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Research in Brief

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Issues and Findings

Discussed in this Brief: The findings of two field studies of acoustic sensing systems designed to detect the sound of a muzzle blast from a gun and, within seconds of the shot being fired, triangulate within some margin of error the location from which the shot was fired, before alerting the police about the gunshot. The research team examined the effectiveness of Trilon Technology's ShotSpotter™ system, which the local police department has operated in Redwood City, California, since early 1996, and the Alliant Techsystems Inc.'s SECURES™ system, which police installed for 2 months in a neighborhood with high levels of random gunfire in Dallas, Texas, in 1996. This Research in Brief also outlines how the police used the technology in Dallas and what officers working in the study sites think of gunshot detection systems.

Key issues: Anecdotal evidence from the media and interviews with local officials, police, and community members suggests that random gunfire is considered a serious problem in many large cities in the United States. Random gunfire has been defined as "the indiscriminate discharge of firearms into the air," which generally occurs during holiday celebrations, during weekends or sporting events, and often in the context of drinking.

Random gunfire problems are distinguishable from other types of shooting incidents such as urban sniper attacks, gang shootouts, domestic homicides, and revenge shootings because (1) random

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Random Gunfire Problems and Gunshot Detection Systems

by Lorraine Green Mazerolle, Cory Watkins, Dennis Rogan, and James Frank

Random gunfire is a significant problem in many large cities throughout the United States.[1] Random gunfire has been defined as "the indiscriminate discharge of firearms into the air," which generally occurs during the celebration of holidays, during weekends or sporting events, and often in the context of drinking.[2]

Communities across the United States have instituted a variety of efforts to reduce random gunfire problems, including public awareness campaigns and the use of technological devices to detect and alert the police to incidents of gunshots and explosions. Generically known as "gunshot detection systems," the technology includes an acoustic sensing system capable of identifying, discriminating, and reporting gunshots to the police within seconds of a shot being fired.[3]

This Research in Brief summarizes the findings of field studies of two gunshot detection systems: Trilon Technology's ShotSpotter™ system, which has operated in Redwood City, California, since early 1996, and Alliant Techsystems Inc.'s SECURES™ system, installed for 2 months in 1996 in a neighborhood with high levels of random gunfire in Dallas, Texas. This Research in Brief also outlines how the police used the gunshot detection system in Dallas and what officers working in the test sites think of the technology.

What is known about random gunfire problems

Random gunfire problems are distinguishable from other types of shooting incidents such as urban sniper attacks, gang shootouts, domestic homicides, and revenge shootings because (1) random gunfire is strictly an outdoor activity; (2) it is not usually part of other criminal activity such as drug dealing, assaults, or robberies; and (3) random gunfire shooters do not fire their weapons to intentionally injure or kill people.

In many U.S. urban areas, random gunfire is considered a problem, typically involving people drinking alcohol and watching televised sporting events and then walking outside to fire their weapons into the air in celebration. People also tend to fire their weapons on New Year's Eve, Cinco de Mayo, Fourth of July, and other significant holidays. Police report that random gunfire shooters believe their actions are harmless. Shooters state that firing their weapons in the air does not endanger lives or damage property.[4]

Policymakers, police department personnel, city prosecutors, and community residents across the United States have implemented a variety of initiatives to control serious shooting and other gun-related problems.[5] Yet only a few local governments have developed programs

Issues and Findings

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gunfire is strictly an outdoor activity; (2) it is not usually part of other criminal activity such as drug dealing, assaults, or robberies; and (3) random gunfire shooters do not fire their weapons to intentionally injure or kill people.

Residents in communities with high levels of random gunfire live in perpetual fear; and law-abiding business owners and residents freely express their willingness to abandon or relocate from a neighborhood with random gunfire problems.

Key findings: The study of the use of gunshot detection technology in local law enforcement led the research team to four broad conclusions:

- Gunshot detection systems are likely to reveal rather high citizen under-reporting rates of random gunfire problems (23 percent of incidents are reported).

