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Smart Gun Technology Requirements Preliminary Report

D. R. Weiss, D. J. Brandt, K. D. Tweet

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Abstract

The goal of the Smart Gun Technology project is to eliminate the capability of an unauthorized user from firing a law enforcement officer's firearm by implementing user-recognizing-and-authorizing surety technologies. This project is funded by the National Institute of Justice. This document reports the projects first objective: to find and document the requirements for a user-recognizing-and-authorizing firearm technology that law enforcement officers will value. This report details the problem of firearm takeaways in law enforcement, the methodology used to develop the law enforcement officers' requirements, and the requirements themselves.

Acknowledgments

Thanks go out to the hundreds of people who supplied the information to make this report possible. This report consists of the aggregate ideas of many people who work in, and are knowledgeable about, the law enforcement profession. Also the assistance of personnel at Colt's Manufacturing Company, and Smith & Wesson firearm manufacturers gave technical insight into firearm specifics. Without all of their input this report would not have been possible.

Reader Feedback

This report contains the preliminary requirements for a smart gun technology. The requirements are from the point of view of the end user, the law enforcement officer. The requirements are preliminary because of the nature of the problem of determining adequate requirements and the ongoing work in this area. It is likely that the requirements will continue to be refined through the smart gun technology project.

We are constantly looking for ways to improve the requirements and the processes used to gather them. Readers can provide the best suggestions for improvement. The reader is encouraged to submit any comments, criticisms, and ideas to be considered for future revisions to the following address.

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Executive Summary

Are officers being killed with their own weapons? Are there enough officers being killed with their own weapons to consider it a problem? The answer to the first question is definitely yes. Not only are officers being killed with their own weapons, other officers and even citizens are being killed with officer's service weapons. The answer to the second question is largely a matter of opinion. Some consider a single officer being killed in any manner a problem, others look at the problem statistically for an answer.

Firearms are used by assailants in most of the attacks that result in serious injury or death to law enforcement officers. In some of these attacks the officer is killed by his or her own firearm. While the total number nationwide killed in this manner may not be large, the potential threat is present for every officer facing violent and unpredictable subjects. In research back to 1979, as many as 19 deaths per year have occurred from an assailant's use of an officer's firearm.

This primary purpose of this report is to state the requirements for a smart gun technology: a technology that, when implemented into a firearm, limits the use of the firearm to authorized users. The secondary purpose of this report is technology transfer. This report is written for a person, possibly a technologist, not familiar with the law enforcement profession. The requirements are conveyed to the readers in such a way that they understand the meaning and significance of each requirement. While many of the requirements may be apparent to some, until this time they have never before been documented with descriptions and evidence to support them. It is hoped that readers' comments will be received so that continuous improvement of the

requirements may occur as the project continues.

Project Description

As the research and development agency of the United States Department of Justice, the National Institute of Justice (NIJ) pursues a wide range of programs to prevent crime and improve the criminal justice system. The National Institute of Justice is sponsoring a multi-year research and development program at Sandia National Laboratories that will ultimately result in technologies usable in a "smart gun." The Smart Gun Technology project was authorized in April 1994 and will last approximately 20 months. Sandia National Laboratories, one of the Department of Energy's multiprogram laboratories, has for over four decades applied its talents, tools, and techniques to solving technical problems of national scale. Since Sandia is not in competition with private industry, an unbiased look at the problem of firearm takeaways can be conducted by Sandia. A separate goal of Sandia is technology transfer. The results of this project will be disseminated to private industry to direct the realization of a "smart gun."

The goal of the Smart Gun Technology project is to eliminate the capability of an unauthorized user from firing a law enforcement officer's firearm by implementing *user-recognizing-and-authorizing* surety technologies. The project intent is not to produce a firearm, but to evaluate technologies capable of being used in a firearm that can recognize a user, as well as being highly reliable, very safe, very secure and meet stringent law enforcement requirements. The focus on law enforcement firearms dictates that authorized users must

always be able to operate the firearm and unauthorized users should never be able to operate the firearm.

The project has three primary objectives. The first objective is to find and document the requirements for a user-recognizing-and-authorizing firearm technology that law enforcement officers will value. This document contains the preliminary results of this objective. Sandia National Laboratories, as an unbiased agency, has collected into this document information from law enforcement agencies, firearm manufacturers, and others. This information was used to determine the appropriate requirements for smart gun technologies that law enforcement officers will value.

The second project objective is to investigate, evaluate, and prioritize technologies that meet the requirements for a user-recognizing-and-authorizing firearm. Various technologies will be reviewed as to how they satisfy the requirements. These technologies will be ranked and a report documenting the process written.

The third project objective is to demonstrate and document the most promising technology's usefulness in models of a user-recognizing-and-authorizing firearm. Models will be fabricated to illustrate identification principles as well as demonstrate proof of concept of the most promising technologies.

Methodology Overview

It is critical that the appropriate requirements for a smart gun technology be ascertained. To correctly determine the requirements a logical approach was taken. The first step was to understand the need for smart gun technologies. To understand the need, facts on takeaway situations were gathered. The annual report titled Law Enforcement Officers Killed and Assaulted, published by the Federal Bureau of Investigation, contains the best documented information in this area. Next, to understand law enforcement officers, their duties, and their firearms, more investigation was conducted.

Information was obtained using various methods including visits to police departments and law enforcement conferences, literature reviews, personal and phone interviews, and a questionnaire. The questionnaire was designed to focus on specific smart gun technology issues, and was followed with personal and telephone interviews as time allowed. The method used to distributed the questionnaire was not intended to give a scientific sampling of law enforcement, and no extrapolation to a larger population of officers is intended. The questionnaire was used to give some quantitative measure to the information gathered by other sources. Finally all of the information was digested into a set of requirements for the technologies. This report summarizes all the information collected.

A wide range of law enforcement personnel responded to the surveys. The goal was to include varied types of officers and this goal was achieved. Over 300 surveys from across the United States were analyzed. A handful of surveys were also received from other countries. The geographic distribution of the responses is comparable to the demographics of the United States. While the majority of surveys were received from municipal agencies, information was received from a wide variety of agencies including county, state, federal, university, tribal, and academies. The typical respondent was well experienced, and encompassed ranks from police chiefs to police officers.

The Firearm Takeaway Problem

To investigate the need for a smart gun technology the problem of firearm takeaways was studied. The majority of the information was extracted from the Law Enforcement Officers Killed and Assaulted reports. Data available from 1979 to 1992 was used for this study. The 1993 detailed FBI report is not yet available, but the information that is available was used where appropriate. This gave a 14-15 year time history to be reviewed. Other reports and information from agencies were also studied. The FBI reports only include officers

killed by their own firearms. For this report, all officers killed by an adversary using the officer's own firearm, as well as an officer killed by an adversary using another officer's firearm, are included.

The FBI data reveals that an average of 16% of the officers killed in the line of duty are killed by an adversary armed with a service firearm, either the officer's own or another officer's. These officers do not voluntarily give up their firearms, and are not substandard officers. The typical incident involves the officer being killed during a physical altercation with an adversary in an arrest situation.

Since a peak percentage in 1986 there has been a downward trend in the percentage of officers killed with a service weapon. The reason for this decline is not known but could be due to increased awareness of the problem, the introduction of security retention holsters, and the increased use of body armor among officers.

Part of the increased awareness of the takeaway problem came from two reports released by the California Commission of Peace Officer Standards and Training (POST) covering data from 1980 to 1989. The reports stated in the summary of findings of California officers killed, that the officer's weapon was used by suspects in up to 16% of the killings, this included both the victim officer's or another officer's firearm. This number is consistent with the data from the country as a whole.

While the above data deal with officer deaths, the police academy in San Francisco has collected data on the number of attempted firearm takeaways. In this information it can be seen that in 1990 there was a significant drop in both the total number of attempts and the percentage of successful attempts, possibly due to specialized training on gun retention. Since that time the number of attempts has remained relatively constant, but the percentage of successful takeaways has returned to their original levels and may be on an increase. If training was the cause for the decrease, the results were short lived. Officers

have reported that adversaries are using the same takeaway maneuvers that officers are taught at the police academies. Takeaway techniques for self defense can be found being taught in magazines and self defense classes for the general public.

Firearm takeaways are most prevalent in the South region of the United States, as geographically defined by the FBI. Over half of the takeaway incidents resulting in death have occurred in the South region. This is true for both the total number of incidents and also when normalized by the number of officers employed. Following the South, in order, are the Midwest, West, and Northeast regions. The reason the South region has historically had more than twice the takeaways resulting in death than the next closest region is not known.

Smart Gun Technology Requirements

The means used to decipher requirements from the law enforcement personnel was to understand, and address, their concerns. The questionnaire included questions to gain understanding of the officers' concerns about smart gun technologies. The responses from these questions were categorized and tallied. For each of the categorized concerns a deductive approach was used to explain the reasons behind an officer's viewpoint, the description then concludes in a list of requirements.

While the set of smart gun technologies describes the idealistic "wants" of law enforcement officers, it is understood that the actual "needs" are a subset of the wants. These wants set a target for the optimum smart gun technology. Although it may or may not be possible to meet the ideal, a standard can be developed to rank various implementations of technologies.

Without a doubt the most important aspect of a smart gun technology is that the entire system must be reliable. To the officer, the firearm is another tool that is available to be used. The difference is that the firearm is only used when

the circumstances of an officer's work demand that lethal force be used. Then the firearm must operate properly because the officer's life is at stake. The addition of a smart gun technology must not significantly reduce the reliability of the firearm system compared to existing firearms. Officers overwhelmingly like the concept of a smart technology, but they require their firearm to operate predictably.

Another concern of officers is that the smart gun technology operates in all circumstances and environments in which they could conceivably find themselves. The officer's firearm must operate in the worst possible environments the officer may face. The call the officer responds to may be a quiet swampy area, or a barroom with deafening music and screaming people. The officer could be sweaty, sandy, wearing gloves, snowy, wet, or shouting. No matter what the circumstances the officer may find himself in, his firearm must still operate.

Many of the concerns the officers have about smart gun technologies are due simply to the fact that a new technology would be incorporated into a firearm that they currently trust and depend. Gaining this trust in a smart gun technology is a hurdle that must be overcome. The technology must be able to

separate the intended users from unauthorized users. Officers want the capability to use another officer's weapon if the need arises. They also want to be able to use a weapon with either hand. The technology must be simple and affordable. Many other concerns are addressed in this report, but the requirements for a smart gun technology are clear: a smart gun technology must not interfere with the manner in which current firearms operate, except by limiting the use to an authorized individual.

Conclusions

The requirements generated in this report are stated from the officer's viewpoint and form an idealistic standard for smart gun technologies. Listing requirements in this fashion allows individual technologists the latitude to develop products that meet the needs of officers, as well as stimulate economic competitiveness in the marketplace with additional features. In the next phase of the project these qualitative end-user requirements will be used to form a set of quantitative engineering requirements. This will allow different technologies to be evaluated against one another, and prioritized for future evaluation.

Chapter 1

The Smart Gun Technology Project

Firearms are used by assailants in most of the attacks on law enforcement officers that result in serious injury or death. In some of these attacks the officer is killed by his or her own firearm. While the total number nationwide killed in this manner may not be large, the potential threat is present for every officer facing violent and unpredictable subjects. In research back to 1979, as many as 19 deaths per year have occurred from an assailant's use of an officer's firearm.

The National Institute of Justice

As the research and development agency of the U.S. Department of Justice, the National Institute of Justice (NIJ) pursues a wide range of programs to prevent crime and improve the criminal justice system. NIJ is authorized to: sponsor research and development programs, and special projects; evaluate the effectiveness of new and promising crime control programs; support technological advances applicable to fighting crime and improving criminal justice; disseminate information from research, development, demonstrations and evaluations.

For more than 20 years, NIJ's Technology Assessment Program (TAP) has been responsible for developing performance standards for law enforcement products including hand-held radios, metallic handcuffs, firearms, surveillance devices and body armor. With the development of tools and technologies aimed at improving the effectiveness of law enforcement being under NIJ's jurisdiction, NIJ is supporting a "smart gun" technology research and development proposal. The Smart

Gun Technology project is an effort to define a user recognizing and authorizing firearm surety system as well as investigate, evaluate and prioritize existing technologies for potential use in a "smart gun." The results of this project will be used to further the goal of eliminating the capability of an unauthorized user from firing a law enforcement officer's firearm.

Sandia National Laboratories

Sandia National Laboratories (SNL), one of the Department of Energy's multiprogram laboratories, has for over four decades applied its talents, tools, and techniques to solving technical problems of national scale. Established in the 1940s as the engineering arm of the nuclear weapon development system, Sandia has since grown into one of the country's largest technical resources, now working in areas as diverse as environmental remediation, healthcare, transportation, manufacturing, and criminal justice.

During its more than 40 years of existence, Sandia has maintained an abiding commitment to technical and scientific excellence in meeting the Department of Energy's and the nation's needs. Sandia's industrial management heritage brings to the Laboratories an emphasis on developing theoretical concepts into useful solutions. The ability to transform knowledge from research laboratory to factory floor, from vision to application, is a Sandia strength.

Sandia's responsibilities fall into three established responsibilities to the federal government: Defense Programs, Energy and

Environment, and Work for Others. The Defense Programs sector includes the stewardship and development of the nation's nuclear weapon stockpile, as well as development of arms control and nonproliferation technologies. The Energy and Environment sector's role includes improvement of the economics, safety, and environmental capability of energy conversion and utilization. The Work for Others sector applies Sandia's unique capabilities to help government agencies meet their missions.¹

The Smart Gun Technology project is a Work for Others project for the Department of Justice. Since Sandia is not in competition with private industry, an unbiased look at the problem of firearm takeaways and technologies to address the problem can be conducted by Sandia. A separate goal of Sandia is technology transfer, the results of this project will be disseminated to private industry to direct the realization of a "smart gun."

Smart Gun Technology Project Description

The goal of the Smart Gun Technology project is to eliminate the capability of an unauthorized user from firing a law enforcement officer's firearm by implementing *user-recognizing-and-authorizing* surety technologies. The project intent is not to produce a firearm, but to evaluate technologies capable of being used in a firearm that can recognize a user, as well as be highly reliable, very safe, very secure and meet stringent law enforcement requirements. The focus on law enforcement firearms dictates that authorized users must always be able to operate the firearm and unauthorized users should never be able to operate the firearm.

This approximately 20 month, \$620,000 project has multiple objectives. The first objective is to find and document the requirements for a user-recognizing-and-authorizing firearm technology that law enforcement officers will value. This document contains the preliminary results of this objective. Sandia National Laboratories, as an unbiased agency, has

collected into this document information from law enforcement agencies, firearm manufacturers, and others. This information was used to determine the appropriate requirements for smart gun technologies that law enforcement officers will value.

The second project objective is to investigate, evaluate, and prioritize technologies that meet the requirements for a user-recognizing-and-authorizing firearm. Various technologies will be evaluated regarding their potential to satisfy the requirements. These technologies will be ranked and a report documenting the process written.

