ShotSpotter Gunshot Location System® Efficacy Study

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Foreword

National Organization of Black Law Enforcement Executives

The National Organization of Black Law Enforcement Executives (NOBLE) was established as a highly competent public service organization at the forefront of providing solutions to law enforcement issues and concerns, and to the ever-changing needs of our communities. Our commitment is to ensure the advancement of quality law enforcement practices and professionals with true equality and opportunity. Consistent with that vision, part of our mission is to support efforts to share knowledge and information among our colleagues, and to enable fair and superior law enforcement capabilities and practices throughout the world.

One significant way we seek to enable action in the cities and communities we serve is to function as a learning and knowledge clearinghouse. In this important role, NOBLE seeks to leverage the collective knowledge of our members and the many professionals in the criminal justice community.

NOBLE is pleased to endorse the ShotSpotter Gunshot Location System® (GLS) Efficacy Study. We believe the study, conducted by CSG Analysis, is a notable research report. It finds, among other things, that the ShotSpotter Gunshot Location System improves the effectiveness of first responders and their investigative process, and ultimately helps improve law enforcement agencies' ability to engage with their communities and to protect those they serve.

NOBLE's hope is that this research and these findings will help educate and inspire new ideas and ways of successfully taking the actionable data this system provides to build on intelligent policing and law enforcement programs and practices throughout the United States and the world.

Law enforcement agencies and professionals are continually challenged to do more with fewer resources, and they must consistently evaluate how they operate and achieve their mission. The most adept agencies leverage smart police technology as a driver of community and predictive-policing strategies. It is NOBLE's aim to promote this approach as an avenue for agencies to better position themselves for long-term success and positive impact in their communities.

As evident in this report, agencies nationwide have found the ShotSpotter Gunshot Location System to be an effective tool for combating gun violence and its downstream effects on the community. The system has also changed the way that agencies respond, investigate, and ultimately and most importantly, reduce and prevent gunfire.

When law enforcement agencies can better assess and respond to gunfire incidents, better outcomes are possible: officers go home safe; illegal gun use is reduced; a greater number of criminals are apprehended; and a strong message of "zero tolerance for gunfire" is sent to the community at large—ultimately building a better relationship between first responders and the communities they serve.

It is a critical goal of NOBLE to make available solutions to the ever-changing challenges which confront law enforcement agencies and communities. As a result of this research, NOBLE recognizes the clear benefit that agencies can realize from the ShotSpotter Gunshot Location System, including its integration with next generation technologies and law enforcement standards. NOBLE endorses the concept that the ShotSpotter GLS is an essential part of technology for law enforcement and intelligence-led policing initiatives.

CSG

About CSG Analysis

As a police officer-owned and operated company providing research and analysis on law enforcement technology and intelligence capabilities and methods, CSG Analysis (CSGA) is uniquely qualified to conduct this research. Since 2009, its principals have provided consulting services to law enforcement agencies and officers on local, county and federal levels. Principals are currently sworn police officers and investigators (full-time and part-time), who are trained in homicide and gunshot investigations and criminal and internal affairs investigations. Prior to founding CSGA, its principals have produced more than 500 industry analysis and user deployment reports for a range of customers in the private sector (F100 firms, large investment banks, and very large online and brick-and-mortar retailers). Prior to and since the founding of CSGA, its principals have advised government organizations including US federal agencies and intelligence organizations, security research organizations and the European Union. CSG Analysis also provides consulting to large private enterprises on threat intelligence and analysis, and network security, and to vendors of products serving these public and private markets. CSG Analysis is behind the successful law enforcement intelligence and technology website, Police-Led Intelligence.[1]

Since 2004, CSGA principal **Nick Selby** has been one of the most published and quoted thought leaders and analysts in the commercial information security and data protection industry. A recently sworn police officer in the Dallas-Fort Worth area, Selby has written more than 500 research reports for commercial customers in the information security, investment banking and manufacturing sectors. From 2005 to 2009, as Vice President for Research Operations and Research Director, Enterprise Security for industry analyst firm The 451 Group, Selby led a team of more than 35 professional research analysts who provided in-depth and objective research reports to more than 800 clients, which included more than 80 investment banks, and several government entities and agencies. Selby is the author of widely quoted research on the Enterprise Security Information Management, criminal malware, anti-fraud and Data Loss Prevention industries. Since 2008, Selby has been researching the law enforcement technology and intelligence markets. A faculty member at The Institute for Applied Network Security, Selby has been a regular speaker at conferences including the International Association of Crime Analysts (IACA); Social Media and Internet in Law Enforcement (SMILE); the RSA Security Conference; BSides Security; Information Security Europe; SANS; and America's Growth Capital Conferences. He is the co-founder, with David Henderson, of the website Police-Led Intelligence (http://policeledintelligence.com).

CSGA principal **David Henderson** is a 13-year veteran police sergeant and investigator who currently serves on a federal law enforcement task force in the Dallas-Fort Worth area. He is a patrol sergeant, who, as a detective, has led numerous homicide and shooting investigations as well as internal affairs and other investigations. He currently conducts information technology-based investigations. A TCLEOSE police instructor and experienced warrants officer, Henderson has contributed to the writing of successful grants, and has a tested understanding of agency procurement procedures (including sole-source items). Henderson is intimately familiar with the budgetary process and the politics and culture of policing. He is the co-founder, with Nick Selby, of Police-Led Intelligence (http://policeledintelligence.com).

Tara Tayyabkhan M.A. is CSGA's statistician and data collection advisor. Ms. Tayyabkhan completed her Master's degree in Psychology at the University of New Hampshire with a specialization in research methods and biopsychology. She has served as assistant professor at the University of Pennsylvania and the University of New Hampshire. Her work has been published in the journal *Pharmacology Biochemistry and Behavior*, and she has presented at many conferences, including the annual conventions of the American Psychological Association, the Society for Neuroscience, and at Harvard's Research Group on Brain and Behavior symposium.

CSGA-ShotSpotter Efficacy Study Project Credits
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1. Executive Summary

This report, based on structured interviews with police agencies around the United States, details how the ShotSpotter Gunshot Location System® (GLS) improves productivity, response time and effectiveness by providing more information and intelligence to law enforcement and public safety professionals responding to incidents. This in turn improves officer safety and officer and investigative efficiency.

The ShotSpotter GLS detects gunshots through acoustic sensors. Using a patented method of computer analysis,[2] it provides police and public safety agency users with information and intelligence on gunfire incidents, including shot location and incident mapping, number of shots detected, and audio playback.

This report was commissioned by ShotSpotter and is endorsed by the National Organization of Black Law Enforcement Executives (NOBLE).[3] Its findings are independent. Its purpose is to examine the effectiveness of the ShotSpotter GLS at locating and reporting gunshots, informing more efficient investigations, increasing arrests, simplifying the jobs and increasing the safety of police officers and communities. It specifically compares the ShotSpotter GLS to 9-1-1[4] in terms of the reporting of gunshots, and examines how having data produced by ShotSpotter GLS has affected the work and procedures of patrol and detectives who respond to and investigate gunshot crimes.

The study's authors from the police officer-owned independent commercial research firm CSG Analysis, met with five respondent groups—command staff, analysts, detectives, patrol officers and dispatchers—from seven police agencies throughout the United States. These agencies were selected by ShotSpotter for characteristics including the length of deployment (all have had ShotSpotter for more than a year), and the fact that before installation, each agency indicated it had a substantial criminal gunfire problem.

The participating agencies were Brockton, Mass.; East Palo Alto, Calif.; Nassau County, N.Y.; Richmond, Calif.; Riviera Beach, Fla.; Rochester, N.Y.; and Saginaw, Mich. The study's authors conducted all of the interviews in person at each of these agencies. No agency received compensation or consideration for its participation. All interview transcripts, surveys and raw data on which the report's conclusions are based are available for inspection to confirm the authors' findings.

The ShotSpotter GLS significantly enhances patrol officers' ability to locate the scene of a shooting over 9-1-1 alone, and provides officers more situational awareness when responding to gunshot calls. This information and enhanced awareness has saved lives and led to arrests. Since many gunshots are not reported to 9-1-1, but almost all within a ShotSpotter-covered area are detected by the ShotSpotter. The system allows cities to better understand the true level of gunfire in their communities and deploy resources more effectively.

ShotSpotter's accuracy in pinpointing the precise location(s) from which shots were fired was critical not only to solving gun crimes, but even in one case, in determining which agency should investigate the incident.

Command staff at all seven agencies noted significant community and public relations benefits and value from ShotSpotter, leading to compelling improvements in community policing, increased community

responsiveness to gunfire, and a decreased sense of disenfranchisement among community stakeholders. In short, ShotSpotter deployments increase positive community engagement with law enforcement.

False positives, a ShotSpotter activation which is ultimately determined to have been caused by something other than a gunshot, are the single most common complaint of ShotSpotter users, and they pose an operational problem. This report examines the cause and level of false positives and makes specific recommendations to reduce them. False negatives, an absence of a ShotSpotter activation when a gunshot is known to have occurred, are very rare and not considered an operational issue by respondents.

Finally, this report considers ways in which agencies may get better value from their ShotSpotter deployment by introducing new workflow management and best practices. Implementing these would result in more strategic use of ShotSpotter to inform Intelligence-Led Policing, Neighborhood and Community Policing, and other important policing, law enforcement and crime reduction initiatives.

2. Key Findings

- **ShotSpotter GLS' accuracy enables a faster response to gunfire.**
  The accuracy of ShotSpotter GLS in pinpointing the precise location(s) from which shots were fired was critical not only to solving gun crimes, but also in determining who was to investigate. ShotSpotter is considered by patrol officers and agencies to be equally or more valid, and more reliable, than 9-1-1 calls from eyewitnesses or others in indicating when and where gunshot crime has occurred. This speed to response has saved lives and led to more arrests. *Page 19*

- **Patrol officers trust ShotSpotter data over 9-1-1.**
  ShotSpotter GLS enhances patrol officers' ability to locate the scene of a shooting more quickly and precisely, and provides more situational awareness. This helps save lives and leads to arrests. Patrol officers respond with a more tactical overall response to ShotSpotter calls. Most important, patrol officers value and trust ShotSpotter information: they trust ShotSpotter data over 9-1-1 information alone in gunfire reports, to tell them exactly when, how many, and where gunshots were fired. *Page 20*

- **ShotSpotter GLS has changed the way detectives[5] approach homicide investigations.**
  ShotSpotter GLS influences the decisions detectives and investigators make about where and what to search for before arrival on-scene and while on-scene. It also informs the types of questions they will ask of witnesses and suspects. With ShotSpotter data, detectives arrive on-scene knowing empirically the number of shots fired, the time of the shots, and the location of the shots, so their initial questions can be corroborative and disqualifying in terms of witnesses and suspects. This differs from the pre-ShotSpotter paradigm, in which the initial questions were inquisitive and reconstructive. *Page 15*

- **False positives are an operational issue...**
  The false positive—a ShotSpotter GLS activation which is ultimately determined to have been caused by something other than a gunshot—is the single most common complaint of ShotSpotter users. False positives pose an operational problem. Those most affected by these operational issues are dispatchers, followed by patrol officers. Detectives and Commanders are typically not affected by false positives. Analysts are affected in that the data they work with is not representative of gunfire incidents without scrupulous cleaning through reclassification of activation data (gunshot alerts). *Page 28*

- **...but false positives are unrelated to efficacy.**
  The critical tactical reality is that patrol officers cannot investigate a report of any kind unless they know where it has occurred. While calls to 9-1-1 can either be confirmed as "true" or left unsolved and "undetermined," a false positive report from the ShotSpotter GLS is easily debunked because of the system's highly accurate geospatial capabilities. ShotSpotter's accuracy means that the human resource may always be effectively deployed to find out whether a gunshot or other sound has occurred. This is distinct from any discussion of whether ShotSpotter is able to programmatically distinguish the sound of a gunshot from the sound of, for example, a dumpster or of a truck backfiring. *Page 29*

2.1 Secondary Findings

- **ShotSpotter increases officer safety when responding to gunshot calls.**
  Patrol officers respond with a more tactical overall response to gunshot calls initiated by ShotSpotter GLS activations.[6] They universally say that ShotSpotter provides them more situational awareness to responding to gunshot calls than 9-1-1 alone,[7] and it "Always" or "Sometimes" affects the route patrol takes to respond to gunshot calls.[8] ShotSpotter GLS data "Often" affects the priority patrol officers assign to a call.[9]

- **ShotSpotter provides agencies with better crime data.**
  All agencies reported that ShotSpotter GLS allowed them to better measure the true level of gunfire in their jurisdictions. Since many gunshots are not reported to 9-1-1, ShotSpotter GLS allows cities to better understand the true level of gunfire in their communities. This effect is most beneficial in agencies with a concerted reclassification regime (see below).

