Mobile Surveillance Trailers in St. Louis: Evaluating the Impact of a Randomized Control Trial

Final Report for the Bureau of Justice Assistance, Smart Policing Initiative

prepared by Dennis Mares and Lindsay Maier

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Disclaimer

This report presents the findings of the Bureau of Justice Assistance (BJA) / Smart Policing Initiative (SPI) award 2018-WY-BX-003. Points of view or opinions expressed within are those of the authors and do not necessarily reflect those of the U.S. Department of Justice (DOJ), the Bureau of Justice Assistance (BJA), or the Saint Louis Metropolitan Police Department (SLMPD). Any errors and/or omissions are the responsibility of the lead author.

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About the authors:

Dennis Mares is a Professor of Criminal Justice and Director of the Crime Science and Violence Prevention Center at Southern Illinois University Edwardsville.

Lindsay Maier is the manager of the Crime Analysis Unit at the Saint Louis Metropolitan Police Department.

Please direct any questions about this report to the lead author: dmares@siue.edu

1. Executive Summary

In 2018 the St. Louis Metropolitan Police Department (SLMPD) was awarded a SPI grant aiming to reduce serious crime by deploying mobile surveillance trailers (MST). The targeted crimes include gun violence and theft of and from vehicles. The SPI award funded three mobile surveillance trailers equipped with license plate readers, cameras and gunshot detection. In addition to the three functioning trailers a fourth shell trailer (placebo) was also purchased to examine if any deterrent impact of the trailers is the outcome of enhanced intelligence capacity or whether the mere presence of the units deter crime by themselves. A total of 95 MST deployments occurred in micro hot spots between June 2020 and July 2022.

Data from the SLMPDs CAD and RMS systems were collected continuously to explore the impact of the deployments. Final analysis of the data reveals some crime reductions. Crime reductions were noted in several targeted categories, including gunfire, larcenies and motor vehicle thefts. While crime reductions were found for violent crimes, comparable areas also experienced declines.

While the SLMPD's SPI project faced some challenges throughout its run, the project stayed the course and implementation of the project may be considered successful. There are numerous lessons learned from this project, a couple of the key items are highlighted here, but more can be found throughout this report:

1. **Deployment** of MSTs should be done by a small group of **well-trained individuals**. SPI trailers were monitored and received regular maintenance, but setup of the specific investigative components (license plate readers, cameras, and gunshot detection) requires specialized knowledge. We therefore recommend that agencies with a substantial number of trailers consider centralizing the deployment and maintenance of the units to minimize technical issues and reduce downtime. Quality of the MST units can be variable. Technical expertise within the department was a critical resource in expediently resolving wiring issues, for example. We recommend that agencies who purchase such units only do so if they have personnel with the technical expertise to handle and fix problems, or have a clear service contract with a vendor. While the vendor was responsive to problems, the vendor was located far from the region, which would delay service for significant issues.

2. Deployment of MSTs can only be adequately measured if **units remain in place for some time** and are **adequately tracked**. In other words: moving the units frequently hampers measurement, whereas leaving them in place too long conceivably reduces deterrent impacts. The SPI MSTs were carefully tracked by the RP, but other MSTs the department owned were tracked on a spreadsheet, which is not only time-consuming, but the information can be outdated quickly. During the course of the project the department improved tracking of all the MSTs . We created two ways to track the units, which could easily replicated in other agencies. We recommend that other agencies find similar ways to track the units, either using GPS trackers or within their CAD system. This allows for easier evaluation of crime prevention strategies but also helps with practical issues such as servicing and refueling trailers.

4. **Deployment strategies** should not just consider the frequency of crime but also the **nature of the location**. We found, for example, that the bright flashing blue lights on the trailers caused some annoyance among residents of narrow city streets. In addition, we found that automatic pan-tilt-zoom (PTZ) functions of cameras yielded less actionable footage in narrower streets as the cameras often would end up zoomed in on nearby properties thereby missing movement in the street. In short,

features that are often promoted by vendors may not always be useful in all situations. We therefore recommend discussing with vendors the types of locations in which the technology is typically deployed and customize the units to best fit the needs.

5. The SPI trailers were outfitted not only with cameras and license plate readers, but also with **gunshot detection**. That latter feature **proved superfluous**. Not only was the gunshot detection feature fairly inaccurate when compared to existing fixed gunshot technology (i.e., ShotSpotter), results indicate that the presence of the units themselves deters gunfire in close proximity (~500 feet) thereby negating any potential benefits gunshot detection system. In short, gunshot detection capability on visually prominent trailers is likely an inefficient and ineffective feature when deployed in most residential streets. In addition, setting up the gunshot detection can be very time-consuming, which in our case had to be redone every deployment. We therefore do not currently recommend adding gunshot detection to highly visible surveillance trailer as the added cost did not improve investigative benefits.

6. Target specific **crime problems for reductions**. We advise deploying MSTs in the highest crime locations that are difficult to surveil with traditional fixed systems (CCTV). Our results show that the most likely benefits can be gained from sites experiencing high levels of theft and gunfire, with no conclusive evidence that the units reduce serious violent crimes.

7. Crime reductions appear most commonly in only a small band around the units (~**500ft**), this makes **careful placement important.** It is also important to recognize that hot spots often may experience 'regression to the mean', meaning that crime often fluctuates in micro hot spots, rapidly heating up and quickly cooling down. This makes evaluating efforts difficult as it is easy to read crime reductions as a result of deployments, while in fact, they are simply returning to baseline levels and might have done so without deployment of MSTs. Using consistent criteria for deployment and measurement as well using comparison locations is therefore key to gain more confidence in results and minimize false conclusions.

8. **Support** of SLMPD personnel for MSTs became more prominent during the project. Survey results indicate that there was broad support for technology in the department, and especially for technologies that may aid investigations. Awareness of MSTs and their capacities grew substantially as the department expanded its use.

8. Finally and importantly, while it is relatively easy to measure crime at MST sites, it proved extremely **difficult to measure how the units enhance intelligence gathering capacity**. We encourage agencies to find ways to determine how MSTs and other technologies contribute to solving and prosecuting offenses. With growing public scrutiny of surveillance technology, it is even more important to develop best practices that can most accurately assess the cost-benefits of the technology.

2. Targeted Problem

St. Louis has long struggled to reduce crime and is well-known for being ranked among the most violent cities in the US. Indeed, gun violence is a persistent problem in St. Louis. Despite deployment of gunshot detection, a growing network of cameras and license plate readers and a Real Time Crime Center that is foremost in the region, gun violence remains a key problem in the city. Specifically, the city's residential communities are poorly covered with existing technology as power and especially network connectivity remains challenging in these communities. The SLMPD therefore proposed to deploy mobile surveillance trailers to provide coverage in areas that have been historically difficult to gather intelligence from.

The theoretical idea behind the crime reducing potential of the MSTs is derived from deterrence/routine activities theory: By raising the chances of positive identification of offenders and vehicles chances should increase to hold offenders accountable for their actions (Cohen & Felson, 1979). While deterrence can be achieved through multiple means we believe that the MSTs will primarily deter crime in two ways.

One, crime may be deterred by simple presence. As the literature on hot spots policing indicates, mere presence can provide a sizeable impact on crime. While hot spots policing involves officers who are able to move around, they are focused on small geographic areas. MSTs could provide a similar type of deterrence, they are highly visible and have the ability to surveil a fairly decent viewshed. Just the same, deterrence can also occur through case resolution. Two, MSTs provide intelligence (LPR hits, video footage, gunshot alerts), this may increase successful arrests and prosecution of offenders. MSTs thus have the potential to generate both general and specific deterrence. In short, any impacts are likely attributable to increased guardianship.

The prior literature on some of the technology incorporated in the MSTs provides some guidance. CCTV deterrence has been noted in the literature, albeit providing typically moderate success, and fairly limited to property offenses (Ratcliffe, Taniguchi & Taylor, 2009; Welsh & Farrington, 2009; Piza et al., 2019). One of the key problems in implementing CCTV is that high crime areas are generally overlooked in implementation. Due to the high cost of network integration, CCTV is more typically installed in high traffic, commercial areas with ample IT infrastructure to accommodate the data flow; given that violent crime generally concentrates in socially disadvantaged communities (Bursik & Grasmick, 1993), there is a spatial disconnect in the typical implementation of CCTV. MSTs may overcome such limitations by offering enhanced flexibility in where and when hot spots can be addressed. In addition, the response time to CCTV is typically not expedient enough to catch offenders with standard police dispatch procedures (Piza, Kaplan & Kennedy, 2017). Cameras in general tend to be mostly passively monitored and most beneficial to reduce property offenses. For a larger department with a substantial number of cameras, much like St. Louis, active monitoring is therefore unlikely.

Our SPI trailers were also outfitted with License Plate Recognition (LPR) technology. LPRs have only recently become financially attractive enough to be implemented on larger scales, so the evidence for their potential functionality and deterrent impact is still limited. LPRs may come as fixed (pole mounted), mobile (squad car), or portable (trailer mounted) and have shown some evidence to reduce offending (Koper, Taylor & Woods, 2013; Wheeler & Philips, 2018). Like CCTV, fixed LPRs are typically not placed in areas with the highest levels of violence but in locations with power and network access. While squad car mounted LPRs have the benefit of creating an immediate response from an officer, they

can be criticized for creating substantial discretion on the part of officers, which has led to accusations of bias. Fixed and trailer mounted LPRs operate without such officer bias, and simply compare a recorded plate against a 'hotlist' of license plate numbers. Only if a plate number matches that of a 'wanted plate' will an alert be issued for officers to respond to. Generally large municipalities, including St. Louis, limit alerts to serious categories, such as stolen vehicles and certain categories of wanted felons (often violent). Lesser violations, such as expired tags, bench warrants and non-violent offenders are commonly not targeted with LPRs, minimizing risks of bias in enforcement. LPRs in fact may reduce bias enforcement activity as false plate reads are quite rare, thereby providing more accurate information prior to stopping a vehicle than typically is provided by victims or witnesses. For example, a standard BOLO may simply instruct officers to look for a black SUV in connection with a robbery, but if a plate number is found on CCTV or LPR footage, officers can be confident that when they pull a vehicle over with the matching plate it is extremely likely to be the correct vehicle. In addition, if an agency has a large number of LPRs it reduces the need to engage in dangerous close pursuits as it is often possible to track the vehicle in real time and set up a roadblock or direct a tracking helicopter. There are a few downsides to LPRs, most notably that systems often cannot read temporary (paper) plate numbers. In addition, offenders may switch plates on a stolen vehicle to avoid detection. There also is some variability in the ability of LPRs to read plates, which is most frequently an outcome of camera quality. Some cameras don't work as well in low lighting conditions, or lack the resolution to read plates from afar.

Despite some limitations, both CCTV and LPRs can provide tangible and recorded evidence that may assist in locating and apprehending offenders, as well provide critical visual evidence in the indictment and prosecution of offenders. We believe that the flexibility of MSTs can provide an enhancement on these technologies as they can be deployed in crime hot spots or in proximity to known locations of offenders, which can increase detection of active crimes, or offenders.

Gunshot detection has also not been extensively studied with respect to its impact on crime and the evidence that is available is decidedly mixed with some sites reporting gun crime decreases (Mares, 2022) but others -including St. Louis, failing to find benefits (Mares & Blackburn, 2021). Gunshot detection does not provide visual evidence, but rather acoustic evidence of gunfire. Despite criticism by some that suggest gunshot detection systems are inaccurate, the evidence in the literature suggests that most fixed systems are, in fact, quite accurate in detecting gunfire while excluding other loud pops and sounds (Mares, 2022). Like LPR hits, gunshot alerts can be relayed nearly instantaneously to officers, likely increasing the chances of arrest and decreasing the time to provide aid to victims (sources). While some recent studies have examined the impact of combining gunshot detection with CCTV, they have noted so far that the combination of the two technologies did not improve outcomes (Ratcliffe et al., 2018; Vovak et al., 2021), but in those cases the gunshot detection systems trigged nearby cameras to swivel to the gunfire locations. Our SPI trailers are outfitted with integrated gunshot technology, which is slightly different as the technology immediately directs on board cameras to point to gunfire. One potential disadvantage is that -unlike fixed systems- gunshot detection relies on sensors placed in one location, whereas fixed systems typically rely on multiple sensors in different sites to triangulate the exact location of gunfire. This may mean that the location accuracy of detection is lower than that of traditional systems. Just the same the addition of gunshot technology to the trailers should make it easier to monitor gunfire and with addition of cameras and LPRs provide information on offenders and their movements.

Taking the outcomes of prior research in consideration it is reasonable to expect that mobile surveillance trailers would most likely impact crimes that primarily occur outdoor, such as assaults, firearm crimes, and theft of/from vehicles. Their visual impact and surveillance capacities are primarily focused on the street environment. We therefore believe that the trailers make the immediate visual area around the MSTs inhospitable to outdoor thefts, robberies, assaults and homicides, but likely also reduce illegal discharging of firearms. Crimes that occur more typically indoors such as sexual assaults, domestic assaults and burglaries are unlikely to be severely impacted, but occasionally may provide enhanced intelligence gathering.

3. Community Outreach and Collaboration

The Saint Louis Metropolitan was the primary stakeholder for this project and delegated the bulk of the project to its Intelligence Division, which includes the RTCC and Crime Analysis Unit (CAU). CAU was responsible for conducting the evidence-based deployment strategy with Intelligence Division personnel responsible for deploying the MSTs and ensuring their continuous operation and monitoring. The RP was integrated in the project by selecting the optimal locations for deployment and studying the impact of the MSTs. Other agencies in the region were not directly involved in the project as the trailers were only deployed inside St. Louis city. Community members were not directly involved, but were able to provide input through a survey attached to the MST.