The third project objective is to demonstrate and document the most promising technology's usefulness in models of a user-recognizing-and-authorizing firearm. Models will be fabricated to illustrate identification principles as well as demonstrate proof of concept of the most promising technologies.

Purpose of the Requirements Report

The primary purpose of this report is to state the requirements for a smart gun technology. A smart gun technology is one that, when implemented into a firearm, limits the use of the firearm to authorized users. The methodology of the research is described to satisfy the reader that the research was thorough. A basis for the need of such technologies is presented by describing the recent history of takeaways in the United States.

The secondary purpose of this report is technology transfer. This report is written for a person, possibly a technologist, not familiar with the law enforcement profession. The requirements are conveyed to readers in such a way that they understand the meaning and significance of each requirement. By listing all the information available, it allows the private sector to continue where this report leaves off: Sandia does not have to be involved. When reviewing the requirements, the reader may find that they merely state the obvious. While many of the requirements may be apparent to

some, until this time they have never before been documented with descriptions and evidence to support them. It is hoped that reader comments will be received so that optimization of the requirements may occur as the project continues.

Initial Comments for the Reader

The following are a set of miscellaneous comments to assist the reader:

- The requirements are given from the viewpoint of the end user, the law enforcement officer. The end user requirements stated are for the technologies used in a smart gun, not for the firearm itself. Sometimes the boundaries between the technology and the smart gun system are not evident. It should be understood that the technology is only one part of the total system along with the officer and the firearm, and that the technology may only meet a requirement in combination with the entire system. It is expected that technologists are able to extract the necessary information to meet their particular needs.
- This report often describes the idealistic “wants” of law enforcement officers; it is understood that the actual “needs” are a subset of the wants. These wants set a target for the optimum smart gun technology. Although it may or may not be possible to meet the ideal, a standard can be set to rank various implementations of technologies.
- The masculine pronoun will be used throughout the report for ease of reading.

This is not intended to overlook the role of the female police officer in law enforcement.

- The geographic regions and divisions of the United States used in this report follow those used by the Federal Bureau of Investigation (FBI).
- The report uses phrases such as “officers killed with service weapons” to include both an officer killed by an adversary using his own firearm, as well as an officer killed by an adversary using another officer’s firearm. Deaths due to friendly fire, unintentional discharges, etc. are not included by these phrases.
- It is realized that it is easy to offer suggestions to particular instances in hindsight. In any comments about actual incidents of law enforcement officers we are not attempting to second guess their actions.
- Round off error may be detected in some of the figures throughout the report. All calculations were completed before rounding.
- Although rifles, shotguns, and other weapons may be candidates for using smart gun technologies, they will not be specifically addressed in this report.
- Although the potential exists for smart gun technologies to be used in all firearms, the focus of this report will be for law enforcement handguns.

Chapter 2

The Requirements Gathering Process

Methodology Overview

To correctly determine the requirements for a smart gun technology a logical approach was taken. The first step was to understand the need for smart gun technologies. To understand the need, facts on takeaway situations were gathered. Literature searches as well as calls to many organizations and individuals brought little documented information. The annual report titled Law Enforcement Officers Killed and Assaulted, published by the Federal Bureau of Investigation, contains the best documented information in this area. Next, to understand law enforcement officers, their duties, and their firearms, more investigation was conducted. A questionnaire was developed and distributed to officers. This survey was designed to focus on specific smart gun technology issues. The survey was followed with personal and telephone interviews as time allowed. Finally the information was digested into a set of requirements for the technologies. To formulate the requirements for smart gun technologies all the information collected, from the literature, survey analysis, and interviews, was studied for commonalties. This report tries to summarize that information.

Data Gathering Process

The process followed to gather data, and described in this section, is modeled after the approach used by AT&T Bell Laboratories.² The process flow is shown in Figure 1. The process is discussed in detail to disclose the exact techniques used.

Figure 1. Data Gathering Process Flow

Planning Stage

A broad reaching method was needed to quickly understand the wants and needs of many officers. Information from officers, at all ranks and in various types of law enforcement, was needed to understand officer's viewpoints on a number of issues. During the planning stage of the process the survey objective, and methods of obtaining information were developed. The type of information that was

needed was determined, and the location of that data was documented. Initial plans were developed for each stage of the process and a Data Gathering Plan drafted.

Preparation Stage

The process continues with the preparation stage. In this stage the areas to be covered in the survey were developed through preliminary conversations with officers and literature searches. A survey was designed to collect the needed data, yet not require more than 5-7 minutes to complete. Appendix B contains the questionnaire.

The surveys were made up of questions to determine the attitude of individuals. Attitudes are the mental states of individuals composed of their feelings, knowledge, and the way they act. These attitudes are the conditions that influence how they take in and use information as the basis for action. The survey included both open and closed ended questions.

Open ended questions were used to obtain opinions and to probe the attitudes of the officers. The responses were characterized to determine the range and number of concerns of officers, and to be able to capture responses in the respondents' own words. It is always possible that open ended questions can be misinterpreted. To minimize this, all open ended questions were interpreted by at least two analysts.

Closed ended questions were used to measure attitude intensity. Closed ended questions used a Likert-type scale. This response format developed by R.A. Likert (1932) represents a bipolar continuum. The low end represents a negative response while the high end represents a positive response.³

Respondents were informed that they were not required to answer all the questions. They were specifically informed that the demographic information was optional.

An informational page was distributed with the surveys to explain more fully the project goals and objectives. A cover letter was also sent

with the mailed surveys asking the respondent to circulate the surveys to appropriate people.

Pilot-Test Stage

The questionnaire was pilot tested before being publicly distributed. Independent reviewers, data analysts, and human subject testing experts reviewed the content, questions, instructions, and mechanics of the survey. Individual trials of the questionnaire were completed with both a set of police officers and persons that would be analyzing the data. Questions were reviewed to assure a consistent understanding (reliability) that would stimulate accurate information (validity). The survey was revised as necessary throughout this stage.

Data Gathering Stage

The surveys were distributed through numerous methods. Surveys were mailed to police departments, distributed at law enforcement conferences, published in a law enforcement professional journal (American Society of Law Enforcement Trainers Journal), and copies passed on from these people to others. People were encouraged to distribute copies to other knowledgeable people. Officers from various organizations at all levels of law enforcement were covered.

This method of distribution was not intended to give a scientific sampling of law enforcement, and no extrapolation to a larger population of officers is intended. Because of the manner of distribution it is impossible to establish a response rate.

A postage paid return envelope was included with the survey when distributed by mailings or direct distribution. Surveys were returned by mail, fax, and e-mail. Surveys were logged into a computer system as they arrived.

Analysis Stage

Analysis started at a date selected to meet project deadlines. At this time sufficient surveys were received (319) to meet the survey objectives, and trends could be seen in the data. After this date new survey results were not

tallied with the rest, but each was reviewed for any comments that would not support the existing data, none were found. These late surveys are planned to be analyzed at a later date and the updated results reported in the final project report.

Qualitative data was received from the open ended questions on officers' concerns. The analysis goal of this information was to reduce the numerous responses into a meaningful few. All open ended questions were interpreted by at least two analysts. The information was categorized, sorted, and rechecked for consistency within the category. Quantitative, or numerical, data was collected from the close ended questions. Descriptive statistical information was collected to look for central tendency and variability.

Follow-up interviews were conducted in person and by telephone until the trends of the answers were repeating and time demanded completion. The interviews were used to check the interpretation of the questions to again validate the survey. The interviews were sought to understand the importance of the respondents' answers and any extenuating circumstances that may influence an answer. During the interviews answers could be elaborated upon and inconsistencies could be questioned. In

depth personal interviews were conducted with officers during the swing shift at the Kansas City Police Department, and the day shift at the Albuquerque Police Department.

Reporting Stage

All of the information collected and analyzed, from preliminary interviews, literature searches, law enforcement conferences, the surveys, follow-up interview, and other means, was used in the analysis of the officers' requirements. This report documents those findings.

Survey results are presented throughout this report with the appropriate sections of text as quantifiable attitudes of the surveyed officers. Data is presented in various manners depending on how it can be best understood in the context of the information presented. The officers' concerns are often used exactly as written on the surveys, or are paraphrased, in the text of the report. The officers' identities are not given for protection of their personal privacy.

Characteristics of Respondents

A wide range of law enforcement personnel responded to the surveys. The goal was to include varied types of officers and this goal was achieved. Some characteristics of the

Figure 2. Survey Respondents By Region

Figure 3. Survey Respondents By Type Of Agency

respondents are charted here.

The persons responding to the survey, as shown in Figure 2, generally match the population characteristics of the Nation, except for the South. The South had a much greater response than the other regions. One reason for this may be that since the percentage of law officers killed is much greater in the South, the officers are more concerned about their safety and methods of prevention. As will be seen in upcoming charts, the number of takeaway incidents is also the greatest in the South. Surveys outside of the United States were received from Canada, Puerto Rico, and the United Kingdom.

Figure 3 shows the percentage of respondents and the type of agency with which they are affiliated. A wide range of agencies responded. The majority of the respondents were from city, or municipal, police departments. The next largest percentages of respondents were from county agencies. Of course, these two types of agencies jointly provide most of the law enforcement service in the Nation.⁴

Figure 4 shows the percentage of survey respondents by the title placed on the survey. Many officers listed more than one position, and usually the first title listed was used. A

wide range of personnel responded to the survey, from management positions, to trainers, to patrol officers. This variation of people allows the information to not be biased by only one category of people responding. Although only 6.3% of the respondents had titles of instructors, a total of 26.9% of the respondents worked in the training areas at various levels. People in the area of training are involved because they are usually well informed on the needs of the officer. They are often responsible for tracking statistics on the officers, as well as recommending and implementing training programs.

The responses that were analyzed came from officers with a wide range of experience, as seen in Figure 5. Over half of the officers were in the range of 11-25 years experience in law enforcement. These are officers that have seen many ideas in law enforcement come and go and have definite opinions on the way things should operate. A smaller percentage of younger officers also responded. These officers often like the concept of advancing the technology of law enforcement. Officers with more experience were usually in administrative roles including planning, teaching, as well as some Chiefs of Police.

Figure 4. Titles of Survey Respondents

Figure 5. Survey Respondents Years of Service

Chapter 3

Firearm Takeaways

The Need For Investigation

Are officers being killed with their own weapons? Are there enough officers being killed with their own weapons to consider it a problem? The answer to the first question is definitely yes. Not only are officers being killed with their own weapons, other officers and even citizens are being killed with officer's service weapons. The answer to the second question is largely a manner of opinion. Some consider a single officer being killed in any manner a problem; others look at the problem statistically for an answer.

From the survey results, only a few officers stated concerns that weapon takeaways are not a problem and other more critical topics should be studied. The majority of officers have never seen the statistics surrounding takeaways. There are also false rumors circulated, such as the only time an officer is killed with his own firearm is when the firearm was surrendered to the suspect. Some officers who have not been involved in a struggle for their firearms believe that training alone can solve the problem. Officers who have been in fierce struggles for their firearms seem to believe that even though training is important, in these situations survival takes over where the training leaves off. If officers being killed with their own weapons were not a problem, there would not be as much emphasis on gun retention training as exists today, and there would not be the availability of products like security retention holsters for the officers. Awareness training of the problem can reveal to officers the extent of the problem of weapon takeaways.

Available Data

The annual report titled Law Enforcement Officers Killed and Assaulted, published by the Federal Bureau of Investigation (FBI), contains the best documented information in this area. One problem with this report is that it is a difficult source from which to extract information; the report is sometimes lacking in details or completely fails to include incidents. The process in which the FBI obtains its information depends on the processes of the individual states that are required to supply accurate information on a timely basis. These processes may be lacking, and could affect the accuracy of the report. Information received directly from the FBI data base did not exactly match their own reports; for this document the information was extracted only from the FBI reports. Examples of text from the FBI reports follow (*warning: these are not pleasant reading*):

Florida, 1991. On January 18 at approximately 8:10 p.m., a 29-year-old patrolman with the Ft. Pierce Police Department for nearly 4 years was shot and killed. After stopping a vehicle going the wrong direction on a one-way street, the patrolman ran record checks on the driver who had given several false names. Since no driver's license could be identified, the patrolman arrested the driver and had him exit the vehicle. While attempting to handcuff him, a struggle ensued during which the driver obtained the patrolman's Sigarms Model P226 9-millimeter semiauto-

matic service weapon. The patrolman was shot once and collapsed on the street. Allegedly, the driver then stood over the patrolman and shot him 12 more times. Although the patrolman was wearing body armor, many of the shots were below his vest. A total of nine rounds entered the patrolman's body; his vest stopped four. An 18-year-old suspect on probation for burglary charges was apprehended about an hour later and charged with Murder.⁵

Illinois, 1990. Two 20-year veteran officers from the Chicago Police Department, ages 43 and 46, were shot and killed at 9:10 p.m. on May 13. The two responded to a domestic quarrel between a grandmother and her grandson at her residence. A struggle ensued when the officers confronted the grandson in the residential garage. During the struggle, the offender managed to obtain one of the victim's service weapons, a Colt Trooper .38-caliber revolver, and shot both in the head, back, and chest. Neither victim was wearing body armor, and both were pronounced dead at the scene. A 23-year-old male was apprehended and charged with two counts of murder.⁶

It can be seen from these examples, some are more descriptive than others. The information in this report reflects our interpretation of the information contained in summaries such as these. This information was later compared to the data extracted from the FBI's database.

In collecting and entering information into their database, the FBI uses the forms submitted by the individual states. One of the pieces of information included is whether the officer was killed with his own service weapon. The FBI data does not reflect if an officer was killed by another officer's firearm (as was one of the officers in the second example). It also does not present data on the number of takeaway attempts, or assaults on officers involving their

own service weapons. Only when an officer was killed with his own service weapon was it included in the FBI data; this means the FBI reports contain the most conservative numbers. In reviewing the FBI data we included the number of other officers killed, but did not include deaths due to officers' firearms when turned on others. It is not unusual for a suspect to use the firearm taken from an officer, and used to kill that officer, to wound or kill others, such as innocent citizens, or to take his own life.

There are many cases where the officer's firearm is stolen after he is killed with the suspect's firearm. A smart gun technology may also help eliminate the value in stealing officers' weapons.

Time Frame of Study

FBI reports were analyzed to extract information concerning officers killed with service weapons. Data available from 1979 to 1992 was used for this study. The 1993 detailed FBI report is not yet available, but the information that is available was used where appropriate. This represented a 14-15 year time history to be reviewed. This was considered a sufficient time frame to be reviewed. Included within this time period is the introduction of the security retention holster to law enforcement, and the publishing of other studies that may have increased the awareness of retention problems.

Security Retention Holsters

Various companies that supply duty gear to law enforcement agencies include retention, or grab-resistant, holsters in their product line. The exact year of introduction of these holsters was not determined, although it is known that the holsters grew in popularity during the early to mid 1980's. As with most new equipment it has taken a few years for the retention holsters to become accepted and to fit into police department purchasing cycles, but now many larger departments are changing to retention holsters. Retention holsters are not a panacea.

