# Optimizing the Use of Video Technology to Improve Criminal Justice Outcomes

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Final Summary Overview

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# Abstract

This publication represents a technical summary report of the Urban Institute's evaluation of efforts with the Milwaukee Police Department (MPD) to improve its public surveillance network. The goal of this study was to conduct a rigorous process, impact, and cost effectiveness evaluation of the process MPD took to optimize its network, which included improving operations, installing new cameras, and integrating video analytic technologies into its system. The two video analytic technologies were (1) automatic license plate recognition cameras and (2) high-definition cameras connected to gunshot detection technology.

The evaluation used a mixed-methods research design. Qualitative data collection included in-depth observations of the department's camera operations to understand their practices and determine which types of improvements would most benefit the program, as well as stakeholder interviews with staff members who either worked directly within the camera program or routinely used its footage in their work. We conducted interviews with camera operators, camera program supervisors, shift commanders, crash reconstruction unit officers, specialized investigations division officers, criminal investigations bureau detectives, and civilian managers from the department's communication division. We also collected numerous quantitative data, including administrative crime data, metadata from the camera system, and systematic data on the costs associated with the system upgrades. We then used these data to assess: (1) the overall impact all of the interventions had on crime at the city, focus area, and intersection levels; (2) the specific impact of the two video analytic components on crime; and (3) the costs of the upgrades relative to their effectiveness.

Our findings indicate that the impact of these interventions was mixed. We analyzed data in the two areas where MPD concentrated their surveillance optimization efforts and found some decreases in crime. However, when we focused on our analyses on the specific intersections where cameras and other technologies were installed, our models found increases in some criminal events, which is likely the result of the new cameras capturing crimes that may have otherwise been missed by the department. We also found no significant changes in crime in the areas where the two video analytic technologies were implemented compared to matched comparison areas.

The findings from this research yielded several important lessons for improving criminal justice policy and practices. First, police departments must have strong, collaborative relationships with the vendors they select to upgrade their surveillance systems. Second, agencies that engage in efforts to optimize their surveillance systems should regularly re-evaluate their goals and processes to maximize the effectiveness of these new technologies. Finally, departments should ensure that all necessary personnel are made aware of the new technologies and have adequate access to them.

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# Acronyms

| | |
|---|---|
| ALPR | Automatic License Plate Recognition |
| CSC | Center Street Corridor |
| DiD | Difference-in-Differences |
| MPD | Milwaukee Police Department |
| NIJ | National Institute of Justice |
| PTZ | Pan, Tilt, Zoom |
| TCD | Technical Communications Division |
| Urban | Urban Institute |
| VA | Video Analytics |

# Introduction and Purpose

In 2015, the National Institute of Justice (NIJ) funded the Urban Institute (Urban) to work with the Milwaukee Police Department (MPD) to develop and execute a rigorous and detailed plan to optimize its surveillance system. This included installing new high-definition cameras in high-crime locations across the city and implementing a host of other technological and infrastructural upgrades to improve the MPD's system. In total, the MPD updated policy and practices that governed its camera program; strategically moved the camera program from its Technical Communications Division to its real-time crime center; more than doubled the amount of cameras in the city; and integrated two video analytic (VA) technologies into the surveillance system. Urban conducted a rigorous process and impact evaluation of the department's efforts using a mixed-methods research design to assess the impact the interventions.

The purpose of this study was to enhance the field's knowledge about how existing public surveillance systems can be improved and how VA can aid policing and investigation activities. Prior research indicates that the impact of public surveillance systems on crime can be mixed, where the effects are largest when placed in or around car parks and with the largest impacts observed on property crimes.[1] To best optimize the MPD's system, we emphasized placing the cameras in strategic and data-driven locations and identifying other technologies that could enhance the effectiveness of the camera program. Furthermore, the cost of supporting trained camera staff is substantial, and even trained camera operators have limited capacity to catch or discern crimes in progress or maximize the use of cameras to aid in criminal investigations. As such, VA – software integrated with surveillance systems to detect people, objects, and events of interest – can enhance policing strategies with real-time alerts, especially with appropriate calibration and high-quality video processing. Despite the promise and increasing accessibility of VA, there have been no rigorous evaluations to guide its deployment and use. This technical summary provides an overview of the interventions, data, the methodologies of and results from the process and impact evaluations, and implications for criminal justice policy and practice in the United States.

# Study Jurisdiction & Interventions

Milwaukee has a population of about 600,000 people with similar shares of white and African-American populations (35.9 and 38.8%, respectively) and a Hispanic population of 18.2%.[2] The city's violent crime rate

in 2017 was 159.74 per 10,000 people, making it the 7th most violent city with a population of 100,000 or more in the country, and its property crime rate (379.20 per 10,000) ranked it in the top third of those cities.[3] The MPD's public surveillance system was originally deployed in 2007 with 15 cameras and a comprehensive management and viewing system. The system was expanded several times between 2007 and 2011, resulting in 42 cameras across 40 locations.