- **False negative rates are very low
  and need not be inversely correlated to false positives.**
  False negatives, an absence of a ShotSpotter activation when a gunshot is known to have occurred, are very rare and not considered an operational issue by respondents. While minimizing false negatives often results in a corresponding increase in false positives in a given system, the design of the ShotSpotter system suggests that false positives may be reduced in ways that need not increase false negative rates: through technology improvements, better reclassification of activations by users, training, and experience with the system. It is also important to note that 9-1-1 calls cannot result in confirmed false positives, only in unexplained incidents. Another important note is that while false negatives are verifiable with both 9-1-1 and ShotSpotter, false positives are only verifiable with ShotSpotter. This is because ShotSpotter provides a highly accurate time and place of activations.

- **Failure to properly reclassify activations decreases customer value.**
  Most customers are not reclassifying activations after investigation by patrol. The cause of this failure lies in both ShotSpotter training, customer time, and resource constraints. The result is less reliable statistical data (which may be used by agencies to inform programs including community, neighborhood and intelligence-led policing) and hindered ability to leverage ShotSpotter as a strategic asset.

3. Methods

To assure objectivity, a methodological framework was created comprising strict adherence to the script and recording of all interviews. All raw data is open for peer review and available at http://www.shotspotter.com/resources/efficacystudy.

3.1 Respondents

Seven agencies were selected by ShotSpotter for the study. These agencies met the criteria that they had a deployed ShotSpotter installation for more than one year, and that the agency had seen notably high rates of illegal gunfire prior to the installation of ShotSpotter. Neither respondents nor respondent agencies were compensated for their participation. Respondents were not promised any consideration by ShotSpotter or CSGA for their participation, but were told that they could review the raw transcripts that pertained to their agency, and receive a copy of the final report. A copy of the email communication sent by ShotSpotter to each agency requesting their participation may be found online at http://www.shotspotter.com/resources/efficacystudy.

3.2 Respondent Groups

ShotSpotter activations (alerts) do not act in a vacuum; detection of a gunshot by the system initiates a cycle of procedures involving personnel at every stage. To evaluate ShotSpotter and its data as deployed in agencies and followed through its lifecycle, the study sought information from five groups.

1. Dispatchers, the first recipients of ShotSpotter activations, were queried about their procedures and policies pre and post ShotSpotter installation, and to determine what information provided by ShotSpotter was being passed to first responders to gunshot incidents.

2. Patrol officers were asked about the information they receive from dispatch, and the trust they place in ShotSpotter data versus that provided by 9-1-1 callers and other channels of reporting gunshots. Patrol officers were also asked how ShotSpotter affects their work, their safety and their tactics.

3. Detectives were asked about their homicide and shooting investigation methods pre- and post-ShotSpotter, their trust in the information provided to them by ShotSpotter, and whether ShotSpotter increases their investigative efficiency.

4. Analysts were asked whether they were using ShotSpotter data to support statistical analysis, crime mapping and predictive intelligence programs, as well as to support further strategic initiatives such as grant writing and resource redeployment.

5. Commanders were interviewed on ShotSpotter's overall effectiveness at reducing illegal gunfire and increasing officer safety.

3.3 Interview Locations

Agencies interviewed were Brockton, Mass., East Palo Alto, Calif., Nassau County, N.Y., Richmond, Calif., Riviera Beach, Fla., Rochester, N.Y., and Saginaw, Mich. Interviews were held in person at each of these agencies. All but two interviews—Brockton, Mass. and Riviera Beach, Fla.—were conducted by David Henderson and Nick Selby. Due to scheduling and travel concerns, all interviews in Riviera Beach, Fla. were conducted by David Henderson. All interviews in Brockton, Mass. were conducted by Nick Selby.

Prior to commencement of the study, an eighth agency was contacted, and early versions of the interview scripts were tested on respondents from the respondent groups represented in this study. No transcripts were made of the recordings of those interviews, nor are any of the responses from those interviews considered as part of the analysis for this study.

3.4 Survey Instrument

Each respondent group received a different set of questions. However, every interview began with the reading of a script introducing the rigor of the interview, informing the respondent that the interviewer works for CSG Analysis' parent company TRM Partners, not ShotSpotter, and disclosing clearly CSGA's financial remuneration by ShotSpotter to conduct the survey. For example, each interview script included the phrase "Once again, I do not work for ShotSpotter. The questions I am asking were developed by us and not ShotSpotter and the study is being independently conducted. ShotSpotter is paying TRM Partners for its work on this study, however it does not have control over our findings. Our findings are independent and based on your answers...." The actual interview scripts may be viewed at http://www.shotspotter.com/resources/efficacystudy.

3.5 Interview Schedule

A schedule was devised to alternate interviewers with respondent groups. Interviews began in East Palo Alto, Calif. on 18 February 2011, and continued with Richmond, Calif. (19 February); Saginaw, Mich. (22 February); Rochester, N.Y. (23 February); Nassau County, N.Y. (24 February); Riviera Beach, Fla. (2 March) and Brockton, Mass. (17 March).

3.6 Administering the Interviews

Interviews were conducted at police headquarters in each of the agencies, in facilities provided by the agency. Interviews were audio recorded using a Sony ICD-SX750 stereo digital recorder, and Apple iPhone 4 monophonic digital recorders (Voice Memo). Access to the raw, unedited recording of any interview is available until 15 April 2012 upon request.[10]

Interviewers were trained to deliver the script in a standard tone which strived to be scripted but neither monotone nor conversational. Interviewers were instructed to carefully rephrase questions which were not understood by respondents. Some pre-crafted, rephrased questions were provided. Prompts to be used to elicit more information were provided where appropriate.

Questions inquiring about stories of specific incidents that illustrate the worst and best qualities of ShotSpotter were pseudo-randomly sorted,[11] so that some respondents were asked to tell an anecdote first of the best, and then the worst, and some were asked the opposite order.

3.6.1 Exceptions

During the course of the project, several variations and exceptions occurred during the interview process. Minor deviations from the scripted survey instrument occurred on several occasions which CSGA considers to be well within the threshold of expected "conversational" deviations and which are themselves not significant with respect to the outcome.

On several occasions questions were asked out of order when pages of the survey instrument were read out of order. This occurred in East Palo Alto, Calif. (Dispatch); Saginaw, Mich.; and Brockton, Mass. (Command Staff); and some other interviews. In one interview, the subject (Dispatch) reconsidered an answer to a question as the interview concluded, and an off-script, recorded discussion took place to modify the previous answer stated. In each such instance, the error was detected and the questions were read, and are transcribed and marked as "Supplemental."

At East Palo Alto, Calif., the crime analyst employee most familiar with ShotSpotter was in the process of being hired by ShotSpotter Inc., and was interviewed by CSGA at the East Palo Alto Police Department Headquarters while in the employ of both the agency and ShotSpotter.

In Richmond, Calif., no analyst was available for interview, and the interview was conducted with a command staff (Lieutenant) who supervised but did not conduct intelligence or crime analysis.

In Saginaw, Mich., two patrol officers sat in on the patrol officer interviews, and jointly provided answers. In Rochester, N.Y., both interviewers attended all but the interview with the detective. In Nassau County, N.Y., Saginaw, Mich., Richmond, Calif., and East Palo Alto, Calif., (and, as stated, Rochester, N.Y.) both interviewers attended the interview with Command Staff. On several occasions, the interviews were interrupted by uninvolved third parties having brief communication with the interviewee (saying hello, asking for some unrelated information, etc). Several dispatch interviews were conducted in dispatch centers, which led to interruptions by actual calls for service or communication with officers in the field.

3.7 Transcription

Raw, unedited audio recordings were digitally transmitted to CA Transcription Service (CATS[12]), a specialist transcription service for academic researchers based in Plymouth, England. Orthographic transcriptions of these audio recordings were made and delivered as Microsoft Word documents. These documents served as the source data for all analyses. Copies of the source (raw, unedited) audio recordings and the unedited transcripts as provided by CATS are available at http://www.shotspotter.com/resources/efficacystudy.

3.8 Analysis

Analysis was performed by Nick Selby and Tara Tayyabkhan. Quantitative data as well as binary answers were extracted and analyzed. These data were used primarily to understand general trends across agencies. Qualitative data (responses) were aggregated per respondent group and per question, examined and categories of response coded. Responses on similar themes were collected and patterns identified using standard qualitative analysis methods. Representative quotations were chosen to illustrate verified patterns and trends.

4. Results

4.1 Command Staff

4.1.1 Key Findings

- Command staff bought ShotSpotter because of gunfire related crime in their jurisdictions.

- Gunfire crime has been reduced since installation, which commanders at least indirectly attribute to ShotSpotter. Other crime types have been reduced as well.

- Commanders like and trust ShotSpotter. They believe it is effective. Indirectly or directly, they say, ShotSpotter saves lives of citizens and officers.

- They place a high value on having ShotSpotter deployed at their agency, and would buy it again if they had to make the decision again.

- Further, commanders feel that the communities into which ShotSpotter has been deployed have generally positive feelings towards it, and have not raised civil liberty or surveillance concerns.

- Command staff view ShotSpotter's value primarily as tactical, though some agencies are leveraging ShotSpotter for strategic value and, notably, strategic community relations.

4.1.2 Analysis

Command staff state that ShotSpotter was purchased because of gunfire-related crime in their cities.[13] When asked to name the driving reasons for deciding to purchase ShotSpotter, commanders told us that gun violence was a major concern for a number of reasons. These included citizen casualties and fatalities, officer safety, and public relations. Some respondents pointed to the reputation of their city as being "violent" as a driving force behind the purchase.

