



**City of Seattle**  
Office of City Auditor

August 3, 2016

TO: Councilmember Tim Burgess

FR: David G. Jones, City Auditor

A handwritten signature in blue ink that reads "David G. Jones".

RE: Considerations for an Evaluation of a Pilot Implementation of an Acoustic Gunshot Locator System

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We understand that the City of Seattle is considering implementing an acoustic gunshot locator system as a pilot project. As you requested on June 10, 2016, our office has prepared a “short summary of the current literature on (acoustic gunshot locator) systems and what factors are essential for conducting an evaluation.”

The attached Research Brief identifies ten things that the City should consider in advance of implementing the system to enable a rigorous evaluation of the pilot project to ensure that the system is producing the desired outcomes for Seattle.

We strongly recommend that the City engage an evaluation research partner as soon as possible to ensure that the evaluation of the pilot program is well thought-out. This will also help ensure that the evaluation will not be compromised by early choices made in planning for the pilot program. Depending on the scope, a rigorous evaluation of the pilot program may cost several hundred thousand dollars. Funding for an evaluation might be something that the City could explore with its federal partners from the U.S. Department of Justice Bureau of Alcohol, Tobacco, Firearms, and Explosives who are supporting the pilot initiative.

Please let us know if you have any questions or would like more information.

## **Ten Things the City of Seattle Should Consider When Evaluating a Pilot Implementation of an Acoustic Gunshot Locator System**

The City of Seattle is considering implementing an acoustic gunshot locator system as a pilot program to “help our officers and detectives working to reduce gun violence in our city by improving shots fired response time and identifying shooters.”<sup>1</sup> The Seattle Police Department (SPD) has received funding support from the U.S. Department of Justice Bureau of Alcohol, Tobacco, Firearms, and Explosives for the pilot initiative. SPD has indicated that the audio technology for such systems has improved recently, and the integration of cameras with the acoustic gunshot locator system can potentially lead to the identification of shooters.

This Research Brief identifies ten key factors that the City should consider in an evaluation of the pilot program. It is important to note that this Research Brief assumes that the City 1) will have addressed concerns with privacy and civil liberties associated with the system, and 2) plans to conduct a rigorous evaluation of the pilot project to ensure that the system is producing the desired outcomes for the City.

Acoustic gunshot locator systems are designed to detect the sound of a gunshot fired outdoors within seconds of the shot being fired, pinpoint the gunshot’s location by triangulating acoustic information captured on several microphones, and immediately transmit this location to police dispatch. Acoustic gunshot locator systems have been implemented in approximately 90 cities worldwide, including 62 in the United States and its territories. However, the current body of research on acoustic gunshot locator systems does not offer clear evidence that such systems are effective in deterring shootings or helping police officers make arrests (See Appendix A for a brief review of the research literature). More research is needed to determine the efficacy of acoustic gunshot locator systems. Therefore, a rigorous evaluation of the pilot program in Seattle would offer an opportunity to contribute to the current body of research and to ensure that the system produces the desired outcomes for Seattle.

Ten key considerations in planning for a rigorous evaluation of an acoustic gunshot locator system fall into two broad categories: 1) evaluation readiness and 2) evaluation design.

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<sup>1</sup> Quote from Seattle Police Department Chief Kathleen O’Toole in June 2, 2016 Mayor’s Office press release: <http://murray.seattle.gov/mayor-proposes-gunshot-detection-pilot-program>

## Evaluation Readiness

The City will need to ensure that it has adequate data collection and tracking systems in place to support an evaluation of an acoustic gunshot locator system. In addition, because the pilot project might occur in two Seattle Police Department (SPD) precincts, there may be a need to develop operational protocols that are consistent for both precincts as well as protocols for coordination with Seattle Public Schools and other sensitive sites.