## Kickoff Meeting

Urban held a kickoff meeting with the MPD, NIJ, and outside experts on VA early in the project to learn more about the MPD's system, identify its strengths and challenges, and determine which surveillance technologies could be implemented as part of this project. Urban also interviewed MPD's camera operators and other staff and conducted observations of the camera program. The focus of this meeting was to provide in-depth information on the different types of video surveillance and analytic technologies the MPD could use to optimize their system, which included examples of:

- **Perimeter detection** is where the camera operator is alerted if an individual or object crosses a predetermined border. For example, someone jumping over a fence or going onto a train track.
- **Crowd detection** is where the camera operator is alerted if groups of people gather together. For example, at a street corner known for drug dealing.
- **Object detection** is where the camera operator will be alerted if an object, such as a bag, is present in an area where it is typically not.
- **Person tracking** is more common with internal surveillance systems, but allows a camera operator to identify an individual to automatically track from camera to camera.
- **Facial recognition** allows the camera system to recognize a human face and potentially run the image through a database to identify the individual. Law enforcement departments can connect administrative records to automatically alert operators when a known suspect is identified.
- **Integration with gunshot detection technology** forces PTZ cameras to automatically turn to a predetermined location or hone in on the location of a shooting when a gunshot detection technology (GDT) alert is registered within a preset distance of the camera.
- **Automatic license plate recognition (ALPR)** analytics is where the camera operator will be alerted if the camera has identified a license plate that matches administrative data on wanted vehicles.

## Upgrades to surveillance system

The MPD deemed many of these technologies and VA too challenging to be integrated in their system (e.g., facial recognition software) but expressed interest in acquiring new, high-definition pan, tilt, zoom (PTZ) and panoramic cameras and integrating two VA technologies into its system, including ALPR cameras and the connection of PTZ cameras to the GDT system. By the end of 2016, a detailed implementation plan was

developed outlining these planned interventions. Urban conducted a competitive bidding process in early 2017 to identify a vendor, which was selected and began work later in the year, resulting in all new cameras and VA being installed by January 2018. In total, the MPD's camera program more than doubled, from 42 cameras to 87, with 24 new panoramic cameras, 12 PTZ cameras, 9 ALPR cameras, and the relocating two old PTZ cameras to more appropriate locations.

**Cameras:** PTZ cameras allow camera operators to adjust the angle of cameras and zoom in and out to better track people and objects and aid in investigations. The movements of these cameras are controlled by one or more combinations of a remote operator, a program for how the cameras should scan an area, or a program that directs the cameras to a given area based on a triggering event. These cameras typically have a viewshed of 35 degrees and most use an optical zoom but can also include a digital zoom at its maximum optical zoom settings. The original PTZ cameras the department used had 600-foot zooming capabilities, but zooming in to this extent resulted in poor quality images that weren't useful. The new PTZ cameras installed as part of this project were able to zoom 1,200 feet and provide high quality images at maximum zoom. The MPD also expanded their use of panoramic cameras in the city. Panoramic cameras are stationary, but they have a much wider viewshed (180 degrees or more) that constantly captures a large area, preventing the operator from missing important details when observing something else. Panoramic cameras typically have a much higher resolution with a single lens, so instead of allowing for the optical zoom of a PTZ camera, they allow for digital zoom.

**Video Analytics:** The MPD and Urban worked with the selected vendor to integrate PTZ cameras into the department's GDT system that were within its coverage area. GDT software automatically detects, verifies, and rapidly notifies police dispatchers and officers of the specific times and locations of firearm discharges.[4] This is accomplished through a network of acoustic sensors mounted on high structures in a city. As part of this project, 17 PTZ cameras were programed to automatically turn when a GDT alert occurred within 500 feet of the camera. To maximize the change of collecting video evidence of vehicles or people fleeing from the scene, the cameras were programed to turn to the center of the intersection and zoom out fully.

The MPD and Urban also worked to install ALPR cameras, which make use of infrared technology that collects light reflected from reflective materials (e.g., license plates), take pictures, and process these images through analytic software. Once the software confirms the reflective material is a license plate, it can identify the characters to output a digital version of the license plate number that can be stored or cross-referenced against a database. The MPD used ALPR cameras to automatically check whether captured license plate numbers were in the department's "hot list" of vehicle tags. The hot list is a daily-updated database of wanted vehicles by the MPD, including vehicles known to be stolen, involved in crimes, or connected to wanted individuals. When a license plate was identified, an alert would appear on the operator's screen to inform them that the wanted vehicle just passed a specific ALPR camera and that follow up was necessary, such as contacting dispatch or radioing officers in the area.