In two cities,[14] commanders referred specifically to their city's reputation: "We've been rated the most violent city of over 40,000 in the nation," said one.[15] All commanders expressed strategic departmental imperative to reduce gunfire violence, and increase arrests for illegal gunfire.[16]

Agencies state that there was an initial increase in

> "A key part of [Commissioner Larry Mulvey's] tenure here has been an integrated effort to reduce the incidence of gun-related violence." — Nassau County, N.Y.[17]

reported gunfire incidents at deployment of ShotSpotter. Some agree that this increase was not indicative of an actual increase in gunfire incidents. It became clear to agencies that prior to installation of ShotSpotter unknown numbers of gunshots were not being reported by citizens using 9-1-1, which itself is an issue of the community's relations with and trust of police and the level of citizens' "comfort" with the sound of gunfire—that is, the level to which they are inured to it in a given area.

Initial spikes in gunfire reports also resulted from false positives that were not properly reclassified. They were incorrectly counted as gunshots rather than as possible gunshot calls for service. As we shall see, reclassification of ShotSpotter GLS activations by agencies is an important aspect of system maintenance. Our research found that reclassification levels, policies and procedures were lacking in almost all agencies we interviewed.

Regardless of the reasons for the initial spike, most of the agencies reported[18] that the level of gunfire incidents in their cities had decreased—sometimes significantly—since installation. The greatest variations were in Brockton, Mass., which reported that the incidents had remained about the same,[19] to Saginaw, Mich., which reported that gunfire incidents were "Down drastically…[P]robably in the area of forty percent [from 2008 to 2010]."[20] One commander said that the situation was too dynamic to answer the question.[21]

> "[After the] initial deployment [gunfire incidents rose] markedly but that's an aspect of non-reporting by people in the community. They were numbed by the amount of gun violence they were hearing. [I] would say we're coming up on the two year mark [during which] our gunfire incidents have gone down now every month slowly and we're in better shape than we were."
> — Richmond, Calif.[22]

Command staff feel that ShotSpotter is at least partially responsible for this downward trend, however they note that non-gunfire-related crimes in their cities had gone down,[23] and this is not credited to ShotSpotter.[24]

Indirectly or directly, commanders say that ShotSpotter saves lives. We asked, "Do you believe ShotSpotter is responsible for saving lives in your community?"[25] and while the responses reflected hesitation to credit any single piece of equipment, technology, or tactics with saving lives, ShotSpotter was recognized as making a significant contribution to lives not being lost. Brockton, Mass. was the only agency stating it had insufficient data to answer, but all other agency commanders replied variants of "yes" or "indirectly, yes." From the crime analyst in Nassau County, N.Y., we heard about a specific example of officers responding to a ShotSpotter activation that preceded a 9-1-1 call and getting to the scene while the victim was still alive. Because the ShotSpotter activation came first, a life was saved by that activation that might have been lost had the officers not responded until the emergency call came into the 9-1-1 system.[26]

Commanders are "Confident" or "Very Confident" of the information ShotSpotter provides[27]; five of the seven agencies (71%) placed a "Very High" value on having ShotSpotter deployed in their city (one agency placed this value at "Somewhat High," while the other placed it at "High").[28]

CSG

While respondents tended towards stating that ShotSpotter did not prevent illegal gunfire incidents[29] (two said it was "Somewhat Effective" or "Effective" at preventing gunfire incidents, three said it was "Ineffective," and two did not answer), when asked to evaluate ShotSpotter generally,[30] commanders called ShotSpotter "Effective" or "Effective [within] limitations (East Palo Alto, Calif.)"[31] or "Effective in the scheme we use it in (Nassau County, N.Y.)"[32] for a range of reasons[33] including:

- Being at least partially responsible for a reduction in gun crime
- Producing real-time and strategic intelligence and crime trend data
- Increased investigative efficiencies and forensics benefits
- Superiority over 9-1-1 calls alone in terms of arriving on the correct scene faster
- Reporting of otherwise unreported incidents of gunfire
- Enhanced officers' situational awareness
- Community and public relations benefits

"It throws an incredible benefit to me as a police administrator to be able to walk into a community that in other places may be very hostile or mistrusting of the police. It builds a relationship between the law enforcement organization and the community. [In] our experience it does have significant forensic benefit. [In] my opinion, the benefit to the individual police officer's situational awareness is incalculable.   – Nassau County, N.Y.[34]

Command staff view ShotSpotter's value primarily as tactical,[35] though some agencies are leveraging ShotSpotter for strategic value and, notably, strategic community relations. In Saginaw, Mich., Nassau County, N.Y., and Richmond, Calif., commanders spoke of ShotSpotter being leveraged by the Chief or Commissioner as a positive community impact, demonstrating the department's level of proactive commitment to the community. When taken as part of an overall campaign to inform communities that the police care about gun violence, commanders report excellent, positive results measured in community relations, more calls to 9-1-1, and more calls to tip lines. The publicity is also used by command staff as a deterrent, putting criminals on notice that the city is proactively listening.[36]

Interestingly, respondents did not report vandalism against the ShotSpotter sensors in the same manner that license plate reader and pole camera technologies have been attacked in the past.[37] Further, commanders feel that the communities into which ShotSpotter has been deployed have generally positive feelings towards it,[38] and have not raised civil liberty, or surveillance concerns.[39] This comment, from Richmond, Calif., was typical: "I think that, overall, the good citizen that's aware of ShotSpotter is happy about it...[W]e have citizens in neighborhoods that don't have gunfire issues that want ShotSpotter, because their belief is it'll make their neighborhood even more safe."[40]

Agency command staff place a high value on having ShotSpotter deployed at their agency, and would buy it again[41] if they had to make the decision again.[42]

4.2 Detectives/Investigators

4.2.1 Key Findings

- ShotSpotter has changed the way detectives approach homicide investigations by influencing their decisions about where and what to search for before arrival on-scene, while on-scene, and when forming questions they will ask of witnesses and suspects.

- Detectives say ShotSpotter data allows them to investigate more efficiently. By this they do not necessarily mean that ShotSpotter saves them time, but that the questions they ask of witnesses and suspects are corroborative and disqualifying as opposed to inquisitive and reconstructive.

- Detectives trust the time and location information ShotSpotter provides[43] and use it to aid investigations.

- They rate their overall confidence in ShotSpotter data as "High" or "Very High."

- Detectives responsible for locating forensic gunshot evidence consider information provided by ShotSpotter before they begin their search.

4.2.2 Analysis

ShotSpotter has changed the way detectives[44] approach homicide investigations by influencing the decisions they make about where and what to search for before arrival on-scene and on-scene, and when forming questions they will ask of witnesses and suspects.[45]

Detectives say ShotSpotter data allows them to investigate more efficiently.[46] This does not necessarily mean that ShotSpotter saves them time.[47] Rather, respondents report ShotSpotter data provides detectives with a more effective questioning paradigm.

Since the deployment of ShotSpotter, detectives tell us that they consider information provided by ShotSpotter on the number of shots[48] and the geographical area to inform the limits of their evidentiary search, and also in forming the questions they will ask of witnesses or suspects. Some detectives have never received information on moving shots (for example, indicating drive-by shooting). All had received, and used, information regarding geolocation and number of shots, in their consideration of search and investigation.

With ShotSpotter data, detectives know empirically the number of shots, the time of the shots and the location of the shots, so their initial questions can be corroborative and disqualifying in terms of witnesses and suspects.[49] This may differ from the pre-ShotSpotter paradigm, in which we are told the initial questions were inquisitive and reconstructive.[50]

This is a fundamental improvement in investigative efficiency due solely to the availability of ShotSpotter GLS data.

For example, without ShotSpotter data, detectives must often first establish how many shots were fired. Since witness accounts vary, finding more than one witness who can corroborate the number of shots fired, the location of the shots and the time of the shots is challenging, as is determining which witnesses are accurate and truthful, and a range of other conditions from lying, confused, merely inaccurate, etc.

Once the witness accounts are gathered and correlated, the detectives must then corroborate these accounts with physical evidence before any reasonable level of certainty can be established as to the facts of the event. Only then can they make determinations about which witnesses, based on their statements, can be believed and counted upon later to assist in the investigation or testify.

With ShotSpotter data, detectives can arrive at the scene knowing specifically how many shots were fired, from where, and at what precise time. If the detective knows that four shots were fired, (s)he won't waste time with a witness who claims to have heard nine; similarly, if (s)he knows one shot was fired and a suspect claims to have fired at someone who shot first, the detective can discredit this story.

Based on respondents' answers, we surmise that when detectives state that ShotSpotter data makes them more efficient, they refer not necessarily to a product of time savings, but rather to the quality of their investigations.

Detectives are split on whether it saves them time on investigations "Always" or "Sometimes." Detectives asked whether ShotSpotter allowed them to investigate more efficiently answered "Yes" at four of the seven agencies (57%), and "Sometimes" at two agencies (28%). One agency did not respond to this question.

At a crime scene without ShotSpotter

With witness reports alone, Detective A is left to determine which witness' stories are credible, and must corroborate those with physical evidence, when found.

Detective A must dynamically build his understanding through the methodical questioning of witnesses.
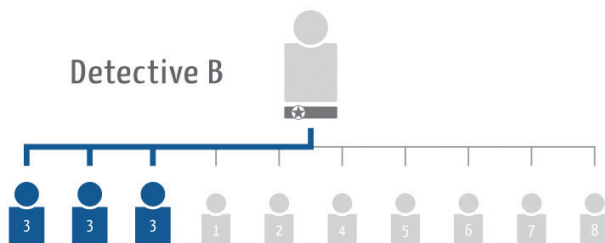
Detective A

Detective A's questions are inquistive and reconstructive.

At a crime scene with ShotSpotter

With ShotSpotter, Detective B arrives on the scene knowing how many shots were fired, and when and where they were fired.

Armed with ShotSpotter data, Detective B can immediately identify reliable and truthful witnesses.

Detective B

Detective B's questions are corroborative and disqualifying.

Figure 1. ShotSpotter's effect on investigative procedures.

Those who answered "Sometimes" said that, for example, ShotSpotter took some of the guesswork out of investigations, but it is important to note that no detective would commit to any concrete time savings afforded by ShotSpotter.[51]

Respondents did allude to efficiencies other than within the questioning paradigm, for example in locating forensics (a reference to the geospatial accuracy which was a common refrain among detectives when referring to locating, for example, forensics[52]) and especially in learning of incidents in which no 9-1-1 calls had been received.[53]

No detective respondent was able to definitively state how much time ShotSpotter saved him when asked,[54] except for comments such as "Minimal."[55] That is not to say, however, that ShotSpotter does not save time on certain investigations, but merely that it may not be the primary indicator of "efficiency" in this context. Some detectives relayed stories of ShotSpotter informing investigators of the location of a shot far from where a body was discovered, for example when the pinpoint location of a shot in a large (six or seven block) area would have otherwise been difficult.

"It might have taken us two, three hours to get to that point where, just going back and looking just because ShotSpotter said an address, we went to that address and fortunately it drew a witness out that probably would have eventually come across but it would have been a lot sooner [with ShotSpotter]."[56]

Another detective relayed a story of a time when the geographical accuracy was wrong, but the time stamp of the incident proved important to an investigation; the detectives had received an activation[57] that was not accurate, but had a witness who provided an important statement about the gunshot and placed it as occurring within a seven minute window.