SPI project members regularly met to discuss progress and address issues and concerns and communicated updates to CNA's TTA team. SPI project members also participated in monthly grant meetings at the SLMPD in order to update other grant teams and make sure that progress continued to be made. The communication between SPI project members was important in uncovering practical issues such as interruptions to deployments, outages of the MSTs and developing better ways to track all MSTs the department has in inventory. For example, during the start of the project existing trailers - outside the current project - were tracked by the department using a spreadsheet that was often inaccurate. An initial way to track the trailers more consistently was proposed by the RP who suggested creating a DSN code (traditionally used as an identifier for officers) for each trailer, so the deployments of trailers could be tracked in the department's CAD system. Trailer deployments (SPI and non-SPI) were subsequently called out to dispatch as a directed patrol with the corresponding DSN code to identify the exact unit. Once a trailer was moved, the deployment was called out as ended. This allowed anyone in the department to know when, where and which trailer was deployed. At the end of 2020 all trailers were outfitted with GPS trackers which additionally allowed real time access to trailer locations, which was helpful for refueling and checking the status of the units. The RP was given access to GPS portal so they could check the location of non-SPI trailers prior to deployment of the experimental trailers and ensure that non-SPI trailers, which grew substantially in number during the project (from about 6 to more than 20) were not in locations selected for treatment.

Community involvement was not a major consideration, as the deployments of MSTs is temporary and intended to be evidence-based. We did solicit feedback from residents but received a rather lackluster response on surveys posted on a QR code attached to the MSTs. In total we only received 28 completed surveys during the two years of deployment, which is difficult to describe as a robust sample.

4. Strategies Employed

The key strategy for the SPI project was the evidence-based deployment of the MSTs to hot spots of crime. The deployment strategy was developed between members of the CAU and the RP (specific details are described in the evaluation section) and included deployments of both fully functional MST as well as deployments of a placebo unit that looked exactly like functional units, but only contained battery operated flashing lights. Despite some initial delays in the purchasing and delivery due to COVID-19 the department commenced with MST deployments in June of 2020. By time of the last deployment in July 2022, a total of 77 functional MST deployments were completed with an additional 18 deployments of the placebo unit. The 95 completed deployments averaged 27.7 days per unique deployment with a standard deviation of just over 7 days. By contrast non-SPI MSTs deployments between December 2020 and July 2022 (n=346) were more variably deployed with an average 19 days but a standard deviation of 33 days, meaning that deployment length was rather inconsistent. Another key difference between SPI and non-SPI MSTs is that the SPI trailers were deployed strictly in residential streets, whereas non-SPI trailers were primarily deployed in commercial areas (especially downtown), which already contained existing fixed cameras and LPRs (see figures 1 and 2 below).

Figure 1. SPI MST deployments, June 2020-July 2022

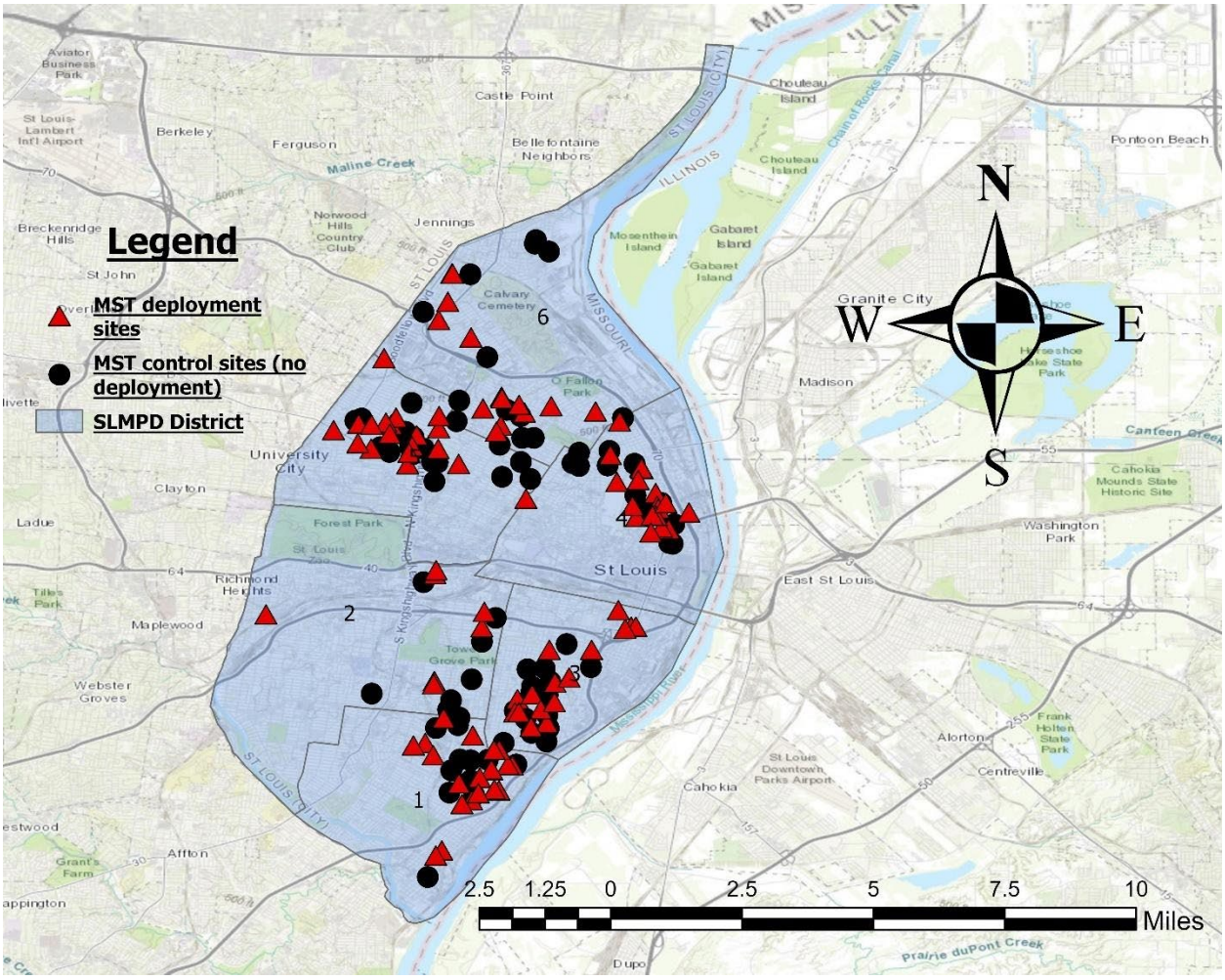
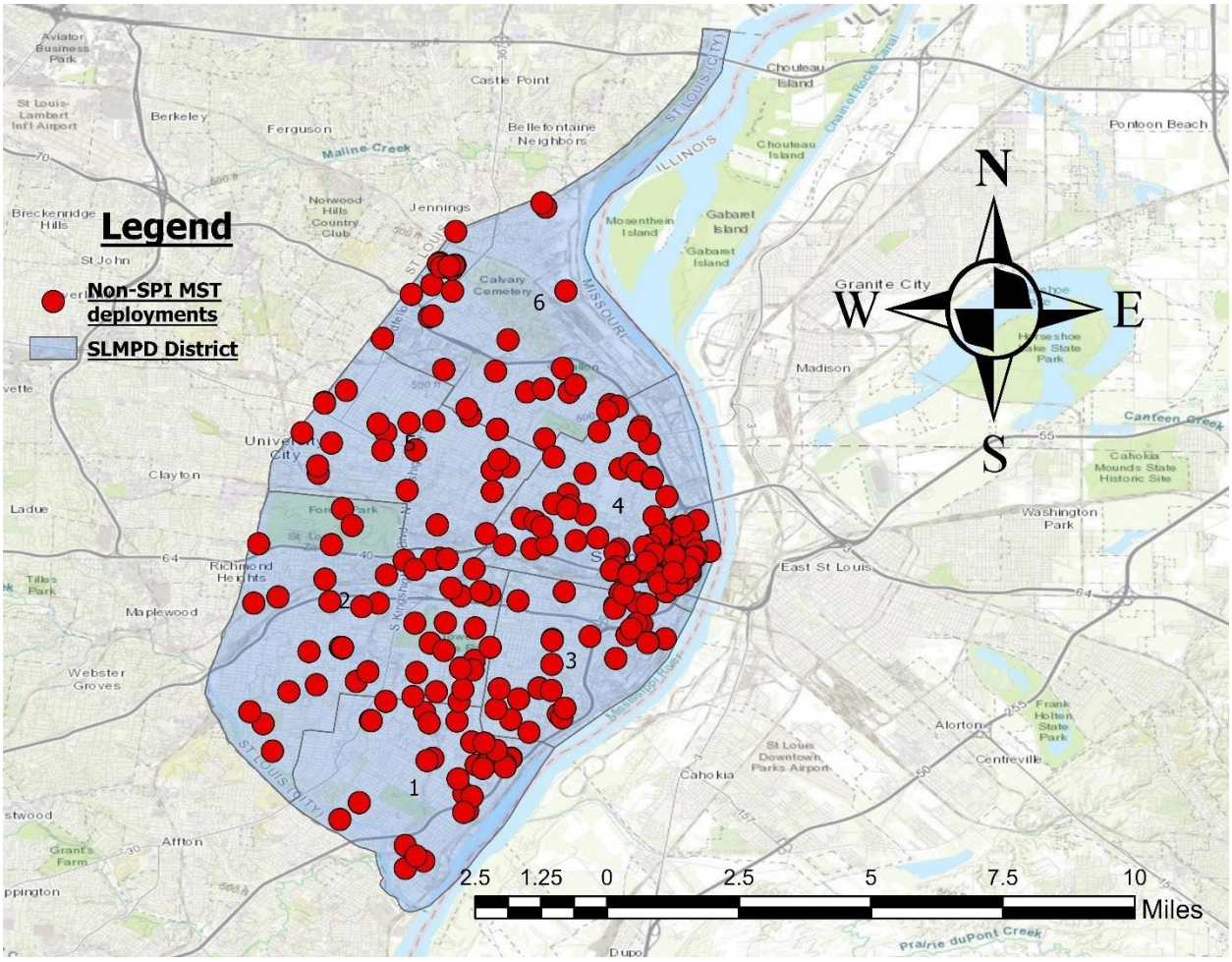


Figure 2. Non-SPI MST deployments, December 2020-July 2022



The deployments of SPI MSTs present an innovation because their deployment was data-driven using consistent criteria and took place in underserved residential areas with little access to fixed surveillance technologies . In addition, SPI trailers contained not just surveillance cameras, but also LPR capability and gunshot detection capability. In conversations with peer cities and vendors it became clear that most agencies typically only use cameras on such trailers. Particularly innovative was the deployment of a non-functioning placebo unit, which was done specifically to figure out if deterrent effects could be attributed to mere presence or were the results actionable intelligence (which the placebo unit obviously could not collect, but the functioning units could). We are not aware of any technology project in law enforcement, which has attempted a similar approach. In addition, as we learned from discussions with other agencies deploying MSTs and the vendor, most agencies do not regularly move their trailers, or determine the location on systematic prior crime data. Indeed, even in St. Louis most prior deployments of MSTs appear to be driven by a serious prior incident (such as a homicide), large event (such as a baseball game), or requests from community members. Our SPI deployments thus are more suitable to measure the impact of the units as they are deployed in specific locations (residential) for a consistent reason (high number of assaults, and motor vehicle thefts) and a relatively consistent period. This consistency allows us to better address how well the units perform their purpose (crime reductions) and ultimately speak of their value to the broader community.

5. Analysis and Evaluation

Both a process and impact evaluation were conducted for the project. The process evaluation reveals that the project was largely implemented as intended and that knowledge of the capabilities of the technology improved exponentially among SLMPD personnel. The impact evaluation finds some declines in gunfire and thefts in the immediate MST area (~500ft), but results for violent crime are less conclusive. Inputs for the process and impact evaluation were collected by discussions with members of the SLMPD involved in the SPI project, surveys among commissioned SLMPD personnel and analysis of deployment, RMS and CAD data.

Process Evaluation, procedures for deployments and impact on practices

Deployment locations were determined by CAU personnel and the RP. The procedure to create the deployment locations was developed in geospatial software (ArcGIS). Although initially we had expected to purchase and use a software tool to guide deployments, that software vendor was bought by another company that changed the capabilities and data extraction options, making it impossible to use the updated tool for our intended purpose. As a result, the CAU unit developed its own systematic procedure to determine deployment sites.

First, we determined the areas that most closely matched residential communities with a low pre-existing coverage of cameras and license plate readers (see figure 3). We excluded St. Louis' central corridor (along Interstate 64) and the Downtown area as those already had good coverage by existing technology.

