Combating the Evolving Threat of Terrorism: Chemical and Biological Terrorism

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Our subject is Terrorist violence, its effects and the mitigation thereof. The operative word is mitigation. There are no 100% solutions to this problem. When we talk about this problem we speak of protecting buildings and infrastructure, we are really talking about protecting people. The object of the exercise is casualty reduction.

It has taken us some time and some sharp lessons to realize it, but we now know that:

1. Terrorism is a real problem
2. It is here. It is an American problem.
3. It is not going to go away.
4. There is no political or policing solution in the foreseeable future.
5. Consequence management is an after the fact reaction. Prevention and protection are better Because they have the potential of saving lives.

The tactics of Terrorism are many:

1. Bombing
2. Arson
3. Assassination
4. Kidnapping
5. Hostage taking
6. High-jacking
7. Chemical Attack
8. Biological attack
9. Radiological attack
10. Electronic (Cyber) attack

The Bomb is the terrorist tactic of choice.

1. It is attention getting. It makes a lot of noise.
2. There is a wide choice of targets.
3. Materials are readily available and inexpensive.
4. Can be carried out by a small group or even a single person.
5. There is, historically, a high probability of escape without apprehension or even identification.

The Oklahoma City Bombing of 1995 was America's wake-up call to Terrorism. The 1993 bombing of the World Trade Center although it foreshadowed our problems, passed relatively unnoticed because of the low number of fatalities count and general feeling that that large well constructed buildings were "robust" enough to resist bombs. The 1993 van bomb was equal to approximately 1200 pounds of TNT.

The Oklahoma City Bomb caused 168 fatalities and 800 major injuries. (The OK State Department of Health identified 1787 non-fatal injuries.)The collateral casualties are still being counted.

The reaction of many experts was resignation at the impossibility of defending against such an attack. Frank Gehry stated "The dream that we can design our way to safety is unrealistic. I don't think you can

protect people." (1) Another prominent architect stated in The New York Times that to provide a level of protection in a building such as the Murrah Building would have increased costs by 200%. (2). This would be disheartening if it were also not incorrect.

The story of the Oklahoma City Bombing and building damage has been discussed at length and I will not repeat it here. The Oklahoma State Department of Health did an unprecedented study in they located each victim before and after the attack and cataloged injuries and probable cause. They determined that 97% of the fatalities, were in the building and effectively were killed by having the building fall on them. Of the surviving casualties, over 60% were struck by flying debris, mostly window glass. Approximately 35% of the non-fatal casualties were attributed to being struck by building equipment, furniture and finishes, including ceilings, partitions , lighting fixtures and ductwork.

A workshop of the ASCE/AEI Working Group on the Mitigation of the Effects of Terrorism (WGMET), in June 1995 at John Jay College, determined that there were actions that architects and engineers could take that would reduce the effects of the Large Vehicle Bomb on both new and existing buildings. Their recommendations concentrated on preventing progressive collapse of buildings when a single vital structural element was destroyed and reducing the breakage, fragmentation and dispersion of shattered glass.

The obvious first solution to the collapse situation was to increase the distance between the bomb and building since explosive force reduces as a cube function of the distance. That is the force of a charge detonated at 10 feet is reduced by a factor of 8 at 20 feet and by a factor of 1000 at 100 feet. This is the basis of the concept of Stand-off Distance and the establishment of a defended perimeter by use of curbside bollards and planters.

Studies were initiated so that new buildings can be designed so that the abrupt removal of a single column or other structural element allows only the collapse of single bay of a building rather than the progressive collapse of the whole structure. Engineers are attempting to develop design that would confine this collapse to a single floor.

Reinforcement of the columns of existing buildings using fiberglass or carbon fiber developed in California to resist earthquake loads can protect buildings like the Murrah Building so that if the failure will still occur, it is not sudden or catastrophic. This will allow the timely evacuation or even the removal and replacement of the failed column.

In November 1996, The FEMA /ASCE report was released. That report included the statement that the increased cost of "necessary" protection would range from 1 to 2% of building cost. (3) Many engineers feel this estimate is overoptimistic and that a figure of 5 to 6% is more realistic.

