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The War on Terrorism and What We Can Learn from our War with Fire

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Abstract

The highly leveraged, asymmetric attacks of September 11th have launched the nation on a vast "War on Terrorism". Now that our vulnerabilities and the enemies' objectives and determination have been demonstrated, we find ourselves rapidly immersed in a huge, complex problem that is virtually devoid of true understanding while being swamped with resources and proposed technologies for solutions. How do we win this war? How do we make sure that we are making the proper investments? What things or freedoms or rights do we have to give up to win? Where do we even start? In analyzing this problem, many similarities to mankind's battle with uncontrolled fire and the threat it presented to society were noted. Major fires throughout history have destroyed whole cities and caused massive loss of life and property. Solutions were devised that have gradually, over several hundred years, reduced this threat to a level that allows us to co-exist with the threat of fire by applying constant vigilance and investments in fire protection, but without living in constant fear and dread from fire. We have created a multi-pronged approach to fire protection that involves both government and individuals in the prevention, mitigation, and response to fires. Fire protection has become a virtually unnoticed constant in our daily lives; we will have to do the same for terrorism. This paper discusses the history of fire protection and draws analogies to our War on Terrorism. We have, as a society, tackled and successfully conquered a problem as big as terrorism. From this battle, we can learn and take comfort.

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Introduction

The United States woke up on the morning of September 12, 2001 to a changed world, a world where our beliefs about our safety and our vulnerability to external attack were shaken to the core. This event is often compared to the surprise attack on Pearl Harbor, to the sudden realization that we were threatened and that major changes in our view of the world were required. It is easy to trace evidence of this change throughout subsequent history with much of our Cold War response coming from this fear of surprise attack. It is true that it usually requires horrific events to cause significant changes in our lives and social institutions, and that both 9/11 and Pearl Harbor were such events. But we would argue that Pearl Harbor required a basically military response and that another major battle that humanity has fought successfully, namely the struggle to control fire, is a much more useful analogy for us to use as we seek guidance in this war on terrorism.[1] In this discussion, let us attempt to take you back to earlier times, fifty, a hundred, two hundred years ago, to a time when the fear of fire dominated men's lives, when small mistakes became conflagrations that destroyed whole cities, when fate seemed to control who lived and who died by fire. Imagine the leaders of these times, struggling to protect life and property with no tools or knowledge or guidance from history. Try to imagine living in these times, being required to make changes in *your* life and *your* choices and how *your* money was spent just to try and solve a problem that seemed insurmountable. But we, as a society, have prevailed, having pushed the threat of fire into the background of our consciousness, having accepted and integrated fire protection into our everyday lives, still watchful, but not fearful. We can learn much from our war on fire; and because of it, if we will learn from history, we can wage this war of terrorism with increased confidence and precision.[2]

The threat of terrorism is new, frightening, real, immense. It is ill defined. It is a threat to the very existence to the American way of life. Unlike fire, which has no motives beyond executing the laws of physics, terrorism has a purpose: to make everyone feel threatened everywhere and all the time, to use fear to destroy or manipulate. We will

[1] Note that this analogy is one of both process (how we solved the problem), and products (technologies used to solve the problem). While there are many examples of fire protection products (such as smoke detectors) that would have a direct counterpart to the war on terrorism (in this case, a biological agent detector), in many cases the important lessons relate to how we eventually arrived at an acceptable solution (see Appendix B for further discussion of this point).

[2] The war on terrorism is a war about terror and dread. Dread is defined as: "great fear especially in the face of impending evil" (Webster). Dread is caused by a sense of a loss of personal control (this is being forced on me, and I don't know what to do), by a strong feeling of relevance (this is something that could happen to me), by a lack of knowledge about the event (what's going on? what should I do? how do I protect myself?), and by the creation of a visual picture of the event affecting you (I've seen pictures of this happening to others!). The actual probability that you may be harmed seems to be a less important factor in creating this sense of dread in most people. We must recognize and deal with these very real issues in fighting this war. Success in winning this war is when very few terrorist events are accomplished, and those that do occur have limited impact, everyone knows what happened, what to do, and that the perpetrators will be found and punished. This knowledge will finally start to restore our sense of safety and control and reverse the sense that the Archbishop of Canterbury, George Carey expressed during the 2002 New Year, that people around the world feel "weak and pretty powerless."

only feel safe again when we have dealt with the threat. But what approach should we use? How should we tackle a problem of this magnitude? As recently as a couple of hundred years ago, finding ways to reduce the fire threat must have seemed an untenable problem to mankind, with no clear paths to a solution (see references 1-13). Civilization needed to utilize fire to survive and prosper, so living with the constant threat of death and destruction by fire seemed inevitable. How could people be made safe without giving up the benefits of using fire? The threat from fire was ever present and major. Given our current experience with fires (over 1.7 million fires in the U.S. in 1998) and historical records, we see that uncontrolled fires are a common occurrence in all cities throughout history. Fire watches and bucket brigades represented some of the initial attempts to deal with this problem, and they helped reduce the risk of death and perhaps limit the destruction to some degree. However, as cities grew in unstructured ways, the potential for uncontrolled, massive fires would grow until a large firestorm would eventually be triggered. Many cities had designated teams to pull down or destroy building with explosives to halt the spread of fires. The problem was truly immense. Whole cities were built with wood, on narrow streets with closely spaced buildings. Water was scarce, communications difficult, and public money was limited. Every house and business had fire-based lighting, heating and cooking sources built by people with limited knowledge and widely varying skills. And to top it off, we knew little about the science of fire; the actual causes of ignition and its behavior when ignited. People were scared, and civic leaders had little to offer in the way of solutions. But we prevailed, and hence we would propose **lesson #1**: *Ultra-scale terrorism, while a new event on American soil, is not unlike the threat posed by fire and can be solved with similar system approaches*.

