EARLY WARNING: A STRATEGY TO PREVENT INJURIES AND LOSS OF LIFE DURING ACTIVE SHOOTER ATTACKS ON K-12 SCHOOLS

by

Susan M. Graves

March 2018

Thesis Advisor: Glen Woodbury
Second Reader: Christopher Bellavita

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# Early Warning: A Strategy to Prevent Injuries and Loss of Life During Active Shooter Attacks on K-12 Schools

**Susan M. Graves**

**Naval Postgraduate School**

Monterey, CA 93943-5000

**ABSTRACT (maximum 200 words)**

Active shooter attacks occur quickly. Schools have to take immediate action to protect students and staff. Public address systems do not adequately warn everyone at the first sign of danger.

This thesis asks to what extent the school “fire alarm system” can be a model for a “lockdown notification system” for emergencies involving violence.

The research reviews the history, mechanics, and regulations of fire alarm systems, and uses that information to design a conceptual lockdown notification system. A tool to evaluate school warning system technologies was also developed. Six case studies reviewed schools or districts that use a lockdown warning system modeled after the fire alarm system.

The thesis concluded the school evaluation tool is useful for identifying strengths and weaknesses of school warning systems. The tool showed that reliability is a strength of the conceptual lockdown notification system because it is aligned with National Fire Protection Association codes. The lockdown notification system has the potential to solve the problem of early warning.

The research recommends school decision-makers use this new tool to evaluate and select communication and warning system technologies. It recommends a pilot project to test the implementation of the conceptual lockdown notification system in schools.
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Susan M. Graves
Safety Coordinator, Lincoln County School District, Newport, Oregon
B.A., Northwest University, 1998

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Approved by: Glen Woodbury
Thesis Advisor

Christopher Bellavita
Second Reader

Erik Dahl
Associate Chair for Instruction
Department of National Security Affairs
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The research recommends school decision-makers use this new tool to evaluate and select communication and warning system technologies. It recommends a pilot project to test the implementation of the conceptual lockdown notification system in schools.
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<td>ADA</td>
<td>Americans with Disabilities Act</td>
</tr>
<tr>
<td>AED</td>
<td>automatic external defibrillator</td>
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<tr>
<td>BYO</td>
<td>bring your own device</td>
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<tr>
<td>CHDS</td>
<td>Center for Homeland Defense and Security</td>
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<tr>
<td>DHS</td>
<td>Department of Homeland Security</td>
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<td>ECS</td>
<td>emergency communications systems</td>
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<td>EVAC</td>
<td>emergency voice alarm communication</td>
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<tr>
<td>FACP</td>
<td>fire alarm control panel</td>
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<td>FBI</td>
<td>Federal Bureau of Investigation</td>
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<td>FCC</td>
<td>Federal Communications Commission</td>
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<td>FEMA</td>
<td>Federal Emergency Management Agency</td>
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<td>FERPA</td>
<td>Federal Educational Rights and Privacy Act</td>
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<td>FOIA</td>
<td>Freedom of Information Act</td>
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<tr>
<td>HIPPA</td>
<td>Health Insurance Portability and Accountability Act</td>
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<tr>
<td>HOT-Fit</td>
<td>Human, Organization, and Technology-Fit</td>
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<td>HS</td>
<td>high school</td>
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<tr>
<td>IBC</td>
<td>International Building Code</td>
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<td>IDEA</td>
<td>Individuals with Disabilities Education Act</td>
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<td>IDS</td>
<td>intrusion detection systems</td>
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<td>IP</td>
<td>internet protocol</td>
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<td>IRB</td>
<td>Institutional Review Board</td>
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<td>JHU</td>
<td>Johns Hopkins University</td>
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<td>K-12</td>
<td>kindergarten through grade twelve</td>
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<td>LED</td>
<td>light-emitting diode</td>
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<td>LNCP</td>
<td>lockdown notification control panel</td>
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<td>MOU</td>
<td>memorandum of understanding</td>
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<td>MS</td>
<td>middle school</td>
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<td>NFPA 72</td>
<td>National Fire Alarm and Signaling Code</td>
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<td>NFPA</td>
<td>National Fire Protection Association</td>
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<tr>
<td>PA</td>
<td>public address</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<td>REMS</td>
<td>Readiness and Emergency Management for Schools</td>
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<td>RF</td>
<td>radio frequencies</td>
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<td>RFID</td>
<td>radio frequency identification</td>
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<tr>
<td>STAT</td>
<td>Student Threat Assessment Team</td>
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<tr>
<td>TA</td>
<td>technical assistance</td>
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<td>TAM</td>
<td>Technology Acceptance Model</td>
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EXECUTIVE SUMMARY

Schools are susceptible to active shooter attacks. Studies show these attacks occur quickly, often within minutes of when an intruder enters a school.\(^1\) Many strategies to prevent injuries and loss of life have emerged. One of these, lockdown, is a commonly accepted practice that shows some success at reducing injuries and loss of life during active shooter attacks on schools.\(^2\) While studies show the importance of rapidly warning everyone in the school, public address systems are often only accessible from a school’s main office.\(^3\) This lack of access can make it difficult to get a timely warning out when an intruder is first detected. An assortment of warning system technologies have emerged to address these problems, including some with lockdown push-buttons or police pull-stations that are modeled similarly to the fire alarm system. Limited research, however, has been done about the efficacy of these systems, and minimal guidance is available to help school leaders make informed decisions when selecting warning system technologies.\(^4\)

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A. THESIS QUESTIONS

The thesis asks and answers two questions:

- To what extent can the school “fire alarm system” (for emergencies involving fire and evacuation) be a model for a “lockdown notification system” for emergencies involving violence requiring lockdown?

- What factors should kindergarten through grade twelve (K-12) school decision-makers and their law enforcement partners consider when evaluating and implementing warning systems that notify both school occupants and law enforcement of an imminent threat of violence at school?

B. RESEARCH DESIGN

To answer these questions, first, I designed a conceptual lockdown notification system using the fire alarm system as a model. I studied the history, regulations, and basic components of the fire alarm system and found that the National Fire Protection Association (NFPA) had established similar codes by regulating emergency communication systems for situations involving violence as they already exist for fire alarm systems. Some of this guidance is even specific to campuses. These and other research documents helped shape the design of the conceptual lockdown notification system.

The system mechanics of my conceptual lockdown notification system are almost identical to those of the fire alarm system. Its components consist of a lockdown notification control panel that is hardwired to lockdown push-buttons and speaker-strobes.

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located throughout the school. If students or staff members detect a suspicious person or hear gunfire, they can quickly activate a lockdown push-button. The control panel then immediately notifies everyone to lock down through a pre-recorded message. The system simultaneously notifies the police department, via the alarm company.

Next, I developed an evaluation tool that K-12 school decision-makers can use to evaluate communication and warning system technologies. To formulate the school tool, I examined existing technology evaluation frameworks and selected the Human, Organization, and Technology-Fit Factors (HOT-Fit) model as a structure on which to build the school tool. To customize it to K-12 schools and to communication and warning systems, I incorporated knowledge gleaned from existing literature and research associated with the conceptual lockdown notification system. I also drew from my extensive experience as a school safety professional.

The new K-12 School HOT-Fit Evaluation Tool includes five core domains that guide the user through a process to assess the suitability of a technology to accomplish the goals of the school organization. The first domain, Foundation, otherwise known as the why, is unique to this new tool. The other domains come from the HOT-Fit framework. These domains involve investigating the Technology itself, assessing the technological interface with Humans in the school system, examining the impact on the Organizations, and identifying the Net Benefits to the school, district, and community partners. Each domain is distinct, but interconnected, and each has unique and customized variables for evaluating the efficacy of the technology’s use within the K-12 school environment.

To test the new K-12 School HOT-Fit Evaluation Tool, I applied it first to the fire alarm system, and then to my conceptual lockdown notification system. This exercise helped reveal some of the strengths and weaknesses of the conceptual lockdown notification system and served to demonstrate how to use the school tool.

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Additionally, I conducted case studies and interviewed personnel at six schools or school districts already using a warning system with lockdown push-buttons or police pull-stations. By laying out the case study data according to the evaluation criteria in the new school tool, many of the strengths and vulnerabilities of each system emerged and I was then able to draw conclusions about the efficacy of the case study warning systems in comparison to my conceptual lockdown notification system.

C. FINDINGS

The following findings are presented about the various warning and fire alarm systems evaluated, as well as the results of the case studies. A conceptual lockdown notification system is also presented.

1. K-12 School HOT-Fit Evaluation Tool

Using the new school tool to evaluate the case study schools’ warning systems, the fire alarm system, and the conceptual lockdown notification system revealed strengths and vulnerabilities of the systems and helped to identify the net benefits of each system.

2. Case Studies

All the case study subjects’ systems, to some extent, solve the problem of early warning that can result in quicker lockdowns. However, the evaluation exposed significant vulnerabilities related to the reliability of these systems; in part because of the system mechanics (that require the use of the internet, radio frequencies, or cellular service), and also due to complexities associated with add-on features of each system. These factors potentially reduce the effectiveness of each system and make them more susceptible to security breaches. The lack of accessibility of the activation devices also emerged as a weakness. Moreover, problems associated with information clarity surfaced, most likely due to a lack of awareness of NFPA guidelines for emergency communications systems.

3. Conceptual Lockdown Notification System

The fire alarm system is a good model for a lockdown notification system. The mechanics of the conceptual lockdown notification system align with NFPA codes and
regulations. Like the fire alarm system, the conceptual lockdown notification system has highly reliable system mechanics that use a control panel to monitor the flow of electricity and current through the wire that connects the lockdown push-buttons and speaker-strobes. It does not require the use of the internet, radio frequencies, or cellular service. It has a built-in battery backup to provide redundancy for a loss of electricity. These attributes contribute to system reliability and support a strong system defense.

The conceptual lockdown notification system, however, is not as flexible or complex as the warning systems in the case studies. It is a basic warning system that only provides that function to accomplish the intended purpose with no extra bells and whistles. Thus, the system is simple to use, reliable, and manageable to maintain. The system is consistent with NFPA emergency communications systems guidance. It is accessible and instructions for use on the push-buttons and associated signage are clear and intuitive. The proposed order and configuration of the alert tone and warning message align with NFPA guidance.

Following the NFPA guidance is judicious because it results in a highly reliable and effective lockdown notification system that is easy to use and appears to have minimal impact on the daily operations of the school. Additionally, a serendipitous effect of positively improving the school climate may result by increasing confidence in the school’s ability to keep students and staff safe. Finally, it is possible that by using the lockdown notification system, schools may even reduce or prevent injuries and loss of life during active shooter attacks by locking down more quickly.

D. RECOMMENDATIONS

First, schools’ decision-makers should consider using the new K-12 School HOT-Fit Evaluation Tool to help them select appropriate communication and warning system technologies to meet their unique needs. The school tool can also be utilized to evaluate the efficacy of existing systems, and with minor modifications, it may even be a practical tool to evaluate the suitability of other school safety and security technologies. It is the hope that by using the school tool, teams will be able to make better decisions about
communication and warning systems that result in informed and prudent financial expenditures.

Second, the lockdown notification system is conceptual; it needs to be tested in schools. A pilot project should be implemented to validate the mechanics of, and actual implementation of, the conceptual lockdown notification system. The pilot project should include a collaborative team of researchers, fire and law enforcement officials, and school safety personnel who design the pilot, implement the project, and evaluate results. I recommend a comparative design testing the system in some schools with lockdown push-buttons primarily in common areas, and in other schools with lockdown push-buttons also in classrooms.
ACKNOWLEDGMENTS

My Center for Homeland Defense and Security (CHDS) experience has been an extremely challenging and immensely rewarding journey, a journey I was blessed to take with many caring, supportive, and inspiring people.

I first want to acknowledge my incredible husband, Kevin, who has been behind me 100% during this entire journey. I cannot imagine doing this thesis without his unwavering encouragement and support. Kevin relentlessly demonstrated how much he believed in me. He was always eager to listen as I talked about all the things I was learning. His insights were invaluable as I processed new concepts with him. He proofread many papers and challenged me to press on when I was weary. Thank you, Kevin, I could not have done this without you!

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Despite the enormity of the demands of this program, life continued to go on around me. I experienced immense personal loss when my Uncle Steve suffered a major heart attack, fought through several surgeries, and subsequently died. Uncle Steve believed in me and never missed an opportunity to tell me how proud of me he was. I miss him more than words can say. Shortly after, my dear mother-in-law, Vivian, also passed away unexpectedly; another significant loss for me. All throughout this journey, my extended family rallied around me, encouraged me, and was gracious and
understanding as I had to be absent from many important family gatherings and activities. My family motivated me by believing in me. I hope I have made them proud.

Writing a thesis was a bigger challenge than I ever expected. I am grateful to my advisors Glen Woodbury and Chris Bellavita for their gracious oversight and valuable feedback. Thank you for trusting me. I would also like to thank Alison Scharmota at the Graduate Writing Center. Her indispensable assistance came at just the right time and helped me get through an intense part of the refining process.

I would like to extend my gratitude to my school safety colleagues around the nation who so generously agreed to participate in my case study research. You know who you are, and I am sincerely appreciative of your time and contributions. I believe my thesis is more robust as a result.

CHDS is a special place. It is marked by brilliant and caring staff and instructors who collectively created an academically rigorous and invigorating experience centered on this world we call the homeland security enterprise. I never imagined the extent to which I would be challenged and stretched during this program. Thank you for believing in me, for inviting me into this program, and for challenging me to grow and to think differently. Thank you for recognizing and embracing the significant place that K-12 schools hold in the homeland security enterprise. My colleagues in the 1611 cohort are incredibly intelligent and talented people, but I am even more struck by what genuinely impressive human beings they are. They are role models for me and I am deeply grateful for their friendship.

It is a profound honor and privilege to have been a part of this CHDS program. My heart is full of thankfulness.
I. INTRODUCTION

A school teacher notices a strange man charging down the hall with a gun in his hand. The teacher needs to think about personal safety while discreetly and quickly notifying the main office to make a warning announcement on the public address system. Depending on where the teacher is in the school, he or she may have to run to the office to make notification of the intruder. This takes valuable time when every minute—every second—may mean the loss of lives.

This fictitious scenario illustrates the challenges of warning school occupants during real active shooter attacks on schools, such as at Reynolds High School in Oregon. The after action report records that after “initial shots [were] fired in the boys’ locker room […] the] Gym teacher runs out of the gym towards the front office to initiate school lockdown and is shot by [the] shooter.” 1 Similar scenarios have unfolded in other shooting attacks on kindergarten through grade twelve (K-12) schools. In the Aztech High School shooting in New Mexico, it was reported that the custodian screamed “at teachers that there was an active shooter on site.” 2 In this instance, screaming was the initial method to warn others of danger.

A. THESIS STATEMENT

The goal of this thesis is to propose and attempt to validate the efficacy of a conceptual lockdown notification system that schools may be able to use to decrease the time it takes to notify everyone in the school of danger, so that protective measures, such as lockdown, can occur more quickly.

To achieve this goal, this chapter first provides a problem statement attesting to the speed of active shooter attacks on K-12 schools. It shows that lockdown is a

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commonly accepted protective strategy that has shown to be effective in reducing injuries and loss of life, and demonstrates the criticality of timely warning announcements. Next, two research questions are identified that evolved in response to this problem and an overview of the research methodology used to address those questions is provided. Then, a literature review is conducted to gain awareness of the current research related to school violence, school communication and warning systems, and the type of assessment tools that exist to evaluate school warning system technologies. The literature review also identifies gaps in the research that inform further research in this thesis. Finally, the remainder of the thesis is presented by providing a brief overview of each upcoming chapter.

B. POINT OF VIEW

I write as a researcher and as a subject matter expert on school safety since I have been in this field with 17 years of experience as a full-time school safety professional in K-12 schools. Ten of those years I also spent consulting—assisting the U.S. Department of Education’s Office of Safe and Healthy Students—writing publications, contributing to federal school guidance, developing training materials, presenting at conferences, and speaking at workshops all over the nation to train school personnel and their community partners how to develop high-quality school emergency plans. I incorporate my experience into this thesis as a supplement to the extensive research I have done.

C. PROBLEM STATEMENT

This section presents research that identifies (1) the speed of active shooter attacks on K-12 schools, (2) that lockdown is a commonly accepted protective strategy, (3) the criticality of timely warning announcements, (4) the emergence of new warning systems, (5) gaps in the research, and (6) a plan to address these problems and gaps.

1. Speed of Active Shooter Attacks

Schools are susceptible to a variety of hazards, threats, and dangerous situations, such as active shooter attacks, all of which require implementing immediate protective measures. Studies show that these events can occur quickly, often within minutes from
when an intruder enters a school.\textsuperscript{3} In 2014, the Federal Bureau of Investigation (FBI) released a report in which it studied 160 active shooter incidents occurring between 2000 and 2013 in a variety of public places, including schools. The FBI’s findings confirm the speed of these events: “Damage can occur in a matter of minutes. In 64 incidents where the duration of the incident could be ascertained, 44 (69.0\%) of 64 incidents ended in 5 minutes or less, with 23 ending in 2 minutes or less.”\textsuperscript{4} The Department of Homeland Security (DHS) agrees with this assessment:

A targeted shooting incident typically evolves so rapidly that by the time emergency responders arrive, it is either too late or too dangerous to intervene. It is a painful, but nonetheless true fact, that once an attacker has entered a targeted school building with the intention of shooting someone, there is practically nothing, or very little, that can be done to avert the attack.\textsuperscript{5}

While this statement may be valid based on current research, I contend that this seemingly hopeless stance is not the case. If schools are equipped with effective lockdown notification systems, they might have a better chance of averting or at the very least, minimizing the severity of a violent attack.

Steven Ausdemore, in “Eliminating the Lost Time Interval of Law Enforcement to Active Shooter Events in Schools,” describes this in-between period of when a shooter begins an attack and when law enforcement arrive, calling it “the lost time interval.”\textsuperscript{6} He identifies a correlation between rapid response and the reduction of loss of life and focuses on strategies and tools to counter an attack before police arrive. He draws an analogy by referring to the benefits of using an automatic external defibrillator (AED) to

\begin{footnotesize}
\begin{itemize}
\item[\textsuperscript{4}] Blair and Schweit, 9.
\item[\textsuperscript{6}] Steven E. Ausdemore, “Eliminating the Lost Time Interval of Law Enforcement to Active Shooter Events in School” (master’s thesis, Naval Postgraduate School, 2015), https://calhoun.nps.edu/handle/10945/47227.
\end{itemize}
\end{footnotesize}
help someone in cardiac arrest while waiting for the arrival of professional medical personnel. He argues “just as automatic external defibrillators address the lost time interval for emergency medical service response, strategies have been developed and proven successful in reducing the consequence of this [police] delay.” A lockdown notification system may be one of the solutions to this lost time interval, since lockdown is a commonly accepted response strategy, as shown next.

2. **Lockdown as a Response Strategy**

Many strategies to prevent an attack have emerged, such as mitigation approaches, security technologies, counter measures, and response strategies. Of these, lockdown is a commonly accepted and practiced response strategy used for many emergency situations involving violence at or near school. The *Final Report of the Sandy Hook Advisory Commission* provides recommendations for schools and states that all classroom doors should be able to lock from inside the classroom. They reasoned, “there has never been an event in which an active shooter breached a locked classroom door.” School safety experts from Safe Havens International reiterated findings in this report and wrote:

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7 Ausdemore, xv.


Despite the fact that the locked front entry door [at Sandy Hook Elementary School] was breached, the report indicates that no interior doors were breached by force. Keeping in mind that most of the staff and students in the school survived, this affords additional evidence that lockdown is still one of our most effective tools to prevent death in mass casualty school shootings.11

They went on to discuss the importance of issuing keys to all teachers and substitutes and training staff to lock doors quickly.

3. **Early Warning Can Save Lives**

The Sandy Hook Report also reiterates the importance of staff and students having greater situational awareness and summoning help quickly, explaining “every second counts between the initiation of a threatening event and the arrival of emergency responders. Seconds and minutes equate to lives lost or saved.”12 I agree with the Sandy Hook Report and would go further to assert that it is also critical to reduce the time between the initial signs of an act of violence and the school-wide notification to take protective measures, such as lockdown. Delays in this notification may cost lives. Keeping in mind that according to the Sandy Hook Report, locked classroom doors have never been defeated in these attacks; the sooner students and staff are alerted to lockdown, the quicker they may be able to get out of open areas and into lockable rooms.13

DHS’s *Primer to Design Safe School Projects in Case of Terrorist Attacks and School Shootings* spells out the importance of timely emergency alerts and explains, “mass notification systems are critical for advising faculty, students, and visitors of impending danger. After the exact nature of a threat is positively identified, unsuspecting occupants must be immediately alerted of the threat or situation and advised of what actions should be taken.”14 While speed of notification to all occupants is critical, many

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13 Sandy Hook Advisory Commission, 32–33.

schools are not equipped with reliable and readily available technology to make notifications at the first sign of danger. Traditional warning systems, such as public address systems, are often only accessible from a school’s main office, which makes it difficult to get a timely warning out to the school community when an intruder is first spotted in another area of the building.

4. **Emerging Warning Systems**

In response to this problem, various new alert and warning systems are emerging. Some are wireless, others hardwired; they are located in various areas of a school building or campus; some connect to an audible alert system, others to a silent alarm; some use cell phone applications, others are worn as a necklaces; and in some cases, the systems include different colored warning lights, strobes, or light-emitting diode (LED) signs. Some are modeled similarly to the fire alarm notification system and utilize different types of emergency push-buttons or pull-stations to send a prerecorded message automatically to the entire school indicating the need to take protective measures, such as a lockdown, while simultaneously alerting the alarm company or police department.

5. **Gap in the Research**

Limited research, however, is available that describes the purpose, functionality, or efficacy of these systems, as the literature review of this thesis shows. Findings from the Johns Hopkins University (JHU) report stipulate:

While application of safety and security technology in schools is not new, headline-generated fears, fiscal issues, and advancements in technology have made the issue increasingly complex. The literature is sparse on how and why technology is selected and employed in schools (assessing need) and its influence on violence and other crimes (evaluation and impact).

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16 Chapter IV of this thesis provides case studies on six school using some iteration of these push-button or pull-station warning systems.
There is minimal literature on brands, vendors, or the advantages and disadvantages of specific technologies.\textsuperscript{17}

While technology evaluation tools exist, I did not find any specifically focused on warning systems applied in the K-12 school environment that school decision-makers can use to evaluate the efficacy of these emerging warning systems.

6. Summary of Problem Statement

In summary, schools are at risk for active shooter attacks, which often occur rapidly once an intruder begins an attack. A need exists to decrease the time it takes to notify everyone in the school to implement a lockdown when a threat of violence is first discovered. New technologies are emerging to address this problem; however, minimal guidance is available to help school leaders make decisions about selecting warning systems.

This thesis does two distinct yet interconnected things. First, it examines the use of warning systems modeled after the fire alarm system that use lockdown push-buttons or police pull-stations to initiate a quick warning. These systems can accelerate a school’s ability to notify students and staff to take immediate protective measures when an emergency involves violence at school. The goal in locking down more quickly is to reduce and possibly eliminate the intruder’s access to school occupants during that critical lost time interval, and thereby, potentially prevent injuries and loss of life. Second, it identifies key factors that may be helpful for decision-makers to consider when selecting or implementing warning system technologies to meet the needs of their unique schools.

D. RESEARCH QUESTIONS AND METHODOLOGY

This section identifies two research questions and describes how the research is designed to answer the questions.

1. **Research Questions**

The goal of this thesis is to answer two questions:

- To what extent can the school “fire alarm system” (for emergencies involving fire and evacuation) be a model for a “lockdown notification system” for emergencies involving violence and requiring lockdown?

- What factors should K-12 school decision-makers and their law enforcement partners consider when evaluating and implementing warning systems that notify both school occupants and law enforcement of an imminent threat of violence at school?

2. **Research Methodology**

The research methodology used for this thesis is discussed as follows.

   **a. Literature Review**

   After identifying this problem involving the speed of active shooter attacks and lack of capacity to notify school occupants of danger quickly, the existing literature was examined to understand these problems more fully and learn about potential solutions. The literature review is the next section in this chapter.

   **b. Fire Alarm System and Conceptual Lockdown Notification System**

   The basic components of the school fire alarm system were studied and a conceptual lockdown notification system modeled after the fire alarm system developed. The standards and requirements for the fire alarm system found in the National Fire Protection Association (NFPA) regulations, the Life Safety Code Handbook, and other pertinent literature, were applied to the conceptual lockdown notification system. This research and proposal is presented in Chapter II of this thesis.

   **c. K-12 School HOT-Fit Evaluation Tool**

   A variety of existing technology evaluation frameworks were examined, as identified in the upcoming literature review, for suitability to evaluate warning system
technologies in the K-12 school environment. From this research, it was determined that the core elements of the Human, Organization, and Technology-Fit factors (HOT-Fit) framework is a feasible structure on which to build a customized evaluation framework for school decision-makers to use to assess the efficacy of warning technologies for use in K-12 schools.\(^\text{18}\) The knowledge gained from the literature review, the study of fire alarm systems, and the development of the conceptual lockdown notification system, along with my experience as a school safety professional, informed the design and customization of this new K-12 School HOT-Fit Evaluation Tool.

d. Case Studies

Simultaneous to researching and developing the new K-12 School HOT-Fit Evaluation Tool, I conducted my own case studies on actual schools using a lockdown notification system with police pull-stations or lockdown push-buttons resembling the fire alarm system yet designed to address school violence. This approach was necessary because I was not able to find any academic research or existing case studies on schools using these systems. Yet, news reports and vendor advertisements revealed that these systems existed. My research fills this gap.

Robert K. Yin, in *Case Study Research Design and Methods*, describes a motivation for this type of research by explaining “you would want to do case study research because you want to understand a real-world case and assume that such an understanding is likely to involve important contextual conditions pertinent to your case.”\(^\text{19}\) Obtaining this understanding is precisely why I conducted case studies; to ascertain what I could learn about how these systems work in the K-12 school environment. I wanted to understand three things: first, what factors influenced the selection of different applications of these warning systems; next, what conditions limited or enhanced a school’s ability to implement the systems successfully; and finally, how

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the warning system solved the problem of timely and early warning for emergencies involving violence at school.

The case studies consisted of interviewing six subjects, some of whom represented schools, and others, school districts. Yin validates the use of interviews for case studies by asserting, “One of the most important sources of case study evidence is the interview.”20 Chapter V presents these six case studies by first describing the parameters for participation in the case study research, how the subjects were selected, and the interview process. Next, the case study data is presented according to the categories defined in the new K-12 School HOT-Fit Evaluation Tool. Finally, the commonalities of the case study’s warning systems are analyzed and compared to the researcher’s conceptual lockdown notification system.

E. LITERATURE REVIEW

The literature includes a myriad of sources, such as federal government research documents, journal articles, books and reports from non-profit organizations, think tank publications, and academic literature. The literature review focused on these areas: (1) works addressing school violence, (2) literature about communication and warning technologies used in schools, (3) the identification of five implementation factors critical to the successful application of warning systems in K-12 schools, (4) the lack of guidance for selecting technologies, and (5) technology evaluation frameworks.

1. Addressing Violence in K-12 Schools

The first part of the literature review features publications that address school emergency plans, school violence, threat assessments, active shooter attacks on schools, and terrorism.

20 Yin, 110.
School personnel are directly in charge of hundreds and sometimes thousands of children and act in place of their parents or guardians, which is called *in loco parentis*.\(^{21}\) Not only do they work to educate students, they must also be prepared to respond to a wide range of hazards and threats, many of which require making timely warning announcements and implementing protective actions, such as lockdown or evacuation.\(^{22}\) In 2013, six federal agencies collaborated to produce guidance for schools on how to develop emergency operations plans. The *Guide for Developing High-Quality School Emergency Operations Plans*, hereafter referred as the K-12 EOP Guide, advises schools to use an all-hazards approach in their emergency planning.\(^{23}\) K-12 EOP Guide includes instructions for assessing risk and vulnerability related to numerous hazards and threats, including various forms of school violence, and takes school teams through a process to develop threat and hazard protocols for their school emergency plan. It also recommends essential components for school lockdown plans.\(^{24}\)

Among the hazards and threats K-12 schools encounter, violence is a consistent topic addressed by scholars and practitioners. In *Indicators of School Crime and Safety: 2016*, Musu-Gillette et al. paint a picture of violence and crime at schools and postsecondary institutions that covers “topics such as victimization, teacher injury, bullying and cyber-bullying, school conditions, fights, weapons, availability and student use of drugs and alcohol, student perceptions of personal safety at school.”\(^{25}\) This report represents their 19th annual publication on school crime. The U.S. Department of Justice provides an estimation of the frequency of school violence in its *Summary of School*


\(^{22}\) See Appendix A for a chart showing many of the threats and hazards for which schools must prepare.


\(^{24}\) Office of Elementary and Secondary Education, Office of Safe and Healthy Students, 7.

Safety Statistics. This publication provides an overview of statistics on school crime rates, school violence, school shootings, traumatic events, and social media threats.26

Threat assessment is an established discipline and proven mitigation strategy to help prevent violence at school. Threat assessment experts delineate between two types of violence, reactive aggression and targeted violence. Fein et al. cites targeted violence as a threat schools are vulnerable to in Threat Assessment in Schools: A Guide to Managing Threatening Situations and to Creating Safe School Climates.27 This work, based on the findings of the Safe School Initiative, promotes the need to create safe school climates to help prevent targeted violence in schools, such as school shootings. It also provides a threat assessment process for schools modeled after the threat assessment process in use by the Secret Service to protect the president. O’Toole also addresses targeted violence in The School Shooter: A Threat Assessment Perspective. This report is based on a collective work from the 1999 Leesburg Symposium that studied 18 cases of school shootings, some of which were thwarted, and promotes the use of a threat assessment system to help prevent targeted school violence.28 In Assessing Student Threats, John Van Dreal describes the Salem-Keizer School District’s research-based, multi-disciplinary Student Threat Assessment Team (STAT).29 It includes the process for school-based teams to conduct a preliminary threat assessment, and for community-based teams to conduct a more extensive assessment. Van Dreal differentiates between reactive aggression and targeted violence since most of the active shooter attacks on schools involve targeted violence.30 The threat assessment process empowers school leaders to


30 Van Dreal.
understand risk and develop supportive interventions for the school and for students at risk of violence that thereby decreases the risk of violent attacks on schools. The Salem-Keizer STAT is a nationally recognized student threat assessment system.

In another significant work, *The Final Report and Findings of the Safe School Initiative*, Vossekuil et al. studied 37 incidents of targeted violence in schools from 1974–2000. They identified 10 key findings about the attacks and attackers, one being, “there is no accurate or useful ‘profile’ of students who engaged in targeted school violence.” The report promotes the need to gather intelligence on the risk of an attack and complete threat assessments to prevent attacks. A key finding in a 2014 report released by the FBI on 160 active shooter events between 2000 and 2013 showed students were often the attackers. Blair explains: “In a majority of the HS [high school] and MS [middle school] incidents, the shooter was a student at the school; this was the case in 12 of 14 HS shootings and 5 of 6 MS shootings.” These works underscore the value of student threat assessments.

Terrorism is another form of violence brought forth in the literature as a risk for schools. The history of terrorism in schools is the focus of Michael and Chris Dorn’s work, *Innocent Targets When Terrorism Comes to School*. In the book, the Dorns lay out terrorist’s tendencies, how schools can combat terrorism, and discuss the psychological effects of terrorism on children. The Federal Emergency Management Agency (FEMA) also addresses terrorism in its 317-page book, *Primer to Design Safe School Projects in Case of Terrorist Attack*. It aims to “provide the design community and school administrators with the basic principles and techniques to make a school that is safe from terrorist attacks and at the same time is functional [and] aesthetically

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32 Vossekuil et al., 11.
33 Vossekuil et al.
35 Blair and Schweit, 16.
37 Dorn and Dorn.
pleasing.”38 The aspect of functionality is particularly important because school leaders are more likely to maintain security systems and strategies if they do not hinder the school’s daily, functional, and practical needs. The report discusses vulnerabilities related to the physical design of the campus and buildings while also addressing exterior and interior protective measures, such as access control, fire protection systems, physical security systems, and communications systems.39

The aforementioned literature represent a variety of publications referencing different types of school violence, such as active shooter attacks and terrorism, and mitigation strategies including threat assessment and the development of emergency plans. Another strategy for responding to school violence involves the use of warning systems in schools.

2. Communication and Warning Technologies

This section brings forth literature addressing traditional and emerging communication and warning technologies used in schools. Johns Hopkins University’s A Comprehensive Report on School Safety Technology, reports, “Communication is one of the most vital capabilities for school officials and first responders in the event of an act of criminal violence or natural disaster.”40 When a suspicious person is seen on campus, gunshots are heard, or some kind of violent attack occurs, schools need a mechanism to alert and warn its occupants quickly to take protective measures. The K-12 EOP Guide identifies several components to include in a school’s communication and warning protocols.41 These components include identifying how a school’s system will interact with its local fire and law enforcement agencies, the importance of training staff members to use the equipment by taking into account barriers related to technology, language, and

38 Department of Homeland Security, Science and Technology Directorate, Infrastructure Protection and Disaster Management Division, Primer to Design Safe School Projects in Case of Terrorist Attacks.

39 Department of Homeland Security, Science and Technology Directorate, Infrastructure Protection and Disaster Management Division, 3–49.


the needs of individuals with disabilities, and addressing activities occurring outside of regular school hours.\textsuperscript{42} The K-12 EOP Guide neither identifies nor provides guidance on any specific types of communication, alert, or warning technologies or systems available to or used in K-12 schools.

\textit{a. Traditional Systems}

Although the U.S. Department of Education does not recommend specific technologies, many methods exist to notify students, staff, and first responders when an emergency occurs that include traditional systems, such as landline telephones, fire alarm systems, public address (PA) or intercom systems, classroom call buttons, and two-way radios. The NFPA establishes codes and regulations for all aspects of fire alarm warning systems in schools. The National Fire Alarm and Signaling Code (NFPA 72) \textquotedblleft covers the application, installation, location, performance, inspection, testing, and maintenance of fire alarm systems, supervision station alarm systems, public emergency alarm reporting systems, fire warning equipment and emergency communications systems (ECS), and their components.\textquotedblright\textsuperscript{43} In \textit{The Appropriate and Effective Use of Security Technologies in U.S. Schools}, Green describes some of the most basic communications as, \textquotedblleft yelling/screaming, sending someone else for help, using the public address (PA) system, using a telephone, or calling on a two-way radio.\textquotedblright\textsuperscript{44} Two-way radios allow the user to communicate with multiple users simultaneously, are easy to use, and require minimal training. In some cases, mega phones or bullhorns are used. These methods have been standard fare in most schools for years, and in some cases, decades. FEMA’s \textit{Primer to Design Safe School Projects in Case of Terrorist Attacks} credits classroom call systems, such as phones and call buttons, with the ability to \textquotedblleft provide a rapid means for staff or

\textsuperscript{42} Office of Elementary and Secondary Education, Office of Safe and Healthy Students, 7.


\textsuperscript{44} Mary W. Green, \textit{The Appropriate and Effective Use of Security Technologies in U.S. Schools} (Washington, DC: National Institute of Justice, 1999), 114.
students to alert the administrators that a serious incident is taking place."^{45} In Schneider’s *School Security Technologies*, he calls hard-wired phones in classrooms “sound investments” saying, “teachers and students can rely on finding them in the same location whenever needed.”^{46} These traditional approaches have several enduring benefits affecting their success in K-12 schools, such as rapid notification, reliability, and sound investments; even so, some weaknesses, particularly with two-way radios, emerged in the literature review.

Two-way radios are limited in range, and transmissions are sometimes compromised by certain kinds of construction. These and other weaknesses specific to two-way radios are spelled out in the “five implementation factors” section of the literature review. Even so, a two-way radio was used with some success in the Arapahoe High School shooting to communicate the presence of an intruder and speed up the lockdown announcement.^{47}

**b. Emerging Systems**

The literature also identifies several emerging communication and warning technologies used in some K-12 schools. These technologies include smartphone warning apps, a variety of silent alarms (such as fixed panic buttons or duress alarms), wearable pendants or badge alarm devices, and computer software alert systems. Johns Hopkins University’s *A Comprehensive Report on School Safety Technology* describes the wearable alarms as a device “worn by school staff […] with a button that, when pushed, will signal an alert to an alarm panel.”^{48} Smart phone panic button applications work in much the same manner in that when activated, they send an alert to an alarm panel, a 911

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47 In the Arapahoe High School shooting, the custodian used a two-way radio to alert the office to announce a lockdown. “Though some staff reported having trouble hearing the radio call and the aggressor was able to make it inside of the school before the lockdown was issued, the lockdown communication was very fast in this incident.” Safe Havens International, *Post-Incident Review, Arapahoe High School Active-Shooter Incident* (Macon, GA: Safe Havens International, 2016), 50.
dispatch center, or to designated personnel in the school. Schneider says that this smart phone technology enables teachers to “call for help anywhere at any time as long as they have a charged phone handy and good reception.”49 Fixed panic buttons or duress alarms are mounted in the school office, and are hidden under a desk or counter. They may also be located in visible locations so they are accessible by all.50

The RAND report entitled *The Role of Technology in Improving K-12 School Safety* describes a computer software alert system in which staff members’ desktop computers have an icon to press to indicate an emergency.51 As the Johns Hopkins report indicates, “a silent alarm may not help with deterring or preventing an intruder, but it can drastically reduce the police response time by triggering a quick alarm.”52 Both the RAND and JHU literature include case studies on schools using these emerging warning and alert technologies, but not on schools using warning systems modeled after the fire alarm system with lockdown push-buttons or police pull-stations.

Along with Schneider’s work, *School Security Technologies*, the RAND and JHU literature identified several weaknesses related to the implementation of traditional and emerging communications systems in K-12 schools, including their inaccessibility, inability to warn the entire school, reliability shortcomings, expense, and lack of fit.53

3. **Five Implementation Factors**

These weaknesses reveal five distinct factors that affect the successful implementation of warning systems in K-12 schools. The system must be readily accessible, provide an immediate warning to all school occupants, be reliable, have manageable initial and ongoing costs, and fit the unique needs and characteristics of the school organization.