In October of the next year, a little noted addendum to this report was issued that said "For an increase of $70,000.00 at the time of construction (in 1997 dollars) fatalities could have been reduced by between 50 and 85 percent. This would have reduced fatalities by 140." (4) The added funds would provide added reinforcement to provide continuity and resist reversal of loads and would have been invisible to the public and require no architectural changes. At $500, a head, that's not a bad buy.

Simultaneously, work has gone forward to address the problems of shattered glass. Normal windows are constructed of annealed glass. Building codes require that this be designed for 35 pounds per square foot (1/4 psi). There are available glazing materials which can sustain loads up to 35 psi. Unfortunately, this load if applied to an existing building face would cause catastrophic damage. New buildings are being designed to adequately support these loads so that these materials can be used where required. For existing buildings we have taken advantage of the long experience of our British friends. They have developed a number of systems including anti-shatter films, bomb blast net curtains and shattered glass catchment devices which allow their installation in existing buildings without special reinforcement to capture shattered glass its preventing its dispersal into a cloud of thousands of dangerous flying pieces.

The WGOMET participated in above research. Their findings have been assembled by the U.S. General Services Administration and are being used in current design.

The problem of defensive specifications for other Architectural Engineering Systems such as wall cladding, ceilings, partitions, etc. is being addressed at this time by a committee of the Architectural Engineering Institute.

Regrettably, when considering the Large Vehicle Bomb, no one envisioned a projectile weighing 200 tons traveling in excess of 550 miles per hour bearing a 40 ton Fuel-Air Bomb (equivalent to 10 times it weight in TNT). Effectively, the energy release of each of the air strikes on the World Trade Center was the equal of a low kilo-tonnage nuclear weapon minus the radioactive component.

The face of Terrorism has changed. It used to be political – designed to:

1. Get attention
2. Demonstrate power
3. Win sympathy and support
4. Send a message
5. Compel negotiations

Brian Jenkins has often said, "Terrorism is theatre. They are playing to the public." This has changed, and for the worse. The terrorist no longer is satisfied with attention, sympathy or the opportunity to negotiate. The terrorist is interested in inflicting casualties, at the risk of public revulsion or even war (if he can be identified).

We have found that attack on US soil is easy (and likely). Our Allies may even see this as an internal American problem. They have faced this situation for years with little attention from us.
In our open society, there are so many vulnerable targets to defend that at times it appears that the offensive potentials far outstrip our defensive capabilities. Unanswered attacks may encourage "copycat" attacks, yet defensive actions are likely to necessitate restrictions of domestic freedom and individual liberties.

CNN on November 15, 2001 published on-line portions of al Qaeda's 10-volume Encyclopedia of Afghan Resistance. The first two volumes cover explosives and their manufacture and assembly. A new11th volume addresses chemical and biological weapons.
The late John O'Neill said the large vehicle bomb is today's major problem, but he strongly supported defensive research on defense against Chemical and Biological Terrorism as an unspeakable future threat. (5).

Chemical and Biological (CB) agents as Weapons of Mass Destruction (WMD) are relatively cheap. (WMD by definition of the US Department of Health and Human Services is a weapon that can cause 1000 or more casualties.) They are often referred to as the "Poor Man's Atom Bomb". (This phrase apparently was popularized at the (Cambridge) Institute for Foreign Policy Analysis and used in a book title by Douglas Livingston in 1984: "CBW: The Poor Man's Atom Bomb.")

There has been much discussion as to whether this is a real threat. One side sees the potential for literally millions of casualties, the other side believes that the sophistication required to produce and disseminate these weapons makes them only a paper threat. The truth is as usual somewhere in between. In the case of Biological weapons, for example:

1. Lethality is comparable to nuclear weapons (Kgs. Are required not KT)
2. The equipment and materials are available COTS. Estimates of the cost of a production facility suitable for a credible attack vary from $15,000 to $ 1 million.
3. Economy – the materials are low cost.
4. Covert dissemination – the delayed effects (Incubation Period) allows escape of the attacker without apprehension or identification.

5. Difficulty in identification of a natural disease event vs. a malevolent act and difficulty in attribution prevents deterrent action.
6. The primary limitations is the knowledge of the attacker.