It was recognized early on that a single point attack would not be successful in reducing the fire risk; hence, beginning with the great fire of London in 1666, a multi-point attack started to develop, involving programs to both improve fire fighting resources and create building codes to reduce the fire ignition and fire spread rate. Like fire, terrorism will also require a multi-point response. Just as we could not reduce the fire risk by focusing on a single element (such as better fire fighting teams), we will not be able to provide safety from terrorism unless we plan to both interdict as many terror schemes as possible while preparing for and creating an infrastructure that reduces the impact and improves our response to any events that do occur. So how did we handle the war on fire? Building on the experiences with protecting themselves with fire brigades (for a couple of thousand years, probably with some success) and on the experience with rules about fire ignition sources (starting with the Normans about 1000 A.D.), the London city leaders, after the great fire, undertook to rebuild the city with plans for:

- Regulating both construction of buildings and the street width
- Improving firefighting equipment
- Improving water supplies
- Spreading the individual risk of loss

They rebuilt the city center using fireproof material (stone), which was possible in great part because the country was (at that time) the richest in the world. The British also formed the first fire insurance companies in 1680 to spread the risk of loss and to facilitate rapid recovery after a fire. Soon these insurance companies formed their own organized fire brigades to fight "their" fires and to salvage contents from buildings

insured by their company. Since the fire brigades needed to know which buildings were theirs, they took to marking the buildings with emblems from their insurance companies. These *fire marks* can still be seen on the fronts of some buildings in London. The city layout was also redesigned with most homes being rebuilt in the outlying areas of the city, thereby separating the residential and business sections of the city.

Unfortunately, as history demonstrates, not all cities in the United States adopted the lessons learned from the London fire. Ben Franklin helped found the volunteer Union Fire Company in 1736 and formed the first insurance company in the U.S. in 1752. Building codes were adopted by many cities, but these were not uniformly enforced and variances were easily obtained, often as political favors. As an example, Chicago had passed significant building codes and formed fire departments both prior to and after the great fire of 1871, but it took another large fire three year later and subsequent pressure from insurance companies to get major building reforms passed and rigorously enforced. Was this because America wasn't yet rich, or did we see building codes as government interference with choice, or was it simple political pressure and personal greed? In all cases, it has always taken a multi-point approach, attacking both city design and fire fighting infrastructure, to make progress on reducing the risk from fire. Sincere but incomplete efforts simply failed.

For our response to terrorism, we are starting to see signs of a similar response. Table 1 shows a partial mapping of our existing system for fire protection and how it relates to a system for terrorism protection. Note the close similarity of elements that leads to **lesson #2:** *the same multi-point, system approach that worked for fire protection will provide valuable guidance in dealing with terrorism. The key elements of this response are prevention, response, recovery, deterrence, and research.*

System element	Fire Protection	Terrorism Protection
Prevention	• Education • Building codes; Inspections • Fire resistant systems	• Education, Foreign Policy • Material and border control • Intelligence with pre-emptive actions • Robust infrastructure
Response	• Education, training and practice • Effective Alarms and Communications • Professional response system	• Education, training and practice • Effective warnings and Communications • Professional response system
Recovery	• FEMA • Clean-up equipment • Victim treatments • Social structure and support	• FEMA • Clean-up technologies • Victim treatments • Social structure and support
Deterrence	• Strong arson laws • "Sting" operations • Effective forensics • "Assured" enforcement of laws and punishment	• Strong anti-terrorism laws • International cooperation and intelligence • "Assured" retribution
Research	• Fire academies • Threat analysis • Detection and response system based on understanding	• Terrorism academies • Continual threat analysis • Detection and response system based on understanding

Table 1. Example comparisons of our system response to fire and a proposed system response to terrorism.

Prevention

Prevention is the holy grail of our terrorism protection plan just as prevention is the key to our fire protection plan. Our current terrorism response has focused primarily on retribution, on finding and stopping those responsible for the 9/11 attacks and those planning future related attacks. The key concepts of prevention are 1) the removal of the root causes that serve as the initiating rational for the terrorist action (or for societal indifference to the existence of terrorist cells within the community), and 2) the interruption of planned events before they can be executed against American targets. The first of these is focused on affecting the terrorists' (or their support structure's) view of the United States such that they no longer desire or support illegal actions against us. Foreign policy, foreign aid, history, and even American attitudes as experienced through visits or the media all influence this perception. The second aspect of Prevention has to do with activities such as effective intelligence (learning about planned events through communication intercepts or human intelligence) and the control of the flow of goods and people into our country across borders along with "choke point" control (note that this includes entry into areas such as airplane cockpits, airports, and stadiums) and all its associated challenges. A complete and continual review of our infrastructure to identify

and protect key capabilities such as our supply of clean water, food, electricity, and commerce is essential. Prevention is only achievable if the event you are trying to stop is difficult to accomplish. A reasonably high degree of difficulty combined with effective intelligence and law enforcement can prevent many events. Money is another necessary asset that can be targeted for preventive action. The key to prevention is the successful *anticipation or discovery* of the targets and methods that would likely be used for an attack. This is also the most difficult challenge. It is in the area of prevention that the greatest debates about infringement of civil rights are generated. How much freedom do we have to give up to be safe? Can we learn anything from our approach to fire prevention?

In finding concrete, effective solutions in the battle against fire, old, accepted ways of doing things had to change. Individuals were rightfully worried about the cure being worse than the problem. Records of heated debates and protests over proposed solutions during the rebuilding of Chicago following the great fire of 1871 show how difficult these issues can be. Chicagoans had to deal with the fire threat by making decisions about money:

- For public fire fighting resources: how many fire fighters, fire stations, and how much expensive equipment?
- For fire fighting infrastructure: how much for water storage and distribution, training facilities, and communication systems?
- For personal insurance: what and how much do I personally insure?

