
Known to have an analyst whose duties include traffic data and crash analysis.			✓		✓		✓
Seasonal weather issues are not a major issue for traffic and data collection.	✓	✓	✓	✓	✓	✓	✓
Commitment to making an effort to reduce speed-related traffic problems.	✓	✓	✓	✓	✓	✓	✓
Existing data that can be used for the identification of corridors where speed-related traffic problems exist.	✓	✓	✓	✓	✓	✓	✓

Characteristic	Chesterfield County	Henrico County	Loudoun County	Prince William County	Stafford County	City of Chesapeake	City of Virginia Beach
One law enforcement agency that would be responsible for coordinating with the project team.	✓	✓	✓	✓	✓	✓	✓

With the list of potential study locations narrowed to seven, the research team established contact with personnel at each jurisdiction. The points of contact from each site were identified through the research team's existing network, input from NHTSA, and information provided on the jurisdiction's public web site. Each jurisdiction received a brief, written introduction to the project and the opportunity for a teleconference to discuss the project in more detail.

The team ultimately recommended Stafford County as the jurisdictional partner due to the preliminary analysis results, the site selection criteria, and the enthusiasm for and commitment to the project exhibited by the SCSO.

To formalize a partnership, an agreement was established between the SCSO and the research team. The agreement described roles and responsibilities and included details about determining roadway segments for the study, instrumenting the selected segments, data collection, and data sharing. Table 4 summarizes the requirements included in the agreement.

Table 4. Agreement requirements

Project Requirement	Requirements in Agreement
Selecting roadway segments	• The jurisdiction's law enforcement agency must work with the project team to select roadway segments to be studied and instrumented. • The jurisdiction's law enforcement agency must provide existing crash data and law enforcement data as appropriate. • The jurisdiction's transportation agency must provide engineering data for the roadway sections being studied.
Instrumenting selected roadway segments	• The jurisdiction's law enforcement and transportation agencies must coordinate with the project team to instrument the roadway segments at an agreed upon time. • The jurisdiction's transportation agency must have the means to provide traffic control if required to install any roadway equipment that would be placed by the project team.
Collecting continuous roadway and law enforcement data	• The jurisdiction's transportation agency must provide access to the project team for obtaining data periodically from the equipment throughout the data collection period. • The jurisdiction's law enforcement agency must provide law enforcement data and crash data to the project team throughout the data collection period using a method and frequency mutually agreeable to the jurisdiction and project team. • The jurisdiction's law enforcement agency must provide, to the extent possible, data on speed reduction/enforcement earned media. • The format of the data will be determined in advance and be described as a requirement for both the project team data sources and jurisdiction data sources. • Any support needed to be provided to the jurisdiction for the project.
Maintaining project data	• The project team must provide a mechanism to maintain project data that is usable to both the research team as well as jurisdiction staff. • The format for project data maintained will be provided for both the project team and the jurisdiction.
Providing data to jurisdiction	• The project team will provide data collected to the jurisdiction's law enforcement agency for their own use and analysis.

After finalizing the agreement, a kick-off meeting was held between NHTSA, the SCSO, and the research team. The meeting provided an opportunity to review the project objectives and timeline; discuss the process for selecting roadway segments and instrumentation; countermeasure deployment; data collection; and establishing lines of communication. Figure 1 summarizes the relationship and communication lines of all project partners.

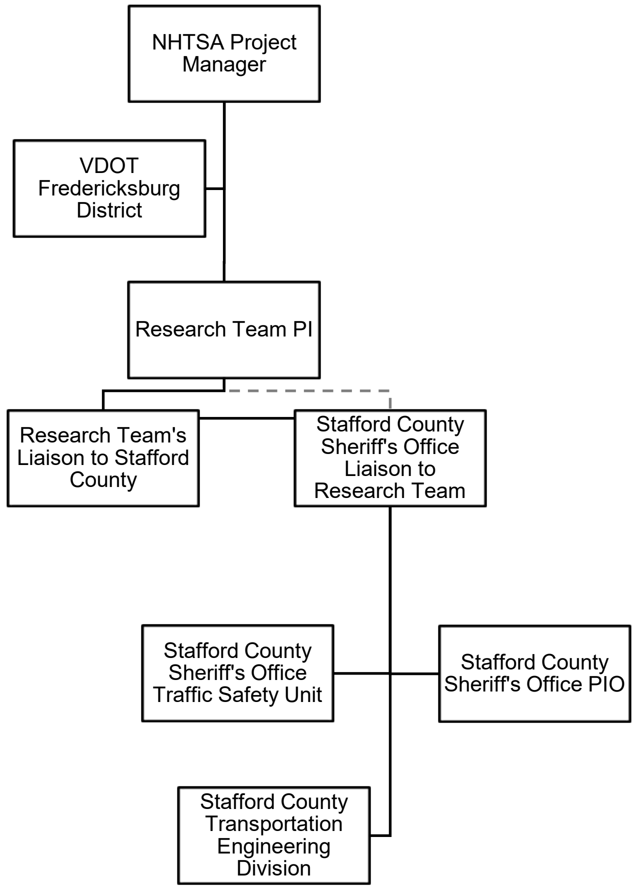

Figure 1. Project partner organization

Data Collection

The SCSO had full responsibility for selecting the roadways to be used during the project, but but the research team provided input for consideration. Some of the factors that the team provided were based on the requirements for data analysis as well as the roadside sensors. The instruments used for the study were designed to operate best on highways with free-flowing traffic and volumes under 1,000 vehicles per hour. To encourage a data-driven approach to roadway selection, the research team also suggested considering the occurrence of speed-related crashes and citations. After evaluating eligible roadways and based on the professional knowledge and preferences of senior leadership, the SCSO selected six initial roadway segments; four were designated as test sites and two as control sites. The control sites were identified for comparison purposes when performing analyses of the data. During the second year of data collection a fifth roadway was included as an additional test site to increase the amount of data available for analysis. Table 5 summarizes the selected roadways and Figure 2 shows a map of all segments.

Table 5. Test and control roadways

Roadway	Segment	Test or Control Site
Ferry Road	State Route 3 to White Oak Road	Control
Garrisonville Road	Joshua Road to Fauquier County Line	Test
Hartwood Road	US 17 to Spotted Tavern Road	Test
Kellogg Mill Road	Poplar Road to Mountain View Road	Test
Poplar Road	US 17 to Stefaniga Road	Control
US 1 (southbound only) *Added during second year of data collection.*	Telegraph Road North to American Legion Road	Test
White Oak Road	Little Whim Road to King George County Line	Test