There is not an industry standard for retention holster operation; this means that any company can name their retention levels any way they like. Holster suppliers state the importance of taking necessary precautions to keep from losing control of a firearm. No holster can completely secure a firearm from being removed by another person or from coming out during vigorous activity. The officer is still responsible for keeping his weapon secure.⁷ A few officers complain that retention holsters slow down the natural draw of the holstered weapon, but others say that after some training and practice there is no difference. Retention holsters, with proper training, appear to be the best product available for use today as a preventive measure against firearm takeaways.

Other Studies

Also within the time frame investigated in this study there were reports written documenting the problem of firearm takeaways. One of these reports was released by the California Commission of Peace Officer Standards and Training (POST).⁸ This report covered data from 1980 through 1986, and stated in its summary of findings of California officers killed, that the officer's weapon was used by suspects in 15% of the killings; this included both the victim officer or another officer's firearm. They also stated that of those officers assaulted but not killed, 7% were assaulted with their own or another officer's firearm. In their analysis they found that even though the method by which the suspect obtained the officer's firearm varies, the majority of the officers killed or assaulted lost their firearms during a "physical altercation" with the suspect. It is also important to note that the physical condition of the victim officers were average or above average. In the killing incidents, 50% were above average, and the remainder were average physical condition. In the assault cases: 21% were above average, 76% were average, and 3% were below average. One of the training guidelines for officers, resulting from this study, was that

each officer should be required to demonstrate proficiency in techniques to prevent the handgun from being taken by the suspect.⁹

In a follow up study, POST investigated the three year period between 1987 and 1989.¹⁰ This report documented many facts concerning incidents where California officers were killed or assaulted. After takeaway incidents agencies often changed training on gun retention, and recommended changes to a more secure holster, ones that impede weapon takeaways. They stated that the most common motive for the felonious killing attacks was to facilitate an escape from the officer. In comparing data to the previous report, they found that the frequency of weapon takeaways resulting in deaths was nearly identical for the two studies: 15 percent for the previous study and 16 percent for this study.

In a special report published by the FBI in 1992, the issue of weapon retention was also addressed.¹¹ Of the 762 law enforcement officers killed from 1981 through 1990, 110, or 14 percent, were killed with their own weapons. The question was asked, 'How much time is provided for teaching officers weapon retention techniques?' No answer was given.

Takeaways in San Francisco

The San Francisco Police Academy is one of the few agencies that could be found that keeps excellent statistics on weapon retention.¹² These statistics are then used for developing training programs for the officers. The information that is gathered includes the number of attempted and successful takeaways, as well as information on the officer, suspect, and circumstances. An attempt, for the San Francisco data, is defined as anyone making an effort to gain control of an officer's firearm. A success is defined as the officer losing primary control of his weapon. Neither number includes facts about killed or assaulted officers, although 5% of the assaults result in weapon takeaway attempts.

Figure 6. Takeaway Attempts in San Francisco

In Figure 6, numerous things can be observed. Note that for 1988 only 8 months of data was available. If the monthly average of takeaways for that year stayed constant, it would have been worse than 1989. The first thing that is noticed is that in 1990 there was a significant decrease in both the total number of attempts, and the percentage of successful attempts. Since 1990 the number of attempts have remained relatively constant but the percentage of successful takeaways have returned to their original levels and is possibly on an increase.

During 1988-89 there was a 2 hour block of weapon retention training added for the San Francisco officers. It is possible that this training was the cause of the decrease, although if it was the reason, the results were short lived. California POST requires some retention training, but individual agencies decide what and how much to implement. Three hours of retention training has again been added to the current training cycle, with an optional three day course available which officers say helps because of the additional training and practice they receive. In-hand retention is also being taught to the officers, suggesting they use the firearms external safeties. Many adversaries are not proficient with firearms and, if the officer knows he is about to lose his weapon, the

simple act of pressing the magazine release or safety may save the officer.

Some of the firearm takeaway trends being found in San Francisco follow. While these trends for attempts in San Francisco do not necessarily match the typical scenario for officers killed around the United States, some valuable information can be obtained.

- Some suspects have practiced weapon takeaways.

This alarming trend may indicate why successes are increasing. Officers have reported suspects using the same maneuvers they have been taught at the police academies. Other takeaway techniques are taught in magazines and self defense classes for the general public.

- Suspects have typically used alcohol or narcotics.

Alcohol or narcotics use is indicative of the majority of assaults on officers, and not only for firearm retention. The FBI reports that 76% of cop killers interviewed stated they were engaged in drug or alcohol activity at the time of the killing of the law officer.¹³

- There are typically multiple officers present.
- Successful suspects are typically the same size or smaller than the officer.
- Officers typically have 6-10 years experience.
- Officers are slow to detect that the suspect has turned from a defensive to an offensive role.

These four trends could suggest that officers let down their guard at certain times or in certain circumstances. Proper tactics must always be used by the officers to eliminate the possibility of takeaways occurring.

Separate statistics on attempted takeaways come from the survey respondents. One of the survey questions asked if a suspect had ever taken, or attempted to take, their firearm. Over one third (38%) of the respondents at some time during their career had been a part of a weapon takeaway attempt.

Typical Takeaway Incidents in the United States

From the data researched for the last 14 years of officers killed, the following information has been charted to understand the typical takeaway incident that resulted in death of an officer.

How many Officers are Killed with a Service Weapon?

The percentage of the officers killed with a service weapon compared to officers killed by any other means varies year to year. Figure 7 shows the number of officers killed with a service weapon as extracted from the FBI reports. These numbers include an officer killed by a suspect using his or another officer's firearm. The number for 1993 is the FBI stated number because the 1993 detailed information is not yet available.

This information reveals that an average of 16% of the officers killed in the line of duty are killed by a suspect armed with a service firearm, either the officer's own or another

Figure 7. Officers Killed With Service Weapons

Figure 8. Percent of Total Takeaway Incidents (1979-1992) by Region and Division

officer's. Since a peak in 1986 there has been a downward trend in the percentage of officers killed with a service weapon. While this chart displays the number of officers killed, it says nothing about either the number of assaults on officers with service weapons, or the number of attempted takeaways. Some possible reasons for the decline in deaths may be increased awareness of the problem, the introduction of security retention holsters, and the increased use of body armor among officers.

In the 14 years of data reviewed, a total of 178 takeaway incidents resulting in an officer's death were reviewed. The number of officers killed in these incidents was 182, giving an average of just over one officer killed per incident where a death occurs. Only seven takeaway incidents occurred which had greater than one officer killed with a service weapon. In all of these incidents two officers were killed; sometimes with one service weapon and sometimes with two. Of the seven incidents where two officers were killed, all were in the South and Midwest regions, with two being in Chicago.

Where do takeaways occur?

Over half of the total number of takeaway incidents resulting in an officer death have

occurred in the South region. Following the South, in order, are the Midwest, West, and Northeast regions. Figure 8, shows the percentage of the total incidents for each region, this is then broken down into individual divisions. The reason the South region has had more than twice the takeaways resulting in death than the next closest region is not known. The South does have the largest population of citizens, and ranks second in officer to population ratio. The Northeast, ranked last in takeaways, has the second greatest population and ranks first in ratio of officers.¹⁴

Showing more detail, Figure 9 displays the takeaway incidents resulting in death by State. While this shows the total number of takeaway incidents during the time period studied it does not show a relationship to the number of officers in that state. Figure 10 shows the number of takeaway incidents per region normalized by the number of full time officers in that division.¹⁵ In this view again the South region stands out as having the most officers killed during takeaways.

A typical Incident

The typical takeaway incident starts as a typical call, either to someone's home or a traffic stop. The person is going to be placed under arrest

Figure 9. Location of Takeaways Incidents by State, Division, and Region

and starts in some manner to resist the arrest. At this time a struggle occurs and at some point in the struggle the suspect realizes he may be able to take control of the officer's firearm and the takeaway attempt begins.

Many variations of this example exist, but some common facts can be seen. Since officers carry firearms, there is a firearm in every situation that the officer enters. Most of the time the firearm is never used, but it is always

available to the officer and possibly to the adversary. Most of the incidents occur along a roadway or in a residence, although quite a few occur in transporting prisoners and at police departments. The most common motive for an attack on an officer is to escape from the officer.¹⁶ This attack may result in an attempted takeaway.

A majority of the officers involved in takeaways resulting in their death were killed

Figure 10. Officers killed in takeaways normalized by the number of officers employed in the division

after a struggle. From the data analyzed, 79% of the incidents involved a struggle, in 13% it is unknown if a struggle occurred. It is not known if the officer was able to draw his firearm in these incidents. Officers relinquishing a firearm to an adversary is not a major cause of takeaway deaths. In the 8% with no struggle, various approaches were taken. These methods include stealing officers' weapons, removing them from their holsters by surprise, or taking officers' weapons after they have been wounded by some means other than a struggle.

The majority of the officers and suspects involved in takeaways are male. Ninety-four percent of the takeaway deaths involved male officers, and 6% were female. The most likely reason for this is that there are more male officers than female. Females make up 8% of the sworn officers in the Nation.¹⁷ Also in the FBI's interviews with offenders they found that some offenders, all males who had killed male officers, stated that they would not have committed the act had the officer been female. The average killer of a law enforcement officer may or may not receive higher status in the prison society for his or her crime, but the one individual interviewed who had killed a female officer found little to boast about within the prison setting. He was even reluctant to talk about the fact that he killed a female.¹⁸

Officers that are killed with a service weapon are usually killed with their own weapons (86%) rather than another officer's (14%). They are usually in a one on one situation with the suspect. Figure 11 shows the ratio of officers to offenders in the incidents studied. In 78% of the incidents the officer killed was older than the suspect, which is typical for a crime of any type.¹⁹

The information also shows that the less experienced officer is more likely to be killed with a service weapon. This data is shown in Figure 12, one should note that this is not normalized by the number of officers in each age category. This trend is similar to the historical FBI data for officers slain.²⁰ This is different from the San Francisco data on attempted takeaways that finds that most takeaway attempts occur to officers in their mid-career years. This may indicate that while more takeaway attempts are made on experienced officers, their experience enables them to remain in control of their firearm.

A takeaway attempt can occur at anytime. Figure 13 shows the known times of takeaway incidents, the greatest percentage of takeaways occur during swing shift hours. This is similar to the historical FBI data for all officers slain.²¹

Figure 11. Ratio of Officers to Offenders During Takeaway Incidents

Figure 12. Years of Service of Officers Killed During Takeaways

Figure 13. Time of Takeaway Incidents

Chapter 4

Officers Concerns

From Concerns to Requirements

One method of determining the requirements of the law enforcement officers is to understand, and address, their concerns. From all of the gathered data, the officers' concerns were listed. In the questionnaires distributed to law enforcement personnel, two open ended questions were asked. One sought to understand the officers two main concerns about smart gun technologies, and another sought any two problems that a smart gun technology could cause them. The responses from these two questions were categorized and tallied. The interpretations of some comments were subjective. At least two analysts categorized each response to minimize bias.

The responses were then analyzed in various ways to see if certain concerns ranked higher than others. No matter which way they were characterized, the rankings did not significantly change. Figure 14 shows the total number of tallied concerns in any single category. Each of the respondents' concerns will be addressed by category in this section of the report; with associated requirements assigned.

As can be seen from Figure 14, the overwhelming concern of the officers is the effect that the addition of a smart gun technology has on the reliability of their firearm. The number of respondents that stated a reliability related concern is almost three times that over any other concern. Many of the other concerns listed by officers have a hint of

Figure 14. Officers' Concerns Relating to Smart Gun Technologies

reliability in them. When the survey results are compared to the data gathered by other means, the results show consistent concerns. It is unlikely that the survey questions influenced the officers concerns.

Discussions of Concerns

There are numerous methods of documenting the information collected during this study. The following sections of this chapter list officers concerns. Each of the concerns listed will be addressed in decreasing order of significance as determined by the number of respondents stating it as a concern. For each concern a deductive approach is used to explain the reasons behind an officer's viewpoint, concluding in a list of requirements. A summary of requirements can be found in Appendix C.

Reliability

Without a doubt the most important aspect of a smart gun technology is that the entire system must be reliable. Numerous terms are used to describe the concern of not operating properly. After personal interviews and follow-up calls, words such as the following, in the correct context, indicated a concern for a reliable technology: reliability, foolproof, fail-safe, malfunctions, disabled, zero-error tolerance, dependability, failure rate, breakdowns, and works every time.

To the officer, the firearm is another tool that is available to be used. The difference is that the firearm is only used when the circumstances of an officer's work demand that lethal force be used. Then the firearm must work because the officer's life is at stake. Lethal force can only be used after the officer determines that his life is in danger. These facts explain why the number one concern among officers is the reliability of the smart gun technology.

The military has very stringent reliability requirements. Handguns used by Special Operations personnel are designed for a service life of 30,000 rounds without repair or replacement of parts. These specialized

firearms can also demonstrate a minimum 10,000 Mean Rounds Between Stoppages (MRBS), where the only class of stoppages allowed are those that can be cleared by the weapon operator within 10 seconds. Another way that the reliability is sometimes stated is: the probability of firing a full magazine without stoppage should be greater than 99.9% probability.²²

Law enforcement standards require firing a total of 600 rounds with a verification of measured parameters after the test. A total of 1 or 5 malfunctions are allowed for revolvers²³ and pistols²⁴, respectively. Information on service life can be found in Appendix A.

However the reliability is stated, either as percentages or MRBS, the addition of a smart gun technology cannot significantly reduce the reliability of the firearm system compared to existing firearms.

Requirement: The addition of a smart gun technology must not significantly reduce the reliability of the firearm system compared to existing firearms.

Environments & Circumstances

A primary concern of officers is that the smart gun technology operates in all conceivable circumstances and environments in which they could find themselves. It was not possible to separate the concerns of operating in all circumstances from operating in all environments, when answering the open ended question about concerns of the officer. Some of the phrases that were interpreted to be contained in this category were the need to operate: at the worst possible moment, in extreme conditions, as needed, through use and abuse, in all weather climates, in all expected and unexpected situations and conditions, during critical confrontations, in all field conditions, and with all types of contaminants such as dirt or blood.

After studying these concerns one learns that the officers working conditions are unpredictable. The environmental conditions that officers face depend mainly on their locale. The same firearms are used by police departments in Florida as in Alaska. This means that a single technology must also operate in the environments presented by those states. For specifics on the environmental requirements of a smart gun technology see Appendix A.

The circumstances that an officer may face are also unpredictable. The people that the officer deals with are often unpredictable. Adversaries may be calm and rational or they may be out-of-control on drugs. The adversary may simply be an average citizen that has gotten themselves into an unintended or embarrassing circumstance, or the adversary may have trained and practiced for the crime they have committed. The officer may deal with a single adversary or be confronted by multiple people. The officer may be alone or have a partner, or backup, available.

The officer must also deal with the particular conditions of the situation. An officer may be called to duty on a hot sunny summer day on a sandy beach, or a cold snowy winter night. The call the officer responds to may be a quiet swampy area, or a barroom with deafening music and screaming people. The officers described in the above scenarios could be sweaty, sandy, wearing gloves, snowy, wet, and shouting. No matter what the circumstances the officer may find himself in, he still must have his firearm operate.