## Focus Areas

As past research has emphasized, Urban and the MPD focused optimization efforts in strategic locations throughout the city to maximize the impact of the new cameras and VA. Through in-depth analyses of violent and property crimes, GDT alerts, and stolen and recovered vehicle data, as well as specialized knowledge from MPD staff, we identified locations in the city that were best suited for these upgrades. The primary focus area was the Center Street Corridor (CSC), an area of approximately 2.27 square miles on the city's North side that has historically had high amount of crime. For example, since early 2012 to mid-2016, the CSC accounted for 5,747 GDT alerts (i.e., individual shooting events), or roughly 118 alerts per month. Prior to the improvements through this project, the CSC had a total of 7 cameras in 5 intersections, but 4 of the locations were located on the border of the CSC, while only one was within the CSC. After the improvements, the CSC had a total of 25 cameras (4 new PTZ, 9 new panoramic, and 5 new ALPR) covering a total of 15 intersections.

The second focus area was the Muskego Way neighborhood on the city's South side, which covers approximately 1.49 square miles. This area also experienced historically high levels of crime and was home to numerous businesses along one of the streets in the area. Prior to this project, the Muskego Way neighborhood had a total of 8 PTZ cameras in 8 locations. After the improvements, the neighborhood had a total of 23 cameras (6 new PTZ, 5 new panoramic, and 4 new ALPR) covering a total of 15 intersections.



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In addition to the two focus areas, the MPD had another 27 PTZ cameras in 27 other locations around the city. The department identified high-priority locations and installed 12 additional cameras to improve surveillance (10 locations with new panoramic cameras and 2 with PTZ cameras). Thus, the full camera network went from 42 cameras (40 PTZ, 1 panoramic, 1 fixed-box) across 40 locations to 87 cameras (52 PTZ, 25 panoramic, 1 fixed-box, 9 ALPR) across 57 locations.

## Operations

Other efforts were made to improve the operations of the camera program. Most importantly, the original camera program operations center was located in a small room inside the MPD's Technical Communications Division (TCD), the 911 call and dispatch center. The original program had two stations with a total of 12 monitors. Three of the monitors were dedicated to internal MPD surveillance and a fourth to the department's CAD system. One radio was available to communicate with patrol officers responding to scenes near cameras. This setup resulted in the camera program being isolated from other operations within the TCD and little recognition of the program from officers and investigators in the field who could have benefitted from the evidence provided by the cameras.

As part of this project, the camera program was moved to the department's Fusion center, its real-time crime investigation center where investigators and crime analysts work and where the GDT program operates. The project also supported the purchase of three new work stations, each with four monitors as well as additional computers and monitors so all five stations could have a CAD connection. The MPD also brought in more staff to operate the new stations. In addition to the physical location change, this move brought the supervision of the program under Fusion, which helped to integrate the cameras more fully into the department's other intelligence-driven operations. **Appendix A** includes photographs of the original and upgraded camera program centers.

In conjunction with the move to the Fusion Division, MPD leadership updated its standard operating procedures in regards to how officers and investigators are expected to request video evidence from the camera program. Prior to this project, department staff where required to submit a form when *obtaining* video footage from the camera program. The research team emphasized that the department was missing many instances of video *requests* made to the program. As such, a new form was created with new

data points to better track requests and evidence collected from the camera program and a new standard operating procedure was created to inform officers to use that form. Furthermore, the operators within the camera program were requested to log success stories, such as instances when their investigation of camera footage provided useful information to a case. As noted earlier, the original camera program was not a well-known tool among officers and investigators, and while this was improved when it was moved to the Fusion Division, MPD leadership also produced a roll-call video with a presentation from the chief to inform officers of the upgrades and the new standard operating procedure. District-specific maps were also installed within each district to help officers know the exact locations of the cameras.

Lastly, the software used for the camera program (Genetec) was updated to the most current version. The MPD determined an old version of the software was being used, which was preventing the operators from using many features released in newer versions. The vendor that installed the new cameras completed this upgrade and lead multiple training sessions to teach the operators the new features available to them, as well as learn from the operators about areas that needed improvement.

## Methods and Data

The research team worked closely with the MPD to collect robust data associated with the camera program. Qualitative data collection included in-depth observations of the department's camera operations to identify best practices and determine which types of improvements would benefit the program most as well as stakeholder interviews with staff members who either worked directly within the camera program or routinely used its footage in their work. We conducted interviews with camera operators, camera program supervisors, shift commanders, crash reconstruction unit officers, specialized investigations division officers, criminal investigations bureau detectives, and civilian managers from the department's communication division. We also collected numerous quantitative data, including administrative crime data, metadata from the camera system, and systematic data on the costs associated with the system upgrades.

