Mitigating Active Shooter Impact; Analysis for Policy Options Based on Agent/Computer Based Modeling

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Project Description

Active shooting violence at educational institutions is a phenomenon that poses serious security concerns about public safety due to the horrifying outcome and potentially large number of causalities and injured individuals stemming from such an event. US Department of Homeland Security has described the active shooter as an:

> "*..Individual actively engaged in killing or attempting to kill people in a confined and populated area; in most cases, active shooters use firearms(s) and there is no pattern or method to their selection of victims.*" [1]

In relation to school settings, active shooter incidents typically take place in densely populated areas within the school perimeter, such as a classroom, administration offices, or common areas like cafeterias, gymnasiums and libraries. These incidents are unpredictable, evolve quickly, and have a main goal of mass murdering, rather than other criminal conduct, such as robbery. In many cases, the perpetrator is equipped with multiple weapons and tries to accomplish his goal in the minimum amount of time. The shooter also typically does not have an escape plan, so he either commits suicide, surrenders, or is engaged by law enforcement or other responding individual[1]. As real life evidence to active shooting phenomena, Table 1 summarizes five incidents of active shootings at educational institutions that took place in the last five years[2, 3, 4, 5, 6].

In studying the effects of active shooter scenarios, the baseline for establishing a hypothesis is the analysis of empirical data from previous active shooter incidents. The common denominator associated with all events, regardless of reason or intent for shooter motives, or type of weapons used, was the location chosen and time expended between the beginning of the event and its culmination[2, 3, 4, 5, 6]. This in turn includes and directly correlates to the number of casualties incurred in any given event. The longer the event protracts, the more casualties are incurred until law enforcement or another barrier can react and culminate the situation.

Given the fact that active shooting incidents can have severe consequences to public safety and can result in significant causalities and injured individuals[2, 3, 4, 5, 6], this research project employed the use of computer based modeling to model and analyze four possible scenarios to address an active shooter in a public school setting to determine which scenario reduces the most casualties:

- Scenario 1 – This is a basic scenario where no access control or any type of security is employed within the school
- Scenario 2 – This scenario assumes that concealed carry individual(s) (5-10% of the work force) are present in the school
- Scenario 3 – This scenario assumes that the school has an assigned Resource Officer
- Scenario 4 – This scenario assumes that the school has an assigned Resource Officer and that there are concealed carry individual(s) (5-10% of work force) present in the school

The research methodology employs four varying scenarios that evaluate implemented barriers, observing their effectiveness on an active shooter event reaching a culminating point. These barriers, therefore, are directly correlated to the time (span of time) for which an event is allowed to exist before being diffused. The intervening time therefore correlates to the number of casualties expected to be

inflicted during the time of the event. Using four different examples, the model allows the injection of varying modes of blocks or barriers which can ultimately result in an event either ending sooner, or lasting longer until final resolution is accomplished. This process then answers the hypothesis: “Does a relationship exists between the number and types barriers injected into an active shooter scenario and numbers of casualties incurred?”

As a main analysis method, agent based simulation models are developed in order to assess the effectiveness of the employed security measures expressed with the number of causalities and injured individuals, and response time of the first responders (time to arrive on scene and time to engage with the shooter). These measurements of effectiveness were chosen since the historical data (including Table 1) indicate that time is the most compelling factor in determining casualty rates for active shooter events. Agent based modeling is chosen because it is the most suitable approach for accurate representation and tracking the actions of the entities involved in the active shooting incident, primarily the shooter, concealed carry individual(s), or the resource officers.

Further analysis of the proximity of the local police station to the modeled school, assumptions about the weapons used by an active shooter, and the movement pattern of the shooter within the school, allowed for identifying the possible security measures that could be employed in order to minimize the number of causalities during an active shooting incident. Another purpose of this analysis is to evaluate the model's ability to differentiate impacts between shelter-in-place and building evacuation during this type of incident.

(Insert Table 1)

Background

The specific nature of the active shooting incident requires reconsideration of security and school safety measures and polices. In this direction, there are several good practices[1, 7] that can be employed for coping with an active shooter situation. Department of Homeland Security recommendations relative to the active shooter response[1] include guidelines on how to respond when an active shooter is in the school perimeter (identifying evacuation, hiding, or active engagement actions with the shooter), training and preparing school staff for an active shooter situation (Emergency Action Plan and training exercises), recognizing potential workplace violence and managing the consequences of an active shooter situation. These recommendations are further impressed by MSA Security, an industry leader in security consulting and management, who suggest school representatives modernize existing engineering controls and coordinate with local authorities to allow them to become familiar with the school characteristics before an event occurs[7].

However, the outlined practices described by the Department of Homeland Security and MSA Security Consultants are developed to serve more to the potential victims of the active shooter incident and do not provide any recommendations about how responders shall enhance their methods for coping with such a situation. In order to provide practical guidelines for responders proactively engaging in active shootings at public schools, two necessary actions are required. First, the responders must have an overview of these incidents and the involved subjects and be able to assess threats based on historical and analytical data. The outcome of Dardsdale’s 2010 report[8] greatly contributes towards the overall active shooter threat assessment and can serve as a guideline in developing responders’ readiness. Second, responders must be able to identify the effectiveness of a particular active shooter engagement situation. Here, the analytical results from the modeling presented within this report can contribute to identifying and improving responders’ methods and actions which are necessary for minimizing the

casualties of active shooting and maximizing school safety. Therefore, of each of the applied four scenarios, it is the scenarios involving the employment of armed Resource Officers, faculty, or combinations thereof, who are immediately available to react to an active shooter, that have been studied least and makes these scenarios exceedingly viable. Further discussion and review of literature set forth below examines these two particular categories in depth and provides validation for their use as scenario conditions.

One of the given scenarios uses a limited number of concealed carry instructors (faculty or employees) for a given location. The justification for employing this as a rational option is set forth below. This option of introducing armed faculty is taken into consideration with both pro and anti-gun points of view, including objections to this option from organizations such as the Brady Campaign to prevent gun violence[9], which disavow arming teachers and faculty. However, from an analysis of the literature and practical point of view, the option of arming teachers and faculty remains credible with the researchers and therefore exists as a realistic option in the methodology. Empirical data validating why the introduction of firearms into the modeling scenarios is a viable option is set forth below.

In 2012 there were an estimated 1,214,462 violent crimes nationwide. This includes all violent crime, including those in which firearms were used. This represents a decrease of over 12.9% from the 2008 level, a 15.4% decrease from the 2011 to 2007 level, and a 15.5% decrease from the 2011 to 2002 level[10]. At the same time firearms ownership increased sharply, by over 61%, or over 118 million between 2004 and 2012[11]. Additionally, during the timeframe of 1999-2000, a full 58% of firearms related deaths were labeled as suicide, 38% as homicides and 3% ruled unintentional death by firearm[12].

The Department of Justice commissioned a study in 1997 titled, Guns in America: National Survey on Private Ownership and Use of Firearms. This study found the number of guns used in self-defense annually at over 1.5 million[13]. This number exceeded the number of crimes in which a gun was used to commit an act of violence. Additionally, since the tragic events at Sandy Hook School in 2012, a handful of states have sought to restrict firearms, but 21 states have concretely expanded their firearms laws, including many whose laws expanded opportunities for concealed carry holders to legally carry firearms in previously restricted locations, including seven states now in which teachers or faculty in some schools are armed[14]. Additionally, over 1300 pieces of legislation introduced nationwide since 2012 have pertained to gun laws, with the majority of which seek to strengthen pro-gun laws and gun rights[14]. These statistics indicate that a growing segment of educators, law enforcement personnel, and citizens are in favor of either introduction armed security into schools or arming teachers themselves.

The evidence of growing firearm popularity and growing strength in both numbers, statistics relating to crime and usage, and laws allowing their use create an undeniable data set that suggests that increased firearms ownership and access does not contribute to increased crime, anecdotally, it statistically results in a reduction[10]. As such, it remained as a valid option for analysis in the constructing of scenarios for this study. Additionally, "According to the National Center for Education Statistics, 57% of public schools in the United States had no security staff present at any time during the week in 2009-2010, the most recent year data were available. Even more — nearly 70% — had no police officer in the school every week[15]." This data further compels the researchers to explore if incorporating this option as a variable in the study could impact active shooter casualties.

Existing data on mass shooting events show overlying consistent themes such as location chosen and time available[2, 3, 4, 5, 6, 16, 17]. Most of the mass shooting events have occurred in locations such as schools, shopping malls, or other locations where people converge in masses[2, 3, 4, 5, 6, 16, 17]. Although primary data for this research sought recent (past five year period) data, additional data covering the most significant school shooting since 1966 was analyzed[16,17]. Analysis on these past events with regard to casualties, location, and time of response are consistent with the interpretation derived from the in-depth analysis of the five most recent; that being duration of event, location, and

ability for responders to act was critical in determining overall casualties. Almost all of these shootings occurred in locations that are typically outside the scope of where licensed concealed carry holders are permitted to carry weapons based on current laws[18]. A concealed carry law authorizes a citizen to lawfully possess a firearm on or near their person in a concealed manner, or manner in which the weapon is not readily visible from another. Examples are firearms kept in purses, in pockets, desk drawers or vehicles.