> *"[Based] off of the ShotSpotter when we went back and reviewed it, we heard one shot and then we determined that the crime happened there, and then as far as our investigation we corroborated with certain phone calls that were made to hit at that particular time so we [were] able to get the exact times. It was very important…to our investigation."[58]*

Before ShotSpotter was deployed, detectives who searched for evidence (and in at least one agency, evidence technicians who search for evidence on behalf of detectives) did so based on unknown variables, including number of shots and geographical area of the crime scene. Respondents describe setting perimeters loosely ("If you think you need to go one street north, go two streets north"[59]) based on low trust of witness statements.[60] If ShotSpotter data is available, some detectives will use it to pinpoint the area and then broaden from the epicenter of the shot location outward.[61]

Detectives trust the location information it provides[62] and use it to aid investigations; four of the seven detective respondents said that they have "High" confidence in the data that ShotSpotter provides them; two rated their confidence level as "Very High"; and one expressed "Somewhat High" confidence.[63]

ShotSpotter has also been used to discredit at least one alibi, such as one in which a gunman shot in self-defense after shots were fired at him. This is a use of ShotSpotter data that we expect to see more of: the use

of activation records and recordings to disprove claims of acting in self-defense. The case in Saginaw, Mich. involved the shooting death of an elderly woman who was apparently not the target but the victim of a single gunshot. In this case ShotSpotter assisted detectives in finding the specific location from where the gunshot emanated, some 800 feet from where the victim was found. The ShotSpotter location data led to a canvas that resulted in a suspect being named by a resident.

When detectives confronted the suspect, he claimed that he was shooting in self-defense and that another man had shot at the suspect first. Examination of ShotSpotter data showed only one activation, debunking his alibi.[64]

"Oh, it's just a winning system. You can't go wrong with being able to locate the victim within inches, and then being there on-scene that quickly, and as people are moving around you're able to capture all of your witnesses, you'd be able to capture people in the area, and you're able to get that story from the beginning. It's just it's like being put at a crime scene literally as the crime is being committed."[65]

4.3 Patrol Officers

4.3.1 Key Findings

- According to patrol officers, ShotSpotter's accuracy—of both geographic location of an incident and of the number of shots fired—is its best attribute. ShotSpotter allows officers to locate the scene of a shooting more quickly and more precisely.

- The accuracy of ShotSpotter GLS in pinpointing the precise location(s) from which shots were fired was critical not only to solving gun crimes, but even to determining who was to investigate.

- Patrol can better qualify calls and make better tactical decisions with ShotSpotter over 9-1-1 alone.

- Patrol officers respond with a more tactical overall response to gunshot calls initiated by ShotSpotter GLS activations. ShotSpotter provides more situational awareness when responding to gunshot calls than 9-1-1 alone, to the extent that it sometimes affects the route patrol officers take to respond to gunshot calls.

- Patrol officers value ShotSpotter information; despite false positives (ShotSpotter activations for sounds other than gunshots) patrol officers trust ShotSpotter over 9-1-1 alone in gunfire reports.

4.3.2 Analysis

ShotSpotter's accuracy, of both geographic location of an incident and of shots, is its best attribute[66] according to patrol officers. The fact that ShotSpotter GLS data allows officers to respond to a specific location, knowing the specific time that a gunshot happened, means that patrol officers feel they have increased situational awareness, especially when compared to 9-1-1.[67] "You know instead of just a general direction within multiple blocks, you can narrow it down to a certain block so it would increase officer safety as better knowing where the shots are coming from."[68]

Other patrol officers also point out the fact that ShotSpotter will provide accurate, verifiable information even in cases when there is no 9-1-1 call, allowing them to "Pinpoint one house and park down the street and approach in a safer and more tactical manner."[69]

Speed of the call, too, is important to responding patrol officers, who feel that even an additional 30 seconds on a gunshot call over 9-1-1 would be of a tactical advantage—let alone the fact that they are given data on single or multiple gunshots and satellite mapping of the area of the gunshot call.[70] The faster officers arrive, the safer they feel, and the more options they have to arrest, investigate, and potentially save lives of victims.

When asked to describe the way ShotSpotter changes how they respond to a call, all seven Patrol group respondents framed their answer in either direct or indirect comparison with gunshot incidents reported by eyewitnesses (which are the source of all 9-1-1 calls). In Riviera Beach, Fla., ShotSpotter is a crucial
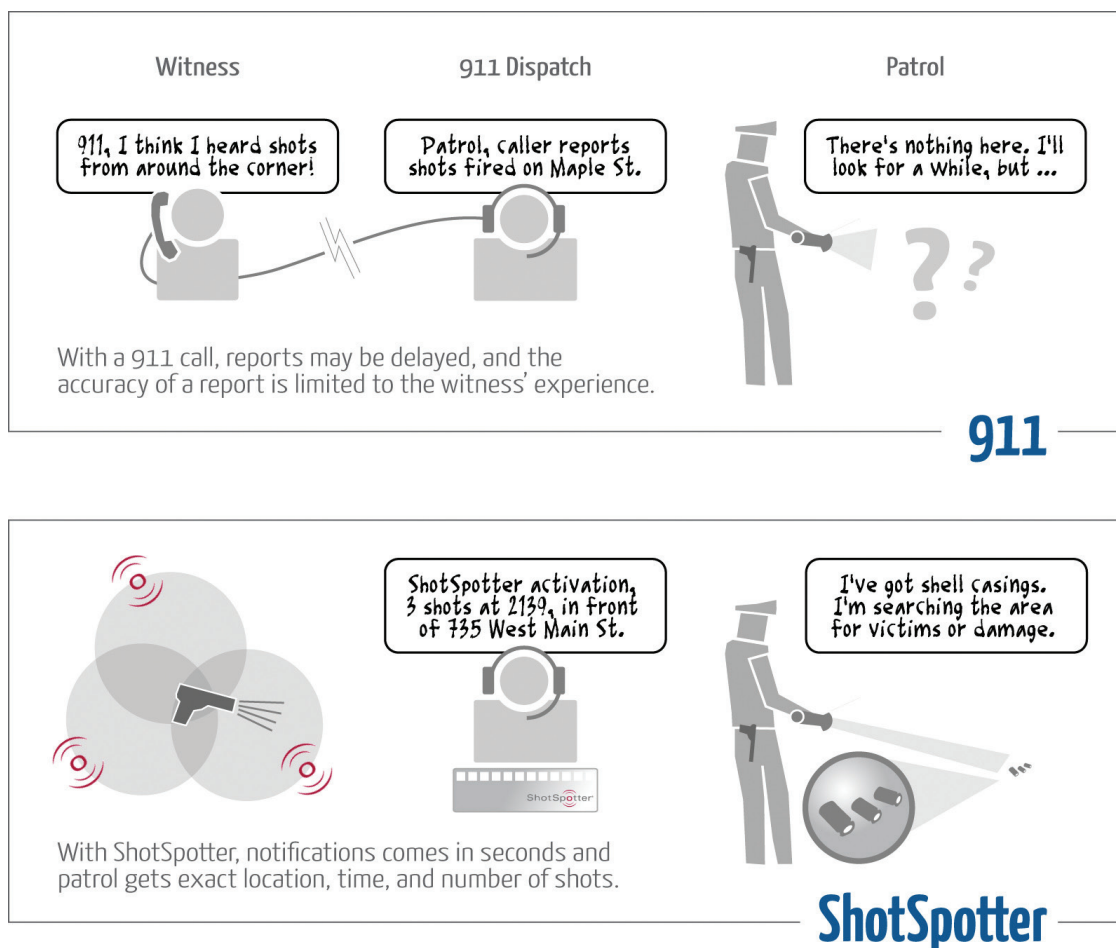
Figure 2. 9-1-1 vs. ShotSpotter on Patrol

information source, providing information about gunshots that would otherwise go unreported: "I don't even know how many we weren't getting because people usually don't call [9-1-1] in this city."[71]

Officers in Saginaw, Mich. and Nassau County, N.Y. corroborate that people often do not report gunshot incidents,[72] while in East Palo Alto, Calif., more gunshots appear to be being reported by residents via 9-1-1 than previously.[73]

Residents of Richmond, Calif. may be calling 9-1-1,[74] but the information from those calls is not considered reliable, while ShotSpotter is,[75] which was also reported by other agencies.[76] It is of note that the Richmond, Calif. patrol officer cites false positives as a central complaint with witness-reported (9-1-1) gunshot calls, and sees ShotSpotter as an improvement over this.

The geospatial accuracy of ShotSpotter provides patrol officers with information about the actual location of a shooter, as distinct from the location where witnesses experience the gunshot. In East Palo Alto, Calif., the

respondent reported an incident in which the victim was in a different location than the shooter, something that was understood through ShotSpotter information.[77]

In a different portion of the interview, the patrol officer from Richmond, Calif. described an incident in which pedestrians fired shots into a bus that was moving across jurisdictional lines. The accuracy of ShotSpotter in pinpointing the precise location(s) from which the shots were fired was critical not only to solving the crime, but even to determining who was to investigate.[78] As it turned out, a witness claimed the shooting had occurred in their jurisdiction, while ShotSpotter said it had occurred in another jurisdiction. Patrol walked to where ShotSpotter indicated the shooting had occurred and found shell casings.

ShotSpotter can improve outcomes by helping patrol officers get to the scene faster, which makes them more likely to encounter the perpetrator, according to the respondent from Brockton, Mass.[79] A nearly identical answer is given by the patrol officer from the Nassau County N.Y. Police Department, who put it this way: "You feel pretty damn sure you're going on a gunfire…a gun call. And you know you're going there and you're going there much faster than you would've in the past. And you've got to be concerned that you're going [to] either come into contact with that person or you're going or passing that person as you are coming into the scene."[80]

The above responses represent five of the seven respondents' answers to the specific question about how ShotSpotter changes their response to a call. Rochester, N.Y. and Saginaw, Mich. patrol officers also discuss the advantages ShotSpotter provides; they see it as mainly corroborative. In Rochester, N.Y., ShotSpotter activations are described as one of the factors that plays into how to respond to a call.[81] In Saginaw, Mich., the ShotSpotter activation may be part of a more complex calculation: "If we receive multiple calls from any residents in addition to a ShotSpotter activation it can…dictate a change in response there."[82]

Patrol officers respond with a more tactical overall response to ShotSpotter calls[83] (in response to the question, 'Do ShotSpotter calls result in a more tactical overall response,' five of seven (71%) say "Yes," one (14%) says "No," and one said "Somewhat," conditioning his response on ShotSpotter plus additional information including corroborating 9-1-1 calls).

Patrol officers universally say that ShotSpotter provides them more situational awareness to responding to gunshot calls.[84] It "Always" or "Sometimes" affects the route patrol takes to respond to gunshot calls,[85] and it often affects the priority patrol officers assign to a call.[86]

Officers make arrests due to ShotSpotter information.[87] Most important, patrol officers value and trust ShotSpotter information over 9-1-1 in gunfire reports despite false positives (ShotSpotter activations for sounds other than gunshots).

4.4 Dispatch

4.4.1 Key Findings

- Dispatchers believe that nearly 70% of ShotSpotter activations are triggered by gunshots.