Using these data, we assessed the impact of the interventions on crime levels by conducting negative binominal panel regressions analyses with different samples to assess the percent difference in the outcomes between pre- and post-implementation, on average. We also identified comparison areas using propensity score matching to conduct difference-in-differences (DiD) analyses. Our samples included the

City of Milwaukee, the Center Street Corridor, the Muskego Way Neighborhood, all intersections with a new camera, intersections that previously did not have a camera but had a new camera installed, intersections that previously did have a camera but also had a new camera installed, intersections where PTZ cameras were connected to the GDT system, and areas with ALPR cameras. We examined many crime outcomes including total violent crimes (homicide, aggravated assault, robbery, rape), total property crimes (burglary, larceny/theft, motor vehicle theft), simple assaults, minor offenses (Group B), offenses that involved a firearm, vandalism offenses, drug crimes, and weapon law violations. We used quarterly time periods in the models, while controlling for aspects of land use and concentrated disadvantage.

# Findings

## Impact of the Cameras

**Appendix B** presents the findings across all of the study's samples and outcomes. There are three noteworthy findings when examining the results as a whole. First, models covering large areas, such as the city and two focus areas, observed significant decreases in the outcomes after the interventions were installed, but few significant changes were noted when compared to match areas without the interventions. The more specific models that focused on intersections where the cameras where installed also found decreases in the outcomes after the interventions, but DiD models found *increases* in the amount of crime. These increases are most likely the result of the camera program observing crimes that may have been missed by the department before the cameras were installed. Finally, cameras connected to the VA found decreases in crime after the interventions, but results were no different from matched comparison groups. It's worth noting that the same quarter the interventions were installed, a new police chief was sworn in, resulting in new policies, operations, and organizational staffing. As such, the DiD analyses are a better examination to assess the changes due to the interventions.

## Challenges Integrating Video Analytics

Through our interviews with MPD staff, we learned that the integration of PTZ cameras with the GDT had numerous challenges. First and most problematic, we learned that instead of having the cameras turn to the center of the intersection and zoom out to maximize their ability to capture a fleeing car or person, the cameras were instead turning to the intersection and zooming in. This yielded footage of pavement –

certainly not useful for investigations. There was also a delay in the alert going from the GDT vendor's software to the camera software, and then having the camera automatically turn in time to capture useful footage. And after the camera automatically turned, it did not reset to its previous settings. This often resulted in an operator coming back to their work station and finding that the camera was focused on the ground for hours after an alert caused it to turn. When the officer was present at the station, they found that the alert would pop up on their maps but only for a short period of time. This would cause the operators to be informed of the alert, but as they were following through to collect more information the alert would disappear, resulting in them potentially losing the location of the alert. That said, the operators supported being able to see where shootings were occurring and being able to review nearby footage from the cameras post hoc, directly from their work stations.

We also learned that the ALPR program had its challenges. The department found it very difficult to integrate the vehicle hit list with the camera software and had to work with the camera program vendor to figure out how to do this. More problematic was that once the hit list was integrated, the operators were overwhelmed with the amount of alerts. The alerts popped up on their computer screens covering their other work, resulting in them having to pause their work, click through the alert's notifications and then return to their work. Another problem was a software bug, where once they finished clicking through the alert, the interface of their camera set up would reset, resulting in them losing how they had their cameras focused or how the windows were set up for their use. But we also found that investigators liked having access to the ALPR information when they were investigating crimes. Most everyone we interviewed requested more ALPR cameras be installed throughout the city.

## Cost-Benefit

We conducted a cost-benefit analysis to determine whether the benefits in crime reduction associated with the interventions outweigh the costs of the technology. The MPD completed a cost-collection tool, from which we were able to calculate system, personnel, and training costs associated with the interventions. After a detailed literature review that rigorously estimated the costs of the crimes under review, we separated costs into four categories: criminal justice costs, victim costs, societal costs, and pain and suffering costs.[5] Individual cost-benefit figures were calculated in four ways, using the costs specific to the

criminal justice system, when including and excluding homicides; and using the costs specific to the criminal justice system, when including and excluding homicides. The first two models provide a more relevant ratio from a local financing perspective, in that they only include savings to the criminal justice system that conceivably would represent a deposit in local government coffers, whereas the last two models acknowledge the potential for gun violence reductions to yield far reaching monetary benefits that impact both individual victims/survivors and society overall. Our decision to run models that both exclude and include homicides is based on the fact that homicides are rare events with extraordinary costs both to criminal justice agencies as well as to victims and society, rendering most any intervention cost-beneficial if it has an impact on reducing even a small number of homicides. Excluding these costs provides a more conservative estimate of averted costs (savings). We detail these results in a forthcoming journal article.