Observing the mass shootings in schools, the environment can be comparted to a "closed system" in which, despite the environment around it, the use, possession, or option of carrying a concealed weapon is prohibited. This can be compared to, with justification for employing this methodology for a scenario, larger environments, such as cities or even states. When looking specifically at "crime spillover", it becomes apparent how areas that allow for the carrying of concealed weapons have decreased rates of crime compared to those which do not[18]. Additionally, the data supports the conclusion that areas adjacent to those with concealed carry permits, and in turn do not authorize concealed carry themselves, have higher rates of crime as criminals migrate to areas without concealed carry in order to carry out criminal acts. This can be used in a microcosm view of schools or other likely targeted locations for mass shootings. If schools are off limits to the carrying of concealed weapons, then they therefore present themselves are a more lucrative target for mass shootings, just as cities who do not possess concealed carry laws see larger amounts of crime if adjacent cities do permit the carrying of concealed weapons.

Bronars and Lott's study[18] elaborates this phenomenon and employs the term, "geographic spillover". The authors study rates of crime over the timeframe of 1977 to 1992 across the demographic spectrum of age, race, sex, income, welfare, and population density. The dependent variables used are FBI uniform crime reports[10] for the categories of violent crime, murder, rape, robbery, aggravated assault, overall property crime, burglaries, auto thefts and larceny as reported per 100,000 population per county. These factors were observed against the independent variable of concealed carry laws and arrest rates. The stated objective was determining if shall-issue concealed weapons laws in one location alters crime in neighboring adjacent areas. The authors posit that, taken as a whole, concealed carry laws (particularly concealed handguns) do in fact deter criminals and that the greatest effect is seen when neighboring counties adopt concealed carry policies. Their study concludes that locations on both the county and state level are representative of the results noted. The authors further speculate that greatest overall crime reduction can be achieved if concealed carry laws are permitted universally.

For the study, a neighboring county was defined as another geographic location with a center within 50 miles of the studied county. To account for variations in arrests the study controls for violent or property crime arrests depending on whether the crime rates studied are related to violence or property crime. This mitigates the non-causal relationship between crime and arrest rates, as arrest rates are functions of crime. The study states that the effects of "spillover" on a county without a concealed carry when a neighboring county enacts a concealed carry law are substantial: an increase of 7.45% in rapes, 4.2% in robbery, and 4.5% in murder. These effects are insignificant if a neighboring county already has a concealed carry law in place. When comparing crime rates of the county itself when implementing carry laws, the rates of crime are reduced by an aggregate 34.16%. In all categories of crime except larceny, the rates of crime are reduced over a seven year period by the adoption of concealed carry laws. In studies where neighboring counties adopt concealed carry laws, and the host county already has concealed carry laws, the only perceived effects are positive, or a decrease in all crime, except larceny[18]. This therefore results in a significant increase in crime to areas without concealed carry laws when an

adjacent county implements such laws and no perceived increase in crime if the host country already possesses such laws when neighboring counties, in turn, enact such legislation.

The article concludes through multiple examples of crime rate statistics that criminals tend to migrate across areas with greater frequency when concealed carry laws are implemented. This migration has a greater effect as related to concealed carry than just increased arrest rates, meaning increased law enforcement techniques which lead to more arrests are still less effective at reducing crime than the deterrent effect of having concealed carry laws. This spillover effect of crime is noted as immediate and increased over time, with counties that implement such laws continually seeing a decrease in crime and counties that don't have concealed carry continually seeing a growth in crime. Taken as a whole, the projection is that aggregate crime reduction can be better achieved through the adoption of concealed carry laws in all states throughout the country[18].

Again, the examples shown demonstrate not only what the effects of concealed carry are on reducing crime in cities and states, but how adjacent cities and states who do not allow for concealed carry see increased rates of crime. This translates, for this study, to schools or other locations susceptible for mass shootings as these locations are comparative of "closed systems" in which crime is more likely to migrate to as there is no immediate deterrent.

As outlined before, one of the effectiveness measures within the analysis is the response time of the first responders. Regardless of the situation, the final determining factor in addressing mass shootings is bringing in police and medical support in a timely manner. As illustrated by the example[10], the "flash to bang" factor, or ability for police to arrive in comparison to the start of a shooting event, directly relates to the number of casualties inflicted. The study[19] is based on data spanning a five year period and covers 24 school shootings in 18 states, and 41 workplace shootings in 12 states. The average time in shooting events ranged from 3 to 4 minutes with an average victim being shot every 15 seconds. The fastest police response time noted in these events was 5 to 6 minutes, with most taking much longer. Here, the authors propose an armed responder, such as a resource officer or nearby law enforcement agent, as a best option for reducing the severe outcomes of an active shooter incident.

In an example at Red Lake High School[20], in Minneapolis, where a student killed five other students, a security guard, and a teacher, the response of law enforcement was critical. Within two minutes of the receiving the call, armed officers responded, headed toward the shooter and hit him twice with gunfire. This caused the shooter to retreat from his position and commit suicide, preventing further casualties. Overall the shooter's attack lasted for over 10 minutes, but the quick response by law enforcement ended the situation before further personnel were hurt.

Contrast this with situations such as the Virginia Tech School shooting in which the University's Police Department numbered over 35 officers, but the shooting events spanned a timeframe of over two hours. When the shooter initially killed two personnel, improper procedures allowed for the campus to remain unaware and the shooter was able to move undetected to another section of the campus and begin shooting again. Even though police were present in mass numbers, they were fixated on the initial shooting site and were unable to influence the second shooting site timely enough to prevent further casualties[21].

Multiple examples of active shooter incidents and the response time for law enforcement can conclusively deduce that the longer an event transpires, the more casualties will be incurred. Additionally, soft targets such as schools or other mass gatherings of people otherwise unable to defend

themselves make a more enticing target[22]. Additionally, the ability for first responders to arrive, organize, and begin addressing the issue almost always results in reacting to the damage already done.

The increased likelihood of active shooter events has proven that even in areas with robust police and military presence, the ability for active shooters to inflict mass damage quickly is not preventable with external law enforcement or responders that must be called to the scene[22]. This implies that readily available deterrents and responders, in the form of concealed carry personnel on scene have a greater ability to end an active shooter situation sooner than waiting for law enforcement to arrive. Much of this discussion focuses on select singular events. The situation becomes much more complicated when law enforcement officers are forced to deal with multiple shooters or multiple locations. As Frazzano, 2010 stated, "Though smaller jurisdictions might have special tactics law enforcement squads, those squads will not likely be able to deal with active shooter scenarios that include multiple shooters in multiple locations with their own-source resources. How, then, are these jurisdictions to protect their citizens when local capabilities and capacities are overwhelmed?"[23] (p. 2)

In a recent study, the National School Security Task Force[24] conducted an in-depth review of the National Status of School Security. The study examined the history of school violence and offered varying recommendations for decreasing violence in schools. The central point of the study referenced the efficacy of having an armed first responder, such as a School Resource Officer (SRO) present. In the study, the commission examined the effectiveness of a previous program sponsored in 1996 which provided federal funding for school districts to conduct security evaluations and receive SRO participation.

The program, sponsored by the U.S. Department of Justice was called COPS, Community Oriented Policing Services and included a 60 million dollar, three-year grant to provide increased security in the nation's school systems. Although expired, the program provided valuable benefits and statistically attributed to less crime during the timeframe in which it was implemented.

The study provided recommendations that included increasing the physical security of schools and mental/behavioral health counseling to prevent and detect problem areas; increasing security through either RSO or armed security of some form to include possible teacher/faculty arming. The overriding consensus is that decreasing response time to threats and increasing ability for armed opposition to engage an active shooter is the most important and effective method for reducing casualties[24].

Process Flow Chart

The process flow chart for Scenario 1 is given in Figure 1. Since this a basic scenario, the model will assume that no access control or any type of security is employed within the school. The active shooter is assumed to be well armed and able to enter the school and randomly chooses the victims in three potential areas: classrooms, common areas (cafeteria, library, gymnasium, etc…), or administration offices. He can further randomly choose to change location and continue shooting in other areas until he encounters a barrier (engaged by the law enforcement officers or commits suicide). Here, the response time and the number of casualties and injured individuals will depend on the timeframe in which the incident is reported and the response time of the law enforcement officers.