- The technology is likely to increase the workloads of police officers, particularly if departments dispatch a patrol unit to every gunfire incident detected by a technological system.

- Gunshot detection systems are not likely to lead to more arrests of people firing weapons in urban settings because it is highly unlikely that offenders will stay at a gunshot location long enough for the police to arrive.

- Finally, gunshot detection systems seem to offer the most potential as a problem-solving tool and would fit nicely within the emerging problem-oriented policing paradigm. The technology can help police identify random gunfire hot spots and develop strategies to address the problem.

Target audience: Local police administrators, local government officials, community groups, and researchers.

that focus specifically on random gunfire problems. In cities such as Dallas (the police department's Gunshot Awareness Program), New Orleans (Gunshot Public Awareness Program), Redwood City (Operation Silent Night Program), and St. Louis (Town Criers' Program), community awareness campaign volunteers and the police work together to inform people of the dangers of random gunfire.

Anecdotal evidence from newspaper articles,[6] television broadcasts,[7] and interviews with police department officials[8] and community members[9] suggests that random gunfire is a serious problem in many cities. Residents in these communities live in perpetual fear: they worry that a stray bullet will kill an innocent bystander; they feel they live in the middle of a war zone on some nights; they hide in their homes, afraid to confront the people disrupting their lives; and law-abiding business owners and residents are willing to abandon or relocate from a neighborhood with random gunfire problems.[10] One Redwood City resident summed up the problem by stating:

> It is not uncommon to find bullets lodged in front porches or gutters. We are afraid for our children. The random gunfire problem is also costly in terms of law enforcement, property damage, and declining property values.

The number of deaths from firearms-related injuries is recognized as a significant national public health problem. In the United States in 1996, for example, there were 12.8 deaths per 100,000 people caused by firearms-related injuries. For males 15 to 24 years old, the problem is even more staggering: in 1996, there were 38.9 deaths from injuries sustained by firearms per 100,000 people.[11] These data are a composite of firearms-related deaths and do not differentiate between intentional and accidental firearms injuries. The statistics also fail to differentiate between random gunfire and other criminal incidents when shots are fired, such as drive-by shootings, revenge shootings, shootings during drug transactions, and so forth. As such, there is very little systematic information about the extent, environmental causes, social context, and societal costs of the random gunfire problem.

The study neighborhood

The Dallas study began with a systematic analysis of the random gunfire problem in that city's Oakcliff neighborhood. Researchers reviewed videotapes of street block attributes, conducted onsite observations and interviews, and reviewed police officer patrol logs to develop a comprehensive view of factors contributing to the random gunfire problem.

Oakcliff is composed primarily of residential rental units mixed with light industrial and commercial enterprises. The community is situated between two major commercial corridors with a park and large lake on its northern border. The majority of Oakcliff residents are economically poor and lease their apartments. Fewer than 20 percent of the Oakcliff residents own their own homes, compared with a citywide ownership rate of more than 50 percent and a nationwide ownership rate of 59 percent.[12] The average monthly rent in the Oakcliff community is $295. By contrast, more than 90 percent of Dallas residents pay more than $300 in rent per month, and, of these renters, 41 percent pay $500 or more per month.[13]

Oakcliff reports high levels of random gunfire: 422 citizen reports of random gunfire shots per 10,000 people per year in the 1-square-mile neighborhood alone. Although random gunfire calls represented 1.1 percent of total police service calls citywide, they represented 4.6 percent of total calls for service in Oakcliff during 1996. Police report no random gunfire calls for 65 percent of Oakcliff streets (similar to call patterns for other crime problems). However, a small percentage (5.5 percent) of the streets generated nearly 45 percent of all random gunfire calls.[14]