1. **Data Ownership** – Currently, for the large majority of jurisdictions using acoustic gunshot locator systems, the system vendor retains ownership of the incident-level data, and these data are not publicly available. Jennifer Doleac, an economist at the University of Virginia and the Brookings Institution, recommends that jurisdictions contractually require their acoustic gunshot locator systems vendor to make data publically available at the incident level.<sup>2</sup> Acoustic gunshot locator incident level data typically include date, precise time, incident longitude and latitude, and whether the incident involved a single shot or multiple shots. These data will be essential for an evaluation of the City’s pilot program. Since the vendor contract for the pilot program will likely be held by the U.S. Department of Justice Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF), the City should work with the ATF to obtain access to incident-level data.
2. **Data Integrity** – To help ensure that the City has reliable data for an evaluation, SPD should develop protocols and assign staff to routinely review and update the data generated by the system to ensure that it accurately reflect gunshots. This process is referred to as “reclassification of system activations.” Acoustic gunshot locator systems are activated by gunshots, but as other jurisdictions have found, they may also be activated by other loud sounds from sources including construction, dumpsters, and fireworks. Each system activation should be analyzed and confirmed as a gunshot or “reclassified” as some other sound (i.e., false positive). For example, in Nassau County, NY, all system activations are reviewed by detectives in the County’s police Intelligence Bureau and reclassified if appropriate. Without the important step of reclassification, the data will not be useful for evaluation. Furthermore, a report prepared for a leading acoustic gunshot locator system vendor found that most jurisdictions studied were not reclassifying system activations.<sup>3</sup>

Jurisdictions using acoustic gunshot locator systems have reported a wide range of false positive activations. For example, seven jurisdictions surveyed in one study reported that false positives

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<sup>2</sup> See February 4, 2016 Brookings editorial <http://www.brookings.edu/research/opinions/2016/02/04-reduce-gun-violence-empower-citizens-doleac>

<sup>3</sup> See 2011 Shotspotter Efficacy Study [https://csganalysis.files.wordpress.com/2011/08/shotspotter\\_efficacystudy\\_gls8\\_45p\\_let\\_2011-07-08\\_en.pdf](https://csganalysis.files.wordpress.com/2011/08/shotspotter_efficacystudy_gls8_45p_let_2011-07-08_en.pdf)

ranged between 3% and 50% of system activations.<sup>4</sup> The City will not be able to evaluate the effectiveness of its pilot program without valid, reclassified data. Therefore, before beginning the pilot, it will be important for SPD to assign staff and establish protocols for reclassifying the system data as needed.

3. **Dispatcher Analysis Procedures** – Acoustic gunshot locator systems are designed to detect the sound of a gunshot and immediately transmit its location to the police. In some jurisdictions, the acoustic gunshot locator system data must be analyzed by police dispatchers before alerting patrol officers. It is also possible to contract with the system vendor to perform this preliminary analysis of system activations. In either case, some new procedures for police dispatch must be developed and implemented.

If the police dispatchers are performing the real-time analysis of system activations, they must be trained to determine whether the activations are from a gunshot or some other sound. This training includes how to interpret the audio-waveform images and audio recordings generated by the acoustic gunshot locator system to verify that the activation is most likely the result of a gunshot. This analysis is typically performed by dispatch immediately as activations occur and before alerting patrol officers. A report prepared for a leading acoustic gunshot locator system vendor found that most jurisdictions studied did not offer consistent training or follow clear and consistent procedures for dispatcher analysis.<sup>5</sup> Inconsistencies in the analysis and classification of data by dispatchers could compromise the implementation and evaluation of the pilot project.

It is also possible that ATF might arrange to contract with the system vendor to perform some or all of this preliminary analysis before notifying the SPD Communications Center of an activation. If this is the case, SPD will still have to develop some new procedures for dispatchers. It might be helpful for SPD to consult with other jurisdictions that have contracted with the vendor for this analysis to determine what new procedures would be appropriate for SPD dispatch.

Finally, if Seattle’s acoustic gunshot locator system is integrated with cameras, SPD will have to determine whether SPD dispatchers or the vendor should also review the video recordings as part of their analysis before alerting patrol officers. In either case, protocols and training will have to be developed for real-time analysis of video footage.

4. **Patrol and Investigation Protocols** – SPD will also have to develop protocols and train patrol officers and investigators to consistently record outcomes for calls that are generated by acoustic gunshot locator system activations. For example, an evaluation of an acoustic gunshot

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<sup>4</sup> Ibid.

<sup>5</sup> Ibid.

locator system in Brockton, MA (Choi, Librett, & Collins, 2014) describes a classification system with ten possible outcomes: unfounded, could not locate, unknown action, investigated, under investigation, report taken, hot sheet, matter settled, complaint filed, and arrest(s). SPD should develop a similar classification system for the pilot project, and it will be particularly important that this information is captured consistently across precincts and watches.

In addition, protocols for shots-fired investigations should be developed and applied consistently. For instance, it will be important to determine what investigative steps will be required to reach the conclusion that a system activation should be classified as unfounded. An evaluation of the use of an acoustic gunshot locator system in St. Louis, MO revealed that investigations of system activations averaged 11 minutes compared with an average of 30 minutes for investigations of shots fired that were generated by 911-calls. (Mares & Blackburn, 2012) However, the differences in time occurred because St. Louis police were following an expedited protocol for investigating system activations. SPD should determine and consistently apply new protocols for investigation of activations the gunshot locator system. Failure to apply consistent protocols will compromise the City's evaluation of the system.