51 Schwartz et al., *The Role of Technology*, 41.


(1) Accessibility

The RAND report highlights the need for quick and easy access to an alarm. “An alarm system is thought to be most useful when it is always activated and ready to be used.” Desktop computer alert systems and cell phone apps are most effective if the device is accessible, turned on, and the software application is readily available and easy to use. If a staff member has to wait to turn on a computer or cell phone and open the software, the delay can cost lives. The RAND report also noted a weakness with the computer software alert system in that those using the school after hours would need training on the system. They also would have difficulty accessing the computers since they are usually password protected and in locked classrooms during non-school hours. Many of these emerging warning systems have weaknesses related to accessibility.

(2) Timely Warning to Entire School

None of these silent alarm devices, whether hidden, visibly mounted on the wall, worn on a body, or on a cell phone app has a mechanism to notify all school occupants quickly of an emergency. As the JHU report indicates, “Duress alarms cannot prevent violence. They also cannot actually protect someone from being victimized […] the effectiveness is critically linked to the ability of an alarm to promptly notify the appropriate people.” Schneider, in School Security Technologies asserts, “Everyone on campus should be able to call for help, pass along a timely warning, or receive a warning —any time, anywhere. A teacher shouldn’t have to choose between staying with students and calling for help.” These emerging technologies are usually only set up to notify designated people, not the entire school. All three reports emphasize the importance of quickly warning everyone on campus of threats of violence. Yet none of these technologies emit an immediate audible warning message to everyone at the school.

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54 Schwartz et al., 14.
55 Schwartz et al., 42.
57 Schneider, School Security Technologies, 8.
(3)  Reliability

A major weakness of using a smart phone application as an emergency panic button revealed by the Schneider, RAND and JHU reports has to do with reliability. Schneider notes that, “some school construction is so dense that cell phones cannot function reliably indoors.”58 The JHU report discusses weaknesses like dropped calls, coverage area limitations, dead batteries, data speed, and the possibility of cell phones being inaccessible or misplaced. The JHU says that “because cellular signals can be overwhelmed by demand, this option carries with it a significant risk especially during an emergency.”59 In interviews cited in the RAND report, “panelists noted that in old buildings or rural school campuses cell phone reception was spotty […] and also noted that schools have a disincentive from improving cell coverage within a building, since they want to discourage students and teachers from spending time on their phones during school hours.”60 The literature named reliability as a weakness with two-way radios and computer software alerts. The RAND report cites the “human element” as a liability, such as “forgetting to charge batteries” and “staff leaving radios in their classrooms.”61 These vulnerabilities related to reliability were consistent in all three reports.

(4)  Cost

Schneider cautions against purchasing low-end radios that are inadequate for school use and discusses the expenses of purchasing and maintaining radios, and replacing batteries. He also cautions against using other people’s money saying, “grant money runs out. Eventually more radios will be needed.”62 RAND’s case study involving wearable alert badges cited the initial cost as prohibitive and notes, “implementation of the program […] would have been nearly impossible without a private donation.”63 The

58 Schneider, 10.
60 Schwartz et al., Role of Technology, 24–25.
61 Schwartz et al., 74
62 Schneider, School Security Technologies, 8.
63 Schwartz et al., Role of Technology, 37.
JHU report agrees that cost is a barrier and states that “the cost of purchasing badge alarms may limit how many badge alarms a school can purchase.”\textsuperscript{64} Replacing batteries and wearable devices that are lost, damaged, worn, or stolen can also be barriers for schools. Schneider also advises that school decision-makers carefully consider the use of grant funds since when funding runs out, it may be difficult to afford the costs of replacing or maintaining equipment.\textsuperscript{65} The JHU report agrees with Schneider by stating that “technologies have an expected life cycle, and as equipment ages and technology advances, equipment and software must be replaced. Grants in response to incidents, however, almost never account for this, leaving schools with aging systems and no means to refresh the technology.”\textsuperscript{66} The report goes on to indicate that sometimes, when a grant competition with a quick deadline is announced, school decision-makers do not have the time to investigate technology options fully and can end up making technology decisions hastily.\textsuperscript{67} The RAND report indicates that “Complex systems of alerts can cost districts millions of dollars; the use of existing infrastructure (e.g., telephone lines, local fire alarms) to send out alarms can eliminate fees and costs while also being reliable.”\textsuperscript{68} Other challenges cited in these reports by both the schools and their law enforcement partners indicate that “as time passes, it has become more challenging to garner both public and financial support to maintain the systems [...] as the memory of past events fades, compliance with school safety policies and procedures [...] also tends to diminish.”\textsuperscript{69} The barriers associated with initial and ongoing costs of warning technologies and systems are a consistent theme in all three reports.

\textsuperscript{65} Schneider, \textit{School Security Technologies}, 8.
\textsuperscript{67} Johns Hopkins University Applied Physics Laboratory, ES–4, 12.
\textsuperscript{68} Schwartz et al., \textit{Role of Technology}, 14.
\textsuperscript{69} Schwartz et al., 42.
(5) Organizational Fit

The literature recognizes the importance of considering the unique situation of a specific school to select a warning technology that fits the school’s needs, yet it does not provide guidance on how to match a technological solution to a specific school. The K-12 EOP Guide stresses the importance of “customiz[ing] plans to the building level, taking into consideration the school’s unique circumstances and resources.” Schneider urges school decision-makers to identify the problems to solve before choosing a technology, consider the school’s specific needs, constraints, and variables, carefully analyze solutions, and then choose the appropriate technology. The RAND report agrees and stipulates that “technological solutions, if adopted, must be based on a need that is specific to a school district and school buildings—there is no one-size-fits-all solution.” The report went on to say that “any technology is only as good as the people running it, who are the key components of making schools safe.” The literature is in agreement about the need for customization and organizational fit.

4. Lack of Guidance for Selecting Technologies

The JHU report cautioned that “although some of the literature references the importance of ‘fit’ and meeting the specific needs of each school, there is limited evidence-based information on how to conduct a technology assessment to address such fit.” The JHU report says that “much of the general information and research on the effectiveness of school security technology [including communication and warning technology] is vendor-driven.” The RAND report agrees and notes that “despite the growth in the school safety technology sector, rigorous research about the effectiveness of these technologies is virtually nonexistent.”

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70 Office of Elementary and Secondary Education, Office of Safe and Healthy Students, Guide for Developing, 4.
71 Schneider, School Security Technologies, 1.
72 Schwartz et al., 33.
74 Johns Hopkins University Applied Physics Laboratory, 1–6.
75 Schwartz et al., Role of Technology, ix.
“Threat of Shootings Turns School Security into a Growth Industry,” Tiffany Hsu interviews Curtis S. Lavarello from the School Safety Advocacy Council following the Parkland, Florida school shooting. He said, “Right now, there’s going to be a lot of appropriations dollars being sent to school districts without a lot of oversight. [...] There are no national standards in terms of products for school safety.” 76 He also warned, “Often, schools react reflexively after high-profile school shootings, snapping up technologies and services as a symbolic gesture.” 77 Hsu also interviewed Heather L. Schwartz, a researcher for RAND, who points out that “There’s not a lot of evidence to help districts sort through the pile before investing in costly systems.” 78 She also contends that “There’s a lot of hunger for some authoritative third-party source to go out and review these options.” 79 In addition to the need for customization and organizational fit, the literature is also clear that school decision-makers lack guidance to draw from when selecting school safety technologies to meet their unique needs.

5. Technology Evaluation Frameworks

Finally, to fill that gap, technology evaluation frameworks were examined to try to identify a tool applicable for evaluating warning systems for use in the K-12 school environment. The models scrutinized included the Technology Acceptance Model (TAM), the HOT-Fit framework model, Morton’s IT-Organizational Fit Model, and Delone’s IS Success Model. From these, a model was identified that could be adapted to formulate an evaluation tool specifically for K-12 schools.

The TAM, developed by Davis in 1986, is a tool used to evaluate the acceptability of a new technology introduced into a system. 80 The main components of the TAM

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77 Hsu, “Threat of Shootings.”

78 Hsu, “Threat of Shootings.”

79 Hsu, “Threat of Shootings.”

framework include two primary factors, perceived usefulness and perceived ease-of-use. These variables are important for evaluating the potential acceptance of warning systems in K-12 schools, but do not go far enough. The complexity of the K-12 school environment also requires a framework that takes into account the organizational structure and environment, the efficacy of the technology in that system, and how the these elements intersect and interact. The TAM focuses primarily on the individual person level, rather than the more complex organizational level, and thus, is not a sufficient model alone for evaluating warning systems for K-12 schools.

These considerations led to the HOT-Fit framework. Yusof Maryati Mohd et al. developed the HOT-Fit framework in 2005 to evaluate the use of health information systems in hospital settings. It builds upon the strengths and limitations of two other technology evaluative frameworks, that of Morton’s IT-Organization Fit Model and Delone’s IS Success Model. Mohd et al. describe the assimilation of the frameworks: “Organizational factors, which are lacking in the IS Success Model, are featured in the IT-Organization Fit. Similarly, specific evaluation dimensions and measures, which are lacking in the IT-Organization Fit, are featured in the IS Success Model.” The basic framework of the HOT-Fit model emerged from these two, as shown in Figure 1.

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82 Mohd et al., 386–398.
85 Mohd et al., 388–389.
According to Mohd et al., the HOT-Fit framework includes three domains with specific performance measure categories: the Technology domain includes system quality, information quality, and service quality, the Human domain includes system use and user satisfaction, and the Organization domain includes structure and environment. The Net Benefits are derived from the evaluation of the three domains. This model is particularly useful for evaluating K-12 school warning technologies and systems because it goes further than the individual person level in Davis’ TAM by including key elements of the organization and technology domains. The HOT-Fit model, while originally designed for use in the hospital setting, is transferrable to the K-12 school setting by customizing each evaluation variable to school-relevant criteria.

6. Summary of Literature Review

In summary, this literature review reveals many reputable works aimed at understanding school violence and associated mitigation strategies. It also shows that several traditional and emerging communication and warning systems are used in schools, identifies five implementation factors related to the effective or ineffective implementation of such systems, and reveals a lack of information on how to evaluate and select warning system technologies for K-12 schools. During the course of the

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86 Adapted from Mohd et al., 389. This figure is a simplified rendering of the HOT-fit framework.
87 Mohd et al., 390–391.
literature review, several technology evaluation frameworks were found and one was identified, the HOT-Fit model, which is expanded upon and customized to evaluate warning system technologies for use in K-12 schools.

Finally, another gap emerged in the literature. It was not possible to locate any literature about warning systems with lockdown push-buttons or police pull-stations that imitate the fire alarm system, which, when activated, emit an immediate, audible warning to all school occupants alerting them to take protective measures, such as lockdown, when a potentially violent emergency is occurring at school. Internet searches, however, reveal that vendors have developed such systems and news reports indicate that some schools are experimenting with various iterations of the systems. Yet, as far as the researcher could find, other than vendor reports and news articles, the academic literature fails to acknowledge that these systems exist.

F. UPCOMING CHAPTERS

In review, Chapter I presented the goal of this thesis, which is to identify and attempt to validate the efficacy of a conceptual lockdown notification system that schools may be able to use to decrease the time it takes to warn school occupants of danger, so that protective measures, such as lockdown, can occur more quickly. The upcoming chapters exhibit how this goal can be achieved.

Chapter II examines the history, components, and requirements governing the school fire alarm system, and proceeds to use it as a model for a conceptual lockdown notification system for schools to address acts of violence.

Chapter III lays out a new K-12 School HOT-Fit Evaluation Tool specifically designed to evaluate communication and warning systems for use within the K-12 school setting. First, an overview of the new framework is presented, followed by a detailed description explaining the philosophy behind and justification for each evaluation variable contained in the tool.

Chapter IV introduces a template for the K-12 School HOT-Fit Evaluation Tool and proceeds to measure the fire alarm system and conceptual lockdown notification
system against the new K-12 School HOT-Fit Evaluation Tool to understand the strengths and weaknesses of each warning system as applied in the K-12 school setting. It also serves as a demonstration on how to use the new K-12 School HOT-Fit Evaluation Tool.

Chapter V focuses on the case study interviews from schools already using an iteration of a lockdown notification system modeled after the fire alarm system. The interview data is summarized according to the organization of the new K-12 School HOT-Fit Evaluation Tool. The chapter concludes with an analysis of the commonalities between the warning systems used by the case study participants and the conceptual lockdown notification system.

Finally, Chapter VI provides a summary of the thesis goals and a description of how those goals were accomplished. Findings related to the case study analysis, the conceptual lockdown notification system, and the K-12 School HOT-Fit Evaluation Tool are presented. The chapter concludes with recommendations.
II. THE FIRE ALARM SYSTEM AS A MODEL FOR A LOCKDOWN NOTIFICATION SYSTEM

This chapter has three sections. The introduction draws a comparison between the risk of fire at school and the need for a fire alarm system, and the risk of violence at school, and a similar need for a lockdown notification system. The next section focuses on the school fire alarm system. Historical information on school fires is provided, and the components of a school fire alarm system and the codes regulating such a system are identified. Since the fire alarm system is examined as a potential model for a lockdown notification system, the focus is on the notification features of the fire alarm system, rather than the detector and suppression features of the system. The third section focuses on a lockdown notification system. A conceptual lockdown notification system for schools modeled after the fundamental components, philosophy, and regulations of the fire alarm system is proposed. Finally, it is concluded that the school fire alarm system does in fact represent a potentially viable model for a parallel lockdown notification system to address the need for speedy notification during active shooter attacks on K-12 schools.

A. INTRODUCTION

Many deadly fires occurred in U.S. schools before the establishment of the fire alarm system. Whether from a fire in the boiler room, school kitchen, or one intentionally set, fire can spread rapidly through a school. Unsuspecting students and staff must be quickly alerted to the danger and immediately evacuate the building. Delays in this notification cost lives. Over time, the fire alarm system was developed and integrated into U.S. schools. The primary goal of a school fire alarm system is a speedy warning to all school occupants to prevent injuries and loss of life from fire, smoke, and associated

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cascading effects. The success of the fire alarm system is indisputable; while fires still occur in U.S. K-12 schools, children have not died in school fires for over 50 years.90

Today, the United States experiences many deadly active shooter attacks on K-12 schools. Studies show that these events occur quickly, often within minutes from when an intruder enters a school.91 Most schools are not equipped with reliable and readily available warning systems to make timely notifications to their staff and students so that they may take protective measures, such as lockdown, at the first sign of danger. Delays in these notification cost lives. The primary goal of a school lockdown notification system is relaying a speedy warning to all school occupants. While active shooter attacks on U.S. K-12 schools may still happen, the hope is that a lockdown notification system will enable school occupants to lockdown quicker and reduce the likelihood that the aggressor will have access to students and staff and thereby prevent injuries and loss of life.

Significant parallels can be drawn between these two threats, fire and shootings, and the need for speedy notification. In “Those Terrible First Few Minutes, Michael and Geoffrey Buerger illustrate these parallels by explaining:

Notification has two stages: internal notice to effect lockdown procedures and communication of the emergency to police authorities. School-intruder situations have no equivalent of the fire alarm, which initiates both notifications simultaneously. Instead, notice is volitional, with an expected hierarchy of action invested presumptively in a central administrative office. Because not all events begin with the office, however, planning needs to encompass circumstances in which notification is executed by other staff.92


91 Blair and Schweit, Active Shooter Incidents, 9.

The goal of this chapter is to answer the question: To what extent can the school “fire alarm system” (for emergencies involving fire and evacuation) be a model for a “lockdown notification system” for emergencies involving violence and requiring lockdown?

B. THE SCHOOL FIRE ALARM SYSTEM

In the first half of the 1900s, U.S. K-12 schools had many deadly fires. According to the NFPA’s historical records, these school fires caused casualties ranging from 15 deaths at Cleveland Hill School in Cheektowaga, NY, to 294 deaths in the New London, TX, Consolidated School. Table 1 shows school fires in the United States with 10 or more deaths.93

Table 1. School Fires with 10 or More Deaths.94

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Number of Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consolidated School, New London, TX</td>
<td>March 18, 1937</td>
<td>294</td>
</tr>
<tr>
<td>Lakeview School, Collinwood, OH</td>
<td>March 4, 1908</td>
<td>175</td>
</tr>
<tr>
<td>Our Lady of the Angels School, Chicago, IL</td>
<td>December 1, 1958</td>
<td>95</td>
</tr>
<tr>
<td>The Cleveland School, Kershaw County, SC</td>
<td>May 17, 1923</td>
<td>77</td>
</tr>
<tr>
<td>Bath Consolidated School, Bath, MI</td>
<td>May 18, 1927</td>
<td>46</td>
</tr>
<tr>
<td>Babbs Switch School, Hobart, OK</td>
<td>December 24, 1924</td>
<td>32</td>
</tr>
<tr>
<td>St. John’s Parochial School, Peabody, MA</td>
<td>October 28, 1915</td>
<td>21</td>
</tr>
<tr>
<td>Cleveland High School, Cheektowaga, NY</td>
<td>March 31, 1954</td>
<td>15</td>
</tr>
</tbody>
</table>

This trend of deadly school fires has dramatically changed over the last 50 years since no children have died in school fires during that timeframe.95 A study of school

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fires from 2007–2011 showed an average of 4,060 structure fires per year in K-12 schools, and while these school fires did cause injuries, no deaths were reported.96 Michael Dorn, in his book, *Innocent Targets, When Terrorism Comes to School*, describes the risk of death at school by fire versus by acts of violence in this way:

> Consider the way we approach fire safety in schools. The probability of a student being killed or seriously injured by violence is significantly greater than the probability of being killed or seriously injured by fire. No child has been killed by school fire in North America in over a quarter of a century. Compare this to the fact that, in any given year in our schools, dozens of students and employees are killed by acts of violence.97

Over the years, the NFPA has worked to reduce and even eliminate school fire-related deaths by implementing an extensive, multi-layered, and research-based fire life-safety system in schools. The purpose of a school fire alarm and signaling system, as recorded in the national fire code, is “to provide notification of alarm, supervisory, and trouble conditions; to alert the occupants; to summon aid; and to control emergency control functions.”98 This system’s successful implementation in United States’ schools has demonstrably saved lives. Fires still occur in K-12 schools in the United States, yet it appears rare that students and staff die in these school fires.

The overarching goal of the fire alarm system is to reduce the amount of time it takes to notify school occupants of the need to evacuate the building to prevent injuries and loss of life when a fire is imminent. The primary objective is to empower anyone in the building to alert the entire school population quickly and easily of a need to evacuate, and to be able to do so from multiple places on the school campus. The secondary objective is that the system automatically alerts the fire department, so it can initiate its response to the school. The fire alarm system accomplishes these very objectives.

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95 Grossman, “How Many Kids Have Been Killed by School Fire?”
97 Dorn and Dorn, *Innocent Targets When Terrorism Comes to School*, xviii.
1. Fire Alarm System Components

A school fire alarm system has many components: The first is a fire alarm control panel (FACP), which is the main hub of operation for all aspects of the system. It has a communication panel to notify an alarm company, 911 dispatch center, or fire department. It also has associated wiring, relays, and circuits. Next, are initiating appliances, such as fire alarm pull-stations and various detectors, as well as notification appliances, such as horns, strobes, and speakers. Also, emergency control functions operate sprinklers, heating, ventilation and air conditioning shut offs, automatic door closure mechanisms, and elevator return functions. Other components of the larger fire life-safety system strategy include fire extinguishers, fire blankets, lighted exit signage, required inspections, and training and drills.

The NFPA establishes codes and regulations for every aspect of these systems, identified in the NFPA 72 National Fire Alarm and Signaling Code as, “the application, installation, location, performance, inspection, testing, and maintenance of fire alarm systems, supervision station alarm systems, public emergency alarm reporting systems, fire warning equipment and emergency communications systems (ECS), and their components.”99 Since this document is so carefully researched, frequently updated, regulated, and enforced, the fire alarm system has become a distinguished and exemplary school warning system.

2. Characteristics of a Fire Alarm Control Panel

FACPs are made up of two types, conventional and addressable. Conventional FACPs are older and work off the zone system that monitors a group of initiating appliances (pull-station, smoke detector, etc.), within a given zone. The result is that if an initiating appliance is activated, the FACP will indicate only the zone in which that appliance resides. With an addressable (sometimes called intelligent) FACP, each individual initiating appliance has its own address, so if it is activated, the FACP will identify the exact initiating device causing the alarm or trouble. For the purposes of this

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99 National Fire Protection Association, NFPA 72 National Fire Alarm and Signaling Code, 1.1 Scope, 1.1.1.
paper, the researcher is focused on the more basic and reliable type, the conventional FACP, as shown in Figure 2.

![Figure 2. Conventional Fire Alarm Control Panel.](image)

A conventional FACP is the main hub of operations for the system. It has a fixed power supply and back up batteries in case of an electrical outage. The Life Safety Code Handbook says that “primary power must come through a dedicated branch circuit […] Secondary power is intended to operate all functions of the system in the event that primary power is lost.”\(^\text{101}\) The fire code requires that the secondary power source provide 24 hours of operation of the entire system, with at least five minutes of alarm sounding capability.\(^\text{102}\) This redundancy represents a key component of the reliability of this system. It is even effective during power outages, internet disruptions, and with cell service limitations and outages.

The FACP has “zones” that monitor the flow of electricity and current to the “initiating appliances,” such as fire alarm pull-stations and various smoke and heat

\(^{100}\) Susan M. Graves created this basic rendering of a FACP.


\(^{102}\) Schifiliti, 1129.
detectors. An “alarm” and “trouble” indicator identifies when an “alarm” has actually been activated by a detector or a pull-station, or if a problem (trouble) exists with the wiring or other part of the system. The FACP has a sounder circuit that activates the “notification appliances,” such as bells, strobes, or horns.\textsuperscript{103} Wire runs from the FACP throughout the school building to all the individual components of the fire alarm system. The NFPA regulates every aspect of the pathway wiring, cables, circuits, and associated equipment necessary for the fire alarm system.\textsuperscript{104} The system also includes a “communication panel” that connects the FACP to two dedicated landline phone lines that automatically notify the alarm company when an initiating appliance is activated. These two dedicated phone lines represent an additional layer of redundancy and reliability essential for school warning systems.

3. Characteristics of Initiating Appliances

Initiating appliances are devices designed to activate and set the fire alarm system in motion. They include fire alarm pull-stations and various detection devices, such as heat and smoke detectors. For the purposes of replicating the fire alarm system into a similar viable lockdown notification system model, the fire alarm pull-station initiating appliance is focused upon rather than the detection devices.

a. Appearance

The fire code has specific requirements regulating the appearance of fire alarm pull-stations, as shown in Figure 3. They are red and have a contrasting background.\textsuperscript{105} They always display the word FIRE and include other instructive words, such as PULL, PUSH IN and PULL DOWN, etc., depending on how the device functions. The NFPA

\textsuperscript{103} Sounder circuits are sometimes called notification appliance circuits.

\textsuperscript{104} National Fire Protection Association, \textit{NFPA 72 National Fire Alarm and Signaling Code}, Chapter 12 Circuits and Pathways states that “Fire alarm system wiring and equipment, including all circuits controlled and powered by the fire alarm system, shall be installed in accordance with the requirements of this Code and of NFPA 70 Article 760.”

code states, “Manual fire alarm boxes shall be used only for fire alarm initiating purpose.” The word “FIRE” serves a dual purpose; it indicates that the device is for fire emergencies and it insinuates that the fire department is alerted when the device is activated.

![Figure 3. Fire Alarm Pull-Stations.](image)

b. Placement and Accessibility

The initiating appliances are about the same size, look similar, and must be easily recognizable and readily available. The NFPA requires that they are “securely mounted […] conspicuous, unobstructed, and accessible.”107 Some appliances have corresponding signage to assist users. The red pull-stations are permanently located throughout the school. They are available when school is in session and during non-school hours for patrons using the school in the evening, on weekends, and during school breaks. Pull-stations are securely mounted between 3-1/2 and 4-1/2 feet high, and are located within five feet of designated exit doors so they can quickly be activated as people exit the building. They are also mounted in other areas so that they are at least within 200 feet of

106 These pictures of pull-stations were taken by Susan M. Graves.

each other.\textsuperscript{108} Schifiliti noted that “some locally adopted codes for the disabled might limit the height to no more than 4 ft (1.2 m).”\textsuperscript{109} Wiring runs throughout the building connecting the FACP to each fire pull-station in the school. This hardwire feature provides another source of redundancy for the warning system.

c.  \textit{Ease-of-Use}

The fire code allows for fire alarm pull-stations to be activated by a single or double-motion; for instance, pushing in and pulling down would be a double-motion.\textsuperscript{110} This activation is significant because fine motor skills can be compromised during emergencies. In other words, the more operations people have to perform when under extreme stress, the less likely they will be able to do them. In fact, when individuals are under extreme stress, diminished capacity to process complex information or accomplish straightforward tasks is experienced. Silver explains, “it becomes very difficult to think clearly, make rational decisions and communicate civilly and effectively.”\textsuperscript{111} The fire alarm pull-stations are intuitive and easy to operate and require little to no training. This ease-of-use helps to reduce confusion during emergencies and empowers students, staff, and visitors to activate the system despite those natural stress responses. Pull-stations do not require any keys, special codes, or knowledge to access or activate. These important criteria contribute to their ease-of-use and accessibility, which are critical factors in emergencies. Once activated, they automatically sound the alarm in the school and alert the fire department via the school’s alarm company. The person activating the system

\begin{footnotesize}
\begin{enumerate}
\item National Fire Protection Association, \textit{NFPA 72 National Fire Alarm and Signaling Code}, 17.14.5 states that “The operable part of a manually actuated alarm-initiating device shall be not less than 42 in. (1.07 m) and not more than 48 in. (1.22 m) from the finished floor.” National Fire Protection Association, 17.14.8.4 states that “Manual fire alarm boxes shall be located within 5 ft. (1.5 m) of each exit doorway on each floor.” National Fire Protection Association, 17.14.8.5 states that “Additional manual fire alarm boxes shall be provided so that the travel distance to the nearest manual fire alarm box will not exceed 200 ft (61 m), measured horizontally on the same floor.”
\item Schifiliti, \textit{Supplement 2 Fire Alarm Systems}, 1117.
\item National Fire Protection Association, 17.14.4, 6, 8.3 states that “Manually actuated alarm-initiating devices shall be permitted to be single action or double action.”
\end{enumerate}
\end{footnotesize}
does not have to follow up with additional actions or notifications for the immediate warning to go out.

d. Protective Covers

Some pull-stations have protective covers that require lifting up to access the device.\textsuperscript{112} This cover helps to avoid accidental activation and keeps out dust and moisture. Some have deterrent alarms “with an internal battery-operated buzzer” that emits directly from the pull-station when the protective cover is lifted.\textsuperscript{113} It is much quieter than a fire alarm and simply acts as a deterrent for times when someone seeks to set off the alarm as a prank. According to the \textit{Life Safety Code Handbook}, “This feature has been shown to greatly reduce nuisance alarms in schools [...since] someone is likely to see or catch a vandal before the station is operated.”\textsuperscript{114} Some pull-stations in high-risk areas, such as gymnasiums, have protective guards to prevent accidental activation from errant balls, etc. The fire code does not require the use of protective covers or deterrent alarms, and leaves the decision up to the schools and their local fire jurisdiction partners.

In summary, initiating appliances, such as red fire alarm pull-stations, are strategically located in many places throughout the school, accessible to anyone using the school, at any time of the day or night. Since they are (a) permanently secured to the wall, (b) always where you think they will be, (c) red, which makes them easy to see, and (d) printed with the word FIRE on the devices, which makes their purpose intuitive for users, they are easy to use and require minimal to zero training. Once activated, they automatically send a signal to the FACP. The FACP simultaneously directs the communication panel to notify the alarm company to alert the fire department and activates the notification appliances so students and staff hear the alarm, see the strobe, and evacuate the building.

\textsuperscript{112} National Fire Protection Association, \textit{NFPA 72 National Fire Alarm and Signaling Code}, 17.14.7 states that “Listed protective covers shall be permitted to be installed over single-or double-action manually actuated alarm initiating devices.”

\textsuperscript{113} Schifiliti, \textit{Supplement 2 Fire Alarm Systems}, 1116.

\textsuperscript{114} Schifiliti, 1116.
4. Characteristics of Notification Appliances

Like initiating appliances, notification appliances are also highly regulated by the NFPA. The purpose of notification appliances, according to NFPA 72, is to “provide stimuli for initiating emergency actions and provide information to users, emergency response personnel, and occupants.”115 The notification appliances notify school staff and students to evacuate while simultaneously notifying the alarm company. The notification appliances use both audible and visual notification stimuli.

The NFPA 72, Chapter 18, regulations provide detailed specifications for the notification appliances themselves and includes guidance related to electrical requirements, the physical construction of the appliances, mechanical protections, mounting requirements, and detailed audible and visual characteristics.116 It also provides regulation for the specific relationship of the notification appliances components to the overall fire alarm system. “The requirements […] apply to the interconnection of notification appliances, the control configurations, the power supplies, and the use of the information provided by notification appliances.”117 The guidance is detailed, comprehensive, and specific.

School fire alarm systems have audible and visible notification appliances. The NFPA fire code dictates the visual appearance of these appliances, the color of the light, wording and text, the decibels, length of time the alarm sounds, the strobe light features, and detailed specifications regarding the placement of the appliances.118 They can be located in indoor or outdoor environments, based on the specific needs of the facility.119

116 National Fire Protection Association, Chapter 18, Notification Appliances.
117 National Fire Protection Association, Chapter 18, Notification Appliances, 18.1.6.
118 National Fire Protection Association, Chapter 18, Notification Appliances.
119 National Fire Protection Association, 18.1.7 states that “Notification appliances shall be permitted to be used within buildings or outdoors and to target the general building, area, or space, or only specific parts of a building, area, or space designated in specific zones and sub-zones”; National Fire Protection Association, 18.3.3.1 states that “Appliances intended for use in special environments, such as outdoors versus indoors, high or low temperatures, high humidity, dusty conditions, and hazardous locations, or where subject to tampering, shall be listed for the intended purpose.”
a. Audible Notification Appliances

Audible notification appliances, such as horns, bells, and chimes, work to get everyone’s attention and signal the evacuation, as seen in Figure 4. The *Life Safety Code Handbook* indicates, “it must be distinct and clearly audible in all occupiable spaces.”\textsuperscript{120} The sound it emits cannot be the same tone, bell, horn or other sound schools use for earthquake or any other notification. “For instance, in a school, bells should not be used on a fire alarm system if bells are also used to signal class changes and recess. Similarly, in buildings equipped with earthquake warning systems, the fire signal needs to be distinct from an earthquake signal and recognizable by the occupants.”\textsuperscript{121} Actions to take for changing classes, as well as responding to an earthquake and a fire are very different. Too many similar tones, horns, or sounds can cause confusion. Confusion in the midst of emergencies can cause students or staff to hesitate or respond incorrectly. Either hesitation or an incorrect response can cause injuries or loss of life. If more than one warning sound is incorporated into the school’s emergency procedures without a corresponding voice message, it must be distinct, and students and staff must be trained accordingly.

\textsuperscript{120} Schifiliti, *Supplement 2 Fire Alarm Systems*, 1132.

\textsuperscript{121} Schifiliti, 1133.
Figure 4. Audible Notification Appliances.122

The fire alarm signaling code is specific about the pattern of a fire alarm signal, “The alarm audible signal pattern used to notify building occupants of the need to evacuate (leave the building) or relocate (from one area to another) shall be the standard alarm evacuation signal consisting of a three-pulse temporal pattern.”123 The code provides specific regulations for the length of each pulse, repetition times, as well as synchronization with other audible alarms in nearby locations.124 Moreover, it even regulates how loud the alarm can be in different environments in the school building, including elevators.125 All areas in a school must be evaluated and equipped with an appropriate audible notification for the environment. The audible notification device must be secured to ceilings or to walls at least 90 inches from the floor.126

b. Visual Notification Appliances

Visual notification appliances, such as lights, strobes, and text displays augment the audible devices and work to meet the needs of people with hearing impairments. The NFPA defers to local jurisdictional regulations and laws regarding any requirements to utilize visual notification appliances.127 If visual appliances are used, the NFPA regulates their specifications. The color of the light has to be clear or white, the flash rate has to be between one and two seconds, and the device must be mounted on the ceiling or at least


124 National Fire Protection Association, Temporal Pattern Parameters, 18.4.2.1–4.

125 National Fire Protection Association, Public Mode Audible Requirements, 18.4.3, Private Mode Audible Requirements, 18.4.4.

126 National Fire Protection Association, Location of Audible Notification Appliances for Building or Structure, 18.4.8.

127 National Fire Protection Association, 18.5.1.2 states that “The coverage area for visible occupant notification shall be as required by other governing laws, codes, or standards.”
80 inches above the floor.\textsuperscript{128} The fire code also regulates the spacing of such appliances based on room or corridor characteristics.\textsuperscript{129} Although the light must be clear or white, the code does not specify the color of the appliance emitting the light.

It is common to combine these audible and visible notification appliances into one device called a horn-strobe, although they can also be separate. Like the initiating appliances, each individual horn-strobe is hardwired to the FACP. This hardwire feature contributes to the reliability of the warning system. The result is that when an initiating appliance is activated, the horn-strobe automatically comes on and notifies the entire school, by a loud alarm and by a visual strobe, to evacuate the building.

5. **Inspection, Testing, and Maintenance**

School fires are relatively infrequent events, but can have great consequences. A fire alarm system must be a reliable and operational warning system at all times through inspection, testing, and maintenance.\textsuperscript{130} Chapter 14 of the NFPA 72 regulations requires strict maintenance guidelines, inspections, and system testing to “ensure operational integrity.”\textsuperscript{131} These requirements can be performed by a qualified building owner or by the owner’s designee or contractor. The code dictates that “system deficiencies shall be corrected.”\textsuperscript{132} For school fire alarm systems monitored by alarm companies, most of these tasks are only required annually, or in some cases, semiannually. The control equipment in the system are inspected and tested annually to “verify a system normal condition.”\textsuperscript{133} A visual inspection is also done to “ensure there are no changes that affect equipment performance. Inspect for building modifications, occupancy changes, changes in environmental conditions, device location, physical obstructions, device orientation,

\begin{enumerate}
\item \textsuperscript{128} National Fire Protection Association, Light, Color, and Pulse Characteristics, 18.5.3, Appliance Location, 18.5.5.
\item \textsuperscript{129} National Fire Protection Association, 18.5.5.4–5 Room Spacing and Spacing in Corridors.
\item \textsuperscript{130} National Fire Protection Association, Chapter 14 Inspection, Testing, and Maintenance.
\item \textsuperscript{131} National Fire Protection Association, Performance Verification, 14.2.2.1.
\item \textsuperscript{132} National Fire Protection Association, 14.2.2.2.2.
\item \textsuperscript{133} National Fire Protection Association, Visual Inspection, 14.3.1.
\end{enumerate}
physical damage, and degree of cleanliness.”\textsuperscript{134} The requirement for audible and visual
notification appliances is semiannual inspections. Batteries may require more frequent
inspections, either monthly or semiannually, depending on the type of battery.\textsuperscript{135} The
system is also exercised and tested during regular fire drills, and has a system built in to
detect trouble situations, such as malfunctions. All these measures work together to
ensure the fire alarm system is functional and reliable at all times.

6. Financial Feasibility

The initial expenses involved with a fire alarm system include the FACP
components, initiating appliances, notification appliances, and all the wire that connects
this system together. The hardware, wire, and installation costs represent the bulk of the
cost of the warning system. After installation, ongoing costs for the fire alarm system are
minimal. Other than the annual (and some semi-annual) inspection requirements, and
minimal maintenance, only a small monthly fee is assessed for monitoring paid to the
alarm company. Once installed, it is generally a financially sustainable warning system
for K-12 schools.

7. Summary of the Fire Alarm System

All the fire alarm system components, the FACP, initiating appliances, and
notification appliances work together to provide a standardized, seamless, and reliable
mechanism built into the infrastructure of U.S. schools by which:

- School occupants who detect smoke or fire can quickly activate a fire pull-
  station (initiating appliance).

- The FACP immediately notifies (using the notification appliances) the
  whole school to evacuate the building.

- It simultaneously notifies the alarm company (through the dedicated
  phone lines) to activate the fire department response.

\textsuperscript{134} National Fire Protection Association, Visual Inspection, 14.3.1.
\textsuperscript{135} National Fire Protection Association, Visual Inspection, 14.3.1.
The fire alarm system works well in the unique environment of K-12 schools. It is easy to use, reliable, affordable, easy to maintain, and effectively fulfills its purpose in schools: while school fires still occur, no deaths in school fires have been reported in over 50 years.137

C. A CONCEPTUAL LOCKDOWN NOTIFICATION SYSTEM

Schools all over the nation are susceptible to intruders, kidnappings, threats of violence, and active shooter attacks. Schools use many strategies to prevent, mitigate, protect from, respond to, and recover from these threats.138 One commonly accepted strategy to protect students and staff from these threats is lockdown. Many schools practice lockdown drills and have lockable classroom doors to secure students and staff during emergencies involving threats of violence.139 To initiate a lockdown, personnel in the school’s front office use the public address system to make an announcement over the

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136 All images are from Creative Commons, a company that issues public copyright licenses to enable the free distribution of otherwise copyrighted work.

137 Grossman, “How Many Kids Have Been Killed by School Fire?”


139 Graves, “Lockdown Terminology in K-12 Schools.”
speakers located throughout the school building. As soon as students and staff hear the lockdown announcement, they immediately implement lockdown procedures.

In many K-12 school districts, the public address system is only accessible from the main office at each school. If someone notices or learns of a dangerous person or threat in another area of the school campus, such as the cafeteria, a hallway, or the gymnasium, it takes critical time to get a message to the main office for them to make a lockdown announcement. This time gap can cost lives. In “Those Terrible First Few Minutes,” Michael and Geoffrey Buerger explain that “the most important duty of the person making first contact is to communicate the potential danger to others.”140 They continue by pointing out, “If lockdown is ordered swiftly and clearly […] the associated protective factors take effect almost immediately. If such action is not an automatic response because of uncertainty, the intruder gains an advantage that expands risk to the school population.”141 K-12 schools need a mechanism to notify students and staff immediately when a threat of violence is first recognized anywhere in the school.

The overarching goal of a lockdown notification system is to reduce the amount of time it takes to lockdown to try to prevent injuries and loss of life when an attack is imminent or occurring. The primary objective is to empower anyone in the building to alert the entire school population easily and immediately of a need to lockdown, and to be able to do so from multiple places on the school campus. The secondary objective is that the system automatically notifies police, so they can initiate their response to the school. Since the fire alarm notification system fulfills these very objectives as they relate to school fires and evacuations, this case study will replicate and modify it as a model to address the need to lockdown during threats of violence in K-12 schools.