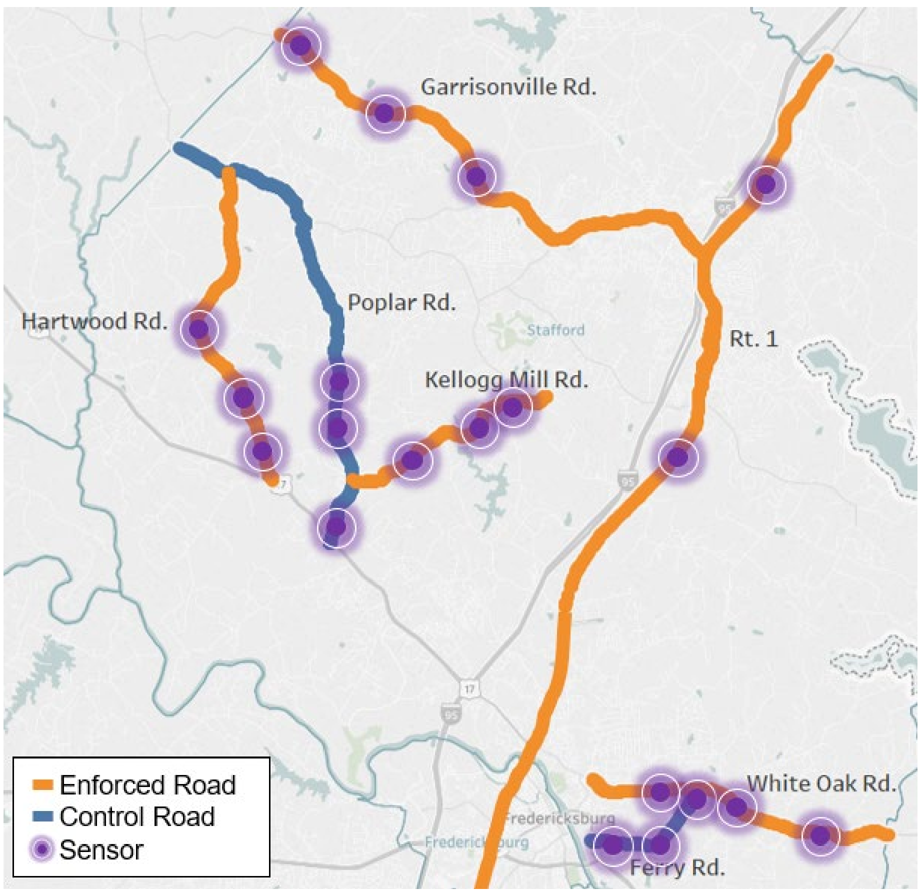

Figure 2. Map of test and control roadways

After the roadways were selected, the research team performed field reviews to identify two to three locations on each segment for data collection. The team looked for sites that met all the following criteria, some of which existed to adhere to the sensor's manufacturer guidelines.

- Adequate distance from horizontal curves and major intersections to ensure free-flowing traffic.

- Adequate sunlight to maintain solar power for the sensor.
- At least 100 feet of unobstructed road in either direction from the sensor's location.
- Ability to install the sensor within 12 feet of the roadside and at an elevation of 6 to 10 feet above the roadside to record vehicle speeds in both lanes.
- Adequate shoulder space for the law enforcement agency to deploy countermeasures and/or perform enforcement activities near the sensors.

Table 6 summarizes the selected data collection sites for each roadway segment.

Table 6. Data collection sites

Roadway	Data Collection Sites
Ferry Road	N Randolph Road (38.296305, -77.437133)
	Blysdale Road (38.296070, -77.429400)
	Scottsdale Drive (38.309287, -77.410909)
Garrisonville Road	Stafford County Gateway Sign (38.5250403,-77.5531325)
	Marine Corps Base Quantico Range 6 (38.505887, -77.526866)
	Rock Hill Volunteer Rescue Squad (38.490767, -77.491576)
Hartwood Road	Bridlewood Lane (38.409408, -77.567398)
	Stonehouse Road (38.445090, -77.591080)
	Hartwood Winery (38.421493, -77.573213)
Kellogg Mill Road	Mt. Olive Road (38.406208, -77.512909)
	Bethany Way (38.414694, -77.489240)
	Red Fox Lane (38.421648, -77.481137)
Poplar Road	Truslow Road (38.388650, -77.540324)
	Amsonia Court (38.420870, -77.540740)
	Burke Drive (38.414692, -77.541482)
US 1 (southbound only)	Kings Crest Drive (38.490934, -77.381688)
	Rowser Building (38.404349, -77.419177)
White Oak Road	New Hope Church Road (38.310673, -77.400761)
	Sandy Ridge Road (38.299370, -77.363560)
	Tyler Lane (38.311524, -77.420415)

The team used radar-based sensors[3] to collect vehicle speed data. These sensors are small and unobtrusive with measurements of 6.8 inches high, 4.8 inches wide, 5.3 inches deep and weigh 3 pounds. Figure 3 and Figure 4 show images of the sensors.

[3] Armadillo Tracker, 24.125 GHz weatherproof bidirectional traffic collector radar device from Houston Radar LLC, Sugarland, Texas

Figure 3. Sensor mounted to county-owned infrastructure

Figure 4. Post-mounted sensor

The sensors have multilane and bidirectional capabilities and low power consumption that allows for 2 weeks of operation using built-in batteries and full autonomy with a 5W solar panel. A sensor's on-board memory could store more than 300,000 individual records and documented the speed, date, time, class, and direction (inbound or outbound from the sensor) of each vehicle passing through the radar cone. Vehicle classifications include three factory-set size classes as shown in Table 7.

Table 7. Sensor vehicle classifications

Sensor Vehicle Class Size	Approximate Length	Example Vehicle Types	Federal Highway Administration (FHWA) Class
Small	<14 feet	Motorcycles, "Smart" car	1
Medium	14–20 feet	All sedans, minivans, pickup trucks, etc.	2 and 3
Large	>20 feet	Delivery vans, buses, dump trucks and 18-wheelers	4 through 12

The sensors and solar panels were either mounted on existing infrastructure with the owner's permission or on VDOT-approved posts installed by the research team on personal property with the owner's permission. With the exception of US 1, all data collection sites were located on two-lane, undivided highways that permitted the sensors to collect bidirectional vehicle data. Since US 1 is a four-lane, undivided highway, the sensors could only collect data from vehicles in one direction. At the request of the SCSO, the US 1 sensors were installed on the southbound side.

Each sensor was tested after installation for 5 minutes to ensure the collection of data from passing vehicles. Members of the research team installed equipment from May to August 2016 and retrieved data on a bi-weekly basis until the sensors were removed in May and June 2018. After all sensors were installed, baseline data were collected from September 2016 to January 2017. Data were not shared with the SCSO during this time. After the baseline data collection period ended, the research team began sharing data with law enforcement. Data sharing started in February 2017 and ended in April 2018.

The research team used Bluetooth technology to retrieve data in the field to remotely connect the sensor and a portable computer. Data were then downloaded using the sensor's supporting software. While the data downloaded, the software was also used to check the health of the sensor including confirmation that the solar panel was continuing to charge the battery. Data were then exported to a CSV file used by the research team's statistician to generate reports in a format the SCSO the requested. Reports for each test segment were uploaded to a file-sharing system that could be accessed by members of the team and the SCSO. Each time that new reports were uploaded the research team's liaison would notify the liaison at the SCSO. The SCSO could then use the data in the reports to monitor speeding patterns and make decisions at their discretion for their speed management program.

The sheriff's office has a collection of strategies available to decrease speeding. Countermeasures include decoy cars, a speed feedback trailer, a post-mounted speed feedback digital sign, variable message board, enforcement using radar, and a Speed Watch Program.[4] The SCSO originally developed a deployment plan for the period from February to June 2017 but the limited availability of resources complicated its execution. For example, officers reported instances of being dispatched elsewhere while patrolling roads for this study and described times when other units would request the use of equipment, such as the speed feedback trailer. As this

[4] The Speed Watch Program operates as a speeding deterrent using trained volunteers in marked cars with radar surveillance (but no enforcement).

study was meant to investigate the effects of SRAs in a naturalistic environment, the research team did not intervene, and the SCSO was not asked to change its operations in any way. In January 2018 a deployment plan was developed and successfully executed.