5. **Coordination with Seattle Public Schools and other sensitive sites** – Findings from a 2014 study of acoustic gunshot locator system activations in close proximity to schools in Washington D.C.<sup>6</sup> suggest that it will be necessary for SPD to ensure there are clear protocols for communication with Seattle Public Schools and other sensitive sites within the pilot areas including other schools, child care centers, preschools, etc.. The Washington D.C. study indicated that in the 2011-12 academic year, the acoustic gunshot locator system detected 249 incidents within 1000 feet of a school during the school day. Some schools were disproportionately affected, experiencing up to 16 incidents during the school year at times when students were in session or were entering and exiting the building.

Based on the experience of Washington D.C., it is possible that during the pilot project some percentage of Seattle's system activations will occur near sites such as schools, child care centers, or preschools during the school day. SPD should consider when a system activation should result in a notification to these sites to "shelter in place" or "lockdown."<sup>7</sup> Also, SPD should establish protocols for lifting the shelter in place and lockdown notifications after an event has been investigated and/or resolved.

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<sup>6</sup> See 2014 Urban Institute study <http://www.urban.org/sites/default/files/alfresco/publication-pdfs/413216-Close-Range-Gunfire-around-DC-Schools.PDF>

<sup>7</sup> According to SPD, "shelter in place" means students are in classrooms with minimal staff movement throughout the school, and a "lockdown" means there is zero movement throughout the school and grounds, and that exterior doors are locked.

## Evaluation Design

The stronger the evaluation design, the more likely it will be to produce findings that will be useful for City decision-making. We strongly recommend that the City engage an evaluation research partner as soon as possible to ensure that the evaluation of the pilot program is well thought-out. This will also help ensure that the evaluation will not be compromised by early choices made in planning for the pilot program. The City's evaluation research partner will be able to formulate a detailed scope for the evaluation including the specific factors that will be evaluated. These factors will help determine how long the evaluation should run to ensure that sufficient data have been collected. In addition, the City should plan for how the evaluation findings will be reported (e.g., to a City Council committee) as well as what actions the final report will trigger (e.g., continuing operations in the pilot areas, scaling up to other areas, modifying aspects of the approach, etc.).

In the meantime, there are a number of things that the City should also consider early on related to its evaluation design.

6. **Valid Theory of Change** – An important first step in evaluating the pilot project will be for the City to develop a valid theory of change. In its simplest form, a theory of change is an articulation of what change is expected to happen as a result of a specific intervention.<sup>8</sup> A valid theory of change is one that is grounded in research evidence or in well-developed theory on what works. Unfortunately, there has been little research to date on the efficacy of acoustic gunshot locator systems for reducing gun crime (See Appendix A). Moreover, although a few available studies have found that acoustic gunshot locator systems can result in slightly faster response times by police, there is no evidence that these small gains in police response times have had a deterrent effect or have led to increased apprehension of offenders.<sup>9</sup> (Mares & Blackburn, 2012) (Choi, Librett, & Collins, 2014)

Although SPD Chief O'Toole has stated that the acoustic gunshot locator system will "help our officers and detectives working to reduce gun violence in our city by improving shots fired response time and identifying shooters"<sup>10</sup>, this statement does not constitute a valid theory of

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<sup>8</sup> For example, United Way of King County's Parent-Child Home Program is designed to improve school readiness and academic success of children from low-income families by providing twice-weekly home visits from trained parent coaches who model educational play. This theory of change clearly identifies the change that is expected (improvement in school readiness and academic success) and the mechanism by which that change will be affected (twice-weekly home visits). See website <https://www.uwkc.org/giving-kids-equal-chance/pchp/>

<sup>9</sup> This is also consistent with the literature on response time, in general, that suggests that faster response does not generally lead to improved investigatory outcomes. This is because the response is, in most cases, still not fast enough to identify someone on-scene who may have been involved. See a review of the research literature here: <http://cebcp.org/evidence-based-policing/what-works-in-policing/research-evidence-review/standard-model-policing-tactics/>

<sup>10</sup> Quote from Seattle Police Department Chief Kathleen O'Toole in June 2, 2016 Mayor's Office press release: <http://murray.seattle.gov/mayor-proposes-gunshot-detection-pilot-program>

change as it is not corroborated by research. To develop a valid theory of change for the pilot project, the City may consider looking to areas in which the research is more conclusive. For example, since the pilot system will include cameras that may assist with investigations, the City may look to the research on closed circuit television (CCTV)<sup>11</sup>. The City might also consider a theory of change in which data from the pilot system is used, in conjunction with other call and incident data, to identify small geographic areas where gun crime is concentrated (i.e., hot spots) and apply problem-oriented policing strategies<sup>12</sup> in those areas. To illustrate, Exhibit 1 below provides some examples of mechanisms and outcomes that the City might consider incorporating into its theory of change.