Requirement: The addition of a smart gun technology must not significantly reduce the circumstances in which the firearm will operate, compared to existing firearms.

Requirement: A single individual must be able to activate a smart gun technology without assistance from others.

Requirement: The smart gun technology must operate in all likely environmental conditions.

Multi-Users

Officers often think in worst case scenarios. This is not unusual when you consider the number of situations that can arise for an officer. One worst case scenario is that an officer may need to use another officer's firearm after he has run out of ammunition or his firearm has failed, and the other officer is incapacitated to a point that they cannot use their firearm (or vice versa). Although actual statistics could not be found on the number of officers having to use another officer's firearm to defend themselves, it is thought that it is a very infrequent occurrence. We do know that these situations occur. Accounts can be found in the FBI Law Officers Killed and Assaulted reports.²⁵ Officers are concerned about losing the capability of using another officer's firearm when their life may depend on it.

Some of the people that officers thought should be able to use their firearms included: partners, other officers within the department, officers from another county/state/jurisdiction, gunsmiths and armorers, trainers, and friends of the officer such as helpful citizens or spouses. In follow-up talks, the majority of officers said that it is not important for friendly citizens to use officer's weapons. Officers cannot depend on citizens to protect them when it is their duty to protect the citizens. Officers agree that it is unlikely that they would ever use one of their fellow officers firearms, some had never even considered it a valid possibility. They felt that it is even more unlikely that they would have to use the firearm of another jurisdiction that would not be compatible with their own firearm. Also with more semi-automatic weapons with larger magazines available, the chance of running out of ammunition and needing to use another officer's weapon is even less. Officers were also concerned that the smart gun technology may be only found on a certain model or type of firearm. This would not only limit selection

Figure 15. Survey responses to: Other authorized people should be able to use my firearm.

and personal choice of firearms, but also may drive up the cost.

Officers realize it is highly unlikely that they would use another officer's firearm. Despite this fact, in responding to the survey statement, 'My partner, or other authorized people, have to be able to use my gun,' they overwhelmingly agree that others should be able to use their weapon. This is shown in Figure 15. This concern is part of not wanting to lose an existing capability of their firearm. While operating between multiple users may not be a requirement, it definitely is something the officers desire and may be needed to gain full acceptance.

Not all police firearms are single user firearms. Frequently in police cars there is a rifle or shotgun that is common to all who use that car. The smart gun technology should also be applicable for use on multi-user firearms.

In some departments, officers are allowed to carry backup firearms. Officers who carry

backups desire the capability of using the same means of identification for the backup as for their primary weapon. This means that the officer could switch between firearms without any special actions.

The number of officers that any one firearm might need to recognize could greatly vary. There are approximately 860,000 police officers in 17,000 departments across the United States. While that works out to be an average of 50 officers per department that statistic is misleading. Currently the size of police departments in the United States is small: only two departments have more than 8,000 officers, 90% have fewer than 24 officers, and 50% have fewer than 12 officers.²⁶

There is no such thing as a standard police firearm. A few departments require that officers use a specific firearm, with the goal of uniformity of training and interchangeability of parts. Some departments may offer a choice of a few makes and models, and other

departments have no stated preference on make or model as long as it operationally meets a departmental standard operating procedure. Information from the survey respondents shows that within this small number of officers, seven different makes of firearms are used. Within these seven makes, there were over 60 different models of firearms used. This information shows that many makes, and many different models within those brands are used by officers.

Requirement: The smart gun technology should be capable of being used by multiple users.

Requirement: There must be a method for armorers and manufacturers to test the smart gun technology.

Requirement: The smart gun technology must be applicable to multiple types and brands of firearms.

Requirement: The technology should also be applicable for use on multi-user firearms, i.e., shotguns.

Requirement: The technology must operate for a single individual on multiple firearms.

Requirement: Individual smart gun product lines should ultimately have interchangeable parts that are not easily misassembled and can be replaceable without special tools.

Characteristics

Officers are concerned about both the appearance and characteristics of their firearm. Sorting through the responses it is found that much of this concern is due to resistance to change and having to relearn how to fire a new weapon. It is assumed that after the appropriate time of getting familiar with any new device, the officers would use it if it had merit. The concerns mentioned by officers deal

mainly with the physical qualities of the firearm.

The firearm should physically look like existing firearms, preferably identical to them. If a suspect cannot recognize the weapon, then the officer may not have the desired intimidation over them. A smart gun needs to look like an existing firearm. Both officers and suspects need to be able to recognize a lethal weapon when they see one. There have been numerous shootings when toy guns have been drawn on officers. If suspects cannot tell if the firearm contains a smart gun technology, if they try or even succeed in obtaining an officer's firearm, the officer will still have an upper hand on the suspect. If suspects could tell the difference, it is possible that they may look for officers who do not have smart guns. Figure 16 shows that officers agree that 'a smart gun should look just like an existing gun.' Officers would like some recognizable feature on the smart gun so that the trained eye could identify one, even from some distance. This allows them to tell what type of firearms other officers are using.

The other part of the concern deals with the actual physical characteristics of the firearm. Weight of the firearm is a concern. Officers must carry on their person all the equipment that they are likely to need in performing their duties. When the situation arises, they are not able to run back to the car to get the equipment that they need. An officer's duty belt is heavy when loaded with equipment such as: their loaded firearm (40 oz.), a pair of extra magazines or speed loaders, a flashlight, handcuffs, keys, chemical agent dispenser, baton, and gloves. Not only is the equipment heavy, it also creates difficulties in getting in and out of the car without snagging objects. The smart gun technology cannot create an appreciable additional weight to carry or cause additional appendages to the firearm that would increase the difficulties in movement while carrying the firearm.

Figure 16. Survey responses to: A smart gun should look just like existing firearms.

The technology should not affect the existing standards that exist for trigger pull. If the trigger pull is too light it could be considered a safety hazard. If it is too heavy the trigger may be too difficult to pull and shoot accurately. In general, laboratory tests and field experience has determined that more than 18 pounds is a difficult trigger pull for most shooters to maintain accuracy.²⁷

The smart gun technology should also not greatly affect the size: the firearm needs to be manageable. Officers with smaller hands need to be able to properly grip the firearm. Some officers will change the grips on their firearm to a more comfortable grip. If the firearm is too bulky or cumbersome it may hinder the officers use, retention, or concealment of the weapon. The additional technologies should not alter the balance of the weapon that could effect the accuracy. Existing holsters should be able to be used. The devices should not affect gripping the weapon, or limit the manner in which the firearm must be held.

Requirement: The smart gun must have the general appearance of an existing firearm.

Requirement: The addition of smart gun technologies cannot appreciably change the weight, size, or balance of existing firearms.

Requirement: The addition of smart gun technologies cannot add appendages which would appreciably increase snagging compared to an existing firearm

Requirement: The smart gun technology should not affect the carrying of firearms in existing holsters.

Requirement: The smart gun technology must not affect the existing trigger pull standards.

Proper Recognition

Another concern that officers have with a smart gun technology is that it may not recognize them properly when it comes time to operate

the weapon. The comments received from the officers concerning proper recognition included statements such as the smart gun technologies must: be owner loyal, recognize the handler, identify authorized persons, recognize legitimate users, and not recognize unauthorized users. In talking to officers, many of these concerns came from unfamiliarity with the technologies that may be applied in a smart gun. The officers' concerns are valid; definite error rates in recognition exist, both for not being accepted by their own firearms, and for adversaries being accepted by officer's firearms.

Error rates are described as percentages of occurrence per verification attempt. Attempts are defined in various ways. An attempt as used to describe a smart gun technology is defined as one cycle of an individual using the technology as proof of being a validly authorized user. In some applications more than one try is allowed per attempt, where a try describes a single presentation of the individual to the technology for measurement.²⁸ For smart gun technologies a try and an attempt are equated: the firearm must operate on the first try (attempt) that an officer makes to use his firearm.

A false-rejection rate (FRR) is the percentage of times an authorized user who makes an honest attempt to be verified is rejected. This is the case when an officer attempts to use his own firearm but is falsely rejected. A false-rejection error is called a Type I error. A false-acceptance rate (FAR) is the percentage of times that an unauthorized user is accepted as authorized. This would be the case where an assailant tries to use on officer's firearm and is successful. A false-acceptance error is called a Type II error. The type of false-acceptance we are referring to in this section of the report are passive attempts, where the assailant submits himself as the authorized user, and not an overt act of the assailant to mimic the item being recognized (covered later in the report). Techniques, such as the use of personal identification (PIN) numbers, can be implemented to reduce both error rates.

Although these terms are most often used in association with biometric sensors they will be applied to the other technologies as well. In general, either of the error rates can be described as follows:

$$\text{Error Rate} = \frac{\text{Number of False Recognitions}}{\text{Number of Attempted Recognitions}} \times 100\%$$

In actual application most recognition technologies use a measurement of what is being recognized compared to a threshold to make decisions. Depending on the technology a number of attributes may be measured and a score determined. This score should be able to be retrieved in some test configuration so that information can be used during specialized diagnostics, training, and for quantifiable ranking of technologies. Many recognition technologies have a threshold that can be varied to change the level that the decision for acceptance or rejection is made. Thus, a police department or officer could set the threshold to control the probability of false rejects versus false accepts. A positive feedback indicator of acceptance is desired by most officers (see section on Indicators).

Requirement: The smart gun technology must properly recognize, and limit the use of the firearm, to the authorized user.

Requirement: The smart gun technology must operate on the first verification attempt.

Requirement: For applicable recognition technologies the actual recognition score, rather than a simple go/no-go indication, should be available in a testing configuration.

Requirement: For applicable recognition technologies, a method of adjusting the recognition threshold by a qualified person is recommended.

Simplicity

Today's firearms are relatively simple devices designed to do one thing: fire a round when the

trigger is pulled. Although the firearm designs have become more efficient and less likely to accidentally discharge, the operational designs have not significantly changed in the past few decades. Various models have different internal or external safety mechanisms, but none are difficult to learn. The addition of a smart gun technology must not effect the primary use of the weapon. The addition of a smart gun technology to a firearm should be transparent to the user.

Officers agree that the addition of a smart gun technology must not complicate the use of their firearm. The KISS principle, "keep it simple," applies. The reasons that officers are concerned about the added complexity cross over to many of their other concerns. In conjunction with the primary concern of reliability, officers fear that the more complex the firearm gets and the more parts it contains, the more likely it will be to fail when it is needed.

The smart gun technology device should also be able to be used during any stressful circumstances. A passive device that requires no actions by the officer is favored. The device should not have too many steps to operate, or be a hindrance to the officer. The device must not be so complicated that it would take too long to operate: it must be ready to operate instantly. It must not "take a rocket scientist" to operate: it must fit into the comprehension level of the officer with the minimum required amount of training and skills. It must be simple to maintain, even possibly in the field. Most of these topics are covered in their individual sections.

Requirement: The addition of a smart gun technology must not effect the primary use of firing the weapon by the authorized user.

Requirement: The addition of a smart gun technology to a firearm should be operationally transparent to the user.

Requirement: The addition of a smart gun technology must not complicate the use of the firearm.

Cost

Cost is an issue for any law enforcement product. Police departments are often funded to only the minimal levels necessary to maintain a status quo in the protection of the general public. The greatest part of a typical department budget is spent paying salaries, and only a small percentage is available to purchase equipment. Many departments cannot afford to supply or update their existing equipment to the latest technologies available. Discretionary equipment that is available to assist the officer in their job may not be purchased until the next model comes out and the price drops, if at all.

An additional factor is that most departments are small and do not have the buying power to get large quantity discounts. This also hurts the manufacturers, in that the law enforcement market is so fragmented it becomes hard for them to recoup their development costs in a time frame such that they can make the product more affordable. Technology experts say that because the law enforcement market is so limited, only one technology could be used for all law enforcement firearms to get volume production costs, or the market would have to be expanded to the general public.

Officers typically have to purchase their own firearms for their jobs. Even for those departments that were to subsidize officers in purchasing new firearms, the cost must be in a range that it is affordable. Officers have views of what is affordable that cross the entire spectrum of possibilities. Some officers suggest that the safety and peace of mind of knowing that someone cannot use their firearm against them would be worth spending up to twice what a current firearm costs. This argument is somewhat supported by the cost of the one commercial magnetic ring firearm that is available and is marketed to the general public; it costs approximately twice that of a normal firearm. On the other extreme, some officers rationalize that if this is a safety device it should be included as part of the firearm without any additional cost. In conversations with various product manufacturers, a possible

target for a smart gun technology may be approximately 10% additional cost in volume production.

Officers also mentioned concerns regarding the financial constraints of departments. Training officers is expensive and if a smart gun was available, a department may reduce training in the area of gun retention to offset the additional cost of the smart gun technology. Also there are other costs that must be considered. These include the routine maintenance of the firearm, which includes purchases such as batteries, and also the cost of any additional infrastructure needed. It is not known whether a department, which would mandate the use of smart guns, could receive a reduced premium for liability insurance.

Requirement: The additional production cost to incorporate a smart gun technology to a firearm should not add more than approximately \$50 to the purchase price.

Requirement: Any additional costs associated with the use of smart gun technologies should be minimized.

Training

Training is important for all aspects of an officer's job. Today this is not only true for the need to enhance officer safety, but also for the need to reduce the possible liability of the department. Officers must be trained in the proper use of each piece of their equipment. Although all departments have requirements for training, the requirements will change from department to department. Training may only be implemented after an incident brings the need into the focus of the department, and possibly the community.

There are two general types of gun retention training: awareness training and physical training. Awareness training is to inform officers of the threat of having their service weapons taken from them. It may cover the

frequency of occurrence, the typical scenarios, and warnings to be prepared. Physical training is to train the officer in various tactics that can be used to prevent a takeaway when in the situation. It may also cover awareness training, but the focus is on the practice of holds and maneuvers that will give the officer the advantage to keep, or regain, control of the situation. The most well known gun retention training techniques may be those started at the Kansas City Police Department by Jim Lindell in the 1970s.

Approximately 27% of the responses to the survey were received from training officers at various levels from academy directors to trainers. One of the main concerns listed by these trainers was that gadgets cannot replace training of officers: no matter how smart the gadget, what is needed is a smart officer. This expresses the concern that officers may become more dependent on a technology and less dependent on their training. A false sense of security may occur when officers depend too much on their equipment and not their own capabilities, because technologies can fail.

Some trainers suggest that with enough training there would be no weapon takeaways. This may have some truth, but is an over statement when all the possible scenarios are reviewed. Of the survey respondents who have been involved in takeaway situations, it is seen in Figure 17 that a wide range of physical responses, from survival to training, were involved. In follow-up conversations, officers said that training is the starting point to remain in control of their firearm during a takeaway incident, and is often all that is needed. The trained responses continue until they are no longer effective, then survival takes over the officer's actions.

Officers are concerned that departments may eliminate training on gun retention if smart guns become available. This would save the department money. Any change in training is time consuming and costly. It can become a logistical problem to cycle officers through new training programs that take them out of the

Figure 17. Survey responses to: The behavioral response used during a takeaway incident.

field. The new training programs may have to be developed. The transition to new equipment and training can cause problems if different equipment is in service and all officers have not been properly trained.