The research team discussed with the SCSO a variety of methods for reporting their speed-related law enforcement activities on the roadway segments being used for the project. At the request of the SCSO, the team created an online form that could be accessed by all assigned officers and staff. The form provided fields to record the roadway segment, information about the countermeasure used, and starting/concluding dates and times. Figure 5 shows a snapshot of law enforcement activity data reported to the research team through the online form.

Segment	Countermeasure	Start Date	Start Time	End Date	End Time	Location
Kellogg Mill Road	Speed Feedback Trailer	1/18/2018	4:30 p.m.	1/22/2018	10:00 a.m.	Kellog Mill at Bethany Way
Hartwood Road	Decoy Car	2/12/2018	10:05 a.m.	2/16/2018	9:30 a.m.	Hartwood at Richland Road
US 1	Deputy On-site Enforcement with Radar/Citations	2/15/2018	9:00 a.m.	2/15/2018	10:10 a.m.	1600 JEFFERSON DAVIS
Garrisonville Road	Variable Message Board	2/22/2018	10:30 a.m.	2/27/2018	10:35 a.m.	Rt. 610 at MCBQ Range 6

Figure 5. Sample law enforcement activity data

Toward the end of the data collection phase, the SCSO public information officer developed a social media plan so the research team could analyze the effects of law enforcement media messages on speeding. The plan used the SCSO's office Twitter account and included a mix of general posts and targeted messages for selected roadway segments. The frequency of message postings also varied to determine if there were any effects on speeds when messages were posted more frequently. Figure 6 shows examples of some of the general messages posted from April 16 to 27, 2018. Figure 7 includes examples of some of the messages targeted to a selected roadway segment. The full social media plan is included in the Appendix.

StaffordCoSheriff @staffcosheriff · 6h

#SpeedKills - The Stafford County Sheriff's Office would like to remind the public that speed is a major cause of fatal crashes #SlowDown #TrafficSafety

2 4

StaffordCoSheriff @staffcosheriff · 16h

Slowing down saves lives. This is a reminder from the Stafford County Sheriff's Office to avoid speeding during the #rushhour commute

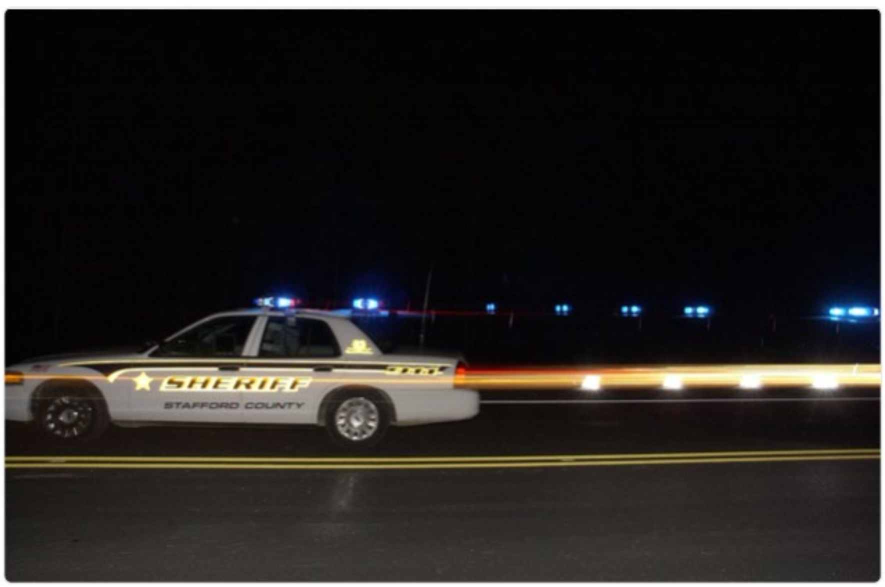

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Figure 6. General social media messages

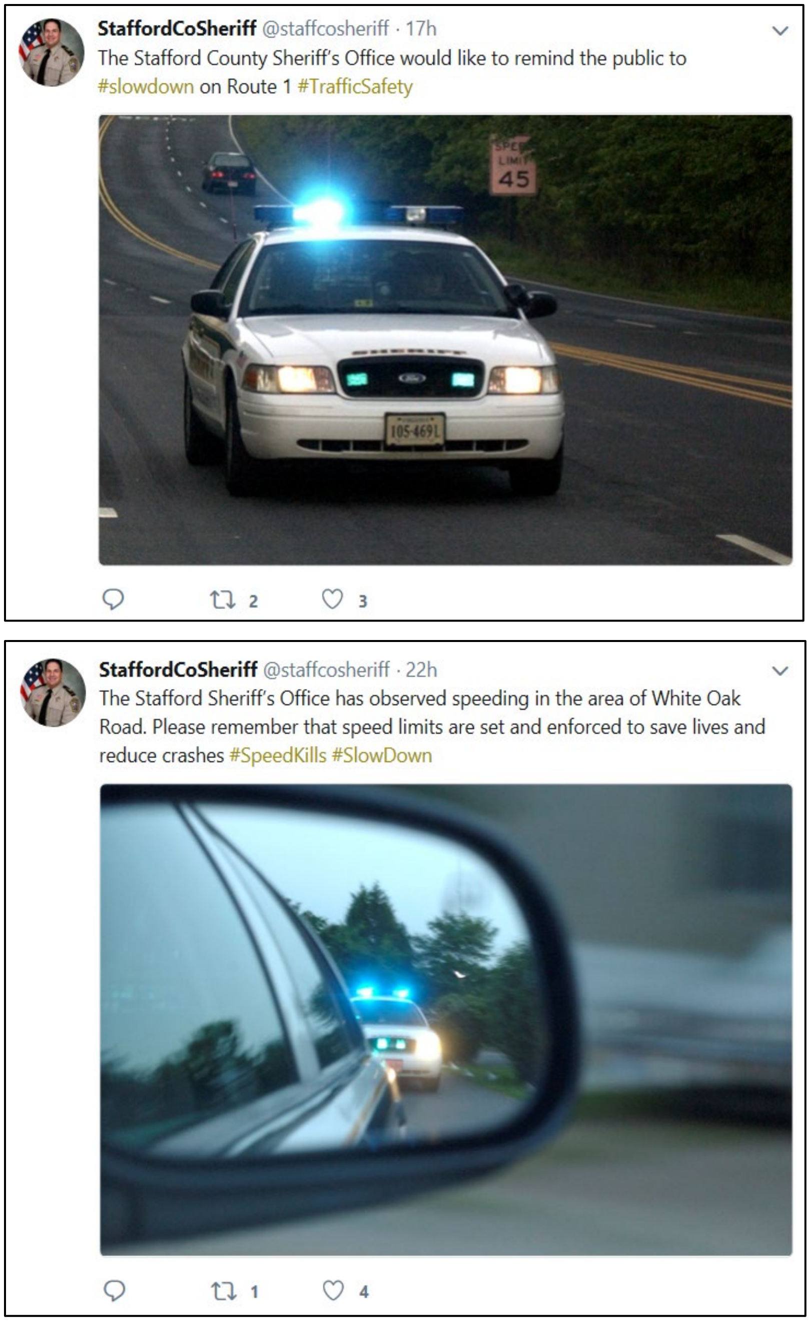

Figure 7. Targeted social media messages

Analysis and Findings

Continuous roadway data were collected from sensors installed on selected roadways in Stafford County, and combined with several other data products to determine the relationship between motor vehicle crashes, speeding, and traffic density; and to assess the impacts of different levels and types of enforcement, including both traditional methods and a brief social media campaign. The following sections detail the methodologies and results associated with each of these objectives.