1. Lockdown Notification System Components

A school lockdown notification system modeled after the fire alarm system has several components. The first is a lockdown notification control panel (LNCP), which is the main hub of operation for all aspects of the system. The LNCP connects to a shared

140 Buerger and Buerger, Those Terrible First Few Minutes.”
141 Buerger and Buerger.
communication panel with the fire alarm system to notify an alarm company, 911 dispatch center, or police department. It also has associated wiring, relays, and circuits. Next are the initiating appliances, such as pull-stations or push-buttons, and associated signage. Finally, a lockdown notification system uses notification appliances, such as speakers and strobes to send out the warning message.

Some elements of the lockdown notification system will connect to the fire alarm system to reduce costs. Other components of the lockdown notification system are independent yet closely modeled after the fire alarm system. The lockdown notification system will be compliant with fire code regulations. The same NFPA 72 code that regulates the fire alarm system will regulate the lockdown notification system.\textsuperscript{142} Chapter 24 of the \textit{NFPA 72}, Emergency Communications Systems (ECS) states:

This chapter establishes minimum required levels of performance, reliability, and quality of installation for emergency communications systems [...] An emergency communications systems is intended to communicate information about emergencies including, but not limited to fire, human-caused events (accidental or intentional), other dangerous situations, accidents, and natural disasters.\textsuperscript{143}

In addition, further guidance from the NFPA, issued in 2015, addresses alerts and warning messages as found in Annex G, \textit{Guidelines for Emergency Communication Strategies for Buildings and Campuses}.\textsuperscript{144} These standards will guide decision making for the actual alert and warning messages used for a lockdown notification system.

\section*{2. Characteristics of a Lockdown Notification Control Panel}

The LNCP will be a standalone unit, almost identical to the FACP but with a sounder circuit that includes a recorder device for housing the prerecorded alert and lockdown message. It will share the main building power supply, but will have its own backup batteries that meet the same code requirements for secondary power as the fire

\textsuperscript{142} National Fire Protection Association, \textit{NFPA 72 National Fire Alarm and Signaling Code}.
\textsuperscript{143} National Fire Protection Association, Chapter 24 Emergency Communications Systems (ECS) 24.2.2–3.
\textsuperscript{144} National Fire Protection Association, Annex G Guidelines for Emergency Communications Strategies for Buildings and Campuses.
alarm system. See Figure 6. This redundancy will aid in the critical reliability component necessary for school warning systems. The LNCP can relay into the same communications hub as the FACP and share the two phone lines to notify the same alarm company used for the fire system. The LNCP would have a specific police notification designation for the alarm company so they would dispatch police rather than fire personnel when the lockdown notification system is activated. Sharing the alarm company for both control panels adds a modest yet feasible monthly cost. Since schools are already accustomed to this regular expenditure, it is likely to be financially sustainable.

![Figure 6. Conceptual Lockdown Notification Control Panel.](image)

The LNCP will use the same NFPA codes and standards for zones, relays, and wiring that monitor the flow of electricity and current to the initiating appliances, as the fire alarm system. If possible, the control panels will be in the same location to tie easily into and share the communications hub. Some schools will have space on the wall

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146 This is a conceptual diagram created by Susan M. Graves of the basic components of a fire alarm control panel and a lockdown notification control panel and their shared components.

147 National Fire Protection Association, *NFPA 72 National Fire Alarm and Signaling Code*, Chapter 12 Circuits and Pathways states that “Fire alarm system wiring and equipment, including all circuits controlled and powered by the fire alarm system, shall be installed in accordance with the requirements of this Code and of NFPA 70 Article 760.”
near the existing FACP to mount a LNCP to make it easier for facilities personnel and first responders to locate the control panels. Other schools may find it challenging to find space near the FACP and will have to mount the LNCP in a different room and take additional steps to connect the LNCP to the communications panel. Regardless, signage is necessary for both control panels so that fire personnel and law enforcement personnel can easily distinguish between the two control panels. Fire personnel are accustomed to the presence of FACPs in schools, and have regular experience using them. Law enforcement officers may not have this regular experience and training advantage. It is necessary to post operation instructions for each control panel describing how to determine from where it is activated, and how to test, silence, and reset the control panel. With clear, intuitive signage and instructions, located at the LNCP, a law enforcement officer with minimal training should be able to operate the LNCP.

3. Characteristics of Initiating Appliances

The initiating appliance for a lockdown notification system can be modeled closely after the fire alarm initiating appliances using pull-station or push-button boxes. In fact, the fire code allows for and regulates such devices, “non-fire emergency manual actuating boxes shall be installed similarly to manual fire alarm boxes.” Even more important than the type of device are decisions about what happens when the initiating device is activated. The system should be part of a school’s comprehensive emergency operations plan. The NFPA code says, “Devices connected to a mass notification system for the purpose of initiating an automatic response to an emergency shall be evaluated based on the emergency response plan.” School decision-makers should collaborate with their emergency service partners to determine what the activation of the device should accomplish. Like the fire alarm system, for this case study, the objectives are automatic notification to everyone at school and to the police via the alarm company. A

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148 Schools may want to consider assessing the current FACPs to see what color they are, and select a different, but consistent color for all the LNCPs so they are clearly distinguishable from the FACP.


150 National Fire Protection Association, 24.5.9.1.
Google search reveals that several of these initiating appliances already exist; however, none have emerged with a standardized appearance, as shown in Figure 7.

![Initiating Appliances](image)

Figure 7. Initiating Appliances.\textsuperscript{151}

\textbf{a. Appearance}

Careful consideration should go into decisions about the appearance of the initiating appliances to communicate its purpose clearly. The color should be distinctly different from a fire alarm pull-station to reduce uncertainty and confusion when under extreme stress. For example, the color red has been associated with fire alarm pull-stations for decades and is standardized throughout the United States. A red “lockdown” push-button device may appear too similar to a red “fire” alarm pull-station, which can cause someone to be confused and either activate the wrong device or delay activation due to uncertainty over which device to use, as shown in Figure 8.

This example shows what a lockdown initiating appliance should not look like due to the potential confusion caused by the similar red devices.

Figure 8. Incorrect Appearance of a Lockdown Initiating Appliance.152

In fact, the fire code requires that a non-fire device “be of a contrasting color to manual fire alarm boxes […] and not be red. [And also requires that they be] mounted on a background of contrasting color.”153 This contrasting color can improve the visibility of the device by reducing the likelihood that it blends in with the background wall.

Just as red is a standardized color for fire alarm initiating appliances, it is ideal that a standardized color emerge for lockdown notification appliances. Blue is an intuitive color choice for a lockdown initiating appliance since blue is widely associated with police and is a distinctly different color than the traditional red fire pull-stations.

Since an existing standardized appearance for initiating appliances for school lockdowns is not already institutionalized in United States’ school systems, the initiating appliances will need to display plain language and be intuitive, easy to understand, and simple to use. The variety of lockdown initiating appliances shown in Figure 7 clearly identifies how to operate the devices: push here, lift & pull, push, etc., and some even display arrows to explain the required action. However, most do not clearly communicate what will occur when activating the device.


School decision-making teams must carefully select and place the text on the device to help establish the intent of the device. Since no standards are in place to guide the exact words on non-fire initiating appliances, other than not using the word “fire,” simply placing the word “lockdown” or “emergency” or “police” on the device may not communicate to the user what will happen when the device is activated. Minimal, carefully chosen words can help communicate the desired message. The text on the initiating appliance should clearly communicate how to use the device, and convey the purpose of the device to assist the user in understanding what type of hazard or threat for which it is to be used. It should also suggest what occurs when the device is activated. For example, a lockdown announcement will play and the police notified. The text should be easy to read. The fire code requires the text to be in “all caps.” The word selection on the initiating appliance should contribute to being intuitive and easy to understand and use.

This conceptual blue lockdown initiating appliance as shown in Figure 9 provides an example that demonstrates word choice to match the purpose of the appliance. The decision-making teams will need to test the word choice and placement of the words to determine if these examples constitute too many words on the appliance.

Figure 9. Conceptual Blue Lockdown Initiating Appliance.154

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The fire code also requires the appliance have markings to accommodate the visually impaired, “Non-fire emergency manual actuating boxes shall have tactile markings.” Teams can consider strategies, such as raising the lettering on key words for lockdown, police, and push since there is not room for text in Braille. The tactile markings may also be placed on associated signage.

The same kind of care is necessary for the appearance and language on any signage associated with the lockdown initiating appliance. Signage affixed near the device can help people understand the function of the device, which is especially important when introducing a non-standardized new warning system. The signage can help with the ongoing education needs of those who use the school facility on a regular basis. It can further aid the understanding of the devices for those who use the school facilities less frequently, such as during non-school hours. It can also be a mechanism for educating students on the school’s consequences for the nefarious use of the device. Signage should be placed near the lockdown initiating appliances, as shown in Figure 10.

Figure 10. Signage Design for the Lockdown Initiating Appliance.

All these factors empower people to use the device with little or no training. This training is particularly important for infrequent events, such as active shooter

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155 National Fire Protection Association, NFPA 72 National Fire Alarm and Signaling Code, 24.5.9.5.

156 The researcher developed this sign based on the plain language text on the conceptual lockdown push-button as an example. Schools will need to determine if they want to include specific sanctions for misuse, and if so, determine appropriate sanctions based on the laws, statutes, and policies of their jurisdiction.
emergencies since it can be difficult to remember how to use warning systems when not used often.

b. Placement and Accessibility

Like fire alarm pull-stations, lockdown buttons should be easy to locate and access. Fire code requires them to be fixed in place, “Manually actuated alarm-initiating devices shall be securely mounted,” and placed between 42 and 48 inches high for ADA considerations. Securely mounting the devices so they are always where they should be, never moved or misplaced, speak to the reliability factor. These NFPA regulations involving “securely mounting the appliances” seem to rule out mobile or portable initiating appliances, such as pendant necklaces.

The placement of the initiating devices should be consistent with the problem the school is trying to solve and align with the goals and objectives set forth for the system. For example, fire alarm pull-stations are typically located near exit doors so that they are easily accessible to activate as occupants leave (evacuate) the building. They are also located in high-occupancy areas like gymnasiums and cafeterias; again, usually positioned near exits. The lockdown initiating appliances need to be easily accessible to activate as occupants lockdown. At a minimum, the lockdown initiating appliances should be placed in common areas, such as hallways, cafeterias, gymnasiums, and other large gathering areas throughout the school. Ideally, they would also be located in every classroom, so that individuals do not feel compelled to exit their classroom to locate and activate a lockdown button.

Emergencies involving weapons and violence can happen at any time the school is being used, day or night. The K-12 EOP Guide instructs schools to “account for incidents that may occur during and outside the school day.” Like the fire alarm pull-stations, the initiating appliances for a lockdown notification system must be functional and accessible during and after regular school hours to anyone using the school. The

strategic placement and ease-of-use of the devices will accommodate access for those using the facilities during non-school hours.

The lockdown initiating appliances should be placed distinctly away from fire alarm pull-stations to lessen further confusion in a stressful situation. Johns Hopkins University’s *A Comprehensive Report on School Safety Technology* considers duress alarms by pointing out, “whether the intent is to create an alert discreetly or overtly, the school must be strategic about placing these alarms in areas that can be accessed during routine operations so that staff are not forced to put themselves into additional danger to activate an alarm.” 159 The same devices can be located in school offices as a point of redundancy for office personnel who normally use the public address system for emergency announcements. For schools that have exterior walkways between buildings, additional security measures may be necessary to protect against intentional false alarms for any devices placed outside, since they may be accessible even when the school is closed.

c. **Ease-of-Use**

Similar to the fire alarm pull-stations, lockdown initiating appliances will have a single or double motion, which makes them easy to use while under stress. They will not require any keys, special codes, or knowledge to access or activate. These important criteria contribute to their ease-of-use and accessibility, which are critical factors in emergencies. With the corresponding signage, they should require little to no training. Once activated, they automatically activate the pre-recorded tone and warning message in the school and alert the police department via the school’s alarm company. The person activating the system does not have to follow up with additional actions or notifications for the immediate warning to go out.

d. **Protective Covers**

Clear protective covers are used to help avoid accidental activation and to aid in keeping out dust and moisture. Guards are used over the lockdown buttons in high

activity areas like gymnasiums to prevent accidental activation. Unlike the fire alarm pull-stations, a deterrent alarm may not be appropriate for a situation involving violence. In such instances, it would be necessary to activate the device quietly and not draw attention to anyone to avoid greater risk.

A key to the successful implementation of a lockdown initiating appliance is how easy it is to use. The appliances meet the NFPA standard of a single or double action mechanism. Like fire alarm initiating appliances, lockdown push-buttons must not require any special tools, keys, or knowledge (such as passcodes) to gain access to them to activate the devices.

4. **Characteristics of Notification Appliances**

   Like the fire alarm system, a network of notification appliances is necessary throughout the school, both inside and outside, to provide audible and visual warning to all school occupants of the need to lockdown. It should include speakers that can play a prerecorded alert tone and voice message along with strobes, all of which interface with the LNCP. The speakers and strobes can be standalone devices or combination units. The notification part of the system will simultaneously notify the alarm company. NFPA 72 allows for audible appliances called emergency voice alarm communication (EVAC) systems that enable a prerecorded message to play over a public address system, speakers, or other mass notification system when an initiating appliance is activated and directs that “Emergency communications systems shall be capable of the reproduction of prerecorded, synthesized, or live…messages with voice intelligibility.” These EVAC systems are also regulated by the NFPA.

   **a. Audible Notification Appliances**

   The fire alarm system activates a very loud horn, bell or chimes to get people’s attention and signal an evacuation. A lockdown notification system would use an attention getter called an “alert” and then continue with a prerecorded warning message.

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161 National Fire Protection Association, 24.3.1.1
Kuligowski explains, “Alert signals are meant only to grab occupants’ attention and notify them that a warning message is about to be provided.” According to NFPA guidance, “alerts should be significantly different from ambient sounds.” This difference is particularly important in a school setting, since it is very noisy both inside and outside schools in gymnasiums, music rooms, wood shops, cafeterias, hallways, and on playgrounds. The alert must be distinct and loud enough to cause students and staff to pay attention so they will have ample opportunity to hear the prerecorded warning announcement. Kuligowski instructs, “a building should use one consistent alert signal to get people’s attention to a building emergency situation, which should then be followed by an expertly crafted and tested warning message specific to the emergency.” A distinct alert tone for a lockdown notification system may be the sound of a police siren, which is congruent with the purpose of the lockdown notification system for incidents involving violence and the fact that police will be notified. The loud police siren tone can work to get the attention of school occupants so they can hear the forthcoming warning message. It may also disorient or interrupt the plans of the aggressors that may also cause them to pause or even call off the attack. This is unknown.

The NFPA provides guidance for warning messages and explains that “an alert signal should be accompanied by a clear, consistent, concise, and candid warning message.” It goes on to say that warning messages should be stated in full and then repeated one or more times in full. Warning messages can be replayed in intervals if desired.

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A very important benefit to using a pre-recorded message is that when people are under extreme stress, like in emergencies, they can have diminished capacity to process complex information or accomplish straightforward tasks.\textsuperscript{167} The NFPA fire code references this benefit and others by explaining “pre-recorded voice methods provide the benefits of easily repeating the played messages for longer periods of time and not relying on the voice announcer training or stress level while delivering the message.”\textsuperscript{168} However, if a pre-recorded message is activated, trained staff members must be able to override or suppress that message to provide other instructions as appropriate to the situation. The content of the warning message is critical to getting the desired response. The following example shows a lockdown alert and prerecorded message.

- **Alert Tone:** Police Siren
- **Prerecorded Message:** Emergency lockdown! Emergency lockdown! A lockdown button was pushed and police are notified. Everyone, lockdown now.
- **Repeat Message two or more times**

Strategies for responding to violence vary depending on the school. School leaders and their local law enforcement and fire partners will need to collaborate to determine the appropriate alert sound and precise warning message that aligns with their unique emergency response plans and philosophies. The alert tone and message must be tested for effectiveness during drills, and adjusted as needed.

The audible appliances present two options, using the existing school PA system loudspeakers, or installing dedicated lockdown notification system speakers. Schools typically have loudspeakers in most interior rooms on campus and in some exterior areas. The speakers are part of the public address system, and used for daily school announcements. It may be possible to leverage a school’s existing speakers for the

\textsuperscript{167} Graves, “Lockdown Terminology in K-12 Schools,” 2.
audible part of the notification appliance. The lockdown notification system would need to be hardwired to the PA system. It would also require a device that would hold the pre-recorded lockdown message, and a sounder circuit relay that would activate the public address system to play the message. A benefit to using the existing PA system speakers is its regular use. If a speaker malfunctions, it will affect the users’ ability to hear the daily announcement, and repairs can be set in motion. This daily use provides consistent testing of the speakers.

At first blush, it may seem that using speakers already in place throughout the school may significantly reduce the initial equipment and installation costs of a lockdown notification system. This may not be the case due to the extensive NFPA requirements regarding reliability safeguards. A significant drawback to using the existing PA speaker system has to do with reliability. Schools are susceptible to power outages due to storms and other factors. The PA system requires power and many schools do not have backup generators. For schools that have PA systems associated with internet or WiFi-based phone systems, reliability is compromised due to the potential for internet disruptions. A warning system must be dependable. The NFPA regulations mandate a redundant, reliable warning system and provide guidance for dual purpose speakers.

Loudspeakers used for emergency communications system functions also providing ancillary functions shall meet the conditions of either 24.3.5.2 (1) or (2):

(1) The fire command center or the emergency command center as applicable shall be constantly attended by trained personnel, and selective paging is permitted by the authority having jurisdiction.

(2) All of the following conditions shall be met: (a) The loudspeakers and associated audio equipment are installed or located with safeguards to resist tampering or misadjustment of those components essential for intended emergency notification. (b) The monitoring integrity requirements of 10.6.9 and Sections 10.18 and 12.6 continue to be met while the system is used for non-emergency purposes.\(^\text{169}\)

Depending on the school’s existing loudspeaker and associated systems, it may be cost prohibitive for schools to meet these and other referenced NFPA standards for

audible voice communication appliances. For these reasons, a school may choose a more reliable audible notification appliance, independent of the existing PA system loudspeakers for its lockdown notification system.

Similar to the fire alarm system, a standardized lockdown notification system could have dedicated speakers, separate from the public address system, hardwired directly to the LNCP. This independent speaker system would also mirror the NFPA requirements of one that detects trouble situations and alerts officials when a device is not working properly. These built in redundancy and reliability factors are essential to the school’s ongoing confidence in the functionality of the warning system.

(1) Visual Notification Appliances

When a mass notification system is in use, fire code requires visual notification along with the audible notification, “Where audible notification is provided, mass notification systems shall also provide visible notification information to serve the hearing impaired and for high-noise areas…and shall be accomplished using strobes.” 170 This type of notification is particularly important in gymnasiums, band rooms, and cafeterias where noise volume can make it difficult to hear announcements right away. As seen in Figure 11, the strobes must have the word “ALERT” printed on the devices.171

![Figure 11. Appearance for Visual Notification Appliances.](https://www.systemsensor.com/en-us/Pages/SPSWK-CLR-ALERT.aspx)

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170 National Fire Protection Association, 24.5.16.1–3.


The NFPA code also allows for textual or graphic visual notification, but it is not required. Regardless, the code requires an immediate visual notification. “Transmission of visible notification and messages shall be simultaneous to audible notification and messages.”\textsuperscript{173} Since delays in this notification are not allowed, the system must be set up so that the audible and visual notifications occur simultaneously upon the activation of the initiating appliance.

The fire code allows several options to accomplish the visual strobe notification requirement. These options include standalone strobes or altering the existing fire alarm strobes to fulfill both the fire and lockdown strobe needs, speaker-strobes, or replacing the existing fire strobes with a combination fire horn-strobe and lockdown speaker-strobe appliance.

(2) Standalone Strobes

For some schools, it may be feasible to repurpose their existing fire alarm strobes to serve as a strobe for both the fire alarm system and the lockdown notification system. This repurposing is especially important if the school uses a standalone strobe device rather than a combination horn-strobe. If an existing strobe used for the fire alarm system is repurposed to include other emergencies, the fire code provides instructions for removing or covering the word FIRE on the device.\textsuperscript{174} “Strobes used in combination systems where the same strobe is used for both mass notification and fire notification shall…be clear or nominal white, [and] have no marking or be marked with the word ‘ALERT’.”\textsuperscript{175} The fire code does not mandate the color of the housing of the appliance. It simply says that the strobe must be clear or white if one strobe is used for both purposes as seen in Figure 12. For schools that use standalone strobes for their fire alarm system, this option would save the schools money because they would not have to buy new strobes and it would eliminate the need to run wire from the LNCP to each classroom and area in the school building.

\textsuperscript{173} National Fire Protection Association, \textit{NFPA 72 National Fire Alarm and Signaling Code}, 24.5.16.4.

\textsuperscript{174} National Fire Protection Association, 24.5.17.3.4.

\textsuperscript{175} National Fire Protection Association, 24.5.17.3.
Figure 12. Appearance for Combination Standalone Strobes.176

(3) Speaker-Strobes

Speaker-strobes can accomplish both the audible and visual notification requirements of a lockdown notification system. Speaker-strobes are dual purpose notification appliances regulated by the NFPA. They look almost identical to the fire alarm system’s horn-strobes but are engineered to play a voice message rather than blow a horn and simultaneously light up the strobe. The use and purchase of speaker-strobes would represent a significant upfront expense, including the need to run wire from the LNCP to all the speaker-strobes around the school. Once installed, they would provide a reliable and sustainable audible and visible warning notification for the entire campus, with very little ongoing maintenance. Power outages and internet outages would not disable the speaker-strobes since they would be connected directly to the LNCP, which has its own battery backup supply. This option would provide the added flexibility of making decisions as to the best places to locate the devices when planning the overall installation of the system. See Figure 13 for an example.

(4) Combination Horn-strobes and Speaker-strobes

Another option is to replace the existing fire alarm horn-strobes with new combination horn-strobe and speaker-strobe appliances to have only one device in each location. Further investigation is necessary to determine if the existing wiring can be used for both strobe units to activate the correct unit based on which initiating appliance is activated. If not a feasible or reliable solution, it may be necessary to run additional wiring from the LNCP to the speaker-strobe portion of the device to leverage the existing wiring path and isolate each device to its respective control panel. If the school decides to use this combination horn and speaker-strobe unit as its notification appliance, careful assessment is necessary to assure that the voice message on the appliance can be heard clearly in all areas of the school. Since voice messages do not fill a space in the same way as a horn or bell, the NFPA regulates the careful and strategic placement of speakers designed for emergency voice messages. Figure 14 shows two examples.

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Figure 14. Combination Horn-strobes and Speaker-strobes.\textsuperscript{178}

5. **Inspection, Testing, and Maintenance**

Active shooter attacks on K-12 schools are infrequent events, but can have great consequences. A lockdown notification system must be a constantly reliable and operational warning system. The inspection, testing, and maintenance requirements of the lockdown notification system should be modeled precisely after the fire alarm system requirements, as described in the fire alarm system section of this chapter.\textsuperscript{179} The system must also be exercised and tested during regular school lockdown drills. All these measures work together to ensure the lockdown notification system is functional and reliable at all times.

6. **Financial Feasibility**

The initial expenses involved with a lockdown notification system include the LNCP components, initiating appliances, notification appliances, and all the wire that connects this system. The hardware, wire, and installation costs represent the bulk of the up-front cost of the warning system. After installation, the ongoing costs for the lockdown notification system are minimal. Other than the annual (and some semi-annual) inspection requirements, and minimal maintenance, only a small monthly fee for


monitoring is paid to the same alarm company used for the fire alarm system monitoring. Once installed, it will generally be a financially sustainable warning system for K-12 schools.

7. Summary of the Lockdown Notification System

As seen Figure 15, like a fire alarm system, all these components the (LNCP, initiating appliances, and notification appliances) work together to provide a reliable mechanism that can be built into the infrastructure of U.S. schools by which:

- School occupants who observe a suspicious person or hear gunfire can quickly activate a lockdown push-button (initiating appliance).
- The control panel immediately notifies (using the speaker-strobes) the whole school to lockdown.
- It simultaneously notifies the police department (via the alarm company) through the dedicated phone lines.

Figure 15. Lockdown Notification System Process Model.\(^{180}\)

\(^{180}\) Adapted from Automation Source, “Egress Devices” for the blue initiating appliance; Source: “SPSWK-CLR-ALERT,” SystemSensor for the white speaker strobe. The blue initiating appliance was adapted to indicate that the text on the blue initiating appliance was modified to demonstrate the proposed plain language for a lockdown initiating appliance.
Like the fire alarm system, the conceptual lockdown notification system is designed to be reliable, easy to use, affordable after initial installation, and easy to maintain. If it performs like the fire alarm system, the hope is that it will effectively fulfill its purpose in schools; while school shootings may still occur, a quicker warning can lead to a quicker lockdown, thereby hopefully, resulting in reduced injuries and loss of life.

D. CONCLUSION

The standardized school fire alarm system has proven to be an effective warning system that quickly alerts all school occupants of the need to evacuate when in danger of smoke or fire. It is effective in the K-12 school environment because it accomplishes its intended purpose, and also because it requires minimal maintenance, is reliable, easy to use, and is financially sustainable for schools.

A standardized lockdown notification system in schools may also be an effective warning system to notify all school occupants quickly of the need to lockdown when in danger of violence at school. It may be effective in the K-12 school environment if it can accomplish its intended purpose, and also because, like the fire alarm system, once installed, it will require minimal maintenance, be reliable, easy to use, and is likely to be financially sustainable for schools.

As shown in this chapter, the school fire alarm system represents a potentially suitable model for a parallel conceptual lockdown notification system. The next chapter layouts the development of an evaluation tool that K-12 school decision-making teams can use to assess communication and warning system technologies, such as this conceptual lockdown notification system.
III. THE K-12 SCHOOL HOT-FIT EVALUATION TOOL

This chapter proposes a new evaluation framework tool designed specifically for evaluating communication and warning system technologies for use within the K-12 school environment. It begins with an introduction to remind the reader of the findings in the literature review that validates the need for this new tool. Next, an overview of the tool is presented, which includes its relationship to the HOT-Fit model, as described in Chapter I, explains how the tool is organized, and gives an overview of the five domains that make up the core structure of the tool.181 A big-picture perspective of the tool is given to contextualize when discussing it in the final section. The bulk of this chapter provides an in-depth description of each of the new K-12 School HOT-Fit Evaluation Tool’s components as they relate to communication and warning system technologies applied in the K-12 school environment.

A. INTRODUCTION

Schools need the capability to make warning notifications to students, staff, and visitors to address a variety of hazards, threats, and emergencies. They also need the ability to communicate with community partners, such as law enforcement, fire fighters, and 911-dispatch centers, and to disseminate emergency information to parents, guardians, and other school stakeholders.

A variety of traditional and emerging communication and warning system technologies are available for schools to consider. Some have been in use in schools for decades; others have emerged in recent years as technology has advanced in response to active shooter attacks on schools. Evaluating warning and communication technologies is complex. School decision-makers have to figure out which technologies are suitable for their unique schools and district. They also need to consider if the technology is compatible with their community partners’ systems and response capabilities.

As revealed in the literature review, a major gap has emerged in the research in providing guidance or recommendations to school decision-makers on how to evaluate and select communication and warning system technologies. The JHU report, *A Comprehensive Report on School Safety Technology*, stipulates, “There is no national clearinghouse or center serving as an ‘honest broker’ to test or recommend specific technologies or vendors to schools. As a result, many school officials rely on vendor-sponsored research, word of mouth, advice from police or security personnel, internal review, or grant funding criteria for making procurement decisions.”\(^{182}\) Several other authors note similar gaps.

Even so, while reviewing the literature, many weaknesses related to the implementation of some of these traditional and emerging communication and warning system technologies emerged as important factors to consider when evaluating new technologies. These weaknesses include the accessibility of the warning system, factors related to timely warning of all school occupants, the reliability of the warning system, initial and ongoing costs, and the importance of organizational fit. Schneider, in *School Security Technologies*, goes further and urges school decision-makers to figure out the problem to be solved before choosing a technology, consider the school’s specific needs, constraints, and variables, carefully analyze solutions, and then choose the appropriate technology.\(^{183}\)

The new K-12 School HOT-Fit Evaluation Tool developed and presented in this chapter fills a gap in the literature. It provides school decision-making teams with a process to identify their needs for a technology, discover if the technology can meet those needs, and determine to what extent the technology is feasible and sustainable for the school and their community partners. Since school communication and warning systems do not only affect the unique school, but also its community partners, such as law enforcement, fire departments, and 911 dispatch centers, it is important to work through this process as a collaborative effort. The K-12 EOP Guide explains, “It is critical that


schools work with their district staff and community partners—local emergency management staff, first responders, and public and mental health officials—during the planning process [...] This collaboration makes more resources available and helps to ensure the seamless integration of all responders.”184 If school decision-makers work with their community partners, this will increase the likelihood of selecting effective, feasible, and sustainable communication and warning system technologies. For these reasons, great value can be found in forming a joint decision-making team, with both school and community partner stakeholders.

The hope is that the new K-12 School HOT-Fit Evaluation Tool will be a useful tool that can help collaborative, decision-making teams make informed choices about the selection of communication and warning system technologies for their unique schools.

B. OVERVIEW OF K-12 SCHOOL HOT-FIT EVALUATION TOOL

The main construct of this new K-12 School HOT-Fit Evaluation Tool (school tool) comes from the HOT-Fit framework, originally designed to evaluate information systems used in the hospital setting.185 The literature review section of Chapter I describes an overview of the history of HOT-Fit. This new evaluation framework draws upon many of the established evaluation variables found in the HOT-Fit framework. It also includes evaluation variables customized to the K-12 school environment and the specific context of warning system technologies rather than hospital information systems.186

The school tool includes five core domains that guide the user through a process to evaluate the suitability of a technology to accomplish the goals of the school organization. The first domain, Foundation, otherwise known as the why, is unique to this new school tool. The other domains come from the HOT-Fit framework that include investigating the Technology itself, assessing the technological interface with Humans in

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186 These new evaluation variables stem from the existing literature and from Susan M. Graves’ unique experience as a school safety professional at the Lincoln County School District since 2001.
the school system, examining the impact on the Organization, and identifying the Net Benefits to the school, district, and community partners. Each domain is distinct but also interconnected. The domains have corresponding dimensions based on the HOT-Fit model, as well as unique and customized variables for evaluating the efficacy of the technology’s use within the K-12 school environment, as seen in Figure 16.

Figure 16. K-12 School HOT-Fit Evaluation Tool.\textsuperscript{187}

1. **Foundation**

The most foundational domain, aptly named Foundation, is the starting point for the evaluation.\textsuperscript{188} It helps decision-making teams identify and clarify the reasons for

\textsuperscript{187} This illustration was created by Susan M. Graves to display the components of the K-12 School HOT-Fit Evaluation Tool.

\textsuperscript{188} This illustration was created by Susan M. Graves to display the components of the K-12 School HOT-Fit Evaluation Tool.
considering a new warning technology. The K-12 EOP Guide calls this step, “understanding the situation.”\footnote{Office of Elementary and Secondary Education, Office of Safe and Healthy Students, \textit{Guide for Developing}, 7.} It begins by conducting risk and capability assessments to identify the \textit{problem(s)} to solve, establishing goals and objectives that articulate \textit{purpose}, recognizing and taking into account internal and external \textit{motivating} factors, such as psychological safety, risk management, regulations, and opportunities, and defining the \textit{parameters}, limitations and priorities of the project. The Foundation domain is essentially about the why and the scope of the project. It is the starting place because it informs all other domain evaluations. Table 2 shows an overview of the Foundation domain.

Table 2. Foundation Domain Overview.

<table>
<thead>
<tr>
<th>FOUNDATION</th>
<th>Dimension</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem</td>
<td>i. Risk Assessment ii. Capabilities Assessment</td>
<td></td>
</tr>
<tr>
<td>Purpose</td>
<td>i. Goals ii. Objectives</td>
<td></td>
</tr>
<tr>
<td>Motivation</td>
<td>i. Internal ii. External</td>
<td></td>
</tr>
<tr>
<td>Parameters</td>
<td>i. Priorities ii. Limitations iii. Scope</td>
<td></td>
</tr>
</tbody>
</table>

2. Technology

The next step in the evaluation process involves examining warning technologies to address the identified problem, goals, and objectives. This domain requires a detailed analysis of the \textit{information quality}, \textit{system quality}, and \textit{service quality} dimensions of the technology against the criteria established in the Foundation domain. Each dimension includes several evaluation variables customized to the K-12 school environment. The
information quality dimension deals with the attributes of the activation devices, notification attributes, and information completeness. The system quality dimension includes evaluating the system mechanics, the reliability of the overall system, security attributes, and system flexibility. Service quality refers to the total support of the warning system as provided by either the external or internal service provider or a combination of the two. Variables to evaluate include the expected lifespan of the system, ongoing technical support, and maintenance requirements. A thorough examination of the Technology domain in light of the Foundation domain findings will help to rule out some technologies since it will become evident they do not have the capacity to accomplish the established goals and objectives. Table 3 shows an overview of the Technology domain.

Table 3. Technology Domain Overview.

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>Dimension</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Information Quality</td>
<td>i. Activation Attributes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Notification Attributes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Information Completeness</td>
</tr>
<tr>
<td></td>
<td>System Quality</td>
<td>i. System Mechanics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. System Reliability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Security Attributes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. System Flexibility</td>
</tr>
<tr>
<td></td>
<td>Service Quality</td>
<td>i. Lifespan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Technical Support and Maintenance</td>
</tr>
</tbody>
</table>

3. **Human**

In the Human domain, teams consider how the warning system technology will impact the humans in the school and stakeholders outside of the school and is made up of two dimensions, *system use* and *user satisfaction*. Evaluation variables for system use start with the impact of the technology on the daily routines of the school personnel. It then moves to variables related to the flexibility of the technology to customize the parameters of the system’s use. Finally, it concludes with the staff’s perceptions of support for using the system. The user satisfaction dimension refers to the staff’s

anticipated perception of the system’s usefulness, variables related to the ease-of-use of
the system, and to the anticipated acceptability of the system by users and school
stakeholders. Analysis of the Human domain informs the likelihood of favorable
acceptance of the technology by its target users. Table 4 shows an overview of the
Human domain.

Table 4. Human Domain Overview.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Use</td>
<td>i. Impact on Daily Routines</td>
</tr>
<tr>
<td></td>
<td>ii. Parameters for Use</td>
</tr>
<tr>
<td></td>
<td>iii. Perceived Support</td>
</tr>
<tr>
<td>User Satisfaction</td>
<td>i. Perceived Usefulness</td>
</tr>
<tr>
<td></td>
<td>ii. Ease-of-Use</td>
</tr>
<tr>
<td></td>
<td>iii. Perceived Acceptability</td>
</tr>
</tbody>
</table>

4. Organization

The Organization domain assists teams with assessing the interaction with and
impact of the warning system technology on the schools, school districts, and their
community partners’ organizational attributes, systems, and leadership acceptance.
Organizational dimensions are two-fold, structure and environment. Evaluation variables
in the structure dimension include compatibility with the school or district and
community partners’ capabilities, response philosophies, and existing communications
systems. The environment dimension variables consider ownership of the technology, the
financial impact on the organizations, and the technology’s alignment with regulations.
The Organization domain helps determine technological compatibility for the school and
community partners who will use the system. Table 5 shows an overview of the
Organization domain.
5. **Net Benefits**

The Net Benefits domain examines findings from the prior four domains against the dimensions of *effectiveness*, *feasibility*, and *sustainability*. It loops back to the very beginning of the analysis process and guides users to revisit questions related to the Foundation domain. Variables in the effective dimension consider if the technology improves the schools’ capability to solve the identified problem(s) and accomplishes its purpose as established in its goals and objectives. It draws upon the Technology domain to determine if it is reliable within the limitations of the organization. It takes into account the Human and Organizational variables to ascertain if the system is operationally compatible and financially feasible for the school, district, and their community partners. Evaluating this domain helps teams weigh the different factors to make decisions about sustainability. The RAND report contends, “To employ technologies effectively and ethically, schools need to consider whether and how particular technologies could feasibly be implemented and used to successfully address the specific issue related to student safety for which solutions are needed.”\(^{191}\) The Net Benefits derived from using the K-12 School HOT-Fit Evaluation Tool will uncover to what extent the technology used within the constraints of the unique school system effectively and reliably solves the identified problem, meets the established goals and objectives, and is a feasible and sustainable solution for the school and its community partners. Table 6 shows an overview of the Net Benefits domain.

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\(^{191}\) Schwartz et al., *Role of Technology*, xvi.
Table 6. Net Benefits Domain Overview.

<table>
<thead>
<tr>
<th>NET BENEFITS</th>
<th>Dimension</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effective</td>
<td>i. Solves Problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Accomplishes Purpose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Reliable</td>
</tr>
<tr>
<td></td>
<td>Feasible and Sustainable</td>
<td>i. Financially</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Operationally</td>
</tr>
</tbody>
</table>

6. Overview Conclusion

As described in this overview, the K-12 School HOT-Fit Evaluation Tool provides a five-step structure and process that school decision-making teams can use as a guide to evaluate communication and warning system technologies.

C. THE K-12 SCHOOL HOT-FIT EVALUATION TOOL EXPLAINED

The prior section introduced an overview of the five domains in the evaluation framework. This section provides a more detailed description of each domain, dimension, and corresponding evaluation variable found in the K-12 School HOT-Fit Evaluation Tool.