(Insert Figure 1)

The process flow chart for Scenario 2 is given in Figure 2. Here it is assumed that there is an armed school resource officer present. The active shooter is assumed to be well armed and able to enter

the school and randomly chooses the victims in three potential areas: classrooms, common areas (cafeteria, library, gymnasium, etc…), or administration offices. He can further randomly choose to change location and continue shooting in other areas. This scenario assumes that once the shooter begins his assault, the resource officer will act to mitigate the threat. Here, the response time and the number of casualties and injured individuals will depend on the timeframe in which the incident is reported and the response time of a barrier (the armed resource officer) can diffuse the situation, or confine it, until law enforcement arrives.

(Insert Figure 2)

The process flow chart for Scenario 3 is given in Figure 3. Here it is assumed that there are 5%-10% of employees (faculty and/or staff) exercising concealed carry. The active shooter is assumed to be well armed and able to enter the school and randomly chooses the victims in three potential areas: classrooms, common areas (cafeteria, library, gymnasium, etc…), or administration offices. He can further randomly choose to change location and continue shooting in other areas. This scenario assumes that staff and faculty with concealed carry will remain static in their respective locations and only respond in a defensive posture to the threat, i.e. teachers with concealed carry would stay in their classrooms and protect their students. Therefore their response is likely to be quantified through the data as less effective than a resource officer who maneuvers to the threat. Here, the response time and the number of casualties and injured individuals will depend on the timeframe in which the incident is reported and the response time of a barrier (those individuals with concealed carry) can diffuse the situation, or confine it, until law enforcement arrives.

(Insert Figure 3)

The process flow chart for Scenario 4 is given in Figure 4. Here it is assumed that there is an armed school resource officer present in addition to 5%-10% of employees (faculty and/or staff) exercising concealed carry. The active shooter is assumed to be well armed and able to enter the school and randomly chooses the victims in three potential areas: classrooms, common areas (cafeteria, library, gymnasium, etc…), or administration offices. He can further randomly choose to change location and continue shooting in other areas. This scenario assumes that once the shooter begins his assault, the resource officer will act to mitigate the threat by maneuvering to it, and those with concealed carry will safeguard and defend from their current locations, thereby resulting in quicker incident culmination and reduced casualties. Here the response time and the number of casualties and injured individuals will depend on the timeframe in which the incident is reported and the response time of a barrier (the armed resource officer/concealed carry personnel) can diffuse the situation, or confine it, until law enforcement arrives.

(Insert Figure 4)

AnyLogic Model

Agent-based modeling is defined as "a system is modeled as a collection of autonomous decision-making entities called agents. Agents may execute various behaviors appropriate for the system they represent"[25]. It is a form of computer simulation modeling that is becoming increasingly popular. Borshchev, Karpov, and Kharitonov are experts in modeling software called AnyLogic[26] and claim that AnyLogic is one of the best pieces of agent-based modeling software in the world. It is widely used in

industry and academia. AnyLogic not only provides agent-based modeling capabilities, but it also allows users to create discrete event and system dynamics models or even combinations of all three types.

Agent-based modeling was used to create the active shooter model in this research, and has many benefits. It “captures emergent phenomena”, “provides a natural description of a system”, and “is flexible”[25]. The agent-based modeling approach was chosen because it is the best technique for modeling human systems. It allows the user to create complex interactions between humans, deal with people in a limited amount of space, allows the population to be heterogeneous, allows the interactions to be complex, and allows agents to execute complex behavior[25]. All five of these attributes are required in the active shooter model.

Accurately creating a human agent-based model requires collecting the correct real-world data. However, a limitation to this stems from the model only allowing a person to perform the predefined actions that the user creates, and understanding that in reality humans possess free will[27.] This ultimately results in model scenarios that replicate reality when provided with correct real-world data to great efficacy, but never with total accuracy as the variable of free will remains undefined.

When the model is launched, the user is prompted with the model setup screen, shown in Figure 5.

(Insert Figure 5)

This screen allows the user to run the model with predefined inputs. The parameters to be determined are the probability that teachers may have concealed carry weapons in their respective classrooms and whether or not the school has an on-duty resource officer at the time of the incident. The time for law enforcement to arrive and casualty rate are based upon the literature events previously mentioned in the project description portion of this study. Once the parameters are set according to the user’s preference, the user can click the button labeled “Run the model and switch to Main view.” This will take the user to the Main view of the model and start the simulation.

Once the button is pressed, the Main view shows the floor plan of the school. The Main view is shown in Figure 6. The walls have been traced with polylines using AnyLogic’s presentation pallet. This serves as the environment for the agents to exist within.

(Insert Figure 6)

The active shooter appears at the front entrance of the school. If a resource officer is present, he appears outside the doors of the gymnasium. The location of the active shooter and resource officer start points can be changed using AnyLogic. The model runs in real time. Once it is completed, the results are shown at the top. The results include how long responders took to engage and stop the shooter, how many people were shot, and who the shooter was engaged by. An example of a result using the default model settings is shown in Figure 7.

(Insert Figure 7)

The model works in three parts of logic. The first part is the active shooter and concealed weapons carry logic, which is shown in Figure 8. The shooter enters through the front door of the school. He then decides, at random, between one of five locations to start shooting. The five choices are Class1,

Class2, Class3, Office, and Cafeteria. The shooter, based upon reviewed literature, stays in the location and shoots victims in 20-second intervals for two to five minutes before leaving and choosing another destination. This will continue until the shooter is engaged and stopped. Only one stopping mechanic is located within the active shooter logic. That is the chance that a teacher or a staff member has a concealed weapon in the room which the shooter enters. If there is a person in the room with a concealed weapon, the shooter is considered engaged, and the model is terminated.

(Insert Figure 8)

The second part of logic is the resource officer logic, which is shown in Figure 9. The resource officer spawns at the predefined resource officer start point, which is currently the gymnasium door. He then moves to a ready position in the hallway. Next, he is dispatched with the location of the shooter inside the school. He moves to the location where the shooter was, unless the shooter has left the room. If the shooter is still present, the resource officer engages the shooter and stops him. If the shooter has already left, the resource officer stops and waits for the next location of the shooter. He then repeats the process until he is able to engage the shooter.

(Insert Figure 9)

The third and final part of the model logic is the police logic, which is shown in Figure 10. It works exactly like the resource officer logic with three exceptions. First, it passes multiple agents through the logic (10 as of the time of this study). Second, the police enter through the front door of the school. Third, police arrive several minutes after the shooting has already begun (5-20 minutes later as of the time of this study). This is controlled using the discrete event framework shown in Figure 11. The police officers start at the police station, or wherever they happen to be located at the time of the incident, and travel to the school. Once at the school, they enter through the front doors and engage the shooter exactly as the resource officer would.

(Insert Figures 10 & 11)

Results

Figures 12-17 show the results of all 50 runs for each of the proposed scenarios. Each graph shows the number of casualties that occurred and the amount of time that passed between the shooter entering the school and the time the shooter was stopped. A trendline is also present on each graph showing a correlation between the number of casualties and the time to engage the shooter.

(Insert Figures 12-17)

Discussion

A compiled set of results is shown in Figure 18. These results include the average time to engage and the average number of casualties calculated by the model in 50 runs of each scenario. As each model run is random and independent, the scenario was run 50 times to ensure adequate sample size would result in credible results. Scenarios 3 and 4 were split into two sub-categories, one with 5% concealed carry and one with 10% concealed carry respectively.

(Insert Figure 18)

As seen in Figure 18, the number of casualties in all other scenarios is less than that of the basic scenario. The comparison between having a resource officer and having teachers and staff with concealed weapons shows that a resource officer is able to decrease casualties and response time more effectively due to the resource officer being able to maneuver towards the threat while the teachers and staff remain static. The effectiveness is most improved, however, when both a resource officer and concealed carry personnel are present. Not surprisingly, increasing the percentage of concealed carry personnel improved the response time and decreased the number of casualties.

Since the basic scenario showed the highest number of casualties, the other scenarios should all be considered successful in minimizing the negative effect of active shooter phenomena. Having a resource officer on duty reduced casualties by 66.4% and response time by 59.5%. Having 5% of personnel carry a concealed weapon reduced casualties by 6.8% and response time by 5.4%. Increasing the percentage of personnel with concealed carry to 10% reduced casualties by a total of 23.2% and response time by 16.8%. Combining 5% concealed carry personnel with a resource officer reduced casualties by 69.9% and response time by 59.7%. The final and most successful scenario of 10% concealed carry personnel with a resource officer reduced casualties by 70.2% and response time by 62.7%.

The relationship between time to engage and number of casualties for each scenario is shown in Figures 12-17. The trend lines confirm that, for each scenario, a longer response time has a positive correlation with number of casualties.