Determine the Relationship Between Crashes, Speeding, and Traffic Density

Methodology

Data on crashes, speeding, and traffic density were collected from the Virgina DOT and roadside sensors installed in Stafford County, Virginia. The monthly number of crashes was then modelled as a function of the number of speeders and non-speeders. These two variables represent both the level of speeding and overall traffic density.

Crash data were retrieved from VDOT's CrashTools database. Only speed-related crashes in clear/cloudy weather occurring within the borders of Stafford County were included; those involving alcohol, animals, or distracted driving were excluded to focus strictly on the relationship between speed-related crashes and speeding. Crashes of all injury severity levels were considered. The analysis spans September 2016 to May 2018 (with the first full month of sensor data for US 1 being August 2017). Figure 8 shows the count of total speed-related crashes per month on each road.

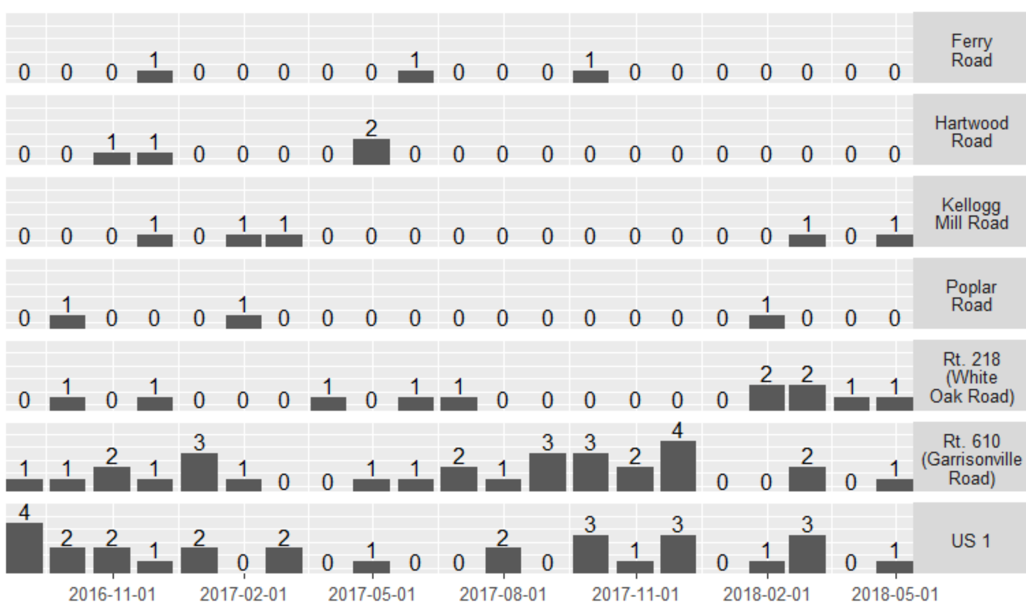

Figure 8. Monthly counts of total (speed-related) crashes on each roadway

Roadside sensors recorded continuous roadway data, including the speed and size of each observed vehicle. For the purpose of this study, those vehicles travelling at least 10 mph above the posted limit were classified as speeders. Other vehicles were classified as non-speeders and counted separately.[5] Only passenger cars (FHWA vehicle classifications two and three) were included in the analysis. This exclusion was performed for three reasons: it was believed that these drivers were the target audience of law enforcement activities, the proportion of larger vehicles was expected to be low, and the sensors used to collect speed data only classified vehicles as large or small (Marti, 2014).

The volume was observed by sensors along each roadway, whereas crashes were counted for the entire roadway within Stafford County. To put the two measurements in the same time scale, volume and speeder counts were aggregated to monthly median counts across all sensors on a given roadway. A generalized linear model with Poisson response distribution and log link function was used to estimate the monthly number of speed-related crashes as a function of the monthly number of speeders and non-speeders.

Results

Monthly crashes on each roadway were estimated as a function of the number of speeders and non-speeders. The number of speeders were statistically significant predictors of crashes, while the number of non-speeders was not. Specifically, a 1 percent increase in speeders during a given month is associated with an 0.84 percent increase in crashes (estimate = 0.843, SD = 0.366, $p < 0.05$). The number of non-speeders did not have a significant effect (estimate = -0.513, SD = 0.407, $p > 0.10$). While more volume of either type of driver increases the opportunity for crashes and thus should increase the rate of crashes, the number of vehicles within the range observed was not a significant predictor. This implies that total volume can increase without yielding more crashes *if the increased volume is composed of all non-speeders.* Overall, speeders accounted for 12.4 percent of total volume. Therefore, if monthly volume on any road is expected to increase by 10 percent, the number of speeders would be expected to increase by 1.24 percent, and the number of crashes to increase by 1.04 percent.

Assess the Impact of Different Levels and Types of Enforcement

The SCSO executed a number of SRAs during the roadway instrumentation period in an effort to reduce speeding. Deputies in the field documented the time and location of each SRA in the field by completing a form on their mobile phones. These SRAs were then examined for their effects on the number of speeders, and the factors that contributed to their success. Following the SRAs, a brief social media campaign was launched. The effects of this campaign on the number of speeders were analyzed separately from the SRAs.

The following sections provide further details on the SRAs, social media campaign, and the methodology and findings associated with each.

Speed Reduction Activities

Each roadway was instrumented with two to three sensors and each sensor monitored two directions of travel. Because the effects were expected to differ based on the order of exposure to the SRA and detection by the sensor, the relative position of the SRA to the sensor was determined and used in the analysis. Figure 9 shows the relationship between an SRA,

[5] The terminology speeders and non-speeders is only used to divide vehicle speed for the purpose of this study, — i.e., whether various speed reduction activities have effects on overall vehicle speeds. In general, any vehicle speed above a posted speed limit violates the law and represents unsafe driving behavior.

surrounding sensors, and directions of traffic. Sensors recorded the direction of traffic for each observed vehicle. Combined with the sensor's position relative to the SRA, traffic was coded as being upstream or downstream of the nearest SRA.

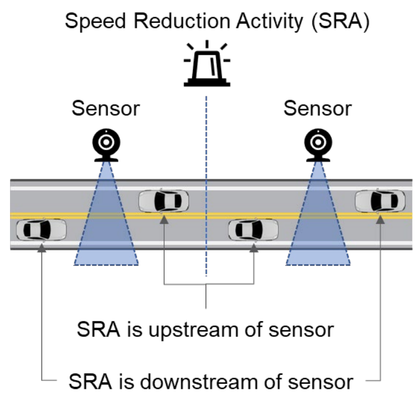

Figure 9. Diagram of relationships between SRA, sensors, and directions of traffic

Using this taxonomy, effects of SRAs on speeding are expected to be more detectable when the SRA is upstream of the sensor. That is, drivers are expected to see the SRA, then modify their speed, then be detected by the sensor.