1. Foundation

The foundational step in the technology evaluation process requires gaining a clear understanding of the reason for considering a new warning system technology. It includes identifying the problem(s), articulating purpose, recognizing motivating factors, and defining parameters. Table 7 explains the Foundation domain.
Table 7. Foundation Domain Expanded.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Problem</td>
<td>i. Risk Assessment:</td>
</tr>
<tr>
<td></td>
<td>ii. Capabilities Assessment:</td>
</tr>
<tr>
<td>B. Purpose</td>
<td>i. Goals:</td>
</tr>
<tr>
<td></td>
<td>ii. Objectives:</td>
</tr>
<tr>
<td>C. Motivation</td>
<td>i. Internal Motivations:</td>
</tr>
<tr>
<td></td>
<td>ii. External Motivations:</td>
</tr>
<tr>
<td>D. Parameters</td>
<td>i. Priorities:</td>
</tr>
<tr>
<td></td>
<td>ii. Limitations:</td>
</tr>
<tr>
<td></td>
<td>iii. Scope:</td>
</tr>
</tbody>
</table>

a. Identify the Problem

To identify the problem, teams should conduct two types of assessments, a risk assessment and a capabilities assessment. A risk assessment will help identify the hazards, threats, and vulnerabilities the schools face. A capabilities assessment examines the schools’ and community partners’ existing systems and personnel to identify their strengths and limitations to address the identified risks. Together, these assessments connect the problems the schools face with the available systemic resources, and examines to what extent the schools’ current capabilities address the problems. Schneider emphasizes, “Don’t start by choosing a technology and looking for a problem it can solve. The process should be reverse: Identify and prioritize the problems before jumping to solutions, and analyze solutions carefully before committing funding.”192 Identifying the problem the schools want to solve will provide important focus to the technology search.

1. Risk Assessment

A risk assessment considers factors such as characteristics of the school and community. The JHU report posits, “The best way to select safety technology is to first

192 Schneider, School Security Technologies, 1.
determine what threats need to be mitigated and then determine the best solution.”

A risk assessment will help teams determine if their school community is vulnerable to specific threats or hazards that require mitigation efforts. In fact, the NFPA requires that a risk analysis be performed when implementing a mass notification system. “Each application of a mass notification system shall be specific to the nature and anticipated risks of each facility for which it is designed.” These risks could be natural hazards, such as an earthquake, tornado, winter storm, or other threats, such as an intruder, kidnapping, or shootings. Environmental and structural risks can also be evaluated, such as if vulnerabilities occur due to the school’s limited access control measures, or if the classrooms have doors that cannot be locked, or if the school has exterior hallways or buildings. A risk assessment can also help teams determine if the physical location of the school (next to a wooded area, in the middle of a city, or next to a hazardous materials facility) increases specific risks; or if the geographic distance between the school and the nearest law enforcement or fire protection agency elevates risk. Acknowledging risks and vulnerabilities helps school teams identify the problems they want to solve.

(2) Capabilities Assessment

A capabilities assessment considers factors related to personnel, equipment, and systems. The K-12 EOP Guide refers to a capabilities assessment saying it “examines the capabilities of students and staff as well as the services and material resources of community partners.” Decision-making teams may consider these questions: Do staffing limitations, such as having no safety or security staff, campus monitors, or school resource officers, create the need for an enhanced warning system? To what extent are current communication and warning systems adequate or inadequate to address the problem? Do infrastructure factors, such as building construction, connectivity

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195 See Appendix A for a list of threats and hazards schools are susceptible to and must prepare for depending on their unique environment.
challenges, etc., impact capabilities? A capabilities assessment also involves evaluating the community partners’ capabilities, strengths, and limitations in relationship to the risks, hazards, threats, and vulnerabilities the schools face. This evaluation includes assessing interoperability factors between the schools and law enforcement, fire agencies, 911-dispatch centers, emergency management, and other community partners.

Understanding both risks and capabilities related to the unique school, district, and their community partners will help decision-makers identify the problem and available resources.

b. **Articulate the Purpose**

Identifying the problem positions the teams to figure out what they want to accomplish, and thereby, articulates the purpose for acquiring a new warning technology. The K-12 EOP Guide directs school teams to stay focused on the problem to solve by encouraging them to identify goals and objectives to address the specific problem, hazard, or threat and explains, “Goals are broad, general statements that indicate the desired outcome in response to the threat or hazard [problem] identified [...] they are what personnel and other resources [such as warning systems] are supposed to achieve. They also help identify when major activities are complete and what defines a successful outcome.”197 The goal generally answers the basic and foundational question of “why” someone wants to do something.

The JHU report describes it another way, “One way to consider safety technology in schools is by taking into account the impact it is intended to have on the incident. Some technologies help to prevent a crime from happening, some are intended to minimize the effects of violence by adding a layer of protection, whereas others are critical during an active incident.”198 With the rapid advancement of technology and the increasing amount of technological solutions on the market, teams may become enamored with a particular technology or what may be the latest fad, and lose sight of the

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197 Office of Elementary and Secondary Education, Office of Safe and Healthy Students, 12.
actual problem to be addressed. Setting clear goals and measurable objectives can help teams avoid this trap and empower them to evaluate potential technological solutions with wisdom and clarity.

c. **Understand Motivation**

Gaining a clear understanding of the problem and carefully articulating goals and objectives are important first steps. The team should also seek to understand the internal and external motivations behind addressing this problem at this time. Motivations driven by reactionary responses can become pitfalls and cause teams to make hasty and uninformed decisions.

   (1) **International Motivations**

   Internal motivations include factors related to psychological safety, physical safety, and risk management. When stakeholders, such as staff, parents, guardians, or other members of the community are concerned about violent events at schools elsewhere in the country, psychological safety may be a driving force. The JHU’s report points out, “the continued focus on mass casualty events is driven by funding (Federal and state grants), school system mandate, media focus on such events, public sentiment and fear, and a genuine desire to foster effective prevention and response measures.” The same report indicates that managing risk is a motivator for implementing security technologies. The “fear of violence and of legal liability” may also be used as justifiable rationale for the expenses associated with technologies.

   (2) **External Motivations**

   Factors involving external motivations may include regulatory conditions and available opportunities. The teams can determine if new legislation, regulation, or policy require establishing a new warning capability, or if funding is available to replace or upgrade old or failing equipment or systems. New grant opportunities, new technological advances, or special vendor offers that are driving forces may be available. The JHS...
report points out, “Prior to selecting and acquiring technology, evaluation is sometimes ad hoc or extremely limited. In some cases, technology is selected to assuage the anxiety brought on by recent news stories or in response to a flood of funding.”201 In these cases, the identified problem should remain the primary focus while the opportunity or motivation is secondary. Recognizing motivating factors will help teams make informed decisions about technologies without succumbing to solutions that do not meet established goals.


d. Establish Parameters

Establishing parameters involves identifying priorities and limitations to determine the scope of the project. Keeping the goals and objectives in mind while being aware of the motivating and limiting factors will help teams delineate the essential components of a warning system from the non-essentials to stay within their scope and work to solve the identified problem. It may be helpful to identify “tier one,” or non-negotiable, functions of the technology (those minimum, must-have requirements essential to accomplishing the stated goals and objectives), “tier two,” or desirable but non-essential, components of the technology, and “tier 3” or features that might be considered luxury items. The schools can then break larger projects into implementation phases and avoid an overly broad scope where they try to solve so many problems that the effort becomes overwhelming and unmanageable. Schneider points out, “Beware of mission drift. Always go back to your originally identified problem and ask yourself, ‘Do the solutions we chose match the problems we wanted to address?’”202 The parameters may expand or contract during the processes of setting goals and objectives and evaluating warning systems.

e. Foundation Domain Summary

As decision-making teams work through the Foundation domain, they will establish a clear and firm basis for a technology search. In the second domain,

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201 Johns Hopkins University Applied Physics Laboratory, ES–12.
Technology, teams will learn to evaluate the technological solutions to determine if the technology will effectively solve the identified problems and meet the teams’ stated goals.

2. **Technology**

The second domain, Technology, requires a detailed analysis of the information quality, system quality, and service quality dimensions of the technology against the criteria established in the Foundation step. Table 8 explains the Technology domain.
Table 8. Technology Domain Expanded.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i. Activation Attributes:</td>
</tr>
<tr>
<td></td>
<td>• Type of Activation:</td>
</tr>
<tr>
<td>A. Information</td>
<td>• Accessibility of Activation:</td>
</tr>
<tr>
<td>Quality</td>
<td>• Times &amp; Locations:</td>
</tr>
<tr>
<td></td>
<td>ii. Notification Attributes:</td>
</tr>
<tr>
<td></td>
<td>• Type of Notification:</td>
</tr>
<tr>
<td></td>
<td>• Reach of Notification:</td>
</tr>
<tr>
<td></td>
<td>• Speed of Notification</td>
</tr>
<tr>
<td></td>
<td>iii. Information Completeness:</td>
</tr>
<tr>
<td></td>
<td>• Message Content &amp; Accuracy:</td>
</tr>
<tr>
<td></td>
<td>• Message Length:</td>
</tr>
<tr>
<td></td>
<td>• Message Intelligibility</td>
</tr>
<tr>
<td></td>
<td>B. System Quality</td>
</tr>
<tr>
<td></td>
<td>i. System Mechanics:</td>
</tr>
<tr>
<td></td>
<td>• Operating Platform &amp; System Functionality:</td>
</tr>
<tr>
<td></td>
<td>• Installation Requirements:</td>
</tr>
<tr>
<td></td>
<td>ii. System Reliability:</td>
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<tr>
<td></td>
<td>• Redundancies:</td>
</tr>
<tr>
<td></td>
<td>• Points of Failure</td>
</tr>
<tr>
<td></td>
<td>iii. Security Attributes:</td>
</tr>
<tr>
<td></td>
<td>• System Defense:</td>
</tr>
<tr>
<td></td>
<td>• Activation Protections</td>
</tr>
<tr>
<td></td>
<td>iv. System Flexibility:</td>
</tr>
<tr>
<td></td>
<td>• Compatible:</td>
</tr>
<tr>
<td></td>
<td>• Customizable:</td>
</tr>
<tr>
<td></td>
<td>• Expandable/Scalable</td>
</tr>
<tr>
<td></td>
<td>C. Service Quality</td>
</tr>
<tr>
<td></td>
<td>i. Lifespan:</td>
</tr>
<tr>
<td></td>
<td>• Replacement or Upgrade Intervals:</td>
</tr>
<tr>
<td></td>
<td>• Planned Obsolescence</td>
</tr>
<tr>
<td></td>
<td>ii. Technical Support &amp; Maintenance:</td>
</tr>
<tr>
<td></td>
<td>• Internal Capacity &amp; Restrictions:</td>
</tr>
<tr>
<td></td>
<td>• External Capacity &amp; Restrictions:</td>
</tr>
</tbody>
</table>
a. **Information Quality**

The information quality dimension focuses on the activation and notification components of the warning system and is based on the user’s perspective of the quality of the information produced by the warning system.\(^{203}\) This dimension examines activation attributes, notification attributes, and the quality and completeness of the information produced by the system.

(1) **Activation Attributes**

For the activation attributes evaluation variable, teams examine the types of activation devices the system provides, the accessibility of those devices for those using the system, the times it is available, and factors related to where the activation devices are located. In this discovery phase, teams learn about what the technology has to offer in terms of activation options.

An initial assessment of the technology helps teams understand the type of activation devices available, how they work, and what they accomplish. Activation devices may include technologies such as cell phone or computer applications, two-way radios or walkie-talkies, push-buttons or pull-stations, pendant necklace devices or keyfob buttons, mobile or fixed devices, or phone activated systems via special codes. Activation accessibility looks specifically at the way the system is constructed related to access and ease-of-use. Teams will need to decide who will use (activate) the system, when it will be available for use, and from where it can be activated to meet the goals and objectives established for the warning system.

Depending on the team’s established goals and objectives, the activation devices may be designated for key school, district, or security personnel; all school staff members; students; or for everyone in the school. They could also be for coaches, bus drivers, and people using the school facilities (inside or outside) during non-school hours. If the system is restricted for use by key personnel, determination is necessary as to the accessibility requirements to ensure these key personnel are always available to activate

the system. It is also helpful to understand if any special keys, codes, or knowledge are required to activate the system and how that may impact decisions about who will be allowed to use the system.

It is also necessary to determine when and where the warning system will be available for activation, such as during school hours only, or non-school hours, or both. The K-12 EOP Guide instructs schools to “account for incidents that may occur during and outside the school day.” It may be helpful to consider the different activities that take place at the school, as well as the various timeframes the system could be needed to address those activities, such as during the school day, for afterschool programs, or when visitors use the school facilities during summer break. Will it serve incidents occurring on school grounds, at athletic venues, on school buses, on field trips, or at off-campus school events? Once these variables are established, the teams can decide where the activation devices should be located and available for use.

Teams should determine the range of capabilities and limits of the system by asking questions about requirements pertaining to the use of the internet, a cell phone or a landline phone, or radio frequencies. Teams can also assess how many activation devices they will need and if the system supports those requirements. The JHU report advises readers to make alarms “accessible to people with disabilities. For example, mounted alarms should be placed within reach of someone in a wheelchair, and badge alarms should not require fine motor skills or the use of two hands.” If off-campus use is desired, determining if the system can be activated remotely would also be important.

(2) Notification Attributes

Notification attributes have to do with the type of notifications the system is capable of providing, and the reach and speed of notification to the target recipients.

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When evaluating the types of notification devices the system supports, teams will need to explore both the audible and visual notification features of the technology. The JHU report breaks up notification into two categories, one-way and two-way communications technologies.206 One-way communications technologies include horns, buzzers, sirens, bullhorns, speakers, digital signs, radios, and public address systems. Two-way communications technologies include two-way radios, phones, intercom systems, email, and emergency call boxes. Some of these one- and two-way technologies are capable of voice messaging, (live voice, pre-recorded voice, text to voice); others use attention-grabbing sounds, such as horns, sirens, or beeps.

Some warning systems include visual notifications, such as strobes, various lights, LED signs, marquees, reader boards, deployable digital message boards, text messages, and email notifications. JHU’s report says, “Digital signs can be integrated with other mass communication technologies to provide greater probability of reaching a larger audience. During routine use, digital signs display non-emergency messages, but during emergencies, the display can be overridden with an alert message.”207 The report went on to say, “the technology is only effective if its use during an emergency has been well communicated to students and staff and if they are accustomed to getting information from the digital signs during normal operations, and they have access to signs during an event, thus such signs have very limited use during a lockdown situation.”208 Teams will want to evaluate to what degree the visual notification features of the system align with their notification goals and objectives.

To evaluate the reach of the notification variable, decision-making teams will begin by identifying the desired recipients of the warning system notifications. Many people have a stake in emergency communications when critical incidents affect schools. Identifying the intended audience includes taking into account the demographics of the intended audience, such as if the warning system is appropriate for the ages and development level of the children or youth to be served, and if it can accommodate the

206 Johns Hopkins University Applied Physics Laboratory, 5–1.
207 Johns Hopkins University Applied Physics Laboratory, 5–38.
languages represented by the schools’ community. A school of the blind or deaf will have unique warning system requirements, and students or staff with access or functional needs may require accommodations. Considering the schools’ homeless populations where parents may not have access to telephones to receive warning messages is also important. It is also appropriate to ask if the system has the capacity to notify the quantity or number of students, parents, guardians, and other stakeholders the schools serve, and within the time required. Examining the technology in light of the unique schools’ stakeholders will help determine compatibility.

An assessment is also necessary to determine the physical and geographical areas the warning system needs to reach. Interior school areas to consider include classrooms, halls, common areas, restrooms, locker rooms, offices, high noise areas, such as gymnasiums, cafeterias, music rooms, industrial arts shops, etc. Exterior school areas to consider include bus loading areas, student drop-off and pick-up areas, parking areas, playgrounds, athletic fields, covered walkways, exterior locker halls, etc. Other locations to consider include school district support offices, other schools, buses, school activity trips and athletic events, mobile devices, etc.

Requirements for the speed of notification are critical to determine because different hazards and threats require a different speed of warning or notification. Some systems are designed to address a specific hazard, such as a fire alarm system or lightning warning system. Others provide a variety of weather alerts like the weather alert radio.209 Outdoor warning sirens are used for tornados, hurricanes, tsunamis, and now Hawaii has repurposed its warning sirens to include the notification of a pending nuclear attack.210 Earthquake early warning systems are also in development. The speed of mass telephone notification systems may be limited by the number of phone lines an organization is able to access. Understanding the necessary speed of notification for the purpose of the

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warning system will help decision-makers determine if the technology performs to the desired speed and required capacity.

(3) Information Completeness

Information completeness deals with the capacity of the system to deliver the precise information the audience needs regarding the hazard, threat, or purpose established in the schools’ goals and objective. The JHU report cautions, “Sending incomplete or inaccurate information can lead to confusion and unsafe actions or decisions by recipients.”211 The National Fire Alarm and Signaling Code Handbook contends, “[…] intelligibility of the voice message is one of the most important aspects of a well-designed system. But equally important is the development of the messages to be used during an emergency.”212 Evaluation variables involve message content and accuracy, length, and intelligibility.

The content of the warning message must provide the appropriate and accurate information needed to take the desired protective action. This is critical. The system must be flexible to enable the schools to tailor the content to match the unique situation. If an intended audience includes an alarm company, dispatch center, or first responder partner, teams will need to ascertain the content needed and the required capacity of the system to house and deliver the desired message. If the system features a language translation application, it is recommended that teams test the translations for accuracy.

To achieve the message content requirements, the system must be capable of producing an adequate length of warning message. Some technologies limit the length of a message. For example, Twitter increased message length from 140 to 280 characters in 2017; some mass phone call or text message systems limit the time or length of

messages. Some messages require delivery in multiple languages, which increases length requirements. Information completeness ideally would not be limited by the system capability of the length of a message or the need for repeat intervals or follow-up warning messages.

Intelligibility includes considerations such as getting people’s attention, and delivering the message so users receive the entire message with clarity and adequate volume. Some systems utilize a distinct alert to command people’s attention effectively. The warning message or announcement must be intelligible; the volume must be adjustable so that it is sufficient for high-noise and low noise areas. The alert must be distinct and loud enough to cause students and staff to pay attention so they will have ample opportunity to hear the warning announcement. For external stakeholders, an attention getting mechanism is crucial, such as an alert tone. Directional considerations include when speakers or sirens oscillate, causing it to be partially cut off to a portion of the intended audience.

b. **System Quality**

The system quality dimension refers to system performance. It facilitates teams’ evaluation of four performance quality variables: system mechanics, the reliability of the overall system, security attributes, and system flexibility.

(1) **System Mechanics**

System mechanics refers to how the system works behind the scenes, including the essential functions and components of the technology. It is the first performance variable in the system quality dimension. The system mechanics along with the schools other systems and limitations (power, internet, cell service) can affect the reliability of the warning system. Its examination helps teams become familiar with the operating

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213 The Lincoln County School District uses a mass phone call system that limits the length of the recorded message to 60 seconds. This length is adequate for some messages. Other messages require more detailed information than the system length limitations allow.

platform, installation requirements, and the underlying mechanics of the activation and notification functions.

To evaluate the system mechanics, it is necessary to understand the specifics of the control panel or operating system functions related to cellular requirements, WiFi, or radio frequencies (RF) to understand any limiting factors associated with the schools’ capabilities assessment. If it is RF-based, it is important to learn how it interacts with other RF-based systems. If the system is software-based, it may require installing software on one master computer console or on hundreds or thousands of devices throughout a school district. Software compatibility with different devices may also be a barrier. Other considerations might be how the bandwidth requirement of the software affects other processes, the costs of time and money to install software on new machines, training new staff, and retraining existing staff, etc.

Teams must also consider the physical space requirements of the technological components, and the complexity of the installation process. Hardwiring a system within a school, installing antennas, affixing components to walls, desks, or ceilings may present challenges. Teams can ask if the school or district have the capacity to do components of the installation versus hiring contractors or licensed technicians. They can also investigate potential unexpected challenges, opportunities, or expenses associated with the installation.

This part of the assessment identifies how system users activate and operate the system to convey the emergency message desired. It also looks at how the consumers of the information receive the intended notification. Gaining a clear understanding of the basic system mechanics will help teams rule out some systems as it becomes evident they do not have the capacity to accomplish the established goals and objectives. The RAND report stresses, “Understanding the nature of these technologies and how they function […] would help stakeholders decide which technologies to invest in and use.”215 For systems that do match the teams’ goals, understanding these factors will help answer many of the questions in the rest of the evaluative process.

215 Schwartz et al., Role of Technology, xvi.
(2) System Reliability

System reliability, the second system quality variable, measures the overall reliable performance of the system under normal and abnormal circumstances. The evaluation considers potential points of failure, built in redundancies, and takes into account the strengths and weaknesses of the warning system, as well as those of the schools themselves.

This part of the evaluation loops back to the capabilities assessment conducted in the first Foundation domain. The teams will need to understand to what extent the schools are vulnerable to power outages, internet disruptions, or repeater deficiencies. Some schools are subject to cell service limitations due to tower inefficiencies, service provider voids, or dense building construction. Some schools have backup generators to provide redundancy to a warning system; others do not. In one of the JHU case studies, several reliability concerns were noted, “overtaxed cellular networks and Internet outages [as well as] uninterrupted power supply.”\textsuperscript{216} The report continued, “The school district experiences frequent storms and power outages, potentially resulting in safety systems that may be interrupted, reset, or power surged, requiring additional maintenance and resulting in lost coverage.”\textsuperscript{217} Schneider went further and noted frequent communication system weakness as “Dysfunctional equipment that works inconsistently, due to bad weather, leaky roofs, or deferred maintenance [and] reliance on towers or systems that predictably overload in genuine emergencies.”\textsuperscript{218} Understanding the schools’ capabilities, risks and limitations will help the team evaluate the warning system’s performance strengths and weaknesses with regard to those limitations.

Warning systems function on a variety of platforms, such as software, analog or digital, electrical currents, cellular, microwave, or landline phone connections. Some use a combination of these platforms. Some systems are hard wired, others wireless; some have built in redundancies like battery backups, while others use cloud storage. Some


\textsuperscript{217} Johns Hopkins University Applied Physics Laboratory, 11–18.

\textsuperscript{218} Schneider, \textit{School Security Technologies}, 8.
have to be taken offline during updates, or turned off while recharging. Teams will need to determine if the technology is vulnerable to signal interference, if the service provider has adequately functioning satellites, or if it has a propensity to malfunction due to the quality or sensitivity of the technology. For example, some fire alarm initiating appliances, such as smoke or heat detectors, are often inadvertently activated due to construction dust or materials, bursts of wind when doors are opened, or fog machines. Some systems require 24-hour monitoring, call centers, or customer service. It can be valuable to check with other organizations using the system to learn if they have experienced any unexpected malfunctions or discovered vulnerabilities to its reliability.

It is important to anticipate the warning system’s potential points of failure and the schools’ ability to compensate for those vulnerabilities, which is done by looking for built in redundancies and examining the feasibility of adding more redundancies to shore up identified weaknesses. Having a reliable system that works as expected and when needed, can save lives. One that fails can cost lives.

(3) Security Attributes

Security attributes is the third variable to evaluate in the system quality dimension and looks specifically at system defense and activation protections. System defense involves the actual configuration of technology and its strength of protections versus vulnerabilities to defend itself from malicious disabling or modifying the system. Activation protections include factors related to access to the devices and protections to prevent intentional (pranks) and unintentional (nuisance) warning system activations.

System defense can be determined by proactively anticipating what circumstances could lead to the warning system being nefariously or accidentally disabled or programmatically altered. The JHU report asks, “Are there ways to circumvent the technology and enable maladaptive behaviors?” Internet-based warning systems are vulnerable to hacking, denial of service attacks, and viruses. Wireless systems have many points of vulnerabilities that make them ripe for compromise. Marc Weber Tobias, in his

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article “This Popular Wireless Alarm System Can Be Hacked with a Magnet and Scotch Tape,” explains many of the vulnerabilities of wireless alarm systems: “gateway receiver[s] can be jammed, just like a denial of service (Dos) attack on network servers.”\textsuperscript{220} He discusses the ease with which wireless home security systems can be disabled. In Brian Rhodes’ paper, “How to Hack an ADT Alarm System,” he explains that Federal Communications Commission (FCC) frequency license records are public information. He summarizes a Defcon 22 presentation about hacking alarm systems: “Find out the frequency the alarm system transmitter uses from publicly available FCC documentation. Get a software defined radio, set it to that frequency to jam it.”\textsuperscript{221} Even the security of a major city’s emergency warning system is vulnerable to this type of hacking. In April 2017, the emergency sirens in Dallas, Texas were maliciously hacked, which caused 156 sirens to blare in the middle of the night.\textsuperscript{222} The same type of frequency vulnerability was used to exploit the system.

Another point of vulnerability has to do with jamming. “Jamming devices emit radio frequency signals at specific bands with the intention of overpowering other signals.”\textsuperscript{223} The result is “disruption or failure of wireless communications or mapping equipment—including cellular, LMR or GPS systems.”\textsuperscript{224} These nefarious activities can have serious consequences, “Jammers interfere with public safety communications and may leave responders without vital communications and critical situational awareness, […] may delay emergency response times, escalate hazardous situations, facilitate illicit


\textsuperscript{224} Kowdley, 3.
activities, or result in loss of life.” These consequences demonstrate the importance that warning systems have adequate system defense.

It may also be helpful to learn about potential unintended consequences due to the presence of the system. For instance, in a school shooting at Westside Middle School in Jonesboro, Arkansas, the fire alarm system was used to lure students and staff out of the school and into the line of gunfire. It is also possible for the fire alarm system sensors to react to smoke from gunfire, which can set off the fire alarms, as was the case in the Las Vegas mass shooting when, in this circumstance, the fire alarm going off actually led police to the shooters location.

Activation protections have traditionally been problematic with the fire alarm system. Fire alarm pull-stations are easily accessible in common areas in schools and are vulnerable to student pranks. However, unintentional false alarms for the fire alarm system are a much bigger risk than malicious pranks. A 2013 NFPA study shows that only 8.2% of false alarm activations in the United States are from student pranks. In contrast, 78.5% of false alarms were from system malfunctions, sensor activations, such as carbon monoxide detectors, and accidental activations. Schools have worked hard to implement strategies, policies, and consequences for dealing with and curtailing intentional and unintentional false alarms.

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Some systems have easy access leading to potential misuse. Public address warning systems accessible from classroom phones can be misused by students gaining access to the passcode or to an emergency button on the phone. Computer keyboards with a clearly identifiable panic button can easily be pranked or even accidentally pressed by students or teachers. A crucial consideration is the impact that these false alarms have on first responder operations and relationships. While false alarms can affect the confidence users have in the system, its greatest cost may be the impact on the schools’ community partners. JHU report says that with duress alarms, “schools must be careful to minimize the number of false alarms. Schools may be subject to service fees or penalties if responders are called to excessive false alarms.”\textsuperscript{230} The report continues, “there is a trust relationship in which school officials trust in a quick response from law enforcement and law enforcement trusts the school to minimize or eliminate false alarms. Schools must find ways to mitigate false alarms to eliminate the possibility of not receiving a response when the alarm is triggered.”\textsuperscript{231} Teams need to discover that ideal balance between access requirements and a system that is overly vulnerable to misuse. Training and consequences can be mitigating factors for this vulnerability.

(4) System Flexibility

System flexibility is the fourth evaluation variable in system quality and seeks to ascertain the degree to which the warning system is compatible with and customizable to a variety of school environments. The flexibility variable also examines to what extent the warning system is expandable to phase in additional features over time.

Assessing for compatibility and customizability helps teams determine if the warning system is transferable and adaptable to a variety of school physical layouts, needs, and philosophies. If teams want to apply the system consistently in all schools in their district, they will need to discover if it is flexible to modify implementation based on site-specific configurations. Schools may have different philosophies regarding


\textsuperscript{231} Johns Hopkins University Applied Physics Laboratory, 4–33.
lockdowns and other protocols. Teams will need to learn if the technology is flexible to allow teams to construct warning messages based on the type of protective measures the schools and their community partners deem appropriate. It may be important to determine if the system allows for messages in multiple languages and if it is flexible enough for schools to customize visual LED messages if that technology is used. The ability to override a pre-recorded message to give other instructions as appropriate to an emerging incident may also be a requirement. Moore says the system should “allow informed emergency managers to provide live and correct information to the population as a situation develops.”\textsuperscript{232} The ability to silence warning systems or cancel an alert or warning message during known false alarms is also desirable.

Teams will also want to learn to what extent the system is expandable to phase in additional components over time as funds are available. With limited funds, schools may prioritize tier-one needs, and thereby choose flexible systems that incorporate existing infrastructure, technology, and systems. In “Supplement 2 Emergency Communications Systems Design and Application Challenges,” Moore discusses some of the benefits of leveraging an existing speaker system:

No one would question that using one speaker system to serve multiple functions offers financial benefits to the owner of the facility. Using one system reduces the costs of design, installation, and maintenance throughout the life cycle of the system. In addition, regular use of the system for normal paging functions provides an end-to-end test of the audible notification components and circuits.\textsuperscript{233}

The JHU report points out, “The benefit of dual-use [communications] technology is increased attention to training and maintenance, thus making it more likely to be available and to be used effectively in the event of an emergency.”\textsuperscript{234} The flexibility to utilize existing systems may be important to the teams.


\textsuperscript{233} Moore, 890.

c. **Service Quality**

The service quality dimension refers to the total support of the warning system as provided by either the external or internal service provider or a combination of the two. Variables to examine include the expected lifespan of the system, technical support, and ongoing maintenance requirements.

1. **Lifespan**

Lifespan is the first variable to evaluate in the service quality dimension and gauges the length of time the warning system is expected to be functional and useful for the school. It includes factors, such as how often the system as a whole and its individual components have to be replaced or upgraded. The expected life of the system and its components can be impacted by the system wearing out or breaking down due to frequent system use, the age of the equipment (degrading), the construction of the equipment (how long the technology lasts), and due to changing or outdated technologies no longer supported. The JHU report cautions, “Technologies have an expected life cycle, and as equipment ages and technology advances, equipment and software must be replaced. Grants in response to incidents, however, almost never account for this, leaving schools with aging systems and no means to refresh the technology.” Some components of a warning system may need to be exercised frequently to stay in good working condition. Environmental factors, such as weather, dust, corrosion, and extreme conditions, can affect the life of a system or its components. The JHU report suggests examining if “the system [can] withstand rain and snow or hot and cold temperatures.”

Teams will also want to determine if the technology is changing at such a rapid pace that it will require frequent replacing or updating of the system. Sometimes this requirement is by design, which is indicated by a business tactic called planned obsolescence. *The Economist* defines it as a “strategy in which the obsolescence (the

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237 Johns Hopkins University Applied Physics Laboratory, 2–18.
process of becoming obsolete—that is, unfashionable or no longer usable) of a product is planned and built into it from its conception. This is done so that in the future the consumer feels a need to purchase new products and services that the manufacturer brings out as replacements for the old ones.”238 This requirement is especially problematic for schools since financial sustainability is such a huge factor. The frequent changes in technologies also impact schools’ ability to support a system due to the time involved in training staff on changing or new systems. The more times a system changes and the school staff has to learn a new system, the less likely the staff will be to accept new technology.

(2) Technical Support and Maintenance

Technical support and maintenance requirements involve the internal and external timely guidance and support necessary to keep the system operational. It is the second evaluation variable in the system quality dimension. Contracts for technical support can be costly. Decision-making teams will need to determine who can provide technical support, diagnose problems, conduct system inspections, perform maintenance, and repair or replace parts. It can be helpful to understand if any special licenses, knowledge, or training are required to perform these functions. Teams may check to see if they have the capacity internally to maintain the system using their own facilities or technology personnel. Depending on the ownership or set-up of the system, it may require external support from a vendor or other supplier. If so, asking questions about the vendor’s record of responsiveness, timeliness, and competence is appropriate. It is also important to learn the availability of individual system components or parts, and if proprietary limitations or requirements exist to using certain parts or vendors.

When assessing the reliability of the software, consider factors, such as if it is housed exclusively in the school district’s IT or if it runs through the vendor’s system. Schneider emphasizes, “Any network will require continual maintenance, eventual upgrading, and constantly updated virus protection and intrusion detection systems (IDS)

to watch for hackers or unauthorized transfers of data.” 239 Ownership and licensing are also factors. The JHU report points out, “Technology may evolve rapidly (and so does the software that may accompany it); consideration must be given to replacement, maintenance, and repair costs. Long-term support for the technology is a key factor; support from unproven vendors or distributors is unknown.” 240 Selecting a warning system with manageable ongoing maintenance requirements is a significant factor for the schools to be able to sustain the system financially for the long run.

\[d. \quad \textit{Technology Domain Summary}\]

Working through the evaluative process in the Technology domain will help decision-making teams narrow down the selection of communication and warning technologies to those that have the capacity to meet their goals and objectives. In the Human domain, teams will evaluate how the technology interfaces with the people designated to use the warning systems.

3. \quad \textit{Human}

The Human domain comprises an evaluation of system use and user satisfaction to inform the likelihood of the users’ acceptance of and ongoing implementation of the considered technology. Table 9 explains the Human domain.

\[239\text{ Schneider, } \textit{School Security Technologies}, 1.\]

\[240\text{ Johns Hopkins University Applied Physics Laboratory, } \textit{A Comprehensive Report on School Safety Technology}, 2–3.\]
Table 9. Human Domain Expanded.

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a. **System Use**

The system use dimension examines three human-user variables: the impact on daily routines, parameters for use, and perceived support. Mohd et al. describe system use as relating “to the person who uses the system as an operator, their levels of use, training, knowledge, belief, expectation and acceptance or resistance.”\(^{241}\) The assessment looks critically at how the technology affects those using the system.

(1) **Impact on Daily Routines**

The first evaluation variable in the system use dimension focuses on the impact on daily routines of the school staff. The daily flow of the school day involves a highly

orchestrated number of routines, as well as carefully and strategically designed schedules, timelines, and class changes to move hundreds or thousands of students to various locations around the school campus. Many activities are staggered due to occupancy limitations that require the sharing and rotation of spaces to accommodate the number of students in the schools who need to eat lunch, have recess, visit the library, go to gym class, etc. If the technology adversely interferes with the school staff’s finely calibrated routines, causes frustration to staff, or if it disrupts the regular flow of the school day, adoption of the technology is hampered and sustainability becomes less likely.

Teacher schedules are also highly regulated. Time in the classroom, called “instructional time” is carefully organized to take advantage of every minute and to empower students to stay on task. Teachers build important classroom management strategies and practices into their daily routines to support positive student behavior and productive class periods. Support staff track attendance, sign in late students, and call home to verify student absences. They provide medical support when students are ill or injured. They coordinate the arrival and dismissal of students, as well as constantly changing, complex transportation arrangements.242 All these tasks, and many others, lend themselves to a fast-paced school environment in which staff members are often stretched to their limits.

If the warning system technology requires extra work, responsibilities, or unjustifiable inconveniences, or if it unreasonably interrupts the daily routine of staff and students, it will very likely fail. The RAND report explains, “Expert panelists noted that entry control technologies were often ‘defeated for staff convenience’ by propping open doors, and others acknowledged that such technologies are hard to implement at schools with many points of entry, particularly open-air campuses or those with modular classrooms.”243 When evaluating the warning system, the team must determine to what

242 Daily transportation changes include sorting out of which children ride which bus, which students will be picked up by parents or guardians in vehicles, which are walking or riding bikes home or being met by a parent walker at the school. Some students stay at the school for various after school programs. Others are picked up early.

243 Schwartz et al., Role of Technology, 22.
extent the impacts to the daily routines of staff and the schools are sustainable both initially and over time.

(2) Parameters for Use

Parameters for use, the second evaluation variable in the system-use dimension, involve factors related to the flexibility of the system to accommodate the specific conditions and needs of the humans using the system. The school needs flexibility to address specific emergencies, hazards, or threats, as defined by school officials and their community partners, to determine the locations from which the system can be activated, and to accommodate the number of users necessary to meet their goals and objectives.

School staff must be clear about the kinds of emergencies, hazards, or threats for which they can use the warning system. If uncertainties about these parameters arise, it could cause people to hesitate and fail to initiate a timely warning to school occupants. Personnel also must understand if this system has any limitations on where it can be activated (school only, buses, field trips, playgrounds, exterior areas, from home, etc.). If activation from a remote location is required, it is necessary to determine if it creates a vulnerability to the security of the warning system. Teams can check to see if the system requires openings in firewalls for IP-based technology or if special permissions or extra devices are necessary to use the system off school grounds. Further assessment will also help decision-makers determine if the technology can be inadvertently or nefariously activated while off campus.

It is also important to determine if the technology will support the number of users who will need to operate or use the system. For instance, some cellular service boosters have a limit of 12 phone numbers. Some school safety tip lines have a limit of three school contact people, and radios often have a limited number of channels or frequencies. Some mass phone-call systems only allow a certain number of separate school accounts. Teams will need to quantify users and assess the technology to ensure it is capable and flexible enough to meet the requirements.
(3) Perceived support

Perceived support is the final variable in the system use dimension and helps teams anticipate the users’ sense of support by management and peers in using the system. Staff should be clear about when it is appropriate to use the warning system, without the fear of management’s reaction when they do activate the system. Mohd et al. posit that the success of a system can be impacted by the user’s resistance to or acceptance of the system “job insecurity and fear are some examples of interaction resistance.”²⁴⁴ If employees are afraid to activate a warning system out of fear of peer rejection, being perceived as overreacting, or from concern about employment consequences, user acceptance might diminish.

System users should understand what type of hazards, threats, or circumstances necessitate the system’s use, should be confident about how to use the system, and should believe they will be supported by management and their peers. School leadership will need to decide if use of the system will be voluntary or mandatory, and if any confidentiality measures will be instituted to reduce exposure to those using the system. Users will need assurance that if they are uncertain about the need to activate a warning, but because time seems to be of the essence due to imminent danger, they will have immunity if they err on the side of caution and it subsequently turns out to be an unsubstantiated threat. A user may be more likely to use the system if an unnecessary activation of the system is reframed as a drill.

b. User Satisfaction

The user satisfaction dimension in the Human domain includes evaluation variables related to the staff’s perception of the system’s usefulness, the system ease-of-use, and the user’s perceived acceptability of the system within the school environment.

(1) Perceived Usefulness

Perceived usefulness is the first variable to examine in the user satisfaction dimension and it reveals the correlation between perception of usefulness and acceptance.

In other words, user acceptance increases if stakeholders believe the problem is worth solving, if the new technology is an improvement on the schools’ existing capability to solve the problem, and if users perceive that the new technology actually solves the problem. The RAND report points out, “For technologies to be used effectively, they need buy-in from the school staff (and sometimes the community) and appropriate resources to work with the technology, and the technology needs to be seen as effective so that people continue to use it.”

If perceived as useful, staff are more likely to sacrifice their limited time from other responsibilities to embrace and utilize the system. A similar assessment is necessary if the system is purposed for student use, such as a school tip line. If students perceive that the proposed technology meets their needs, they will be more likely to use it.