Researchers examined the social and physical attributes of Oakcliff street blocks that experienced random gunfire calls for service. These results are specific to the Oakcliff neighborhood and cannot be generalized to Dallas or any other community in the United States. The research shows predominately residential street blocks that had higher property values or rental fees experienced *more* random gunfire calls for service than Oakcliff street blocks with lower property values or those comprising commercial properties or vacant blocks.[15] Random gunfire calls were *not* generally a problem on Oakcliff street blocks that had a large proportion of properties in disrepair or on streets with high levels of physical decay, a lot of foliage, or on blocks with relatively high levels of calls about serious crime problems.[16]

Random gunfire calls were more prevalent on street blocks that generated a substantial number of prowler, suspicious person, and disturbance calls. This suggests other types of suspicious and unruly behavior are probably correlated with Oakcliff's random gunfire problem.

The study findings are somewhat inconsistent with crime and place research that finds signs of decay are indicative of other social and crime problems.[17] Nevertheless, the study findings suggest random gunfire may be a unique type of crime problem not necessarily part of, nor indicative of, systemic decline and decay on a street block. The study results are consistent with Dallas police officer perceptions that random gunfire problems occur in Oakcliff's residential areas, specifically in the context of people drinking in their homes and backyards, watching sporting events, and celebrating.

Gunshot detection systems

What are they? Acoustic gunshot detection systems are designed to pick up the sound of a muzzle blast from a gun and, within seconds of the shot being fired, pinpoint or triangulate within some margin of error the gunshot's location, before alerting the police about the shot being fired.

Manufacturers of gunshot detection systems expect the technology to increase the ability of the police to get to the scene of random gunfire quickly, increase the number of people arrested for firing weapons, and reduce the detrimental effects (injuries, fear, disinvestment) of shots being fired in urban settings. Community advocates of gunshot detection systems believe the technology can deter would-be shooters and improve the quality of life in their neighborhoods.

Alliant Techsystems Inc.'s SECURES. The gunshot detection system installed in Oakcliff was developed and demonstrated by Alliant Techsystems Inc. (ATI) and subsequently marketed as SECURES (System for the Effective Control of Urban Environment Security). SECURES identifies the location and time of gunfire in a specified target area through a series of small units (or acoustic sensor modules) mounted on utility poles. These battery powered "pole units," which are about the size of a video cassette, are composed of an acoustic sensing element, gunshot identification electronics, and a transmitter. Eighty-six pole units were erected in the 1-square-mile Oakcliff target area to provide adequate system coverage for the 2-month study period.[18]

The pole units are designed to acoustically identify gunshots and transmit that information to a police dispatch center through a network of transmitters and receivers connected to the local phone system. The gunshot location and time are transmitted to a personal computer in the dispatch center in less than 2 seconds, and the gunfire information is displayed on a computerized map, enabling dispatchers to relay the information to officers on the street.

The SECURES prototype alerts police dispatchers to the location of the first pole unit to detect a shot. ATI claims, however, that subsequent enhancements to the system "triangulate" gunfire alerts such that real-time information from responding pole units pinpoint the precise location from which the shot was fired. ATI claims this type of "triangulation" procedure can pinpoint 99 percent of gunshots within a 65-foot radius of the firing spot, 88 percent of gunshots within 30 feet, 63 percent of gunshots within 20 feet, and 35 percent of gunshots within 10 feet.[19]

Trilon Technology's ShotSpotter. The ShotSpotter gunshot detection technology installed in Redwood City was designed and demonstrated by Trilon Technology. The ShotSpotter system, installed in the 1-square-mile Redwood Village area since early 1996, consists of eight acoustic sensors, a central computer located in the Redwood City Police Department's dispatch center, and gunshot detection and location identification software.

The acoustic sensors include microphones, acoustic sensing elements, and gunshot identification electronics. The sensors installed in Redwood Village resemble birdhouses and heating vents and are enclosed in weatherproof containers approximately 1 cubic foot in size. The acoustic sensors detect muzzle blasts from gunfire or other explosions and then transmit the sound of the gunfire via telephone line to a central computer located in a police department dispatch center.

