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PHASE I FINAL SUBMISSION

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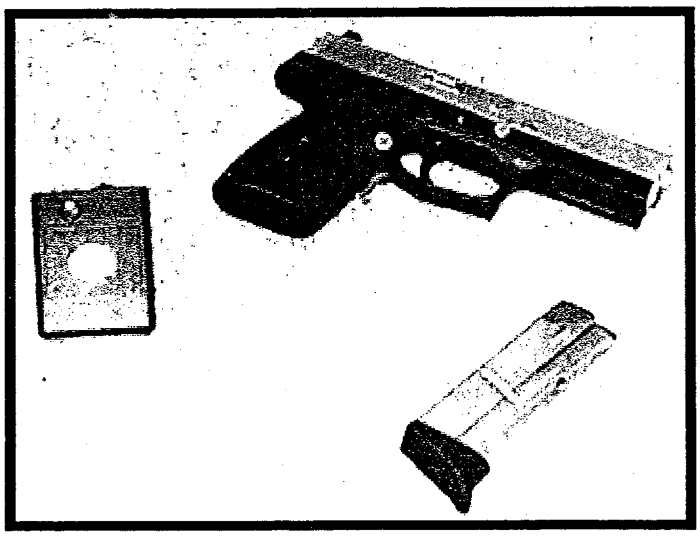

FN MANUFACTURING, INC.

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FN Manufacturing Inc
Columbia SC

Summary of Findings Report

SWS
Secure Weapon System

Smart Gun Technology

Phase 1

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Introduction

The Phase One grant of this project funded FNMI to continue research and development of "smart gun" Technology, which we call the "Secure Weapon System" (SWS), that we began in 1995 to reduce criminal use of firearms and unintended/accidental shootings. This Summary of Findings Report addresses the three deliverables for Phase One, being "Feasibility Analysis", "Functional Requirements", and "Failure Modes & Effects Analysis" (FMEA) reports. We have developed a functional requirement specification and, through feasibility analysis and FMEA, we evolved our "**demonstration unit**" design to an "**engineering model**" that more closely meets the needs of the law enforcement community. The following summary briefly describes the journey through Phase One.

Starting Point

The project began with a demonstration unit built into the FN "Five-seveN" pistol, which was used as a starting point upon which to base the project development. This demonstration unit used Ultrasonics as a means for communicating with a PD (personal device) in the form of a wristband, to determine both proximity and authorization (because the user was wearing the wristband). Batteries were used for powering an electro-magnet, which disconnected the firing control whenever the weapon was not in proper proximity to the PD and/or not in use by an authorized person.

Law Enforcement Input

A significant part of the functional requirement analysis involved the interviewing of law enforcement (LE) personnel. The results of the interviews led us to the following, most notable conclusions. An SWS gun must:

- Not be usable against an officer.
- Look like existing guns.
- Be able to be fired if batteries are dead.
- Be able to be fired when there is an electrical malfunction.

- Work when your partner picks it up, and not work if an unauthorized user picks it up.
- Work left or right-handed.
- Be as reliable and durable as a current duty gun.
- Work if you are wearing heavy clothing or gloves.
- Have a visible low-battery power indicator
- Fire despite wireless communication transmission.
- Work in underground and aboveground structures.
- Pass all environmental tests for current duty guns.
- Fire a chambered round with magazine removed.

Items noted as not important were:

- Ability to function only during a specific time period.
- Ability to function at only a specific location.

Platform Change to Law Enforcement Model

Phase One evolved the design from the FN "Five seveN" 5.7mm pistol to the "Forty-Nine Police Model" pistol with a PD in the form of a pager-type unit rather than a wrist unit. The "Forty-Nine" is issued in two very popular law enforcement calibers, e.g., the 40 S&W and the 9mm.