Conclusion

The results of the study show that to decrease the number of casualties, the response time must be reduced. The model data shows that the most efficient way to reduce response time is to have armed personnel present at the school who can engage the active shooter before the police arrive. The effectiveness of this method can be optimized by having both armed resource officers and armed teachers or staff members with concealed weapons with which they can engage the shooter if he enters their room. The results of this data can therefore be interpreted as when teachers and faculty serve as a static deterrent or by not maneuvering on a shooter but rather just responding defensively, then the greater the number of teachers or faculty armed, therefore result in a greater number of reduced casualties.

Teachers and staff who choose to carry concealed weapons would need to be fully trained and would likely be required to pass examinations to ensure that they are well-suited to carry concealed weapons on school property. These examinations would likely be required multiple times throughout their career. Very strict rules on where the weapons would have to be located would be needed. School administrators would need to be willing to accept the liability of having weapons present in their schools.

Controversy exists over whether non-law enforcement personnel should be able to react to an active shooter situation. Additional training of both law enforcement and concealed carry personnel would be required to determine at what point self-defense measures transition to law enforcement roles. Through additional training concealed carry personnel could maneuver towards active threats instead of just sheltering in place. This, in conjunction with resource officers, would likely result in even fewer casualties. However, considerations of friendly fire and liability issues preclude modeling this scenario at this time as it assumes policy decisions. The results of the study show an improvement to both response time and decreased number of casualties when responders are able to maneuver towards the threat. Further research on the cost/benefit ratio of this topic should be done to determine whether the reduction of casualties can be, or is, of value based on the training, casualties to students, and concealed carry. Another area of future research would be to expand the model to recreate and analyze a historical event

to determine how concealed carry personnel and resource officers or law enforcement could have mitigated the threat.

Lastly, it is the intent of the authors that rational discourse on the aforementioned topic will be sought and reasonable alternatives to safeguard innocents from violence will be considered in the making of policy decisions. A product of the research of active shootings in schools, and violence in general, is the discussion of violence amongst youths. Fowler, 2009 conducted a study revealing that 50 to 96 percent of youth in urban environments are exposed to episodes of violence ranging from being a victim, to witnessing or knowing first hand someone has been exposed to violent episodes. Over time, youth exposed to violence increases the likelihood they will become victims of psychological disorders, such as PTSD or insecurity. Fowler states these combined factors contribute to rising violence, especially among young persons who are desensitized to violence and are therefore more prone to reacting with violence themselves[28].

Gil Kerlikowske, a staunch anti-gun advocate, concedes that addressing the issue of violence in society by singling out guns alone will have little value. He reveals that starling levels of violence are being identified in children, particularly those from fractured families or large urban settings[29]. As these studies illustrate, there seems to be the distinct possibility of drawing a correlation to the rising violence rate among youth, urbanization, and moral decay. This might also be substantiated as we look at the historical context of the situation; firearms have been an intimate and substantial element of American lifestyle since prior to the inception of the constitution, but it is only within the relative recent past that we associate increased violence with access to guns. Therefore, this might suggest respective of firearms being present, that changing culture, specifically that associated with urban development and changing demographics, are more likely causal factors and indicators of violence, than firearms themselves. Even in studies that control for social and economic factors, the results indicate that gun control does not reduce violence or crime[30]. This suggests that despite best intentions and alternative efforts, the need to arm school teachers or faculty for the defense of their students should not be dismissed on face value simply because of the initial contemporary cultural aversion to firearms.

This data should compel us to look closely at the changing societal norms that seemingly produce more young people with contempt for authority and less regard for life as a causal factor for many of the incidents discussed in this report.

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Table 1. Active shooting incidents at educational institutions that took place in the last 5 years

Active Shooter Incidents					
Location	**Virginia Tech[2]**	**Northern Illinois University[3]**	**Chardon High School[4]**	**Oikos University [5]**	**Sandy Hook Elementary School[6]**
Date	7:15 am – 9:51 am, April, 16, 2007	3:05 pm -3:11 pm February 14, 2008	Approximately 7:30 am , February 27, 2012	Approximately 10:30 am, April 2, 2012	9:35 am – 9:49 am, December 14, 2012
Target	Students and faculty	Students and faculty	School students	Stuff and random students	Students and staff
Shooter Profile	23-year-old Seung-Hui Cho, a South Korean citizen - diagnosed with a severe anxiety disorder	Steven Phillip Kazmierczak - mental illness	Thomas M. Lane, III - arrested short time later in a location outside the school	One L. Goh -angry at the administration after being expelled from the university; Surrendered after siege	Adam Lanza - diagnosed with Asperger syndrome
Number of causalities	33 (including the perpetrator)	6 (including the perpetrator)	3	7	27 (including perpetrator)
Number of injured	23 (17 by gunfire)	21 (17 from gunfire)	3	3	2
Type of weapons	Glock 19, Walther P22	12 gauge Remington Sportsman 48 shotgun; 9 mm; Glock 19 semiautomatic pistol; 9mm Kurz Sig Sauer P232 semiautomatic pistol; .380 Hi-Point CF380 semiautomatic pistol;	Ruger MK III .22 caliber semi-automatic handgun	.45-caliber handgun with 10-round magazines	223-caliber Bushmaster XM15-E2S rifle, a 10mm Glock handgun and a 9mm SIG Sauer P226 handgun
First responder actions	Police arrived within three minutes of receiving an emergency call but took about five minutes to enter the barricaded building	Campus police on scene within two minutes of shooting, neutralized threat within five min	The police arrived quickly and arrested the shooter outside of the school (teacher was chasing the perpetrator)	n/a	Police arrive six minutes after shooting began

Disclaimer: Described work and the respective results given in this project report do not refer to any particular incident or specific school location