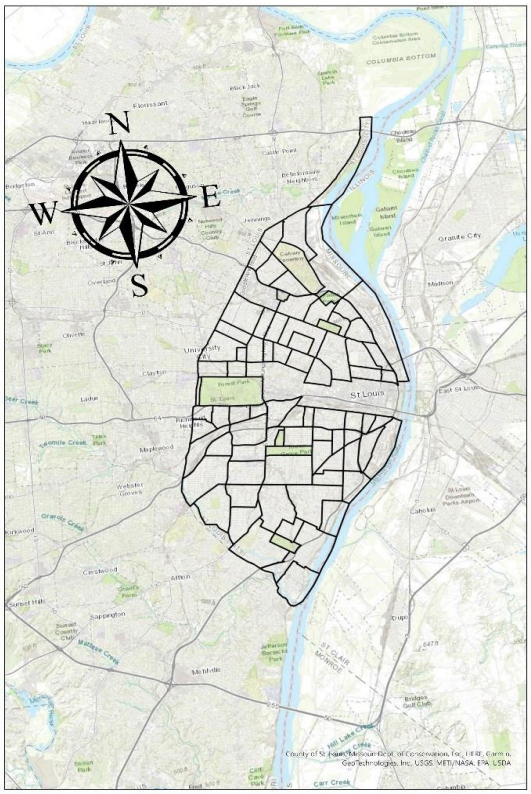
Next, we developed an optimized hotspot model that uses RMS data (violent crime and car thefts during the preceding three weeks) to identify which areas in the selected district saw the most incidents. This procedure creates hexagonal tiles across each district, about 2,000 feet in diameter and tallies up violent crime as well as motor vehicle thefts, creating standardized Z-scores for each tile. We selected the size of the area because we anticipated that the main impact of the trailers would not extend beyond 1,000 feet (the effective camera visibility is about 400ft) and we did not want to create potential overlap in impact between treatment and control sites, should they abut. The research partner selected the eight hottest tiles in the district and randomized the tiles to either treatment or control status. Because multiple streets are located in each tile the RP selected the most central intersection in each tile for deployment/control sites and communicated the exact location to RTCC personnel to deploy the MSTs to those locations. This procedure was done by police district as we wanted to equalize deployment across districts so that each district received similar treatment. This design created a randomized control trial in which each actual deployment had a matching control site.

Small deviations from this deployment procedure were deemed necessary. After several deployments, however, it was clear that District 2, an area predominantly white, affluent and with low crime levels would create some issues as even the hottest areas in that district had very low crime levels. We feared this might reduce the ability of the project to determine statistically significant changes. This district was thus taken out of the pool altogether and deployments going forth were only randomized over the remaining districts (1,3,4,5, and 6).

During the first year, several complaints surfaced in the community surveys (which were attached to the MST using a QR code) about the brightness of the flashing blue lights. After discussion among the SPI team the RP additionally used Google maps street view option to determine the location of an intersection where the trailer would have the least impact on the immediate residents. This was done by finding the location in the intersection that had a visibly vacant property/parcel or selecting a non-residential building where possible. After this more thoughtful deployment we received no further complaints from community members. We do not believe this negatively impacted the study as vacant properties are quite common in the city, and especially in hot spots, so finding a unoccupied parcel/property in an intersection was never an issue.

After treating each district, it became apparent that we might end up selecting identical tiles, as some hot spots showed continuity over time. To avoid placing trailers in the exact same location the RP therefore shifted from using the most central intersection in the grid to using the corners of the hexagon (NW/NE/SW/SE) after each district received treatment. To keep results equivalent the same was done for selecting the control sites, so if a tile received treatment in the NW quadrant, the control sites coordinates were also pulled from the intersection in the NW quadrant; this ensured that we would never treat the exact same location and kept potential overlap between treatment and comparison site minimal.

Figure 3. Neighborhoods eligible for MST deployments



During the project periods 26 deployments of the three fully functional SPI trailers occurred between June 2020 and July 2022. One trailer could not be deployed during one wave due to a malfunction that required extensive repairs, resulting in 77 total deployments of functioning trailers. In addition, 18 deployments occurred of the placebo trailer. Unfortunately, the placebo trailer took a bit longer to start deployments as its parts had to be separately ordered and assembled by the officers in the Intelligence Division, which was further complicated by supply chain delays and personnel guidelines during the initial COVID-19 period. Placebo MST deployments began in late November 2020, so about five months after initial deployments began. The placebo trailers also saw slightly shorter deployment periods, resulting from the fact that its lights operated on batteries, which had to be recharged after each deployment. Charging took place in the fleet services building, which meant RTCC personnel had to make additional trips to and from this building, delaying deployment.

Table 1. Overview of MST/Control deployments by type

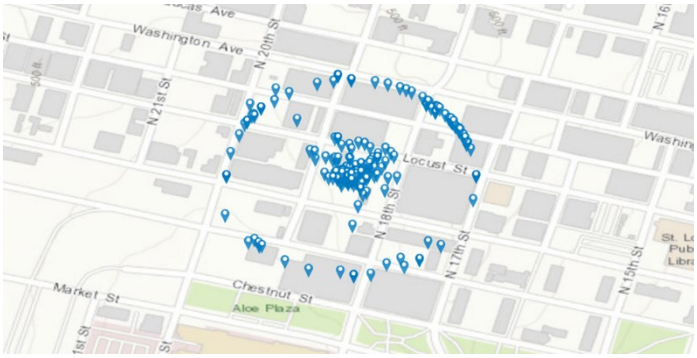
	Functioning trailers	*Controls*	*Placebo Trailer*	*Control*	*Total*
Unique Deployments	77	77	18	18	180
Average deployment length (days)	28	28	26.61	26.61	27.74

As the grant cycle progressed personnel shortages became somewhat problematic in the speed with which deployments occurred. The plan was to keep trailers on site for 3 weeks (21 days), while this deployment length was maintained during 2020 (median deployment length was 21 days), it increased slightly in 2021 (median=30 days) and 2022 (31 days). While this increasing length is not ideal, it was difficult to avoid as the number of personnel tasked -in part- with deployments decreased and their workloads increased.

Equipment issues

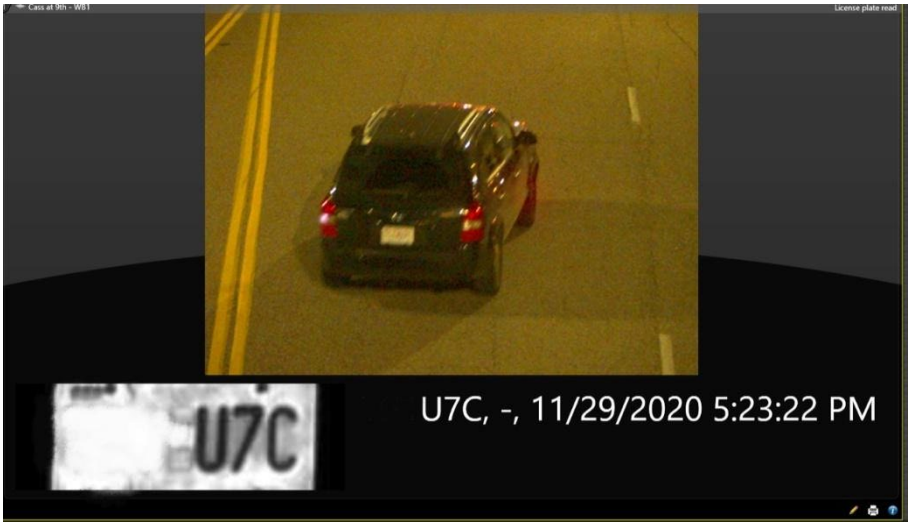
Integration of the MSTs into the RTCC was achieved by SLMPD personnel in collaboration with the vendor, which meant the cameras and LPR capabilities could be accessed directly in the RTCC and remotely for investigators. The gunshot detection feature was more problematic and did not send notifications automatically. Instead, data had to be downloaded to access, which is not an ideal feature for a gunshot detection system. For example, the city's ShotSpotter systems automatically can notify either dispatchers or officers in the field if a gunshot is identified. Moreover, the gunshot detection system has to be calibrated each time the unit is redeployed, which is a time-consuming process. If this is not done correctly the locations can be systematically biased. In addition, if one fails to reset the internal GPS function of the gunshot detection board, the coordinates of the prior deployment remain in effect, again making it difficult to determine the exact location of gunfire.

Figure 4. Calibration 'hits' for gunshot detection system on MST.



Both the cameras and LPR functionality largely operated as intended, allowing both real time monitoring and remote, post-recording viewing by investigators. Figure 5, below shows, for example, an MST hit of a stolen vehicle that was tracked and resulted in the apprehension of the occupants.

Figure 5. Example of MST LPR hit (plate number partially obscured to protect owner privacy)



One problematic issue that emerged during deployments is that the cameras on the units do not have a 360 degree view, but rather are PTZs that can only monitor one street in an intersection, not both. This led to some occasional disappointments for investigators. In one dramatic case, for example, a homicide occurred near an SPI trailer but because the cameras were pointed in a different direction no useful evidence emerged from the trailer (see figure 6 below).

Figure 6. Missed opportunity to collect evidence

While discussions between SLMPD personnel and the vendor were made to find a way to outfit the trailers with 'quad cams' instead of PTZ, it became clear that the current configuration would not be able to support additional cameras.

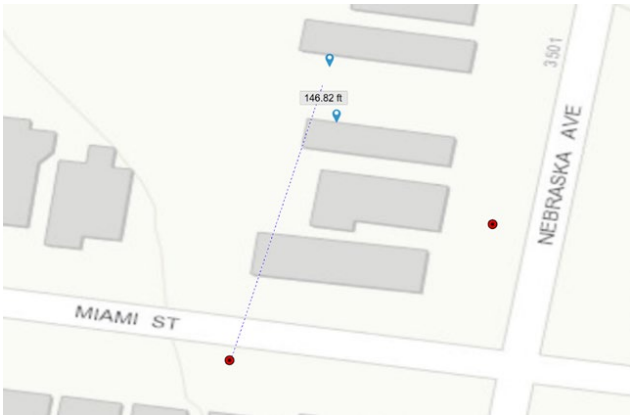
During the course of the grant period, we found an additional disadvantage of PTZ cameras. Initially the cameras were set up to swivel and zoom in on 'gunfire'-type noises. The primary problem was that the cameras would remain in that zoomed-in position. This was discovered when investigators would look at footage and found the camera fully zoomed in. While the zoom can be undone remotely, it would have to be done by personnel. This is problematic in a department with hundreds of cameras, which makes it unfeasible to quickly detect and manually correct this issue. After consultation with the vendor, we found the best solution to entirely decouple the PTZ function from gunshot detection and have the cameras remain pointed at the road (the PTZ function could still be remotely operated by the RTCC during an active incident). We suspect that this particular PTZ function may be less problematic in an area with wide views, but in narrower city streets this clearly is not always helpful.

Finally, we found the gunshot detection system to be less accurate than anticipated. Because St. Louis also has several square miles of ShotSpotter coverage many of the deployments took place inside areas with ShotSpotter, which allowed us to compare hits from the MST gunshot recognition system to ShotSpotter alerts. As can be seen below on figures 7 and 8, there is little overlap between the two gunshot detection systems. We also know that ShotSpotter is generally accurate in its identification of gunfire as well as the location of said gunfire. The effective accurate detection area of the MST gunshot detection was roughly 600-700 feet, which is not a large area.

Figure 7. ShotSpotter and MST gunshot alerts*

*The white circles represent MST locations, the blue markers are gunshots identified by the MST gunshot detection, whereas the red circles are ShotSpotter alerts.

Figure 8. ShotSpotter and MST alert overlap



Among all the incidents for the two deployed MSTs, only one incident occurs both in ShotSpotter (1 incident) and MST (2 incidents, one second apart). It should be noted that this is the only gunshot picked up by ShotSpotter occurring likely in the direct viewshed of the MST during this period (i.e. no obstructions), which is a good indicator that the MST acoustics may have trouble properly locating gunfire. The ShotSpotter alert indicates 7 rounds. MST detections reports two separate incidents at the exact same moment about 145ft away from the ShotSpotter location (and 580ft from MST). As we will discuss in the impact evaluation a further problem is that the presence of MSTs tends to suppress gunfire in the direct visual reach of the MSTs. This make some sense as most people know the units are equipped with cameras and probably rather not be filmed firing a gun. Fixed gunshot detection systems such as ShotSpotter rely on multiple sensors placed in a high location to triangulate gunfire; mobile systems such as that equipped on the MST often use multiple sensors but in one location and at lower altitude, which in our example appears to reduce accuracy.

In sum, equipping the MSTs with gunshot detection technology appears to create multiple failure points in our configuration. The units fail to pick up most gunfire *and* the PTZ function on the cameras hurt investigators more than they helped. Until such time that the technological capabilities of single-point mobile gunshot detection are comparable with that of triangulated fixed systems we would probably not recommend this expensive upgrade (around $20-30,000 per unit).

In general, the overall dependability of the MST was reasonable. Some initial problems with undersized wiring were found. This resulted in breakers frequently tripping. SLMPD personnel replaced the wiring after which the problems ceased. After discussions among project personnel several features of the units were considered less helpful than others. As mentioned, the gunshot detection system was found to be inaccurate compared to fixed systems and time consuming to set up. Another, less serious, issue was the gasoline generator which provided power to the system. Gasoline engines are less fuel efficient than diesel engines and require more maintenance and generally are less durable. Given the option the personnel in charge of deploying and maintaining the MSTs indicated they would opt for diesel engines going forward.