- Dispatchers always receive and pass on to patrol the time, number and location of shots as provided by ShotSpotter. This is much more information than can possibly be given by 9-1-1.

- Dispatchers have high confidence that when the ShotSpotter graphical waveform display shows the appropriate "signature" waveform, an actual gunshot—and not a false positive—has occurred.

- Dispatchers have the greatest exposure to, and the most operational challenges with, false positives.

- Neither analysis of activations as they occur, nor reclassification after patrol investigation is being completed to an optimal level. Activation analysis procedures and policies on reclassification are vague and not well followed.

- A failure to adhere to best practices and consistent procedures means customers do not get all the strategic value possible from ShotSpotter.

4.4.2 Analysis

Dispatchers are most affected by false positives. When the ShotSpotter monitoring screen displays an activation bearing the signature gunshot graphical acoustic signature,[88] they believe that[89] 67% of alerts on average are caused by actual gunfire.[90] Specific estimates from dispatchers as to what percentage of ShotSpotter activations constituted real gunshots and not false positives included 75% (Saginaw, Mich.[91]); 50% (Rochester, N.Y.[92]); 70% (Riviera Beach, Fla.[93]); 97% (Richmond, Calif.[94]); 50% (Nassau County, N.Y.[95]); 60% (Brockton, Mass.[96]). An outlier reported five percent; see endnote[97] for why his comments have not been included in our calculation of the average.

Dispatchers reported a range of events which would trigger false positive activations. The most commonly reported sources of false positive activations are, in no particular order: dumpsters, trucks, motorcycles, helicopters, fireworks, construction, vehicles traveling over expansion plates on bridges or into potholes, trash pickup, church bells, and other loud, concussive sounds common to urban life. Dispatch respondents report that false positives are more likely to occur during daytime shifts when more of these noises are likely to occur.[98]

Six of seven dispatchers also reported that when the graphical waveform display showed what we have come to call the "classic ShotSpotter gunshot waveform" which is described by respondents and people at the company with whom we spoke as a waveform resembling "a sideways Christmas tree" that they had high confidence that the activation was caused by a gunshot and not something else.[99]

Because of the prevalence in pre-study interviews[100] of dispatcher complaints of false positives, we sought information from dispatchers on their real-time analysis of ShotSpotter activations based on the graphical waveform displayed by the GLS and the audio playback of gunshots from various sensors. Dispatchers reported that the audio of candidate gunshots was nearly always available for their review[101] and that agency policy dictates that dispatchers view and listen to candidate gunshots on activation.

While respondents said in many cases that there was a policy or procedure to analyze activations and determine whether they thought it was a gunshot or some other sound,[102] we found that, other than "just listening to it," we did not find among the respondents a cogent procedure to better differentiate between actual gunshots and other sounds.[103] We do not suggest that this is an insufficient procedure given a dispatcher trained to discern a recording of an actual gunshot. However, prior to ShotSpotter being installed, few dispatchers had experience or training in discerning recorded gunshots; none had experience with audio waveform analysis, and three of the seven dispatchers had never heard a live gunshot. Four had, though on the shooting range, where presumably they wore hearing protection which muffles the sound of the gunshot.

Dispatchers say that they rely on a range of methods which indicate either a lack of guidance or training—training which dispatchers themselves say they have not received.

For example, in Saginaw, Mich., dispatch reported that "We're not the experts, but if it does…sound like a gunshot we still advise police…."[104] While in Rochester, N.Y., the dispatcher believed that larger caliber weapons and rapidity were key to detecting real gunshots from fireworks, which he believed were the most common false positive source.[105] Riviera Beach, Fla. and Brockton Mass. staff dispatch with police officers, who base their determinations both on the sound[106] and the distance from the sensor as reported by ShotSpotter.[107] At Nassau County, N.Y., the dispatcher says she listens repeatedly to make certain when she is unsure.[108]

Others depend on the classic ShotSpotter gunshot waveform[109] or a combination of looking and listening.[110]

Dispatchers report that false positive activations are more likely during day shifts,[111] saying that more of the types of noises which seem to trigger false positives occur then.

Dispatchers say that, despite their annoyance at false positives, they always monitor ShotSpotter activations, and they nearly always report key ShotSpotter information—the location address, the number of shots and the time of the shots—to patrol.[112]

A false negative (when a gunshot is known to have occurred and the ShotSpotter system does not detect it) is a far more serious issue than a false positive. Five agencies—Rochester, N.Y., East Palo Alto, Calif., Riviera Beach, Fla., Brockton, Mass., and Richmond, Calif.—reported false negatives had occurred.[113] However, each said that these occurrences were very rare,[114] and in Nassau County, N.Y., on follow-up it was revealed that the "false negative" was actually a shot from inside a building.[115] One dispatcher indicated false negatives were a problem, however we discount this for reasons stated at endnote."[116]

4.5 Analysts

4.5.1 Key Findings

- Analysis departments show the widest degree of variation, and analyst sophistication varies so widely that it is impossible to generalize based on the responses that we received.

- Based on reports from other respondent groups and analyst responses, analysts are not receiving reliable and correctly reclassified ShotSpotter data. This hinders strategic and even tactical analysis of the ShotSpotter activation data.

- The agencies best at analysis and workflow are ensuring that ShotSpotter activation data is reclassified, then aggregating and correlating it with other crime data—for example crime mapping, gang intelligence, parolee and probationer, open source intelligence—to form a rich and predictive intelligence view of an area.

- Lessons of use from the better analysis shops should be disseminated among the ShotSpotter user community so that more agencies may understand the strategic potential of the data ShotSpotter produces.

4.5.2 Analysis

Analysis departments show the widest degree of variation, and analyst sophistication varies so widely that it is impossible to generalize based on the responses that we received. Therefore, we have elected to show how a "best case" scenario can look, with inputs from Nassau County, N.Y. Police Department; and the Rochester, N.Y. Police Department.

Perhaps the most important consideration in terms of successful analytics is the human factor, and human involvement, with the ultimate success of a strategic use of ShotSpotter. An analyst in Rochester, N.Y. referred to looking through ShotSpotter data and finding a recent event which had activated ShotSpotter, but which was merely acknowledged by the dispatcher. No dispatch to patrol had been made, nor had any reclassification of the alert.[117]

The decision not to dispatch the call to patrol may have been, according to the analyst, acceptable in the context of a maturing program, in which dispatchers are trained to acknowledge but not dispatch calls when it is clear that it is an "algorithm error."[118] But the failure to reclassify has a snowball effect. Not only do the analysts not have accurate gunshot activation data for even basic statistical analysis purposes, but any algorithmic improvements made by ShotSpotter to the GLS are halted when sounds which are clearly helicopters to a human listener, are allowed to be misclassified by the system: "It speaks to the human factor challenges of having ShotSpotter work effectively as part of an operational strategy."[119]

During our field interviews, we had hoped to learn that analyst departments were leveraging the ShotSpotter data to support intelligence operations at the department consistent with crime analysis, intelligence analysis,

or national policing programs such as community policing and intelligence-led policing. However, we found that for many reasons observed, due to a lack of standard ShotSpotter data workflow or activation data lifecycle management primarily associated with lack of consistent and comprehensive reclassification or cleaning, analysts cannot access the data necessary to support the use of ShotSpotter to inform these programs. Several respondents[120] agreed that this model represents an effective workflow:
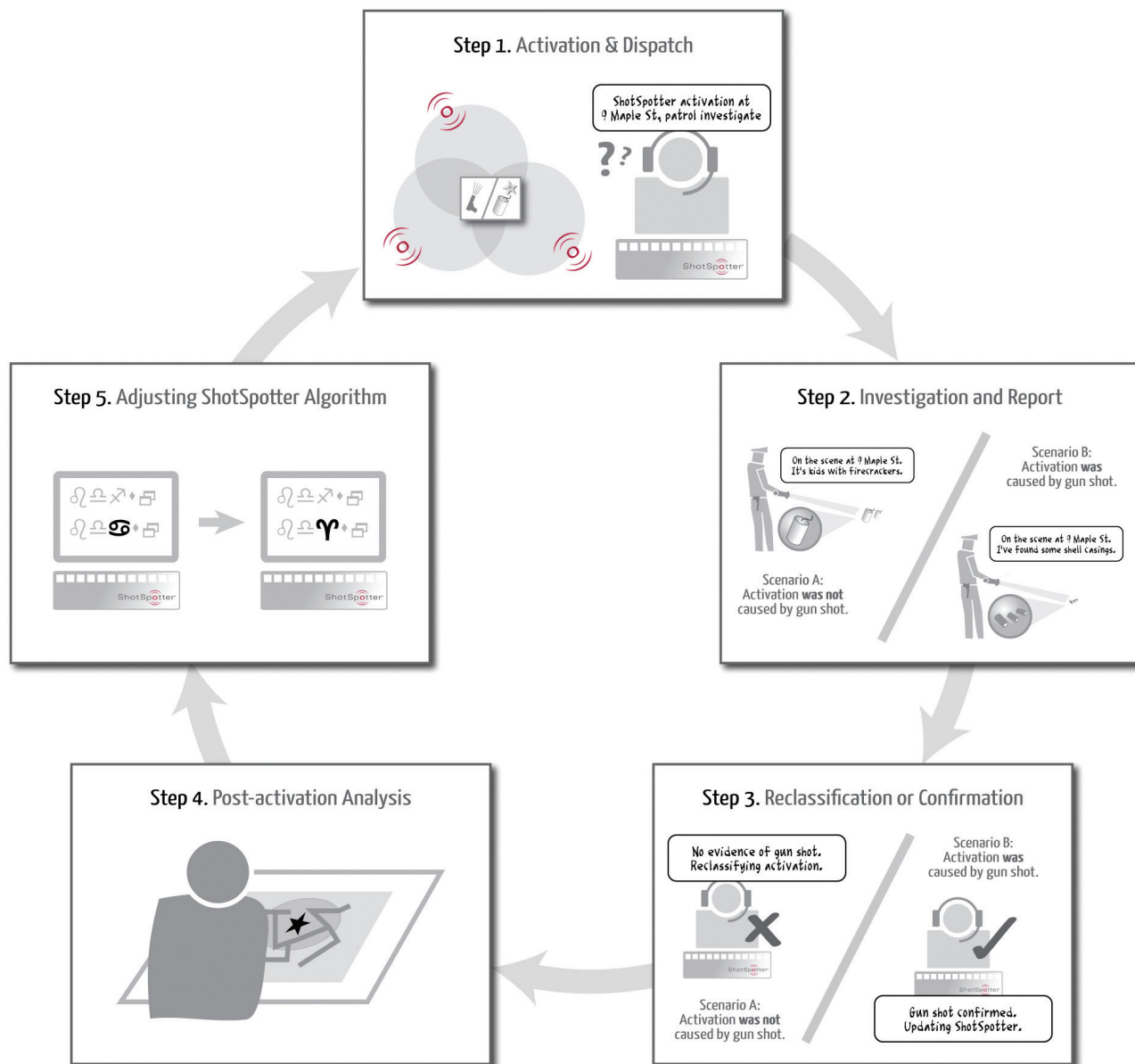

Figure 3. Sample ShotSpotter GLS Activation Lifecycle

Without accurate reclassification of activation data, based on empirical data provided by established patrol investigative techniques, neither effective analysis nor retraining of the ShotSpotter algorithm or personnel is possible. This relegates ShotSpotter data to merely tactical usage and aggravates the operational issues of false positives experienced by dispatchers. Ironically, the work of reclassification by dispatchers would likely ameliorate future false positives as it would identify problem areas which may be addressed by ShotSpotter technicians.