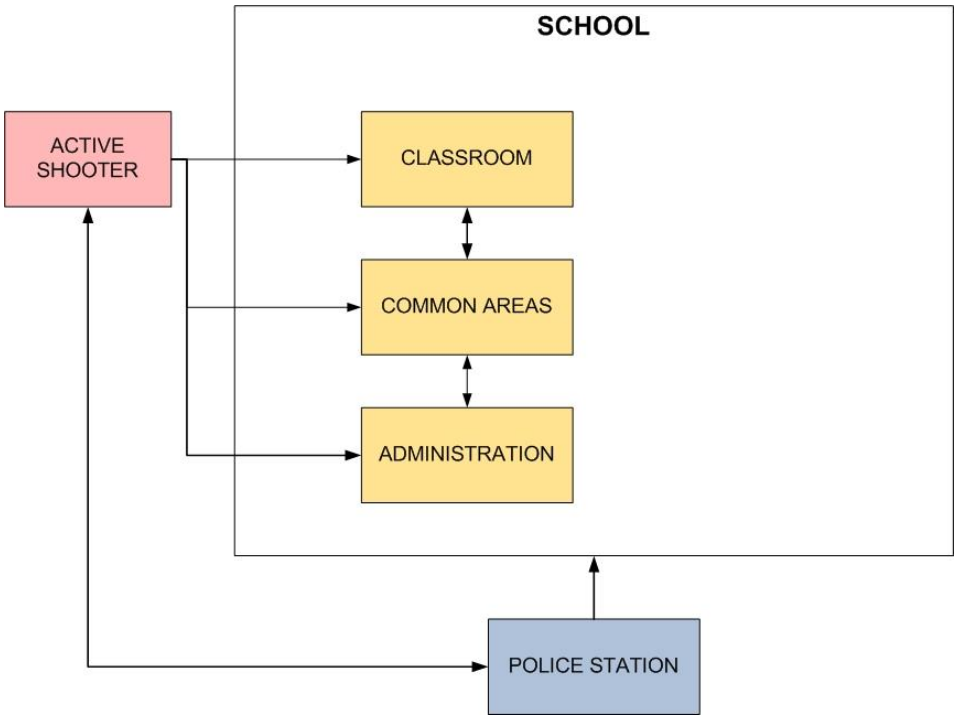

Figure 1. Basic scenario of active shooting incident in a school

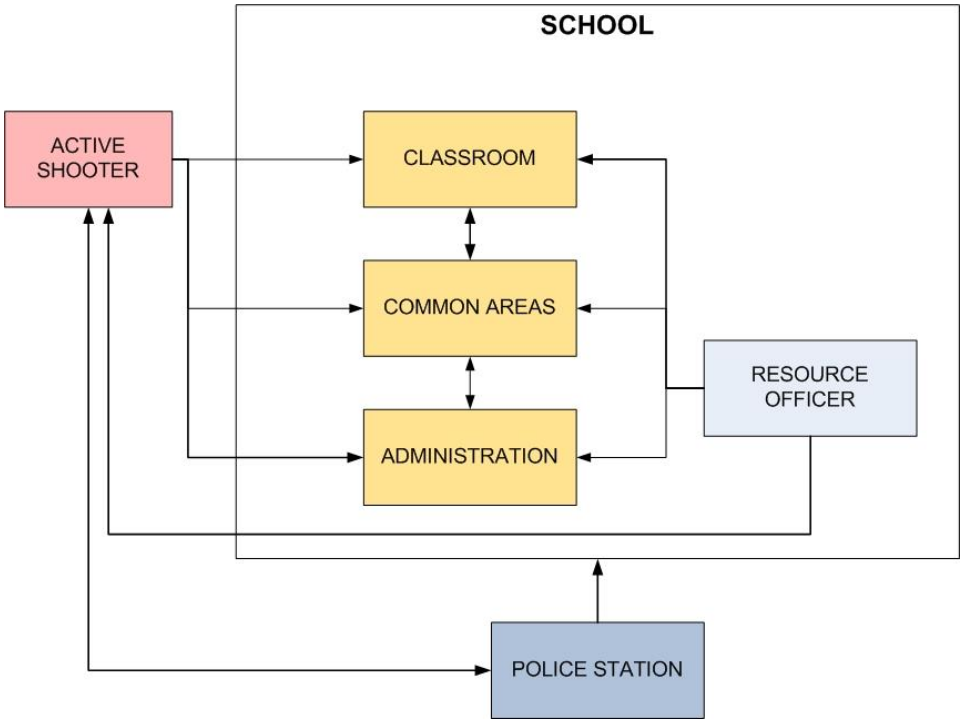

Figure 2. Active shooting incident in a school with resource officer.

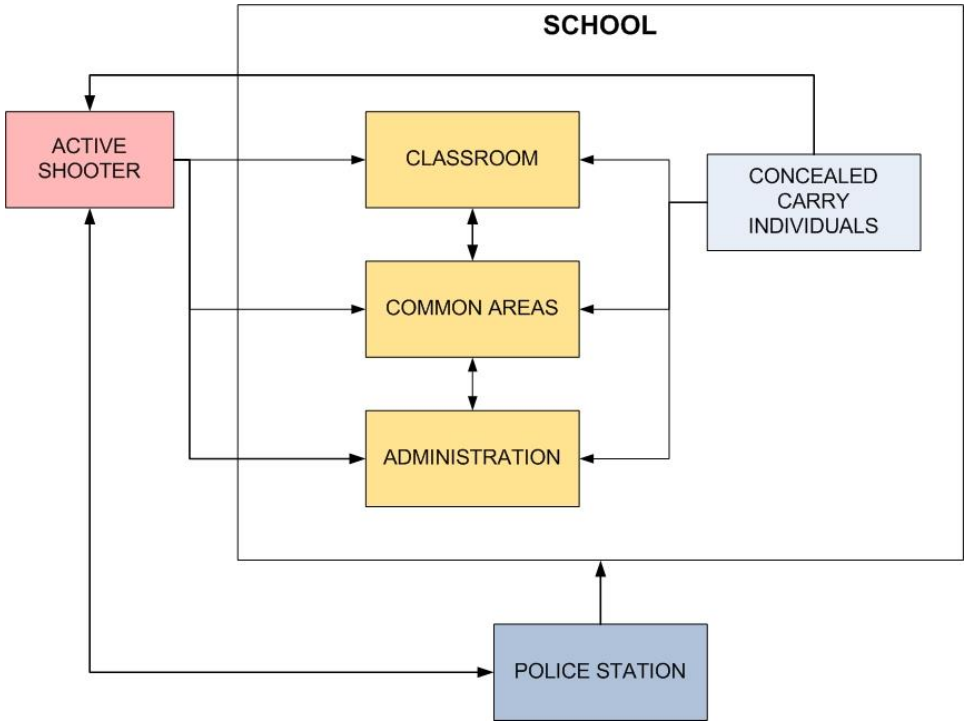

Figure 3. Active shooting incident in a school with 5% - 10% concealed carry individuals

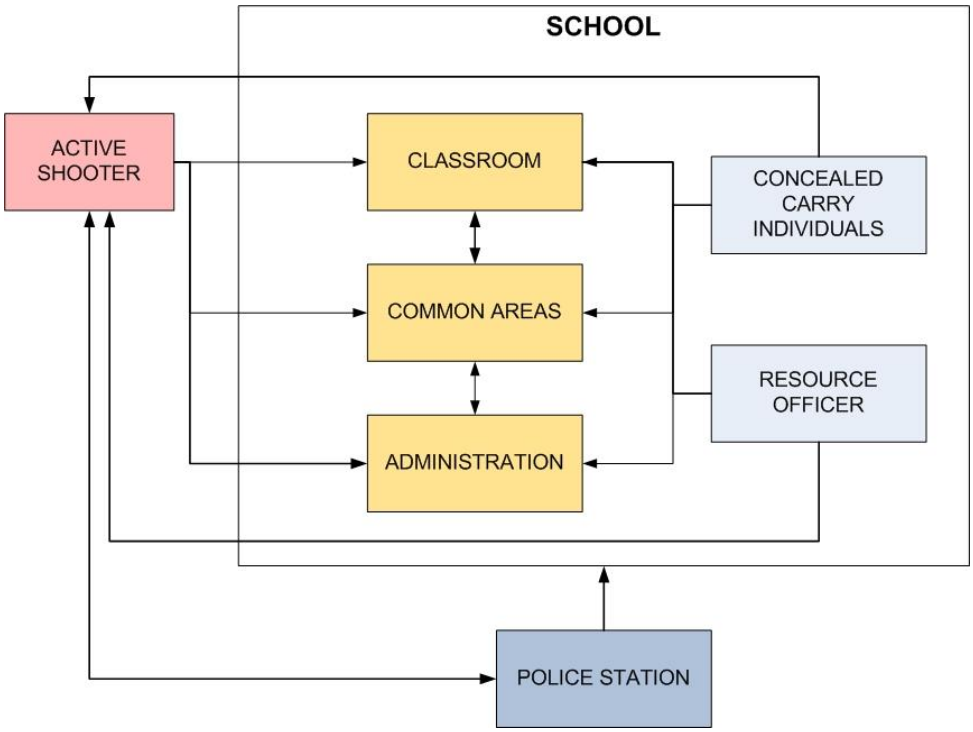

Figure 4. Active shooting incident in a school with 5% - 10% concealed carry and armed resource officer.