Technology Survey Results

Despite delays of equipment deliveries due to supply chain issues and the problems with gunshot detection systems as well as personnel shortages toward the end of the grant cycle, the SLMPDs SPI project operated as intended in implementation and functionality. We also explored how personnel in the department viewed the MSTs compared to other technology (Cameras, LPRs, hot spots Policing and ShotSpotter). To that end we conducted two personnel surveys, one at the beginning stages of implementation (2020) and one near the conclusion of the grant (2022). It is important to point out that at the time of the initial survey, MSTs were limited in scale (about 6) and deployment (mostly downtown), but by 2022 about 20 units were deployed throughout the city. Key findings of this survey show:

- Widespread support for the use of crime-fighting technology
- Both surveys show consistency in levels of support
- of all technologies MSTs show relatively most progress between the 2020 and 2022 survey
- Perceptions of specific technologies are closely related to perceived personal success with them
- Training in the use of technology is viewed as inadequate

Respondents were recruited by departmental emails to commissioned personnel. Sample sizes were almost identical with 160 complete responses in 2020 and 165 in 2022. Considering growing attrition of officers that occurred during this time, the responses rates are 13.3% and 16.5% respectively. While these are relatively low response rates, they are not unusual for web-based surveys. The question whether results are representative is difficult to answer, but based on demographics presented below, we believe the diversity of respondents likely taps the majority of people employed by the department, with an overrepresentation among senior personnel.

Demographics of the respondents are largely similar across survey waves, with the bulk of respondents being either a patrol officer or detective. Similarly, a majority of respondents indicate working either in patrol or investigations and about 2/3 are stationed in patrol districts, which indicates

some under-sampling in the districts and over-sampling of those working at headquarters. Most of the respondents have been with the department for more than 5 years (see tables 1 through 4 below)

Table 2. Rank of respondents

	2020		2022	
Patrol Officer	67	42%	50	35%
Detective	37	23%	41	28%
Sergeant	32	20%	37	26%
Lieutenant or above	22	14%	12	8%
n/a	2	1%	5	4%
Total	160	100%*	145	100%*

*May not add to 100% due to rounding.

Table 3. Role of respondents in agency

	2020		2022	
Patrol	67	42%	55	37%
Investigations	52	33%	54	37%
Specialized	19	12%	16	11%
Other	22	14%	23	16%
Total	160	100%	148	100%

Table 4. Tenure at PD

	2020		2022	
< 2 years	10	6%	13	9%
2-5 years	21	13%	14	10%
6-15 years	59	37%	50	34%
>16 years	66	42%	66	46%
Not sure	2	1%	1	1%
Total	160	100%	144	100%

Table 5. Primary location of respondents

	2020		2022	
North Patrol	19	12%	28	19%
South Patrol	29	19%	29	20%
Central Patrol	40	26%	26	18%
Headquarters	56	36%	46	31%
Other	13	8%	19	13%
Total	157	100%	148	100%

General views on technology

The vast majority of survey respondents ranked their understanding of police technology as either moderately, or extremely good (72% in 2020 and 71% in 2020). Similarly, the vast majority of

respondents indicated that they believed the crime-fighting technology deployed by the department is effective in reducing crime (see table 5 below) with only about 2% of respondents seriously opposing this view. It is thus fair to say that our sample of respondents is likely to hold positive views of police technology.

Table 6. Technology reduces crime

Is technology effective in reducing crime?	**2020**		**2022**	
Strongly agree	71	44.4%	71	43.0%
Somewhat agree	59	36.9%	65	39.4%
Neither agree nor disagree	15	9.4%	18	10.9%
Somewhat disagree	11	6.9%	8	4.8%
Strongly disagree	4	2.5%	3	1.8%
Total	160	100%	165	100%

A small difference between the two survey waves occurred. In 2020 we asked a broader question: does technology improve police work? In this case 92.5% of respondents indicated with an affirmative answer (somewhat or strongly agree). In 2022 we created a greater distinction between technology improving the response to active incidents (83.6) or technology improving the investigation (97.6%). Although largely similar, these results may indicate that respondents believed that investigative benefits of technology may be greater than those of the immediate response.

Views on Specific Technologies

When we turn our attention to specific technologies (ShotSpotter, cameras, LPRs, Hot Spots policing and MSTs) opinions are more divergent depending on the specific technology. When we ask respondents to rank these technologies, we found the following: In 2020, 4% of respondents ranked ShotSpotter as the best technology, compared to 61% of respondents that ranked cameras highest, compared to 26% who ranked ALPRs as the leading technology, 1% of respondents ranked MSTs highest and 8% ranked hot spots policing as their preferred technology. In 2022, these numbers shifted somewhat. ShotSpotter was ranked top by only 3% of respondents (-1%), cameras were ranked highest by 58% (-3%) of respondents, ALPRs by 28% (+2%), MSTs by 4% (+3%) and hotspot policing by 7% (-1%). Overall, these numbers show some stability, although impressions of MSTs improved most.

Important is that not everyone in a police department will have the opportunity to gain experience with each type of technology. ShotSpotter, for example is limited in coverage throughout the city. To more accurately measure how respondents' familiarity with technology impacted perceptions we asked questions about direct experience with the technology. In 2020, 67% of respondents indicated they have at some time responded to a ShotSpotter alert, 77% indicated experience with cameras, 78% with LPRs, 12% with MSTs, and 56% to hot spots policing. This strongly suggests, for example that knowledge about MSTs was limited at that time. By 2022, respondents indicated slightly higher levels of experience with almost all technologies, 73% (+6%) indicated experience with ShotSpotter, 87% (+10%) with cameras, 76% (-2%) with LPRs, 27% (+15%) with MSTs and 61% (+5%) with hot spots policing. Whereas there is a general increase for experience with most technologies, the increase in experience with MSTs in both absolute and relative terms is especially notable and likely reflects the rapid growth of these units.

Experience is not necessarily an indicator for perceived efficacy. To measure this, we asked respondents to indicate if they favored expansion of each technology. Here results are interesting, and

largely reflect the aforementioned ranking of technology. In 2020, respondents who indicated direct experience with the technology; for ShotSpotter 36% (n=111) advocated for expansions (definitely yes, or probably yes), for cameras 98% responded positively (n=130), for LPRs 92% favored expansion (n=132), for MSTs 73% (n=37), and for hot spots policing, 48% (n=159). By 2022, results indicate 44% (n=129) would advocate for expansion of ShotSpotter, 95% advocate for expansion of cameras (n=149), 89% for LPRs (n=163), 70% for MSTs and 45% (n=74) for hot spots policing (n=120). These numbers, with some minor variations across categories indicate that even though more police may become familiar with certain technologies there is no noticeable (proportionally) increase in average support for the technology. This is most clearly seen for MSTs, which saw a doubling of the raw number of respondents that indicated direct experience with the units, but the percentage advocating for expansion remained essentially flat.

This brings us to the idea that support for technology may be rooted in (1) the (perceived) ability of technology to solve incidents or (2) deter crime more broadly. To tackle this issue, we asked all respondents (regardless of direct experience with the technology) how effective they believed a particular technology is in solving an incident. In 2020, 9% of respondents indicated that they believed ShotSpotter was effective (extremely or very effective) in solving incidents, 81% indicated this for cameras, 72% for LPRs, 42% for MSTs, and 20% for hot spots policing. Because solving incidents is only one aspect of technology, we also asked respondents about possible deterrent effects. Here results indicated that 3% believed ShotSpotter was a deterrent, 26% believed this to be true for cameras, 16% for LPRs, 38% for MSTs and 43% for hot spots policing. This clearly shows that respondents believe some technologies are better at solving crimes through intelligence gathering (cameras, ALPRs and MSTs) and others also have a deterrent impact (MSTs and hot spots policing). One may suspect that respondents believe that the visual footprints of technology matter as the technologies with the greatest visual impact (MSTs and hot spots policing) score particularly high in deterrence. In 2022, the numbers largely reflect similar perceptions. For solving incidents, 15% indicated ShotSpotter was effective, 81% believed cameras were effective, 67% believed LPRs were effective, 43% believed MSTs were effective and 20% believed hot spots policing was effective in solving incidents, essentially unchanged from 2020. Deterrence potential shows similar results as well with 6% believing ShotSpotter is a deterrent, 25% believing cameras are a deterrent, 16% believing LPRs are a deterrent, 32% believing MSTs are a deterrent, and 46% believing hot spots policing is a deterrent. Again, these results indicate some consistency in the responses with visual technologies (LPR, cameras and MSTs) able to solve incidents and technologies with the most direct visual impact (MSTs and hots spots policing) leading the perceptions of deterrence.

In short, MSTs are considered favorable in both solving crimes and enhancing deterrence. As awareness of the units expands it stands to reason that these units become more seen as critical components of technological approaches to crime.

In addition to specific technologies the survey also asked respondents about some global aspects of technology. For example, we asked respondents to grade the use of crime-fighting technology at the SLMPD on a scale of 0-10. Results in 2020 indicated an average score of 6.83 (median=7) whereas results in 2022 produces a score of 7.0 (median=7), effectively indicating a general supportive attitude with little change. We also examined how officers viewed the impact of technology on prosecution of cases. In 2020, 79% of respondents indicated they believed technology improved prosecutorial success, whereas in 2022 77% of respondents believed this. For respondents who indicated they also participated in court cases in which technological evidence was presented, 97% of respondents in 2020 and 86% in 2022 indicated they believed the evidence produced by technology made a positive contribution to case outcomes. Again, the results indicate an overall supportive view of the benefits of technology in prosecution.

Despite lower response rates, we see consistent responses on views of technology across the two waves of surveys giving greater confidence in the conclusions. In general, the attitude towards technology is largely supportive, ranking the use of technology in the SLMPD quite high. Disaggregated results, however, show that some technologies received greater approval than others. Cameras and LPRs enjoy the largest support, hot spots policing and especially ShotSpotter receive the least support. It is reasonable to believe that these levels of support are largely the result of specific outcomes respondents may have witnessed. To this end we asked for all technologies (except hot spots policing as its main goal is deterrence) what the respondent remembered as the last outcome of a response to an incident with the respective technology (see table 7 below). These results indicate that respondents indicate more positive views on technologies if they believe they produce results for them (whether they do or not may be a different matter).

Table 7. Last experience with technology

2020	**No evidence**	**Evidence only**	**Suspect identified**	**Arrest**	**unknown**	**Total #**
Camera	3.8%	35.1%	32.8%	19.8%	8.4%	131
ALPR	5.3%	21.2%	13.6%	50.8%	14.4%	132
MST	13.5%	35.1%	10.8%	5.4%	35.1%	37
ShotSpotter	60.9%	29.1%	0%	1.8%	8.2%	110
2022	**No evidence**	**Evidence only**	**Suspect identified**	**Arrest**	**unknown**	**Total #**
Camera	3.4%	29.5%	27.5%	20.8%	18.8%	149
ALPR	4.3%	12.9%	15.3%	34.4%	33.1%	163
MST	12.3%	30.1%	9.6%	5.5%	42.5%	73
ShotSpotter	46.5%	28.7%	0%	.6%	18.8%	129

It should come as no surprise that the views of the efficacy of technology are related to the views on implementation of technology at the SLMPD. Questions that asked about the efficacy of technology to improve response, investigations and reductions in crime correlate moderately strong to the grading of technology use in the 2022 survey.

In addition, a few new questions were introduced on the 2022 survey. One of these questions asked about the adequacy of training to use technology. Here results indicate that most respondents feel they need additional training. Fifty-four percent indicate that current training is insufficient to some degree, whereas 22% indicate training is adequate. This is given further importance by the fact that 30.3% of respondents indicate they didn't receive any training at all. Additional qualitative comments from respondents indicate especially a need for training on how to use cameras for investigations and training in the use of ShotSpotter's data portal.

Summary

In sum, overall respondents on the survey indicate a high level of support and appreciation for technology implemented at the SLMPD. That being said, some technologies (LPR/Cameras) enjoy broader and deeper support than others (ShotSpotter/Hot Spots policing). Mobile surveillance trailers fall somewhere in between, but respondents do acknowledge its potential by a combination of case resolution and visual deterrence. Respondents largely show stable support for technology across the two surveys, suggesting that the support and appreciation for technology remains high over time. As mobile surveillance trailers rapidly expanded during this time (going from about 6 to 20+ units), it is

clear that respondents are becoming more familiar with them. Despite the general positive findings about use of technology at the SLMPD, a substantial group of respondents indicate a need for additional training in the use of the technology.

Summary for the process evaluation

We believe our implementation of the SPI grant was largely in line with expectations. Yes, the project encountered some early delays due to the impact of COVID-19 and toward the end of the project personnel shortages created somewhat longer deployments. This resulted in slightly fewer deployments than anticipated. In addition, quality issues of the MSTs and breakdowns also created some downtime for the units, but this was largely expected. The units, however, were deployed in line with requirements for an RCT and the units functioned as intended (with exception of the gunshot detection). As an aside the functionality of the units was not only noticed by SLMPD personnel, but on occasion also helped neighboring agencies. During a conversation with a sheriff's deputy in a neighboring county, for example, the RP was made aware of a successful homicide investigation in which one of the MSTs contributed to key evidence. At the beginning of the grant we did not think about the investigative benefits to other law enforcement agencies, but it is clear that these do exist.

All told, we believe that the SLMPD SPI project was executed in spirit with the initial ideas and despite some challenges stayed true to its evidence-based deployment approach.

Impact Evaluation

The impact evaluation is at the heart of our project. At the end of the day, we want to understand the potential benefits of the units. While we present below the results of crime impacts, what has been impossible to systematically examine is how the units add to the investigative capacity of the police department. There are several reasons that make this difficult to assess. First, only very few serious crime incidents occurred in direct view of the MST. Second, tracking how such cases are enhanced by technology and move through the different layers of the justice system would rely on non-traditional record keeping that is rarely done. Also, while police can present a solid case this does not mean it will be prosecuted vigorously.