Table 8 lists all 46 analyzed SRAs. A total of 54 were recorded, but 6 lacked the geographical data required to match to a sensor.

Table 8. Speed reduction activities

SRA ID	Road	SRA Type	Starting Date and Time	Ending Date and Time
2	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	2/6/2017 7:00	2/6/2017 9:00
3	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	2/6/2017 16:00	2/6/2017 18:00
4	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	2/7/2017 16:00	2/7/2017 18:00
7	Rt. 610 (Garrisonville Road)	Decoy Car	2/15/2017 7:00	2/16/2017 9:00
9	Hartwood Road	Speed Trailer/Digital Speed Sign	3/4/2017 7:00	3/4/2017 9:00
11	Rt. 218 (White Oak Road)	Deputy On-Site Enforcement With Radar/Citations	3/8/2017 7:50	3/8/2017 9:10
12	Rt. 218 (White Oak Road)	Deputy On-Site Enforcement With Radar/Citations	3/8/2017 15:00	3/8/2017 19:00
13	Rt. 218 (White Oak Road)	Deputy On-Site Enforcement With Radar/Citations	3/8/2017 15:15	3/8/2017 16:15
14	Rt. 218 (White Oak Road)	Deputy On-Site Enforcement With Radar/Citations	3/9/2017 7:35	3/9/2017 8:50

SRA ID	Road	SRA Type	Starting Date and Time	Ending Date and Time
15	Rt. 218 (White Oak Road)	Deputy On-Site Enforcement With Radar/Citations	3/10/2017 7:45	3/10/2017 8:20
16	Rt. 218 (White Oak Road)	Deputy On-Site Enforcement With Radar/Citations	3/10/2017 16:00	3/10/2017 18:00
17	Rt. 610 (Garrisonville Road)	Decoy Car	3/13/2017 7:00	3/24/2017 9:00
18	Hartwood Road	Decoy Car	5/3/2017 7:00	5/4/2017 9:00
19	Hartwood Road	Speed Trailer/Digital Speed Sign	5/8/2017 7:00	5/8/2017 9:00
21	Rt. 610 (Garrisonville Road)	Speed Trailer/Digital Speed Sign	5/15/2017 7:00	5/16/2017 9:00
22	Rt. 610 (Garrisonville Road)	Decoy Car	5/15/2017 7:00	5/16/2017 9:00
24	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	1/8/2018 7:00	1/8/2018 8:00
25	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	1/8/2018 7:10	1/8/2018 8:00
26	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	1/9/2018 7:00	1/9/2018 8:00
28	Rt. 218 (White Oak Road)	Stealth Radar Sign	1/9/2018 12:00	1/15/2018 12:00
29	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	1/10/2018 7:15	1/10/2018 8:30
30	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	1/10/2018 13:00	1/10/2018 14:30
31	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	1/12/2018 7:45	1/12/2018 8:50
32	US 1	Deputy On-Site Enforcement With Radar/Citations	1/16/2018 7:30	1/16/2018 8:00
33	Kellogg Mill Road	Speed Trailer/Digital Speed Sign	1/18/2018 16:30	1/22/2018 10:00
34	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	1/26/2018 11:30	1/26/2018 12:15
35	US 1	Deputy On-Site Enforcement With Radar/Citations	1/26/2018 13:45	1/26/2018 14:30
36	Rt. 218 (White Oak Road)	Deputy On-Site Enforcement With Radar/Citations	1/30/2018 10:00	1/30/2018 10:30
37	Rt. 218 (White Oak Road)	Deputy On-Site Enforcement With Radar/Citations	1/31/2018 7:50	1/31/2018 8:10
38	US 1	Deputy On-Site Enforcement With Radar/Citations	1/31/2018 11:30	1/31/2018 12:00

SRA ID	Road	SRA Type	Starting Date and Time	Ending Date and Time
39	Hartwood Road	Speed Trailer/Digital Speed Sign	2/1/2018 12:05	2/6/2018 14:10
40	Rt. 218 (White Oak Road)	Speed Trailer/Digital Speed Sign	2/6/2018 9:00	2/13/2018 19:00
41	Rt. 218 (White Oak Road)	Speed Trailer/Digital Speed Sign	2/6/2018 9:40	2/8/2018 19:00
42	US 1	Deputy On-Site Enforcement With Radar/Citations	2/8/2018 7:25	2/8/2018 8:45
43	Hartwood Road	Decoy Car	2/12/2018 10:05	2/16/2018 9:30
44	US 1	Deputy On-Site Enforcement With Radar/Citations	2/15/2018 9:00	2/15/2018 10:10
45	Hartwood Road	Deputy On-Site Enforcement With Radar/Citations	2/20/2018 12:00	2/20/2018 12:35
46	Hartwood Road	Deputy On-Site Enforcement With Radar/Citations	2/21/2018 6:50	2/21/2018 7:40
47	Rt. 610 (Garrisonville Road)	Variable Message Board	2/22/2018 10:30	2/27/2018 10:30
48	Rt. 218 (White Oak Road)	Decoy Car	2/26/2018 9:00	3/2/2018 9:00
49	Hartwood Road	Speed Feedback Trailer	2/28/2018 9:00	3/6/2018 21:00
50	Kellogg Mill Road	Deputy On-Site Enforcement With Radar/Citations	3/7/2018 12:00	3/7/2018 12:30
51	Kellogg Mill Road	Speed Feedback Trailer	3/26/2018 10:00	3/28/2018 12:00
52	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	4/4/2018 13:00	4/4/2018 15:30
53	Rt. 610 (Garrisonville Road)	Deputy On-Site Enforcement With Radar/Citations	4/6/2018 10:00	4/6/2018 11:30
54	Kellogg Mill Road	Decoy Car	4/9/2018 9:00	4/13/2018 16:00

Methodology

The effects of these SRAs on speeding were analyzed in two steps. First, the number of hourly speeders at nearby sensors was modelled. These models assessed the success (defined below) of each SRA. Success was then modelled as a function of characteristics of the SRA. Step 1 is essentially a data reduction task, while Step 2 identifies the factors that contribute to a successful SRA.

Step 1: Determine SRA Success

SRAs are intended to reduce the number of speeders observed on roadways. Failure to do so is a clear example of an unsuccessful SRA, but an observed decrease is not a clear example of success. The numbers of speeders can change due to random chance, or simultaneously at all sensors. Control roads were used to distinguish between successful and random or "global" changes. Thus, an SRA was considered successful if it both yielded a statistically significant decrease in hourly speeders, and that decrease was larger in magnitude than any concurrent decrease observed on the control road.

The effect of each SRA was estimated using negative binomial models with the hourly number of speeding passenger vehicles as the dependent variable. Each model predicted the hourly number of speeders at the sensor closest to the SRA as well as a control sensor (the next closest sensor on a control road) for 120 days surrounding the SRA. The research team fit each SRA with four to six models: one for each direction of travel at each sensor on the roadway. With 44 of the 46 SRAs usable, each monitoring two directions of travel, and 2 to 3 sensors on each roadway, this amounts to 254 models.

Variables used in these models served one of two purposes. "Time Period" (relative to the SRA), "Group" (the roadway group on which the sensor is installed), and their interaction were used to assess individual SRA success, while several others were used to mitigate confounding effects. The aim of these models is to determine the success of the SRA; therefore, the effects of prior SRAs and all other potentially influential factors must be accounted for and distinguishable from the effect of the SRA in question. Table 9 describes the parameters used in these models.