As a basic example, simple quantitative expression of ShotSpotter data such as that in Figure 4 is not possible unless the data are properly reclassified:
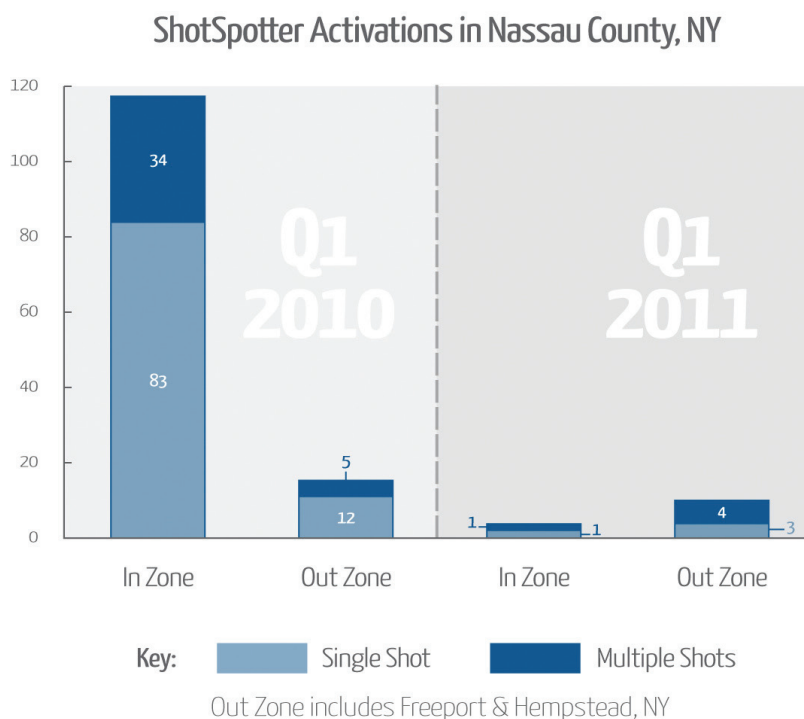
ShotSpotter Activations in Nassau County, NY

Key: Single Shot ▮ Multiple Shots
Out Zone includes Freeport & Hempstead, NY

Figure 4.
Source: Nassau County Police Department, Asset Forfeiture and Intelligence Unit

In this chart, the analyst shows that "In Zone," meaning within the area of the ShotSpotter coverage, the number of single gunshots fell from 83 in the first quarter of 2010 to one in the first quarter of 2011; multiple gunshots fell from 34 to zero in the same period. This fundamental articulation—it is not analysis—is literally impossible without accurate reclassification of ShotSpotter activations. Nassau County, N.Y. is certain that the 83 ShotSpotter activations which occurred in the first quarter of 2010 were gunshots, not anything else.

Further, depictions of changes in level of ShotSpotter activations without such cleaning will use data riddled with false positives, leading to precise sounding statements based on (at best) imprecise data and potentially faulty conclusions.

Because so few agencies can demonstrate that they engage in this regular, systemic, and predictable reclassification, we believe that ShotSpotter must better educate its customers as to the critical importance of reclassification, and provide training and re-currency training for all users.

At the Nassau County, N.Y. Police Department (NCPD), all reclassification of ShotSpotter activations are conducted by detectives in the intelligence bureau[121]; all ShotSpotter activations are reviewed by detectives in the intelligence bureau.[122] The Intel bureau reviews all reports generated by the department, including officer "aideds" (reports by officers coming to the aid of an injured person). "[The Intelligence Unit reads] any report that comes into the police department's possession or [which is] created by a police officer."[123]

The NCPD performs daily, weekly, monthly, quarterly, and annual crime statistical reporting, trend analysis, Uniform Crime Report (UCR) preparation, COMPSTAT (called NassSTAT locally); it also creates strategic crime analysis reports, intelligence analysis and intelligence reports, and crime mapping.[124] The unit overlays the ShotSpotter confirmed shot map with gang member residencies, sex offenders, probationers and parolees, party houses, and drug houses.[125]

The NCPD as a whole uses ShotSpotter as a source of data to support not just its tactical response to gunshots, but is used by command staff for strategic imperatives including personnel and resource decisions[126] and to support applications for grants to purchase equipment other than ShotSpotter, for example, license plate readers and cameras:

> *"We've used ShotSpotter to show one our activity of shots being fired in the zone. We then take that activity and the ShotSpotter [activity] to apply for technology such as cameras license plate readers and we're in the process now of interacting the three together."[127]*

It seems that the key to this strategic use of data by NCPD relies wholly on the use of reliably cleaned ShotSpotter data. NCPD reported among the lowest rates of false positive and false negative complaints by Dispatch and Patrol of any of the agencies interviewed. We speculate that this is because of the strictly followed agency-wide procedures and written policies governing the use of ShotSpotter at each stage of an activation's lifecycle.[128]

4.6 Trans-Respondent Group Findings

Two high level issues emerged during the research of this study that transcend any single respondent group and affect each of them. These issues are false positives—a ShotSpotter activation which is ultimately determined to have been caused by something other than a gunshot—and the comparison of ShotSpotter to 9-1-1 alone.

There are aspects of these two issues which are related, however it is important to note a critical distinction between 9-1-1 and ShotSpotter:

ShotSpotter is a reporting channel in which there may be activations which report:

- Actual gunshots
- False positives
- False negatives (no activation when a gunshot is known to have occurred)

9-1-1 is a reporting channel which can have reports of:

- Actual gunshots
- False negatives

By definition, 9-1-1 cannot have "false positives"—the system is too imprecise and there are too many unknowns—but rather a relatively high degree of "unexplained incidents" in which officers are summoned to a call at an imprecise set of coordinates as reported by a caller and fail to find evidence.

4.6.1 False Positives

The false positive, a ShotSpotter activation which is ultimately determined to have been caused by something other than a gunshot,[129] is the single most common complaint of ShotSpotter users. False positives pose an operational problem for users. Those most affected by these operational issues are dispatchers, followed by patrol officers. Detectives are typically not affected by false positives. Analysts are affected in that the data they work with is not representative of gunfire incidents without scrupulous cleaning through reclassification of activation data. Command staff did not feel that ShotSpotter placed undue burden upon non-financial resources.[130]

While false positives are a problem that must be addressed (and we see in the data some likely avenues of remediation[131]), it is important to note that these operational issues do not diminish and indeed are orthogonal to the general efficacy of the ShotSpotter product.

We began investigating this when most patrol officer respondents, and even some dispatchers, made the counterintuitive statement that false positives do not affect their confidence in the accuracy of the data they receive from ShotSpotter.[132]

In the case of ShotSpotter, accuracy—a quality that each respondent across all categories allowed was a clear product characteristic, and which patrol officers referred to as the product's best attribute[133]—refers to the ability of ShotSpotter to accurately determine a specific temporal and geospatial, or geographical, location of an event.

To understand the seeming contradiction, we analyzed the inputs and responses from the different channels of 9-1-1 and ShotSpotter, and our hypothesis follows.

Simply put, "what happened" is separate from "where and when it happened." Cops will tell you that they would rather handle a call of "something is happening at 521 North Adams Street" than one of "a homicide is in progress somewhere in the city." ShotSpotter is accurate about the "where" which means that incidents can be rapidly investigated.

Any comparison of ShotSpotter to other reporting channels, like 9-1-1, which do not give a reliable and accurate statement of at least "where," will favor ShotSpotter because "what" can be investigated when the "where" is known, while the reverse is not true.

More specifically: geospatial accuracy means that the human resource may always be effectively deployed to find out whether a gunshot or other sound has occurred. This subject is clearly distinct from and more important than any discussion of whether ShotSpotter is able to programmatically distinguish the sound of a gunshot from the sound of, say, a dumpster or truck backfiring.

The critical tactical reality is that patrol officers cannot investigate a sound of any kind unless they know where it has occurred. Conceptually, this means that a false positive report from ShotSpotter is easily debunked because of its highly accurate geospatial capabilities.

Conversely, on a 9-1-1 call in which the caller heard a gunshot, and when patrol officers respond and do not immediately find an injured person or other evidence of a shooting, it is highly difficult if not impossible to determine whether a gunshot has occurred, because no location information is available other than that of the caller, and the caller's perceived direction of sound at an approximate time as estimated and reported.

4.6.2 ShotSpotter versus 9-1-1

As we have seen, patrol officers trust ShotSpotter over 9-1-1 as a single source reporting tool. Patrol officers believe that ShotSpotter activations arrive faster, and provide crucial time-of-incident, specific location and number of shots information not given by 9-1-1.[134] They trust ShotSpotter over 9-1-1 to activate more often when gunshots are fired because of repeated gunshot incidents in which no 9-1-1 call was made."[135] However, some agencies report that, since gunshot incidents have been on the decline and the community has seen more proactive response since ShotSpotter deployment, more gunshots appear to be reported by residents via 9-1-1 than previously.[136]

When witnesses call 9-1-1,[137] the information from those calls is not considered reliable, while ShotSpotter is.[138] The geospatial accuracy of ShotSpotter provides Patrol officers with information about the actual location

of a shooter, as distinct from the location where witnesses experience the gunshot. This is a crucial distinction, and has led, as described in the patrol section, to settlement of discussions over which agency has jurisdiction on a particular incident.[139]

ShotSpotter can improve outcomes by helping Patrol officers get to the scene faster than 9-1-1 alone,[140] increasing the likelihood of an arrest and, as we have seen, decreasing the time to get gunshot victims to life saving medical treatment. In the case of a shot police officer or citizen, seconds count, and ShotSpotter is seen by first responders as effective in providing fast and highly accurate alerts of gunfire much faster and more accurate than 9-1-1.

When combined with 9-1-1, ShotSpotter offers patrol and detectives a powerful tool that helps them to quickly communicate with witnesses and potential suspects. Taken together, the two systems form a corroborative network of information which can be used by patrol to investigate incidents in progress: ShotSpotter gets them to the correct location while 9-1-1 provides a number to call to ask additional questions about the incident that the witness may be able to answer.[141] This corroborative is seen in priority given by patrol officers to calls coming from multiple channels as well.[142]

Command staff in Richmond, Calif. say that patrol officers also look to ShotSpotter to confirm 9-1-1 calls in a similarly corroborative fashion:

> *"They're so embraced with this technology, if we get a standard 9-1-1 call of shots fired at the corner of Walk and Don't Walk, the radio puts it out that way. The immediate question is, "Did you get a ShotSpotter hit?" Because they know that's going to put them at the right place. I think officers feel it makes them safer, because they know they're going to the correct location." [143]*

5.   Suggested Further Study

5.1   Activation Lifecycle

More in-depth analysis of the lifecycle of ShotSpotter activations in the context of departments such as Nassau County, N.Y. is required in order to identify the factors that can increase the integration of ShotSpotter into strategic crime reduction programs, policies and practices.