Approach and data collection

Data for the evaluation were collected from the SLMPDs CAD, RMS and ShotSpotter databases. First, all trailer deployments and control locations were mapped in ArcGIS. Buffers were created in mapping software around each site. Buffer sizes used include 500 (.028 square mile), 1,000 (.113 square mile) and 1,500ft (.254 square mile). These buffers are unquestionably arbitrary sizes, but they do reflect important distances. Five hundred feet is the approximate maximum distance at which camera and LPR functionality begins losing the ability to provide actionable intelligence. The second buffer (500-1,000ft) roughly corresponds to the distance at which the trailers are clearly visible to the public and likely represents the area in which visual deterrence might occur. The final buffer (1,000-1,500ft) represents the area in which displacement/diffusion of benefits may occur.

With buffers established RMS, CAD and ShotSpotter data are mapped and merged into the buffers. Date calculations are performed to determine if the occurrence of an incident fell in the deployment period, or the same deployment length before or after deployment. This provides three measuring points at three levels of geography for both treated and control locations. Because our project is primarily interested in reducing violent (gun) crime and outdoor thefts (of and from vehicles) we explore dependent variables that measure a variety of such incidents, but we also explore a few other crime types that are not expected to be impacted.

The design of the completed data set allows for a difference-in-differences (DID) approach. Because sites were randomly assigned treatment or control status this represents the best argument for measurement of causal effects. Nonetheless, caution has to be expressed about results as the numerical frequency of incidents is particularly low at the smallest buffer range (500ft), which means statistical power for relatively rare crimes (especially violent crime) is low.

First, we will explore descriptive statistics for the different geographies and experimental sites. This will help us understand not only the general changes that may occur in crime levels, but also provide better insight into the statistical power of the data.

Table 8. Descriptive statistics, gunfire related calls for service

	Max. Distance	*Type*	*Before N=95*	*During N=95*	*After N=95*
Shots Fired	500	Treated	1.052632 (2.13067)	1.052632 (1.806421)	1.052632 (1.87576)
	500	Control	.8736842 (1.408501)	.8526316 (1.494447)	1.136842 (1.916394)
	1000	Treated	3.715789 (4.428302)	3.442105 (3.967195)	3.442105 (3.419953)
	1000	Control	3.347368 (3.299801)	3.168421 (3.668882)	3.378947 (4.512816)
	1500	Treated	6.273684 (5.728692)	5.557895 (5.983516)	5.505263 (5.533022)
	1500	Control	5.852632 (5.966161)	5.042105 (4.746591)	5.136842 (4.861071)
Shooting	500	Treated	.2105263 (.8492141)	.1473684 (.4830845)	.1473684 (.4605367)
	500	Control	.1789474 (.5254977)	.1052632 (.3987663)	.0947368 (.4144641)
	1000	Treated	.4105263 (.8185968)	.5684211 (1.14532)	.5789474 (1.106835)
	1000	Control	.3473684 (.7546793)	.4421053 (.7816484)	.3578947 (.7133348)
	1500	Treated	.8105263 (1.323235)	.8210526 (1.246091)	.7473684 (1.304399)
	1500	Control	.6631579 (1.216994)	.7368421 (1.141206)	.8315789 (1.14532)

Shots in property	500	Treated	.1052632 (.4246071)	.1157895 (.4090247)	.0842105 (.4037894)
	500	Control	.0947368 (.3285586)	.1473684 (.5046259)	.1789474 (.7142761)
	1000	Treated	.3789474 (.8401994)	.3578947 (.6174034)	.5052632 (1.009252)
	1000	Control	.5157895 (.9437719)	.3368421 (.6935957)	.3157895 (.7754636)
	1500	Treated	.6526316 (1.089294)	.4105263 (.6918175)	.8947368 (1.215797)
	1500	Control	.5368421 (.8096562)	.5368421 (.954391)	.7157895 (.952747)

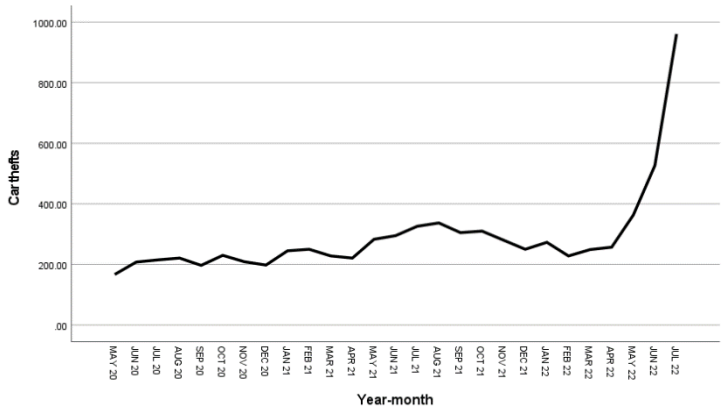
The table above presents means and standard deviations (in parentheses) for several categories of gunfire reported by community members to the SLMPDs CAD system. The numbers in general look quite stable and show that both treated (MST) and control sites present similar means. Independent t-tests confirm that there is no statistical difference in the means of the pre-treatment periods between treated and control locations and that any difference we can observe are most likely the outcome of 'noise' in the data. This serves to confirm that the randomization process more than likely led to pre-treatment equivalence. Just the same, just because the treatment and control sites are similar statistically does not mean we can easily detect significant changes. This is dependent on the statistical power of the sample, or its ability to detect meaningful shifts before, during and after deployment of MSTs. Statistical power is in large part determined by the size of the average and standard deviation. Small numerical averages with relatively large standard deviations can substantially cut into the power of a statistical test and require a larger sample size than larger means with smaller standard deviations. As we described earlier, crime trends in St. Louis have been especially volatile during the project period, meaning that this likely undercuts our ability to detect significant changes. This holds particularly true if the relative percent change before and after is small.

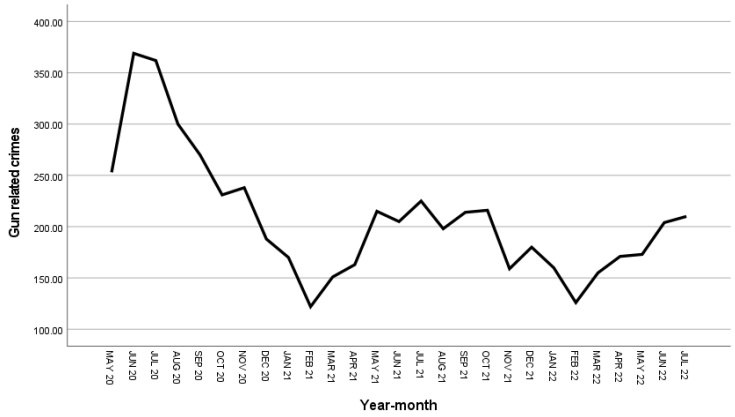
In some cases, therefore, it makes sense to 'aggregate' data, meaning we tally up the cases for related incidents. Below for example we combine shots fired, shootings and shots in property to create a new variable named 'gunfire'. To illustrate how many observations we need to determine if we can detect statistical shifts before and during deployment we use the 500ft buffer of variable 'shooting'. With a mean of .211 and a standard deviation of .849 we would need ~6,386 deployments to detect a statistical difference of 20 or more percent. By contrast if we want to be able to detect a statistical difference of 50 or more percent the number of deployments needed is reduced to 1,022. By contrast if we use the variable 'gunfire' with a mean of 1.368 and standard deviation of 2.601 'only' needs 1,418 deployments to detect a 20% difference and 227 deployments to detect a 50% difference. Because serious crime is relatively infrequent, this means that for many crime categories attaining statistical significance between treatment and pre/post levels of crime is difficult unless the differences between treated and control sites are exceptionally large.

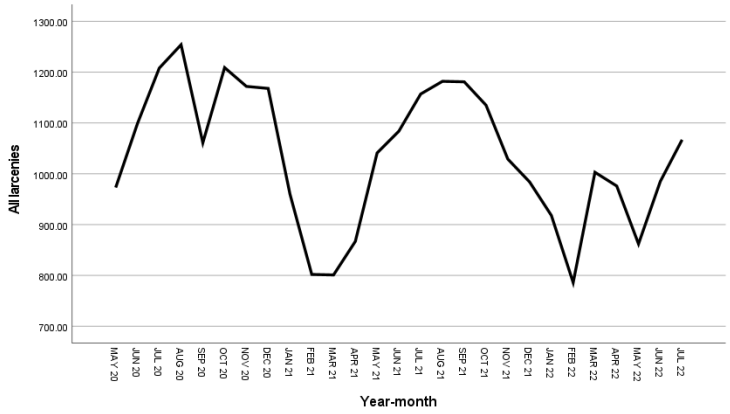
One possible solution is to combine 500 and 1,000 feet buffers, but if treatment effects are smaller in the 1,000 feet buffer as expected, even this will not remedy low statistical power. Another solution is to combine pre and post data and compare both periods to the treatment time, but this may also not be effective if post levels of crime in treated locations show lingering treatment impacts. A final problem in detecting treatment impacts is related to the volatility of crime levels in the past few years.

COVID-19 and urban unrest severely impacted routine activities in urban communities and led to wild swings in crime levels, with gun violence quickly soaring and property crime decreasing. More recent crime trends for car thefts are also extremely volatile, as many communities experience rapid increase in vehicle thefts due to a known security defect in KIAs and Hyundais (Insurance Institute for Highway Safety, 2022). Rapidly fluctuating crime levels, especially if not geographically evenly spread, can further impact significant findings. Below graphs show these rapid changes in gun violence (2020), and vehicle thefts (2022), but show that larcenies show more typical seasonal variation only.

Figures 9-11. Crime trends during project period







The table below shows descriptive statistics for ShotSpotter alerts and the combined gunfire-type incidents reported by residents. This allows us to some extent compare whether reporting itself may change in treatment locations. It is possible, for instance, that residents may be more inclined to call police when an MST is present. This could be driven by their belief that a MST captures relevant footage to aid in resolving their victimization, or it could also be that residents feel less likely to be accused of 'snitching' when such units are deployed; there is no obvious way to test such a hypothesis unfortunately. Just the same, ShotSpotter alerts near MST sites appear to have declined during treatment slightly more than gunfire calls reported by community members. Additionally, control sites show smaller declines.

Table 9. Descriptive Statistics for ShotSpotter Alerts and Combined Gunfire calls for service.

	Max. Distance	*Type*	*Before N=95*	*During N=95*	*After N=95*
ShotSpotter	500	Treated	1.821053 (4.089371)	1.494737 (3.211925)	1.915789 (4.165877)
	500	Control	1.442105 (2.897966)	1.431579 (2.381903)	1.4 (2.896807)
	1000	Treated	6.378947 (11.21566)	4.978947 (8.177524)	4.378947 (7.290593)
	1000	Control	5 (9.058909)	4.789474 (7.714169)	4.284211 (6.981226)
	1500	Treated	9.494737 (14.76329)	7.2 (9.819217)	7.031579 (10.03022)
	1500	Control	8.115789 (12.92356)	7.031579 (10.03022)	7.421053 (13.17685)
Gunfire	500	Treated	1.368421 (2.601361)	1.315789 (2.012002)	1.284211 (2.137125)
	500	Control	1.147368 (1.557196)	1.105263 (1.68519)	1.410526 (2.308609)
	1000	Treated	4.505263 (5.105011)	4.368421 (4.354144)	4.526316 (4.16378)
	1000	Control	4.210526 (3.741358)	3.947368 (4.008949)	4.052632 (5.068401)
	1500	Treated	7.736842 (6.294561)	6.789474 (6.618631)	7.147368 (6.567114)
	1500	Control	7.052632 (6.582324)	6.315789 (5.696701)	6.684211 (5.336074)

For the larger categories of larcenies, robberies and aggressive crimes (the latter combines assault, fights and disturbances-but not domestic disturbances) we see changes concurrent with expectations, with strongest declines in MST sites at 500ft, but increases/smaller declines in control sites.

Table 10. Descriptive Statistics for larcenies, robberies and assaultive calls for service

	Max. Distance	*Type*	*Before N=95*	*During N=95*	*After N=95*
CAD Larceny	500	Treated	.3789474 (1.112587)	.3473684 (.9313502)	.3578947 (.8110381)
	500	Control	.2421053 (.5402086)	.3473684 (.7259392)	.2736842 (.5347918)
	1000	Treated	.8105263 (1.123205)	.8105263 (1.094422)	.9368421 (1.060013)
	1000	Control	.8842105 (1.405636)	1.021053 (1.54354)	.9263158 (1.599482)
	1500	Treated	1.536842 (1.820746)	1.378947 (1.531089)	1.126316 (1.377958)
	1500	Control	1.810526 (2.833293)	2.010526 (2.919103)	1.915789 (3.388539)
CAD Robbery	500	Treated	.0842105 (.3149859)	.0736842 (.300429)	.0631579 (.351608)
	500	Control	.0842105 (.3149859)	.0947368 (.3285586)	.0631579 (.2445372)
	1000	Treated	.1473684 (.385051)	.1578947 (.4206325)	.1684211 (.403512)
	1000	Control	.2736842 (.6264066)	.2631579 (.5498651)	.2 (.4519461)
	1500	Treated	.3578947 (.7567538)	.4631579 (.6966565)	.3894737 (.6887351)
	1500	Control	.6 (.9038923)	.4 (.6747734)	.3473684 (.6960133)
CAD Aggressive	500	Treated	2.842105 (3.591704)	2.484211 (3.052251)	1.936842 (2.291569)
	500	Control	3.010526 (3.150463)	2.915789 (3.4042)	2.821053 (3.518882)
	1000	Treated	7 (5.735296)	7.105263 (5.483968)	6.8 (5.704795)
	1000	Control	7.336842 (6.257949)	7.778947 (5.705874)	7.789474 (5.559915)
	1500	Treated	11.37895 (7.59224)	11.94737 (8.038959)	11.66316 (7.11099)
	1500	Control	13.63158 (9.853234)	12.93684 (10.22493)	13.22105 (11.31576)

It is also possible that the presence of MSTs may increase or decrease the number of self-initiated police activity as officers could read their presence as a sign that the area is in need of more policing (such as patrol, or vehicle stops). It may, however, also signal that the area is monitored and therefore not in need of additional policing. Regardless, the numbers show roughly similar increase in police activity in both treatment and control sites in the area immediately around the MSTs (500 feet). This likely simply suggests that police presence increases more generally in areas that recently experienced increases. SLMPD does encourage hot spots policing and uses that to some extent in formal fashion as well, so seeing an uptick of policing efforts in high crime locations is not entirely surprising.