**Exhibit 1: Potential Elements of a Theory of Change for the Pilot Project**

Intervention	Mechanism	Role of Acoustic Gunshot Locator System	Pilot Outcome Measure(s)	Community-Level Outcome
Camera-assisted investigations	Incapacitation of offenders through arrest and prosecution	Cameras identify offenders	Increase in identification and prosecution of gun offenders	Decrease in gun violence
Place-based problem-solving	Deterrence of crime through situational prevention	System identifies hot spots for focused prevention efforts	“Cooling” of hot spots of gun violence	Decrease in gun violence

7. **Control Sites** - An evaluation can be significantly strengthened by the use of control sites. To date, only St. Louis has included control sites in its study of an acoustic gunshot locator system. (Mares & Blackburn, 2012) Control sites would allow the City to have more confidence that the outcomes in the pilot areas were a result of the use of the acoustic gunshot locator system rather than a general trend. The control sites must share similar characteristics (size, demographics, crime rates, etc.) as the pilot sites. So, the City should identify the control sites and pilot sites concurrently.
8. **Potential Unintended Consequences** – As important as measuring the pilot project’s impact on reducing gun crime is ensuring that the project does not unintentionally result in negative consequences. Exhibit 2 below identifies some factors that the City may want to incorporate into its evaluation to ensure that unintended consequences are not occurring as a result of the pilot.

<sup>11</sup> See a review of the research evidence for CCTV at <http://cebcp.org/evidence-based-policing/what-works-in-policing/research-evidence-review/cctv/>

<sup>12</sup> See a review of the research evidence for Problem-Oriented Policing at <http://cebcp.org/evidence-based-policing/what-works-in-policing/research-evidence-review/problem-oriented-policing/>

**Exhibit 2: Suggested Factors to Track for Potential Unintended Consequences**

Factor	Description
<b>Willingness of residents to report gunshots</b>	A study of an acoustic gunshot locator system in St. Louis found that 911 calls to report gunshots declined by 37% without a corresponding decrease in actual gun incidents. The researchers suggested that people might be less inclined to call 911 to report gunshots because they believe that the gunshot locator system will handle it. Since eye witness reports can be helpful to police investigations, the researchers suggested that future studies of acoustic gunshot locator systems should include surveys of residents (pre- and post-implementation, and in treatment and control sites) to detect any decrease in the willingness of residents to report gunshots. (Mares & Blackburn, 2012)
<b>Perceptions of neighborhood safety and police/community relations</b>	An increase in police presence in a neighborhood due to activations from the acoustic gunshot locator system may affect perceptions of neighborhood safety and police/community relations, either positively or adversely. Therefore, it would be helpful for the evaluation of the Seattle pilot project to include surveys of residents (pre- and post-implementation, and in treatment and control sites) to detect any potential negative impacts on perception of safety or police/community relations. Some of these data may already be captured as part of the surveys conducted for SPD’s Micro Community Policing Plans. <sup>13</sup> In addition to the survey data, a comparison of citizen complaints filed in the pilot and control areas will also provide a measure of police/community relations.
<b>Shelters in place and lockdowns</b>	Shelters in place and lockdowns at schools, childcare centers, and preschools can be emotionally triggering events, especially for children who already suffer from complex trauma. It will be important to track the number of shelters in place in the pilot areas compared to occurrences in prior years as well as occurrences in the control sites during the pilot period. Particularly important data to track would be the numbers of shelters in place or lockdowns by classification (e.g., unfounded, under investigation, arrest, etc.).
<b>Student, parent, staff perceptions of safety in and around schools</b>	The Seattle Public Schools administers an annual school climate survey <sup>14</sup> to students, staff, and parents/guardians that asks about perceptions of safety in and around the school building. This would be an important and easy measure for the City to track for schools in the pilot and control areas to monitor any changes in perception of school safety associated with the implementation of the acoustic gunshot locator system.
<b>Project cost</b>	Although a federal grant will pay for the acoustic gunshot locator system it will be important for the City to track the full costs of the pilot including: new protocol development and training, re-classification of system activations, data subscription, evaluation, etc.. A full accounting of the costs will help the City assess the value it is getting from the project, and it will be a helpful reference point, if the City later chooses to scale-up the implementation of the acoustic gunshot locator system.