Parameter settings in the ShotSpotter software determine the system's level of sensitivity: if the thresholds are set quite high, background noise is less often identified as gunfire. Conversely, if the thresholds are set quite low, more background noise can be detected as gunfire, increasing the potential that extraneous noises will be incorrectly identified as gunfire.[20] Once the sensors detect a sound and transmit the information to the central computer, the ShotSpotter software discriminates against most other community sounds (such as car backfires, jackhammers, thunder, and barking dogs) and pinpoints the location of the gunfire or explosions. Gunshot events are displayed on a computer map in the police dispatch center within approximately 15 seconds of the noise being made. The computer map distinguishes property boundaries, including front or side yards, curbsides, or street corners.

Determination of the precise location of gunfire events is conducted through a series of iterations of triangulation algorithms. The system can generate an overview map that presents the locations of historical shootings to discern patterns in space or time. The ShotSpotter computer can be placed in a dispatch center with stand-alone or integrated outputs, or it can be placed at a remote site.[21]

The ShotSpotter system stores all waveforms for every detected gunfire event and 6 seconds of audio from each detecting acoustic sensor (2.3 megabytes each). As such, a significant amount of system memory is required when numerous gunfire events occur simultaneously or when many noises are relayed to the system in quick succession (during New Year's Eve or Fourth of July, for example). Once the ShotSpotter system detects a shot and reports the location on the computer screen, dispatchers can play back the 6-second snippet of sound from any sensor to assist them in determining what they believe to be the true source of the sound: firecracker string, multiple gunshots, shotgun blast, or car backfire. The ability to play back the sound of the apparent gunfire alert is unique to ShotSpotter and offers police an opportunity to determine whether they think the sound is in fact gunfire.

Do they work?

The Redwood City Police Department, the San Mateo County Sheriff's Office, and Trilon Technology agreed to submit the ShotSpotter system to a series of field trials. The police department approved the firing of test blanks under controlled conditions to measure the performance of the technology in June 1997.[22] Similar permissions were not granted during the field test of the SECURES system in Dallas.

The evaluation team worked with police department personnel to select weapon types, the number of shots to be fired, and the times and locations from which test shots would be fired. The police suggested that three weapon types be used: an MP5 assault rifle, a .38 caliber pistol, and a 12 gauge shotgun. The police department notified community residents and business owners about the inordinate number of shots that would be fired during the field test to avoid calls from concerned citizens about the gunfire. All test shots were fired from sidewalks at intersections or along street blocks.

The evaluation team assessed the performance of the ShotSpotter system based on three outcomes:

- Did the ShotSpotter gunshot detection system annunciate and triangulate the "shot" location (true positive)?
- Did ShotSpotter fail to annunciate or triangulate the "shot" location (false negative)?
- What was the location error from the true shot location to the triangulated shot location (in feet)?

Exhibit 1 presents the results of the field trial, examining the breakdown of results for each weapon type and each of the evaluation outcomes (annunciation and location error).

Of the 31 field trial events, 8 tested the MP5 assault rifle, 13 tested the .38 caliber pistol rounds, and 10 tested the 12 gauge shotgun. The technology annunciated shotgun tests at the highest rate (90 percent), followed by pistol tests (77 percent), and the MP5 assault rifle (63 percent). Overall, the ShotSpotter technology annunciated nearly 80 percent of the test shots (true positives) and failed to annunciate random gunfire events about 20 percent of the time (false negatives). It should be noted that the muzzle blast waveform from blank rounds is different from the muzzle

Exhibit 1. ***Redwood City's ShotSpotter Field Trial Results***

	Total Number of Gunfire Events	Percent of Shots Annunciated	Median Location Error (In Feet)
MP5 Assault Rifle	8	63	27.0
.38 Caliber Pistol	13	77	25.0
12 Gauge Shotgun	10	90	23.5

blast waveform from live rounds; it can be difficult for gunshot detection technologies to discriminate between the two.[23] Therefore, the ShotSpotter technology should annunciate significantly more than 80 percent of gunfire incidents when live rounds are fired under real-life conditions.