It required decisions about civil freedoms:

- Control of ones property – the right of society to specify, inspect, and even deny the use of personal property (even today there are continual complaints about the cost and infringements required by building codes)
- Dealing with accusations of discrimination by those unable to afford the cost of meeting fire regulations (Chicago had major protests after the great fire over new building codes, with some saying that these building codes were discriminatory and priced the poor out of the housing market).

It required decisions about personal responsibility:

- How much personal responsibility do I assume and how much time do I spend in prevention efforts?
- How much of my time is spent in personal education on how to respond to fires?
- Should I keep fire-fighting equipment? Should I volunteer to watch for or fight fires?

In the same vein, we are entering a time of difficult discussions and decisions about how we will respond to the terrorism threat. Decisions about money:

- How much to spend on law enforcement and intelligence?
- How much to spend on improved response and detection?
- How much to spend on infrastructure hardening?

Decisions about civil freedoms:

- How much intrusion (if any) will be allowed into our personal lives to help us possibly catch terrorists before they act?

- How much infringement (if any) will we allow of basic judicial processes for those suspected of involvement in terrorism to make us feel safer?

Decisions about personal responsibility:

- What responsibilities will we accept for observing and reporting suspicious events?
- What responsibility will we accept for learning how to respond to terrorist events?

Pretending that things can stay the same will not work. We will never be able to return to the pre-September 11 world. Assuming that we have to give up *everything* to feel safe again is also not wise. What we need is a focused, thoughtful discussion of these critical issues and the willingness to constantly reevaluate our assumptions and actions, learning as we go. We need strong national action, for, unlike fire, terrorism prevention is primarily a federal government role and not centered directly on the individual.

As a last point, one of the difficulties that we face with our battle against fire (and with all preventive programs) is measuring the progress that we make. Where should we be investing our money? Did that program work, or should we have done something else? Measuring our success in fire protection is the challenge of trying to measure what did not happen. We know, for example, that the number of deaths by fire in both absolute numbers and in deaths per thousand have declined over the past forty years, from about 12,000 per year in the 1960's to about 4,000 per year in the 1990's. Most of this decline can probably be attributed to the introduction of smoke detectors in private homes. But what about all the other fire efforts? How many lives did we save by building the new fire station in the town last year? By investing in fire research? By running the fire safety program in the schools? The fact is that we have not effectively solved this issue for fire protection, and efforts to improve and validate the investments in fire protection are underway. We need to tackle this issue early in our War on Terrorism. Huge requests for money to protect against terrorism are being proposed and granted. Determining how to effectively and efficiently allocate our limited resources will be a major challenge in this war. We must provide resources and guidance on how we will measure what does not happen. It is difficult to make intelligent pubic policy decisions without an understanding of the impact of decisions on the thing we are trying to affect.

Response

While prevention of future acts of terrorism is the hope, reality and experience indicate that we will experience more major acts of terrorism on U.S. soil. Terrorism is and will always be a patient and persistent threat. It is perceived by its adherents as an effective and acceptable means of creating the atmosphere to achieve their desired goals. It seems to operate from a belief-driven system (14) that is willing to "morph" itself to achieve these goals. It has a regenerative source of disenfranchised, violent followers that can and will keep testing the system, accepting frequent failures to achieve infrequent results. We will never succeed in making everyone like us, no matter what we do or how noble our motives. We can try to reduce the source of hatred by avoiding ignorant or selfish policies and by working to improve the human condition in the underdeveloped world, but fundamental differences in societal philosophies, religious conflicts, and racial intolerance will persist. So what course can we take? Do we try to create safety by

closing our borders and eliminating freedoms? Can we survive another attack? How did we get to the place of living in comfort with the threat of fire without giving up the value that fire provides?

The first point from this analogy, which is absolutely crucial, is that we still have fires and people still die from fires! Despite our concerted efforts and huge expenditures, fires are still a major problem, but we seem to have found a way to live successfully in an uneasy truce with the fire threat. The Chicago fire department, on the week preceding the great fire, successfully put out 20 major fires. One could say that they successfully put out over 95% of the fires that week, but that would not be very comforting. Even with all our current building code requirements and extensive public education, there are still currently over 1.7 million fires per year in the United States (11) with an annual property loss of $8.6 billion, in spite of the approximately $100 billion that we spend annually on fire protection, response and recovery. Why is this? Simply put, fire is persistent. With literally billions of potential ignition sources, the often seemingly random coincidence of events required to create the conditions to start an uncontrolled fire still occur with alarming frequency. And we still have fires intentionally set for profit or thrill. We will never completely "win" this battle by preventing all uncontrolled fires. As long as we utilize fire and combustible materials in our lives, we will have the threat of fire, so we create and maintain extensive systems to respond to fires that occur. Some of these systems are passive and operate without activation such as fire retardant construction materials, fire breaks, fire doors that slow the spread of fires, and making sure that buildings have multiple escape routes to avoid being trapped by fire and smoke. Other systems are active and include smoke detectors, required fire drills, sprinkler systems, alarm systems, emergency communication systems, fire hydrants, and professional fire fighting units with expensive, specialized equipment. While no one plans on a fire, when they occur we are ready to respond to minimize the loss of life and property.