We have seen in recent months, that a successful attack needs no jet aircraft or artillery. An attacker has successfully disseminated Anthrax with lethal results using a box of stationery and some postage stamps, spreading fear, dislocating government operations and costing tens of millions of dollars. A flood of copycat letters has swamped our investigative resources. The same attacker using a sprayer, aerosol can or even a perfume atomizer could produce significant casualties.

The military has years of experience with these agents. The military response is a part of what is called Force Protection. This involves getting the affected personnel into masks, suits and gloves upon first warning. This is a satisfactory solution for a healthy disciplined group aged 17 to 55 with no predisposing medical conditions and with protective clothing and equipment readily available, but is not too satisfactory for the general public ranging from new-born children to bed-ridden old age.

The prevailing civilian planning is called "Consequence Management" which deals with post attack response and recovery. It deals with the medical and public health concerns of identifying the toxic agent, treating casualties, decontamination and restoration of service. There is a secondary concern with preserving and gathering evidence to identify and apprehend the perpetrator. This reactive approach does not prevent the casualties, it treats them.

A better alternative is available to us, Although Chemical and Biological agents are very different in their effects and time of onset; the pathways and the vulnerabilities they exploit are very similar. It is this similarity that provides our defensive opportunities. As the loss of life in building fires has been reduced by the use of sprinklers, smoke detectors and fire resistive construction and highway safety by the seat belt and air bag. A similar approach is available to us by a multi-disciplinary program of vulnerability assessment, surveillance, security, architectural and engineering design to:

1. Prevent/deter the attack
2. Protect the public
3. Mitigate weapons effects

Chemical agents suitably disseminated produce incapacitating, lethal or damaging effects on man, animals or materials. They are comparatively immediate in their effects. There are four commonly recognized classifications of lethal Chemical Warfare Agents:

1. Vesicants – Blistering Agents
2. Cyanide – "Blood" Agents
3. Pulmonary Agents – Attack the lungs
4. Nerve Agents – Attack neuro-muscular systems

Nerve Agents are considered the primary threat because they are of high toxicity and are absorbed through the eyes, respiratory tract and skin. In some cases very small amounts cause death.

The primary weaponized nerve agents are:

Name	Vapor Toxicity – LCt50 (Inhalation) (Mg-Min/M-3)		
GA (Tabun)	(6)140	(7) 400	(8) 70
GB (Sarin)	50-100	50-100	35
GD (Soman)	70	70	35
VX	30-35	10	15

Dosage is defined by concentration and time of exposure -LCt50= Lethal to %0% exposed.

The subject of effective dosage is quite controversial for both chemical and biological agents. There is a wide range of estimated values, as there has been no human testing, the values are extrapolated from small animal testing. Properly, they represent a best guess of the effect on a155 pound hamster.

There are hundreds of Toxic Industrial Chemicals (TIC) that while less efficient can be used as attack agents. They have the advantage to the terrorist that they are inexpensive and very easily obtainable commercially without regulation and therefore leave no "paper trail".

Biological Agents include agents effective against humans, animals, plants and food (and possibly even against petroleum products.) The anti-personnel agents are of three general categories:

1. Pathogens – bacteria, viruses, rickettsia and fungi
2. Toxins
3. Bioregulators

Potential Bio Agents include:

Anthrax
Plague
Encephalitis
Staphlococcal Enterotoxin
Tularemia
Smallpox
And many others

Anthrax is considered by the US Joint Chiefs of Staff the biggest threat to the armed forces. It is also a threat to the civilian community. There were 300 threats of Anthrax attack in 1999, each cost an estimated $500,000 in response and service dislocation costs.

Bacillus Anthracis: Anthracis is derived from the Greek word for coal – the color of the formed scab. It is an endemic infection of animals. Humans are infected through skin, inhalation or by eating infected meat. Anthrax was the self-styled national disease of Czarist Russia. It caused 3500 deaths annually.
It is widespread world wide. An estimated 165 varieties have been identified.