Trainers are concerned about the amount and complexity of new training that would be required. Trainers say that with proper training any new conditioned response can be developed. What is needed is an education of how a smart gun technology would work, at least to the level of understanding the required maintenance and proper operation. Officers fear that in stressful situations they may revert to old training and habits. When new equipment becomes available new recruits will usually transition easily. Many departments grandfather in existing officers when new equipment becomes available because of the officers concerns of changing old habits, or even sometimes because of union constraints. Training at the range and in class must also be considered as a way to get officers to know and trust this new technology. The training of the trainers, the armorers, and others should also be considered.

All of these concerns are not specific to smart gun technologies. Many of these same concerns are used when any change occurs, such as the transition from revolvers to semi-automatic weapons. The issues raised are more easily dealt with when the officers and trainers understand the need for change, and desire the change to be made.

Requirement: Smart gun technologies must cause only minimal additional training, such as transitional training and in service training on proper use.

Requirement: Smart gun technologies must enhance and not eliminate weapon retention training.

Requirement: Smart gun technologies training must extend beyond the use of technologies and include training for armorers and others as appropriate.

Adversarial Compromise Of Technology

The majority of scenarios of police officers being shot with their own firearms are not planned attacks. Although there are exceptions, the adversary does not usually plan to find an officer and take his firearm. The question that is still on the mind of many officers is: "How secure can a smart gun be?"

Just as hackers attack computer networks, it is a fact that the criminal element will try to find out how to defeat the smart gun technologies. Any technology such as this becomes widely known. Many officers feel that the general public should not be allowed to have a technology such as this. They feel that in the hands of the general public the "secret" will be out, and they will be left having a useless firearm. The general public will probably have this technology available to them. It is unlikely that the judicial system will allow the firearm industry to withhold any feature that could reduce fatalities caused by firearms from any sector of the population.

The technology must not be easily defeated even with full knowledge of how the system operates. The technology used in a smart gun must have a unique characteristic that is not easily replicated, or jammed by an outside source. The identifier that enables the firearm must be unique. There must not be a method by which an aggressor can easily override an officer's firearm and make it useless. If this is possible, the problem is no longer officers being killed with their own firearms, but officers left with useless firearms leaving them helpless against armed criminals.

Requirement: The technology must be such that even with full knowledge of how the system operates it cannot be easily defeated.

Requirement: The technology used in a smart gun must have a unique characteristic that is not easily replicated, or jammed by an outside source

Maintenance

The amount and type of maintenance necessary for a smart gun technology is a concern to many officers. Comments from numerous officers reflected the statement of one who said: "Most police officers do not maintain their weapon very carefully," and another who said, "...the average shooter/officer will not maintain the system". The consensus is that there is a history of poor maintenance by officers. The maintenance requirements for smart gun technologies must be held to a level that the average officer will do. Proper documentation must be supplied.

There are maintenance time and costs associated with both the acquisition and/or installation of the technologies, as well as while the firearm is in service. The smart gun must be capable of repeated maintenance without damage or a decrease in performance. Problems may occur if the maintenance is increased to a level that is too complicated. Officers may not perform the normal suggested maintenance. It could become so technically complex the department's armorer could not repair them. The technology might be so advanced that service and repairs could not be done on site and would require factory service. If there is a problem, there needs to be a way that officers can easily use another firearm if theirs is in for repairs. Repair time should be short for any failures. Any auxiliary equipment associated with the smart gun must also be simple and easy to maintain, and the technology should also be upgradable as the next version of the technology is introduced.

Once the system is set up the officer should need to do little to keep it operational. A once a day check of the recognition technology, and possibly a battery check is the most that seems practical for the average officer. There should be an equivalent method to a "tap-rack-bang" maneuver to check for and reset possible malfunctions quickly in the field. The existing maintenance and cleaning that is performed must not harm the smart technologies.

Many officers feel that maintenance is a training issue. Officers can be trained to complete proper maintenance. From the interviews, an observation made is that those officers volunteering that they had prior military experience were the same that kept their equipment well maintained. These officers did not have concerns about normal maintenance issues.

Requirement: Maintenance requirements for smart gun technologies must be held to a level that the average officer will do.

Requirement: The smart gun must be capable of repeated maintenance without damage or a decrease in performance.

Requirement: Department's armorer or trained personnel should be able to perform most diagnostic tests and repairs.

Requirement: Simple procedures must be available to allow an officer in the field to quickly reset the recognition system in case of a technical malfunction.

Requirement: The technology should be upgradable when the next incremental version of the technology is introduced.

Requirement: Proper documentation for operational use must be supplied.

External Devices

There are many methods by which a firearm could recognize an authorized user. Two of the possible categories are biometrics, and tags. Biometrics would include those technologies that recognize a characteristic of the person, tags would include those technologies that recognize something that the person carries. Officers have some concerns about the specifics of this second category: external devices that the firearm would recognize. External devices could be any piece of equipment that was necessary in conjunction with the operation of the firearm. Possible examples are rings, wristbands, and buttons to be pushed.

The first widely known "smart gun" was the Magna-Trigger Safety System, this was invented in the early 1970s as a modified Smith & Wesson .38 revolver that was enabled by a magnet on a ring. Although only a few departments had their firearms modified, the information that was spread around the law enforcement community, true or not, was that the ring placement was critical. If the firearm was not gripped exactly right, it was said, the firearm would not operate. This first-of-its-kind product of 20 years ago still influences officers opinions about any type of smart gun technology.

Officers have the same concerns about the external devices as the smart technology itself. The external devices must meet the same requirements as the technologies themselves. The external device must be reliable. It must operate in all possible environments that an officer may encounter. It also must be easy to carry.

The majority of officers agree with the survey question 'I would be willing to wear something such as a ring, or wristband, that my gun would recognize' as shown in Figure 18. The officers who do not like the idea say that their firearm should not depend on something they would wear. They do not want to have to depend on another device to operate their firearm, another thing that could go wrong. The device would also be one more thing that they would have to carry or wear. For them to wear a device it has to be comfortable and unobtrusive. Some officers still do not wear soft body armor because of these complaints. It can not be affected by the weather, be broken in a physical altercation with an individual, or be affected by apparel such as gloves or long sleeves. Many officers had concerns that they might lose the device or just forget to wear it to work. Sometimes officers borrow equipment from others who are coming off duty when they forget to bring something to work. The device could also be stolen from them.

Figure 18. Survey responses to: I would be willing to wear something such as a ring, or wristband, that the firearm would recognize.

In operation the external device has many constraints. It must be safe to the user, it cannot cause medical effects to the officers, such as the fears raised by radar guns or contain common items that cause allergic reactions. It must be simple because it has to work in stressful situations. The officer must know where the device is, be able to obtain it quickly, and remember how to use it.

If the device is a ring, it should not interfere with the officers grip on the firearm, or be easily snagged or caught on other objects such as fences, ropes or clothing. It cannot be so big as to cause sufficient additional injury to a suspect in a physical altercation that it could be viewed as a weapon in itself. One officer said that he could not wear jewelry, and another mentioned that her hands swell and she cannot always wear her rings. Some officers suggested that implanting something in their hand would be a lot more convenient, although others were disgusted with the idea.

External devices that could be easily identified as enabling devices concerned some officers. In some departments the officers are required to carry a firearm while off duty. There are also undercover agents that need to be able to go undetected as a police officer. If an external device is unique to a police officer it could blow their cover or just identify them as an off duty officer. An obvious device could give a felon an upper hand knowing that an officer is nearby while the officer would not know there is a felon present. Most officers were not concerned about being known as police officers while off duty.

There are two general classes of external devices. Those devices that would actively control the firearm and those devices that the firearm would look for to identify a user. An example of an active control would be similar to a remote control firearm. A model of this technology has been seen by numerous people. With this technology the firearm can be

enabled or disabled at the push of a button. As seen in Figure 19, there are mixed feelings about this concept. What officers like about this concept is that their firearm is always ready to be used when they need it, and they have the choice when to disable it. The main concern is being able to get to the button to disable the firearm when in a struggle for the firearm. Most agree that with proper training this would not be a concern in most of the situations where takeaways occur. In scenarios where the officer is unconscious it could cause a problem if the adversary knew where the button was located on the officer. This raises another concern, if the adversaries know where the officer's disable buttons are located, then they may go around hitting officers in the common storage locations to disable their firearms. Of course the officer could re-enable the firearm. Unintentional pressing of the button is also a concern. Stories exist about officers walking around without any magazines

in their firearm because the release button was pressed by accident. Many officers are in the habit of frequently feeling that the magazine is fully engaged. An indicator would likely be needed to alleviate the concerns of officers that they disabled their firearm by unintentionally pressing the button.

The other class of external devices is where the firearm looks for the device to identify the user. Instead of identifying a characteristic of the officer, the firearm identifies a device that the officer carries. For this type of device there are a number of characteristics that must be considered.

What type of device would the officer wear? Officers generally liked to have an option. If the device would be something like a ring they would like to be able to modify their existing rings. Many liked the idea of a wrist band better than a ring. The range the device works over is an important consideration. The

Figure 19. Survey responses to: I would be willing to do something (like press a button on my uniform) to disable the firearm if it was taken from me.

majority of all the scenarios have the officer and the suspect in very close proximity when the officer is shot. If the device operates over too long of a distance it may operate even when the suspect has the firearm. This leads to the need for ring and wristband type identifiers, as opposed to body mounted devices that would have a range of at least the officers arm length. Most of the incidents involve a struggle for the firearm. Officers may have to be retrained to let go of the firearm and remove their identifiers from the proximity that could make the firearm operable. Officers understood that they would have to wear two devices to be able to shoot with either hand. This did not effect the opinions of the officers as long as they could have a choice of things to wear. The identifier should also be a passive device not needing a power source. An additional power source, the associated maintenance concerns, and the size of the identifier device may be too great of a hindrance to officers.

No matter how the external device may operate it must be such that it cannot be easily duplicated. Felons must not be able to simply recreate the identifying device. The device must be such that it can work with other officer's firearms. The device must also not be alignment critical. In stressful situations, or situations where the officer's hand has been injured, the officer can not be concerned with proper orientation of the device.

Requirement: Ideally no external devices are needed to operate the smart gun technology.

Requirement: Smart gun technologies using external devices must not be alignment critical.

Requirement: Any external devices must be consistent with other smart gun technology requirements, i.e., reliability, durability, easy to maintain, small, accessible, simple...

Requirement: Smart gun technologies and external devices should not cause medical side effects.

Requirement: Any external device should have optional methods for attachment to the

person, i.e., multiple fingers; fingers or wrists; implantable...

Requirement: Ideally external devices can be attached to existing items, i.e., rings, watches, badges...

Requirement: The operational range of any external device must be consistent with other requirements.

Fail Armed

An officer must be able to operate his firearm at any time. Today's firearms, having efficient designs, are relatively easy to understand and correct misfire situations. Pistol users are taught the "tap-rack-bang" to correct the most common failures simply and quickly. One concern of officers is what happens when the smart gun technology fails. Overwhelmingly, the officers desire a smart gun that will still fire if the smart technology fails. Their ideal is to err on the side of reliability and not security. The term officers often use is "fail-safe" meaning guaranteed not to "fail to fire." For the purposes of this report we will use the term "fail armed" meaning if a failure occurs the device is left in an armed, ready to operate, condition. The last thing an officer wants is a useless firearm.

The officers need to trust that the technology will not fail, but if it does fail they want the firearm to operate. This means that if the technology was somehow damaged during a struggle, if it was not maintained properly, or if the batteries just ran out, they would rather have their firearm be able to be used by anyone and not just themselves. This is reasonable when you realize that statistically a police officer will fire his weapon in defense of himself or another, more often than he will be fired upon by his own weapon. A weapon that is functioning will more often help the officer than the adversary.

Many different implementations of a fail armed feature are possible. Two optional ideas that were mentioned for use instead of a fail armed

system were a semi-permanent disable or timed lock-out. In a semi-permanent disable system, once the firearm was disabled it could not be easily reset in the field. This would leave the officer with the choice to manually disable his firearm knowing that it would remain useless until it could be reset. For the timed lock-out system the firearm would be disabled for a predetermined time if the officer chose to manually disable his firearm.

The problem that could be caused by a fail armed system is if a weakness is found that can easily disable the smart gun technologies. Criminals may learn the weaknesses of a certain model of smart gun: that by removing the batteries, or by rapping the firearm in a certain manner on the ground, the technology may become inoperable.

Requirement: A smart gun technology for law enforcement officers should fail armed, such that the failure of the technology does not inhibit firing of the weapon.

Requirement: A smart gun technology must not be easily disabled by an adversary.

Power Failure

Smart gun technologies may either use active or passive technologies, meaning that they may or may not require separate power. Many of the potential smart gun technologies are active devices. The most probable type of power source would be the use of batteries. Officers have concerns about the reliability of battery operated devices. A battery is one more thing that could go wrong in a system. Many officers opinions are that batteries run down, need recharging, corrode, and are generally unreliable. For a firearm that their life depends on, officers want to minimize the number of things that could go wrong. Other officers do not have a problem with batteries. They say they depend on their radios for their life more frequently than their firearms. They have instituted a maintenance program for their radio batteries, and the same could be done for their firearms. They have no problems using rechargeable batteries that work fine.

Figure 20 shows that although the greatest single category of officers responding to the

Figure 20. Survey responses to: It is acceptable to have batteries in firearms.

survey chose that they agree the statement 'it is OK to have batteries in my gun', a greater total majority disagree. Many of the officers dislike batteries because of the bad experiences they have had with their battery powered equipment. Flashlights and tape recorders seem to be the biggest culprits of promoting a bad reputation, although not all officers have problems. Other bad experiences come from departments not having batteries in supply when needed, and buying lower quality batteries in bulk to save money.

These bad experiences along with the personality types of officers lead to a common dislike for batteries. Many officers are notorious for not maintaining their equipment; others are extremely conscientious about maintenance. Often the best maintainers of equipment are those with previous military experience, both because of the regimented military maintenance programs and because of the fear of malfunctioning equipment. Batteries will have to prove themselves to officers to gain their confidence.

Since maintenance is a key factor, departments may have to enforce that batteries are checked and changed at regular intervals. Low power indicators may help promote proper maintenance. The indicator would have to meet the same requirements as in the indicator section of this report. Officers would rather not have to replace their batteries frequently. They would like to be able to change them in the field if necessary. Officers do not want to have to check their batteries more often than at the beginning of the shift. This means that the reserve capacity of the battery, assuming that the low power indicator came on immediately after it was checked, should allow the officer to fire three magazines approximately 10 hours later. Three magazines is the maximum a typical officer carries on his person, and 10 hours later implies that the officer is working longer than an eight hour shift. Ideally the officer would only have to change batteries at closer to one year cycles. Officers suggest that redundant power supplies may alleviate many officers concerns.

Two other concerns are as follows. One concern that is brought up when batteries are discussed is the bulkiness of the firearm. They fear that large batteries will increase the size and weight of their firearm. Another concern, along with the concern of maximizing reliability, is the officers desire that if the batteries fail, that the firearm not be rendered useless. The firearm should fail armed if the batteries fail.