The ShotSpotter system identified and triangulated random gunfire events within about 25 feet of the true shot location. Shotgun events had the lowest median location error of 23.5 feet; pistol events were correctly identified within 25 feet of the true shot location; and the MP5 assault rifle tests were identified within 27 feet of the correct firing location.

Random gunfire alerts and police response

Citizen reporting of a gunshot fired is typically dependent on (1) the citizen hearing the shot, (2) the citizen identifying the noise to be gunfire, (3) the citizen making the decision to call the police shortly after the shot has been fired, and (4) the citizen telling the police the location from which the shot was fired. Prior to the introduction of the gunshot detection system in Dallas, the police took approximately 20 minutes to dispatch a citizen call about random gunfire and an additional 5 minutes to respond (arrive on the scene) to citizen alerts in the study area. This response pattern was consistent with the low priority response the police department placed on random gunfire calls. Officers typically stayed on the scene of a call for about 15 minutes. In total, citizens' random gunfire reporting calls took approximately 40 minutes to clear from the time the call was placed to the time the officer concluded the investigation of the scene.[24]

The introduction of gunshot detection systems in Dallas removed the citizen contingencies influencing random gunfire reporting and somewhat changed the patterns of police response. During the field trial in Dallas, the police received 188 alerts of gunfire from the SECURES system and 49 citizen calls. They subsequently dispatched 151 of the SECURES alerts and 39 of the citizen calls.[25] The police dispatched both citizen calls and SECURES alerts quicker during the field trial (13 minutes and 18 minutes, respectively) than before the introduction of the gunshot location system. The police continued to take about 5 minutes to arrive on the scene for a citizen alert and about 7 minutes for a SECURES alert. Once on the scene, the police cleared the citizen call quicker (12 minutes) than before the field trial, yet they took significantly longer to clear the SECURES alert (19 minutes). It is possible the police spent less time on citizen calls about random gunfire due to the greater total number of random gunfire alerts generated by the gunshot location system and the subsequent increase in the number of dispatches for random gunfire alerts.[26] Overall, the Dallas police received and cleared citizen random gunfire calls in about 30 minutes, and they received and cleared SECURES alerts in about 44 minutes during the field trial.

Using gunshot detection systems

During the 2-month Dallas field trial, the police made 190 radio runs (151 SECURES alerts and 39 citizen random gunfire calls) in the 1-square-mile Oakcliff community.[27] The number of citizen calls during the field trial was similar to the average number of citizen calls to the police about random gunfire incidents prior to the field trial.[28] As such, the extra SECURES-dispatched radio runs over and above the citizen-initiated calls during the field trial represent an almost fivefold increase (190/39=4.87) in the number of police dispatches to random gunfire problems.

Alliant Techsystems Inc. claims SECURES correctly identifies 88 percent of all shots whose propagation path to the microphone is not blocked by a close building.[29] The acoustic database used to support this claim was collected by ATI during tests conducted at military proving grounds and police test ranges and when live rounds were fired in open field environments as well as among building structures.[30] Thus, assuming the SECURES true-positive rate is correct, the field trial suggests that many random gunfire incidents are not reported by citizens.[31]

How should the police respond to an inordinate increase in random gunfire alerts? Indeed, introduction of the technology challenges the police to carefully consider the manner in which they mobilize their resources to respond to alerts: on the one hand, the technology provides police with much more information about random gunfire problems than previously generated through citizen calls. If the ATI claim that SECURES fails to detect only 12 percent of all shots and if the citizen reporting figure of 23 percent of all random gunfire incidents in the Dallas field trial is accurate,[32] then one can reasonably conclude that gunshot detection systems provide the police with important insights as to the nature, extent, and locations of random gunshots.