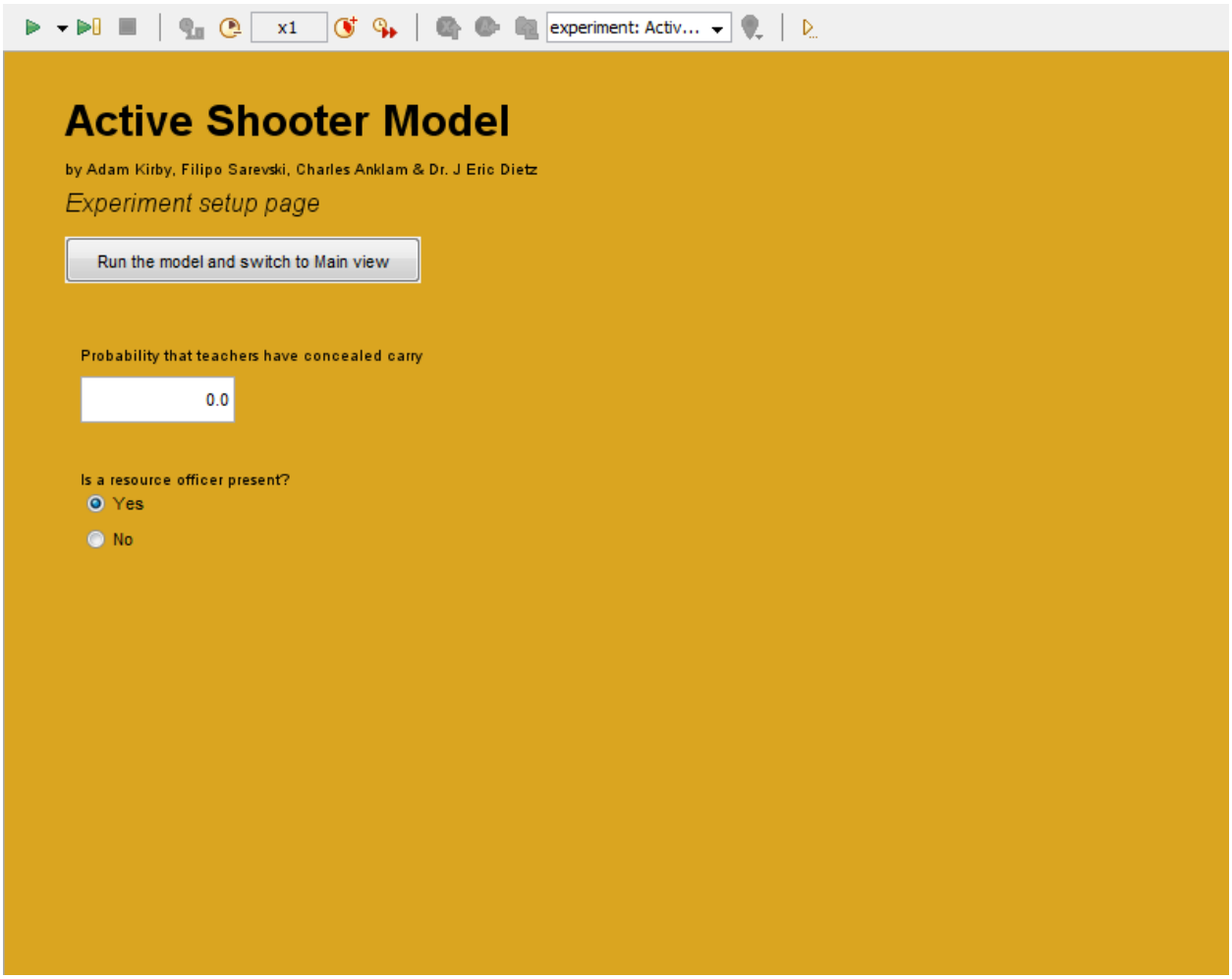

Figure 5. Model setup screen

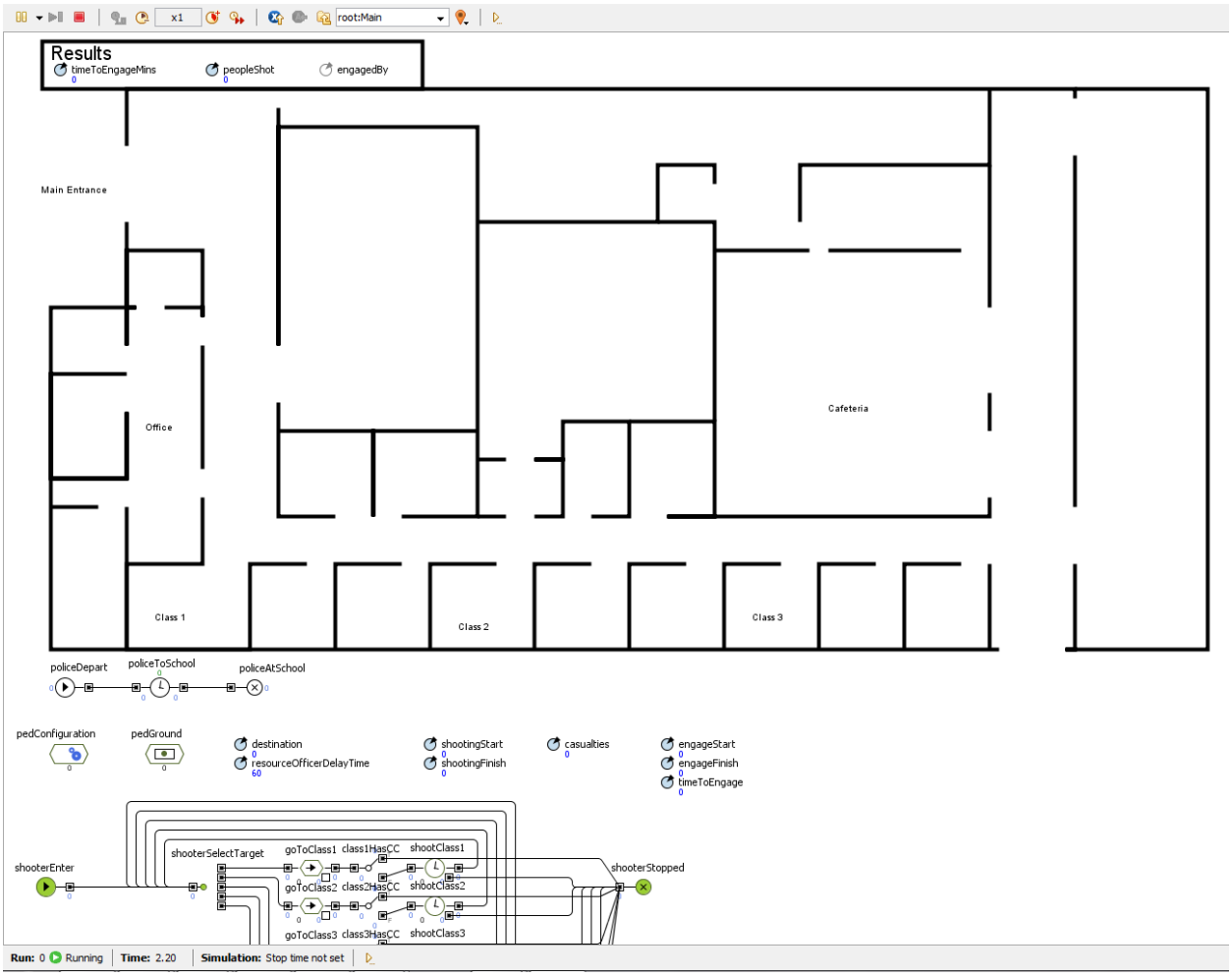

Figure 6. Main view

Figure 7. Results displayed

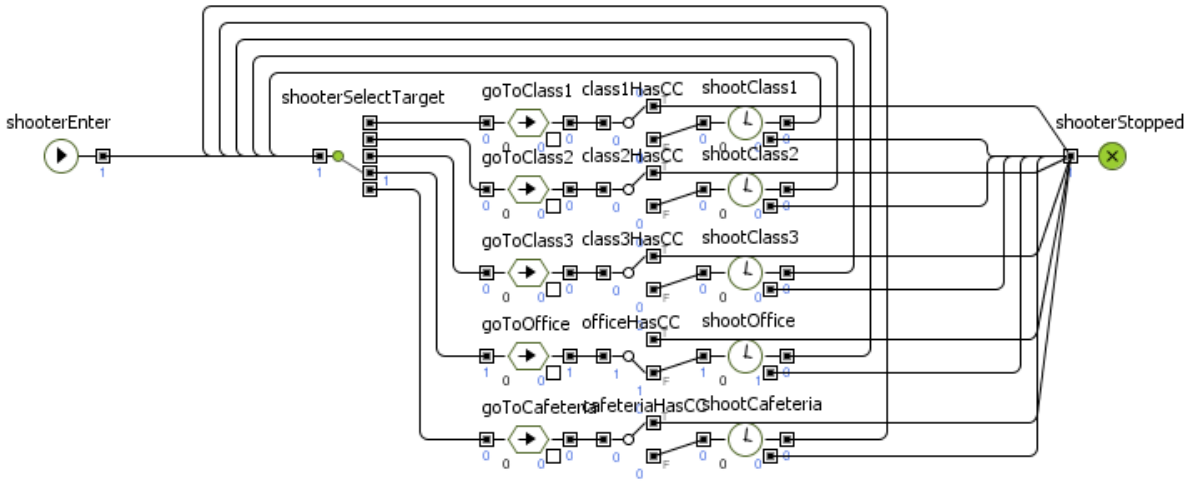

Figure 8. Shooter and Concealed Weapons Carry logic

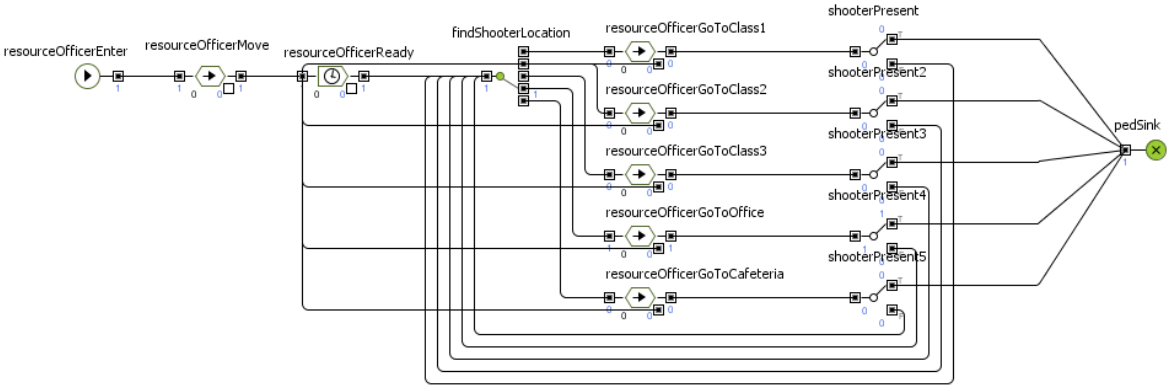

Figure 9. Resource officer logic