Key Findings

The FMEA narrowed our engineering model design by identifying areas for improvement in the demonstration system. One of the most evident areas was the need to reduce power consumption and thereby increase battery life. Another noteworthy area concerned issues relating to communication between the gun and the wrist unit. The resulting data from the feasibility analysis, functional requirements, and FMEA of the demonstration system were used to determine the engineering model system configuration:

1) **Reliability, durability** and **resistance to environmental effects** are a major focus. The production version of this weapon system will be as reliable and durable as a standard duty weapon and must pass

the same environmental testing. The engineering model is a modified design of an existing conventional production design, but is still considered a "breadboard" and is not intended at this point in time for subjection to these types of tests. At a later date, such as in Phase Four, the system could be designed such that the gun is built around the SWS system, which could then be subjected to extensive environmental and durability testing.

2) Not all **ultrasonic issues** have been addressed at this time. The use of ultrasonics as a communications medium presents advantages as well as disadvantages. Further study into emerging technologies for other means of communication will be explored in Phase Three.

   a) Similar in concept to the **sonic "pinging"** used by submarines as a form of radar, ultrasonic communication provides the ability to perform proximity detection between the gun and the PD. Other forms of communication, such as radio frequency (RF), do not lend themselves well to **proximity detection,** so ultrasonic was chosen as the communications medium.

   b) In contrast to RF (without the use of directional antennas), ultrasonic communication is **directional** (like the light beam cone of a flashlight). This characteristic is an advantage as well as a disadvantage. Being directional, it lends itself quite naturally to attitude with respect to the **gun's position in relation to the user**. This also means that care must be taken to insure the PD is positioned within the "cone" of the communication. This disadvantage becomes an even larger issue when one considers handling characteristics such as the requirement to operate the weapon in either hand. This challenge was addressed by using a different recognition process in combination with a different disconnect method.

   c) Continuing with the analogy of the flashlight beam, **ultrasonics can be blocked** by an object such as heavy clothing or a glove. Since law enforcement personnel frequently encounter varying environments, **heavy clothing and gloves can be quite common**. Even in warm weather, bicycle and motorcycle patrol officers have a need to wear gloves. To deal with this issue, the PD can not effectively be in the form of a wristband. A clip-on pager-style PD was chosen, among many other possibilities, as the best method of employing the PD. This allows the officer to **strategically place the PD** on the body for optimal performance. The pager-style PD also better contributes towards undercover situations, as well as lowering vulnerability during struggle situations where the assailant would not be able to grab the wristband.

d) **Coding** is now included in the prototype to satisfy **multiple authorized users.**

3) The use of a **battery** in a duty weapon can be quite controversial. A law enforcement officer is often hesitant to rely on a battery for operation of a duty weapon because experience with battery powered devices has been less than favorable in many cases. Environmental temperature ranges also can have adverse affects on batteries.

a) The definition of the system is configuration as "**fail-fire**," including a drained battery situation. This configuration was contained in the demonstration unit inherent in the disconnect method. The capability for the gun to "fail-fire", in a dead battery condition, contained in the engineering model is now by **monitoring the battery** condition and providing a battery indicator. Future design improvements could include diagnostics to automatically insure the gun's state as fire mode, when the battery condition is detected as low.

b) **Battery life** was a shortcoming of the demonstration unit due to a disconnection method and a lack of a power switch, which consumed a large amount of battery-powered energy. The engineering model now employs a power switch and a different disconnection method which uses less energy (over time) to activate/deactivate, and **consumes virtually no energy** while maintained in an activated or deactivated state. The expected battery life of the engineering model is approximately 6 years.

c) Further energy conservation could be gained as a result of the engineering model's **recognition algorithm**. Recognition can be established, as authorized or unauthorized, within a very brief period of time upon drawing the gun. Once the recognition routine is complete and the firing control is engaged/disengaged, the battery is only required to provide a **minute amount of energy** to the system, which represents enormous energy savings. Another result of the engineering model's system architecture is that fire control is not required to change states each time the gun is handled by the user, although the engineering model software protocol presently places the fire control in secure mode immediately when the gun is gripped, before the state of recognition is established. Phase Two evaluation results may allow this immediate placement in secure mode upon gun gripping to be changed such that the gun would only be placed in secure mode when an unauthorized person is recognized. If employed, this would represent additional energy savings.

d) The **battery type** specifically chosen is a type that is **resistant to temperature extremes**. Phase Three will be used to investigate alternate energy sources, such as bio-energy for example.