On the other hand, the increase in random gunfire alerts has the potential to significantly influence the delivery of police services. The nearly fivefold increase in radio dispatches represents a significant increase in the police workload for a very small geographic area (less than 1 square mile). Moreover, during the study period, not a single arrest was made in response to a dispatch for random gunfire in Dallas, and police officers patrolling Oakcliff spent less time processing citizen calls for random gunfire during the field test (compared with the time spent on citizen calls before the field trial) to handle the large increase in radio runs generated by the SECURES technology.[33]

What do police think of gunshot detection systems?

Patrol officers from both the Dallas and Redwood City police departments were surveyed about their perceptions of the impact of gunshot detection systems on their work routine, their confidence in the technology to report gunfire incidents, and their perceptions of the ability of the technology to improve police effectiveness in handling such incidents. All officers assigned to areas in which the technology was deployed and they could possibly be dispatched to gunshot incidents received questionnaires. In Dallas, 58 percent (124 of 212) of patrol officers completed the questionnaires, while in Redwood City, 66 percent (27 of 41) of patrol officers returned the questionnaires.

As happens with many technological and strategic innovations introduced into police departments,[34] patrol officers from both Dallas and Redwood City reported some frustrations with the gunshot detection systems. They generally lacked confidence in the ability of the systems to identify and locate gunfire occurrences. They also worried about false alerts, and they expressed concern about the time spent responding to gunfire alerts and the low likelihood of catching or arresting the shooter.

Officers in both cities feel they are more likely to talk with citizens when responding to citizen-generated calls than to gunshot detection system calls, and they make more problem-solving progress on citizen alerts than technology alerts. Generally, officers feel citizen calls about gunfire give them a focal point in responding to the call. Officers can ask the citizen about what he or she heard, and they can glean details about the context of the shot fired. By contrast, officers explain that the gunshot detection systems provide no details about the apparent shot, leaving them without any guidance to pursue an investigation.

Summing up

The study of the use of gunshot detection technology in local law enforcement led the research team to four broad conclusions:

- Gunshot detection systems are likely to reveal rather high citizen under-reporting rates of random gunfire problems.
- The technology is likely to increase the workloads of police officers, particularly if departments dispatch a patrol unit to every gunfire incident detected by a technological system.
- Gunshot detection systems are not likely to lead to more arrests of people firing weapons in urban settings because it is highly unlikely that offenders will stay at a gunshot location long enough for the police to arrive.[35]
- Finally, gunshot detection systems seem to offer the most potential as a problem-solving tool and would fit nicely within the emerging problem-oriented policing paradigm. The technology can help police identify random gunfire hot spots and develop strategies to address the problem.

Notes

1. Egan, Timothy, "Police Surveillance of Streets Turns to Video Cameras and Listening Devices," *The New York Times,* Feb. 7, 1996; and Kass, Jeff, "Police Aim to Silence Celebratory Guns at New Year's," *The Los Angeles Times*, Dec. 17, 1995: B1 and B13.

2. Dallas Police Department, *Random Gunfire Reduction Proposal*, Dallas, TX: Dallas Police Department, 1993.

3. Page, Edward, and Brian Sharkey, "SECURES: System for Reporting Gunshots in Urban Environments," *Society of Photo-Optical Instrumentation Engineers*. 2497 (1995): 160.

4. Interview with Dallas Police Department personnel, Dec. 14, 1996.

5. Kennedy, David, Anne Piehl, and Anthony Braga, "Youth Violence in Boston: Gun Markets, Serious Youth Offenders, and a Use Reduction Strategy," *Law and Contemporary Problems*. 59 (1) 1996: 147–159; also see Sherman, Lawrence W., and Dennis P. Rogan, "Effects of Gun Seizures on Gun Violence: 'Hot Spots' Patrol in Kansas City," *Justice Quarterly* 12 (4) 1995: 673–693.

6. Associated Press, "Ringing in '97 With Bullets, Bombs; Police, Fire Officials Prepare for Illegal New Year's Revelry," *The Lubbock Avalanche*, Dec. 31, 1996; see also Pimental, Benjamin, "Redwood City OKs Test of System to Locate Gunshots: First City to Use the New Sensors," *The San Francisco Chronicle*, Aug. 30, 1995: A16; "Support Builds for Gunshot Locator," *The San Jose Mercury News*, Feb. 12, 1997: 1B and 4B.