So how can we accomplish this state of readiness for terrorism? Many of the same types of systems that we have developed for fire response will work for terrorism events, and in many other cases new terrorism systems can build on the existing fire-response infrastructure. For example, we need to develop alarm systems that detect chemical, biological, and nuclear agents early to allow for successful escape or mitigation of effects. This will require new sensors and buildings (or cities) with smart infrastructures and can take appropriate actions. Individuals and institutions need to train and practice how to respond to these alarms to reduce exposure to the toxic agent or event. Our first responders need the tools and training to be able to rapidly identify the nature of the event, treat victims, protect property, and preserve evidence, all while protecting both the public and themselves from further harm. We need to develop and improve our basic infrastructure to make them more robust against terrorist events. New buildings need to be designed from conception to resist attack, protecting both themselves and their occupants from harm as much as possible. If buildings fail, they should fail slowly and in such a manner as to allow successful escape. High-profile existing buildings should be modified to make a successful attack more difficult. Our medical system should have the capacity and resources to successfully treat a biological attack. And finally, effective public education as to the extent of the danger is essential. We most fear what we do not understand; and while the threat is grave, the public needs access to authoritative

information as rapidly as possible. We do not have an excessive fear of fire because we know that we have a sophisticated response system in place. We can and should create the same system for terrorism. We may not be able to stop every terrorist, but we can take away the much of the public's fear through an effective education and response system.

Recovery

The third and final piece of the puzzle to reducing the dread of terrorism is to have in place an effective recovery system. The system should instill the knowledge that if one is a victim of a terrorist event, services and resources will be available to assist in restoring one's well-being as quickly and to the fullest extent possible. We have in place significant recovery services for fire disasters. Immediately after removal from the fire, injured individuals receive specialized treatment for burns and smoke inhalation. Both social service and government organizations offer temporary housing and living assistance, and insurance is widely available to assist in the replacement of personal property. Specific counseling techniques have been developed to help those affected by fires to deal with the trauma of the event and the loss of loved ones and treasured belongings. One can easily find cleaning and recovery services for fire-damaged goods in the phone directory. In general, the processes for recovery from a damaging fire are well developed, and while ordinarily invisible, are easily engaged when needed.

One can observe many of these same elements coming into play after terrorism events of the past few years (such as Oklahoma City and 9/11). The same social and government services that serve victims of fire have demonstrated exceptional service to recent victims of terrorism. The major difference lies in the scale of the events: most fires of recent history are confined to dozens of fatalities due to our successful efforts in prevention and response. We must be prepared for future terrorist events to cause hundreds or thousands of casualties (at least until we have instigated effective prevention measures for terrorism). Insurance coverage for terrorism incidents needs to be better defined and the role of government in providing payments for loss of life or damages needs to be specified prior to the emotional period following catastrophic events. Specific treatments for victims of terrorism (i.e., chemical and biological agents) need to be further developed and made widely available within our health care system. Better technologies and standards for cleanup and restoration of areas to useful service, such as the decontamination foam developed at Sandia National Laboratories, need to be developed and deployed.

In summary, we have reduced the dread from fire by 1) having a strong and pre-emptive prevention program, by 2) having a response program based on distributed technologies to provide early warning, a robust infrastructure to slow the spread of the incipient fire, planned escape routes, and a professional fire-fighting force, and 3) by having an effective support system to assist in rapid recovery from the effects of the fire. But fires have a dark human element; about twenty percent of fires are set intentionally by humans and many other destructive fires are facilitated by the willful illegal acts of building owners. Deterrence is required in these cases.

Deterrence

While the goal of deterrence is to prevent the event from occurring, the method is quite different from prevention in that deterrence is aimed at those individuals who would otherwise engage in the illegal act if not for the existence of an effective deterrence. Our experience with fire falls into two broad categories, namely those who intentionally set fires (arsonists) and those who bypass laws and rules designed to reduce the fire risk in the name of profit or convenience. To this end, we have in place strong laws dealing with arson that include significant penalties if convicted. To assist this process, fire departments receive training in arson detection and specialized forensics dealing with arson have been developed. In addition, law enforcement monitors the *street* and runs sting operations to detect arson schemes. In similar veins, fire inspectors trace fire histories and identify any contributing code violations and pursue prosecution of those responsible. Stiff civil and criminal penalties exist for willful disregard of safety.

For terrorism, a similar well-publicized deterrence scheme is required. Strong anti-terrorism laws must be in place, we must have effective intelligence methods to identify terrorists and anticipate their activities, we must use the best forensics available to identify and track the perpetrators after the event, and international cooperation must exist such that anyone or any organization that carries out or supports a terrorist event will be identified and punished. We need to develop methods and intelligence to find and stop those responsible for preparing or carrying out terrorist acts while avoiding civilian casualties. We need agreements and methods to trace financial resources so that we can destroy the ability of the sponsoring organization to exist. We must make it known that any organization or nation that supports terrorism is running a high risk of discovery and destruction.

Research

One of the most critical lessons to learn from the fire story is that the threat is not, and will never be, static. We should fully expect that those interested in harming us through terrorism will be able to adapt their techniques and strategies in response to our protective actions. In our history with fire, much of the progress that had been achieved in dealing with the fire threat was pretty much eliminated as we entered the industrial age, where now both the sources of ignition and the means to mitigate the threat changed dramatically. This required (and still requires) an ongoing analysis coupled with research and development to stay ahead of the threat. One example is the introduction of gas heating. While this had a beneficial effect of reducing the uncontrolled ignition sources from fireplaces and coal furnaces, it required a reanalysis of the fire threat created by new problems such as the buildup of explosive quantities of gas from the pilot light blowing out and the failure of pipelines by aging or construction accidents. The electrification of cities created another new set of fire problems. While eliminating the threat from candles, electrical circuits and appliances now represented a whole new class of ignition sources. Existing building codes, building techniques, and fire fighting techniques have had to continually adapt to these new threats. The construction of high-rise buildings created another new challenge in both building design and fire fighting techniques. And more recently the prevalence of plastic materials created new dangers in the toxic smoke produced during a fire. On the response side, our ability to respond also changed

dramatically as we moved into the industrial age, with technology advances leading to major improvements in fire fighting machines (such as steam-driven fire pumps, fire hoses, fire nozzles, fire engines), central fire alarms, advanced communication systems, and building sprinkler systems. Today, we have personal, affordable smoke detectors, personal fire extinguishers, sophisticated fire fighting equipment, and so on. The fight to control our risk from fire is a continual battle between new technologies and devices creating new fire threats and new technologies and fire protection strategies reducing the threat.