## Implications for Criminal Justice Policy and Practice

The lessons learned from this study have yielded several important lessons for improving criminal justice policy and practices. First, it is critical that police departments have a strong, collaborative relationship with the vendor they select to make upgrades to their surveillance systems. These vendors must be responsive to the requests of the department and work closely with them to identify and address issues that arise during implementation. There were several instances in our project where the MPD would identify a problem (such as having PTZ cameras zoom in to intersections after GDT alerts) that would take several months for the vendor to fix as they negotiated and worked with the vendor to find a solution. This resulted in periods where some aspects of the technology were rendered useless; in some cases, these issues actually impeded the department's surveillance operations.

Relatedly, it is critical that departments continuously reassess how the program is working. In partnership with the MPD, we planned for and implemented these technologies in ways that we thought would be most effective at improving public safety and aiding in criminal investigations. However, we learned along the way that we had to revisit and modify these plans on a regular basis as technical and practical issues arose. For example, we had originally planned to have PTZ cameras point and zoom toward the direction of the actual gunshot (which was geo-located by the GDT software), rather than to the nearest intersection. However, after working with the MPD and the vendor, we learned that his would lead to

cameras pointing into trees, buildings, or other visual obstructions. Also, because there is a lag between the actual gunshot and the alert being connected to the PTZ camera, it is unlikely that this approach would have yielded actionable intelligence. Thus, agencies that engage in efforts to optimize their surveillance systems should regularly re-evaluate their goals and processes to maximize the effectiveness of these technologies.

Departments should also ensure that all necessary personnel are made aware of the new technologies and have adequate access to them. Through the course of our interviews in Milwaukee, we found that many officers and investigators were not aware of their department's camera program, nor the technologies that could benefit their day-to-day work (e.g., high-definition surveillance and ALPR cameras). This limited awareness of the program persisted even after we worked with MPD to create poster board printouts of the cameras locations for each district and had the police chief record a roll-call video detailing the program. Therefore, it is important that departments use multiple methods to promote and regularly remind officers about these programs and their benefits. Similarly, it is crucial that departments provide access to these tools. For instance, we found that patrol officers in Milwaukee had direct access to the department's GDT software on their phones and computers in their squad cars, but camera operators were only given indirect access to this technology through its integration with the camera software (e.g., when a PTZ camera was pinged by a GDT alert in the area). This resulted in delays in the operators being able to review camera footage and look for useful intelligence.

## Guidebook on Optimizing Public Surveillance Systems

We developed a guidebook for law enforcement agencies on how to optimize a public surveillance system to enhance crime control and prevention.[6] This deliverable outlines eight steps a decision maker should consider in order to enhance their existing system, along with the relevant considerations and questions that inform this process. This guidebook will help agencies identify their surveillance goals, consider the limitations and constraints of their current system, and develop a strategy to make meaningful improvements. These eight steps include: (1) Review current infrastructure and define surveillance goals; (2) Understand and develop policies and practices; (3) Identify focus areas and incorporate community voice; (4) Assess system performance; (5) Plan how to overcome constraints; (6) Acquire the right solution; (7) Implement and maintain the program; and (8) Continue monitoring the system for optimal performance.

# End Notes

[1] Cameron, A., Kolodinski, E., May, H., & Williams, N. (2007). *Measuring the effects of video surveillance on crime in Los Angeles*. CRB-08-007. Sacramento, CA: California Research Bureau.

La Vigne, N., Lowry, S., Markman, J., & Dwyer, A. (2011). *Evaluating the use of public surveillance cameras for crime control and prevention*. US Department of Justice, Office of Community Oriented Policing Services. Urban Institute, Justice Policy Center: Washington, DC.

Piza, E. L., Welsh, B. C., Farrington, D. P., & Thomas, A. L. (2019). CCTV surveillance for crime prevention: A 40-year systematic review with meta-analysis. *Criminology & Public Policy*, *18*(1), 135-159.

Welsh, B. C. & Farrington, D. P. (2002). *Crime Prevention Effects of Closed Circuit Television: A Systematic Review*. Home Office Research Study. 252. London: UK Home Office, Research, Development and Statistics Directorate.

Welsh, B. C. & Farrington, D. P. (2004). Surveillance for crime prevention in public space: Results and policy choices in Britain and America. *Criminology and Public Policy*, *3*(3), 497–526.

Welsh, B. C. & Farrington, D. P. (2009). Public area CCTV and crime prevention: An updated systematic review and meta-analysis. *Justice Quarterly*, *26*(4), 716-745.

[2] U.S. Census Bureau. (2018). 2012-2016 American Community Survey 5-year estimates. Retrieved from https://factfinder.census.gov/.

[3] Federal Bureau of Investigations (FBI). (2017). Table 8: Offenses Known to Law Enforcement by State by City, 2017. *Crime in the United States*.