7. *CBS Evening News*, "New High Tech Help for Tracking Down Criminals," *CBS Evening News*, Jan. 17, 1996; *ABC Evening News*, "Redwood City Council Votes to Purchase ShotSpotter after Successful Test," *ABC Evening News*, July 28, 1997; *Channel 10 San Diego*, "Does ShotSpotter Really Work?" *Channel 10 San Diego*, Aug. 27, 1998.

8. Based on personal communications, interviews, and discussions with Dallas Police Department and Redwood City Police Department representatives in 1996 and 1997.

9. Focus groups conducted with Redwood City residents in June 1997.

10. Personal communication with Redwood City residents in 1997.

11. National Vital Statistics Report. 47 (19) June 30, 1999.

12. U.S. Census Bureau, *Census of Population and Housing: General Profile for the United States*, Washington, DC: U.S. Department of Commerce, U.S. Census Bureau, 1990.

13. U.S. Census Bureau, *Census of Population and Housing: General Profile for Dallas City, TX*, Washington, DC: U.S. Department of Commerce, U.S. Census Bureau, 1990.

14. Sherman, Lawrence, Patrick Gartin, and Michael Buerger, "Hot Spots of Predatory Crime," *Criminology* 27 (1) 1989: 27–56; also see Watkins, C., "Environmental Correlates of Random Gunfire: A Block Level Analysis of the Relationship between Random Gunfire Problems and Physical and Social Incivilities," unpublished doctoral dissertation, University of Cincinnati, 1998.

15. Oakcliff is a designated "dry" neighborhood. As such, no public bars or liquor stores operate in the neighborhood. However, private drinking clubs exist in Oakcliff, primarily in residential areas.

16. Watkins, C., "Environmental Correlates of Random Gunfire: A Block Level Analysis of the Relationship between Random Gunfire Problems and Physical and Social Incivilities."

17. Eck, John, and David Weisburd, "Crime Places in Crime Theory," in *Crime and Place*, ed. J.E. Eck and D. Weisburd, Monsey, NY: Criminal Justice Press, 1995; Mazerolle, Lorraine Green, Jan Roehl, and Colleen Kadleck, "Controlling Social Disorder Using Civil Remedies: Results from a Randomized Field Experiment in Oakland, California," *Civil Remedies and Crime Prevention: Crime Prevention Studies*, vol. 9, Monsey, NY: Criminal Justice Press, 1998: 141–160; Skogan, Wesley, *Disorder and Decline: Crime and the Spiral to Decay in American Cities*, New York: Free Press, 1989; Taylor, Ralph, "Social Order and Disorder of Street Blocks and Neighborhoods: Ecology, Micro Ecology and the Systemic Model of Social Disorganization," *Journal of Research in Crime and Delinquency* 34 (1997): 113–155; Wilson, J.Q., and G. Kelling, "Broken Windows," *The Atlantic Monthly*, March 1982: 29–38.

18. ATI personnel in an Oct. 30, 1996, interview said the pole units cost about $1,750 each, and the batteries last about 2 months. They suggest that approximately 80 pole units are required to cover a 1-square-mile area. To lease, SECURES will cost approximately $5,500 for each square mile covered per month. This cost covers the lease of 100 pole units, 3 repeaters, 1 base station, and maintenance on the system. The quoted cost does not cover installation and assumes medium density housing.

19. Alliant Techsystems Inc. failed to install the triangulation enhancement of the SECURES system at the time of the field trial. Officers were dispatched to the first pole unit that recorded a shots-fired incident rather than a triangulated location identified through a series of detections by numerous pole units. (Based on an Oct. 30, 1996, interview with ATI personnel.)