(2) Ease-of-Use

Ease-of-use is the second element in user satisfaction and considers factors related to user interface, frequency of use, and training. Evaluating the warning technology to determine if it is intuitive will help teams understand user interface. Teams can check to see if it is distinct from other systems, if the nomenclature of the system conflicts with existing terminology, and if the terminology makes sense. It is also prudent to determine if the introduction of the new warning system creates confusion or if it clashes with other systems or competing capabilities. For instance, if teams want to add a new safety tip line for their students, they will need to consider how other existing tip lines, such as a suicide hotline, a bullying reporting platform, or local mental health call center, would interact with the new tip line. Teams may be able to reduce unnecessary redundancy by eliminating or combining systems.

The ease of the user interface increases if the system does not require special knowledge, codes to remember, skills or ability to operate the system. If it does, teams may develop strategies, such as providing users with quick-reference cards with the required information. If the system requires any special tools, keys, or equipment to access or activate the system, users will need to know where those things will be stored.

Schwartz et al., Role of Technology, 74.
and how to access them in a timely manner. Examining the instructions for using the warning system and associated signage to determine if they are intuitive and easy to follow will also provide valuable data about user interface. When people are under extreme stress, like during emergencies, they can have physiological and psychological reactions such as limited fine motor skills, memory challenges, and a diminished capacity to perform basic functions. Thus, prioritizing the ease-of-use of the technology becomes important to empower the users of the system to overcome these natural stress responses in emergencies. With warning systems, it is imperative that designated users are able to access and use the system with ease.

Frequency of use is also a factor to consider when trying to understand how easy the system will be for people to use. If a communication or warning system is in use frequently, the users are more likely to develop competency and speed in their ability to effectively use the system. If the technology is to be used for infrequent events, recall becomes a limiting factor, which makes it difficult for people to remember how to use a system. Another consideration may be how overuse of the system can affect the intended recipients. For example, if a school uses a mass phone call service to send out regular educational related phone messages to parents or guardians, (i.e., science fair announcement, fundraiser reminder, open house invitation, attendance notifications, parent-teacher conference schedule, etc.), target audiences may become desensitized to the phone messages due to overuse of the system. When the schools need to use the same system to send an important, time-sensitive emergency message to parents, they may already be in the habit of ignoring those calls, which can result in missed or delayed critical notification.

Training gives users experience with the technology, and aids in developing a sort of muscle memory to help overcome those natural responses to extreme stress. Training also helps identify problems, so that problems can be resolved or averted. Teams will need to determine the type and frequency of training necessary to equip the intended users properly. Identifying who needs the training, how often they need to receive

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These reactions to extreme stress are sometimes called fight, flight, or freeze responses.
training, and who will provide the training is also part of the assessment. Another important variable involves the time involved and the cost of initial and ongoing training, and how staff turnover affects training requirements. Teams will need to clarify to what extent the school can maintain this time investment for training; they may even consider developing simple and sustainable training tools to aid in the ease-of-use of the technology. Quality training directly affects ease-of-use. Likewise, ease-of-use directly affects user satisfaction and is a key to the sustainability of a school communication or warning system.

(3) Perceived Acceptability

Perceived acceptability, the final element in the user satisfaction dimension, challenges teams to focus on the system’s impact on the schools’ culture and climate. The K-12 EOP Guide calls school climate “a range of campus conditions, including safety, relationships and engagement, and the environment, that may influence student learning and well-being.” School climate and culture include factors related to the technology being psychologically and socially acceptable to the school and community stakeholders, including parents and guardians. The RAND report points out that school climate is a possible barrier to the adoption of school safety technologies. Panelists interviewed expressed worry about making “schools feel too fortified or unwelcoming.” If it is psychologically acceptable, the warning system will foster psychological safety due to the addition of an enhanced or improved safety capability. The system will promote confidence in the schools’ ability to protect students and staff. If socially acceptable, it will be aesthetically neutral or positive, the appearance of the system will decrease fear, and it will not make schools look like a dangerous place or feel like a jail. The physical existence of the system will reduce anxiety rather than raise anxiety. The warning system will support a positive, welcoming, and safe school culture and climate with minimal to no controversy. The chosen technology will add to a positive school climate rather than take away from it.

248 Schwartz et al., Role of Technology, 30.
c. Human Domain Summary

The human domain of the evaluation helps teams assess if the technology will be acceptable to the humans interacting with it, which directly affects feasibility and sustainability of the technology in the school system. In the Organization domain, teams will evaluate the technology in light of how compatible it is with both the unique school system and its community partner organizations.

4. Organization

The dimensions in the Organization domain include structure and environment. The focus is on the interaction between the warning system technology and the unique structure and environment of the schools, school districts, and their community partners’ organizational attributes and leadership. The RAND report believes, “To employ technologies effectively and ethically, schools need to consider whether and how particular technologies could feasibly be implemented and used to successfully address the specific issue related to student safety for which solutions are needed.”\textsuperscript{249} The report went on to identify a common theme among participants in their research and stated that school safety technology “solutions must be context specific.”\textsuperscript{250} The fourth domain, Organization, considers how the technology works within the unique structure and environment of the organizations it will serve. Table 10 explains the Organization domain.

\textsuperscript{249} Schwartz et al., xvi.

\textsuperscript{250} Schwartz et al., 32.
Table 10. Organization Domain Expanded.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables</th>
</tr>
</thead>
</table>
| A. Structure | i. School Attributes:  
  • Characteristics & Demographics:  
  • Physical Configuration:  
  • Personnel Capacity:  
  • Existing Systems:  
  • Acceptable to Leadership:  
  ii. Community Partner Attributes:  
  • Impact on Daily Operations/Personnel:  
  • Existing Systems:  
  • Response Capabilities & Philosophies:  
  • Acceptable to Leadership: |
| B. Environment | i. Management and Ownership:  
  • Internal:  
  • External (Proprietary Limitations):  
  ii. Financial Impact:  
  • Initial Costs:  
  • Ongoing Costs:  
  • Funding Sources:  
  iii. Aligns with Regulations:  
  • Codes or Licensing:  
  • Policies/Statutes/Laws:  
  • Labor Relations:  
  • Risk Management: |

**a. Structure**

The organizational structure dimension speaks specifically to whether the warning system is compatible with the various attributes and characteristics of the school and its community partners.

(1) School Attributes

Examining school attributes is the first half of the structure dimension and helps teams look at the relationship between the warning system technology and its compatibility with the schools’ unique characteristics and demographics, physical
configuration, and existing school safety systems. A related factor is the extent to which the schools’ leadership accept and support the warning system.

The characteristics and demographics of schools refer to the type of school and the population who will interact with the warning system. For example, the warning system needs of K-12 schools are quite different than higher education environments, where college students carry cell phones around campus and to classes versus elementary school students who may not even own cell phones. Likewise, the developmental level of the students served is also a consideration, since warning messages may require age-appropriate terminology.

The physical configuration and layout of the campus can reduce or enhance the efficacy of a given warning technology. The planning teams should consider what factors reduce or enhance the system’s use in different environments, especially if it is to be implemented in numerous schools in a district that requires interoperability. Another consideration is if the technology can be equally effective in self-contained buildings versus sprawling campuses with unconnected buildings, or in schools with outside locker halls, corridors, or walkways between buildings. The building construction, utility services, and geographic terrain can affect communications reliability, connectivity, and compatibility. If the technology requires cellular service, it is prudent to determine if the cell carrier actually provides service to all the schools in the district, if coverage is consistent in all areas inside and outside the school, and if the system requires stakeholders to subscribe to a particular cell carrier that may only serve a particular geographic area. If the warning technology is on buses, geographic factors may affect suitability.

Understanding the schools’ capacity to dedicate personnel for ongoing implementation of the warning system technology is essential. Some larger school districts have their own dedicated safety staff, security departments, campus police, or even dispatch centers. For many small- to medium-size school districts that do not have any of those resources, safety responsibilities are included in existing school job descriptions and roles. Schools are fast-paced, dynamic environments. School personnel are responsible for managing many tasks simultaneously. These factors are important to
consider because some warning systems require constant, daily, and ongoing monitoring, management, and operations. Others are self-monitoring. The RAND report discusses video surveillance technologies used in schools and points out that “rarely is live video under constant monitoring.”251 It is not common for schools to have the capacity to dedicate staff to continual monitoring of school safety technologies. If monitoring is required, the teams will need to learn if it needs internal or external monitoring, or both. For internal monitoring, a determination is necessary on the number of personnel required to monitor the system. For some, it may be feasible for dedicated personnel at the district level to monitor schools for the entire district to cut down on personnel requirements. If external monitoring is an option, the districts may be able to utilize the existing alarm company that monitors their fire alarm system, or use an affordable vendor to handle system monitoring and management. Understanding and being realistic about these factors will help school teams select the right warning system that is sustainable over the long run.

The compatibility of the warning system technology with the schools’ existing safety systems also needs to be considered. Is it compatible with existing radio frequencies, software platforms, repeaters, antennas, digital versus analog equipment, etc.? Assessment will help to determine if adding the system brings in necessary or unnecessary redundancy with existing systems, or if it causes confusion or brings clarity. For example, if one department in a school uses a different type of two-way radio than another group of staff members use, interoperability may become an issue. Having two different channels or frequencies on which to broadcast an emergency announcement is another step that requires extra time and may be overlooked during a stressful situation. If one school in a district uses a particular tip line app, and the feeder school uses something different, this can confuse students as they transfer to new schools, or cause confusion for parents who have children in more than one school. Mass phone notification systems used by some schools in a district, and not by others can also create unnecessary redundancy, confusion, and expense. Teams can evaluate the warning system against

251 Schwartz et al., Role of Technology, 24.
existing safety systems to streamline use, and to ensure consistency, ease-of-use, and overall compatibility.

Another variable to evaluate is whether the warning system technology is acceptable to school leadership. For a warning system technology to be feasible and sustainable in a school, it is imperative that it be embraced by the school principal and supported by district leadership. School principals are responsible for the daily implementation of the technology. If they understand and believe in the purpose and functionality for their school, they are more likely to devote the necessary time and resources needed for ongoing implementation of the system. If it demands an unreasonable amount of their time or resources, they are less likely to support its ongoing implementation. The RAND report found this to be the case for school administrators with regard to social media monitoring for safety purposes, “Panelists bemoaned the time required to effectively monitor social media…and were skeptical that school administrators could realistically add this to their already long list of responsibilities.” 252 It is also important for it to be acceptable to and supported by district administrators and school board members. If the technology aligns with the school district’s safety and emergency response philosophies, with little to no controversy, it is more likely to be accepted. If it is perceived as a fad, a band-aid, or temporary solution, or if it is supported by one-time grant funding that is not sustainable long-term, leadership may be resistant. If specific school-district people are championing the project and they leave the school’s employment, support for the system may fizzle out if district leadership does not maintain interest. If district leadership has a clear vision for the technology, they are more likely to provide the initial and ongoing support necessary for sustainability.

(2) Community Partner Attributes

Community partner attributes is the second evaluation variable teams will consider in the structure dimension. When selecting warning system technologies, schools must consider its potential interaction with local law enforcement, fire, 911 dispatch centers, and other partners. The K-12 EOP Guide says that when developing

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252 Schwartz et al., 28.
emergency plans, “It is critical that schools work with their district staff and community partners—local emergency management staff, first responders, and public and mental health officials—during the planning process[…] This collaboration makes more resources available and helps to ensure the seamless integration of all responders.”

The JHU report agrees and says, “schools should coordinate with first responders when making decisions about communications technology to ensure the systems can interoperate or integrate as needed.” Factors to consider include the compatibility with and impact on community partners’ daily operations and personnel, interaction with existing communications systems, compatibility with response capabilities and philosophies, and to what extent the system is acceptable to leadership.

As teams evaluate how a school warning system can impact the daily operations of its community partners, it would be prudent to learn if the community partners will need increased capabilities, such as additional staff, equipment, or training for effective and reliable operation of the proposed warning system. If the system is highly vulnerable to false alarms, and the emergency response agency uses a significant number of volunteers who have to leave their day jobs whenever an alarm sounds, it can negatively impact local business owners. The geographic distance between the first-responder agency and the school can also affect decision making regarding warning systems, particularly when response time capabilities are a factor. The RAND study explains what their stakeholders said about this factor, “a key distinction in thinking about school safety is police response times—roughly under five minutes (i.e., urban districts) and over five minutes (i.e., suburban/rural districts)—since response times dictate how self-sufficient schools need to be in response to crisis situations such as cases of active shooters.”

The number and availability of first responders may be another factor.

Another consideration involves the impact on 911 centers, how the warning system may affect their daily operations, and the capacity of their staff to handle


255 Schwartz et al., Role of Technology, 19.
emergency calls. If the warning system is for mass notification to parents or guardians, the message may result in 911 centers being flooded with unnecessary phone calls. Differences can result in local versus regional 911 dispatch center capabilities. In a rural area, a local 911 center may have greater familiarity with the local schools and more availability for ongoing training on new warning systems but fewer staff. A larger, regional center may have more personnel and capacity to meet demands created by a new warning system, but familiarity with local schools may be more limited and may require additional and ongoing training for dispatchers. Moreover, if the warning system requires a phone, radio frequency, or alarm company interface with the 911 center, evaluation is necessary to determine if their existing systems and technologies are compatible to receive the notification.

The community partners’ existing communication and warning systems are also a primary consideration. Interoperability challenges or opportunities, necessary or unnecessary redundancies, or radio frequency incompatibility may occur. Learning if the new system will cause interference with community partners’ existing warning systems is another part of the evaluation. If a local jurisdiction uses the same mass notification system as the school, the system may experience competing demands, and the local phone company’s capacity to deliver calls may be overloaded if more than one agency needs to use it at the same time. If sharing radio frequencies, the volume of radio traffic may overload the system’s capacity during emergencies involving the school and community partners.

Another part of the evaluation asks if the schools’ new warning systems are acceptable to the leadership of the emergency response agencies that serve the schools during emergencies. The schools or districts should involve their community partners in decisions to adopt a new system, as well as decisions regarding system operations, the placement of warning devices, wording of emergency messages, and critical response procedures. The teams should explore if the system creates a need to modify standard operating procedures for response to school emergencies or if it represents a conflict with existing response philosophies. They will also need to consider how the new communication or warning technology will positively or negatively affect the schools’
relationship with their community partners. It may lead to increased contact, greater collaboration, joint training or drills, and additional emergency planning, which are all positive outcomes. On the other hand, it may put a strain on limited personnel resources. If the schools’ community partners are in support of the increased warning system capability, and help participate in the evaluation and decision-making process, the likelihood of effectiveness and sustainability increases.

b. Environment

The organizational environment dimension refers to factors related to who owns the system, the financial impact on the school and community partners, and if the warning system aligns with regulations.

(1) Management and Ownership

The first evaluation variable in the environment dimension examines potential keys to sustainability based on who controls, manages, and holds the ownership of different aspects of the warning system. Teams will need to look very carefully at factors involving proprietary limitations that keep ownership of certain components of the system with a vendor. For example, some warning systems require a combination of wiring and hardware installed in the school and software installed on school computers. In this case, teams must determine who owns which components of the system. If software updates are required for the system to remain operational, the school may be at the mercy of a vendor’s schedule and rising prices. Several factors need to be explored, such as if restrictions or limitations exist when desiring to change vendors, if the hardware is proprietary, or if it can be used with another vendor’s software. It may be helpful to determine if safeguards are in place in case the vendor discontinues the product line, goes out of business, or sells the business. The RAND report brings up student tracking technologies and identifies concerns, such as “cost and the internal IT capacity to successfully host and maintain such a tracking system.”

256 Schwartz et al., Role of Technology, 26.
and control the software, they will need to determine if they have the internal capacity to maintain and service the software to ensure long-term operational sustainability.

(2)  Financial Impact

Financial impact is the second element in the environment dimension. Schools and their community partners must consider the initial costs and ongoing financial impact of the warning system technology on their organizations. The JHU lists several cost considerations, “acquisition, exceptional installation costs (e.g., special wiring), personnel, training, maintenance, consumables, energy and energy dependency (e.g., backup power), software licenses, system integration (e.g., cameras integrated with alarm systems).” Costs may also be associated with ongoing contracts. The report also suggests exploring “low-cost alternatives.”

Teams should also consider the financial impact on the community partner agencies and their ability or willingness to contribute to initial or ongoing expenses of the proposed warning system. There may be a potential for a shared financial investment in the system through grant funding opportunities that are available to fire or law enforcement agencies. The RAND report notes a potential barrier to the adoption of school safety technologies as, “Cost to adopt reduces funds for more important safety initiatives.” The report continues, “Almost half of the stakeholders interviewed cited cost issues and specifically how investing in [school safety] technology reduced other resources that they felt were more important.”

Ways to mitigate the financial impact may arise. The RAND report asserts, “Complex systems of alerts can cost districts millions of dollars; the use of existing infrastructure (e.g., telephone lines, local fire alarms) to send out alarms can eliminate fees and costs while also being reliable.” If necessary, schools can consider the feasibility of starting with just the minimum, basic system features necessary to

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258 Schwartz et al., *Role of Technology*, 30.

259 Schwartz et al., 14.
accomplish the primary goal, and work to utilize existing systems and resources where applicable. They may consider making a plan to phase in enhanced capabilities over time as additional funding is allocated or available.

Schools can consider a variety of funding sources, such as grants, bonds, partnerships with community partners, insurance companies, teachers’ unions, booster clubs, and parent organizations. Even allocating funds from their own school or district budget may be possible. When existing school systems, like phone or intercom systems, are past their useful life, some schools use it as an opportunity to explore new systems with greater capacity to provide warning. The JHU report indicates that after serious and horrific school incidents occur, districts often make quick spending decisions, by saying that funding opportunities often have a “short spending window. This curbs the ability of districts to conduct even limited evaluation and frequently results in the purchase of technology to demonstrate a strong commitment to ‘doing something’.” Some vendors provide free or discounted initial use of their systems to try to hook schools into using their products. Others will look for schools to pilot their products. Many open-source, free software and cell phone applications are available for pushing out communications. While some warning systems, like statewide school safety tip lines, may be state funded and free to all schools in the state, they may still represent costs to the school. These costs include those associated with the time involved in training personnel, marketing expenses, system management, and maintenance costs. All these are important considerations, and teams would be wise to be cautious and have the foresight to anticipate costs involved in free technologies.

Examining ongoing costs loops back to information identified in the technology domain section of the evaluation. It includes costs related to equipment, contracts, and personnel. Ongoing vendor contracts can be a barrier for some schools. Monthly or annual user or subscription fees can be based on student enrollment, number of schools participating, amount of phone numbers to which a warning message will be sent, or may be based on actual frequency or volume of system use. Personnel costs will also need to

be factored into the ongoing costs. If the system requires constant monitoring, personnel costs may be much higher than automated, self-monitoring systems. If monitoring can be done by an alarm company the school already uses to monitor other systems, the ongoing fees may become more manageable. Teams will need to understand the costs associated with annual inspections, replacement of batteries or system components, ongoing maintenance, software upgrade fees, etc. The anticipated life of the system should also be taken into account. The RAND report explains:

With respect to specific costs, one issue that was brought up was the up-front cost of acquiring technology. But the more frequently raised concern was about the recurring cost to staff to maintain the technology. A superintendent told us: [I]n the last 6-7 years there’s been a lot of funding to enhance safety technology resources but unfortunately tech changes so quickly and so there’s been no funding to keep those projects updated and funding has actually dropped. There are many districts who’ve placed tech in the buildings they can no longer afford to keep maintained.261

Decision-making teams will need to carefully consider both initial and ongoing costs and evaluate their ability to fulfill the associated financial commitment over time.

(3) Aligns with Regulations

The final evaluation variable in the environment dimension assists teams in ascertaining to what extent the technology aligns with a variety of potential regulations. Teams will need to do research to learn if any codes regulate components of the warning system. Communication systems that use two-way radios and associated elements, such as narrowband versus wideband frequency spectrum, and repeater licenses are regulated by the FCC. The FCC “regulates…communications by radio, television, wire, satellite, and cable in all 50 states, the District of Columbia and U.S. territories.”262 The International Building Code (IBC), followed by most U.S. jurisdictions, may be a regulatory body for the technology under consideration. Building codes may affect decisions about school warning systems, such as fire protection systems, electrical and mechanical systems, rooftop structures like antennas, as well as earthquake recording

261 Schwartz et al., Role of Technology, 31.
instrumentation. The NFPA is in alignment with building codes and regulates many aspects of school warning systems.

Another area of regulation to evaluate is if any local, state, or federal laws, statutes, or policies govern the use of warning systems in K-12 schools. Some state education agencies mandate a certain type of warning system used in schools in their state. Schools also have to consider if the use of the warning system will be compatible with privacy laws, such as the Federal Educational Rights and Privacy Act (FERPA) and the Health Insurance Portability and Accountability Act (HIPPA), the Americans with Disabilities Act (ADA), and special education laws, such as the Individuals with Disabilities Education Act (IDEA). The RAND report cites “violation of student privacy” as a potential “barrier to adoption” when it comes to school safety technologies. The JHU report also cites privacy concerns as a factor to consider, by warning, “Some badge alarms are being designed using radio frequency identification (RFID) technology. The built-in RFID tag broadcasts the location of the badge alarm. With this tracking capability, schools may encounter privacy issues.” Schools must also ascertain if the warning system aligns with local, state, or national school safety or emergency response guidelines, protocols, or practices.

Labor relations and equity issues may also be factors to consider. Anticipating if any real or perceived equity issues surround the warning technology is an important exercise. If the technology is implemented for one school in a district and not another,

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266 Schwartz et al., Role of Technology, 28.

staff, parents, or students in other schools may assume that they are at greater risk of danger by not having the warning system in their schools. If the system includes an opt-in or opt-out policy, it will be important to evaluate if that negatively or positively affects labor relations. For instance, a cell phone-based warning system may only be accessible to staff who own cell phones and may be perceived as inequitable by those staff members who do not own cell phones. In some cases, staff members may require a financial reimbursement from the school for using their personal cell phones as part of the school’s warning system. If staff do use their personal cell phones for a school safety purpose, they may lose some personal privacy if a Freedom of Information Act (FOIA) request is made. The JHU report says, “If the district is using a BYOD [bring your own device] policy, there must be a means to communicate with users who do not have a smartphone or cannot use the services provided by the district because of the type of cellphone or calling plan they use.”

Teams will need to collaborate with their agencies’ unions to ensure that they approve of any proposed system.

Risk management is also a consideration. Decision-making teams would be wise to evaluate in what ways the proposed warning system could decrease or increase risk to its stakeholders, and determine if it is acceptable to the school district’s insurance company. Some insurance companies provide discounted premium rates to school districts that implement certain safety and security technologies that reduce risk.

c. Organization Domain Summary

The organization domain of the evaluation helps teams assess if the technology is compatible with the school and community partners’ organizational structure and environmental factors. It places value on the extent to which the leadership of both the school and community partners accepts the warning system. It also equips teams with data to help evaluate the net benefits of the system, which is the final domain in this K-12 School HOT-Fit Evaluation Tool.

5. **Net Benefits**

Net benefits are the fifth and final domain and are the culmination of the investigative effort. The Net Benefits domain takes the team through an evaluative feedback loop by revisiting findings from the prior four domains and analyzing them against the dimensions of effectiveness, feasibility, and sustainability.

This part of the analysis looks at the strengths and weaknesses of the technology revealed by other domains. In the HOT-Fit model, the net benefits are expected to, “capture the balance of positive and negative impacts on the user.”269 This part of the analysis is also an objective with this new K-12 School HOT-Fit Evaluation Tool, but this school tool goes further by looking less at the *balance* of positives and negatives, and more at how they impact the effectiveness of the technology to meet the teams’ established goals and purpose, as identified in the foundational domain of the evaluation process. Some limitations may still be acceptable if the strengths of the technology allow the teams to accomplish their established purpose in a way that is feasible and sustainable for the schools and their community partners.

Working through the Net Benefits domain of the evaluation process equips teams with accurate, detailed, and realistic data. Teams can use this data to inform their selection of communication or warning system technologies that meet the needs of their unique school or district. Table 11 explains the Net Benefits domain.

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269 Mohd et al., 391.
Table 11. Net Benefits Domain Expanded.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Effective</td>
<td>i. Solves Problem:</td>
</tr>
<tr>
<td></td>
<td>ii. Accomplishes Purpose:</td>
</tr>
<tr>
<td></td>
<td>iii. Reliable:</td>
</tr>
<tr>
<td>B. Feasible &amp; Sustainable</td>
<td>i. Operationally:</td>
</tr>
<tr>
<td></td>
<td>ii. Financially:</td>
</tr>
<tr>
<td>C. Notes &amp; Findings</td>
<td></td>
</tr>
</tbody>
</table>

**a. Effective**

The effective dimension examines a review of the previously collected data to determine if the technology will solve the identified problems, accomplish the stated purpose, and is a reliable technology.

1) **Solves Problem**

The first evaluation variable involves the originally identified problem. It directs teams to return to the beginning and focus their attention on the problem they set out to solve in the Foundation domain. Next, by reviewing the strengths and weaknesses of the Technology identified in the information quality, system quality, and service quality portions of the evaluation, teams can determine if the technology can improve the schools’ capability to solve the identified problems.

2) **Accomplishes Purpose**

The second evaluation variable informing the effective dimension also looks back at the Foundation domain to determine if the technology can fulfill the requirements set out in the purpose statement the teams established at the advent of the evaluative process. Examining the findings in the Human and Organizational domains also helps to inform the extent to which the technology aligns with and can accomplish the teams’ purpose.
(3) Reliable

Reliability is the third evaluation variable in the effective dimension. It involves looking critically at the findings in the Technology domain to determine if the technology is reliable in light of the strengths and limitations of the organization. For example, if the mechanics of the technology require the use of cellular service, and the schools have known cell service dead spots, the technology will not be reliable. The organization-related strengths and limitations are revealed in the risk and capabilities assessment portion of the Foundation domain. Findings related to the reliability of the technology itself are most notably found in the system quality and service quality sections of the Technology domain. Together, these assessments will assist the teams in identifying the depth of reliability of the warning system technology.

If the technology passes the “effective” test, solving the problem, accomplishing the purpose, and being reliable, it then requires further evaluation for feasibility and sustainability.

b. Feasible and Sustainable

To evaluate the feasibility and sustainability dimensions in the Net Benefits domain, the teams assess the technology for operational and financial compatibility with the school and its community partners.

(1) Operationally

The first evaluation variable, operational feasibility, leads teams to draw heavily upon the data collected in the Human and Organizational domains to ascertain if the system is operationally viable and sustainable for the schools, districts, and their community partners. Revisiting the Human domain will help to inform the likelihood of the users’ acceptance of and ongoing implementation of the technology. Findings in the Organization domain will reveal the technology’s compatibility with the identified organizational attributes. Together, these variables inform the degree to which the technology is operationally feasible, which increases its expected sustainability.
(2) Financially

Financial feasibility is the second evaluation variable and is critically linked to the ability of the organization to sustain the implementation of the technology over the long run. The teams can refer to the Technology domain for an evaluation of the technical support and maintenance requirements. The Organization domain will have findings related to initial and ongoing costs involved with the technology. The literature review makes it clear that schools have financial challenges and barriers related to implementing and sustaining school safety technologies feasibly over time. Decision-making teams must carefully study and consider the costs involved in maintaining equipment, ongoing vendor fees, and replacing aging equipment to help teams conduct an honest and realistic assessment of their ability to sustain the technology financially over the long run.

c. Summary of Net Benefits Domain

The net benefits emerge by uncovering to what extent the technology, used within the constraints of the unique school system, is effective to solve the identified problem, accomplish the established purpose, and is reliable both mechanically and operationally. It also ascertains the degree to which the technology is an operationally and financially feasible and sustainable solution for the schools and their community partners.

D. CONCLUSION

The literature review in Chapter I exposed a gap in the research in how to evaluate school communication and warning system technologies. In response, the researcher designed this new K-12 School HOT-Fit Evaluation Tool using the HOT-Fit framework as the structural basis for the school tool, yet focused the evaluation variables on the unique environment of K-12 schools. The next chapter applies the school tool to two specific warning technologies, the school fire alarm system and the researcher’s conceptual lockdown notification system. It also serves as a demonstration on how to use the new K-12 School HOT-Fit Evaluation Tool shown in Figure 17.
Figure 17. K-12 School HOT-Fit Evaluation Tool.
IV. K-12 SCHOOL HOT-FIT EVALUATION TOOL APPLIED

The previous chapter presented an evaluation tool that K-12 school decision-making teams can use for assessing communication and warning system technologies. This chapter tests the new K-12 School HOT-Fit Evaluation Tool on a school fire alarm system and on the researcher’s conceptual lockdown notification system. The goal is to test the school tool and learn to what extent the new school tool can help answer the two thesis questions:

- To what extent can the school “fire alarm system” (for emergencies involving fire and evacuation) be a model for a “lockdown notification system” for emergencies involving violence and requiring lockdown?

- What factors should K-12 school decision-makers and their law enforcement partners consider when evaluating and implementing warning systems that notify both school occupants and law enforcement of an imminent threat of violence at school?

To accomplish this goal, an attempt is first made to validate the efficacy of the fire alarm system that already exists in schools by applying it to the new K-12 School HOT-Fit Evaluation Tool template. Next, the conceptual lockdown notification system is applied to the school tool to identify its strengths and weaknesses and evaluate its suitability to address the problem involving the speed of active shooter attacks and the need for quick notification to lockdown. A template for the K-12 School HOT-Fit Evaluation Tool can be found in Appendix B.

Applying the K-12 School HOT-Fit Evaluation Tool to the fire alarm system and conceptual lockdown notification system also serves as an example on how to use the school tool.
A. THE FIRE ALARM SYSTEM APPLIED TO THE SCHOOL TOOL

This assessment of a fire alarm system is based on a fictitious school, and is not necessarily representative of the conditions at all schools.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
</table>
| A. Problem | i. **Risk Assessment**: School fires, need for quick notification of school occupants, quick evacuation, and quick notification to fire department. Some of our schools have built in sprinkler systems; others do not.  
 ii. **Capabilities Assessment**: The school district has reliable landline phone service, but experiences power outages several times a year due to winter storms. Some schools have radio frequency barriers due to dense construction. Most have some cell service dead spots. Schools have established evacuation routes and assembly areas, and practice fire drills once per month. Schools with multiple floors have portable evacuation devices for assisting people with limited mobility down the stairs. Fire departments are located within 5 miles of each school. |
| B. Purpose | i. **Goals**: Primary goal is to prevent injuries and loss of life due to fire, smoke, and cascading effects. Secondary goal is to prevent building damage.  
 ii. **Objectives**: The schools will have an accessible and reliable warning system that automatically and immediately notifies all school occupants to evacuate at the first sign of smoke or fire; and simultaneously notifies the fire department. |
| C. Motivation | i. **Internal Motivations**: Concern about school fires and the school’s inability to quickly warn everyone in the school to evacuate once fire or smoke is detected.  
 ii. **External Motivations**: History of deadly school fires. Fire Chief is unhappy |
with new building codes that do not require the installation of sprinklers.

| Parameters | i. Priorities: Non-negotiable: Primary focus is to alert occupants and summon aid. Desirable: Secondary focus are the emergency control functions such as sprinklers to suppress the fire and door closures to stop the spread of fire.  
| Limitations: Financial limitations for initial equipment and installation; once installed there are manageable maintenance fees. Staff and parent/guardian buy-in due to perceptions of scaring children when the alarm sounds.  
| Scope: The scope is limited to alerting occupants and summoning aid. An expanded scope would include features to extinguish a fire, such as sprinkler systems, fire extinguishers, and fire blankets. |

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**Domain #2: TECHNOLOGY**

In the next step, teams will evaluate technological solutions to determine if the technology can solve the identified problems and meet the team’s stated goals. The second domain, Technology, requires a detailed analysis of the information quality, system quality, and service quality dimensions of the technology against the criteria established in the Foundation domain. Working through the evaluative process in the Technology domain will help teams narrow the selection of communication and warning system technologies to those that have the capacity to meet their needs.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
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</table>
| **A. Information Quality** | i. Activation Attributes:  
| Technology | - Type of activation: The system is activated through the use of red pull-stations that are mounted on the walls, fixed in place, and hardwired throughout the school. They are always functioning.  
| | - Accessibility: Initiating devices are accessible, easy to locate, and can be activated from many places in the school. A key is not needed to access the areas in which the pull-stations are located. A code is not necessary to activate the pull-stations. There is an adequate number of activation devices to serve the size and layout of each school facility. The setup of the system does not place limits on the number of users. It is available to anyone at any time. It does not depend on a school administrator, staff member or security personnel being on site, available, monitoring anything, or at a certain desk, computer, or office to activate the system.  
| | - Times & Locations: It is accessible to activate when school is in session and during non-school hours for athletics, afterschool programs, and visitors using the facility on weekends. The system is not dependent upon the time of day or night that someone is in the building; it does not favor school being in or out of session. It is constant, 24/7/365.  
| ii. Notification Attributes:  
| | - Type of notification: The system provides notification to all building occupants through the use of horn-strobes that are hardwired, fixed in place, and mounted on walls and ceilings throughout the school. The horn-strobes provide both a visual strobe-light notification and an audible horn that sounds like an alarm.  
| | - Reach of notification: The horn-strobes are located throughout the school building so that it can be heard and seen in all rooms. They are
also placed on the exterior of the school buildings to alert those in the immediate vicinity of the school buildings. They are always there and always functioning.

- **Speed of notification** is instant. When a pull-station is pulled, the system is activated and causes all of the horn-strobes inside and outside the school to instantly light and sound the alarm. Building occupants do not need to access any special device or tool in order to hear and see the warning.

iii. **Information Completeness**:
- **Content & Accuracy**: The information is always presented as an alarm/horn sound and a visual strobe-light. There is no verbal or textual content with the basic horn-strobe notification device. It does not depend on any person to make a warning announcement.
- **Length**: The horn-strobe continues to sound and light indefinitely until the system is silenced at the fire alarm control panel.
- **Intelligibility** is impacted only by the volume of the horn-strobes. The volume can be adjusted based on the environment in which they are located. A music room, gymnasium, kitchen, or industrial arts classroom may require a higher volume than a traditional classroom or office environment.

### Dimensions

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<tr>
<td><strong>B. System Quality</strong></td>
</tr>
<tr>
<td>- <strong>System Mechanics</strong>: The operating platform consists of a conventional fire alarm control panel mounted to the wall and drawing a minimal amount of electricity. The communications panel is connected to two dedicated landline phone numbers. When a pull-station is activated, it immediately sends a signal to the Fire Alarm Control Panel (FACP) which simultaneously activates the notification appliances so students and staff hear the alarm, see the strobe, and evacuate the building. At the same time, the communication panel notifies the alarm company to alert the fire department. Installation is extensive as it requires running wire throughout the building from the control panel to all of the pull-stations and horn-strobes. There are no ongoing installation requirements. The system’s operation does not depend on a school administrator, staff member, or security personnel being on site, or at a certain desk, computer, or office to activate the system or send notification to school occupants. It does require an alarm company that provides 24/7/365 monitoring for the notification to the fire department.</td>
</tr>
<tr>
<td>i. <strong>System Reliability</strong>: The conventional fire alarm control panel has a fixed power supply and battery backup for power redundancy. Every component of the system is hard wired. It includes two designated landline phone lines for alarm company/fire department notification. Points of failure include aging or faulty equipment or compromised wiring, however there are built in notifications for supervisory and trouble conditions to alert the school of such conditions. This system is highly reliable. There are built-in redundancies. Performance is not compromised by power outages, internet outages, WiFi outages or limitations due to service capacity, cell service outages or limitations due to building construction, or radio frequency connectivity. It does not rely on people failing to charge or change batteries, and does not have to be taken off-line for updates.</td>
</tr>
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</table>
ii. **Security Attributes:**

- **System Defense** is strong. The fire alarm control panel is affixed to the wall typically in a school office or in a school’s mechanical room. If in a mechanical room, the door to that room is locked and not accessible to the general school population. If in an office, the door to the control panel itself is closed and locked. Locating it in an office area that is staffed by school personnel is also a protective measure. The system is not internet based which precludes it from cyberattacks such as viruses, hacking, and disabling remotely.

- **Activation Protections**: There is a significant risk of intentional false alarms due to the accessibility of the pull-stations. For intentional false alarms, activation protections include protective covers with deterrent alarms on all pull-stations. For unintentional false alarms, guards are installed over the pull-stations located in high-risk areas such as gymnasiums. For further activation protection, the school can educate staff and students on the appropriate use of pull-stations and consistently implement consequences for intentional false alarms. Schools that have security cameras in the building can use the cameras as a deterrent and for investigative purposes after an intentional false alarm activation. (If smoke and heat detectors are included in the assessment, the risk of false alarms increase and require additional mitigation measures.) Another risk involves the possibility of using the fire pull-stations nefariously to draw unsuspecting students and staff into the line of gunfire during an active shooter attack on schools. Additionally, it is possible that fire alarm sensors could inadvertently set off the fire alarm due to smoke from gunfire during an active shooter attack, causing students and staff to evacuate into the line of gunfire.

iii. **System Flexibility:**

- **Compatible**: The fire alarm system can be implemented consistently in all schools. It is compatible with any school construction or configuration. The control panel, pull-stations, and horn-strobes require minimal physical space. The existing phone lines can be leveraged for the alarm company notification.

- **Customizable**: The school can select different types of control panels (addressable or conventional), different looks of pull-stations and horn-strobes based on their needs. There is also the ability to select the alarm/horn tones, to silence the system, or cancel an alert during known false alarms. Can contact the alarm company in advance of a drill in order to practice response without activating the dispatch of fire personnel.