[4] La Vigne, N. G., Thompson, P. S., Lawrence, D. S., & Goff, M. (2019). *Implementing gunshot detection technology: Recommendations for law enforcement and municipal partners.* Washington, DC: The Urban Institute.

Lawrence, D. S., La Vigne, N. G., Goff, M., & Thompson, P. S. (2019). Lessons learned implementing gunshot detection technology: Results of a process evaluation in three major cities. *Justice Evaluation Journal*, *1*(2), 109-129.

Lawrence, D. S., La Vigne, N., & Thompson, P. S. (2019). *Evaluation of gunshot detection technology to aid in the reduction of firearms violence.* Washington, DC: Office of Justice Programs.

[5] La Vigne, N., Lowry, S., Markman, J., & Dwyer, A. (2011). *Evaluating the use of public surveillance cameras for crime control and prevention*. US Department of Justice, Office of Community Oriented Policing Services. Urban Institute, Justice Policy Center: Washington, DC.

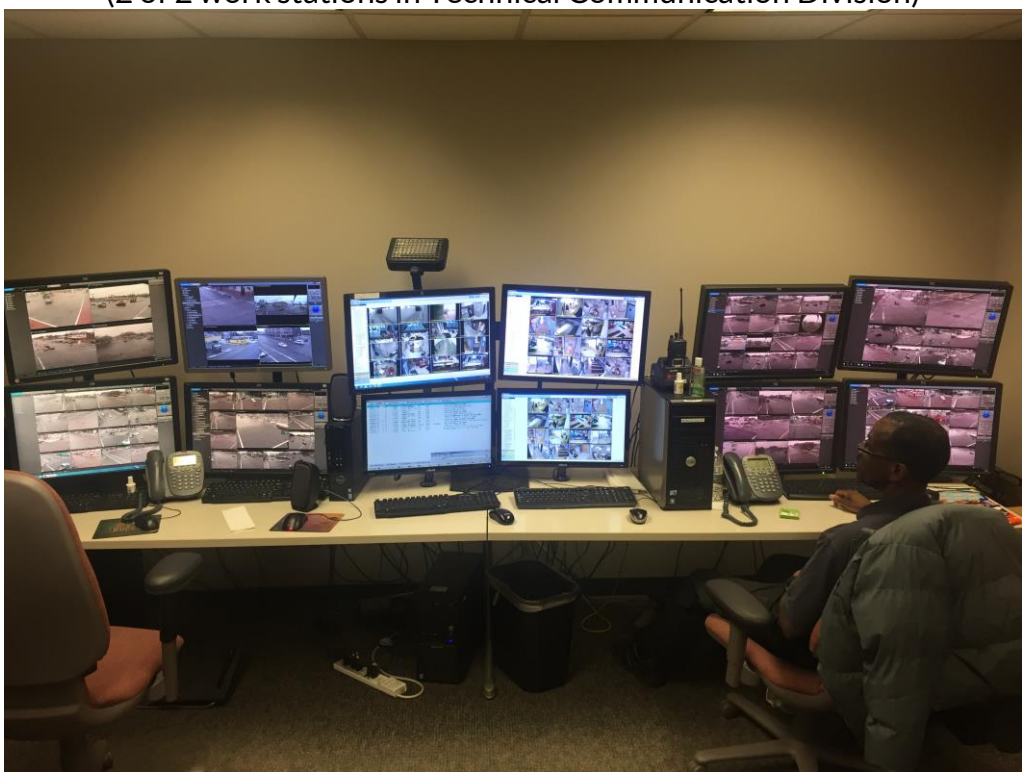
McCollister, K. E., French, M. T., & Fang, H. (2010). The cost of crime to society: New crime-specific estimates for policy and program evaluation. *Drug Alcohol Dependency*, *108*(1-2), 98-109.

Miller, T. R. (2012). *The cost of gun violence.* Calverton, Maryland: Pacific Institute for Research and Evaluation.