Table 9. Description of variables used in models of hourly speeders in response to SRAs

Purpose	Variable Name	Definition	Values
Dependent (outcome) variable	Hourly speeders	The hourly number of speeding passenger vehicles (those travelling at least 10 mph above the posted speed limit) observed in one direction of travel by one sensor	Numeric value
Assess SRA success	Time period	Time period relative to SRA.	Before SRA; during SRA; 1,3,6,12 hours after SRA; 1, 3 days after SRA; 1, 2 weeks after SRA
	Group	The roadway group on which the current sensor is installed.	Test, Control
Mitigate confounding effects	Count of SRAs in past month	The number of SRAs deployed on the current roadway in the preceding month (28 days).	Numeric value

Purpose	Variable Name	Definition	Values
	Count of all previous SRAs	The cumulative count of SRAs deployed on the current roadway since sensors were installed.	Numeric value
	Volume	The logarithm of the total volume of passenger cars observed by a sensor.	Numeric value
	Adverse weather conditions	Proportion of the present hour marked by the presence of fog, rain, snow, or storms.	Numeric value from 0 to 1
	Daylight	Proportion of the present hour between sunrise and sunset.	Numeric value from 0 to 1
	Federal holidays	Indicator that the present day corresponds with the observance of a Federal holiday.	0/1
	Presence of a crash	Indicator of a crash during the present hour on the present roadway.	0/1
	Day of modelling period[a]	Number of days until/after the SRA.	Numeric value between -60 and +60, with 0 corresponding to the date of the SRA.
	Weekend	Indicator that the present day is a weekend.	0/1
	Hour[b]	Transformed value of current hour.	See note below.
	Lagged hourly count of speeders[c]	Previous values of the number of hourly speeders observed by the present sensor.	Numeric value

Notes:

a. The day of the modelling period was used to detect a linear trend in speeders over time, as distinct from other fluctuations (hourly, daily, etc.).

b. Natural splines with three knots (at 6, 12 and 17, with boundaries at 0 and 23) were used to transform “hour” from a linearly increasing series (0,1,2,…,23) into a fourth-order polynomial with peaks corresponding to typical morning and evening commute times.

c. Using previous values of the dependent variable is typical in the modelling of time series data. Often the most valuable predictors of a current value are previously observed values of the same variable.

After the models were fit, relevant parameters were examined for significance. An SRA was considered successful if it met two criteria: it yielded a statistically significant decrease in hourly speeders at various time points relative to before the SRA was implemented, *and that decrease was larger in magnitude than a concurrent decrease observed on the control road.* The relevant parameter is the interaction between time period and group.

Step 2: Identify Factors That Contribute to SRA Success

After determining the success of each SRA in reducing the number of speeding drivers, a reduced dataset was produced describing the characteristics of each SRA and its success at several time points. An SRA could be considered successful at any of the nine defined time periods relative to the SRA (excluding the time prior to the SRA); with just 69 successes out of 2,285 measured opportunities, success was aggregated to two time periods: within 1 day of the SRA’s conclusion (during the SRA; 1, 3, 6, 12 hours after; 1 day after), and beyond (3 days after; 1 week after, 2 weeks after). SRA success was then modelled as a function of SRA type, the

SRA's position relative to the sensor (upstream or downstream), duration (in hours), distance from the sensor (in miles), and the cumulative count of SRAs.

SRA success was modelled using a generalized linear mixed model with a binomial response distribution. Such models are known as "mixed" because they include both *fixed* and *random* effects. Fixed effects are identical for all groups (roadways) modelled, while random effects are allowed to differ (Gelman, 2005). Ultimately, the mixed effects models allow SRAs to have different baseline success probabilities for each sensor. This may help account for unknown differences among sensor locations and enable more precise estimates of the fixed effects (type, position, duration, etc. of SRA). Table 10 describes the parameters used in these models.

Table 10. Description of variables used in models of success in response to SRAs

Variable Name	Definition	Values
SRA Success	Indicator of a successful SRA	0/1
Type	Type of SRA deployed	Decoy car, digital speed sign, deputy on-site enforcement with radar and citations
Position	Relative position of SRA to sensor	Upstream, downstream
Distance	Distance, in miles, between SRA and sensor.	Numeric value
Duration	Duration, in hours, of SRA.	Numeric value
Count of all previous SRAs	The cumulative count of SRAs deployed on the current roadway since sensors were installed.	Numeric value

Results

The success of each SRA at two or more locations (sensors) was modelled for two time periods: within 24 hours of the SRA, and beyond. SRA type and distance from the sensor were statistically significant predictors of success beyond 1 day, while the cumulative count of SRAs was statistically significant in both time periods. Neither the SRA's position (upstream or downstream of the sensor) nor its duration achieved statistical significance.

SRA success beyond 1 day happened more often with decoy cars than with either speed trailers or active on-site enforcement. Figure 10 shows the estimated probability of success and 95 percent prediction interval for each SRA type (using averages of all other variables). The decoy car's estimated success rate given average values for other variables in the model was 7.6 percent, versus 2.7 percent for the speed trailer and 3.0 percent for active on-site enforcement. These percentages represent the probability of successfully reducing the number of speeding drivers at any point more than 1 day (3 days, 1 week, or 2 weeks) after implementing the SRA. The SRA that requires the least resources (a decoy car) seems to have the biggest impact.

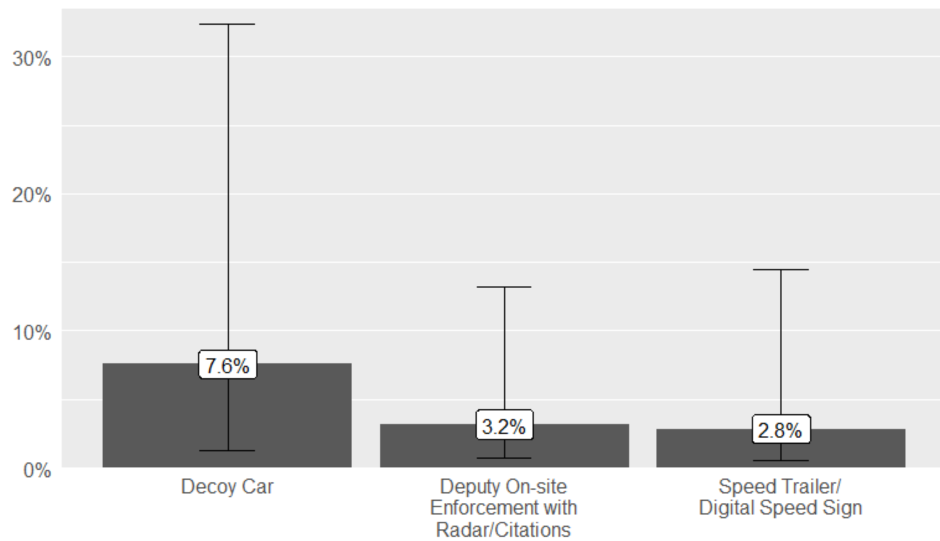

Figure 10. Predicted probability of SRA success beyond 1 day, by SRA type

The distance between each countermeasure and relevant sensors (upstream and downstream along the same roadway) was measured and used to assess the effect of distance on SRA success. This distance was significantly associated with SRA success more than one day after the SRA's conclusion. Figure 11 shows the estimated success rate by distance between SRAs and sensors, using average values of other variables. At 1 mile, the estimated success rate is 3.8 percent, versus 2.8 percent at 2 miles, 2.0 percent at 3 miles, 0.7 percent at 6 miles, etc. In other words, the farther drivers are from an SRA, the less likely they are to reduce their speed in response to the SRA. This relationship suggests that SRAs exert a very localized effect on speeding. It is possible that SRAs far away from sensors did produce significant changes, but those changes were not detected by any sensor.