- **Expandable/Scalable**: The system is flexible to accommodate a different number of pull-stations based on the size and configuration of the school campus. It can be expanded to include various detectors, and a large variety of emergency control functions.
### Dimensions

#### Evaluation Variables & Team Assessment Notes

**#2: TECHNOLOGY (continued)**

| Dimensions | i. Lifespan: Age, wear, and planned obsolescence can impact the replacement or upgrade interval for components of a fire alarm system. The basic conventional fire alarm control panels that work on the zone system have a long shelf life. Since they are not internet based, they do not require software updates, and frequent advances in technology do not impact their relevance or shelf-life. Schools that get more advanced fire alarm systems like the IP based addressable fire alarm systems that also use IP for the phone notification components, are at risk for a shorter lifespan due to planned obsolescence, and may require more frequent component replacement or upgrades. Pull-stations in a conventional system are not at risk for wearing out due to frequent use, but may be at risk for component breakdown due to lack of use. This can be mitigated by rotating the use of pull-stations for starting planned fire drills. Horn-strobes are used more often than pull-stations since detectors in the fire alarm system have frequent problems causing false alarms. This use may cause more frequent replacement of horn-strobes. In general, the lifespan of a well-maintained, conventional fire alarm system in a K-12 school is manageable. Conditions at some schools, including the climate, dust, and extreme weather conditions may cause components to corrode or degrade at a faster pace, requiring more frequent inspections, maintenance, and replacement of components. The more complex the system, the more frequent replacement and upgrades.  

ii. Technical Support & Maintenance: A basic, conventional fire alarm system does not have proprietary limitations. Parts such as pull-stations, horn-strobes, circuits, relays, wiring, and backup batteries are not patent-protected, and are readily available from a variety of vendors. Some school districts have maintenance personnel on staff who have the expertise to perform the necessary maintenance on most components of a fire alarm system. Others may have to contract with a licensed electrician or other service vendor. Fire alarm systems are low maintenance, serviceable warning systems, generally requiring only an annual and some semi-annual inspection and maintenance.|

### Domain #3: HUMAN

In the Human domain, teams will assess, and to a certain extent, anticipate, how the technology interfaces with the people designated to use the warning systems. The Human domain comprises an evaluation related to system use and user satisfaction to inform the likelihood of the users’ acceptance of and ongoing implementation of the technology. A realistic assessment of the Human domain will help teams determine if the technology is a feasible and sustainable solution for those designated to use the system.

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<th>Dimensions</th>
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</table>
| A. System Use | i. Impact on Daily Routines: The impact on school personnel is minimal to none. The impact on school flow and schedules is minimal to none. The pull-stations are there if needed and do not require staff intervention or modifications to daily schedules or routines for system functionality. If the school has a high volume of false alarms, the impact on the learning environment will be greater.  

ii. Parameters for Use: The fire alarm system is designed for use when there is fire or smoke in the building. Pull-stations are located in common areas and near exits and can be activated by anyone in the school, adult or student. The parameters for use are clear. |
iii. **Perceived Support**: Because the parameters for use are clear, staff are supported by peers and by management when activating a pull-station to warn school occupants of smoke or fire and initiate an evacuation. Staff are taught to err on the side of caution. If it is a false alarm, it can be counted as the required monthly fire drill. Perceived support is high.

### B. User Satisfaction

i. **Perceived Usefulness**: The fire alarm system solves the problem of quick notification of fire or smoke. It is an improvement to the public address system because anyone can activate it at any time, from many locations throughout the school. Staff perceptions of usefulness is high.

ii. **Ease-of-Use**: Training needed on how to activate the fire alarm system is minimal to none because the pull-stations are highly intuitive. The red color makes them easy to see and distinguish from other warning system technologies. The plain-language ‘push’ or ‘lift and pull’ text on the pull-stations makes them simple to use, even while under stress. They do not require any tools, keys, or special codes to know or remember in order to activate the warning system. All of these factors are critical since the frequency of use is low. The system is easy to use.

iii. **Perceived Acceptability**: The fire alarm system supports a positive and welcoming environment. The presence of fire pull-stations do not promote fear or anxiety, but fosters confidence in the school’s ability to protect students from school fires. Perceived acceptability is high.

### Domain #4: ORGANIZATION

In the fourth domain, Organization, teams evaluate the technology in light of its compatibility with the organizations it is to serve. The focus is on the interaction between the warning system technology and the unique structure and environment of the school, school district, and their community partners’ organizational attributes. It places value on to what extent the leadership of the school and their community partners accept the warning system.

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<th>Dimensions</th>
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<tr>
<td><strong>#4: ORGANIZATION</strong></td>
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</table>

#### A. Structure

i. **School Attributes**: A fire alarm system is compatible with any type of physical configuration, however, the size and layout of the school will affect the number of initiating and notification appliances required. Since the system is self-monitoring, it does not require dedicated school personnel for daily operations. Since the system has minimal impact on the ongoing operations of the school, it is acceptable to leadership.

ii. **Community Partner Attributes**: Fire department personnel are supportive of the system since it helps to prevent/reduce injuries, loss of life, and property damage. They are also accepting of it because it meets fire codes and because it reduces risk for their fire fighters. The biggest negative concern involves the frequency of false alarms. It does not conflict with their communications systems. The alarm company notifies the 911 dispatch center, who notifies the fire department.

#### B. Environment

i. **Management & Ownership**: All hardware, including the fire alarm control panel, initiating appliances, and notification appliances, including all wiring, belong to the school district. There is no vendor ownership associated with the system.

ii. **Financial Impact**: The fire alarm system is not susceptible to changing software, technologies, vendors, philosophies, or budget constraints. Once
installed, it is constant. There is a small monthly fee for monitoring by an alarm company, and modest inspection fees.

iii. **Aligns with Regulations**: The system is set up to comply with all NFPA fire codes and building codes regulations. The school complies with the state’s required fire drills. There are no conflicts between the fire alarm system and FERPA/HIPPA laws or labor relations.

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**Domain #5: NET BENEFITS**

Net Benefits is the fifth and final domain in the K-12 School HOT-Fit Evaluation Tool and embodies the culmination of the investigative effort. The Net Benefits domain creates an evaluative feedback loop by revisiting findings from the prior four domains and analyzing them against the dimensions of effectiveness, feasibility, and sustainability. The Net Benefits emerge by uncovering to what extent the technology, used within the constraints of the unique school system, is effective to solve the identified problem, accomplish the established purpose, and is reliable both mechanically and operationally. It also ascertains the degree to which the technology is an operationally and financially feasible and sustainable solution for the school and its community partners.

### Dimensions

<table>
<thead>
<tr>
<th><strong>A. Effective</strong></th>
<th><strong>B. Feasible &amp; Sustainable</strong></th>
<th><strong>C. Notes &amp; Findings</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>i. Solves Problem</strong>: The fire alarm system solves the problem of early warning for emergencies involving smoke or fire at school.</td>
<td><strong>i. Financially</strong>: Once installed, the fire alarm system has minimal and reasonable ongoing maintenance costs and alarm monitoring fees. These fees are feasible for schools and sustainable over time.</td>
<td><strong>Use this area to record other concerns, limitations, opportunities, benefits, and findings related to the technology.</strong></td>
</tr>
<tr>
<td><strong>ii. Accomplishes Purpose</strong>: The fire alarm system accomplishes the goal of preventing injuries and loss of life due to fire, smoke, and cascading effects.</td>
<td><strong>ii. Operationally</strong>: Because the fire alarm system has such a minimal impact on the daily routine and operations of the school and its community partners, it is operationally feasible and sustainable.</td>
<td>The most notable limitations or weaknesses include:</td>
</tr>
<tr>
<td><strong>iii. Reliable</strong>: The fire alarm system has built in redundancies to overcome potential weaknesses in reliability, such as backup battery power and two dedicated landline phone lines.</td>
<td></td>
<td>• The possibility of and impacts of false alarms. Schools can implement strategies to mitigate these risks.</td>
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The most notable limitations or weaknesses include:

- The initial financial outlay due to system acquisition and installation.
- Another risk involves the possibility of using the fire pull-stations nefariously to draw unsuspecting students and staff into the line of gunfire during an active shooter attack on schools.
- Additionally, it is possible that fire alarm sensors could inadvertently set off the fire alarm due to smoke from gunfire during an active shooter attack, causing students and staff to evacuate into the line of gunfire.
B. THE CONCEPTUAL LOCKDOWN NOTIFICATION SYSTEM APPLIED TO THE SCHOOL TOOL

This assessment of the conceptual lockdown notification is based on a fictitious school, and is not necessarily representative of the conditions at all schools.

### K-12 School HOT-Fit Evaluation Tool

To evaluate communication & warning system technologies for use in K-12 schools

**Name of Technology:** Conceptual Lockdown Notification System  **Evaluation Date:** 3/11/18

**Evaluation Team:** __________________________________________________________

**Instructions:** Establish an investigative team. Begin with the Foundation domain to establish goals. Proceed to evaluate Technologies to meet the goals. Anticipate the impact on Humans. Determine compatibility with the Organizations. Finally, analyze information in all domains to determine the Net Benefits and select a technology.

### Domain #1: FOUNDATION

**Overview:** The foundational step in the technology evaluation process requires gaining a clear understanding of the need, “the why” for a new communication or warning capability. The Foundation domain is the starting place for the evaluation because it provides a focus for the evaluation of the subsequent domains. It includes identifying the Problem(s), articulating Purpose, recognizing Motivating factors, and defining Parameters. As decision-making teams work through the Foundation domain they will establish a clear basis and scope for a technology search.

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<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
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</table>
| **A. Problem**    | i. **Risk Assessment:** We are concerned about active shooter attacks on schools and understand that taking quick action to warn everyone in the school is essential since most attacks end within minutes. A secondary problem is the need to quickly notify law enforcement of actual or imminent violence at school.  
ii. **Capabilities Assessment:** Our public address system is only accessible from the public address system in the front office. This limits our ability to quickly notify school occupants to lockdown when an intruder is first identified in the school. The school district has reliable landline phone service, but experiences power outages several times a year due to winter storms. Some schools have radio frequency barriers due to dense construction. Most have some cell service dead spots. |
| **B. Purpose**    | i. **Goals:** Our goal is to prevent injuries and loss of life during active shooter attacks on K-12 schools.  
ii. **Objectives:** To obtain an accessible, reliable, and sustainable warning system that automatically and immediately notifies all school occupants to take protective measures at the first sign of danger, and simultaneously notifies local law enforcement. |
C. Motivation
i. **Internal Motivations**: We are concerned about intruders and violence, and have identified a deficiency in our school’s ability to quickly warn students and staff.

ii. **External Motivations**: For a limited time, a vendor is offering schools to try their cell phone warning app for free for three years. We are receiving pressure from the vendor, local law enforcement, and from a member of the school board to sign up for this technology.

D. Parameters
i. **Priorities**: Priority is on the need for easy access for anyone to quickly warn all school occupants and local law enforcement of violence at the school. Tier one priorities have activation devices in common areas and offices; tier two priorities have activation devices also in classrooms.

ii. **Limitations**: Financial sustainability is a non-negotiable since we continually face budget shortages. Ease-of-use is also necessary due to our high mobility rate and staff turnover. Staff and parent buy-in are also desirable so that our schools are perceived as safe, welcoming places, rather than dangerous places.

iii. **Scope**: Our focus is on violence on the school campus, when school is in session and during after school events. It does not include situations involving violence on school buses, during field trips, or at athletic events off school campus.

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**Domain #2: TECHNOLOGY**

Overview: In the next step, teams will evaluate technological solutions to determine if the technology can solve the identified problems and meet the team’s stated goals. The second domain, Technology, requires a detailed analysis of the Information Quality, System Quality, and Service Quality dimensions of the technology against the criteria established in the Foundation domain. Working through the evaluative process in the Technology domain will help teams narrow the selection of communication and warning system technologies to those that have the capacity to meet their needs.

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<td><strong>A. Information Quality</strong></td>
<td>i. <strong>Activation Attributes</strong>:</td>
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<td>• <strong>Type of Activation</strong>: The system is activated through the use of blue lockdown push-button devices that are mounted on the walls, fixed in place, and hardwired throughout the school. Once installed, they are always functioning.</td>
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<td>• <strong>Accessibility of Activation</strong>: The lockdown buttons will be accessible, easy to locate, and can be activated from many places in the school. A key is not needed to access the areas in which the lockdown push-buttons will be located, neither are codes necessary to activate the lockdown buttons. There will be an adequate number of activation devices to serve the size and layout of the school facility. The system is scalable to allow for locating activation devices in common areas first, and then classrooms as finances permit. The setup of the system does not place limits on the number of users. It will available to anyone at any time. It does not depend on a school administrator, staff member or security personnel being on site, available, monitoring anything, or at a certain desk, computer, or office to activate the system.</td>
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<td>• <strong>Times &amp; Locations</strong>: The system can be activated when school is in session and during non-school hours for athletics, afterschool programs, and visitors using the facility on weekends. The system is not dependent upon the time</td>
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of day or night that someone is in the building; it does not favor school being in or out of session. It is constant, 24/7/365. A drawback is that people using the school after hours may not have keys to lockable rooms, inhibiting their ability to lockdown if needed.

ii. **Notification Attributes**:

- **Type of Notification**: The system will provide notification to all building occupants through the use of speaker-strobes that will be hardwired, fixed in place, and mounted on walls and ceilings throughout the school. The speaker-strobes provide both a visual strobe light notification and an audible alert tone and pre-recorded message that the school can choose.

- **Reach of Notification**: The speaker-strobes will be located throughout the school building so that the message can be heard and seen in all rooms. They will also be placed on the exterior of the school buildings to alert those in the immediate vicinity of the school buildings. The speaker-strobes will always be there and always functioning.

- **Speed of Notification**: Speed of notification is instant. When a lockdown button is pushed, the system instantly causes all of the speaker-strobes inside and outside the school to illuminate, and play the pre-recorded alert tone and message. Building occupants will not need to access any special device or tool in order to hear and see the warning.

iii. **Information Completeness**:

- **Message Content & Accuracy**: Because the alert tone and message is pre-recorded, it is always consistent and accurate. It does not depend on any person to make a warning announcement when they are under extreme stress. The visual strobe is separate than the fire alarm strobe and only illuminates in conjunction with the lockdown announcement. Schools will need to work with their law enforcement partners to devise a message that is consistent with their specific lockdown terminology and response protocols.

- **Message Length**: The pre-recorded message can be set to play multiple times in a row. The school will need guidance from law enforcement on whether they want the strobe to turn off when the recording turns off or if they would like the strobe to stay lit until the system is reset. There are pros and cons to consider.

**Message Intelligibility**: The volume of the speaker-strobes can be adjusted based on the environment in which they are located. A music room, gymnasium, kitchen, or industrial arts classroom may require a higher volume than a traditional classroom or office environment. These will need to be tested during drills for adequate volume.

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<tr>
<td>B. System Quality</td>
<td>i. <strong>System Mechanics</strong>: The operating platform consists of a conventional Lockdown Notification Control Panel (LNCP) mounted to the wall and drawing a minimal amount of electricity. The system will share a Communications Panel, connected to two dedicated landline phone numbers, with the fire alarm system. When a lockdown button is activated, it immediately sends a signal to the lockdown notification control panel which simultaneously activates the speaker-strobes so students and staff hear the alert tone and recorded message, see the strobe, and lockdown. At the same time, the communication panel notifies the alarm company to alert the police department. Installation is extensive as it requires running wire throughout the building from the control panel to all of the lockdown buttons and...</td>
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speaker-strobes. There are no ongoing installation requirements, unless the school phases in additional lockdown buttons in classrooms or other locations. The system’s operation does not depend on a school administrator, staff member, or security personnel being on site, or at a certain desk, computer, or office to activate the system or send notification to school occupants. It does, however, require an alarm company that provides 24/7/365 monitoring for the notification to the police department.

ii. **System Reliability:** The lockdown notification control panel will have a fixed power supply and battery backup for power redundancy. Every component of the system is hard wired. It includes two designated landline phone lines for alarm company/police department notification. Points of failure include aging or faulty equipment or compromised wiring, however there are built in notifications for supervisory and trouble conditions to alert the school of such conditions. This system is highly reliable. There are built-in redundancies. Performance is not compromised by power outages, internet outages, WiFi outages or limitations due to service capacity, cell service outages or limitations due to building construction, or radio frequency connectivity. It does not rely on people failing to charge or change batteries, and does not have to be taken off-line for updates. Using the system during regularly scheduled drills can also verify the system’s reliability and provide the added benefit of exercising the system.

iii. **Security Attributes:**

- **System Defense:** System Defense is strong. The Lockdown Notification Control Panel will be affixed to the wall in either a school office or in a mechanical room in the school. If in a mechanical room, the door to that room will be locked and not accessible to the general school population. If in an office, the door to the control panel itself will be closed and locked. Locating it in an office area that is staffed by school personnel is also a protective measure. Even so, if someone gained access to these protected areas, they could take measures to nefariously disable the system. The system is not internet based which precludes it from cyberattacks such as viruses, hacking, and disabling remotely.

- **Activation Protections:** There is a significant risk of intentional false alarms due to the accessibility of the lockdown buttons and because of the need to draw attention to the system for training purposes. Strategies for dealing with and curtailing intentional and unintentional false alarms consists of protective covers & guards on lockdown buttons, educating staff and students on the appropriate use of the devices, consistent implementation of consequences, cameras, and signage. Cameras can provide a deterrent and be an investigative asset. Signage will include instructions for use as well as consequences for misuse.

iv. **System Flexibility:**

- **Compatible:** The lockdown notification system can be implemented consistently in all schools. It is compatible with any school configuration, although the complexity of installation may be affected by the building construction. The control panel, lockdown buttons, and speaker-strobes require minimal physical space. The existing phone lines can be used for the alarm company notification.

- **Customizable:** The pre-recorded message can be customized to match the
school’s lockdown terminology and procedures. This is important because there are a variety of different lockdown terminologies in use around the U.S. The repeat interval and length of time the message plays is also customizable. The system is independent of the school public address system, so the school can provide further instructions using the public address system after the recorded message stops broadcasting. Further investigation is necessary to determine if the public address system can override the lockdown system’s announcement.

- **Expandable/Scalable**: The system is expandable and scalable. The system is flexible to accommodate a different number of lockdown buttons based on the size and configuration of the school campus. It can be expanded so that lockdown push-buttons are placed in classrooms as funds become available.

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<th>Dimensions</th>
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| C. Service Quality | i. **Lifespan**: The conventional lockdown notification control panel that works on the zone system (like the fire alarm control panel) has a long shelf life. Since it is not internet based, it does not require software updates, and frequent advances in technology do not impact their relevance or shelf-life. Lockdown buttons in a conventional system are not at risk for wearing out due to frequent use, but may be at risk for component breakdown due to lack of use. This can be mitigated by rotating the use of lockdown buttons for planned lockdown drills.  

ii. **Technical Support & Maintenance**: A conventional lockdown notification control panel is not affected by proprietary limitations, since it will essentially be a repurposed fire alarm control panel. Parts such as lockdown buttons, speaker-strobes, circuits, relays, wiring, and backup batteries are not patent protected, and are readily available from a variety of vendors. The text on the lockdown button will need to be customized, but will not be patented. Some school districts have maintenance personnel on staff who have the expertise to perform the necessary maintenance on most components of a lockdown notification system. Others may have to contract with a licensed electrician. Like fire alarm systems, a lockdown notification system is a low maintenance, serviceable warning system, generally requiring only an annual inspection and maintenance. |

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**Domain #3: HUMAN**

Overview: In the Human domain, teams will assess, and to a certain extent, anticipate, how the technology interfaces with the people designated to use the warning systems. The Human domain comprises an evaluation related to System Use and User Satisfaction to inform the likelihood of the users’ acceptance of and ongoing implementation of the technology. A realistic assessment of the Human domain will help teams determine if the technology is a feasible and sustainable solution for those designated to use the system.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
</table>
| A. System Use | i. **Impact on Daily Routines**: The impact on school personnel is minimal to none. The impact on school flow and schedules is minimal to none. The lockdown buttons are there if needed and do not require staff intervention or modifications to daily schedules or routines for system functionality. If the school has a high volume of false alarms, the impact will be greater.  

ii. **Parameters for Use**: The lockdown notification system is designed for use when there is an intruder in the building, or in emergencies involving imminent or actual violence, such as a shooting or stabbing. Lockdown buttons will be located |
in common areas (away from fire pull-stations) and in designated offices, and potentially in classrooms so they can be used by anyone in the school: staff, students, or visitors. The parameters for use will be taught, and posted on signage near the lockdown buttons.

iii. **Perceived Support:** Staff will need to be educated on the purpose and function of the lockdown notification system to help understand the type of situations the lockdown notification system will be useful for. The school leadership will have to be clear about the parameters for use, and assure staff that they will be supported for taking the initiative to use the lockdown button to warn school occupants of violence and initiate a lockdown. Staff should be taught the implications of pushing the button and also to err on the side of caution.

### B. User Satisfaction

i. **Perceived Usefulness:** The lockdown notification system has the potential to help solve the problem of quick notification of the threat of violence at school. It is an improvement to the public address system because anyone can activate it at any time, from many locations throughout the school. Once stakeholders are educated about the system and the benefits, the perception of usefulness is likely to be high.

ii. **Ease-of-Use:** After stakeholders understand the purpose and parameters for use, training on how to activate the lockdown notification system will be minimal because the lockdown buttons are highly intuitive. The blue color makes them easily distinguishable from fire alarm pull-stations. The plain-language ‘push’ text on the lockdown button makes them simple to use, even while under stress. They do not require any tools, keys, or special codes to access or remember in order to activate the warning system. All of these factors are critical since the frequency of use is expected to be extremely low. The system is easy to use.

iii. **Perceived Acceptability:** The lockdown notification system supports a positive and welcoming environment. If the school is deliberate to communicate the value of this system as improving the school’s capability to make quicker warning announcements, the presence of lockdown buttons should not promote fear or anxiety, rather it is likely to foster confidence in the school’s ability to protect students and staff should an attempted violent attack occur. Anticipated perceived acceptability is high.

### Domain #4: ORGANIZATION

**Overview:** In the fourth domain, Organization, teams evaluate the technology in light of its compatibility with the organizations it is to serve. The focus is on the interaction between the warning system technology and the unique Structure and Environment of the school, school district, and their community partners’ organizational attributes. It places value on to what extent the leadership of the school and their community partners accept the warning system.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
</table>
| A. Structure | i. **School Attributes:** A lockdown notification system is compatible with many types of school physical configurations, however, the size and layout will affect the number of lockdown buttons and speaker-strobes required. Since the system is self-monitoring, it does not require dedicated school personnel for daily operations. Since the system is effective and has minimal impact on the ongoing operations of the school, it will likely be acceptable to leadership.  
ii. **Community Partner Attributes:** Law enforcement is likely to be supportive of the system since it helps to prevent/reduce injuries and loss of life, and may possibly even make their response to an emergency involving school violence more manageable, especially if more people are locked down. The biggest |
negative concern involves the potential for pranks/false alarms. It does not conflict with their communications systems. The alarm company notifies the 911 dispatch center, who notifies the police department. Training for dispatchers on the meaning of the lockdown activation will be necessary so they will know how to dispatch law enforcement.

### B. Environment

i. **Management & Ownership**: All hardware, including the lockdown notification control panel, lockdown buttons, and speaker-strobes, including all wiring, will belong to the school district. The blue lockdown buttons are already readily available from many vendors and the text on the devices is customizable. Once parts are purchased by the school district, there will be no vendor ownership associated with the system.

ii. **Financial Impact**: The biggest financial impact regarding the lockdown notification system will involve the initial expenses associated with equipment purchases and installation costs. Ongoing expenses are minimal and manageable. There is a small monthly fee for monitoring by the alarm company, which can be combined with the fire alarm system monitoring, and modest annual inspection fees.

iii. **Aligns with Regulations**: The system will be set up to comply with all NFPA fire codes and building codes regulations. The school will comply with the state’s required lockdown drills. There are no conflicts with the lockdown notification system and FERPA/HIPPA laws and no anticipated labor relation issues.

### Domain #5: NET BENEFITS

Net Benefits is the fifth and final domain in the K-12 School HOT-Fit Evaluation Tool and embodies the culmination of the investigative effort. The Net Benefits domain creates an evaluative feedback loop by revisiting findings from the prior four domains and analyzing them against the dimensions of effectiveness, feasibility, and sustainability. The Net Benefits emerge by uncovering to what extent the technology, used within the constraints of the unique school system, is effective to solve the identified problem, accomplish the established purpose, and is reliable both mechanically and operationally. It also ascertains the degree to which the technology is an operationally and financially feasible and sustainable solution for the school and its community partners.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
</table>
| A. Effective | i. **Solves Problem**: The lockdown notification system has the potential to help solve the problem of early warning for emergencies involving violence at school, such as active shooter attacks. It may even help to solve the problem to a greater extent if lockdown push-buttons are placed in offices, common areas, and in classrooms. The system will most likely be an improvement on the school’s existing warning capabilities.  
  ii. **Accomplishes Purpose**: By obtaining an accessible warning system to automatically and immediately notify all school occupants to take protective measures at the first sign of danger, the school has a better chance of getting staff and students locked down quicker, and potentially even reducing injuries and loss of life.
  iii. **Reliable**: The lockdown notification system has built in redundancies to overcome potential weaknesses in reliability, such as backup battery power and two dedicated landline phone lines. It is not reliant upon cell service, internet, |
radio frequencies, or a human continually monitoring the system. It is a highly reliable warning system.

B. Feasible & Sustainable

i. **Operationally:** Because the lockdown notification system is intuitive and easy to use, and because it is expected to have such a minimal impact on the daily routines of the people in the school or on the actual operations of the school, it should have a high degree of operational feasibility and sustainability. This could be negatively impacted by pranks/false alarms, causing serious consequences for the school, community, and law enforcement partners.

ii. **Financially:** If the school is able to procure the funds for the initial purchase and installation of the lockdown notification system, it will be a sustainable warning system. The system requires only minimal and reasonable ongoing maintenance costs and alarm monitoring fees. These fees are feasible for schools and sustainable over time.

C. Notes & Findings

Use this area to record other concerns, limitations, opportunities, benefits, and findings related to the technology.

The most notable limitations, implementation considerations, and possible unintended consequences include:

- The initial financial outlay due to system acquisition and installation.
- Schools will need to customize the system to match their unique emergency response protocols and philosophies, such as decisions about the parameters for use, the terminology on the lockdown activation devices, signage, and the prerecorded message.
- The possibility of and impacts of false alarms. Schools can implement strategies to mitigate these risks.
- Keeping the fire alarm pull-stations and the lockdown push-buttons separate is essential. This will help reduce the chance of the wrong alarm activated. Either system accidentally activated for the opposite hazard or threat could increase injuries and loss of life.
- If a lockdown button is activated and an immediate announcement is played, not only will all students and staff be alerted, but the perpetrator will also be alerted. This could cause him/her to cancel the attack, compel him/her to speed up the attack, or it might not change his/her plans at all.
- If a student or staff member sees someone in the school with a gun, and decides to stop and push a lockdown-button in order to notify everyone in the school, that delay may place the student or staff member in greater risk of danger because it will take them longer to get to safety themselves. Clear guidelines, expectations, and associated training can help mitigate this risk.

C. CONCLUSION

By applying the new K-12 School HOT-Fit Evaluation Tool first to the fire alarm system, and then to the conceptual lockdown notification system, it was learned that the school tool is useful for evaluating both existing and prospective warning systems.
technologies. Using the school tool in this manner also helped to identify some of the strengths and weaknesses of the conceptual lockdown notification system.

Furthermore, while the K-12 School HOT-Fit Evaluation Tool’s stated purpose is for evaluating communication and warning system technologies, with minor modifications, it may also be useful for evaluating other school safety and security technologies. In the Foundation domain, all the same dimensions (problem, purpose, motivation, and parameters) and their corresponding evaluation variables are relevant to taking the first step in evaluating safety and security technologies.

In the Technology domain, the system quality and service quality dimensions will also be necessary evaluative categories to help a team determine if the technology meets their established purpose. The information quality dimension, however, corresponds specifically to communication and warning system technologies, and therefore, may not be helpful criteria to use for evaluating other school safety and security technologies.

The dimensions in the Human domain (system use and user satisfaction) and those in the Organization domain (structure and environment) are very specific to the K-12 school environment and may also be appropriate for evaluating other safety and security technologies.

For each of the dimension’s evaluation variables, especially in the Technology domain, customized criteria will need to be established associated with the problem the team is trying to solve, the identified purpose, and the proposed technological solution.

Each dimension in the Net Benefits domain (effective, feasible, and sustainable) along with their corresponding evaluation variables are fitting criteria for the final step of the evaluative process. Going through the exercise of weighing the positives and negatives in light of how they affect the effectiveness of the technology will help to determine to what extent the technology can accomplish the established goals and purpose. Using this evaluation framework tool can assist school decision-making teams to make informed decisions when selecting school safety and security technologies for their unique schools.
The next chapter presents case study data from six schools or school districts already using some form of a warning system for violence modeled in some way after the fire alarm system. The data is presented according to the five domains in the K-12 School HOT-Fit Evaluation Tool.
V. CASE STUDIES

A. INTRODUCTION

The previous chapter applied the fire alarm system and the conceptual lockdown notification system to the new K-12 School HOT-Fit Evaluation Tool. This chapter focuses on the case study interviews conducted on schools using a warning system with police pull-stations or lockdown push-buttons that are in some ways similar to the fire alarm system. First, the need for this research is reviewed and the case study research design is described. Next, the case study data is exhibited according to the domains in the new K-12 School HOT-Fit Evaluation Tool. Finally, an analysis of the commonalities of the case study subject’s warning systems with the conceptual lockdown notification system are presented.

The literature review identified some existing case studies on K-12 schools with lockdown notification systems using cell phone applications, pendant necklaces, and computer warning systems. These case studies also exposed many significant shortcomings of these systems. The literature review revealed a gap in the research since the researcher was not able to find any case studies on schools using a lockdown notification system with lockdown push-buttons or police pull-stations similar to the fire alarm system. This chapter describes data from six explanatory, program implementation case studies to fill that gap.270

For a school to be included in the case study portion of the research, it had to have a warning system for violent emergencies that had components modeled similarly after the fire alarm notification system, specifically, lockdown or police pull-stations or push-buttons. Although this was the primary focus, some of the case study subjects incorporated other forms of warning technology, such as cell phone apps and pendant emergency alert buttons, into their lockdown systems. Moreover, the case studies were

270 Yin describes explanatory case studies as “a case study whose purpose is to explain how or why some condition came to be.” He describes descriptive case studies as “a case study whose purpose is to describe a phenomenon (the “case”) in its real-world context.” Yin, Case Study Research Design and Methods, 238.
limited in scope to alert and warning technologies specifically applied in the K-12 school environment rather than those used in institutions of higher education.

To find schools using these warning systems, the researcher reached out to a colleague from the National Institute of Justice who pointed to the new RAND and JHU school safety studies for research on these systems.\(^\text{271}\) These studies provided great data for the development of the evaluation framework tool, but did not produce information that met the case study research criteria. School safety colleagues were also consulted at the state and national levels, police and fire partners were questioned, the internet was searched for news articles, and vendors were contacted. These sources proved most fruitful in identifying subjects who met the case study research criteria.

When schools were found to have this push-button or pull-station technology, an attempt was made to contact them by phone or email. Some did not respond to requests to participate. For the six that did, the project was explained and phone appointments set up with an employee of the school system who had a working knowledge of their warning system. The six subjects include entire districts and individual schools. In some cases, it was also possible to speak with someone from the school or district’s corresponding law enforcement agency who also had experience with the school warning system.\(^\text{272}\) To protect the case study participant’s identities, they are identified by the term “subjects” rather than school names or letter or number identifiers. Subjects are also referred to as “he/she” or “him/her.” These measures help to minimize the risk of the data revealing the specific schools participating in the study.

The researcher proceeded to conduct partially structured, qualitative phone interviews using questions pre-approved by the Naval Postgraduate School’s Institutional Review Board (IRB) to see what could be learned about how these systems work in the

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\(^{272}\) For every person agreeing to participate in the study, a consent form was emailed that described the project and explained that the Naval Postgraduate School’s Institutional Review Board (IRB) had waived the requirement for a consent form for this research project, but the researcher provides it anyway to help with understanding the process. All interviews were done over the telephone and began by reiterating the confidential and anonymous nature of the interviews as described in the consent form, and explained that a coding system was in use to protect against disclosure of identifying information of school or personnel participating in the research.
K-12 school environment. The focus was on three items: first, what factors influenced the selection of different applications of these warning systems, next, what conditions limited or enhanced a school’s ability to implement the systems successfully, and finally, how the warning system solved the problem of timely and early warning for emergencies involving violence at school.

During the phone interviews, the researcher maintained a conversational tone and exploratory frame of mind. The interviews were not recorded. Careful notes were taken, impressions documented, and additional questions related to the main topic were asked as new discoveries or information emerged.273

Some limitations include that some subjects were part of their school or district when the system was first installed and implemented, and had a greater sense of its evolution. Others came on after the system was already in use and did not have answers to several questions. Most had significant time challenges in their busy school schedules. The interviews lasted approximately 30–60 minutes. Most did not have time to answer all the questions. Some agreed to a second phone call interview; others did not. All the interviews provided helpful insight in the quest to understand the use of these systems in the K-12 school environment.

B. CASE STUDY DATA

This section organizes the case study data according to the five domains in the new K-12 School HOT-Fit Evaluation Tool: Foundation, Technology, Human, Organization, and Net Benefits. At the time of the case study interviews, the school tool was not complete, and some gaps resulted due to the interview questions not addressing every dimension of the school tool.

273 Yin provides guidance for this method of interviewing. Yin, Case Study Research Design and Methods, 73–76.
1. **Foundation**

The Foundation domain includes four primary dimensions—problem, purpose, motivation, and parameters—and several corresponding evaluation variables, as shown in Table 12.

### Table 12. Foundation Domain.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem</td>
<td>i. Risk Assessment</td>
</tr>
<tr>
<td></td>
<td>ii. Capabilities Assessment</td>
</tr>
<tr>
<td>Purpose</td>
<td>i. Goals</td>
</tr>
<tr>
<td></td>
<td>ii. Objectives</td>
</tr>
<tr>
<td>Motivation</td>
<td>i. Internal</td>
</tr>
<tr>
<td></td>
<td>ii. External</td>
</tr>
<tr>
<td>Parameters</td>
<td>i. Priorities</td>
</tr>
<tr>
<td></td>
<td>ii. Limitations</td>
</tr>
<tr>
<td></td>
<td>ii. Scope</td>
</tr>
</tbody>
</table>

When conducting the case studies, the Foundation domain had not yet been identified as part of the K-12 School HOT-Fit Evaluation Tool; nonetheless, some questions posed are germane to this domain, such as *What was the impetus to acquire/implement such a system? What was the problem you were trying to address?* A number of responses were received. Three subjects expressed concern about active shooter events; one included concern about firearms. One said that early warning gives them a much better opportunity to save lives. One simply stated, “It does for police what fire-pulls do for fire.” Another was in the process of upgrading the phone system and learned of the inability to make a quick lockdown announcement if a threat occurred in the front office area. He/she followed the lead of the phone vendor who had a warning system technology to address this gap. One subject discussed the problem of human error in extreme stress incidents saying, “we had situations where too many human elements can go awry due to high stress situations […] pushing a button eliminates the human element in high level stress situations.” He/she also said that prior to this system being implemented, not everyone was always notified of emergencies, “We wanted to make
sure everybody, no matter where you are will know.” This school uses the system to provide warnings for many hazards and threats, not just violent incidents. It was not evident that any of these schools had gone through any type of assessment or formal process to identify their risks and capabilities, establish goals and objectives, understand their motivation, or establish parameters in selecting a warning system for their schools. Nor did any indicate they had considered systems other than the one they implemented. However, these topics would have been pertinent questions to explore.

2. **Technology**

The Technology domain includes three primary dimensions—information quality, system quality, and service quality—and several corresponding evaluation variables, as shown in Table 13.

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>Dimension</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Information Quality</td>
<td>i. Activation Attributes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Notification Attributes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Information Completeness</td>
</tr>
<tr>
<td></td>
<td>System Quality</td>
<td>i. System Mechanics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. System Reliability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii. Security Attributes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iv. System Flexibility</td>
</tr>
<tr>
<td></td>
<td>Service Quality</td>
<td>i. Lifespan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii. Technical Support and Maintenance</td>
</tr>
</tbody>
</table>

**a. Information Quality**

Information quality, the first dimension in the Technology domain involves learning about the activation devices, system notification features, and the completeness of the information put forth by the warning system. Subjects were asked: *Can you describe the devices you use to activate your warning system? Can you describe any signage associated with your warning system? Can you describe where the alert/warning goes and the rationale behind those decisions?*
(1) Activation Attributes

Case study participants were eager to describe the actual technology. All have activation devices affixed to the wall, similar in size and function to fire alarm pull-stations as shown in Figure 18. Three are bright blue with a red push-button, displaying the term, LOCKDOWN. Two have light blue pull-stations that display the word, POLICE. One is a yellow device with a red push-button that shows the words, EMERGENCY LOCK DOWN. None of these devices require any special tools, codes, or knowledge to activate, although some are located behind locked doors during non-school hours, so access is only available to people with a key to those offices or locations. All these lockdown notification systems incorporate additional activation devices with more features and complexity than the basic fire alarm system pull-stations or the proposed conceptual lockdown notification system.

Figure 18. Activation Devices.274

**Bright Blue LOCKDOWN Devices:** The three subjects with the bright blue LOCKDOWN push-button devices restrict access to the devices by only placing them in secure locations, such as the main office, principal’s office, security office, custodial office, counselor office, and for one subject, in the library. Two of the subjects expressed great concern about false alarms as the reason for the limited locations. The other subject did not know the reason. None of these devices has associated signage. Two of the three

subjects indicated the devices have protective covers. When a lockdown push-button is activated, it produces an immediate emergency announcement to the entire campus and simultaneously alerts the alarm company or 911-dispatch center. The system is only accessible for use during school hours since the activation devices are located in locked and secured areas of the school.

Several other notable features are used by these three subjects’ schools. For two, a software program enables the system to send text and email messages to designated people. For a different combination of two subjects, teachers can enter a 4-digit code into their classroom phone to activate the system, which bypasses the use of the blue lockdown device. For one, the principal and gym teacher can activate the system from their cell phones. Two subjects have expanded activation devices in designated offices in addition to the lockdown button. One has buttons for Shelter-in-Place, Evacuation, and Reset; the other has buttons for Lockout, Evacuation, Evacuation Alternate, and Reset. When pressed, these devices play pre-recorded messages that correspond to the purpose of the button.

**Light Blue POLICE Devices:** Two subjects have light blue POLICE pull-stations located in common areas throughout each school and in the office. They do not have protective covers, except those in the gym. Associated signage is affixed to the wall above each pull-station. When a police pull-station is activated, it produces an immediate pre-recorded emergency announcement to the entire campus and simultaneously alerts the alarm company. The police pull-stations also generate a text message alert, an email notification, and a phone message to designated people. Since the pull-stations are located in multiple areas around the school, they are accessible to people using the school facilities during non-school hours, as well as when school is in session. These two schools also provide wireless pendant lanyard push-button devices to designated staff, such as recess supervisors and gym teachers. For one school, the pendants activate a silent signal; for the other, it activates both audible and silent notifications.