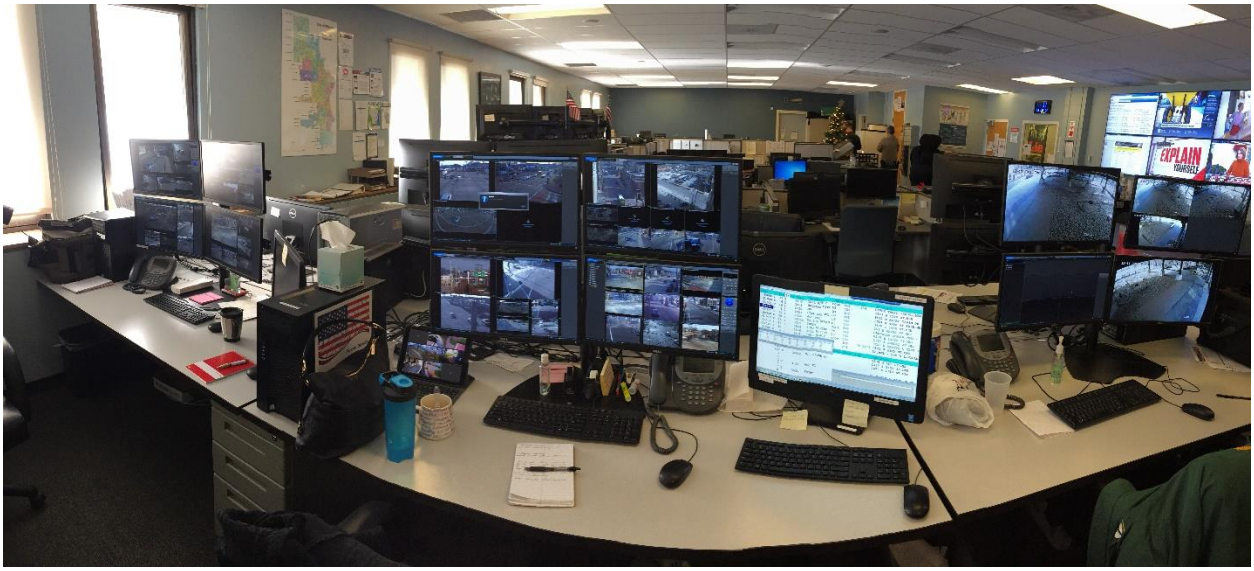
[6] Shukla, R. Lawrence, D. L., Peterson, B. E., McClure, D. (2019). *Optimizing public surveillance systems for crime control and prevention: A guidebook for law enforcement and their municipal partners*. Washington, DC: The Urban Institute.

# Appendix A - Camera Operation Centers

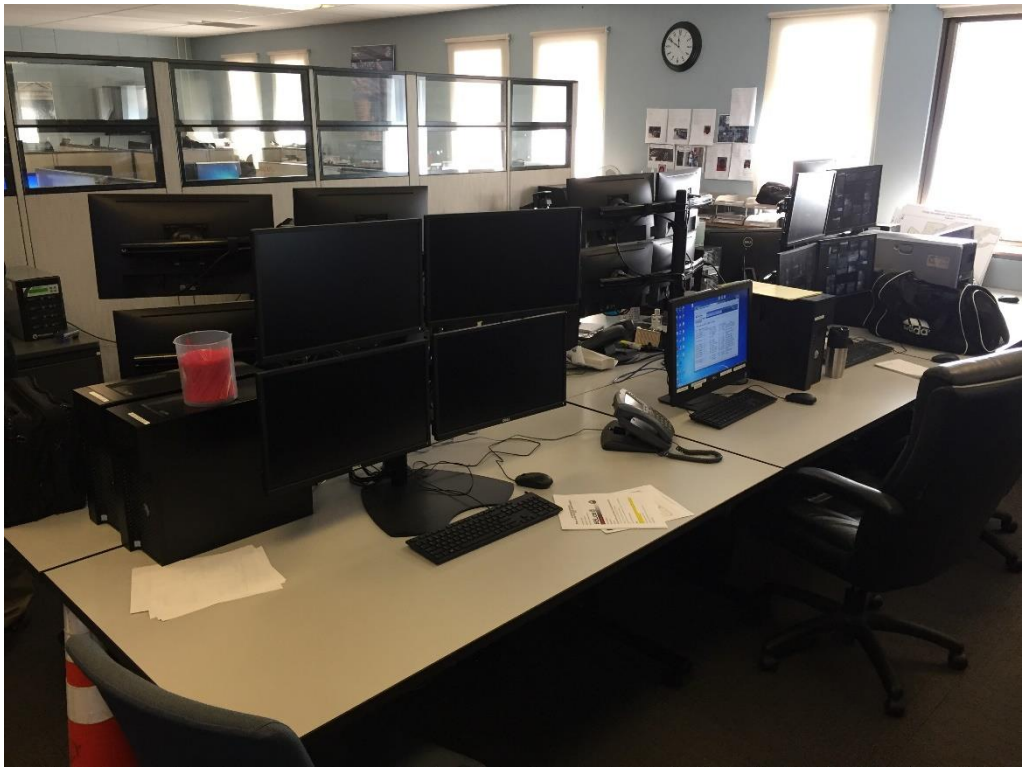
Pre-Optimization
(2 of 2 work stations in Technical Communication Division)



Post-Optimization
(3 of 5 work stations in Fusion Center)



Post-Optimization
(other 2 of 5 work stations in Fusion Center)