<sup>13</sup> See SPD’s Micro Community Policing Plans <http://www.seattle.gov/police/mcpp/>

<sup>14</sup> See Seattle Public Schools school climate survey [https://www.seattleschools.org/district/district\\_scorecards/school\\_surveys/](https://www.seattleschools.org/district/district_scorecards/school_surveys/)



9. **Baseline Data Collection** – If the City’s evaluation of the pilot project will require any data that are not routinely collected, such as community survey data, it will be important to plan to collect these data before implementing the pilot project. This will ensure that the evaluation will include valid baseline data for the both the pilot and control areas.
10. **Racial Equity Analysis** – An important aspect of the evaluation of the City’s pilot implementation of an acoustic gunshot locator system is a racial equity analysis, and the City’s racial equity toolkit outlines the process steps.<sup>15</sup> If the City chooses to have its research partner perform the racial equity analysis, the City should ensure that the research partner it selects to conduct the evaluation of the pilot project has experience with examining racial equity. Quantitative data that should be included in the racial equity analysis should include:
- Racial demographics of pilot areas
  - Racial demographics of schools in pilot areas
  - Racial demographics of arrests and final dispositions (e.g., no charge, prosecution, etc.) of arrests made based on acoustic gunshot locator system activations

The racial equity analysis should also include a qualitative component, and it should be planned in such a way that it includes input from youth as well as members of immigrant and refugee communities.

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<sup>15</sup> See the City of Seattle’s Racial Equity Toolkit [http://www.seattle.gov/Documents/Departments/RSJI/RSJI-Racial\\_Equity\\_Toolkit-2016.pdf](http://www.seattle.gov/Documents/Departments/RSJI/RSJI-Racial_Equity_Toolkit-2016.pdf)

## Appendix A – Review of Research Literature for Acoustic Gunshot Locator Systems

To date, there have been three independent studies<sup>16</sup> that reviewed the effectiveness of acoustic gunshot locator systems.

- A 1999 study evaluated the acoustic gunshot locator systems in use in Redwood City, CA (ShotSpotter) and Dallas, TX (SECURES) and found that the systems could fairly accurately identify the location of gunfire (within 23.5 to 27 feet of the true location). However, the systems did not tend to help officers make more arrests, as shooters tended to quickly leave the scene. The study suggests that the technology could be useful as a problem solving tool, as it could aid police efforts to analyze high gunfire locations.<sup>17</sup> (Mazerolle, Watkins, Rogan, & Frank, 1999)
- A 2012 study evaluated the effectiveness of a gunshot location system in St. Louis. The study found the system may be related to a decrease in gun-crime related calls for service to police, but not in gun incidents. The authors conclude that the decrease in calls for service is not necessarily a positive development, as it may suggest that residents are less likely to call in incidents because they believe the system will take care of it for them. (Mares & Blackburn, 2012)
- A 2014 evaluation of an acoustic gunshot locator system in Brockton, MA found that the system was associated with decrease of 32 seconds in the mean police response time for gunshot incidents. However, the study found no improvement in gun-related case resolution, such as making arrests or prosecuting suspects. (Choi, Librett, & Collins, 2014)

More broadly, a 2015 National Institute of Justice report on the potential of technology in policing by the Center for Evidence-Based Crime Policy and the Police Executive Research Forum<sup>18</sup> cautions that technology may not always bring anticipated benefits to police agencies and may sometimes have unintended undesirable consequences. The report offers recommendations for police agencies to consider when adopting new technology, including: broad participation in planning; ample testing and refinement; integration of technology with evidence-based strategies; and a commitment to rigorous evaluation of police technology. (Koper, Lum, Willis, Woods, & Hibdon, 2015)

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<sup>16</sup> A search of Google Scholar by Office of City Auditor staff in June 2016 found only three studies that used a quasi-experimental design and were conducted by independent researchers.

<sup>17</sup> This study is publicly available at <https://www.ncjrs.gov/pdffiles1/nij/179274.pdf>

<sup>18</sup> See the full report at <http://cebcp.org/wp-content/technology/ImpactTechnologyFinalReport.pdf>

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