**Yellow EMERGENCY LOCK DOWN Device:** The yellow EMERGENCY LOCK DOWN push-buttons have protective plastic covers and are located throughout the school in common areas and in classrooms. This subject was the only one with the
initiating appliances affixed to walls in classrooms. Above the designated lockdown device are two additional buttons, “OFFICE” and “MEDICAL,” with no protective cover. No signage is associated with the devices. When the emergency lockdown button is pressed, it does not send an audible warning message to the school, but it provides a visual notification, and automatically turns on warning lights in all areas of the school and locks all doors. It simultaneously alerts the office and signals the location of the activated device on a designated office computer. It causes the camera feed to appear on the computer screen so the school administration can view the distress area. The administration can use this information to determine what type of emergency message to announce manually over the PA system. Sometimes, the administration simply announces that teachers must check their email for information.

While these activation devices are readily accessible throughout the school, they are for use only during school hours since the alert generated by the devices require the office to be open and staffed. If people using the school after hours for an athletic event activated one of these push-buttons, it would only cause the lights inside the building to turn on and the doors to be locked. It would not provide any other type of emergency notification.

When first installed, the system sent an immediate alert to the local law enforcement office. It also activated the school’s camera feed so law enforcement could observe it from their emergency operations center to coordinate their emergency response. The law enforcement notification function has since been discontinued. It became unmanageable for the law enforcement agency to have someone constantly stationed at the computer.

(2) Notification Attributes

Five of the six subjects’ systems immediately notify the alarm company or 911-dispatch center that a lockdown device has been activated. One school simply calls 911 on its own when a lockdown button is pushed.275

275 More details about the interaction of these systems with their 911-dispatch centers and law enforcement are found in the Organization Domain section of this chapter.
Audible Notification: Subjects were asked: *Can you describe the audible message used to alert/warn school occupants, where the alert/warning goes, and the rationale behind those decisions?* All five subjects with the audible notification feature use their existing public address system speakers for the notification appliance. Four subjects reported that their audible message can be heard both inside and outside the school building, even as far as the athletic fields. One subject explained how the vendor came on a non-school day and played music on the intercom throughout the school to determine areas that needed additional speaker coverage. Five of the six subjects’ warning systems put out an audible pre-recorded message over the public address system for all students and staff to hear. Two subjects include an alert or attention-getting tone or sound to either precede or play along with the message. Table 14 shows the alerts, message content, length of message, and repeat interval for each subject.

Table 14. Audible Notification Comparison.

<table>
<thead>
<tr>
<th>Alert</th>
<th>Content of Message</th>
<th>Length and Repeat Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police Siren</td>
<td><em>Code Red Lockdown</em></td>
<td>Siren and message play simultaneously and repeats indefinitely until system is turned off</td>
</tr>
<tr>
<td>None</td>
<td><em>The building is in lockdown. The authorities have been called.</em></td>
<td>Messages repeats indefinitely until system is turned off</td>
</tr>
<tr>
<td>3 Loud Beeps</td>
<td><em>The emergency alert system has been activated. Police have been notified and are on their way. Please follow our lockdown procedures.</em></td>
<td>The message repeats three times over a 1-1/2 minute period. Then it is silent.</td>
</tr>
<tr>
<td>None</td>
<td><em>Attention all students and staff. This is a Lockdown emergency. Locks, Lights, Out of Sight.</em></td>
<td>The message repeats three times over a 1-1/2 minute period. Then, it is silent.</td>
</tr>
<tr>
<td>Unknown</td>
<td><em>Lockdown, Lockdown, Lockdown</em></td>
<td>Repeats three times then goes silent.</td>
</tr>
<tr>
<td>Audible Buzzer Only to Office</td>
<td>The office is alerted (by a buzzer) to the type of button pushed: lockdown, medical, or office. Camera footage come up on the office computer screen showing the area where the button was pushed.</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
**Visual Notification.** Visual notification features vary among subjects. Subjects were asked: *Can you describe your visual alert system, if there is one?* For five of the six subjects, visual communications play a role in warning school occupants, bus drivers, and arriving parents. One subject has no visual alert associated with their warning system.

Two subjects use blue strobe lights while two use red lights. One uses a variety of colored lights based on the type of emergency. Two use marquees or reader boards in addition to strobes that display the term LOCKDOWN when the system is activated. In one of these schools, the marquees are mainly at the main entrance; in the other, they are also located in the gym, auditorium, cafeteria, shop classes, and outside at the stadium. In two schools, strobes are everywhere inside the building. In three, they are sparsely but strategically placed: in one school, in the main corridors; in the other two, in high-noise areas, such as gyms, music rooms, and cafeterias.

The reasons for visual notification varied. One subject with a limited number of strobes inside the school explained, “These don’t play an important role. Once locked down, they are no longer necessary.” In contrast, for the school where the audible alert notifies only the front office, the lights throughout the school are essential. They provide the only initial alert to school occupants that some type of emergency is underway, until the administration makes a manual announcement over the public address system.

Three subjects referenced factors related to exterior visual notification; two cited the need to alert bus drivers; the other offered concerns about parents. One of these said, “We are in process of getting more for the exterior of the building and to help provide warning to bus drivers.” Another remarked, “Even bus drivers see the strobe light flashing. Then bus drivers can call their dispatch and receive instructions.” One of the three explained the ineffectiveness of strobes on the exterior of the building for communicating with parents, “We used to just have strobes on entrances but parents were confused. Parents would see the strobe and just look at it and still try to get into the building. Now they see the lockdown sign and eventually figure out that they cannot get in.”
Information Completeness

Intelligibility: Subjects were asked: Does the system provide the type of information both the school and law enforcement need for the hazard/threat it was designed for? Responses related to audible intelligibility varied. One subject reported that because it is a pre-recorded message, it is always consistent and accurate. Two said that the volume is loud. Another subject indicated that his/her intercom system allows for volume change. The subject using the police siren along with the pre-recorded message admitted that during the original pilot he/she only used the siren, but people were confused as to whether it was a fire alarm or lockdown alarm, so they added the phrase “Code Red Lockdown.” The subject added that his/her leadership hopes the noise of the siren is a deterrent to a bad person: “It’s gonna be loud!” However, he/she did express concern that the loud siren sound could interfere with responding officers’ ability to communicate with each other. One of the subjects that does not use an alert reported that his/her leadership thought about using a police siren in the building, but decided against it since it could conflict with and distract law enforcement officers arriving on the scene.

Speed of Notification: Subjects were asked, How long does it take in seconds or minutes for the alert/warning to broadcast once the activation device has been triggered? Four of the six subjects reported that the audible pre-recorded message notification to the entire campus occurs immediately once a push-button or pull-station is activated. For one school, a 3-second delay occurs. For the school without audible notification, the lights come on immediately; the emergency message follows only when the school administration makes an announcement on the PA system. When a pull-station or push-button is activated, five of the six systems notify an alarm company or a 911-dispatch center. Four provide immediate notification; one has a 3-second delay. One subject contended, “The amount of lives saved is the amount of time the message goes out and law enforcement comes.” For the two subjects who have the ability to activate the system by dialing a 4-digit number on classroom telephones, a 5-second delay occurs in sending out the message to give the staff member a brief window to cancel the activation if done unintentionally.
b. System Quality

The system quality dimension includes system mechanics and the reliability of the overall system, security attributes, and system flexibility. The system mechanics, along with the school’s other systems and limitations (power, internet, cell service), can impact the reliability of the warning system. Reliability also includes redundancies and potential points of failure. Subjects were asked: *Can you describe how the system works behind the scenes? Is there a control panel, computer console, or operating system that makes it all work? What have you learned about the reliability of the system? What redundancies are built in? What are the points of failure?*

(1) System Mechanics

The way the warning systems work behind-the-scenes at each school or district varied. For two subjects, each school has a 4 x 6” box, similar to a burglar alarm, that identifies when and where trouble is occurring with the system. In addition, a software dashboard is used by the school administration and law enforcement to enter phone numbers and email addresses for everyone they want to receive phone, text, and email notifications. The system utilizes WiFi from the vendor’s server; the vendor manages the software and the system. The school and law enforcement officials manage the data input and ongoing upkeep of the data. For one of these subjects, the activating pull-stations are wireless; for the other, they are hardwired. Both have wireless pendants that connect to the system through WiFi.

For another two subjects, the system incorporates a wireless RF technology that requires a license from the FCC. These have a software notification platform with a computer console and the overall system is tied into the school’s phone system. One of the two subjects reported that the devices communicate over the same radio bands as its first responders. No wiring is used. The other did not know how the system worked behind the scenes and simply described it as a “gray box.”

One subject described its system as a vendor-run computer software system, “basically a closed circuit TV security system.” The cameras, lights, and activating
devices are hardwired throughout the school and are tied into the server that runs the software program.

The final subject said that its system uses a combination of internet protocol (IP) and contact closures. Each lockdown button has three contacts and each is hardwired to existing systems: (1) a voice dialer holds a recorded message and uses the school’s landline phone to notify the alarm company and 911 dispatch center, (2) the intercom PA system plays the recorded lockdown message, and (3) a software program allows the subject to input contact information to send text messages and emails to designated people. This subject said that the software system is not necessary and schools can use just the other two parts of the system if desired.

(2) System Reliability

System reliability includes factors related to the mechanics of the system in relationship to the infrastructure of the school, and how the school’s essential services, such as power, internet connectivity, cell service, and RF capacity, affect system reliability.

**Impact of Power Outages:** Power is necessary for the operation of all the systems represented in the case studies. For one subject, the district’s newer schools have generators and their older schools do not. For the older schools without backup generator power, the system would not function in a power outage since it utilizes the school’s public address system to make the warning announcement. For another subject, the system’s control panel has a battery backup for 1-1/2 hours. Extended power outages would affect the system’s operability. For two subjects, all their schools have generators in case of emergencies. Two subjects did not report on the presence of generators or backup systems.

**Impact of Cell Service:** Three of the subjects said they have cell service limitations affecting the system’s reliability. Of these three, one remarked they do not have cell coverage in many of their buildings, and two reported they experience poor cell service or cell issues, which reduces their ability to send the pre-recorded message over the phone to those designated to receive warnings on their cell phones. However, one
subject underscored that even with these cell coverage limitations, the text message
notifications still work and reported, “We have some old buildings with solid thick brick
walls and have not had problems with the [text message] system working under these
conditions.” Of the five subjects with systems that make a pre-recorded warning
announcement, none reported that cell service limitations negatively affected the
functionality of their pull-stations or push-buttons to make the pre-recorded warning
announcement. The cell service limitations only affect the auxiliary functions such as
phone notifications. For one subject, principals can activate the system, including the
intercom announcement from their cell phones, as well as gym teachers meeting outside.
Cell service outages, however, would affect the reliability of these activation devices.

**Impact of Internet Connectivity:** All six subjects are reliant upon the internet for
some components of the system’s functionality. All operate using a software platform.
Five subjects have software systems that depend on an internet connection to the
vendor’s systems. For one subject, the PA system is web-based, so the pre-recorded
message will not broadcast if the internet is down. For another, if its server goes down,
the text message notification will still send to the designated people, but the pre-recorded
message will not broadcast. One subject reported that a catastrophic network failure
would negatively affect the reliability of the system. The email notification components
of these systems will not function if the internet is down. The reliability of WiFi pendant
necklaces and WiFi push-buttons or pull-stations would also be problematic since they
are dependent upon the internet.

**RF Limitations:** Two of the subjects use hybrid systems that rely on both RF and
software. Disruptions in service due to tower, repeater, or antenna deficiencies, like
during severe storms, could reduce the reliability of the system. One subject reported that
the system at his/her school is RF wireless to the outdoor athletic fields as well.

(3) Security Attributes

Security attributes involve system defense and activation protections. The
placement of the push-buttons and pull-stations directly affect access for intentional or
unintentional activation of the system. Subjects were asked: Can you describe the
strengths and vulnerabilities of the system in terms of intentional or unintentional disabling? Have you had any false alarms? How many and in what timeframe? Can you describe any times you actually used the system for a real emergency?

Three of the six subjects have the activation appliances fixed to the walls in common areas throughout their schools, which makes them easily accessible to everyone in the school. One said, “We have never had a student pull the pull-station intentionally. We train students on the difference between the fire & police pull-stations and explain that it’s a big deal.” Another subject with pull-stations located throughout their schools indicated they have had a few false alarms. This subject stated that, “The police take care of it by having a very firm conversation with the student and parent. This has solved the problem. There is no disciplinary action.” He/she added that one time a staff member forgot to notify dispatch in advance of a lockdown drill, and once it was inadvertently activated due to construction work. Another subject reported that “one student pushed it nefariously, but it hasn’t really been an issue. We do an investigation and give consequences. We do the same thing for fire alarms.”

Three subjects limited the placement of the activation appliances to offices and other locations with restricted access so that only designated staff have access to the devices. One subject pointed out, however, that, “In nine years, we have never once had someone pull the fire alarm.” He/she did not know the reasoning behind the decision to restrict access to the lockdown buttons. In terms of after school activities, the subject believes that “Most schools don’t address after school areas since principals are not there to handle a situation.”

Two of the three subjects raised concerns about false alarms, specifically student pranks. One emphasized that false alarms are a driving force in decisions about the location of activation devices, and expressed concern that numerous false alarms would have the effect of people not taking the system seriously. Another subject expressed a similar fear and reported that she/he decided not to place the devices in common areas due to the potential for false alarms and concern that false alarms would cause people not to take the warning seriously. This subject’s district has about 10–15 false fire alarms per year and he/she claims, “If the lockdown buttons is pushed, there is an immediate and big
response. They take it very seriously when it does go off—a ‘drop everything’ kind of event. Everyone goes to the location with lights and sirens. Officers will come very fast and could cause someone in the community to get hurt.” This same subject also expressed concern that fire drills are conducted so regularly that the fear is that students do not take the fire alarm seriously. His/her leadership does not want either of these things to happen with the lockdown buttons. For this reason, the lockdown buttons are in limited and protected locations. One subject explained, “These locations are monitored closely and are not accessible after hours. This restricts unwanted access to the lockdown button system.” One of these subjects described an actual false alarm at his/her school by describing an incident involving a staff member who did not know what the lockdown button was and pushed the button to see what would happen.

Subjects reported that the wireless pendant buttons have a built-in mechanism to reduce false alarms. They are set up so that users have to press two buttons simultaneously to activate the system. Even so, one subject had two accidental activations of the wireless pendant push-buttons. Another had a pendant in a desk drawer malfunction that activated the system.

Only two subjects reported using the system for a real emergency. One said, “One time we had something written on a bathroom wall and we put the school in lockdown to understand it.” The other used the lockdown system during a cougar sighting.

Regarding system defense, one subject believes it would be very difficult to disable or hack into the system, “the effort would be excessive.” In contrast, another admitted, “It is a web-based system, and anything can be hacked.” Still another subject spoke about the WiFi vulnerabilities of his/her system, which would allow people to break into the system.

(4) System Flexibility

System flexibility has to do with the ability to customize the system to a specific school environment. Subjects were asked: What factors may reduce or enhance the system’s use in different school environments? Have you implemented it in the same way in all of the schools in your district?
One subject reported consistent implementation in all schools, districtwide. Another indicated that the number of required pull-stations varies based on building configuration; some have as few as 20 pull-stations, others as many as 48. In terms of expansion capabilities, one subject explained that in addition to the pull-stations and pendant alarms, the system provides access to activate it from desktop and laptop computers. School personnel can upload all its safety plans into the system, and officers get access to those plans when the system is activated. The system also can expand to include video imaging, and cameras can be linked into the system. All five subjects with the audible notification feature utilize their existing PA system and speakers, some with minor modifications. One subject’s system even has an added capability that causes all classroom doors to lock when the lockdown button is pressed, and it activates the cameras in the school.

**c. Service Quality**

The service quality dimension involves examining the projected lifespan of the system, and requirements for technical support and maintenance. Subjects were asked: *Can you describe the quality of service you have received on the warning system?*

Five of the six case study subjects have ongoing vendor involvement and maintenance agreements. One has an existing maintenance contract with a vendor who does an annual system check on the phones and intercom systems. The subject with the wired police pull-stations reported that their vendor customer service is outstanding, and added that “they also help when the principal needs a reminder on how to send out notifications—this is important because it is easy to forget how to do tasks like this that are low frequency tasks.” This vendor helps the subject problem-solve false alarms and assists school staff with downloading employee cell phone information into the system. The subject with the wireless police pull-stations claims their system requires extremely low maintenance. The vendor changes the batteries on the pull-stations each year when they come to perform an annual system test. The school district personnel change the batteries in the pendants button devices each year. The district also has a contractor come and test the intercom speakers once per year. Any time during the year that a staff
member notices an intercom not working properly, he/she puts in a work order and the district maintenance department handles the repair.

Two subjects use the RF-based system. The subject with a new system has not needed any maintenance or technical support. The other noted a high level of involvement with the vendor, over three years, through an annual service contract. The subject described them as “the best contractors by far we’ve ever had come into our schools,” and added that the vendor checks the system better than the fire system is checked. He/she explained that the vendor is constantly checking that the software is up to date. The vendor tests to ensure all RFs are working properly, checks the multiple antennas associated with the RFs, and resets things when necessary. The brightness of their strobes has been an issue and the vendor has replaced the strobes twice.

The subject with the visual notification lights has everything wired throughout the building. The subject reported, “Nothing can break down unless a wire is severed or a connection goes bad.” He/she does not have an ongoing vendor relationship or maintenance plan in place.

3. Human

The Human domain includes two dimensions, system use and user satisfaction, and several corresponding evaluation variables, as shown in Table 15.

Table 15. Human Domain.

<table>
<thead>
<tr>
<th>Dimension</th>
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<td>User Satisfaction</td>
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System Use

System use involves evaluating the impact that the technology has on the daily routines of school staff. It includes the school’s staff’s understanding of how the system is to be used, and evaluation around their perceptions of support for using the system. Subjects were asked: *Can you describe the impact this system has on the daily operations of the school and staff? Under what conditions do you allow the use of this system? What factors impacted those decisions?*

(1) Impact on Daily Routines

Five of the six case study subjects incorporate a software system that includes entering the contact information of personnel who are to receive text, email, or cell phone notifications when the system is activated. One subject acknowledged difficulty with the continual data entry requirements due to large turnover of employees and the need to take out employees no longer working for the district, and entering in the new employees. She/he noted that law enforcement handles updates for their own staff. Another reported, “The lockdown push-buttons are just there if needed, and they haven’t been needed yet.” He/she added that the system requires no extra work for personnel. Other than data entry requirements, no one cited any negative impact to their daily routines.

(2) Parameters for Use and Perceived Support

The placement of the activation devices impacts the clarity of the parameters for use of the system. For three of the subjects, anyone can use the system because the activation devices are in common areas. Two of the schools with activation devices in common areas of the school utilize signage above the devices to help educate building occupants on the parameters for using devices. One subject emphasized, “Anyone using the facility can use the system. Signs are located above the pull-stations to further explain the purpose.” The signs display these words: “Pull to Dispatch Police.” Another subject explained that the pull-stations are in hallways by exits, in the library, gym, and in areas where large numbers of students congregate. He/she even provides a packet of information about the pull-stations for people using the school during non-school hours through the school’s building rental process. One subject reported that his/her devices are
hardwired and fixed in place and said that they cannot be moved or misplaced. He/she pointed out that they are easy to locate, and always where office staff and administrators expect they will be.

For the other three subjects who elected to place the activation devices in secured areas, use is restricted to designated staff at the school. One subject said that office personnel are taught to “be absolutely sure” before they push the lockdown button, for instance, if they see someone with a firearm. This school’s leadership teaches to err on the side of caution. Still, some district personnel are afraid someone will overreact to a situation and push the button. Another subject conceded, “Teachers want to do things right. They are worried about making mistakes. We empower our staff to know and understand they are to use the system—they don’t need permission.” They are instructed to use the system if they are fearful for their lives. Teachers can activate the system from their classroom phones.

b. User Satisfaction

User satisfaction depends upon the perceived usefulness and acceptability, and ease-of-use of the system. Subjects were asked: Can you describe your staff’s perceptions about the system? Can you describe the training your staff receives to be able to use the system?

(1) Perceived Usefulness and Acceptability

Three subjects reported minimal negative perceptions about the lockdown system when first installed. For one, some questions were raised about how the system impacts existing protocols. Another expressed “a little apprehension.” A third brought up concern about police having access to cameras and cited “big brother” fears. To address that concern, they have a memorandum of understanding (MOU) that guides use of the system and requires that law enforcement provide notice to the school district any time they access the camera system. Some personnel from this school were resistant to using the system from their classroom phones since it would alert 911. All three subjects clarified that the concerns were raised by only a small minority, and have since been resolved.
Overall, case study subjects reported positive perceptions about the system. One observed that staff members had expressed some relief for having this added capability. This subject emphasized that parents like it and are happy they have it, saying, “Wow, I’m surprised you have this out here.” He/she reported receiving nothing but positive feedback from parents about the system. Another offered that staff, “love anything that’s going to make the school safer.” One subject said it provides a sense of security, a better comfort level, and that staff are positive about it: “they love it.” A fourth subject claimed, “They feel comfort and feel we are taking measures to ensure their safety at school.” One simply said they have heard nothing negative. The final subject, one with activation devices only in secured areas, believes that the system makes front office people and administration feel secure due to the quick and immediate nature of the system, and noted that “they don’t have to take the time to dial in and punch in a 3-digit code to activate the intercom system. The staff love knowing it’s there.” The subject revealed that he/she has had requests from staff to place lockdown buttons in other locations but have decided not to because of the belief that they must be very well controlled by staff to avoid the risk of accidental activation.

(2) Ease-of-Use

Training and drill practices varied among the case study subjects. Two subjects with restricted access to lockdown buttons conduct some sort of emergency drill every month. These drills include lockdown, shelter-in-place, evacuation, and fire drills. The administration and secretarial staff talk about the use of the buttons. When using the lockdown button system, the subject does not announce drills in advance or tell them it is a drill. One clarified, “We want them to think it’s real.” Another remarked, “We want to see how they respond.” These same two subjects provide a 4-digit code to their staff through email that they can use to activate the lockdown system via their classroom phones. For one, teacher training was provided at the beginning of the year using a power point training and actual demonstration of the system. The other subject described that the principal does a couple of drills each year from the classrooms. The principal will visit a classroom and say, “can you put the building in lockdown?” Teachers are
responsible for keeping the 4-digit code easily accessible for responding to a real emergency or when asked by the principal to initiate a drill.

The two schools with police pull-stations in common areas of the school use the system to conduct a minimum of two lockdown drills per year. One subject contends, “What is practiced gets done.” When asked about staff training, one cautioned, “Training has to occur. Activating the system means you’re calling the SWAT team to your building.” He/she teaches staff not to use it for medical emergencies. The other said that his/her school provides an awareness piece only, and teach staff, “What is that thing and what does it do?” Unlike the previous two subjects, both of these subjects always announce that it is a drill before activating the system.

One subject stated that his/her staff never push the lockdown button during drills. Lockdown drills are done by verbal instructions and a description of what to expect. The subject reasoned, “We want them [school occupants] to take it seriously and are concerned that they will get complacent if used frequently.” The lockdown buttons are restricted for use during real emergencies. This practice is applied consistently in all the schools in his/her district.

The case study subject that uses lockdown buttons to alert the office of a need to make an emergency announcement conduct scenario-based drills. He/she trains teachers by announcing a scenario, which gives the teachers time to make a decision and respond, and then makes another announcement with a slight change of scenario. “It gives them practice with decision-making based on the scenario they are confronted with.”

Other methods of training students and staff emerged during the phone interviews. When discussing false alarms, one subject reported that he/she educates students on the difference between the fire and police pull-stations. Another described using real-life close calls for training purposes and explained that one time a teacher saw a stranger in the school and called the main office to make a report. He/she used the incident as a teaching tool. During the debrief, he/she discussed scenarios with the teacher asking if she/he would have used the lockdown button system if the person had a weapon.
4. Organization

The Organization domain includes two primary dimensions, structure and environment, and several corresponding evaluation variables, as shown in Table 16. The basic school characteristics and demographics were assessed to see if these factors affected the implementation of the warning systems. Subjects were asked: *In what ways does the system require the school/district to have a dedicated safety or security department or staff for ongoing system monitoring, operations, or management?*

Table 16. Organization Domain.

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<th>ORGANIZATION</th>
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**a. Structure**

The organizational structure dimension refers to the warning system’s compatibility with the school, district, and their community partner’s attributes, and assesses its acceptability to the respective leaderships.

(1) School/District Attributes

Case study subjects are located on the East and West Coasts, Midwest, and in the South. Four subjects represent rural areas, and two suburban. Together, they represent elementary, middle, and high schools. Four subjects have the lockdown system in all of their district schools. Two subjects are the only schools in their district with the system. Some subjects have self-contained buildings, others have multiple buildings on campus, and others have athletic fields served by the warning system. None of these distinct attributes emerged as a factor that hindered the implementation of the lockdown systems in their schools.
One subject that restricts access to lockdown buttons reported that his/her district placed additional activation devices in some bigger, spread out schools, in somewhat protected areas, such as in a classroom that are located up high to deter false alarms but still give the teacher access. Another described the necessity to change an existing emergency nomenclature and explained that they used to call medical emergencies “code blue.” However, since the term means something different in hospitals and since the subject uses the term “code red lockdown” for their lockdown terminology and their lockdown activation devices are blue, the subject now refers to a medical emergency as a “medical lockdown.”

Four of the subjects rely upon the system’s vendor for monitoring the system’s functionality. One reported that the district does not have a security department to monitor the control panel and asserted, “It’s there, we pull it, and everything automatically happens.” She/he added that the vendor who monitors the system is “flawless.” Another subject has a security office at the main entrance of the school and a centrally located safety office in the school; however, personnel in these offices do not monitor the system; monitoring is done by a vendor. One subject has a district-level safety department with personnel who monitor cameras, the lockdown system, the electronic lock system, and other systems for all their schools. Personnel in this department receive automatic notifications when a lockdown button is pressed, and can remotely initiate a lockdown for any of their schools. For the other subject whose system no longer notifies law enforcement, his/her system is now entirely in-house no monitoring is involved. In summary, four rely heavily on vendor relationships for their systems, one monitors its own system, and the other involves no monitoring.

(2) Community Partner Attributes

Community partners include local law enforcement partners, 911-dispatch centers, and fire departments. Subjects were asked: Can you describe your local Law Enforcement agency’s interaction and involvement with the warning system? Can you describe how the system interacts with 911-dispatch center? What have you learned about the interaction of this system with the fire alarm system and your fire partners?
**Law Enforcement Partners:** Five of the six case study subjects reported positive law enforcement support and involvement with their systems. One said that law enforcement has input on and would need to be in agreement on every decision before they ever put the system into place. He/she pointed out, “Officers like the system and believe it’s a smart system to use, they feel empowered because it provides a quicker means of them knowing of a situation.” Another boasted, “Our law enforcement are involved, they are a driving factor. They don’t mind the false alarms. They are 100% behind it.” Another subject offered that they have a great relationship with law enforcement even though law enforcement was not involved in the decision-making process for the location of activation devices. Another asserted, “Law enforcement embraces the system 100%. It improves their response time.” One did not describe the law enforcement’s support, but did report that he/she always invites police, fire, and dispatch to participate in school drills saying, “It is important for them to understand the system.” One reported that law enforcement uses the exact same standard operating procedures for a lockdown whether it is called in by a live person, or activated by the lockdown push-button system. Another indicated that no standard operating procedures changed since the addition of the system, and added that “For training, troopers go to schools, observe, and hear the message to see what it sounds like.”

**911-Dispatch Centers:** Two subjects reported that their systems send an immediate alert to their alarm company and 911-dispatch center. One of these subjects reported collaborating with the 911-center initially to determine what information they needed and to test that the system worked well. The lockdown system plays a recording twice (for the 911-center) that indicates the name of the school and that they are in lockdown. The approximate message is “An emergency event has been activated at X School.” The other subject described its recorded message to the alarm company and 911-dispatch center as saying something like, “This is X School. We are in a lockdown. Please send help.” It also activates the school’s camera feed for the police. The subject reported that training 911-dispatchers is not necessary, and added that the system provides a big improvement on the speed of notification.
Another subject said that the signal goes directly to the 911-dispatch center. It tells them where in the school the button was pushed and the type of button: lockdown, shelter-in-place, or evacuation. This subject does not have an alarm company intermediary. Police chiefs, supervisors, and any additional designated personnel also get a text message and email. The system provides access to the school camera feed to police cars.

Two subjects reported that their signal goes directly to the alarm company, who, then contacts the associated 911-dispatch center. The signal is supposed to indicate an active shooter or serious threat of harm. One subject noted the limitations of the information that goes to law enforcement. The upside is that they can quickly dispatch police to the school. The downside is they do not have specific information why the lockdown button was pushed. “The advantage of the caller on the phone line is that the dispatchers are able to get a lot of information.” Both subjects reported that law enforcement and 911-dispatch have had some confusion with what the activation means; it has been misinterpreted as a burglar alarm. One revealed, “We have to train the 911-dispatchers or else they typically dispatch the signal as a burglar alarm.” For one of these schools, designated police personnel receive an immediate text message, cell phone call, and email when a lockdown device is activated. For the other, the system sends an immediate phone call and text message to the alarm company and the police department.

One of the subject’s systems used to notify local law enforcement automatically and activate their cameras as it currently does in the school office. Due to law enforcement budgetary and personnel limitations, it no longer automatically notifies law enforcement. This school is not financially able to support the system being monitored by a vendor alarm company, so it is currently configured with no external alert, only an

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276 One subject described some confusion with emergency terminology: “Years ago we used the word lock out, but it sounded too similar to lockdown so the state changed it to shelter-in-place.” The subject reported that the school has had a couple different changes in terminology because the teachers were confused about lockout and lockdown. They changed lockout to shelter-in-place, and reported that it helped to reduce confusion, but after a time, the district decided to change the term back to lockout. This subject reported that his/her law enforcement agency cautioned against using the term lockout due to confusion, yet the school district leadership decided against their advice.
internal alert to the school. The school leadership calls 911 when the situation warrants it, and the law enforcement agency visits the school more regularly.

**Fire Partners**: All six subjects reported that their fire departments are on board with the system and have not had any confusion between the existing fire alarm system and the lockdown system. Three of the six reported that it is standard for 911-dispatch to send fire along with police whenever a school lockdown button is pushed or when a 911 call is made. One of these three subjects stated that the reason was because many of their fire agencies are doing warm zone training for active shooter attacks.277

**b. Environment**

The organizational environment dimension refers to factors related to who owns the system, the financial impact on the school and community partners, and if the warning system aligns with regulations. Subjects were asked, *What can you tell me about ownership of the warning system? Discuss initial costs verses ongoing costs, and the concept of sustainability. Can you describe any policy, legal, or union considerations you encountered?*

(1) Ownership

Five of the six case study subjects claim to own the hardware associated with the lockdown system, such as the lockdown push-buttons, pull-stations, and wiring. One was unsure of ownership. The software components were a different story. One reported that ownership of the software had not been defined since it was a component of their phone system. He/she believes that if the school changed phone vendors, they could still use the software if the school maintained it. Another subject admitted that the vendor has a patent protecting their pull-stations, so while the school district owns the hardware, the vendor owns the software and web-based part of the system. Two subjects with the same

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lockdown system and vendor had different understandings of ownership. One said that the equipment could be supplied by anybody, but that, “the software is different. We could change the software but we would not do that due to liability, [such as] personal negligence if the system did not work properly.” The other holds that they own the entire system and purported that “it’s our software, our infrastructure. We own the system. Once it’s in, it’s in.” A different subject also claimed owning the entire system, both the hardware and software. This subject did not indicate any ongoing relationship with the software vendor.

(2) Financial Impact

One subject with a minimal number of lockdown buttons in secured places in their school said they utilize the school’s existing intercom and PA system and phone system. No additional standalone speakers are used, and as a result, no associated costs are spent for wiring or notification devices. The subject stated further that the lockdown buttons and wiring represented a one-time purchase, and added that “There are things you can do that are not very expensive, that improve safety.” The subject did not disclose the initial equipment and installation costs but did say that his/her system requires no annual ongoing fees or licensing costs.

A subject with police pull-stations throughout his/her schools explained that his/her first school did not incur costs upon implementing the system, since it was the pilot school for this vendor. They were able to utilize the existing intercom system speakers with some minor modifications. The subject did not know the initial costs for the other schools in their district but pointed out that the district made a commitment to safety and budgeted for the system. The district started with a pilot school and then incrementally rolled it out to the other schools. This implementation process also helped with affordability. The annual vendor fees were unknown.

The other four subjects disclosed the initial costs for their systems. One subject with pull-stations located throughout her/his schools said that the initial costs for 12 schools were $430,000. Costs per building vary due to the number of pull-stations required depending on the size and layout of the school. He/she uses the existing
intercom for the audible notification piece. The annual vendor fees are just under $8,000 for the 12 schools combined.

A subject representing a single school with a minimal number of lockdown buttons in secured locations used a grant that paid 40% of the $340,000 cost to upgrade their phone, PA, and clock systems that included the RF lockdown button system. The school paid an additional $45–50,000 for the lockdown notification system to serve the athletic fields. The subject pays an annual vendor fee of $6,000 for the phone and lockdown system combined.

One subject using the RF lockdown buttons in limited and protected locations spent $300,000 for the initial costs for two schools. This subject incorporated the existing phone and public address system but added some speakers. The subject reportedly convinced the school board of the importance that they would use the money wisely, and drew money from the capital fund. The subject did not report annual vendor fees.

The school without audible notification reported costs of over $200,000 for the equipment and installation of the system in every classroom and throughout the school. It also included the creation of a command center in the Sheriff’s office to monitor the system. The subject explained that the bulk of the money came from drug forfeiture funds, and said, “local businesses pitched in to help install the system in the school.” The subject also reported obtaining an estimate from the vendor about three years ago to outfit other schools in their district and learned that it would cost between $4,000–$16,000 per classroom depending on the size of the room and number of doors. Additional fees would be incurred for hardware, software, and network ports that would total over $55,000. Should the school decide to use the vendor for monitoring, it would cost approximately $300–$400 per school.

(3) Aligns with Regulations

None of the subjects were aware of any codes, regulations, or policies governing their systems. One expressed union issues with cameras. One reported that his/her state

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278 Equipment includes lockdown buttons, lights, cameras, automatic door locks, and associated wiring.
requires schools with WiFi video capabilities to grant access to law enforcement. Another talked about drill requirements. One subject said that a text message is sent to everyone in the building who provides a personal cell phone number. Another explained that her/his district does not issue cell phones to staff, but they have an optional notification feature that delivers a text and phone call to everyone registered in the system and allows those registered to text information they might have during a lockdown. Subjects with optional cell phone notifications did not report any known real or perceived equity issues reported by those who do not own cell phones. One subject’s system automatically locks all classroom doors when a lockdown button is pushed, and requires people pushing a separate button to unlock their door to exit. The subject did not know of any issues related to fire code regulation due to the extra door egress measure.

5. Net Benefits

The Net Benefits domain evaluates three dimensions—effectiveness, sustainability, and feasibility—and corresponding evaluation variables, as shown in Table 17. These three dimensions were not established by the time the case study interviews were conducted.

Table 17. Net Benefits Domain.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Evaluation Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effective</strong></td>
<td>i. Solves Problem</td>
</tr>
<tr>
<td></td>
<td>ii. Accomplishes Purpose</td>
</tr>
<tr>
<td></td>
<td>iii. Reliable</td>
</tr>
<tr>
<td><strong>Feasible and Sustainable</strong></td>
<td>i. Financially</td>
</tr>
<tr>
<td></td>
<td>ii. Operationally</td>
</tr>
</tbody>
</table>

The researcher concluded the interviews by asking subjects general questions about the benefits of their systems, including what they would tell other school districts who may be considering such a system. Their responses follow.

One subject with lockdown buttons throughout his/her schools contends, “It’s all about reducing the response time.” The subject went on to say that it is an improvement
to their previous system since they formerly used the intercom and PA system to make lockdown announcements. Schools were limited by the few locations in the school that have control phones (mostly main office areas), and a staff member who had a 3-digit code to make an announcement on one of those phones. “The key benefit of the [lockdown] system is that we lower the response time dramatically.”

A case study subject with lockdown buttons in limited secured locations, such as offices insisted, “We just eliminated our worst case scenario. Fast notification. When someone walks into the front office and shoots, who is going to make that notification? It’s a huge issue if it doesn’t get sent out. With this system, we push it, forget it, and get out of sight or flee the scene.” The subject explained that adrenaline causes the slowing of motor skills during emergencies, and contended, “With our prerecorded notification you’re hearing a calm, cool, collected message to everybody. It is automatic and it is clear. We are taking reasonable measures to get to school safety.”

One subject simply said there is nothing he/she would change about the system and added that he/she would do it exactly the same way. Another subject described his/her system as a comprehensive, multi-layered, web-based system, with hardwired and wireless features that uses both strobes and fobs. They said it is affordable and expandable. The case study subject with the visual notification and office notification emphasized, “The primary benefit of this system is the ability for anyone to quickly push a button to notify the front office of an emergency. The front office receives quick notification and then can respond accordingly.” The subject with the new system reported that they used to make emergency announcements on the intercom system and they recently completed their first drill using the push-button to initiate the drill.

To those schools that may be considering a lockdown notification system, one subject recommended, “Do not hesitate to do it, but check with your local law enforcement first,” and continued by stating that “It works very well, not a lot of issues.” Another liked the benefit of teachers and staff having the ability to text information about the emergency, but admitted the drawback of continually having to update staff contact information so the right people get the information. Another urged, “Don’t wait until it happens in your area, or your school. This is an effortless task from many locations. You
don’t want to be that school district that could have done something to save lives, but
didn’t.” A law enforcement officer interviewed asserted, “If you’re going to spend
money, use it on notifying law enforcement and on an alert system. Cameras are good for
barricade situations, but not for immediate response.”

Another subject offered this advice, “Make sure you have good procedures in
place. Practice. And model expectations during emergency drills.” One subject reported
seeing all kinds of cell phone alert apps at conferences, “I would encourage other schools
to do your research. A lot of people have great spiels, but don’t deliver.” Their IT
department developed their own cell phone safety app that teachers can elect to download
on their personal cell phones.