20. Muzzle blasts from gunfire have distinctive waveforms, as do the sounds from other similar sources. However, the setting parameters determine what level of extraneous noise will trip the system. Hence, the less sensitive the parameter settings, the less likely it is that jackhammers, thunder, and car backfires will set the system off (false positives). Alternatively, the more sensitive the parameter settings, the more likely it is that extraneous noise will trip the system.

21. The system can be its own operating system within the dispatch center, or it can be linked into the dispatch system's operating system.

22. The original proposal was to discharge live rounds of ammunition. However, numerous discussions with the police chief, his advisers, and personnel from Trilon Technology led to an agreement to discharge blanks as opposed to live rounds. Although the amplitude waves generated by blanks are not identical to the amplitude waves generated by live ammunition, they were close enough for the blanks to serve as adequate substitutes.

23. Personal communication with John Collins, ed., *Association of Firearm and Toolmark Examiners Journal*, Nov. 9, 1999.

24. Comparative response time data were not readily available in Redwood City. Calls were placed to both the San Mateo County Sheriff's Office and the Redwood City Police Department. Only selected calls were available for analysis from the police department data, compromising a complete analysis of their call data.

25. Mazerolle, Lorraine Green, Cory Watkins, Dennis Rogan, and James Frank, "Using Gunshot Detection Systems in Police Departments: The Impact on Police Response Times and Officer Workloads," *Police Quarterly* 1 (2) 1998: 21–49.

26. *Ibid.*

27. There were 151 SECURES alert "events" that were not linked at any time to a citizen call and resulted in a radio run. There were 39 citizen alert events during the study period resulting in 39 radio runs. Of these 39 citizen-initiated radio runs, 10 included a SECURES alert that was "referenced" to a citizen call. That is, the call-taker and/or dispatcher linked the SECURES call to the citizen call and dispatched it as a citizen call. As such, a total of 190 radio runs for random gunfire alerts were made during the study period: 151 that

involved the technology only, 29 that involved citizen calls only, and 10 that were dispatched as citizen calls but involved a combination of citizens and SECURES initiating the alert.

28. See Mazerolle et al., "Using Gunshot Detection Systems in Police Departments: The Impact on Police Response Times and Officer Workloads."

29. Page and Sharkey, "SECURES: System for Reporting Gunshots in Urban Environments": 170.

30. *Ibid.*: 162.

31. The research team cannot provide any independent measure of this claimed false-positive rate because no field test of SECURES was conducted in Dallas where blank or live rounds were fired under field trial conditions.

32. The 23-percent citizen reporting rate was reached in the following manner: using the baseline of 151 SECURES-initiated radio runs during the 2-month field trial, researchers applied the 12-percent error rate to identify 169 estimated shots. The 39 citizen-initiated radio runs over the test period were divided by the 169 estimated incidents to identify the 23-percent reporting rate (39/169x100).

33. Officers in both cities believe they tend to respond quicker to gunshot detection system calls than citizen-generated calls. Some officers explained they merely want to clear the call quickly and move on to the next call. It is reasonable to expect that the police would spend more time handling calls that they thought worthwhile. Possible explanations for these apparent contradictory findings: (1) the police "leave open" the SECURES alerts longer because there is no citizen waiting to talk with them when they arrive, and they move on to the next call; (2) police deal with a citizen-initiated alert in a more expedient manner because there is a set of standard procedures to follow (i.e., visit the caller, elicit information from them, and then take a look around). This is not the case for the SECURES alerts. The police get to the scene and then have to knock on a few doors to gather information about the gunfire.

34. Chatterton, Michael, "Targeting Community Beat Officers: Organisational Constraints and Resistance," *Policing and Society* 3 (1993): 189–203.

35. One caveat here is the initiative recently announced by Trilon Technology called "The Communicator," which is linked with the ShotSpotter system to systematically place calls to households and businesses within a close geographic area of the gunfire alert to inform them of the incident. If the citizen has information, he or she can press a key on a touch-tone phone to be immediately transferred to a live dispatcher.

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