Like fire, terrorism is not and will never be a static threat. Terrorists have proven that they are intelligent and resourceful and will constantly adjust their techniques to achieve their goals. We should anticipate that they will work on ways to use our defensive responses to their acts to create new threats. The only effective response is to realize this fact and plan on creating, from the beginning, a dynamic system that can constantly re-evaluate and update both the threat and our vulnerabilities and respond accordingly. This will require not only continually analyzing the means and methods that they could employ to harm us, but also the social and cultural factors that provide motivation and rewards. We need to learn how to "think like the terrorist" and create permanent "red teams" to continually challenge our preparedness. It will not be enough to simply study group behaviors, but it will require extensive attempts to analyze and model behavior of the extreme elements of societies that plan and conduct terrorism. Better intelligence, better understanding of motive and means, better understanding of our vulnerabilities are all key elements of winning this war without the repeating disastrous mistakes made with fire. Examples of current activities that deal with this problem are extensive efforts to identify infrastructure vulnerabilities (i.e., can a single terrorist event damage or destroy connected facilities such as electrical generators or transmission devices, or can a single event cause widespread economic disruption through inter-connected systems with cascading failures) and efforts to understand and predict future terrorist behaviors. Continual and formal research and analysis is the key to staying ahead of the threat.

A formal interdisciplinary research and development program which includes both the physical and social sciences is a key element. The most rapid advances in dealing with the threat of fire started when we began to undertake a science-based, systemic view of the threat. In addition to the basic physics and chemistry of fire, understanding and dealing with the human aspect of the fire threat was also a major factor (people will still do dumb things and start fires if given the opportunity[3]). The first step in this process required understanding the enemy, in this case, uncontrolled fire. Fire science identified the three elements required for a fire to burn, namely energy, fuel, and oxygen. Put these elements together in proper proportions, and you will get fire. Do it outside of a controlled environment, and you will get an uncontrolled fire, limited in scope only by the availability of one of more of these elements. Note that, as was said before, fire behavior is driven by physics. And it's the same physics that leads to "good" fires and "bad" fires! A combustible molecule combining with oxygen to release energy doesn't care if it is inside a boiler performing work or destroying your home. The physics and chemistry of fire is neutral. As we began to really understand the science of fire and the

[3] It is often said in the fire protection business that the three leading causes of fires are men, women, and children. (1)

behavior of people, intelligent, well-conceived building codes and city designs were developed, and major advances in the design of fire fighting equipment occurred.

As we moved to a science-based fire protection model, the multi-prong approach that had been slowly evolving over the years suddenly became more focused and effective in attacking all three elements causing uncontrolled fires, allowing us to identify the basic chemistry and thus create fire suppression techniques based on interfering with the chemical reaction of a fire. Examples include electrical codes (to avoid overheated electrical circuits) and personal training to attack the energy element (Don't play with matches; Don't smoke in bed). Building codes also attack the fuel element by requiring the use of fire-retardant construction materials such as sheetrock, and specifying the minimum separation between buildings. Building codes also attack the oxygen component by specifying firebreaks in walls, fire doors in public buildings, and sprinkler systems. Finally, science-based understanding has improved personal and professional response to uncontrolled fires through the design of fire escapes and exit doors, personal education and preparation, smoke detectors for early warning, and air packs and efficient nozzles for fire fighters. We, as a nation, fund national fire research centers that continue the study of fire protection techniques, fire fighting techniques and equipment, and the evolving fire threat. Numerous local and regional fire-training centers provide advanced, state-of-the-art training to fire fighting professionals. Building codes are periodically updated based on our evolving best understanding of the fire threat.

We can create an analogous three elements required for terrorism to occur. For a terrorist to succeed, the event requires a motive (with an advocate), resources, and opportunity. Motive is often supplied by an ideology or a perception of injustice with no perceived avenue of recourse, and is usually created in recruits by a charismatic leader (14). Resources include recruits willing to carry out the act, items for the act, means to position for the attack, a communication/control system, and money. Opportunity represents both the ability for the terrorist to cause real harm and the impact of the actual event on public perception of harm (does the event create fear and dread). Interrupt one or more of these elements, and the terror event will not be successful. Note that while the behavior of fire is driven by fundamental physics, terrorism is often driven by an ideology. The holding of an ideology is not wrong, and we (especially in the U.S.) highly value a diversity of beliefs and draw benefit from diversity. The unacceptable action is to use an ideology as a justification for violence and illegal actions against innocents.