For all the case study subjects, they expressed positivity about the net benefits.
Still, it was evident that had an evaluation framework tool been available and utilized,
they may have been able to articulate more thoughtfully about the evaluation of the
effectiveness, feasibility, and sustainability of their systems.

C. ANALYSIS

None of the subjects participating in the case studies had warning systems that
were an exact mirror of the researcher’s conceptual lockdown notification system. Many
commonalities were found from which some important conclusions were drawn.

1. Commonalities with Conceptual Lockdown Notification System

All six subjects have systems with push-buttons or pull-stations, affixed to the
wall, and with a single- or double-action activation mechanism, similar in size to fire
alarm initiating appliances and to those proposed in the conceptual lockdown notification
system, which makes them easy to use.

All subjects’ systems emit an immediate audible or visual notification to the entire
school, with the exception of one with a 3-second delay. Five of these systems use an
audible prerecorded message that announces a customized lockdown message. As lauded
by one subject, “you’re hearing a calm, cool, collected message to everybody. It is
automatic and it is clear.” Another combination of five subjects has systems with a visual
notification, such as a strobe or a colored light. Four of the overall subjects’ systems used both an audible and visual notification, similar to the conceptual lockdown notification system.

Also similar, five of the six case study’s systems send an immediate, automatic notification to an alarm company and/or 911-dispatch center that results in the speedy dispatching of law enforcement to the school.

Two subjects make their system accessible at all times and to all school occupants by placing police pull-stations in common areas throughout the school to allow people using the school facility, when school is not in session, to benefit from the warning system.

For all six case study subjects, their school characteristics and demographics did not appear to limit the effectiveness of the warning system. The size and physical configuration did, however, influence the number of activation devices required for schools placing the devices in common areas throughout the school.

Other significant findings are that user satisfaction is high. In addition, subjects were unanimous that school stakeholders had positive perceptions related to increased safety. All also reported that their law enforcement partners are overwhelmingly positive about the systems. All six subjects reported that their fire departments are on board with the system and have not had any confusion between the existing fire alarm system and the lockdown notification system. None reported stakeholders being confused about the difference between the fire alarm system and the lockdown push-buttons or police pull-station systems.

2. **Solves the Problem of Early Warning**

The case study subjects were unanimous and enthusiastic that their systems solve the problem of early warning and result in quicker lockdowns. Even the three subjects with lockdown push-buttons only in secured locations indicated this timeliness. One of these three insisted, “We just eliminated our worst case scenario. Fast notification.” A case study subject with pull-stations in common areas claimed, “The key benefit […] is
that we lower the response time dramatically.” Although the six subjects’ systems’ were very different, the researcher agrees that they all solve the problem of timely and early warning for emergencies involving school violence; some to a greater degree than others.

Of all the case study subjects, the two subjects with the light blue POLICE pull-stations in the common areas of the school solve the problem of early warning most comprehensively. The pull-stations are accessible to anyone using the school building any time of the day or night. Once a pull-station is activated, the system automatically and immediately emits a prerecorded lockdown message over the public address system, turns on a strobe light notification feature, and simultaneously alerts the alarm company or 911-dispatch center. Its limitation lies with the absence of the pull-stations in classrooms.

The three subjects with the bright blue LOCKDOWN push-button devices in rooms with restricted access, such as school offices, also solve the problem of early warning, but to a lesser extent. Like the POLICE pull-stations, when activated, the LOCKDOWN push-buttons automatically and immediately (except one with a 3-second delay) trigger a prerecorded lockdown message over the PA system, and immediately notify an alarm company or 911-dispatch center. Two of these systems also include a visual notification device. Since they are mostly located in secured rooms, the system does not provide the added capability of enabling people in common areas of the school to use it, nor is it accessible for people using the school during non-school hours. Even so, it is an improvement on the subject’s prior capabilities of making manual lockdown announcements over the PA system, since those with access to the push-buttons simply push a button to generate a lockdown announcement.

Even the subject with the yellow EMERGENCY LOCK DOWN push-buttons that only provide a visual notification to the entire school improves the school’s prior capabilities when it comes to early warning, particularly for people inside the school. The buttons are located in common areas and in classrooms throughout the school and provides many opportunities for staff or students to activate the system at the first sign of danger. While the system does not generate an audible warning, the lights help to get people’s attention and signal them to take protective measures; and the doors, if already
closed, automatically lock. Unfortunately, the system no longer sends an automatic notification to law enforcement, which is a downside.

While all six case study subjects improved their existing warning capability, all can further improve their capabilities by phasing in additional initiating or notification appliances. The subjects with POLICE pull-stations in common areas can improve by adding pull-stations in classrooms. The subjects with LOCKDOWN push-buttons in secured offices can improve by adding pull-stations in common areas, and eventually, in classrooms. The subject with the EMERGENCY LOCK DOWN buttons can improve their capabilities by adding an audible alert and prerecorded message to their system, as well as an alert to an alarm company.

D. CASE STUDY CONCLUSION

Why does this matter? Conducting these case studies was important because the researcher was able to learn from schools already using some form of the conceptual lockdown notification system. The subjects described the different applications of these warning systems, and the variety of ways they have been implemented in the different schools.

Matching up the features of the case study subjects’ systems to the new K-12 School HOT-Fit Evaluation Tool helped to inform the refining of the school tool. Laying out the data according to the school tool domains, dimensions, and evaluation variables demonstrates that the school tool is useful for identifying many of the strengths and weaknesses of school warning systems.

The researcher also learned that even though these case study warning systems were not as robust or comprehensive as the conceptual lockdown notification model, they all provided value or “net benefits” toward the goal of speed of notification. One of the biggest takeaways from conducting this case study research is that a school equipped with one of these systems has a greater possibility of minimizing the damage of an active shooter attack because of their increased capacity to get a quicker warning out to students and staff.
Nevertheless, all the case study subjects have systems with serious shortcomings, most notably related to the reliability of the technology. The next chapter extracts those identified weaknesses from the case study data and draws comparisons that will show how these vulnerabilities may be able to be avoided by using the conceptual lockdown notification system model.
VI. CONCLUSION

This final chapter provides a summary of the thesis goals, describes how those goals were accomplished, presents findings, and concludes with recommendations.

A. SUMMARY OF THESIS GOALS AND DESIGN

Schools are susceptible to active shooter attacks. Studies show these attacks occur quickly, often within minutes of when an intruder enters a school. Many strategies to prevent injuries and loss of life have emerged. One of these, lockdown, is a commonly accepted strategy that has shown to have benefits toward protecting students and staff during active shooter attacks. Studies also highlight the criticality of rapidly warning everyone in the school so they can quickly lockdown, and thus deny access to the intruder. Unfortunately, PA systems are often accessible only from a school’s main office, which can make it difficult to get a timely warning out when an intruder is first detected at school.

In response to these problems, an assortment of warning system technologies have emerged, such as cell phone warning applications, pendant emergency-buttons, and computer panic-buttons. However, case study research found in the existing literature exposes many weaknesses with the implementation of these technologies in K-12 schools. Vendor advertisements and news reports show that some schools are using other warning systems that have lockdown push-buttons or police pull-stations, similar to the fire alarm system, to address timely warning in active shooter attacks. Research is limited, however, about the efficacy of these systems and minimal guidance is available.

279 Blair and Schweit, Active Shooter Incidents, 9.
281 Department of Homeland Security, Science and Technology Directorate, Infrastructure Protection and Disaster Management Division, Primer to Design Safe School Projects in Case of Terrorist Attacks, 3–49.
to help school leaders make informed decisions about selecting warning system technologies. This thesis was written, in part, to address this gap.

Specifically, the goal of this thesis was to answer two questions:

- To what extent can the school “fire alarm system” (for emergencies involving fire and evacuation) be a model for a “lockdown notification system” for emergencies involving violence and requiring lockdown?

- What factors should K-12 school decision-makers and their law enforcement partners consider when evaluating and implementing warning systems that notify both school occupants and law enforcement of an imminent threat of violence at school?

Four tasks were undertaken to answer these questions. First, a conceptual lockdown notification system was developed that used the fire alarm system as a model. The history, philosophy, regulations, and basic components of the fire alarm system were studied. This research found that there are similar codes regulating emergency communications systems for situations involving violence as for fire alarm systems. The NFPA identifies the “minimum required levels of performance, reliability, and quality of installation for emergency communications systems.” Further NFPA guidance is explicit regarding alert and warning messages used specifically on campuses. These and other research documents helped shape the design of the conceptual lockdown notification system.

The system mechanics of the conceptual lockdown notification system are almost identical to the basic structure of the fire alarm system. Its components consist of a

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lockdown notification control panel that is hardwired to lockdown push-buttons and speaker-strobes located throughout the school building, as shown in Figure 19. If a student or staff member detects a suspicious person or hears gunfire, they can quickly activate a lockdown push-button. The control panel immediately notifies the whole school to lockdown by playing a pre-recorded message over the speaker-strobes. The system simultaneously notifies the police department (via the alarm company) through the dedicated phone lines.

![Conceptual Lockdown Initiating Appliance and Speaker-Strobe](image)

Figure 19. Conceptual Lockdown Initiating Appliance and Speaker-Strobe.288

Second, an evaluation tool was developed that K-12 school decision-making teams can use for assessing communication and warning system technologies. The core elements of the HOT-Fit model were used as a structure on which to build the school tool.289 To customize it to K-12 schools and for communication and warning systems, knowledge gleaned was incorporated from the existing literature, such as the federal Guide for Developing High-Quality School Emergency Operations Plans.290 Three key pieces of literature were also consulted: Johns Hopkins University’s A Comprehensive Report on School Safety Technology, Tod Schneider’s School Security Technologies, and

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288 Photo 1: Adapted from Automation Source, “Egress Devices”; Photo 2: Source: System Sensor, “SPSWK-CLR-ALERT.” The text on the image on the left of a blue initiating appliance was modified to demonstrate the proposed plain language for a lockdown initiating appliance.


Heather L. Schwartz’s et al. *The Role of Technology in Improving K–12 School Safety.* After examining the fire alarm system as a model for a conceptual lockdown notification system, guidance from the NFPA’s *National Fire Alarm and Signaling Code*, and from Erica D. Kuligowski’s *General Guidance on Emergency Communication Strategies for Buildings* was incorporated. These and other resources helped inform the evaluation variable criteria. The researcher also drew from extensive experience as a school safety professional to help shape and explain the new K-12 School HOT-Fit Evaluation Tool.

The new K-12 School HOT-Fit Evaluation Tool includes five core domains that guide the user through a process to assess the suitability of a technology to accomplish the goals of the school organization. The first domain, *Foundation*, otherwise known as *the why*, is unique to this new tool. The other domains come from the HOT-Fit framework. These include investigating the *Technology* itself, assessing the technological interface with *Humans* in the school system, examining the impact on the *Organization*, and identifying the *Net Benefits* to the school, district, and community partners. Each domain is distinct, but are all interconnected. The domains have corresponding dimensions based on the HOT-Fit model, as well as unique and customized variables for evaluating the efficacy of the technology’s use within the K-12 school environment, as shown in Figure 20.

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Third, to test the new K-12 School HOT-Fit Evaluation Tool, it was first applied to the fire alarm system, and then to the conceptual lockdown notification system. In doing so, it was learned that the new school tool is useful for evaluating both existing technologies and prospective technologies. This exercise also helped to reveal the strengths, weaknesses, and potential unintended consequences of the conceptual lockdown notification system. Furthermore, it became evident that while the school tool’s stated purpose is for evaluating communication and warning system technologies, it may also be useful for evaluating other school safety and security technologies.

Finally, case studies were conducted on six schools or school districts already using a warning system with lockdown push-buttons or police pull-stations resembling fire alarm pull-stations yet designed to address school violence. By laying out the case study data according to the evaluation criteria in the new K-12 School HOT-Fit Evaluation Tool, it was ascertained that the school tool is useful for identifying many of the strengths and weaknesses of these existing school warning systems. It was then
possible to draw conclusions about the efficacy of the case study schools’ warning systems in comparison to the conceptual lockdown notification system.

B. FINDINGS RELATED TO CASE STUDIES AND THE CONCEPTUAL LOCKDOWN NOTIFICATION SYSTEM

The preceding chapter presented the case study data and examined many of the commonalities between the case study subjects’ warning systems and the conceptual lockdown notification system. For example, the case study schools’ systems use push-buttons or pull-stations affixed to the wall, most emit an immediate audible or visual notification to the entire school, and most send an immediate alert to the alarm company for police notification. Another commonality is that all these systems, to some extent, solve the problem of early warning, which results in quicker lockdowns.

Differences in the systems also represent weaknesses and vulnerabilities in the case study warning systems. These differences include issues associated with regulations, information quality, system mechanics and reliability, security attributes, and liabilities related to system complexity.

First, none of the subjects seemed aware of the NFPA codes regulating the mechanics of their warning system.293 This lack of awareness resulted in vulnerabilities related to the quality of information and with system reliability.

Information quality was reduced because of the inaccessibility of the activation devices and due to problems with information completeness. Four of the six subjects’ systems were deficient in their accessibility to people using the school during after school hours. Moreover, three of these four did not have lockdown push-buttons in common areas of the school for when school is in session. These three limited placement mainly to secured office areas.

The use of one subject’s lockdown push-button proved to be difficult to understand without training, as reflected in the report that a staff member did not know what the button was and pushed the button to see what it would do. This school did not

use signage near the lockdown buttons, which revealed that the text on the push-buttonalone is not intuitive or instructive enough for a staff member to understand its function. All had incomplete information on their push-buttons or pull-stations and lacked clarity about what the device would do when activated. Two subjects augment with the use of signs, but the signs only indicate the police response portion of the system and not the lockdown function.

Furthermore, the actual notifications produced by the warning systems were problematic. The NFPA requires the use of an alert tone preceding the prerecorded message to get people’s attention. Only one subject met this requirement. Another subject’s system sounds a police siren as an alert tone but it plays simultaneously with the recorded message (rather than prior to), which causes potential communications difficulties for law enforcement.

The primary difference between the conceptual lockdown notification system and the warning systems from the six case studies involves system reliability due to system mechanics. All the case study systems are dependent upon power, utilize software operating systems, and rely upon the internet to some extent. Several rely on cellular service, and two rely on RF. Five of the six systems use the existing PA system speakers, and while this could certainly be a cost-saving measure, it creates problems due to dependence upon other systems, and thereby decreases the reliability of the warning systems. This measure includes the need for electricity, and many of the schools have no backup generators to support their PA system.

Even though all these systems had significant vulnerabilities related to reliability, none of the subjects interviewed expressed concern. These vulnerabilities may have emerged by conducting risk and capability assessments as called for in the new K-12 School HOT-Fit Evaluation Tool. Similarly, these conditions could have come to light when evaluating the technology against the system quality section of the school tool.

The system mechanics and reliability vulnerabilities result in flaws in the systems’ security attributes. Software and internet-based systems, as well as RF-based systems bring with them weaknesses in terms of system defense, which makes them
vulnerable to nefarious actors hacking into the system and creating havoc by reprogramming the recorded message, disabling the system, or causing a system to activate when not desired.

Also related to security attributes are false alarms. For some subjects, the fear of false alarms was the exclusive reason for not placing the lockdown push-buttons in common areas of the school. However, the subjects with the push-buttons or pull-stations in common areas throughout the school did not express any concerns about pranks and false alarms. In fact, these subjects had few false alarms even though the lockdown devices were in public areas. Research shows that false alarms due to pranks for fire alarm systems have declined and represent a very small percentage of false alarms. While the risk of pranks and false alarms is a real concern, since schools have found ways to mitigate this risk, this fear may or may not be a well-founded rationale for decisions against lockdown push-button in common areas. All schools, districts, and their community partners must decide the level of risk they are willing to assume.

Additionally, it is evident that the complexity of these systems increase vulnerabilities and produce a false sense of security. Five of the six case study subjects’ systems include additional activation and notification devices than just the lockdown push-buttons or pull-stations. These devices include wireless emergency pendant buttons, classroom phone emergency activation codes, and cell phone applications and alerts. Although these extra features appear to provide a more robust and flexible warning capability, the literature review identified several vulnerabilities related to the implementation of these technologies. These vulnerabilities include the potential inaccessibility of the devices, limitations in their ability to warn the entire school, significant reliability weaknesses, challenges with initial and ongoing costs, and a lack of organizational fit. These extra warning features also require greater reliance on and control by vendors, are more difficult to use while under extreme stress, and require more frequent upkeep and maintenance. These vulnerabilities related to reliability can increase risk. If school staff members count on one of these methods during a real emergency, and

it is not reliable, it could cause a delay in a warning announcement and increase the risk rather than decreasing it. Using the new K-12 School HOT-Fit Evaluation Tool could be useful in revealing these shortcomings.

Finally, not only does complexity create liabilities but it can also affect the financial outlay involved. Substantial differences occur in the costs associated for each of the case study subjects’ warning systems. While the reasons for these vast differences are unclear, system mechanics and complexity are likely contributing factors.

Thus, the conceptual lockdown notification system may be able to address and mitigate the weaknesses and vulnerabilities identified in the six case study subjects’ systems. First, the conceptual lockdown notification system aligns with NFPA codes and regulations. It also follows the guidance for emergency communications systems. Where guidance is not specific to a “lockdown” system, the system mechanics are configured to match the requirements of the fire alarm system. Since the NFPA regulations are in place to support a highly reliable and efficacious fire alarm system, following NFPA codes should also support a highly reliable and efficacious lockdown notification system.

The information quality aspects of the conceptual lockdown notification system align with the NFPA emergency communications systems guidance. The system is accessible, instructions for use on the push-buttons and associated signage are clear and intuitive, and the proposed order of the alert tone and warning message is based on research. Even so, all these conceptual information quality features will need to be customized to the unique school or district, and tested for clarity and efficacy once an actual system is implemented in a school.

Like the fire alarm system, the conceptual lockdown notification system is a hardwired system. A control panel monitors the flow of electricity and current through the wire, which connects the lockdown push-buttons to speaker-strobes, and to its control panel. It does not require the use of the internet, radio frequencies, or cellular service. The system has a built-in battery backup to provide redundancy if electricity is interrupted. These attributes contribute to system reliability and support a strong system.

defense. Moreover, since the conceptual lockdown notification system is not RF or internet based, it is not vulnerable to cyberattacks, such as viruses, hacking, or remote disabling.

The conceptual lockdown notification system is not as flexible or complex as the warning systems in the case studies. It is a basic warning system that provides only that function necessary to accomplish the intended purpose and does not have any extra bells and whistles. The system, therefore, is simple to use, reliable, and manageable. Due to these attributes, the service quality variables of lifespan, technical support, and maintenance, as well as ongoing costs, are more sustainable. Moreover, initial costs for system acquisition should be consistent, with variance related mostly to the physical size and layout of the school.

C. FINDINGS RELATED TO THE K-12 SCHOOL HOT-FIT EVALUATION TOOL

The new K-12 School HOT-Fit Evaluation Tool is useful for evaluating existing and proposed communication and warning systems technologies. It may also be suitable to evaluate the efficacy of other school safety and security technologies, as established in Chapter IV.

1. Evaluating Existing Systems

The K-12 School HOT-Fit Evaluation Tool can be used to evaluate existing warning systems, as demonstrated with the case studies. The structure of the school tool was used to organize the warning system data from the six case study subjects’ interviews, as shown in Chapter V that helped to reveal the strengths, weaknesses, and benefits of the systems. It also showed how using the school tool in advance may have revealed some significant vulnerabilities, and possibly even influenced the decision making about the technology selections. Since the school tool was not complete at the time of the case study interviews, not all dimensions were discussed. Consequently, the case study data was not entered into the school tool template as for the fire alarm system and the conceptual lockdown notification system. Findings related to the fire alarm system are explained next.
Using the template for the new K-12 School HOT-Fit Evaluation Tool, the efficacy of the fire alarm system was examined in light of the five evaluative domains with the following results.

The Net Benefits revealed that the fire alarm system is effective. It solves the problem of early warning for emergencies involving smoke or fire at school. It accomplishes the goal of preventing injuries and loss of life in K-12 schools due to fire, smoke, and cascading effects. Moreover, it has built in redundancies, such as backup battery power and two dedicated landline phone lines, to overcome potential weaknesses in reliability.

The Net Benefits also showed that the fire alarm system is a feasible warning system technology for K-12 schools. Once installed, the fire alarm system has minimal and reasonable ongoing maintenance costs and alarm monitoring fees, which makes the system sustainable over time. Since the fire alarm system has such minimal impact on the daily routine and operations of the school and its community partners, it is operationally workable. A potential negative impact revolves around the possibility of false alarms. However, schools have successfully implemented strategies to minimize this risk.

Two possible unintended consequences or risks emerged. One involves the potential nefarious use of the fire alarm system to draw unsuspecting students and staff into the line of gunfire during an active shooter attack on schools. Another potential unintended consequence during active shooter attacks is that the fire alarm sensors may set off the alarm due to smoke from gunfire that can cause students and staff to evacuate into harm’s way.

Working through the school tool helped to determine the net benefits of the fire alarm system, which were mostly positive and outweighed the system’s limitations.

2. **Evaluating Proposed Systems**

The new K-12 School HOT-Fit Evaluation Tool was also used to evaluate the proposed conceptual lockdown notification system. Working through each step of the school tool helped expose the strengths and weaknesses of the conceptual lockdown
notification system, and ultimately answered the first thesis question: *To what extent can the school “fire alarm system” (for emergencies involving fire and evacuation) be a model for a “lockdown notification system” for emergencies involving violence and requiring lockdown?* Lessons gained from the case studies and from using the school tool are revealed as follows.

The Net Benefits showed that with an accessible warning system that can immediately notify all school occupants to lockdown at the first sign of danger, it is possible a school can prevent or reduce injuries and loss of life during active shooter attacks, if the use of the warning system helps them to lockdown more quickly.

Moreover, unlike the warning systems described in the case studies, the conceptual lockdown notification system is highly reliable. It does not rely upon cell service, internet, software, or radio frequencies. The mechanics of the conceptual lockdown notification system, like the fire alarm system, have built in redundancies (backup battery power, two dedicated landline phone lines, and all components hardwired together) to overcome potential weaknesses.

The Net Benefits suggest that the initial financial outlay, due to system acquisition and installation, may be a potential barrier for schools. Even so, once installed, the lockdown notification system is likely to be a feasible and sustainable warning system technology for K-12 schools. The lockdown notification system will require minimal ongoing maintenance costs and alarm monitoring fees. These modest fees have shown to be feasible for schools over time as demonstrated with the fire alarm system.

Since the lockdown notification system is carefully designed to be intuitive and easy to use, and because it appears to have such a minimal impact on the daily routine and operations of the school and its community partners, it is likely to be operationally workable. The biggest potential negative impact to operational feasibility has to do with the possibility of pranks and false alarms. Even though the frequency of fire alarm pranks has reduced significantly over the years, they are still a valid concern. The implications are serious. As one of the case study subjects expressed, when law enforcement is
notified of a possible active shooter, they arrive at the school with weapons drawn. Someone could accidentally get hurt or emotional trauma associated with this type of false alarm could result. Research shows that pranks for fire alarms can be mitigated, but it does take work to implement strategies for curtailing intentional and unintentional false alarms. Some of these strategies consist of protective covers and guards on lockdown buttons, educating staff and students on the appropriate use of the devices, consistent implementation of consequences, signage, and cameras. Schools that have cameras may be able to leverage those as a deterrent and use them as an investigative asset. If schools include the consequences for misuse on the signage near the activation devices, this could also be a deterrent.

The evaluation also brought to light several implementation considerations, as well as possible unintended negative consequences. In terms of implementation, it will be important to keep the fire alarm pull-stations and the lockdown push-buttons separate to help reduce the chance of activating the wrong alarm. This separation is essential since either system accidentally activated for the opposite hazard or threat could actually increase injuries and loss of life.

While the Final Report of the Sandy Hook Advisory Commission pointed out the benefits to lockdown and that locked classroom doors have not been defeated in a school shooting, some schools do not have lockable rooms, so the protective strategies at these schools might look very different from schools that have lockable doors.296

Moreover, lockdown is not the only protective strategy schools use to respond to active shooter attacks. In some cases, students and staff may be in common areas, such as cafeterias, halls, or playgrounds and may need to try to run to safety. This strategy could include running out of the school, or to a lockable area within the school, or possibly even running off-campus. Some schools even teach students and staff to defend themselves, or teach how to try to disable an aggressor.297 These tactics, however, are

Schools or districts must collaborate with their law enforcement partners to customize plans that align with their unique situation, polices, laws, and emergency response philosophies. This collaboration will help decision-making teams determine how to customize a lockdown notification system to meet their circumstances.

Similarly, customizing the pre-recorded message to match schools’ unique response philosophies and procedures is also critical. If schools do not want to use the word “lockdown” because they use other terminology, the conceptual lockdown notification system provides that kind of flexibility. Schools can customize the message to correspond with their emergency plans.

Another implementation consideration concerns the activation devices. The conceptual model proposes a lockdown push-button. This proposal does not preclude a decision-making team from choosing another color for the device or a different activation mechanism. There may be merit to the police pull-station concept. Police and fire are distinct terms representing distinct emergency responders. The terminology for lockdown may change; however, the terminology for police is not likely to change and may be a more sustainable term for these devices. If the police pull-station is selected, it might be prudent to include other descriptive terminology on the devices or on nearby signage, so school occupants understand the device’s purpose and what will happen if the device is activated.

The potential for unintended negative consequences exist. For instance, if a student or staff member sees someone in the school with a gun, and decides to stop and push a lockdown-button to notify everyone in the school, that extra effort may place the student or staff member in greater risk of danger because it will take them longer to get to safety themselves. Clear guidelines, expectations, and associated training can help mitigate this risk.

298 Trump, “ALICE Training Co-Founder Admits.”
Furthermore, if a lockdown button is activated and an immediate announcement is played, not only will all students and staff be alerted, but the perpetrators will also be alerted. While this notification could cause them to cancel the attack, it could also compel them to alter or speed up the attack, or it might not change their plans at all; all are unknown variables.

Even though the conceptual lockdown notification system is designed to be a highly reliable system mechanically, and has strong security attributes, the system could still experience compromise if someone, with nefarious intent, gained access to the control panel. School personnel will need to provide access protections to the lockdown notification control panel, similar to what they do for their fire alarm control panel.

In summary, the evaluative categories in the new K-12 School HOT-Fit Evaluation Tool proved to be valuable in bringing to light some of the potential strengths, weaknesses, and unintended consequences of the conceptual lockdown notification system. Using the school tool to evaluate the fire alarm system, the conceptual lockdown notification system, and the case study subjects’ warning systems helped to answered the second thesis question: *What factors should K-12 school decision-makers and their law enforcement partners consider when evaluating and implementing warning systems that notify both school occupants and law enforcement of an imminent threat of violence at school?*

### D. RECOMMENDATIONS AND AREAS OF FURTHER RESEARCH

These findings lead to two recommendations, use the new K-12 School HOT-Fit Evaluation Tool and conduct a pilot project on the Conceptual Lockdown Notification System.

First, schools and their community partners should try using the new K-12 School HOT-Fit Evaluation Tool when considering communication and warning system technologies to help them gain a better understanding of their unique needs and select appropriate technologies to meet those needs. Schools can also use the school tool to evaluate the efficacy of their existing systems. Moreover, with minor modifications, school leaders may be able to use the school tool to evaluate the suitability of other safety
and security technologies. School decision-making teams can access the new K-12 School HOT-Fit Evaluation Tool in the Readiness and Emergency Management for Schools (REMS) Technical Assistance (TA) Center tool box at https://rems.ed.gov/ToolBox.aspx. It is also provided in Appendix B of this thesis.

Second, a pilot project should be implemented to validate the mechanics and implementation of the conceptual lockdown notification system in schools. The pilot project should have a collaborative team of researchers, fire and law enforcement officials, and school safety personnel that design the proposal, implement the project, and evaluate results. The pilot could be a comparative design that would test the system in some schools with lockdown push-buttons primarily in common areas, and in other schools with lockdown push-buttons also in classrooms. To fund the pilot project, the research team could initially apply for available grants. This research would fill a specific gap in the current literature on the efficacy of school safety and security technologies.

E. CONCLUSION

This research contributes to the existing body of knowledge for K-12 schools about communication and warning system technologies; specifically, those that address violence.

The first output is a conceptual lockdown notification system modeled after the fire alarm system. The thesis shows that the conceptual lockdown notification system can provide a practical and reliable improvement to schools’ ability to warn students and staff when in imminent danger of violence. If students and staff can indeed lockdown more quickly because of the immediate warning announcement, it may be possible to reduce the intruder’s access to school occupants, and potentially prevent injuries and loss of life. It is a simple and elegant solution.


The second output is an evaluation framework tool for selecting communication and warning system technologies for use in K-12 schools. The new K-12 School HOT-Fit Evaluation Tool may be useful in helping school policy makers from state and local education agencies, and their emergency response partners, understand some of the factors to consider when making decisions about communication and warning system technologies for their schools.

The potential positive outcomes of using the new K-12 School HOT-Fit Evaluation Tool and the Conceptual Lockdown Notification System include three things. First, teams can make better decisions when selecting communication and warning systems, with the potential results of more informed and prudent financial expenditures. Next, a serendipitous effect of positively improving school climate may result by increasing confidence in the schools’ ability to keep students and staff safe. Finally, doing so may possibly even reduce or prevent injuries and loss of life during active shooter attacks on schools.
APPENDIX A. THREATS AND HAZARDS

This chart, adapted from the K-12 EOP Guide, shows examples of many of the threats and hazards for which schools may need to prepare. Threats and hazards fall into these general categories: natural hazards; adversarial, incidental, and human-caused threats; and technological and biological hazards. This list is not exhaustive, nor do all schools encounter all these threats, hazards, or emergencies.

Table 18. Examples of Threats and Hazards.

<table>
<thead>
<tr>
<th>EXAMPLES OF THREATS AND HAZARDS</th>
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</thead>
<tbody>
<tr>
<td><strong>Natural Hazards</strong></td>
</tr>
<tr>
<td>Cold Weather (severe)</td>
</tr>
<tr>
<td>Dust Storm</td>
</tr>
<tr>
<td>Earthquake</td>
</tr>
<tr>
<td>Flood</td>
</tr>
<tr>
<td>Heat Wave</td>
</tr>
<tr>
<td>Hurricane</td>
</tr>
<tr>
<td>Landslide/Mudslide</td>
</tr>
<tr>
<td>Lightning</td>
</tr>
<tr>
<td>Snow/Ice</td>
</tr>
<tr>
<td>Tornado</td>
</tr>
<tr>
<td>Tsunami - Distant</td>
</tr>
<tr>
<td>Tsunami - Local</td>
</tr>
<tr>
<td>Volcanic Eruption</td>
</tr>
<tr>
<td>Wildfire</td>
</tr>
<tr>
<td>Wind (severe)</td>
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<td></td>
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</tbody>
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303 Adapted from Office of Elementary and Secondary Education, Office of Safe and Healthy Students, 36.
APPENDIX B. K-12 SCHOOL HOT-FIT EVALUATION TOOL

K-12 School HOT-Fit Evaluation Tool Template
To evaluate communication & warning system technologies for use in K-12 schools

Name of Technology: __________________________ Evaluation Date: ________________
Evaluation Team: ______________________________________________________________________

Instructions: Establish an investigative team. Begin with the Foundation domain to establish goals. Proceed to evaluate Technologies to meet the goals. Anticipate the impact on Humans. Determine compatibility with the Organizations. Finally, analyze information in all domains to determine the Net Benefits and select a technology.

Domain #1: FOUNDATION
The foundational step in the technology evaluation process requires gaining a clear understanding of the need, the why for a new communication or warning capability. The Foundation domain is the starting place for the evaluation because it provides a focus for the evaluation of the subsequent domains. It includes identifying the Problem(s), articulating Purpose, recognizing Motivating factors, and defining Parameters. As decision-making teams work through the Foundation domain they will establish a clear basis and scope for a technology search.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
</table>
| A. Problem | i. Risk Assessment:  
|            | ii. Capabilities Assessment: |
| B. Purpose | i. Goals:  
|            | ii. Objectives: |
| C. Motivation | i. Internal Motivations:  
|              | ii. External Motivations: |
| D. Parameters | i. Priorities:  
|              | ii. Limitations:  
|              | iii. Scope: |
In the next step, teams will evaluate technological solutions to determine if the technology can solve the identified problems and meet the team’s stated goals. The second domain, Technology, requires a detailed analysis of the Information Quality, System Quality, and Service Quality dimensions of the technology against the criteria established in the Foundation domain. Working through the evaluative process in the Technology domain will help teams narrow the selection of communication and warning system technologies to those that have the capacity to meet their needs.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Information Quality</td>
<td>i. Activation Attributes:</td>
</tr>
<tr>
<td></td>
<td>• Type of Activation:</td>
</tr>
<tr>
<td></td>
<td>• Accessibility of Activation:</td>
</tr>
<tr>
<td></td>
<td>• Times &amp; Locations:</td>
</tr>
<tr>
<td></td>
<td>ii. Notification Attributes:</td>
</tr>
<tr>
<td></td>
<td>• Type of Notification:</td>
</tr>
<tr>
<td></td>
<td>• Reach of Notification:</td>
</tr>
<tr>
<td></td>
<td>• Speed of Notification</td>
</tr>
<tr>
<td></td>
<td>iii. Information Completeness:</td>
</tr>
<tr>
<td></td>
<td>• Message Content &amp; Accuracy:</td>
</tr>
<tr>
<td></td>
<td>• Message Length:</td>
</tr>
<tr>
<td></td>
<td>• Message Intelligibility</td>
</tr>
<tr>
<td>B. System Quality</td>
<td>i. System Mechanics:</td>
</tr>
<tr>
<td></td>
<td>• Operating Platform &amp; System Functionality</td>
</tr>
<tr>
<td></td>
<td>• Installation Requirements</td>
</tr>
<tr>
<td></td>
<td>ii. System Reliability:</td>
</tr>
<tr>
<td></td>
<td>• Redundancies</td>
</tr>
<tr>
<td></td>
<td>• Points of Failure</td>
</tr>
<tr>
<td></td>
<td>iii. Security Attributes:</td>
</tr>
<tr>
<td></td>
<td>• System Defense:</td>
</tr>
<tr>
<td></td>
<td>• Activation Protections:</td>
</tr>
<tr>
<td></td>
<td>iv. System Flexibility:</td>
</tr>
<tr>
<td></td>
<td>• Compatible:</td>
</tr>
<tr>
<td></td>
<td>• Customizable:</td>
</tr>
<tr>
<td></td>
<td>• Expandable/Scalable:</td>
</tr>
<tr>
<td>C. Service Quality</td>
<td>i. Lifespan:</td>
</tr>
<tr>
<td></td>
<td>• Replacement or Upgrade Intervals:</td>
</tr>
<tr>
<td></td>
<td>• Planned Obsolescence:</td>
</tr>
<tr>
<td></td>
<td>ii. Technical Support &amp; Maintenance:</td>
</tr>
<tr>
<td></td>
<td>• Internal Capacity &amp; Restrictions:</td>
</tr>
<tr>
<td></td>
<td>• External Capacity &amp; Restrictions:</td>
</tr>
</tbody>
</table>
In the Human domain, teams will assess, and to a certain extent, anticipate, how the technology interfaces with the people designated to use the warning systems. The Human domain comprises an evaluation related to System Use and User Satisfaction to inform the likelihood of the users’ acceptance of and ongoing implementation of the technology. A realistic assessment of the Human domain will help teams determine if the technology is a feasible and sustainable solution for those designated to use the system.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
</table>
| A. System Use | i. **Impact on Daily Routines:**  
  - Personnel  
  - School Flow  
  ii. **Parameters for Use:**  
    - Type of emergency:  
    - Activation Locations:  
    - Number of Users:  
  iii. **Perceived Support:**  
    - Management:  
    - Peers: |
| B. User Satisfaction | i. **Perceived Usefulness:**  
  - Need/Problem:  
  - Improves Existing Capability:  
  ii. **Ease-of-Use:**  
    - User Interface:  
    - Frequency of Use:  
    - Training:  
  iii. **Perceived Acceptability:**  
    - Culture & Climate:  
    - Psychologically & Socially: |
In the fourth domain, Organization, teams evaluate the technology in light of its compatibility with the organizations it is to serve. The focus is on the interaction between the warning system technology and the unique Structure and Environment of the school, school district, and their community partners’ organizational attributes. It places value on to what extent the leadership of the school and their community partners accept the warning system.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
</table>
| A. Structure | i. School Attributes:  
| | • Characteristics & Demographics:  
| | • Physical Configuration:  
| | • Personnel Capacity:  
| | • Existing Systems:  
| | • Acceptable to Leadership:  
| | ii. Community Partner Attributes:  
| | • Impact on Daily Operations/Personnel:  
| | • Existing Systems:  
| | • Response Capabilities & Philosophies:  
| | • Acceptable to Leadership:  
| B. Environment | i. Management & Ownership:  
| | • Internal:  
| | • External (Proprietary Limitations):  
| | ii. Financial Impact:  
| | • Initial Costs:  
| | • Ongoing Costs:  
| | • Funding Sources:  
| | iii. Aligns with Regulations:  
| | • Codes or Licensing:  
| | • Policies/Statutes/Laws:  
| | • Labor Relations:  
| | • Risk Management:  


Domain #5: NET BENEFITS

Net Benefits is the fifth and final domain in the K-12 School HOT-Fit Evaluation Tool and embodies the culmination of the investigative effort. The Net Benefits domain creates an evaluative feedback loop by revisiting findings from the prior four domains and analyzing them against the dimensions of effectiveness, feasibility, and sustainability. The Net Benefits emerge by uncovering to what extent the technology, used within the constraints of the unique school system, is effective to solve the identified problem, accomplish the established purpose, and is reliable both mechanically and operationally. It also ascertains the degree to which the technology is an operationally and financially feasible and sustainable solution for the school and its community partners.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Evaluation Variables &amp; Team Assessment Notes</th>
</tr>
</thead>
</table>
| A. Effective | i. **Solves Problem:**  
  ii. **Accomplishes Purpose:**  
  iii. **Reliable:** |
| B. Feasible & Sustainable | i. **Operationally:**  
  ii. **Financially:** |
| C. Notes & Findings | Use this area to record other concerns, limitations, opportunities, benefits, and findings related to the technology. |

Figure 21. K-12 School HOT-Fit Evaluation Tool Template.
LIST OF REFERENCES


INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center  
   Ft. Belvoir, Virginia

2. Dudley Knox Library  
   Naval Postgraduate School  
   Monterey, California