Table 11. Descriptive statistics for Combined 'Self-Initiated' Activities

Preventative policing	*Distance*	*Type*	*Before N=95*	*During N=95*	*After N=95*
	500	Treated	5.431579 (7.013138)	6.336842 (8.934288)	5.863158 (8.074929)
	500	Control	5.115789 (5.688479)	6.421053 (8.658508)	5.663158 (6.999408)
	1000	Treated	16.13684 (20.73368)	17.17895 (20.44192)	16.90526 (19.40337)
	1000	Control	20.83158 (33.6966)	20.56842 (23.22629)	18.95789 (20.87446)
	1500	Treated	29.58947 (32.05331)	29.97895 (31.88409)	29.84211 (27.11611)
	1500	Control	30.38947 (31.3397)	33.36842 (34.35517)	30.93684 (28.14469)

Turning to RMS incidents, we can see in the table below that while overall trends in crime may increase or decrease rapidly serious offenses will still occur extremely infrequently at small geographic and temporal scales such as our treated and control locations. Especially homicides and robberies occur rarely within the 500 feet buffers in both treated and control areas. Aggravated Assaults occur more than the other two categories but even here frequencies are too low to be able to measure meaningful changes. What is more in each category at 500 feet we see declines in control sites outstripping those in MST sites.

Table 12. Descriptive statistics for violent crimes, larcenies and motor vehicle thefts

	Max. Distance	*Type*	*Before N=95*	*During N=95*	*After N=95*
Homicide	500	Treated	.0421053 (.2018947)	.0315789 (.175804)	.0315789 (.175804)
	500	Control	.0421053 (.2018947)	.0210526 (.1443214)	.0210526 (.1443214)
	1000	Treated	.0421053 (.2018947)	.0842105 (.2791765)	.0736842 (.2626423)
	1000	Control	.0631579 (.2847368)	.0315789 (.175804)	.0421053 (.2018947)
	1500	Treated	.1052632 (.3412644)	.0947368 (.2944047)	.1052632 (.3085203)
	1500	Control	.0631579 (.2445372)	.0947368 (.3285586)	.1157895 (.3821317)
Aggravated Assault	500	Treated	.1894737 (.4447026)	.1789474 (.4370829)	.1368421 (.4024004)
	500	Control	.1894737 (.4200997)	.1578947 (.3945315)	.1368421 (.3455038)
	1000	Treated	.5052632 (.7561617)	.5894737 (.8314911)	.6526316 (.8600893)
	1000	Control	.6 (.8042441)	.4842105 (.6662559)	.5684211 (.8586559)
	1500	Treated	1.021053 (.9673274)	.9052632 (1.11158)	.7894737 (1.060858)
	1500	Control	1.031579 (1.161919)	.9263158 (1.023574)	.9684211 (1.004804)

Robbery	500	Treated	.0947368 (.2944047)	.0842105 (.3149859)	.0631579 (.2445372)
	500	Control	.0947368 (.2944047)	.0315789 (.175804)	.0526316 (.2244815)
	1000	Treated	.1578947 (.3945315)	.1684211 (.4290671)	.0842105 (.2791765)
	1000	Control	.2421053 (.4774888)	.1052632 (.3085203)	.2105263 (.4098452)
	1500	Treated	.3052632 (.6027187)	.2842105 (.5190654)	.4 (.5907082)
	1500	Control	.3894737 (.6571171)	.2210526 (.4876986)	.2 (.4277601)
Larceny	500	Treated	.4947368 (.7837944)	.4315789 (.8206462)	.4210526 (.6454249)
	500	Control	.5684211 (.8461758)	.5578947 (.7816484)	.5578947 (.8084104)
	1000	Treated	1.652632 (1.569445)	1.578947 (1.717116)	1.347368 (1.382015)
	1000	Control	1.684211 (1.846579)	1.842105 (1.996357)	1.378947 (1.524125)
	1500	Treated	2.705263 (2.492003)	2.578947 (1.938298)	2.631579 (2.264681)
	1500	Control	2.989474 (2.486109)	2.831579 (2.332256)	2.557895 (2.40441)
MVT	500	Treated	.2631579 (.5097043	.1894737 (.4200997)	.1368421 (.3455038)
	500	Control	.2 (.474902	.2105263 (.4814591)	.1578947 (.4452059)
	1000	Treated	.5684211 (.7670423	.6 (.8678661)	.5578947 (.8214646)
	1000	Control	.7368421 (.9476794	.4947368 (.7561617)	.4947368 (.7274801)
	1500	Treated	.9368421 (1.30311	1.147368 (1.228807)	.8631579 (1.135599)
	1500	Control	1.031579 (1.161919	.9052632 (1.158444)	.8526316 (.999664)

While property crimes are generally more abundant than violent crimes, frequencies are still relatively limited at 500 feet, however at 1,000 feet results can be measured more confidently. For aggregated categories (such as all crimes, or violent crimes, or crimes occurring outdoors), the frequencies are adequate, but such categories are certainly less meaningful. Outdoor crimes and all crimes combined are primarily driven by larcenies, for examples, whereas the combined group of violent crimes is driven mostly by assaults.

Table 13. Descriptive statistics for aggregated crime categories

	Max. Distance	*Type*	*Before N=95*	*During N=95*	*After N=95*
*Violent Crime**	500	Treated	.3263158 (.5731975)	.2947368 (.5991782)	.2315789 (.5350011)
	500	Control	.3263158 (.6594986)	.2105263 (.4350284)	.2105263 (.4350284)
	1000	Treated	.7052632 (.8857463)	.8421053 (1.044904)	.8105263 (1.034457)
	1000	Control	.9052632 (.8881451)	.6210526 (.7879268)	.8210526 (1.051634)
	1500	Treated	1.431579 (1.293623)	1.284211 (1.17295)	1.294737 (1.295439)
	1500	Control	1.484211 (1.43559)	1.242105 (1.164326)	1.284211 (1.190951)
*Outdoor** crimes*	500	Treated	.6842105 (.8538169)	.5684211 (.7807884)	.5684211 (.7670423)
	500	Control	.7684211 (1.046297)	.7578947 (.9533345)	.6210526 (.7743075)
	1000	Treated	2.052632 (1.788667)	2.073684 (1.702577)	1.863158 (1.541004)
	1000	Control	2.252632 (1.929438)	1.957895 (1.929148)	1.873684 (1.531528)
	1500	Treated	3.347368 (2.770546)	3.568421 (2.332256)	3.157895 (2.459527)
	1500	Control	3.484211 (2.559351)	3.305263 (2.154035)	2.926316 (2.208504)
*All Crimes***	500	Treated	1.189474 (1.214231)	1.157895 (1.29085)	.9052632 (1.052592)
	500	Control	1.231579 (1.476429)	1.147368 (1.228807)	1.063158 (1.192267)
	1000	Treated	3.273684 (2.354001)	3.505263 (2.48773)	3.326316 (2.438355)
	1000	Control	3.726316 (2.773131)	3.463158 (2.696769)	3.084211 (2.229699)
	1500	Treated	5.694737 (4.179671)	5.957895 (3.63469)	5.442105 (3.493812)
	1500	Control	6.442105 (4.109449)	5.757895 (3.45092)	5.315789 (3.501559)

* Excludes sexual assaults.

** Based on RMS indication where incident occurred

*** Also includes sexual assaults, burglaries and arson

Multivariate Analysis

Given the data constraints-low counts of serious crime—it will be difficult to detect anticipated results with models. Here we describe the results of the main categories. Our approach is relatively straightforward. We use Difference-in-Differences (DID) models that describe the relative change in

crime levels controlling for both pre-existing levels in the treatment site as well as controlling for the changes in the control site (Abadie,2005). Such an approach gives greater confidence in causal effects than a simpler pre/post vs treatment approach.

In addition to comparing pre-experimental levels of crime to those of deployment dates, we also explore post-deployment results to see if any crime reductions are sustained after the MSTs are removed. Combined results comparing before/after against treatment are also reported.

In addition to results for each buffer level (500, 1,000 and 1,500 ft) we also examine models for fully functional MSTs and the placebo trailers to explore if there are substantial differences, and whether impacts can be attributed to the investigative capacity of the trailers or whether deterrence is the most likely source of crime changes.

Our expectation is, of course, that the placement of MSTs reduces crime in areas up to 1,000 feet with no serious displacement beyond the locations (1,000-1,500 feet). Ideally, we also would expect that crime levels post-deployment remain lower than pre-deployment, but the literature on hot spots policing suggests that benefits of such interventions usually recedes quickly post deployment. While there is no guidance in the literature on whether placebo technology works as well at deterring crime, we would expect that the investigative benefits of technology add to the deterrent impact and produce greater crime reduction benefits.

All models are estimated using a Generalized Linear Modeling (GLM) strategy with a negative binomial 'log link' to account for overdispersed dependent variables (Allison, 2009). Overdispersion is a typical problem in events that occur relatively infrequently, meaning that zero occurrences of an event are typical in the data (which is often true if the mean for a crime category is below 1). The advantage of a negative binomial approach is that if a dependent variable is not overdispersed such models revert to a Poisson distribution, which would be appropriate for a typical count model. Because of the random assignment we theoretically should not have to worry about seasonal effects (as control 'deployments' occur over the exact same time as the MST deployments). Given that deployments were not always the same length we do add a variable to our model indicating the length of the deployment.

Because of the large number of models estimated (27 models for each dependent variable), we only report the DID coefficients below and indicate if they attain statistical significance. The coefficients reported roughly translate into proportionate/percent change in the dependent variable (crime type) during deployment, while controlling for pre-deployment and control site levels. A reported coefficient of 1.25 would mean a roughly 25% increase during deployment, whereas a coefficient of .75 would indicate a roughly 25% reduction during deployment.

First, we explore the impact that MST presence may have on policing efforts as we found some sizeable increases in self-initiated, preventative police activity in the descriptive data (see table 10). The table below shows what are effectively flat results (coefficients are all close to 1, indicating little change either way) with only minimal variation in coefficients and no statistically significant impacts. This suggests that the presence of MSTs does not appear to influence police activity in the immediate area.

Table 14. GLM results Preventative Policing activities.

	Max. Distance	*Before-During*	*After-During*	*Before and After-During*
Preventative Policing				
all MSTs	500	.9943513	1.021146	1.005612
n=380	1000	1.075801	.9479949	1.009561
	1500	.9477108	.9418049	.9433611
Functional MSTs	500	1.030773	.9698732	.9914132
n=308	1000	1.133842	.9193031	1.012815
	1500	1.023419	.9594382	.9843015
Placebo MSTs	500	.9974314	1.044056	1.018518
n=72	1000	.9709485	1.007573	.9896439
	1500	.8451627	.885527	.8657115

* P<.1 ** P<.05 *** P<.01 ****P<.001

Results for gunfire calls for service and ShotSpotter are returning non-significant coefficients, but again this is largely the result of low counts and high standard deviations. For ShotSpotter alerts, however, the results do show consistent reductions at 500 feet compared to both pre and post deployment and control sites. What is more, reductions are also seen at 1,000 feet and even at 1,500 feet, but the latter are largely cancelled out once we compare both before and after, indicating that any suppressant effects are quickly reversed post-deployment. Effectively we see reductions in line with expectations, averaging around 20% in the first buffer (500 feet) and just a bit more than 10% in the 2nd buffer (1,000 feet). While these results are not statistically significant, we believe they do likely represent a real change. It is important to note here also, that not all deployments occurred in areas with ShotSpotter coverage, which increases the variability in the data.