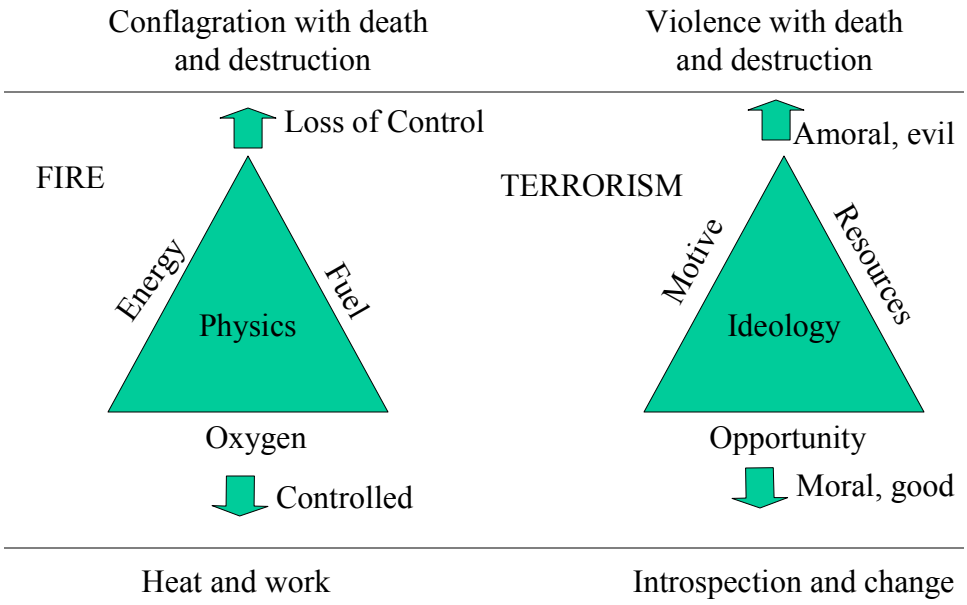

Figure 1. A comparison of the Fire triangle with the Terrorism triangle. Fire, if controlled, supplies heat and comfort. Ideologies, if morally applied, supply the driving force for societal change and improvement. Both can take opposite paths to death and destruction.

As we deal with the fire threat, we keep creating unintended consequences for many of the actions we take. A few examples will illustrate the point. Fire insurance was created in the 1680's to spread the monetary risk that an individual had from fire. With insurance, you sacrificed a known small amount of money to avoid a large loss from a fire. But the creation of insurance pools added a new element to fire ignition sources. Prior to insurance, people would only purposefully start uncontrolled, destructive fires to either enact revenge or to satisfy a pyromaniac urge. Now, with insurance, people were presented with an opportunity to profit by setting fires through fraud, and they do! Estimates are that about 20% of fires in the U.S are arson. Another unintended consequence of controlling fires is the stagnation of city centers. Frequent fires provided cities an "opportunity" to rebuild areas from scratch after a major fire. Now, existing buildings have to be destroyed before new ones can be built. Chicago, London, and many other cities were able to redesign and rebuild without the pain of removing existing buildings. Finding ways to renew city centers without fires has been a challenge for urban renewal programs. Another example is the suppression of natural fires in forests, allowing the buildup of undergrowth and thus increasing the probability of more dangerous and damaging fires. We ended up, in many cases, of enabling worse consequences than if we had done nothing!

As we deal with terrorism, we must constantly monitor the unintended consequences of our actions. Throughout history, every action taken to solve one problem always causes ripple effects not fully appreciated when the plan was created. We shouldn't expect to successfully anticipate every consequence of our actions as we deal with the war on terrorism, so we should plan from the beginning on having to deal with the unexpected.

Nothing will work as planned, and someone somewhere will always figure out how to misuse almost every action we will take.

Political Lessons from the Past

Understanding and dealing with the politics of prior situations and threats can help guide us through the present uncertainties. Our fire history is wrought with stories of political struggles and battles that we should not repeat. Some of our early history with volunteer departments illustrates this well. Fighting fires was historically viewed as an obligation of living in an organized settlement. Neighbors were expected to assist each other in watching for and fighting fires. Bucket brigades were formed with the men usually occupying the line to pass the full buckets, and the women and children forming the return line of empty buckets. Ben Franklin lead in the formation of organized volunteer departments which added structure to this response and the ability to obtain and manage central equipment. This event was an important advancement in fire fighting--utilizing volunteerism to deliver this valuable service without the collection of tax monies for salaries. As cities grew and fire fighting advanced, volunteer units began obtaining hand-operated fire pumps that dramatically increased the amount of water that could be applied to the fire. These high-capacity hand pumps required large groups of men to supply the power, with some volunteer units growing to hundreds of men. Membership in these volunteer units often became socially desirable and the units took great pride in their critical and dangerous work. Often many separate volunteer units co-existed in large cities, with social recognition (and often a payment from an insurance company) for the first unit to put water on a fire. This would sometimes lead to interference and even brawls between competing units to see who would be the heroes of a given fire. These large fire-fighting units also represented voters, and local politicians had strong interest in keeping this voting block happy. This led to resistance to technological advances (namely the steam-powered fire pump) that would reduce the need for these large fire-fighting forces. These steam pumpers, while invented in the U.S., were adopted in Europe long before they were in America. It took a large fire in downtown Cincinnati in 1853, which burned out of control while competing fire companies fought in the streets, to bring about change in the structure of the fire fighting units and to allow for the adoption of advanced technologies. Cincinnati responded by commissioning the construction of horse-drawn steam pumpers with a much smaller, professional fire fighting force. Other cites soon followed.

The fight against terrorism is also plagued with political and human pitfalls. Numerous agencies and organizations have valid roles, and everyone wants to be the *hero* that eliminates the threat and brings us back to safety. The counter-terrorism system must present an integrated structure, avoid duplication, and encourage expenditures and efforts in the most effective technologies and processes. The need for a reward system that recognizes and encourages positive efforts and avoids pork is essential. We have some difficult political decisions to make, and hopefully it will not take another “Cincinnati” to make it happen.

Summary

So what have we done in this war to protect ourselves from Fire? Basically, we have generated a multi-point attack by reducing the ignition sources, reducing the flammability of construction materials, improving city design, improving the fire fighting capabilities, educating the public on how to prevent and respond, improving technologies to warn of and respond to fire, creating a deterrence system, creating systems to assist in recovery of those effected by fire events, and maintaining an ongoing research and development program to stay ahead of the evolving threat. We have accomplished this through building codes, slowing the rate of spread of a fire by specifying materials, designs, equipment, building, and city design. We have reduced the warning time with inexpensive smoke detectors, allowing time for escape. We have dramatically improved our response time to fires, the quality of the equipment used for fire fighting, and we have invested public resources in fire fighting infrastructure. But we by no means got here by accident or easily! It was a long, painful battle where we mostly leaned through costly, devastating events. We can and must tackle this new war more effectively, learning the lessons of the past.