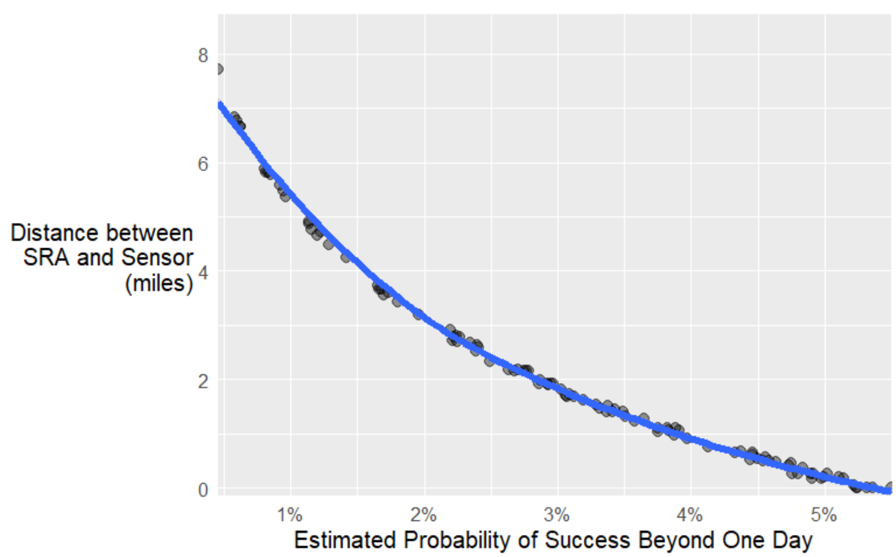

Figure 11. Estimated probability of SRA success beyond one day following the SRA, by distance

The cumulative count of prior SRAs on a given roadway had a negative effect on success more than 1 day after the SRA's conclusion. Each prior SRA decreases the odds of a given SRA's success by a factor of 0.94. Though the effect is small, it suggests that drivers become desensitized to seeing SRAs, thus diminishing their effects over time. For example, drivers who drive down a road and see many SRAs are less likely to slow down relative to when drivers see an SRA on a road for the first time. It is also possible that the model is encountering a "floor effect," failing to distinguish between becoming less effective with additional SRAs and reducing the number of speeders to a minimum. If many SRAs are successful, the number of speeders may reach a natural minimum, leading to subsequent "failed" SRAs. On the other hand, drivers may be responding to increased SRAs around town by speeding when they believe they can do so undetected.

Social Media Campaign

The SCSO + used Twitter to deliver messages to the public warning them of the dangers of speeding and reminding them to slow down, in addition to other messages that they would typically post on Twitter. Figure 12 shows 1 of the 23 speeding-related tweets sent from April 4 to April 27, 2018. Note that the Twitter campaign did not coincide with the SRAs. At the time, @staffcosheriff had approximately 3,790 followers, but no speeding-related tweet earned more than 1 reply, 9 retweets, or 26 likes. All others were general message, while 5 of the tweets mentioned specific roads.

Figure 12. SCSO Twitter message

Methodology

The effect of Twitter messages on speeding was modelled differently than the effect of SRAs. First, the number of speeders and volume were summed over both lanes of travel for each sensor. Doing so, sensors are treated as independent sampling points along the roadways of Stafford County, and everyone is equally likely to view the tweets, so direction becomes irrelevant. One generalized linear model with negative binomial response distribution and log link function was then fit for each sensor. The parameters used in these models are described in Table 11.

Table 11. Description of variables used in models of hourly speeders in response to social media campaign

Purpose	Variable Name	Definition	Values
Dependent (outcome) variable	Hourly speeders	The hourly number of speeding passenger vehicles (those travelling at least 10 mph above the posted speed limit) observed in both directions of travel by one sensor	Numeric value
Assess social media campaign success	Tweet	Indicator of a tweet being sent during the present hour.	0/1
	Tweet count	The cumulative count of all tweets made as part of social media campaign.	Numeric value
Mitigate confounding effects	Adverse weather conditions	Proportion of the present hour marked by the presence of fog, rain, snow, or storms.	Numeric value from 0 to 1
	Daylight	Proportion of the present hour between sunrise and sunset.	Numeric value from 0 to 1
	Federal holidays	Indicator that the present day corresponds with the observance of a Federal holiday.	0/1
	Volume	The logarithm of the total volume of passenger cars observed by a sensor.	Numeric value
	Presence of a crash	Indicator of a crash during the present hour on the present roadway.	0/1
	Day of modelling period[a]	Number of days until/after the tweet.	Numeric value between -60 and +60, with 0 corresponding to the date of the Tweet.
	Weekend	Indicator that the present day is a weekend.	0/1
	Hour[b]	Transformed value of current hour.	See note below.
	Lagged hourly count of speeders[c]	Previous values of the number of hourly speeders observed by the present sensor.	Numeric value

Notes:

a. The day of the modelling period was used to detect a linear trend in speeders over time, as distinct from other fluctuations (hourly, daily, etc.).

b. Natural splines with three knots (at 6, 12 and 17, with boundaries at 0 and 23) were used to transform "hour" from a linearly increasing series (0,1,2,…,23) into a fourth-order polynomial with peaks corresponding to typical morning and evening commute times.

c. Using previous values of the dependent variable is typical in the modelling of time series data. Often the most valuable predictors of a current value are previously observed values of the same variable.

Results

The exponentiated mean and 95 percent confidence intervals for *Tweet* and *Tweet Count* coefficients across all sensors are shown in Table 12. A value of 1 indicates that the tweet or cumulative number of tweets had no impact on the hourly number of speeders.

Table 12. Tweet and tweet count coefficients (exponentiated and averaged across all sensors)

Parameter	Mean (95% Confidence Interval)
Tweet	1.001 (0.970, 1.033)
Tweet Count	0.998 (0.997, 0.999)

These results suggest that tweets do not significantly affect speeding in the moment, but each additional tweet lowered the hourly number of speeders by a factor of 0.998. That is, after a tweet, hourly speeding is 0.2 percent lower. This result should be interpreted in light of the size of the SCSO's audience (approximately 3,790 followers).

Conclusions and Discussion

The project was designed to evaluate the effectiveness of various enforcement strategies on driver speed selection. To ensure success, it was important to identify a law enforcement partner that was dedicated to data driven speed enforcement and had dedicated staff with expertise in traffic safety enforcement. Additionally, there had to be a documented history of speed-related crashes in the jurisdiction. The SCSO proved to be the right partner. Because the study was an observational field study, researchers did not predetermine the execution of SRAs, so there are some limitations. However, the data were analyzed considering the limitations and some conclusions can be collected from model results.