5.2   Dispatcher Training

The variation among dispatchers seems to point to training issues (ab-initio or re-currency) that should be easily addressed. Dispatchers seemed unclear on the total amount of ShotSpotter training they had received. However, five dispatchers said specifically that they had received an hour or less on waveform recognition and audio gunshot recognition training.[144] All mentioned that the training heavily focused on waveform recognition and the system's distinction between fireworks and gunshots,[145] and some limitations on the system such as the inability to detect gunshots from within buildings.[146]

Dispatcher complaints and attitude towards false positives are an operational concern: we suspect dispatcher hostility towards the technology may lead to less attention being paid to initial monitoring of activations (including waveform and audio review), and in agencies where dispatch is charged with reclassification, poor acknowledgement of alerts without dispatch or even reclassification. An examination of this scenario was not in the scope of this paper and may require additional study.

5.3   9-1-1 versus ShotSpotter: False Negatives

Few agencies have reliable data of ShotSpotter activations that have been verified as gunshots correlated with events in which no 9-1-1 call was received. However, this is an interesting topic and may be valuable to agencies seeking to increase their community policing and neighborhood policing efforts to better engage with citizens and encourage participation and cooperation. It would also be useful to have hard data on the percentage of known gunshots (through confirmed ShotSpotter activations) which are not typically reported to 9-1-1 for statistical analysis.

5.4   Policy and Lifecycle Best Practices

The study results suggest that agencies would benefit from assistance from ShotSpotter based on its experience with agencies throughout the world in developing more effective policies. Best practices regarding activation response, dispatch and reclassification, analysis and activities on the part of agencies will lead to the most effective ShotSpotter system implementation. Additionally, ShotSpotter sharing information with customers on how to use ShotSpotter in strategic analysis, and in support of other initiatives such as grant writing, hotspot identification, and other intelligence-led policing activities, is suggested.

6. Endnotes

1   http://policeledintelligence.com

2   US Patent #7,474,589 B, issued 6 Jan 2009

3   National Organization of Black Law Enforcement Executives, http://noblenational.org

4   9-1-1, the universal U.S. emergency number for all telephone services, source:
http://www.fcc.gov/pshs/services/911-services/Welcome.html

5   CSGA views the titles "Detective" and "Investigator" as descriptive of the same role:
those who investigate gunshot crimes or homicide

6   "Does a ShotSpotter alert to a gunshot call result in a tactical response from you overall?" n=7

7   "Does ShotSpotter help increase your situational awareness while dealing with a "shots fired" call?" n=7

8   "Does information gathered by ShotSpotter affect the route that you travel when responding to a gunfire call?" n=7

9   "Does a ShotSpotter alert affect the priority which you assign to a gunfire call?" n=7

10   Requests may be made at http://policeledintelligence.com/contact. Please allow one business-day for a reply.
Replies will contain a hyperlink pointing to the recording requested on a public-facing Internet server.

11   Interviewers were instructed within the script to "flip" the question order per respondent.

12   http://bit.ly/hiklEN

13   What were the driving reasons for deciding to purchase ShotSpotter? N=7

14   See, eg, Saginaw, Mich., Command, lines 4-8 and Rochester, N.Y., Command, lines 5-6

15   Saginaw, Mich., Command, lines 4-8

16   See, e.g., Riviera Beach, Fla., Command, line 5, and Nassau County, N.Y., Command, lines 7-9

17   Nassau County, N.Y., Command, lines 7-9

18   "Have gunshot incidents in your city gone up or down since deployment of ShotSpotter?" N=7

19   Brockton, Mass., Command, line 42

20   Saginaw, Mich., Command, lines 128-133

21   Nassau County, N.Y., Command, lines 87-88

22   Richmond, Calif., Command, lines 390-400

23   "Have other non-gun related crimes gone up or down since ShotSpotter deployment?" N=6

24   See for example, Saginaw, Mich., Command, lines 142-144, and Nassau County, N.Y., Command, line 91

25   "Do you believe ShotSpotter is responsible for saving lives in your community?" n=7

26   See Nassau County, N.Y., Analysts, lines 179-184; "The police officer responded before the 9-1-1 calls got out. One
individual was already deceased. The second individual was wounded and due to that quick response it possibly
saved his life from bleeding out in the street." Also see Saginaw, Mich., Command, lines 130-133: "[W]e've had…
probably in the area of a 40% reduction in the two years that we've been using ShotSpotter. Our homicides have
been cut in half…I'm assuming ShotSpotter is at least responsible for a portion of that. I couldn't tell you exactly how
much."

27   "How confident are you in the information ShotSpotter provides?" Six-point Likert-scale, n=7

28   "What value do you place on having ShotSpotter deployed in your city? Six-point Likert-scale from "very low" to "very high." n=7

29   How effective is ShotSpotter at preventing illegal gunfire incidents in your city? Six-point Likert-scale from "very ineffective" to "very effective." n=7

30   "Is ShotSpotter effective?" n=7

31   East Palo Alto, Calif., Command, lines 157-158

32   Nassau County, N.Y., Command, line 229

33   For example, see Saginaw, Mich., Command, lines 130-133; Nassau County, N.Y., Command, lines 231-239; Brockton, Mass., Command, lines 148-150; Riviera Beach, Fla., Command, lines 167-178; Rochester, N.Y., Command, lines 216-242

34   Nassau County, N.Y., Command, lines 231-239

35   Do you see the value of ShotSpotter at your agency being primarily tactical or primarily strategic? N=7

36   See, for example, Nassau County, N.Y., Command, lines 21-24; Richmond, Calif., Command, lines 140-143; and Saginaw, Mich., Command, lines 20-22

37   See, for example, Richmond, Calif., Command, 535-537, "[E]vidence that ShotSpotter is not viewed as a threat...even by the crooks is that no one has taken any counter-measures to destroy or damage the equipment."

38   Do citizens in your city say it makes them feel safer? N=7; In your opinion how do your citizens feel about ShotSpotter do they have a good or bad perception of it? N=7; Any Big Brother or similar civil liberties concerns? N=7

39   See responses including, "I would say the general law abiding citizen probably has [a] positive [perception of ShotSpotter] (East Palo Alto, Calif., Command, lines 63-64)"; "I think there are excellent perceptions in the area where ShotSpotter is deployed...which actually flood over into areas where it's not deployed. People have very good feelings about it. I've actually run across [no civil liberties concerns]. Ten years ago I would tell you that this may have been problematic. Today, people are clamoring for an expansion or enhancement (Nassau County, N.Y., Command, lines 94-102)."

40   Richmond, Calif., Command, lines 512-516

41   If you had the decision to make over would you decide the same way? N=7

42   Saginaw, Mich., Command, line 171; Rochester, N.Y., Command, line 83; Riviera Beach, Fla., Command, line 63; Richmond, Calif., Command, line 567; Nassau County, N.Y., Command, line 108; Brockton, Mass., Command, line 57; East Palo Alto, Calif., Command, line 74

43   "What's your confidence level in ShotSpotter information on a scale from very high to very low?" n=7

44   CSGA views these titles as descriptive of the same role: those who investigate gunshot crimes or homicide. The only difference is a regional one, that detectives are referred to as investigators in some regions.

45   Agencies differ in the manner in which detectives are notified, and the time at which they arrive on the scene. Saginaw, Mich., Rochester, N.Y., Riviera Beach, Fla., Richmond, Calif., Nassau County, N.Y., and Brockton, Mass., detectives arrive as the scene is being processed and/or the scene is held for their arrival, while East Palo Alto, Calif., detectives sometimes arrive after the scene is cleared. Some agencies (Richmond, Calif., and Rochester, N.Y.) rely heavily on evidence technicians to locate and collect evidence. We have taken these factors into account in our analysis but note that we have not interviewed these evidence technicians to determine whether they receive and/or use ShotSpotter data.

46   "Does ShotSpotter allow you to investigate more efficiently?" n=6. Four replied, "Yes." Two others specified that it did, "on some occasions, I think so (Saginaw, Mich., Detectives, line 212)" or, "In some situations, yes." (Richmond, Calif., Detectives, line 213).

47   "Does ShotSpotter save you time on investigations?" n=6

48   Detectives were asked if they consider the geographical data, number of shots, time of shots and information on whether the shots were moving (as in a drive-by shooting) from ShotSpotter before arriving on the scene, and on the scene before conducting a search or questioning witnesses and suspects: "Do you consider the following information from ShotSpotter and make that consideration part of your search strategy: Geodata? Number of shots? Time of shots? Time between shots? Moving shots?" n=7

49   For example, "Absolutely, because you may be asking 'how much shots did you hear' when you already have that answer. Where were you in po...you know, the vicinity when you heard the shots. And again, because the sensors depending on their location may actually closer than a witness (Nassau County, N.Y., Detectives, lines 187-192)," and, "If ShotSpotter said seven shots and the witness said seven shots obviously, y'know, we know that there are counts consistent with the information we have (Saginaw, Mich., Detectives lines 172-176)."

50   For example, "If I'm talking about witnesses what am I going to...ask them again their observation. What were they doing particularly there. How long they've been there. Are they related to anybody at the scene. Are they injured. And we'll go from that (Nassau County, N.Y., Detectives, lines 118-122)."

51   See, for example, Richmond, Calif., Detectives, lines 209-215, and Saginaw, Mich., Detectives, lines 209-215

52   See, for example, Brockton, Mass., Detectives line 258; East Palo Alto, Calif., Detectives lines 312-323;

53   Nassau County, N.Y., Detectives, lines 269-291

54   "On average, how much time do you think ShotSpotter saves you in a given investigation?" n=7

55   e.g., Brockton, Mass.: "It's a minimal time" (Line 248); "It could probably save us less than an hour on incidents where maybe an eyewitness account isn't available... (Saginaw, Mich., Detectives, lines 221-223)" etc.

56   Saginaw, Mich., Detective, lines 273-282

57   It is unclear from this interview (East Palo Alto, Calif., Detective Kevin Ferreira, lines 246-268) whether the shots occurred inside the ShotSpotter coverage area.

58   East Palo Alto, Calif., Detective Kevin Ferreira, lines 246-268

59   Brockton, Mass., Detectives, lines 117-118

60   Brockton, Mass., Detectives, lines 64-82

61   See, for example, Saginaw, Mich., Detectives, lines 144-153

62   "What's your confidence level in ShotSpotter information on a scale from very high to very low?" n=7

63   Detectives: Saginaw, Mich., lines 225-231; Brockton, Mass., lines 266-269; Nassau County, N.Y., lines 305-309; Richmond, Calif., lines 221-229; Riviera Beach, Fla., 236-329; Rochester, N.Y. lines 199-201; East Palo Alto, Calif., lines 380-384

64   Chief Cliff, Saginaw, Mich., lines 84-97

65   Riviera Beach, Fla., Detectives, lines 388-397

66   "What's the best attribute of ShotSpotter?" n=7

67   See, e.g., Saginaw, Mich., Patrol, lines 486-503, and Rochester, N.Y., Patrol, lines 410-417

68   Saginaw, Mich., Patrol, lines 486-503

69   Riviera Beach, Fla., Patrol, lines 344-348; and Richmond, Calif., Patrol, lines 300-302

70   Nassau County, N.Y., Patrol, lines 468-477

71   Riviera Beach, Fla., Patrol, lines 123-125

72   "I would say that the question has to do with the neighborhood, too. You know, if you get down to the worst part of the neighborhood, they're used to gunfire—so no one's calling (Saginaw, Mich., Patrol, lines 264-266)." "You would be surprised how many times that people don't call up for gunfire (Nassau County, N.Y. Patrol, lines 234-236)."