Part of the engineering design of a smart gun system must include how to initially turn on the firearm when it is needed. Some technologies may allow power to be on continuously; others will have to be turned on only when needed. This turn on feature may be as challenging as other parts of the system.

Requirement: Ideally the smart gun technology would not require the use of batteries.

Requirement: If batteries are used, they must be easily obtained, and factored into the cost of maintaining the equipment.

Requirement: Ideally a battery used in a smart gun system would last longer than 1 year.

Requirement: The minimum lifetime of a battery used in a smart gun system would allow an officer to fire 3 magazines, 10 hours after first indication of a low battery.

Requirement: A low power indicator must be supplied if batteries are used in a smart gun system.

Requirement: Batteries should be easily replaceable, even in the field.

Requirement: Addition of batteries should not greatly change the characteristics of the firearm, i.e., size, weight...

Speed of Operation

Officers many times have to make split second decisions. Their lives and the lives of others may depend on the outcome of that decision. The addition of smart gun technologies must not increase the time of drawing and firing

when the decision for using lethal force has been made.

Officers are taught how to cover suspects: to be in a ready position with firearms out aimed at the ground 4-6 feet in front of them, having the advantage of seeing and responding to the first threatening movement of an attacker. Experience has shown that officers can reliably hit an 8 inch circle at about 10 feet in .5 to .7 seconds from a ready position.²⁹ Drawing from a holster adds some additional time.

Officers are concerned that the addition of smart gun technologies could affect the readiness of their firearm by increasing the time needed to draw the firearm from the holster. The smart gun needs to fit existing holsters. It needs to be able to clear the holster quickly. Access to their firearm cannot be delayed. Once the firearm is drawn, it must be ready to use. Whether on or off duty, quick use in an unexpected situation is primary to officer safety. The device cannot be so secure that it delays the intended use.

Things that could slow an officer down are extra steps that would be required before use. Activation or deactivation may take too long, in either a normal or a takeaway scenario, if it is too complicated or must be done manually. Also, the exchange between officers should be with a minimum delay.

Another decision for the smart gun system designer is how to initially tell the firearm to look for the user, and whether to re-authorize the user between each round. This affects the power and speed that the technology can operate. For instance, in the following scenario the firearm should not operate. A suspect has his hand on the firearm and the officer's hand is on the suspect. The identification ring on the officer's hand has enabled the firearm. When the officer removes his hand from the suspect's hand, and the suspect's hand is still on the firearm, the firearm should become disabled.

Requirement: The addition of smart gun technologies must not increase the time of

drawing and firing when the decision for using lethal force has been made by any authorized user.

Loss of Capability

Firearms have not significantly changed for decades. Officers are familiar with their operation. Anything new is going to cause a concern about losing a capability from the old model. Officers do not want to lose any capability that they now have with their firearms. The smart gun, compared to existing firearms, should not operate dramatically differently, should have the same performance, and should not detract from the officers effectiveness.

As mentioned in the discussions of other concerns, the smart gun technologies must be as reliable as present firearms. Sacrifices cannot be made in the use of the weapon in imperfect circumstances. The smart gun must be as fast and accurate as current weapons.

Requirement: The smart gun, compared to existing firearms, should not cause a loss of capabilities.

Safety

While many officers view a smart gun technology as another firearm safety it is better considered as a security feature. A safety is a device designed to prevent accidents from occurring. A security device prevents unauthorized use. A smart gun technology may add both safety and security to a firearm. Whatever it is called, firearm safety is on the mind of officers since they must carry their firearm with them each day. Every situation that an officer is involved in has a firearm present: their own. Safety concerns in the survey can be broken into two major categories. The first category includes the basic rules of firearm safety and how they

relate to a smart gun technology. The second category includes the physical safety mechanisms in place within firearms today.

The basic rules of gun safety are²⁷:

1. All firearms are loaded. This is a state of mind that should be used when handling firearms. A person should never allow themselves to be comfortable with the theoretically unloaded firearm.
2. Never permit your muzzle to cover anything which you are unwilling to destroy. This rule is often violated among new firearm users and contributes most to tragic unintentional discharges. New firearm owners are sometimes taught to imagine that a powerful laser is aimed out the barrel that can never be turned off, such that anything it crosses is destroyed.
3. Keep your finger outside the trigger guard and on the receiver until beginning the shot. This is the second contributor to

tragic accidental discharges. Unless an immediate discharge of the weapon is acceptable, the fingers should not be on the trigger.

4. Be sure of your target and its background. The target must be identified as appropriate to hit. Officers have been killed by other officers firing at muzzle flashes.

All of these rules should involve subconscious programming. The addition of smart technologies should not affect these or other gun safety rules.

The second category of safety is the internal safety mechanisms built into today's firearms. Even firearms that do not have a visible external safety device have internal protections. NIJ has standards that establish the minimum performance standards for "combat ready" police revolvers³⁰ and autoloading pistols.³¹ The Sporting Arms and Ammunition Manufacturer's Institute, Inc. (SAAMI, pronounced "sammy") also maintains voluntary

Figure 21. Survey responses to: A smart gun technology should replace existing firearm safety mechanisms.

standards.³² Among other topics, these standards include items dealing with safety. See the section on law enforcement standards for more details.

As seen in Figure 21, officers disagree with the statement 'the smart gun's identification feature should replace my gun's existing safety mechanisms'. Officers agreed that the addition of smart gun technologies should not interfere with, unduly complicate, or replace the existing safety mechanisms. The manufacturer's safety functions should exist with the additional enhancements of the smart gun technologies.

A separate concern is that the smart gun technology can not in any way operate as a second trigger. There should be only one manner in which the firearm can be fired, that is by pulling the trigger. There should be no way that the addition of smart technologies can cause an unintentional discharge of the weapon, i.e., the sequence: cock, press disable button, press enable button, and the gun fires. One method to help protect against this is not

to pre-store energy or information needed to activate the firearms locking mechanism.

Requirement: The addition of smart technologies should not affect existing gun safety rules.

Requirement: Smart gun technologies must meet the existing law enforcement standards.

Requirement: The addition of smart technologies cannot act as a second trigger.

Acceptance By Officers

One of the hardest requirements may be to gain the acceptance of law enforcement officers. The majority of officers are interested in how smart gun technologies would work, and would like to try one. Figure 22, shows the response to 'I think it would be valuable to have a gun that only fires for an authorized person, such as law officer'. When asked, 'If a smart gun was available I would be interested in trying one',

Figure 22. Survey responses to: Smart gun technologies have value.

even more officers responded favorably. There is a difference in curiosity and acceptance. Prior user recognition technologies using magnetic rings have not been accepted by law enforcement. One soft body armor manufacturer voluntarily included thousands of brochures about the magnetic ring guns with their own material, but the concept still did not catch on.

Many officers have the "it can't happen to me" attitude; many of those same officers have never seen the statistics on the number of officers killed with their own firearms. Educating officers about the need is one step in gaining this acceptance. Police departments recognize that a problem does exist or they would not offer gun retention training. Industry knows that a problem exists or security holsters would not be marketable.

One pitfall of smart gun technologies are those who declare that a smart gun is the total solution before it is proven and accepted. Officers are concerned that smart guns may be less reliable than standard firearms and would thus create more of a hazard to the officer than they would potentially counter. The smart gun technology must operate in a predictable manner. A proper test program, demonstration program, and field trials will be necessary to gain the confidence of the end user.

Requirement: The smart gun technology must operate in a predictable manner.

False Security

As new inventions add conveniences to products, people start to rely on those conveniences. When the new invention adds security, opposed to convenience, the danger lies in people putting full reliance on the technology and not paying attention to other signals of danger.

This is the concern of many officers when it comes to smart gun technologies. Police

trainers are concerned that officers are already depending more on technology and less on training. This can cause over-reliance of the weapon's safety mechanisms rather than retention skills in takeaway situations. Officers need to be trained so as not to have a false sense of security, or become complacent. Trainers are having a difficult time convincing officers that gizmos are not a substitute for safe practices. It is possible that departments may also fall into the same trap and de-emphasize traditional firearms training.

Requirement: The limitations of smart gun technologies must be made known so the technology is not declared the end all solution to the problem of weapon takeaways.

Retrofit

The ideal situation for firearm owners is that they could have a smart gun technology installed in their existing firearm. Replying to the survey question, 'I would want to be able to install the smart gun device in my existing gun' the majority of respondents agreed, as shown in Figure 23. Since many officers have to pay for their service weapon themselves this would save out of pocket expenses. This may also make the multitude of existing firearms able to be made more secure.

There are concerns about retrofitting existing firearms with smart technologies. The main concern is whether the technologies could be added to existing firearms. Is there enough volume within the firearm, would it affect normal operation, could it adapt to all the different models? If a firearm was retrofitted, what happens to a manufacturer's warrantee, who is liable for the changes that were made, how much would it cost, and who would do the installation? Could the firearm manufacturers be forced to retrofit existing firearms? These are all questions that do not currently have complete answers.

Retrofitting all existing firearms is a very complicated, if not impossible job. Even within one manufacturer, the various models are different to a point where one device may not fit them all. If modifications to older weapons are made, it is difficult to know what effect it would have on the normal operation of the firearm since it was not initially designed to operate in the same fashion. For these reasons the implementation of a smart gun technology may best be introduced into a new generation of firearms.

Requirement: The ideal smart gun technology could be installed in existing firearms without reducing the existing firearms capabilities.

Control and Infrastructure

With the addition of smart guns, the addition of other equipment may be necessary. This equipment would be used to manage the information stored within the firearm (if applicable for that technology). If multiple users are allowed to use a firearm then there must be some way to program that firearm: to verify who is authorized, as well as add and delete users. The enrollment process should be relatively quick and easy. This type of re-coding equipment could be available for use at police departments, practice ranges, and even firearm dealers.

The system can be imagined as a very basic computer that has a database with valid user names and identification numbers. The database system should be able to tell which officers are authorized to which firearms. Protocols must be established for a common interface and communication scheme between

Figure 23. Survey responses to: A smart gun technology should be retrofitable.

this ancillary equipment and all brands of firearms. This will eliminate the possibility that each manufacturer develops a separate piece of equipment that only works with their firearms so that departments would have to purchase multiple systems.

Departments would have to establish standard operating procedures on how identification codes would be secured and managed. It would have to include who would be authorized to use a particular officer's firearm, i.e., everyone in the department, only his partner, or even a spouse. The procedure would include the security of the identification numbers so that criminals could not obtain the information and more easily duplicate identification devices. Also included would be steps for reprogramming the appropriate firearms if an authorized officer loses an identifying device, and how often identifying numbers are changed (if ever).

Any further discussion of ancillary equipment is out of the scope of this report.

Requirement: Ancillary equipment needed must be identified.

Requirement: Recommendation of special procedures must be listed.

Ability To Make The Concept Work

A few officers responding to the survey had doubts about the ability to find technologies that could make a smart gun meet needed requirements. This is a valid concern, and that is part of the purpose of this project and this report. In interviewing officers, many of those who had doubts were relieved when the goals of the project, the systematic approach being taken, and some of the technologies that could be applied were explained to them.

The majority of the comments received in this area were attached with questions about how a smart gun would identify the user, and how it would be made reliable.

Other Concerns

Works Under Stress

A situation where the use of lethal force may be necessary, whether during a weapon takeaway or not, is a stressful situation for an officer. If the firearm becomes too complex, or requires the officer to do something complicated, the less likely an officer will use it effectively under stressful conditions. They may forget how to work the device or there may be too much confusion during the "heat of the moment" if officers are looking for a button mechanism instead of reacting to the situation.

In a very high stress situation such as a takeaway attempt, all but the most well trained officers will tend to change from training techniques toward survival. Their physical responses will follow this trend. The officer may only be able to use gross body movements. Expecting officers under stress to do something using fine motor skills is unacceptable. In these situations officers may forget steps of operations, their voice may change, the will to survive may take over.

Requirement: A smart gun technology must operate within the capabilities of an officer in a highly stressful situation.

Meet Law Enforcement Standards

As this report has tried to make clear, law enforcement officers have a unique set of requirements for their firearms. Some officers are concerned that smart gun technologies would not meet these standards. To be acceptable, any technology that is introduced must meet current standards: acceptable reliability, performance, range of ammunition calibers, models, and meeting individual agency criteria. Some of these concerns stem from the original Magna-Trigger device that could only retrofit to one model of firearm.

There are existing standards for firearms. NIJ has standards that establish the minimum

performance standards for “combat ready” police revolvers³⁰ and autoloading pistols.³¹ The Sporting Arms and Ammunition Manufacturer’s Institute, Inc. (SAAMI) also maintains voluntary standards.³²

In these standards, items such as User Information, Visual Inspection, Dimensional Requirements, Functional Requirements, Firing Requirement, Drop Safety Requirement, Drop Function Requirements, Hammer Safety Requirement, Drop Test, Exposed Hammer Test, Jar-off Test, and Criticality of Requirement are included as applicable to either revolvers or autoloading pistols. Detailed information can be found in the standards themselves. Summary information can be found in Appendix A.

Requirement: Smart gun technologies must meet existing applicable firearm standards.

Gun Control

A small number of officers fear smart gun technologies may be used to promote gun control policies. While this is out of the scope of this report it is worthwhile to separate the issues of who should be able to own a firearm, and who should be able to fire a firearm. A smart gun should simply limit who can operate the weapon, not own it. One former police internal affairs officer said that this type of device may assist in the investigations of police involved shootings by limiting investigations to authorized individuals.

Unconscious or Incapacitated Officer

Some officers are concerned about the scenario where during a takeaway the officer is unconscious or incapacitated. Although this does occur, it is a small part of the officer deaths due to takeaways. Some officers would like to have the smart technologies operate even if the officer was incapable of doing anything. Therefore, there would be no ability

to push a button, enter a code, or say a code word to deactivate the system. The system would have to be passive, in that when it is not in the officers hand it will not fire.

Requirement: The ideal smart gun technology operates without action by the officer.

Override

A few officers have suggested that they would like to see a manual override of the smart technology. Their real concern is the reliability of the device, and that if it fails they will be without their firearm. An override is possible, and it would let anyone use the device without the smart technologies operating. This override, depending on its implementation, could contradict the feature of not allowing a criminal to easily override the system. Whatever the override system, it cannot be kept a secret. Criminals would have a wide open “backdoor” to defeat the system. If the requirements for reliability of the smart gun technologies can be met, there is not a need for an override. If the smart gun fails enabled, then there is not a need for an override. If a system can be implemented which can only be overridden by the authorized user there is not a problem with an override, but this would have the same concerns as the technology itself.

Off Hand

The cases where an officer must fire with their off hand are statistically very few. Many officers do not even know of a time when someone has had to fire with their off hand, outside of police academy training. Figure 24, in asking ‘a smart gun has to work with my off-hand’ shows the majority of the officers still refer to the need to be able to shoot with either hand, just in case.