4) **Retrofitting** research has now concluded that it would be **difficult** in most and impossible in some existing duty guns to retrofit. Liability is also an important issue when retrofitting another manufacturer's products.

5) The engineering model drastically improves the issue of **magazine disconnect**. Since the demonstrator unit contained batteries and electronics in the magazine it would fire a chambered round, with the magazine removed, by anyone who used the weapon. The engineering model now contains the battery and electronics in the gun frame and will fire a chambered round **only by an authorized user.**

Significant Developments

Quite possibly the most significant improvement seen by the engineering model is an effect of its architecture. Individual changes made small contributions to improvements, but the combination of several changes made vast improvements. A good example to illustrate this is the situation where there is no ultrasonic communication taking place, because the batteries in the magazine have expired. Adding a grip switch and a battery strength indicator, using a more efficient disconnect system (such as a latching device), and involving higher capacity batteries improved the system battery power consumption from 3 hours to several years.

Two major advantages accrued as a result of incorporating our new grip switch in the new recognition and disconnect systems. This is best illustrated by stepping through the process, assuming a scenario beginning with an authorized user:

The grip switch unblocks the trigger and activates the electronics, the fire control is placed in "secure" mode, and the recognition process with coding begins soon after gripping the gun. When the recognition process between the gun and the PD is complete and the user is authorized, *fire control is allowed to be in the "fire" position. The entire process, which occurs almost immediately, is complete and electronics are now consuming negligible energy from the battery. The user continues to be authenticated for as long as the grip switch is held, with no regard for the position of the gun in relation to the PD. This capability is a remarkable improvement from the earlier demonstration unit because once the user is authorized, the system no longer uses the ultrasonic communication to retain authorization. The user can orient the gun in any position without concern for losing authentication, so long as the user continues to grip the gun and thus the switch.*

Continuing to step through the process, the user releases the grip switch as the gun is returned to a holster. Since the gun was in "fire" mode when the grip switch was released, the gun stays in "fire" mode. No battery energy is used to return the gun to "secure" mode. This is acceptable because, whenever the gun is gripped, the recognition process will again take place. For example, if an unauthorized person is next to grip the gun, that person will not be authorized, the fire control will disconnect, the gun will be in "secure" mode, and electronics are consuming negligible energy from the battery. Conversely, if an authorized person is next to grip the gun; the fire control is placed in "secure" mode, the person will be authorized again by the recognition system, and the fire control returns to "fire" mode.

This is of great significance because with normal use and a slight modification to the algorithm (removing the immediate placement in "secure" mode upon gripping the gun), the gun could spend its entire life in "fire" mode. The battery would never be needed to supply the extra energy required to disconnect the firing control. Contrasted to the earlier demonstrator gun battery that lasted only a few hours, the new engineering model battery will last as long as several years or more, and could last much longer.

There was one caveat to the remarkable new engineering model's system. The grip switch must be integrated so that it must be pressed in order to use the gun. Otherwise, an unauthorized person could be able to grip the gun in an unusual manner and fire the gun. Using ergonomics in switch placement as well as the use of a "forcing lever" corrected this situation. The switch was strategically placed in the front of the grip, so that the switch activation lever would naturally be pressed. The "forcing" mechanism is an obstructive device that prevents the gun from being used without pressing the grip lever, thus activating the switch and beginning the recognition process.

Conclusion

In conclusion, the results of our Phase One research have been highly fruitful. Functional Requirements, Feasibility, and FMEA studies have assisted in directing the engineering model toward an architecture that addresses the concerns of interviewed law enforcement officers as well as moving away from potential causes of system failure. The following examples highlight the culmination of Phase One developments:

- Substantially improved Battery life and system reliability.
- Increased proximity communication range with coding, which enables specific multiple users.
- Improved recognition methodology enhanced with non-continuous authentication checking.
- Platform change to a gun caliber with LE familiarity.

The engineering model demonstrates improved system maturity and incorporates the SWS system into a gun model with which law enforcement personnel are more comfortable. We are eager to develop the higher maturity levels that can be obtained in Phases Two through Four.