73   "In the past we used to didn't get that many calls, but now, if you get a shooting, we're gonna get two or three calls (East Palo Alto, Calif., Patrol, lines 278-281)."

74   "Usually citizens will usually call on multiple gunfire. If it's a one shot it's probably a fifty-fifty, you know, between a ShotSpotter and a citizen calling in (Richmond, Calif., Patrol, lines 161-164)."

75   "Before, we'd get a shots fired call from a citizen [and] it may or may not be the case. The citizen may think [there's] a backfire, or it could be a backfire or fireworks or whatever. Now we have a system in place that verifies gunfire (Richmond, Calif., Patrol, lines 102-105)."

76   "Yes, I put more belief in [ShotSpotter] than I do the general public calling in (Brockton, Mass., Patrol Interview, lines 140-141)."

77   "We had one time when they pinpointed right to the front yard, and it even gave us an address [for this camera from then]. When we got there, people were shot in one area, they were looking, [and] they say 'ShotSpotter picked up [shots] over in this area' and we looked inside there, [and] we found the casings in his area. So definitely they were shooting down the street at the person. So even though the person was shot say down the street ShotSpotter told us exactly where they were shooting from (East Palo Alto, Calif., Patrol, lines 168-177)."

78   "Last week there was a shooting, a bus pulled up to a bus stop and there was some guys standing outside; they knocked on the window and fired three two or three rounds into this bus. Nobody on the bus got hit, but somebody got nicked with some flying glass. Well, we got the call that the bus had stopped at a certain location. We get there, they give us a ShotSpotter alert at a location that's about two blocks in a different jurisdiction outside of the coverage area. So when the officer get there he talks to the bus driver who said that the incident occurred at a different location other than what the ShotSpotter gave. So the particular incident where the ShotSpotter claimed it occurred was in the County's Sheriff's department jurisdiction, and the and the location where the bus driver said it occurred would be in our jurisdiction. So we had the Sheriff's department out looking at our area for casings and there wasn't any there. So I went to the location of the ShotSpotter activation and right where it said it occurred were the casings (Richmond, Calif., Patrol, lines 307-324)."

79   "One is the accuracy—you know you're actually going to where you believe the gunshots are coming from instead of a third party calling in and saying they heard gunshots from a particular area. You know where that area is. [Two] is the speed of it which increases the likelihood that we're actually going to come across, hopefully, the perpetrator himself (Brockton, Mass., Patrol, lines 105-113)."

80   Nassau County, N.Y., Patrol, lines 122-136

81   "If you have a citizen that's calling in shots fired, or if you have a call after that that says, you know, report that somebody shot, it just lends more credibility to the call and all the factors together kind of play in together (Rochester, N.Y., Patrol, lines 97-99)."

82   "If we receive, like I said before, if we receive multiple calls from any residents in addition to a ShotSpotter activation, it can dictate, or if it's traveling in a certain direction, dictate a change in response there (Saginaw, Mich., Patrol, lines 174-178)."

83   "Does a ShotSpotter alert to a gunshot call result in a tactical response from you overall?" n=7

84   "Does ShotSpotter help increase your situational awareness while dealing with a "shots fired" call?" n=7

85   "Does information gathered by ShotSpotter affect the route that you travel when responding to a gunfire call?" n=7

86   "Does a ShotSpotter alert affect the priority which you assign to a gunfire call?" n=7

87   "Have you ever been able to effect an arrest due to the use of ShotSpotter?" n=7

88   The "classic gunshot waveform" the dispatchers say, resembles a sideways "Christmas tree" and is a distinctive graphical representation.

89   "When you see the classic gunshot waveform, how confident are you that the system has detected actual gunfire and not something else that might trigger a ShotSpotter activation?" n=7

90   "And in your estimation what percentage of activations are really gunshots and not one of those other things?" n=7

91   Saginaw, Mich., Dispatch lines 293-294

92   Rochester, N.Y., Dispatch, line 290

93   Riviera Beach, Fla., Dispatch, lines 327-328

94   Richmond, Calif., Dispatch, lines 324-328

95   Nassau County, N.Y., Dispatch, line 375, amended from an earlier statement in the interview that it was 80% (at line 258)

96   Brockton, Mass., Dispatch, line 268

97   The outlier in this case was the dispatcher in East Palo Alto, Calif., where the respondent reported (East Palo Alto, Calif., Dispatch, lines 258-265) a 95% false positive rate–that is, only five percent of ShotSpotter GLS activations are actually gunshots. We have no analysis of the reason for this divergent opinion. We do note that when this same dispatcher, East Palo Alto, Calif., was asked the previous question about his confidence when he sees the "classic gunshot waveform," he responded, "I'm only confident if I hear it." [Ibid., line 255]. In response to a different question "When you listen to the audio, what are your criteria for determining whether something is not a gunshot?" [lines 197-198] he responds, "I do look at the waveform," [Line 199] however it is unclear whether these responses when taken in their totality indicate this dispatcher is following the procedures to properly use the system upon initial activation. We have discounted the estimate from this dispatcher for these reasons. We note that, if we were to have included his estimate, this would reduce the perceived true gunshot reporting rate to 58%.

98   This table is based on a series of questions asked of each respondent dispatcher. The questions and the responses which have been tabulated here may be found in the following documents: East Palo Alto, Calif., [Lines 306-341]; Saginaw, Mich., [lines 341-401]; Nassau County, N.Y., [lines 299-346]; Riviera Beach, Fla., [lines 386-477]; Rochester, N.Y., [lines 329-386]; Richmond, Calif., [lines 377-440]; Brockton, Mass., [lines 300-345].

99   See, Saginaw, Mich., Dispatch, lines 286-290; Rochester, N.Y., Dispatch, lines 274-286; Riviera Beach, Fla., Dispatch, lines 300-324; Richmond, Calif., Dispatch, lines 318-321; Nassau County, N.Y., Dispatch, lines 249-253; and Brockton, Mass., Dispatch, lines 261-265

100   See Section 3.4

101   For example, Richmond, Calif., Dispatch Lines 271-272; East Palo Alto, Calif., Dispatch, lines 182-183; Nassau County, N.Y., Dispatch, line 197; Rochester, N.Y., Dispatch, lines 197-197; Brockton, Mass., Dispatch, line 212; Riviera Beach, Fla., Dispatch, line 257, Saginaw, Mich., Dispatch lines 235-239

102   "Let's look a little closer at those activations resulting from something other than a gunshot. When you detect one is there a procedure to reclassify that activation in the system?" n=7

103   "When you listen to the audio what are your criteria for determining whether something is not a gunshot?" n=7

104   Saginaw, Mich., Dispatch, lines 249-256

105   Rochester, N.Y., Dispatch, lines 206-213

106   Brockton, Mass., Dispatch, lines 226-229

107   Riviera Beach, Fla., Dispatch, lines 266-273

108   Nassau County, N.Y., Dispatch, lines 211-216

109   Richmond, Calif., Dispatch, lines 282-294

110   East Palo Alto, Calif., Dispatch, lines 199-203

111   "Does [the ratio between false positives and actual gunshots] change between any given shift? N=7

112   This is a series of questions to each dispatcher, starting, e.g., at line 114 in Brockton Dispatchers and continuing to line 198. A complete compilation of the questions to and responses from each Dispatcher in this series is available at http://www.shotspotter.com/resources/efficacystudy. In the table on that page, the column D indicates that the dispatcher receives the information from ShotSpotter Always, Sometimes or Never, and the column P indicates that the Dispatchers passes this information on to patrol Always, Sometimes or Never.

113   Ibid.

114   See, for example, East Palo Alto, Calif., Dispatch, line 341, and Richmond, Calif., Dispatch, lines 433-439

115   Nassau County, N.Y., Dispatch, lines 343-346

116   Brockton, Mass., Dispatch, lines 365-369; respondent first called these "false positives" but on confirmation referred to them as "false negatives." "The false positives. I wish they would pick up. That's my one grief. Sometimes even in the sensor area they don't pick up a gunshot when its there." This is inconsistent with other reports from that agency, and separately, the dispatcher appeared confused by the question, so we have discounted it in our analysis.

117   Rochester, N.Y., Analysts, lines 311-330

118   Ibid.

119   Ibid.

120   Richmond, Calif., Analysts, lines 143-149; Nassau County, N.Y., Analysts, lines 87-90; Riviera Beach, Fla., Analysts, lines 96-98; East Palo Alto, Calif., Analysts, lines 86-90

121   Nassau County, N.Y., Analysts, lines 87-88

122   Ibid., line 2

123   Ibid., lines 5-7

124   Ibid., lines 12-38

125   Ibid., lines 46-74

126   Nassau County, N.Y., Command, lines 137-138

127   Nassau County, N.Y., Analyst, lines 134-138

128   Nassau County, N.Y., Command, lines 130-133

129   The most commonly reported sources of false positive activations are, in no particular order: dumpsters, trucks, motorcycles, helicopters, fireworks, construction, traffic hitting expansion plates on bridges or potholes, trash pickup, church bells, and other loud, concussive sounds common to urban life. Dispatch respondents report that false positives are more likely to occur during daytime shifts, when more of these noises are likely to occur.

130   When asked whether ShotSpotter was a burden to resources other than financial, commanders replied "No" in Saginaw, Mich., Command, line 78; Rochester, N.Y., Command, line 43; Richmond, Calif., Command, line 275; Riviera Beach, Fla., Command, line 25; Nassau County, N.Y., Command, line 76; East Palo Alto, Calif., Command, line 35; and "Yes" in Brockton, Mass., Command, line 26.

131   ShotSpotter technology and recognition-engine improvements, and more effective, re-currency user training leading to better, more thorough and accurate reclassification of activations can reduce the overall number of false positives

generated programmatically. These steps also will render the historical data stored by ShotSpotter of activations more suitable for analysis and use to improve the ShotSpotter recognition technology. This suggests a best practices recommendation of a "ShotSpotter Activation Lifecycle Management" framework.

132   See "Patrol responses to questions on accuracy and false positives" at http://www.shotspotter.com/resources/efficacystudy

133   "What's the best attribute of ShotSpotter?" n=7

134   Nassau County, N.Y., Patrol, lines 468-477

135   Riviera Beach, Fla., Patrol, lines 123-125

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143   Richmond, Calif., Command, lines 177-183

144   Saginaw, Mich., Dispatch, lines 97-98; Rochester, N.Y., Dispatch, "Minimal" (line 63) and "The training should have been more in-depth" (line 52); Richmond, Calif., Dispatch "30 minutes on each" (lines 79-80); Nassau County, N.Y., Dispatch "I would say a good 20 minutes or half hour. He kept saying did we want to go over more until we were comfortable with it." (lines 51-53); East Palo Alto, Calif., Dispatch "Thirty or 40 minutes" (line 54-56)

145   See, eg, Richmond, Calif., Dispatch, lines 82-88

146   Ibid.