Table 15. GLM Coefficients for Gunfire reported by ShotSpotter and community residents

	Max. Distance	*Before-During*	*After-During*	*Before and After-During*
ShotSpotter Alerts				
All MSTs	500	.8200571	.7445705	.7809175
n=380	1000	.7927788	1.005589	.8761386
	1500	.8706852	1.077638	.9566834
Functional MSTs	500	.7459371	.7998469	.7698063
n=308	1000	.6615495	.9619832	.7799849
	1500	.74398	1.000488	.8508339
Placebo MSTs	500	.993126	.4132426	.648559
n=72	1000	1.552764	1.234457	1.389953
	1500	1.818906	1.48466	1.686868
Reported Gunfire				
All MSTs	500	1.006252	1.285812	1.139339
n=380	1000	1.047463	.9711694	1.011643
	1500	.9816287	1.021241	1.001354
Functional MSTs	500	.84368	1.142812	.9858019
n=308	1000	1.063752	.9535435	1.013014
	1500	1.01461	1.010313	1.013572

Placebo MSTs	500	3.489477*	3.334574	3.439532*
n=72	1000	1.10916	1.040434	1.069063
	1500	.7873908	1.087952	.93049

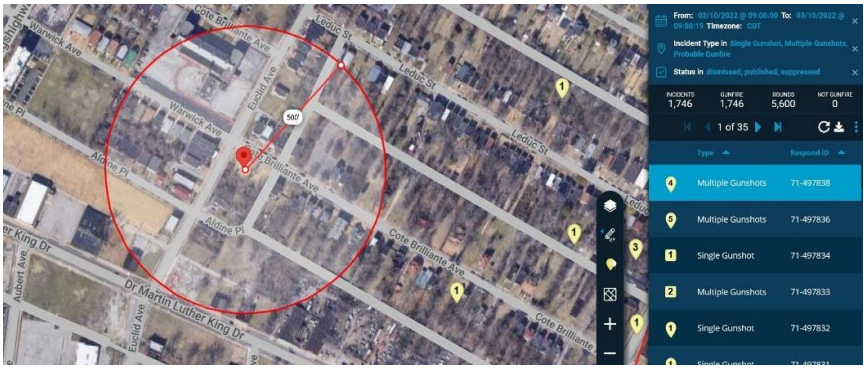
* P<.1 ** P<.05 *** P<.01 ****P<.001

Our belief is that the reduction in gunfire as measured by ShotSpotter alerts is likely a real change is based on additional review of ShotSpotter alerts. We visually checked several deployment locations and found that during deployments of MSTs ShotSpotter alerts are typically minimized in direct viewshed of the location (see figures below for an example).

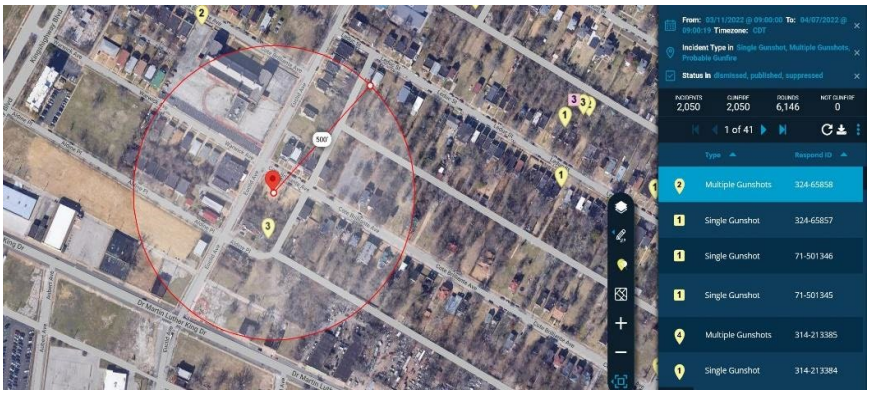
Figures 12-14. ShotSpotter alerts around MST deployment.

Before

During



After



For gunfire reported by community members results are a bit different, indicating relative increases in all buffers (an outcome of control areas experiencing steeper declines on average). While it should be pointed out that gunfire reporting may occur in a location that does not necessarily mean the gunfire occurred at that site. Gunfire can often be heard from quite far away, certainly more than 500-1,000 feet. We therefore tend to give most credit here to ShotSpotter alerts as they are generally more accurate and complete than gunfire reported by community members. While for both dependent variables (ShotSpotter alerts and gunfire) results seem to indicate relative increases in the placebo trailers, but decreases in the functioning trailers we caution against putting too much value on that difference due to the lower frequency of placebo deployments, meaning that only a few additional cases can generate such coefficients. In sum, the deployment of MSTs does appear to have had a modest effect on gunfire reported by ShotSpotter alerts, but no discernable impact on gunfire reported by community members. While these results are not statistically significant, we believe that the results for ShotSpotter alerts are likely indicative of real changes.

Table 16. GLM coefficients for assaultive categories in CAD (assault, fight, disturbance)

	Max. Distance	*Before-During*	*After-During*	*Before and After-During*
CAD Assaultive				
All MSTs	500	.9146846	1.273576	1.059459
n=380	1000	.9646466	1.06342	1.01305
	1500	1.144377	1.059148	1.100987
Functional MSTs	500	.9364751	1.243946	1.069548
n=308	1000	1.0178	1.056369	1.037381
	1500	1.133043	1.04908	1.090533
Placebo MSTs	500	1.168519	1.402799	1.240084
n=72	1000	.6819935	1.097177	.8900745
	1500	1.194847	1.096267	1.145318

* P<.1 ** P<.05 *** P<.01 ****P<.001

For both aggravated assaults and robberies, we see increases in our coefficients, and they especially appear in the second buffer (500-1,000 feet). This does not mean that incidents increased in treated areas, rather that the decrease we say in descriptive data was smaller than in control areas. It is possible that the presence of MSTS could create an uptick in reporting, but due to the presence of MSTs. Either way, result do not favor treatment effects, which combined with the declines observed in the descriptive tables indicate that both treatment and control sites likely just experienced regression to the mean. Similarly, CAD data for aggressive incidents (fights, non-domestic disturbances and assaults) show roughly the same lack of impact as can be seen in RMS data on aggravated assaults. Coupled with the slightly more positive results of ShotSpotter incidents what this likely tells us, is that while actual violent crime may likely not be impacted much, firing guns is. This suggests that the MSTs may raise the deterrence for randomly firing guns, but perhaps not for cases where a person is victimized with a firearm. What this suggests, is that there may be a profound difference between simply firing a gun and using that firearm against another person. Whereas random firing of weapons may be deterrable by improving surveillance, it makes some sense that assaultive use of guns -which likely involves more profound emotions- may be more difficult to prevent.

Table 17. GLM coefficients violent crimes

	Distance	*Before-During*	*After-During*	*Before and After-During*
RMS Aggravated Assault				
All MSTs	0-500	1.141627	1.111928	1.124824
n=380	500-1000	1.465981	1.060836	1.238366
	1000-1500	.9934225	1.1992	1.083269
Functional MSTs	0-500	1.168669	1.155691	1.157564
n=308	500-1000	1.397243	1.082083	1.231521
	1000-1500	1.063187	1.278641	1.155149
Placebo MSTs	0-500	1.204499	.9995039	1.126299
n=72	500-1000	1.918345	1.090683	1.36053
	1000-1500	.6237707	.8277988	.7319501
RMS Robbery				
All MSTs	500	2.577162	2.157272	2.409079
n=380	1000	2.445487 *	3.990553**	2.983133**
	1500	1.661438	.6396404	1.073286
Functional MSTs	500	1.118328	.7945655	.9811137
n=308	1000	3.455024 **	3.480093**	3.463731**
	1500	2.087856 *	.7460079	1.318479
Placebo MSTs	500	2.31e+07 ****	6.40e+07 ****	1.28e+07***
n=72	1000	.3334502	1.23e+07 ****	1.500249
	1500	.6155939	.3323848	.4490774

* P<.1 ** P<.05 *** P<.01 ****P<.001

To explore this a bit further we aggregated all violent crimes (homicide, aggravated assault and robbery) and additionally restrict them to incident reported to have occurred outside. Again, results indicate relative increases in treatment sites compare to prior levels and control sites. We believe these results are driven primarily by relative increases in robberies. In further analysis we extracted robberies that occurred on the street (not shown here), which indicates similar results. By contrast when we explore robberies reported in CAD data we see the opposite, with roughly an average 25% reduction at 500 feet, a 10% reduction at 500-1,000 feet and an increase beyond 1,000 feet. So, whereas reported incidents decreased (CAD data), police verified incidents relatively increased (RMS data) in the treated areas. These contrasts are difficult to logically unify, and likely an outcome of the relative rarity of such incidents.

Table 18. GLM results Violent crime

	Max. Distance	*Before-During*	*After-During*	*Before and After-During*
RMS Violent Crime[1]				
All MSTs	500	1.359784	1.224254	1.302449
n=380	1000	1.764038**	1.368972	1.55373**
	1500	1.080927	1.020741	1.050702
Functional MSTs	500	1.132444	.9535761	1.049267
n=308	1000	1.880688 **	1.403704	1.637088**
	1500	1.151147	1.071558	1.113192
Placebo MSTs	500	3.340459	3.807592	3.506979
n=72	1000	1.204726	1.157932	1.158312
	1500	.7477137	.7484795	.7531437

RMS Violent Outdoor				
All MSTs	500	1.290358	1.132027	1.221499
n=380	1000	1.86202**	1.418312	1.61443*
	1500	.9718034	1.249522	1.100424
Functional MSTs	500	1.063978	1.003743	1.039157
n=308	1000	1.706939	1.326286	1.511924
	1500	.9696302	1.279218	1.110391
Placebo MSTs	500	2.26996	2.853583	2.427731
n=72	1000	2.958484	1.425227	1.929042
	1500	.9887818	1.062121	1.032588
CAD Robbery				
All MSTs	500	.7528187	.7247597	.7322341
n=380	1000	1.113577	.7135167	.9007139
	1500	1.953642*	1.018099	1.458824
Functional MSTs	500	.5350411	1.53833	.7463033
n=308	1000	1.212649	.7534309	.9827957
	1500	2.940839**	1.286285	1.985426**
Placebo MSTs	500	3.11047	.2541663	.8881916
n=72	1000	4.65e-07***	8.42e-08***	2.30e-07***
	1500	.17625*	.1423324*	.1647058**

1. Includes: aggravated assaults, homicide and robbery, but excludes sexual assaults.

* P<.1 ** P<.05 *** P<.01 ****P<.001

The picture for larcenies is a bit more consistent across data sources, and given its greater we believe these results are more indicative. Here we find that larcenies reported in both CAD and RMS data show substantial but non-significant reductions. For RMS data the reported average reductions are around 10% at 500 and 1,000 feet and a smaller reduction further out. CAD reported larcenies indicate almost a 30% reduction at 500 feet, a 15% reduction between 500 and 1,000 feet and essentially a flat reading beyond 1,000 feet. What is more for both data sources the pre-treatment period produces greater reductions than the post-treatment period, which further may suggest that treatment effects may persist to some extent beyond deployment. Furthermore, here we see few differences between functional trailers and placebo trailers, indicating that any deterrent effects are likely similar, regardless of functioning or a placebo MST.

Table 19. GLM results Larceny.

	Max. Distance	*Before-During*	*After-During*	*Before and After-During*
RMS Larceny				
All MSTs	500	.7921588	.9918048	.8909277
n=380	1000	.8578883	.8869797	.8715595
	1500	1.026554	.877658	.9502023
Functional MSTs	500	.8580287	1.071411	.9596758
n=308	1000	.8214847	.8270192	.8233432
	1500	1.003445	.8587369	.9283272
Placebo MSTs	500	.5645976	.7595036	.6788677
n=72	1000	1.109287	1.39382	1.228327
	1500	1.141821	.9712025	1.058063

CAD Larceny				
All MSTs	500	.6451982	.7886666	.714452
n=380	1000	.9188728	.8286759	.8660611
	1500	.8073672	1.213794	.9784826
Functional MSTs	500	.7588713	.6847793	.719236
n=308	1000	.9067379	.8272101	.860417
	1500	.787956	1.317325	1.002175
Placebo MSTs	500	.3166654	1.014295	.6088942
n=72	1000	.7501682	.7409988	.7473484
	1500	.8779546	.7563949	.7992255

* P<.1 ** P<.05 *** P<.01 ****P<.001

For motor vehicle thefts we do see sizeable reduction (~30%) at up to 500 feet comparing before to treatment, but we also find an increase in the area 500-1000 feet and those effects hold for both functioning and placebo trailers. This could indicate that some displacement occurs, but given the dramatic 2022 increases in vehicle theft (see figures 9-11), it is also quite possible that the coefficients are statistical noise created by the rapid increases.

Table 20. GLM results vehicle thefts.

	Max. Distance	*Before-During*	*After-During*	*Before and After-During*
RMS Vehicle Theft				
All MSTs	500	.6998607	1.044709	.8172233
n=380	1000	1.656452*	1.147547	1.417167
	1500	1.354875	1.267093	1.312956
Functional MSTs	500	.8304332	.9911613	.8889566
n=308	1000	1.533132	1.171906	1.365504
	1500	1.441102	1.350629	1.397329
Placebo MSTs	500	.3349101	1.494528	.6239544
n=72	1000	2.281807	.9870669	1.643504
	1500	1.060926	1.020492	1.027063

* P<.1 ** P<.05 *** P<.01 ****P<.001

Finally, we compare two aggregated categories. For all RMS incidents the results suggest no real impacts. For incidents occurring outdoors (primarily driving by larcenies), results suggest some impact in the smallest buffer with a relative reduction around 20%, essentially replicating what we saw for larcenies.