There are documented cases where officers have had to fire with their off hand. Injuries

often happen to an officer's shooting hand since it is their strong hand that is likely to be used to physically defend themselves. Officers will hold a baton or flashlight in their weak hand so that their strong hand is ready to draw their weapon if needed. Officers have already stated their concern about losing capabilities in changing to a smart gun, shooting with either hand is one of those capabilities. It is also not improbable to be shot in the hand or arm. Trainers observe this trait in practice with video and picture systems when the officer is confronted by an adversary holding a gun. When a person's attention is placed on the other's firearm, shots will sometimes center around the gun instead of center of mass.

Requirement: A smart gun technology must be capable of ambidextrous one-handed operation.

Off Duty

Some police departments require that officers carry a firearm while off-duty. Officers are

concerned about how they can use their firearm in an emergency or unexpected situation off duty. Many will carry a separate, smaller firearm off duty. Officers asked if a smart gun system would be too cumbersome to be practical for off duty use. They also wondered about wearing an identifying device all the time. This could let felons know that they are an off duty officer while there is no way to identify the felons. Most officers were not concerned with being recognized as an off duty officer.

Requirement: Smart gun technologies should be capable of being used by an off duty officer.

Proven Thorough Testing

Before a smart gun technology is fielded it must be thoroughly tested. Many officers already have a bad feeling because of the previous magnetic ring guns. It would only take one mishap to lose officers trust in the

Figure 24. Survey responses to: A smart gun technology must operate with either hand.

system. All malfunctions must be eliminated before field testing. A systematic test program must be used to cover all aspects of the design before actual use. Long term performance issues must be understood.

Along with the normal testing that a firearm manufacturer does both in development and during production, additional testing of the smart technologies must be performed. It will be necessary for a standard to be produced to adequately inform consumers about possible sub-standard products.

Requirement: A systematic test program must be performed before actual field testing a smart gun technology which at a minimum includes studies of long term performance issues, and design failure modes and effects analysis.

Passive Technologies

Officers prefer a passive device that would become disabled without the officer having to initiate any actions. For incidents when the officer is unconscious or incapacitated this may be the only manner of successful operation. This also may help the officer who is in a struggle for their firearm, so that they do not have to actively disable the device. The question may be, for some types of technologies, how to define the definition of out of the officer's hand. Proximity sensors operate over a range of distances. If the suspect's hand is on the officer's firearm, and the officer's hand is on the suspect's hand, some proximity devices may still operate. This concern also infers that the firearm becomes enabled as soon as the weapon enters the officer's hand.

Requirement: The smart gun technology should become enabled or disabled without action by the officer.

Requirement: The smart gun technology should only be operational while in the officer's hand.

Gloves

The question of whether a firearm needs to operate while the officer is wearing gloves continues to be an issue. While Figure 25, shows the officers agree to the statement 'A smart gun has to work if I am wearing gloves' few concerns were along these lines. Firearm instructors say that officers are trained not to shoot while wearing gloves. With a glove the same sensation is not felt by the trigger finger and it is possible that unintentional firings may occur. Officers in the northern states insist that the firearm must operate while wearing gloves. They agree that they would rather not have their gloves on if they have to fire their weapon, but if they have to be outside on a winter night without gloves their hands may be so numb that they could not use the weapon anyway.

A number of other types of officers also wear gloves on duty. Bicycle, motorcycle, and mounted police often wear gloves as part of their uniform for safety reasons. Also more and more officers are carrying some type of glove to be worn while frisking a suspect during an arrest. The common types of gloves that are worn by officers include thin leather gloves, latex gloves, or the newer kevlar gloves.

Requirement: The smart gun technology must operate while wearing gloves typically worn by officers.

Liability

Legal concerns are everywhere. Law enforcement is not excluded from law suits of every type. Departments and officers are brought into court for reasons from using excessive force, to improper training and use of equipment. There are probably more unanswered questions in this area than any other at the current time. This is partly because until cases are tried there is not a precedent to

Figure 25. Survey responses to: A smart gun technology must operate while the officer wears gloves.

understand how varying incidents may be received in the courts.

For smart gun technologies, some of the liability concerns include weapons warranty & liabilities if the device failed to operate, or issues involving the use of deadly force if an officer loses a smart gun. More possibilities exist in conjunction with retrofitting a firearm.

The question exists of whether an officer's smart gun in the hands of an assailant should be considered a deadly threat. One scenario could be that an officer loses his smart gun to a suspect who is now threatening the officer with it. A backup officer arrives and sees the suspect with a firearm aimed at the officer. The backup officer shoots and kills the suspect who, because of having the officers smart gun, may be interpreted as being unarmed. The appropriate legal bodies must clarify the liability aspects of smart gun technologies to the law enforcement community. These issues are considered outside the scope of this requirements document.

Indicator

An indicator can be any type of status monitor. For a smart gun application it could be a light or buzzer that tells that the firearm recognized the user, or that the battery is getting low. While most officers say that indicators are necessary, others say that status monitoring is a training and maintenance problem and no indicators should be used. The latter indicates that the user must trust their firearm without relying on an indicator as a crutch.

Because smart gun technologies are a new concept and not yet accepted, most officers want indicators that they can use to build confidence in the device. Figure 26, shows the sum of the responses from the two questions 'An indicator is needed to show that the smart gun can identify me as an authorized user', and 'An indicator is needed to show if the gun is safe or enabled'. The fear that the device will not function reliably is too great not to have an indicator. Officers today frequently check to

Figure 26. Survey responses to: Is an indicator necessary?

make sure that their magazines are engaged and that they have not inadvertently pressed the release button making their firearm inoperable. A simple test is needed that can be performed by the officer whenever desired to confirm the device is functioning properly without firing the weapon. This may be a feature whose importance will diminish as time passes and officers gain trust in the reliability of the firearm.

Two types of monitors are normally mentioned. One indicates whether a user has been accepted as an authorized individual. The other is a low battery monitor to warn when batteries are about to fail. Officers would like to check their weapon when they first arrive on duty and then maybe on the way to a 'hot' call. Otherwise the firearm only needs to warn them if something is wrong. Officers say the indicators cannot be distracting. Fighter pilots are known to turn off distracting alarms in stressful situations. Officers have different suggestions on what is good and bad. Some suggest a light as part of the sights, others want to be able to see the indicator while the firearm is holstered.

Buzzers and other noise making indicators are generally not liked. If they could be heard when needed by an officer in a noisy situation, then they could also be heard by a perpetrator when the officer was trying to be quiet. Some liked the idea of something they could feel, whether a knob that sticks out or an internal thump or click, they would not have to look at the weapon to tell the status. A press to check indicator may allow independent monitoring without constant current drain to the batteries. The power indicator must be noticeable enough that it will not be overlooked, and be at a time that the firearm will still operate for some period, as mentioned in other sections of the report.

The following are some possible drawbacks of indicators that should be avoided. One is causing the officer to look at the weapon instead of the situation at hand. Another is if the indicator would somehow delay the firing of the weapon. If the indicator fails to indicate the proper status is another problem. One final concern if an indicator is present may be the scenario where a suspect has obtained a smart

gun. They could continue to try various tricks to make the smart gun technology operate and they would know if they had succeeded. This should not be a concern for a properly designed smart gun.

Requirement: A simple test to confirm that the smart gun technology is functioning properly must be available.

Requirement: An indicator cannot be distracting to the officer.

Chapter 5

Summary and Conclusions

The National Institute of Justice is concerned about the number of officers killed each year by suspects using a law enforcement officer's service weapon. NIJ has funded Sandia National Laboratories to objectively review this concern. The Smart Gun Technology project will evaluate the feasibility of eliminating the capability of an unauthorized user from firing a law enforcement officer's firearm by implementing user-recognizing-and-authorizing surety technologies. These smart gun technologies would increase the security of a firearm by limiting its use to authorized users.

An extensive process was used to gather information on the officers' attitudes about smart gun technologies. This process included visits to police departments and law enforcement conferences, literature reviews, personal and phone interviews, and a survey. The survey was used to give some quantitative measure to the information. The information was collected from officers having wide ranging experience in various types of law enforcement agencies. The analysis of the information started when over 300 law enforcement personnel, that were geographically distributed around the United States and internationally, had responded to the survey. More have since responded and the results are planned to be updated in a future report.

Information was presented in this report to validate the concern of firearm takeaways. Data extracted from FBI reports for the years 1979 to 1992 were analyzed. Although the number of deaths due to weapon takeaways has

recently been on a decline, there is evidence that suggests the number of attempted takeaways may be on the increase. The reason the number of deaths has decreased is not known. Possibilities include an increased awareness of the problem, more training in weapon retention, the introduction and use of security retention holsters, and the increased use of body armor in law enforcement.

It was found that typical takeaway incident in which an officer is killed occurs along a roadway or in a home when the officer is alone with an adversary. There is usually a struggle involved between the adversary and the officer that results in the suspect gaining control of the firearm. The officer is typically older than the suspect. While some data reveals that the officers have relatively little experience, other data shows that officers are prone to takeaway attempts during their mid-years of service. The South region of the United States has over half of the takeaways resulting in death, which may have explained why more survey responses were received from the South.

This report states the requirements for a smart gun technology from the officer's viewpoint. This qualitative set of requirements form an idealistic standard for smart gun technologies. A summarized list of requirements can be found in Appendix C, while a descriptive account of each requirement can be found in the body of the document.

Officers overwhelmingly like the concept of a smart gun technology, a technology that would limit the firing of the firearm to an authorized user. With the addition of the smart technology

they want their firearm to operate predictably: the firearm must remain reliable in all the environments and circumstances that an officer may encounter. To achieve the acceptance of the law enforcement community the addition of a smart gun technology must not noticeably degrade any of the capabilities that exist in firearms today. It should be able to be used by fellow officers, and it should be able to be fired by either hand. The characteristic properties of size, weight, and shape should not noticeably change. It should remain easy to operate and maintain. Officers like the idea of the smart gun technology being able fail and still allowing the firearm to fire, even though anyone could fire it.

While all of the "wants" listed by the officers may not ultimately be met, their needs must be met. Listing requirements in this fashion allows individual technologists the latitude to develop products that meet the needs of officers, as well as stimulate economic

competitiveness in the marketplace with additional features. The number of features that could be added is nearly limitless. Features may include information such as the total number of rounds fired, the number of rounds since last maintenance, and the last time a round was fired. The introduction of smart technologies could be the inception of a new generation of electronic firearms.

Although a difficult set of requirements have resulted from the wide ranging opinions of officers, this gives a basis for the next objective of the project. With the assistance of existing quality techniques, the officer's qualitative requirements can be transformed into a set of quantitative engineering requirements. In this way the individual technologies can be analyzed, and prioritized for future evaluation.

Appendix A

Operational Environments

This appendix describes the requirements listed in the existing firearm standards, and from other sources such as firearm manufacturers. The requirements are not separated from the text, but should be obvious to the reader. Due to the severe conditions that could be encountered, both by law enforcement personnel and the handguns that they possess, any smart gun technology must be rugged. **The technology may not meet the requirements individually, but must be able to meet them when incorporated into a smart gun system.**

There are many standards available for firearms. The National Institute of Justice has standards^{28,29} which establish performance requirements and test methods for firearms to be used by law enforcement officers. The Sporting Arms and Ammunition Manufacturers' Institute, Inc. also has voluntary industry performance standards³² to provide the firearm designer and manufacturer with recommendations for methods to simulate certain conditions where the firearm is subjected to abusive mishandling. Individual companies typically develop their own internal quality procedures to meet and exceed these standards³³. When government organizations need to develop a firearm they will develop their own specifications for its design and testing²². All of these specifications are different and the following requirements were selected based on these current standards. Since the following is an aggregate set of these requirements, references will not be individually listed.

Rough Handling and Dropping Shock

Police service weapons are occasionally dropped or handled roughly. At these times it is critical that the firearm does not discharge. Generally weapons fall as they are drawn from the holster or returned to the holster. Usually a weapon will be ready to be fired when it is dropped, and generally it is dropped on hard surfaces such as roads, walkways, and inside buildings. The smart gun technology must also survive these drops. The minimum drop test requirement for the smart gun technology is for the firearm to remain fully functional after a shock pulse type, duration, and magnitude such that the conditions emulate those that would be encountered if a fully loaded firearm were dropped on a 0.5 inch thick steel plate backed by concrete from a height of 4.0 feet. The drop test shock shall occur on each of seven axes, which are defined in Figure A-1, and each shock shall be repeated at hot (160 °F), ambient (70 °F), and cold (-60 °F) temperatures.

Firing Shock

A separate shock environment is associated with the firing of live ammunition from the firearm. The smart gun technology shall be fully functional after the smart gun has been subjected to the operating shock environment. The operating shock axes are defined below in Figure A-2. On each axis the firearm shall be exposed to an acceleration signal with a frequency and amplitude content consistent with the firing of live ammunition. The number of test cycles shall be consistent with the service life of the firearm, however, the number of test cycles need not necessarily be equivalent.

Accelerations on the order of 950 g can be expected during the firing of live ammunition in test set-ups using fixtured firearms³⁴.

Figure A-1. Dropping Shock Axes

Figure A-2. Operating Shock Axis

Service Life

The number of live rounds that a firearm must survive varies with the way it will be used. The service life for a military firearm may reach 30,000 rounds. The NIJ only specifies a total of 600 rounds in their testing because they are looking for mechanical failures of the firearm that they have determined usually occur in the first 200 rounds of use. Manufacturers will test a firearm to 5000 rounds during development, while the useful life is expected to be between 10,000 and 15,000 rounds. The smart gun technology must have a service life that meets or exceeds the 10,000 live round capability of the firearm itself. For dry cycle testing the smart gun technology shall be able to authorize the firing mechanism greater or equal to 100,000 times.

Temperature

The firearm that the officer in hot and humid Florida carries is the same type of firearm that the officer in Alaska uses. Temperatures vary greatly around North America. The highest temperature recorded in North America, 134 °F, was in Death Valley, California the lowest temperature, recorded in Canada, was -81 °F.³⁵ While these are the extremes, it shows the wide range of operating temperatures that can exist in North America. Typical military electronic requirements list -55 °F to 165 °F, and electronics certified to operate during these levels are available. We see by comparison to the record temperatures that the military temperature requirements are not unrealistic. It is also possible the firearm will self heat given that enough rounds are fired. The smart gun technologies shall be fully functional when the temperature throughout the smart gun system is between -60 °F and 160 °F.

Noise Environments

Officers will often work in noisy environments. Some of the noise environments that must be dealt with include rock concerts, barrooms, and gun fights. Two examples of noise environment levels are heavy trucks which produce 90 dB at 50 feet, and freight trains that produce 75 dB at 50 feet.³⁶ The smart gun technology must operate during intermittent and constant noise environments up to and including a person's threshold of pain (approximately 130 dB).

Chemical Compatibility

The following is a list of substances taken from a specialized military handgun specification. It is included only as a reference list of substances that could come into contact with a firearm.