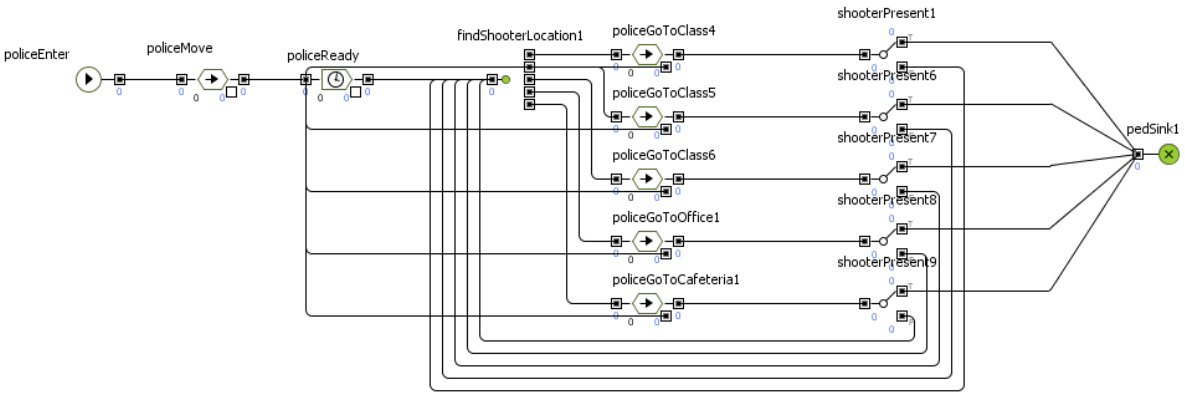

Figure 10. Police logic

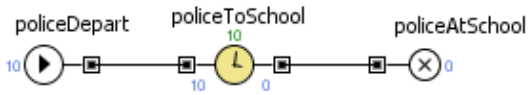

Figure 11. Police travel logic

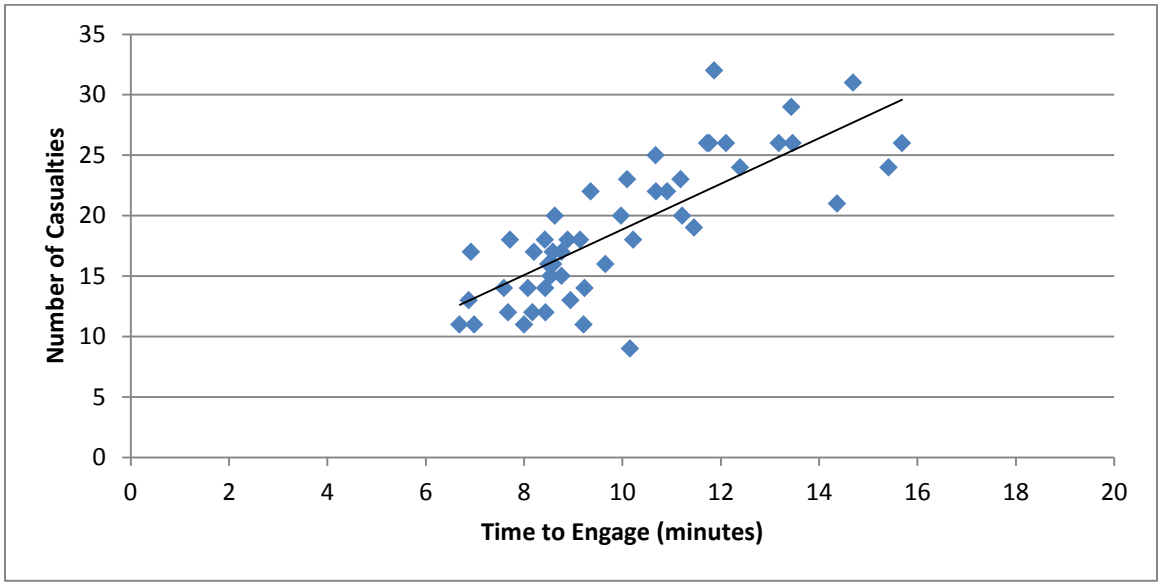

Figure 12. Basic scenario

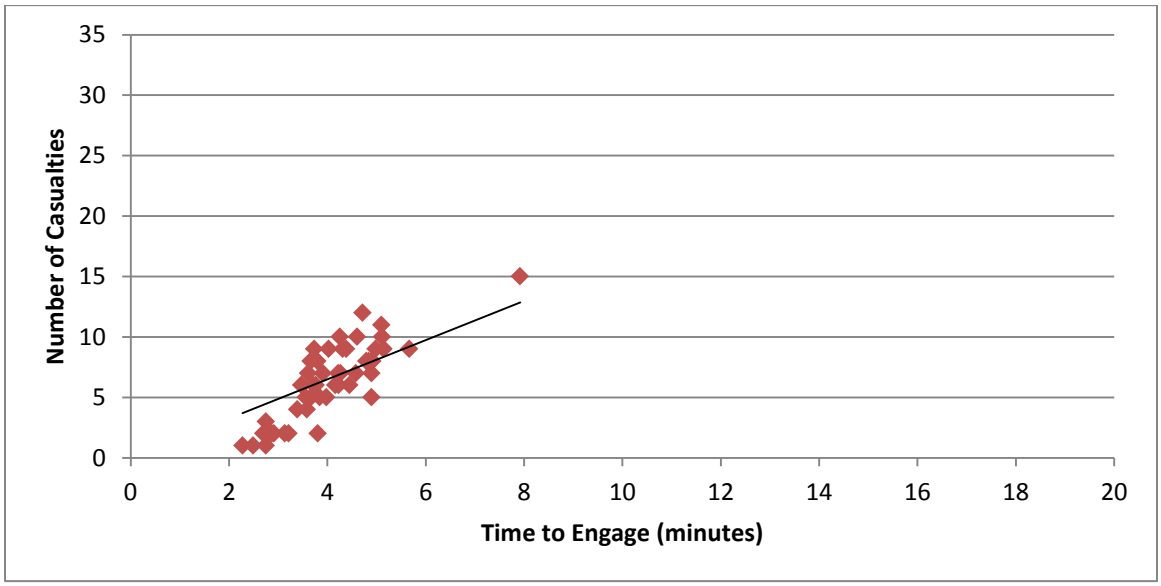

Figure 13. Resource officer

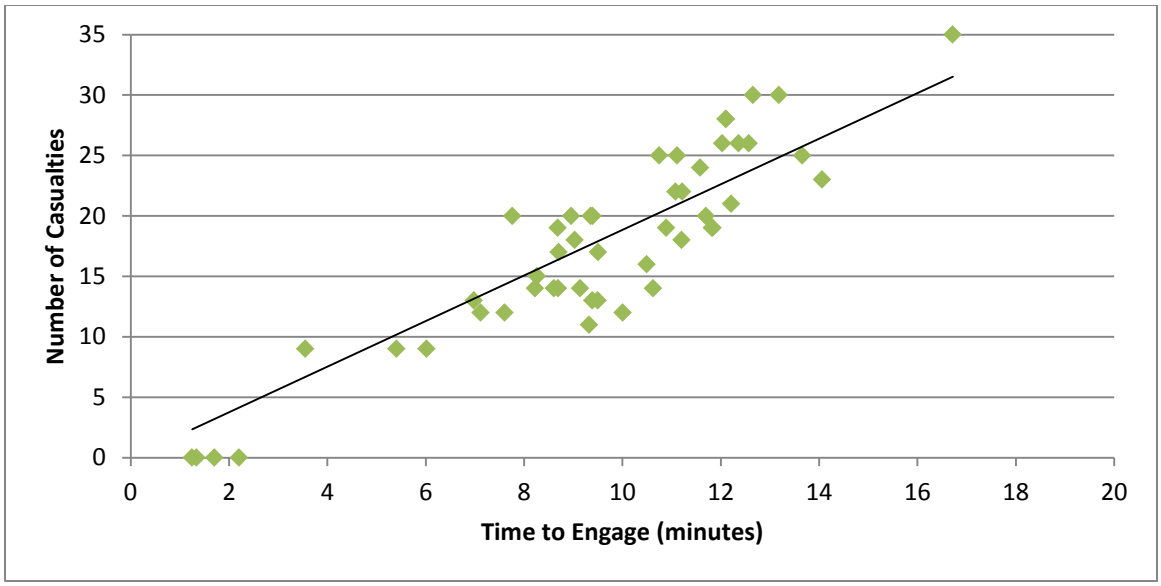