Table 21. GLM results total incidents

	Max. Distance	*Before-During*	*After-During*	*Before and After-During*
RMS All Incidents[1]				
All MSTs	500	.9450027	1.146204	1.039133
n=380	1000	1.16845	.9603755	1.064168
	1500	1.185553	1.008597	1.097602
Functional MSTs	500	.9438705	1.115599	1.027579
n=308	1000	1.122803	.9563037	1.040314
	1500	1.211054	1.038532	1.126061
Placebo MSTs	500	.967575	1.308549	1.123101
n=72	1000	1.426235	.999515	1.181919
	1500	1.058852	.8609726	.9522027
RMS Outdoor only[2]				
All MSTs	500	.8020863	.80731	.8083122
n=380	1000	1.227132	1.1267	1.180267
	1500	1.128771	1.005235	1.069343
Functional MSTs	500	.7438743	.7658004	.7584665
n=308	1000	1.099646	.9969242	1.053779
	1500	1.166719	1.003023	1.089067
Placebo MSTs	500	1.128293	1.037899	1.109148
n=72	1000	2.114789*	2.025623*	2.089658**
	1500	.9290762	.9983076	.9593073

1. Includes all categories commonly present in UCR Part I incidents, homicide, sexual assault, robbery, aggravated assault, larceny, burglary, motor vehicle theft and arson.

2. Only includes those reported to have occurred in an outdoor setting

* P<.1 ** P<.05 *** P<.01 ****P<.001

Results of the evaluation thus suggest limited impacts on some property offenses (larceny and MVT) and gunfire (ShotSpotter alerts), but conflicting evidence on violent crimes. One of the primary reasons for the lukewarm results may well be a combination of limited crime incidents in the small locations, limiting the ability to find significant results, coupled to volatile crime trends during the experimental period.

We did see encouraging results in the ability of MSTs to reduce gunfire and create modest reductions in larcenies (both decreasing by around 20%). Results for vehicle thefts were a bit more mixed with those up to 500ft from the trailer reducing, but also showing a relative increase 500-1,000 feet. Results for violent offense displayed more volatility in the results but generally indicate relative increases, particularly for robberies, although results were only found in RMS data, whereas CAD did show some modest reductions. It is important though to point out that most categories of crime did experience actual reductions during deployments, which means that the increases in DID models suggest that the control sites experienced greater relative declines than the MST sites.

Obviously, these inconclusive results are somewhat disappointing. During a midpoint evaluation, results pointed more toward consistent reductions, especially for violent crimes but at that point even fewer datapoints were available. Even in the final results many categories of crime, including violent crime do show drops in crime in the treated locations, but some of these drops are eclipsed by drops in

the control sites. Coupled with volatile crime trends during the period and an overall limited number of crimes in areas close to the MST and control sites means that detecting significant changes in crime is difficult. We are encouraged by the fact that larcenies and ShotSpotter alerts did show promising drops in crime and that especially for larcenies those drops were relatively larger nearer to the MST sites as well as showed most improvements compared to pre-deployment crime levels. We also saw few differences between functioning and placebo trailers. While the placebo coefficients are a bit more variable they generally move in a similar direction as the coefficients of the functional trailers. While it is certainly too early to state that functioning trailers create greater crime reductions, it is reasonable to conclude that both appear to reduce gunfire, larcenies, and motor vehicle theft.

One of the key issues is that gun violence in particular was at a multiyear peak when the experiment began and those numbers rapidly dropped throughout 2020 and the beginning of 2021. The introduction of such volatility in the data requires a much larger number of observations/deployments to achieve valid statistical conclusions. In addition, the SLMPD faced substantial attrition among its commissioned officers during the experimental period (2020-2022), dropping from around 1,200 officers to below 1,000. This not only impacted the ability of the project to remain consistent in the length of deployments, but also may have well impacted response times. Civil unrest at the beginning of the research period likely contributed to growing distrust in police more broadly and this may well have impacted reporting of incidents. The presence of an MST in vicinity of a victim, however, could potentially also increase reporting of incidents. It is well known that only a fraction of all crimes are reported and a variety of factors may explain this (distrust in police, fear of reprisal, etc.). The presence of an MST may improve confidence in a victim to report an offense or may reduce fear of reprisal for reporting victimization. In short, the fact that our results may not show conclusive results could well have been an outcome of structural conditions beyond control of the implementation of the project.

It is also important to note that MSTs provide enhanced intelligence gathering capability and anecdotal input from officers in and outside of the SLMPD does indicate that having eyes on the streets can make a difference in developing leads and resolving cases. Indeed, our survey results also suggest that support for technology is closely aligned with personal successes with a particular technology. Unfortunately, the lack of tracking of investigative outcomes with technology makes this point difficult to confirm.

6. Integration and Sustainability

With completion of the SPI project comes the question of how we can sustain progress made. There are several ways in which this project has already altered practices. First, as a direct result of our SPI project we have created ways in which the trailer locations are tracked, both in real-time (GPS portal) and in our agency's CAD system. Second, as part of this project we have designed a way to more systematically deploy the MSTs. We believe this practice can be (relatively easy) implemented both at the SLMPD, but also by other agencies committed to evidence-based deployments. Given our results we would advocate focusing deployments on gunfire hot spots as well as hot spots for thefts.

Although we initially considered using new software to guide deployments, we believe the procedure we developed in ArcGIS is easier and more cost-effective as most agencies considering this type of technology are likely to already using similar geospatial software, which can help with standardizing deployment on relatively objective standard. We feel the importance of using consistent criteria cannot be overstated. Over the last few years police technology has been maligned for using nebulous criteria and over-policing of communities of color. Having a transparent process in place for deploying technology, be it fixed or mobile, allows closer scrutiny of technology implementation and allows easier communication of police practices to community members. This can help enhance accountability and improve trust between police and communities. Developing in-house procedures may in fact provide a benefit as these procedures can often be documented easier than models and algorithms developed by vendors who -somewhat understandably- tend to shield their modeling for business purposes.

Given that MSTs' utility seems limited to deterring gunfire and thefts we have discussed how the SPI trailers will be used going forward. As we are awarded another SPI project focused on improving the use of ShotSpotter technology, we intend to deploy the SPI MSTs in gunfire hot spots for the next few years. Not only will this help us understand if the MST are truly effective in deterring gunfire by adding to the data collected thus far, but they will also assist the department to provide surveillance on extreme gunfire hot spots and hopefully increase intelligence gathering efforts

Another important lesson from the current project is that gunshot detection on the surveillance units adds no real value, in our case. As we found, the onboard gunshot detection is far less accurate than the fixed gunshot detection system the SLMPD also uses. In addition, we find some evidence that presence of MSTs reduces the number of gunfire incidents near the units. Give that the practical reach of gunshot detection on the MSTs is only about 600 feet means that the gunshot capability is a self-defeating feature. Given the substantial cost of onboard gunshot detection we do not recommend it for most circumstances. In situations where an agency has no other means of tracking gunfire and the trailer is deployed in an area with wide views the detection may prove helpful. For our situation integrated gunshot detection in the trailers was clearly not advantageous. While we are hopeful that future advancements in reliably detecting gunfire may improve in mobile solutions we would encourage other agencies to carefully consider the need for gunshot detection on mobile surveillance equipment.

Another important element that our project has made us realize is that most agencies do not do a great job of tracking the utility of technology with respect to case resolution. It is extremely difficult to systematically figure out which cases have been substantially impacted by camera footage, LPR hits or gunshot detection alerts. We recommend that agencies attempt to create a sound way to track which

technologies aid in cases and ideally also quantify technology's relative impact on outcomes (arrest, referral, prosecution and conviction). This is now more important than ever as public resistance to police technology has grown. Given our lackluster results with respect to crime impacts, it is therefore important to understand how technology helps agencies beyond any crime reductions. Being able to quantify what proportion of cases sees improvements in outcomes as a result of technology deployment is important not only to justify public funding of such technology, but also to provide a reasonable counterweight to arguments that technology leads to over-policing of communities of color. If technology can increase the effectiveness of holding offenders accountable it has the potential to serve justice for those communities most at risk.

We would encourage agencies with a RTCC to develop a database in which anyone who accesses technological surveillance resources has to report which technologies they accessed (and where) as well as provide updates to the results. Understandably, this is a big ask of agencies as tracking these data is not part of existing data sources. However, the potential that this can help the agency, researchers, but more importantly the wider community understand the importance of technology cannot be overstated. Did video footage, for example, help identify a suspect? This would be for most agencies reasonably doable. Where it gets more difficult, for example, is in answering questions like: Did the footage provide the key evidence to refer a case to prosecution? Capturing this kind of data, which are generally not available in most CAD/RMS systems is unquestionably difficult.

If -as anecdotal evidence suggests- technology can enhance case resolution, we should document this more systematically as part of law enforcement growing commitment to evidence-based solutions. Aside from systematic tracking there are other -less perfect- ways of capturing this. We touched on this somewhat when we asked respondents in our law enforcement surveys about the ability of specific technologies to produce certain outcomes (see table 7). This is an ad hoc approach, but it is instructive as it can help determine which technologies produce relatively more results.

7. Summary and Conclusions

St. Louis received funding to deploy Mobile Surveillance Trailers (MSTs) equipped with cameras, license plate readers and gunshot detection. During its SPI project the SLMPD deployed MSTs 95 times in areas that were systematically selected for high violent and vehicle related crimes. To measure if the deployments were effective the department also tracked crime trends in similar high violence areas that did not receive trailers (control areas). In addition, our RCT includes deployments of an MST that had no surveillance capacity (placebo) to further help understand if any deterrence is related to investigative capacity, or whether simple presence is sufficient.

We are encouraged that the trailers indicate some moderate crime reductions (~20%) for gunfire and thefts in a 500 feet area around the MSTs, but are somewhat disappointed that those reductions did not attain statistical significance and especially that no strong evidence for reductions in violent crime was found. Even though the results for gunfire and theft reductions are not statistically significant we believe they are most likely real outcomes and not due to random chance. For one, the declines are strongest at 500 feet, but still shows -albeit smaller- declines at 1,000 feet, which is consistent with the literature on the diffusion of crime reduction benefits. Also, the prior literature on crime impacts of cameras, identifies thefts as most likely impacted. In addition, both thefts and gunfire are the most common crimes occurring in general and therefore have a higher statistical power than violent crimes. We are therefore cautiously optimistic about these findings. Our results further indicate that there are no substantial differences in deterrent impact regardless whether the MSTs were fully functional or not, but given that we have far fewer deployments of the placebo unit (18 placebo, versus 77 functional) it may be too early to tell if deterrent benefits are truly equal as the crime numbers around placebo units fluctuated more. This, however, may be a simple outcome of sample size differences.

In line with our initial expectations for the project we performed a randomized control trial of mobile surveillance trailers. The SLMPD successfully completed its deployments throughout the grant period. Each deployment was guided by a consistent hot spots identification strategy developed by the CAU. As MST capacity expanded at the SLMPD more broadly, growing awareness of the technology's capabilities developed among SLMPD personnel. Support for the technology suggests a growing buy-in to the functionality of the trailers, but also for technology use more broadly

We faced numerous challenges throughout the project period, from COVID related delays, to urban unrest, to personnel shortages. While these disruptions caused some initial delays of implementation once our deployments began, they continued without further serious disruptions. Our deployment strategy remained consistent, but deployment length did become longer on average toward the end of the project as personnel shortages had some impact on the speed with which trailers were moved. The units themselves largely operated as intended with relatively few outages.

We did find some problems in implementation, such as the gunshot detection system that was not very accurate and required a lot of time setting up after each redeployment, but we believe this did not substantially impacted our ultimate results. The limited viewshed on the PTZ cameras was another functional drawback and may limit evidence collection. In short, implementation of the project may be considered successful with only minor setbacks. We believe it is important to point out that our project also received the 'project of the year award' from the International Association of Police Planners in

2020 and we gave a presentation for CNA's 2021 national SPI conference highlighting our unique approach and early results.

We also took advantage of BJA's TTA opportunities and early on in the project -before implementation- several project personnel visited Memphis, TN to get a closer look at their MSTs and deployment strategies. We believed this TTA was extremely useful as it helped us gain insights in how the trailer could be integrated in our RTCC. Our monthly meetings with CNA's TTA team were also quite helpful to relay progress and receive feedback. We believe this TTA program is fundamental to keeping us on track and a resource we could draw on with specific questions, particularly during development of our Action Plan. In general, we believe the TTA assistance we received helped our approach be more methodical and was critical in keeping communication and feedback flowing through all project members. We see the SPI program as the key program in BJA's policing focused grants that promote evidence-based approaches and commend its emphasis on integrating research partners in all aspects of the program. Given the growing importance of technology in policing the results of SPI project have meaningful impacts, not just on the departments who implement them, but also serve to inform the wider law enforcement community.

Our project also produced important lessons with broader applicability. First, we found that integrating gunshot detection in MSTs is unlikely to be helpful. The technology is no match for fixed gunshot detection systems as the accuracy is substantially lower. In addition, because the MSTs likely deter gunfire in immediate sightlines there is not much additional intelligence gained by adding gunshot detection to its capabilities. PTZ cameras can be great in situations where cameras feeds are actively monitored, but can hurt investigative capacity if they are deployed in fairly narrow city streets and restrict the field of view.

The MSTs we deployed appeared to only have a limited deterrent distance with moderate impacts occurring up to about 500 feet. This indicates that deployments should be extremely focused on micro hot spots for crime to gain deterrent effects. Just the same, the units can be a great tool to gather additional visual intelligence in areas that lack critical infrastructure for fixed surveillance equipment. Much like prior research on cameras the deterrent impact appears mostly limited to property offenses with no discernable impact on violent offenses. This makes some sense as thefts are probably more driven by calculating behavior than violence. One exception is that we found some evidence for reduction in gunfire, but not violent crime. The type of gunfire that is suppressed by MSTs is therefore likely gunfire that has no assaultive intent (target practice or celebratory gunfire). Just the same, being able to reduce gunfire increases public safety and may likely impact residents' feelings of safety.

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