1. Water
2. Lubricant, cleaner and preservative for weapons and weapon systems, MIL-L-63460D (CLP)
3. Lubricant, semi-fluid (automatic weapons), MIL-L-46000C (LSA)
4. Lubricating oil, weapons, low temperature, MIL-L-14107C (LAW)
5. Lubricating oil, general purpose, preservative (water displacing, low temperature), VV-L-800C (PL-S)
6. Aerosol lubricant
7. Cleaning compound, solvent (for bore of small arms and automatic aircraft weapons), MIL-C-372C (RBC)
8. Dry-cleaning and degreasing solvents, P-D-680A, type 1
9. Insect repellent, NSN 6840-00-558-0918
10. Carbon-removing compound, P-C-111D, type 11
11. Trichlorethane solvent

12. Hydraulic fluid
13. Antifreeze (ethylene glycol)
14. Salt water (20% NaCl)
15. Gasoline
16. Kerosene
17. Diesel fuel
18. Jet fuel, JP-4
19. Decontaminating agent, STB, MIL-D-12468C (MU)
20. Decontaminating agent, DS2, MIL-D-50030H

Miscellaneous Environments

The following is a list of other environments taken from a specialized military handgun specification. It is included only as a reference list of environments that a firearm may experience.

Waterproof Capabilities

Capable of functioning after a two hour submersion of the smart gun in sea water at a pressure of 2 atmospheres (depth of 66 feet).

Salt Fog

Fully functional after the smart gun has been placed in a salt fog environment for 10 days. The salt fog solution shall be prepared in accordance with MIL-STD-810E (method 509.1).

Sand and Dust

Capable of operation during exposure of the smart gun to a sand and dust environment. Fully functional after the smart gun has been subjected to 96 hours of continuous exposure to a sand and dust environment.

Mud

Fully functional after the smart gun has been subjected to 96 hours of continuous exposure to a mud environment with only hand cleaning and wiping of the smart gun.

Surf Environment

Fully functional after the smart gun has been subjected to 96 hours of continuous exposure to a surf environment. The test chamber shall emulate conditions encountered in a surf environment: salt water and a sand and dust mixture.

Icing

Fully functional after the smart gun has been subjected to an icing environment until 1/8 to 1/4 inches of ice has accumulated on its exterior, and after removal of the ice using only tools normally available in the field.

Solar Radiation

Fully functional after the smart gun has been exposed to solar radiation for a period of ten 24 hour cycles.

Appendix B

Smart Gun Technologies Questionnaire

Smart Gun Technologies Questionnaire For Law Enforcement Officers

The National Institute of Justice (NIJ) is concerned by the FBI Uniform Crime Report study citing that 14% of the officers killed between 1981 and 1990 were killed with their own weapon. That means 1 out of every 7 officers who are killed in the line of duty are killed with their own weapon. In its effort to help law enforcement officers, the NIJ has asked Sandia National Laboratories to research the requirements for a Smart Gun. The most important requirements come from the law enforcement officers, and other people who would use a Smart Gun.

Please help us determine the correct requirements and features a Smart Gun would contain. We request that you assist us by completing this 10 minute questionnaire and return it in the post paid envelope attached. As appropriate, please fill in the blank, or circle the response that indicates the extent that you agree or disagree with the statements. Please provide any other information or comments you feel would be useful to us in this pursuit. While it is not required that you answer all of the questions, we appreciate and value your responses.

What is a Smart Gun? A Smart Gun is a firearm that uses a technology to determine if the person shooting has authorization to use the firearm. In this way the firing of a gun can be limited to the authorized person, such as a law officer. This could eliminate the possibility that an officer's gun is used against him or her. There are many ways that this can be accomplished. To find out what you want in a Smart Gun, we need your input.

		Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
SMART GUN FEATURES						
1.	A Smart Gun should look just like existing guns.	1	2	3	4	5
2.	An indicator is needed to show that the Smart Gun can identify me as an authorized user.	1	2	3	4	5
3.	An indicator is needed to show if the gun is safe or enabled.	1	2	3	4	5
4.	I would want to be able to install the Smart Gun device in my existing gun.	1	2	3	4	5
5.	A Smart Gun has to work if I am wearing gloves.	1	2	3	4	5
6.	A Smart Gun has to work with my off-hand.	1	2	3	4	5
7.	My partner, or other authorized people, have to be able to use my gun.	1	2	3	4	5
8.	I would be willing to wear something such as a ring, or wristband, that my gun would recognize.	1	2	3	4	5
9.	I would be willing to do something (like press a button on my uniform) to disable my gun if it was taken from me.	1	2	3	4	5
10.	It is OK to have batteries in my gun.	1	2	3	4	5
11.	The Smart Gun's identification feature should replace my gun's existing safety mechanisms.	1	2	3	4	5

MISCELLANEOUS QUESTIONS

12.	I think it would be valuable to have a gun that only fires for an authorized person, such as a law officer.	1	2	3	4	5
13.	If a Smart Gun was available I would be interested in trying one.	1	2	3	4	5
14.	My two main concerns about a Smart Gun are:					
	1. _____					
	2. _____					

15. What are two ways a Smart gun could cause you problems?

1. _____
2. _____

FAMILIARITY WITH THE CONCEPT

16. Have you previously heard of a gun that limits it's use to authorized people?

- ☐ Yes
☐ No (If No, go to number 18)

17. What have you heard or seen?

- ☐ Magnetic ring
☐ Remote control
☐ Capacitive sensors
☐ Fingerprint
☐ Voice Activated
☐ Other: _____

USE SITUATIONS

18. Has a suspect ever taken, or attempted to take, your gun?

- ☐ Yes
☐ No (If No, go to number 20)

19. My response to someone taking my gun was based mostly on:
(Circle the appropriate number)

Survival		Training		
1	2	3	4	5

DEMOGRAPHIC INFORMATION (OPTIONAL)

20. City: _____

21. State: _____

22. Your position/title/rank/job function: _____

23. Service weapon: _____
(Brand-Model-Caliber)

24. Number of years in Law Enforcement work: _____

25. Name: _____

26. Department: _____

27. Daytime phone: _____

FOLLOW-UP QUESTIONS

28. I am interested in being further involved in this project in the following way(s):

(If you are interested please complete your name and phone number above.)

- ☐ Face to face interview
☐ Telephone interview
☐ Test and evaluation
☐ Other: _____

29. Additional comments may be written below if desired.

RETURN TO: Douglas R. Weiss, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87185-0537, Phone: (505) 845-9134, Fax: (505) 844-2925, Email: drweiss@sandia.gov.

Appendix C

Summary of Preliminary Requirements for a Smart Gun Technology

The following are the identical requirements as found in the text. They are rearranged in this appendix in a topical order. The section of the report that describes the requirement is listed in parenthesis.

1. PHYSICAL CHARACTERISTICS

1.1 FEEL

- 1.1.1 The addition of smart gun technologies cannot appreciably change the weight, size, or balance of existing firearms. (Characteristics)
- 1.1.2 The smart gun technology should not affect the carrying of firearms in existing holsters. (Characteristics)
- 1.1.3 The smart gun technology must not affect the existing trigger pull standards. (Characteristics)
- 1.1.4 Addition of batteries should not greatly change the characteristics of the firearm, i.e., size, weight... (Power Failure)

1.2 APPEARANCE

- 1.2.1 The smart gun must have the general appearance of an existing firearm. (Characteristics)
- 1.2.2 The addition of smart gun technologies cannot add appendages which would appreciably increase snagging compared to an existing firearm. (Characteristics)
- 1.2.3 Any external device should have optional methods for attachment to the person, i.e., multiple fingers; fingers or wrists; implantable... (External Devices)
- 1.2.4 Ideally external devices can be attached to existing items, i.e., rings, watches, badges... (External Devices)

1.3 MISCELLANEOUS CHARACTERISTICS

- 1.3.1 The addition of a smart gun technology to a firearm should be operationally transparent to the user. (Simplicity)
- 1.3.2 The smart gun technology must be applicable to multiple types and brands of firearms. (Multi-Users)

- 1.3.3 The technology should also be applicable for use on multi-user weapons. i.e., shotguns. (Multi-Users)
- 1.3.4 Ideally no external devices are needed to operate the smart gun technology. (External Devices)
- 1.3.5 Any external devices must be consistent with other smart gun technology requirements, i.e., reliability, durability, easy to maintain, small, accessible, simple... (External Devices)

2.0 PERFORMANCE

2.1 FUNCTION

- 2.1.1 A single individual must be able to activate a smart gun technology without assistance from others. (Environment and Circumstances)
- 2.1.2 The ideal smart gun technology operates without action by the officer. (Unconscious or Incapacitated Officer)
- 2.1.3 The smart gun technology should become enabled or disabled without action by the officer. (Passive Technologies)
- 2.1.4 A smart gun technology must operate within the capabilities of an officer in a highly stressful situation. (Works Under Stress)
- 2.1.5 A smart gun technology must be capable of ambidextrous one-handed operation. (Off Hand)
- 2.1.6 The smart gun technology must operate while wearing gloves typically worn by officers. (Gloves)
- 2.1.7 The addition of smart gun technologies must not increase the time of drawing and firing when the decision for using lethal force has been made by any authorized user. (Speed of Operation)
- 2.1.8 A smart gun technology for law enforcement officers should fail armed, such that the failure of the technology does not inhibit firing of the weapon. (Fail Armed)
- 2.1.9 The addition of a smart gun technology must not complicate the use of the firearm. (Simplicity)
- 2.1.10 Smart gun technologies using external devices must not be alignment critical. (External Devices)
- 2.1.11 Proper documentation for operational use must be supplied. (Maintenance)
- 2.1.12 The smart gun technology should only be operational while in the officer's hand. (Passive Technologies)
- 2.1.13 The operational range of any external device must be consistent with other requirements. (External Devices)
- 2.1.14 Smart gun technologies should be capable of being used by an off duty officer. (Off Duty)

2.2 RECOGNITION

- 2.2.1 The smart gun technology must properly recognize, and limit the use of the firearm, to the authorized user. (Proper Recognition)
- 2.2.2 The smart gun technology should be capable of being used by multiple users. (Multi-Users)

- 2.2.3 The technology must operate for a single individual on multiple firearms. (Multi-Users)
- 2.2.4 The smart gun technology must operate on the first verification attempt. (Proper Recognition)
- 2.2.5 For applicable recognition technologies the actual recognition score, rather than a simple go/no-go indication, should be available in a testing configuration. (Proper Recognition)
- 2.2.6 For applicable recognition technologies, a method of adjusting the recognition threshold by a qualified person is recommended. (Proper Recognition)
- 2.3 POWER REQUIREMENTS**
- 2.3.1 Ideally the smart gun technology would not require the use of batteries. (Power Failure)
- 2.3.2 A low power indicator must be supplied if batteries are used in a smart gun system. (Power Failure)
- 2.3.3 If batteries are used, they must be easily obtained, and factored into the cost of maintaining the equipment. (Power Failure)
- 2.3.4 Ideally a battery used in a smart gun system would last longer than 1 year. (Power Failure)
- 2.3.5 The minimum lifetime of a battery used in a smart gun system would allow an officer to fire 3 magazines, 10 hours after first indication of a low battery. (Power Failure)
- 2.4 INDICATORS**
- 2.4.1 A simple test to confirm that the smart gun technology is functioning properly must be available. (Indicator)
- 2.4.2 An indicator cannot be distracting to the officer. (Indicator)
- 2.5 READINESS**
- 2.5.1 The addition of a smart gun technology must not significantly reduce the circumstances in which the firearm will operate, compared to existing firearms. (Environment and Circumstances)
- 2.6 SAFETY**
- 2.6.1 The addition of smart technologies should not affect existing gun safety rules. (Safety)
- 2.6.2 Smart gun technologies must meet the existing law enforcement standards. (Safety)
- 2.6.3 The addition of smart technologies cannot act as a second trigger. (Safety)
- 2.6.4 Smart gun technologies and external devices should not cause medical side effects. (External Devices)
- 2.7 RELIABILITY**
- 2.7.1 The smart gun technology must operate in a predictable manner. (Acceptance by Officers)
- 2.7.2 The addition of a smart gun technology must not significantly reduce the reliability of the firearm system compared to existing firearms. (reliability)
- 2.7.3 The addition of a smart gun technology must not effect the primary use of firing the weapon by the authorized user. (Simplicity)
- 2.7.4 Simple procedures must be available to allow an officer in the field to quickly reset the recognition system in case of a technical malfunction.

2.8 SECURITY

- 2.8.1 A smart gun technology must not be easily disabled by an adversary. (Fail Armed)
- 2.8.2 The technology must be such that even with full knowledge of how the system operates it cannot be easily defeated. (Adversarial Compromise of Technology)
- 2.8.3 The technology used in a smart gun must have a unique characteristic that is not easily replicated, or jammed by an outside source. (Adversarial Compromise of Technology)

2.9 COMPATIBILITY

- 2.9.1 The smart gun, compared to existing firearms, should not cause a loss of capabilities. (Loss of Capability)
- 2.9.2 The ideal smart gun technology could be installed in existing firearms without reducing the existing firearms capabilities. (Retrofit)
- 2.9.3 Smart gun technologies must meet existing applicable firearm standards. (Meets Law Enforcement Standards)

2.10 TRAINING

- 2.10.1 Smart gun technologies must cause only minimal additional training, such as transitional training and in service training on proper use. (Training)
- 2.10.2 Smart gun technologies must enhance and not eliminate weapon retention training. (Training)
- 2.10.3 Smart gun technologies training must extend beyond the use of technologies and include training for armorers and others as appropriate. (Training)

2.11 MAINTAINABILITY

- 2.11.1 Maintenance requirements for smart gun technologies must be held to a level that the average officer will do. (Maintenance)
- 2.11.2 There must be a method for armorers and manufacturers to test the smart gun technology. (Multi-Users)
- 2.11.3 Individual smart gun product lines should ultimately have interchangeable parts that are not easily misassembled and can be replaceable without special tools. (Multi-Users)
- 2.11.4 The smart gun must be capable of repeated maintenance without damage or a decrease in performance. (Maintenance)
- 2.11.5 Department's armorer or trained personnel should be able to perform most diagnostic tests and repairs. (Maintenance)
- 2.11.6 The technology should be upgradable when the next incremental version of the technology is introduced. (Maintenance)
- 2.11.7 Batteries should be easily replaceable, even in the field. (Power Failure)

3.0 ENVIRONMENTAL

- 3.0.1 The smart gun technology must operate in all likely environmental conditions. (Environment and Circumstances)
- 3.0.2 The remainder of the Environmental requirements are found in Appendix A.

4.0 EXTERNAL EQUIPEMENT

4.0.1 Ancillary equipment needed must be identified. (Control and Infrastructure)

5.0 MISCELLANEOUS

5.0.1 The additional production cost to incorporate a smart gun technology to a firearm should not add more than approximately \$50 to the purchase price. (Cost)

5.0.2 Any additional costs associated with the use of smart gun technologies should be minimized. (Cost)

5.0.3 The limitations of smart gun technologies must be made known so the technology is not declared the end all solution to the problem of weapon takeaways. (False Security)

5.0.4 Recommendation of special procedures must be listed. (Control and Infrastructure)

5.0.5 A systematic test program must be performed before actual field testing a smart gun technology which at a minimum includes studies of long term performance issues, and design failure modes and effects analysis. (Proven Thorough Testing)

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