For the War on Terrorism, we should learn the following from our war on Fire:

- A solution must attack all segments of the problem: prevention alone will still leave us vulnerable. Chicago would not have made significant progress if they had decided to concentrate their efforts on the location and extermination of all the "cows"[4] in the city! Other "cow-like" sources of fire were everywhere!
- An investment in a rapid response infrastructure is required. We must be able to rapidly detect (especially in the case of biological attacks) and respond to these events. Terrorist events, like fire, need to be rapidly detected to minimize the harm.
- Personal education and response will play a valuable role. Government cannot and should not be expected to protect and detect everything. Every person and every organization will have a part to play in this war.
- Difficult issues around personal freedom must and can be addressed. Giving up our basic freedoms is too large a price to pay, but letting the enemy use our system to our demise is no better. We must find the workable balanced solution.
- Unintended consequences will occur and must be managed. Just plan on it.
- Taking a science-based approach will have long-term benefits. We must understand the threat, develop the technologies to detect, protect, and respond, and develop the technologies and capabilities to find and destroy those who would destroy us.
- There are usually multiple "no regrets" benefits from a system approach; an example would be the improved public health system that would be of value for its own sake even without the threat of bio-terrorism.
- The threat will continue to evolve as technology evolves. The attack of tomorrow will not be the attack of today. We must stay ahead of all potential adversaries.
- This war does not have an end but must be managed for the long term. We may eliminate the current threat, but another will occur. The secret is out: we can be

[4] The actual cause of the Great Chicago fire is undetermined and we realize that it was probably not caused by a cow, but the point is the same and the cow makes a better story than a rat or a careless human!

attacked and we can be hurt. This knowledge will energize foes of all types for all time. The war will not end, but we can still win by reducing the threat and eliminating the terror. We can get to the place where we may still be hurt, but we will not be terrorized. We can restore our overall sense of safety and security even through we will still suffer some loss.

- Trust is a major factor in winning the war on terror. Most people do not avoid normal life functions due to a fear of dying in a fire. They go to public buildings, sleep in their houses/apartments/hotels, even go into skyscrapers. A major portion of this success is based on trust, trust that these places have been required to follow the rules and codes; trust that alarms and exits are available; trust that the system solution is in place. Obtaining this trust in the system solution is a major factor in our success in dealing with the fire danger. Our solutions in the war on terrorism must also be real and trusted.

Being an analogy, there are major differences between this challenge and that of fire protection. First, fire is basically a personal and local issue with a limited role for the federal government. The fight against terrorism, however, has a strong component that depends on federal intelligence gathering and on the ability of the government to act internationally and militarily. Secondly, fire is driven by science and is governed by the invariant laws of the universe. Terrorism, however, is driven by ideology, which can change and can even be influenced. Terrorism, being human driven, can be devious, creating false indicators and even working as an insider violating a trust relationship. And finally, terrorism will be expected to occur less frequently than normal sized fires, making it more likely to fall off of the public radar screen between major events.

In the end, we need to deal with terrorism through a continuing, balanced, and forever evolving national response – one that engages the appropriate government (local, state, federal, international) and private (both organizational and individual resources) in a system solution. As with fire protection, the solutions that we develop to protect ourselves against attack will eventually become commonplace, being integrated into the fabric of our daily lives and yet, while largely unnoticed until needed, they will leave us more secure, both in fact and in perception.

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Appendix A: Some History with Fire

Learning that fire and smoke kill was certainly the first experience that man had with fire. Fire during this early time period would have come from natural sources such as lightning and volcanoes and your risk of being killed by fire depended mostly where you lived. Living in a cave on a rocky mountainside would have been safer than living in the middle of a dry forest or, even worse, in the middle of a large prairie. In any event, an approaching fire was something to be feared and avoided.

At some point, Man learned that fire could be harnessed and used to provide warmth, protection, and to prepare food. The ability to utilize fire is such a differentiating advantage for man that Greek mythology features this story, attributing this event to Prometheus, who stole fire from the Gods and gave it to man, and was doomed to suffer for this act. Man's learning to control and utilize fire did not change its nature as it still could and would kill. This great new power man had discovered had now introduced a new risk to his safety, as he now not only had to worry about natural fires, but now could be harmed by fires that he himself had created. The development of settlements and cities upped the risk: now a neighbor's careless fire could jump over and kill him and his family or destroy his home or food supply. It now not only mattered where one lived, but it also mattered who one lived around and what kind of dwellings everyone lived in, with stone or adobe dwellings presenting much less risk than wood and grass. This continual battle is shown in virtually all uncovered prehistoric sites, which show evidence of destruction by fires, as do all ancient villages and cities. Protection from harm by fire was wholly a personal responsibility during these times.

In more recent recorded history, we have a large list of famous fires. Most of the city of Alexandria, Egypt and its vast library were destroyed by fire in about 30 B.C., apparently from collateral damage of the battle for the city. We know that the Roman's formed bands of slaves as far back as about 300 B.C, the Familia Publica, that kept watch for fires and warned residents when fires were discovered. The Chinese Ming dynasty also had fire brigades back to at least this time period. Clearly, city leaders have had organized efforts to protect communities from fire for over 2000 years, recognizing that personal efforts alone were not adequate to protect the cities from cataclysmic fires. Other efforts to reduce the ignition sources are also recorded; for example, the Norman conquerors of England required all house fires extinguished at nightfall. The Middle French word *covrefeu* was called out every evening to require everyone "cover the hearth," a term which evolved into our word Curfew.