Figure 14. 5% CCW

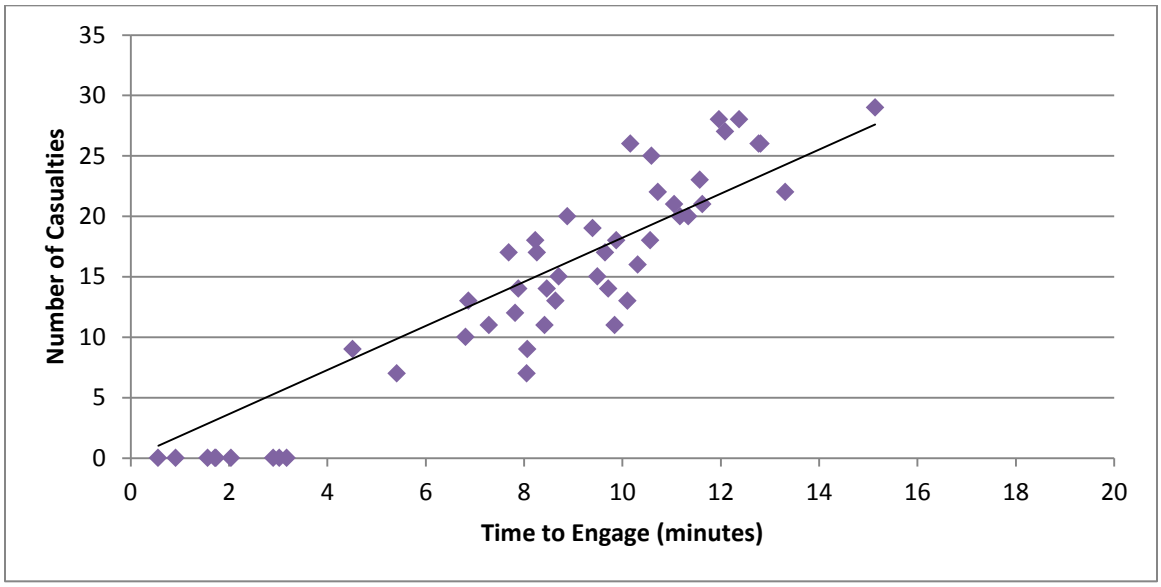

Figure 15. 10% CCW

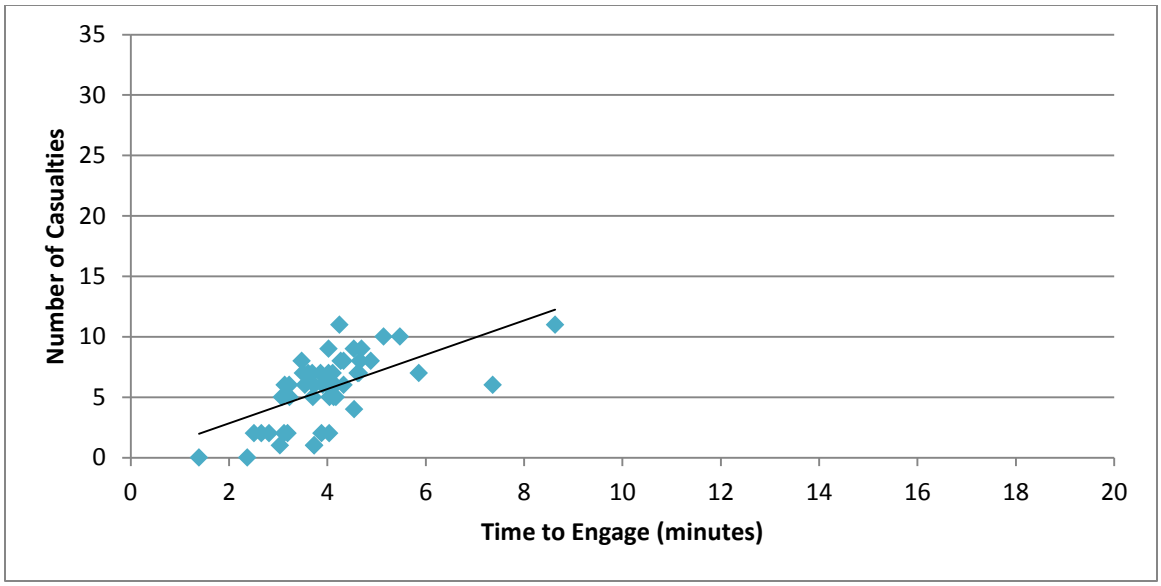

Figure 16. 5% CCW + resource officer

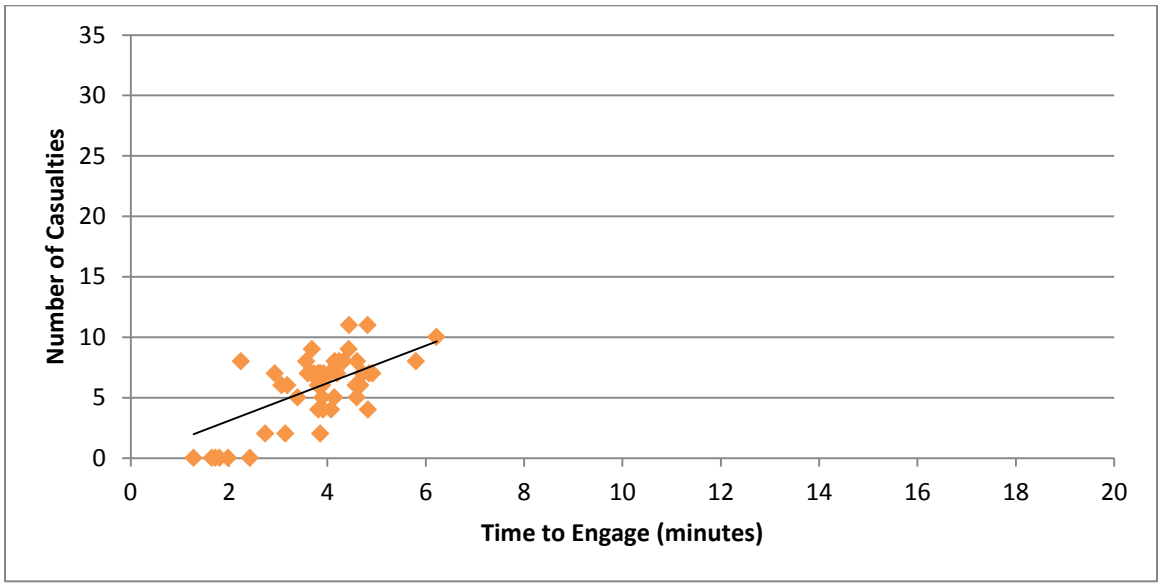

Figure 17. 10% CCW + resource officer

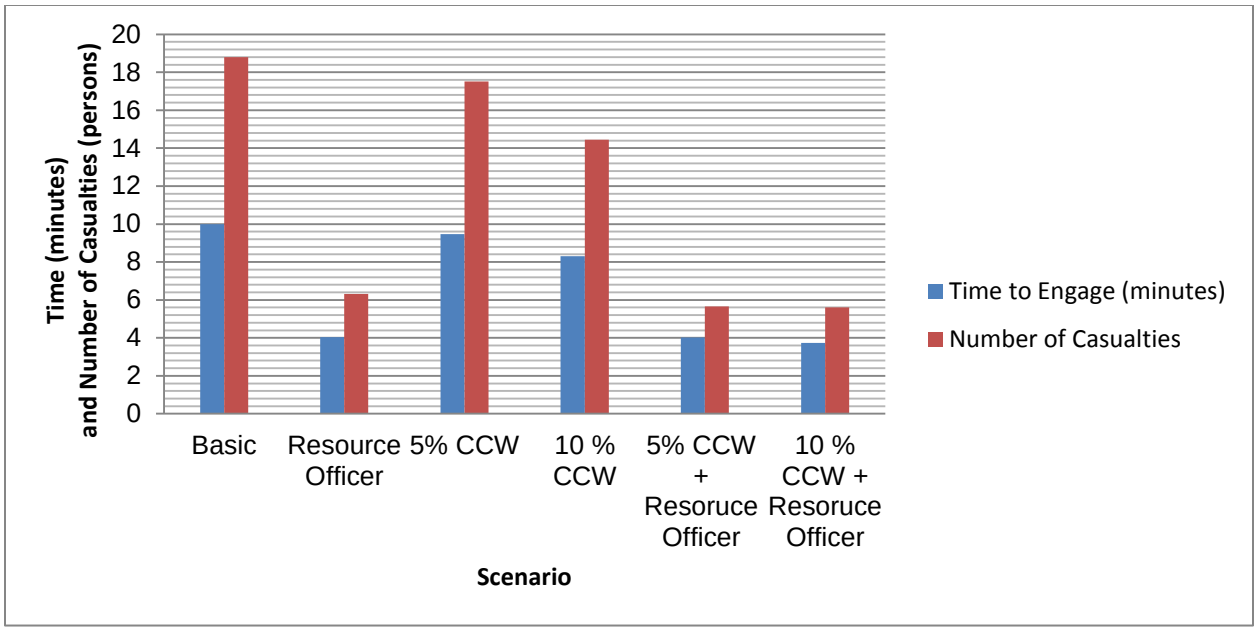

Figure 18. Compiled results