As the sensors were deployed continuously, the research team had the benefit of analyzing traffic volumes, the number of speeders, and crash data. Not surprisingly, there was a direct relationship between the number of speeders and the number of crashes: a 1 percent increase in speeders during a given month was associated with a 0.84 percent increase in crashes. Traffic volume increases that included non-speeders, however, did not have a significant effect. While more volume of either type of driver increases the opportunity for crashes and thus should increase the rate of crashes, the number of vehicles within the range observed was not a significant predictor. This implies that total volume can increase without yielding more crashes *if the increased volume is composed of all non-speeders.* Overall, speeders accounted for 12.4 percent of total volume. Therefore, if monthly volume on any road is expected to increase by 10 percent, the number of speeders would be expected to increase by 1.24 percent, and the number of crashes to increase by 1.04 percent.

The research team analyzed 46 SRAs throughout the study. These included deputy presence with on-site enforcement, decoy cars, speed trailers with digital speed signs, and changeable message signs. In addition, the SCSO used social media to release public safety announcements to discourage speeding and warn about locations where speeding was an issue. Decoy cars proved to be the most successful of the SRAs for reducing speeds more than 1 day after SRA deployment stopped, followed by speed trailers, and then deputies on-site issuing citations. While the result might not be intuitive, deputy presence is only limited to a few hours at a time (at most) so the time that a deputy spends at a given site would typically be less than the time that another SRA would be in place at a given site. In addition, the effects seem to be localized. In light of this, one optimization strategy would be to place speed reduction activities as close to a problem area as possible. Looking at the impacts over longer periods of time, the total number of activities lead to reduced speeds, but using the same technique several times seemed to reduce the effect.

The social media campaign through Twitter indicated that the messages may slightly reduce speeds, but given that the audience was only around 3,790 followers, the followers may or may not be local to Stafford County, and there are many drivers from other jurisdictions, it is not possible to discern whether the effect was causal or just coincidental.

Future efforts could explore variances in concentrated enforcement efforts and evaluate a larger number of speed reduction activities. The study team did not design the enforcement strategies as it was determined best to allow the jurisdiction to enforce posted speed limits as they normally would. Additional research could look at efforts where a law enforcement agency agrees to certain enforcement strategies in advance. In addition, as the study showed that speed reductions were very localized to the enforcement effort, additional research using a higher concentration of sensors might provide more information about the length of the impact.

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Appendix A: Stafford County Sheriff's Office Social Media Plan

NHTSA Speed Study Social Media Plan

Impact of Social Media on Speeding and Traffic Enforcement

Summary

With the final phase of the NHTSA speed study ending on April 15, 2018, the Stafford County Sheriff's Office and NHTSA plan to study the impact of social media messaging on speeding and traffic enforcement over a 2-week period. The messaging will include a mix of general posts and targeted messages for select speed monitoring locations.

Timeframe

April 16, 2018, to April 27, 2018—2 Weeks

Timeline

Monday, April 16: Rush Hour Messaging
- Morning, 7 a.m.: Targeted Message
- Afternoon, 5 p.m.: General Message

Wednesday, April 18: All-Day Messaging
- Morning, 7 a.m.: General Message
- Morning, 9 a.m.: Targeted Message
- Afternoon, 4 p.m.: General Message
- Afternoon, 5 p.m.: General Message

Thursday: April 19: All-Day Messaging
- Morning, 7 a.m.: General Message
- Morning, 9 a.m.: Targeted Message
- Afternoon, 4 p.m.: General Message
- Afternoon, 5 p.m.: General Message

Friday, April 20: Rush Hour Messaging
- Morning, 7 a.m.: Targeted Message
- Afternoon, 5 p.m.: General Message

Monday, April 23: Rush Hour Messaging
- Morning, 7 a.m.: Targeted Message
- Afternoon, 5 p.m.: General Message

Tuesday, April 24: All-Day Messaging
- Morning, 7 a.m.: General Message
- Morning, 9 a.m.: Targeted Message
- Afternoon, 4 p.m.: General Message
- Afternoon, 5 p.m.: General Message

<u>Thursday, April 26: All-Day Messaging</u>

- Morning, 7 a.m.: General Message
- Morning, 9 a.m.: Targeted Message
- Afternoon, 4 p.m.: General Message
- Afternoon, 5 p.m.: General Message

<u>Friday, April 27: Rush Hour Messaging</u>

- Morning, 7 a.m.: Targeted Message
- Afternoon, 5 p.m.: General Message

Messages

General

1. In 2016, speeding killed 10,111 people, accounting for more than a quarter of all traffic fatalities that year, according to @NHTSA What can you do to help? #SlowDown #TrafficSafety
2. #SpeedKills - The Stafford County Sheriff's Office would like to remind the public that speed is a major cause of fatal crashes #SlowDown #TrafficSafety
3. Speed limits are set and enforced to save lives and reduce crashes. The Stafford County Sheriff's Office would like to remind the public to obey all speed limit signs and #slowdown
4. #SlowDown and follow the posted speed limit – This is a reminder that speeding is a major problem across America and here in the county #TrafficSafety #SpeedKills
5. Don't Rush! Slowing down during rush hour commute can save lives #SlowDown #DontRush #TrafficSafety
6. According to @NHTSA, about a quarter of all fatal traffic crashes are speed-related. Please remember to #SlowDown
7. Stay safe and survive the #rushhour commute by obeying all speed limit signs. Remember to #SlowDown and #DontRush
8. Slowing down saves lives. This is a reminder from the Stafford County Sheriff's Office to avoid speeding during the #rushhour commute
9. Stop speeding before it stops you – This is a reminder from the Stafford County Sheriff's Office that speeding is a major cause of traffic fatalities #SlowDown #SpeedKills
10. Obey the sign or pay the fine – This is a reminder from the Stafford County Sheriff's Office not to speed and to follow all speed limit signs #SlowDown #TrafficSafety

Targeted

1. Speeding is a major problem on Garrisonville Road. The Stafford County Sheriff's Office would like to remind commuters to #slowdown and obey speed limit signs #TrafficSafety #SpeedKills
2. The Stafford County Sheriff's Office would like to remind the public to #slowdown on Ferry Road #TrafficSafety #SpeedKills

3. The Stafford County Sheriff's Office has observed an uptick in speeding on Garrisonville Road. We'd like to remind the public that speeding is a major cause of traffic fatalities so please remember to #slowdown
4. Speeding is a problem on Garrisonville Road. Please #slowdown and follow the speed limit #SpeedKills #TrafficSafety
5. During the #rushhour commute, remember to avoid speeding and #slowdown on Route 1
6. Garrisonville Road can be dangerous during the morning and evening commute. Please remember to #slowdown
7. The Stafford County Sheriff's Office would like to remind residents to #slowdown and remember that #speedkills. Please reduce your speeds in area of Kellogg Mill Road.
8. The Stafford County Sheriff's Office has observed speeding in the area of White Oak Road. Please remember that speed limits are set and enforced to save lives and reduce crashes #SpeedKills #SlowDown
9. In 2016, speeding killed 10,111 people, accounting for more than a quarter of all traffic fatalities that year, according to @NHTSA What can you do to help? #SlowDown on Garrisonville Road
10. Stay safe and survive the #rushhour commute by obeying all speed limit signs. Remember to #SlowDown and #DontRush on Route 1 and Garrisonville Road

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