# Appendix B - Panel Regressions on the Impact of Camera Program Interventions on Crimes

| | | Large Area Samples | | | | Intersection Samples | | | | | | Video Analytic Samples | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | City | Sample A | | Sample B | | Sample C | | Sample D | | Sample E | | Sample F | | Sample G | |
| Outcome | Pre/ Post | Pre/ Post | DiD | Pre/ Post | DiD | Pre/ Post | DiD | Pre/ Post | DiD | Pre/ Post | DiD | Pre/ Post | DiD | Pre/ Post | DiD |
| Violent crimes | 0.84 *** | 0.87 * | 0.98 | 0.78 *** | 1.04 | 0.83 * | 1.25 * | 0.82 t | 0.91 | 0.84 | 1.57 * | 0.68 ** | 1.03 | 0.88 * | 0.97 |
| Property crimes | 0.81 *** | 0.80 *** | 0.85 * | 0.72 *** | 0.90 | 0.77 *** | 1.12 | 0.75 *** | 0.96 | 0.80 * | 1.22 | 0.82 * | 1.13 | 0.86 ** | 1.10 |
| Simple assaults | 0.67 *** | 0.64 *** | 0.91 | 0.66 *** | 1.09 | 0.71 ** | 1.05 | 0.65 *** | 0.78 | 0.84 | 1.42 | | | | |
| Group B offenses | 0.57 *** | 0.59 *** | 0.95 | 0.53 *** | 1.08 | 0.70 *** | 1.41 ** | 0.77 * | 1.54 * | 0.60 *** | PTV | | | | |
| Crimes with a firearm | 0.75 *** | 0.65 *** | 0.96 | 0.77 *** | PTV | 0.71 *** | 1.38 * | 0.64 *** | 1.01 | 0.81 t | 1.55 * | 0.69 ** | 0.90 | | |
| Vandalism | 0.90 *** | 0.88 | 1.04 | 0.88 | 0.96 | 1.00 | 0.82 | 0.94 | 1.05 | 1.09 | 1.17 | | | | |
| Drug crimes | 0.88 ** | 0.63 *** | PTV | 0.79 | PTV | 0.84 | PTV | 0.66 * | 1.07 | 1.02 | 1.72 | | | | |
| Aggravated assaults | 0.93 ** | 0.94 *** | 0.97 | 0.80 * | 0.96 | 0.83 * | 1.17 | 0.83 t | 0.83 | 0.84 | 1.35 | | | | |
| Burglaries | 0.76 *** | 0.72 *** | 0.73** | 0.59 *** | PTV | 0.69 ** | 1.11 | 0.62 ** | 0.81 | 0.80 | 1.61 | | | | |
| Larceny/ Thefts | 0.80 *** | 0.80 ** | 0.93 | 0.79 ** | 0.98 | 0.78 ** | 1.23 | 0.73 ** | 1.09 | 0.83 t | 1.30 | | | | |
| Motor vehicle thefts | 0.88 *** | 1.01 | 0.92 | 0.76 ** | 0.91 | 0.80 * | 0.97 | 0.89 | 0.80 | 0.66 * | 0.82 | | | 0.75 ** | 1.09 |
| Robberies | 0.75 *** | 0.70 ** | 0.91 | 0.74 ** | 1.17 | 0.82 t | 1.37 t | 0.74 * | 1.00 | 0.92 | 2.17** | 0.67 * | 0.97 | | |
| Weapon law violations | 0.61 *** | 0.56 *** | 0.84 t | 0.64 *** | 1.50** | 0.62 *** | 1.26 t | 0.58 *** | 1.13 | 0.68 ** | 1.88** | 0.71 * | 1.32 | | |
| Arrests | 0.78 *** | 0.69 *** | 0.80** | 0.70 *** | 1.12 | 0.83 * | 1.17 | 0.83 t | 0.83 | 0.84 | 1.35 | 1.01 | 0.97 | | |

**Notes:** $^{t}p<.10$, $^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$, Negative binominal random effects panel regressions, controlling for land use (square mileage, population), concentrated disadvantage levels (percentages of: female headed households, public assistance, under poverty line, unemployment, under 18 years old, Black, Hispanic, foreign born). Incident Rate Ratios (IRRs) reported, group x time IRRs reported for the DiD models. PTV indicates a parallel trends violation in pre-period.
Sample A: Block group parcels within the Center Street Corridor (pre/post n=38, DiD n = 76)
Sample B: Block group parcels within the Muskego Way Neighborhood (pre/post n=30, DiD n = 60)
Sample C: Any intersection with a new camera (pre/post n=32, DiD n = 64)
Sample D: New intersections with a new camera (pre/post n=17, DiD n = 34)
Sample E: Old intersection with a new camera (pre/post n=14, DiD n = 28)
Sample F: Intersections with PTZ camera connected to gunshot detection technology (pre/post n=17, DiD n =34)
Sample G: Block group parcels with an ALPR camera and bordering parcels (pre/post n=26, DiD n = 52)



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