In modern times, there have been many famous fires, significantly shaping our history with each followed by cries for action. Among these are (along with estimates of death and damage):

- London, 1666: 6 deaths, 80% of city, including 80 churches and 13,000 homes
- Chicago, 1857: 23 deaths, "extensive" property damage
- Chicago's Great Fire, 1871: 300 deaths, 2000 acres, 17,000 building, $200 million loss

- Peshtigo forest fire in northern Wisconsin, on the same day as Chicago, 1871: 1,200 killed, 2,400 square miles, $5 million loss
- Downtown Boston, 1872: 13 killed, 776 buildings, and a $75 million loss
- Chicago again, 1874: 50 acres, 800 buildings
- Brooklyn Theater, New York City, 1876: 295 killed
- Charlestown, South Carolina, 1886, earthquake and fire: 80 deaths, $6 million.
- Chicago's new, "modern and absolutely fireproof" Iroquois Theater, 1903: 602 deaths
- Downtown Baltimore, 1904: 140 acres of downtown, $100 million
- The excursion steamer *General Slocum*, New York, 1904: 1,030 deaths, vessel destroyed
- The San Francisco earthquake and fires. 1906: 3,000 killed, 490 city blocks, 25,000 buildings
- The Lakeview Grammar School, Collinwood, Ohio, 1908: 175 deaths
- Triangle shirtwaist factory, New York City, 1911, 146 killed
- Ohio State Penitentiary, Columbus, Ohio, 1930: 320 deaths
- The Consolidated School, New London, Texas, 1937: 294 deaths
- The Boston nightclub "Coconut Grove", 1942: 482 deaths
- The Ringling Brothers and Barnum and Bailey Circus, Hartford, CT, 1944: 168 deaths
- Winecoff Hotel, Atlanta Georgia, 1946: 119 killed
- The S.S. Grandcamp, exploded while taking on a load of fertilizer in Texas City, Texas, 1947: 468 killed (including entire fire department of Texas City), $67 million in property loss
- Katie Jane Nursing Home, Warrenton, Missouri, 1957: 72 killed
- And the list goes on and on

The threat was everywhere. You were threatened when you were at home, at work, while shopping, in the woods, in school, at play, even in prison! Based on the writing and actions of civic leaders and individuals following these events, it is clear that the populace was fearful, even terrified, of living and working in high-risk areas such as cities. Action was demanded from public leaders as the populace couldn't move away or just decide to do without the heat and energy provided by using fire. What was required of society was that it embark on a long, rocky, difficult, and seemingly overwhelming and impossible journey to reduce the terror and damage caused by uncontrolled fire.

- There were 1,755,000 fires in the United States in 1998. Of these, residential fires represent 22 percent of all fires and 74 percent of all structure fires.
- Direct property loss due to fires is estimated at $8.6 billion annually.
- The total cost of fire protection is about $100 billion per year.
- The U.S. has one of the highest fire death rates in the industrialized world.
- For 1998, the U.S. fire death rate was 14.9 deaths per million population.
- Between 1994 and 1998, an average of 4,400 Americans lost their lives and another 25,100 were injured annually as the result of fire.
- About 100 firefighters are killed each year in duty-related incidents.
- Over 40,000 firefighters are injured each year at fire scenes.
- Each year, fire kills more Americans than all natural disasters combined.
- Fire is the third leading cause of accidental death in the home: at least 80 percent of all fire deaths occur in residences.
- Senior citizens age 70 and over and children under the age of 5 have the greatest risk of fire death, about double the average population.
- Men die or are injured in fires almost twice as often as women.
- African Americans and American Indians have significantly higher death rates per capita than the national average. Although African Americans comprise 13 percent of the population, they account for 26 percent of fire deaths.

Table 2 Some recent fire statistics for the United States (4,5,11,12).

Appendix B: The Terrorism Analogy

In tackling a difficult problem, it is often useful to identify and study challenges that have been dealt with in the past to see what lessons can be learned. This paper proposes that death and destruction by fire is one such threat that society has faced and managed, and that we can gain both guidance and hope by looking at how we have mitigated and managed the threat of uncontrolled fire. Note that this analogy is one of both process (how we solved the problem), and products (technologies used to solve the problem). While there are many examples of fire protection products (such as smoke detectors) that would have a direct counterpart to the war on terrorism (in this case, a biological agent detector), in many cases the important lessons relate to how we eventually arrived at an acceptable solution. How did we decide how to organize? How did we decide how to distribute responsibility between individuals, private firms, local, state and federal governments? How did we decide how much to spend? How did we decide what personal freedoms to give up? How did we decide that we were safe enough? How did we reduce the dread even though thousands still die each year? What is surprising is how many parallels seem to exist between the fire protection situation during the mid 1800's and the current terrorism threat.

This threat of terrorism is truly terrifying! We seem to have too many things and places to protect. We have long, relatively porous borders with vast amounts of goods and people entering our country daily. We value our open, free, diverse society and don't see how to maintain these and at the same time find and stop the terrorist. Everything in our nation seems to be tied to everything else; even a "small" attack can propagate and cause great harm. Beyond our military and intelligence efforts to try to find and stop existing and potential terrorist, we don't even know how to start. We want to restore our sense of safety. We want to remove the threat from our lives. But can we? What can and should we do? So, look at this analogy as something that can give guidance:

- How was this prior problem attacked?
- What was done right? Done wrong?

And as something that can give comfort:

- We have tackled huge problems before
- We can resolve difficult issues with resolve and perseverance
- We can and will prevail!

In looking at terrorism, many examples of these huge, seemingly intractable problems that mankind has faced and resolved can be cited. Among them are public health (dealing with plague and other diseases with most effort on prevention), natural disasters (earthquakes, hurricanes, floods with most effort on response), civil defense (mostly training and systems for response to events), and fire protection (which includes major efforts for both prevention and response). Fire protection was used as the case study for this discussion, recognizing that much can be also learned from these other examples. One word of caution: analogies are just that: they are "resemblance in some particulars between things otherwise unlike." (Webster) Use analogies to help understanding; do not use them to extremes. Nothing is ever exactly like something else.

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