There are one trillion spores of anthrax per gram (approximately 30 grams to the ounce).
The LD50 dosage is 8000 to 10,000 spores by inhalation (US or USSR manufactured level of virulence). Recent practice is refer to the above as "Median infectious dose:" or ID50 in lieu of LD50. It is noted that this not the minimum infectious dose. It is estimated that the LD33 dose is 1000 spores and LD14 is 100 spores. Lethality is possible from a single spore. At high doses, LD80 is estimated at 100,000 spores. Russia produced 5000 tons in 1987. Iran produced 6000 liters prior to the Gulf War.

The most current experience with anthrax is in Sverdlovsk, Russia in 1979. There was an accidental release from a laboratory. An estimated 50,000 people were exposed. An estimated 7000 were in the "plume" and 1% were infected. There were 64 deaths. Fourteen percent of those infected recovered. The total release of anthrax is estimated between 2 milligrams and 70 grams. The estimated exposure was 2-10 spores per person. The period of the epidemic lasted 42 days. Continued infection was possibly due to re-aerosolization of surface deposited spores. (9)

Although the spores are adversely affected by sunlight, spores survive for decades when buried. Spores were recovered from the grave of a German spy who was carrying a supply of this material and was executed in 1918. Viable cultures were grown from these spores.(10)

The effects of anthrax are a one to six day incubation, followed by fever, muscle pain, cough and fatigue. (it is easily mistaken for Flu.) Pre-treatment with vaccines and anti-biotics has been found effective in reducing and preventing fatality. Once symptoms occur- fatality rate is more than 90%.

Our recent US experience with anthrax," killed 5 people, infected at least 13 more and terrified large segments of the population. Doctors had difficulty diagnosing inhalation anthrax, by the time it has progressed to its severe phase it is easy to diagnose , but virtually impossible to cure. Many of those infected did not have the classic symptoms of Anthrax, but were only diagnosed after CT Scan or blood test. However surprisingly, with aggressive treatment using antibiotics, recoveries were made. Considering how deadly the advanced stage of the disease is considered it is questioned whether many more Russians were infected but recovered. The medical records of antibiotic treatment of the exposed group are not available. (11)

The necessary requirements for planning a Biological Attack (Anthrax) are:

1. Willingness to use the weapon.
2. Ability to secure a virulent strain as a basis for production.
3. Ability to produce/grow a quantity of the agent.
4. Ability to design and build a dissemination device capable of producing large numbers of casualties.

On March 3, 1999, The Departments of Defense (US Army Soldier Bio-Chem Command), Energy (Oak Ridge National Laboratory) and Justice (Federal Bureau of Investigation) together with representatives of professional societies (United Engineering Foundation, ASCE, AEI, ASME, AIChE) established the Joint Working Group: Chemical and Biological Terrorism Defense (JWG:CBT) to carry out a program of research and planning to assess the vulnerability and mitigate the effects of WMD on our homes and work places using currently available technologies..

As its first project, JWG:CBT commenced the "Building Protection Project"(BPP) to consider the vulnerabilities and defense of tall office buildings using currently available technologies. Tp paraphrase, the American philosopher (and bank robber) Willy Sutton, who when asked why he robbed banks, replied, "That's where the Money is". The tall office building represents an attractive target, because it represents a large capital investment, is a central point of any community and has a large population with a potential for generating a large number of casualties. "That's where the people are."

The BPP was carried out as a "one-turn war game" using three high-rise federal office buildings; ALPHA – 20 stories; BETA – 30 stories and GAMMA – 46 stories and approximately 2.4 million gross square feet.

Red Team was composed of experts from USA SBCCOM assessed the building, identified its vulnerabilities, created attack scenarios for both interior and exterior attack, using a chemical agent, Sarin (GB), a biological agent, Anthrax and in one instance a second agent, Tularemia. It then estimated the fatalities and casualties in the unprotected building. For estimating purposes:

A. Agents were estimated at three virulence levels:
   USSR manufacture;
   State sponsored manufacture of Iraqi level
   Independent (relatively unsophisticated) terrorist manufacture.
B. Dissemination devices and methods with varying efficiencies between 1.5% and 50%.

Blue Team was composed of professional engineers, and security experts with FBI observers, then surveyed the buildings and their operating systems, recommended/specified defensive measures and identified the economic costs thereof. The recommended defensive measures are within the current state of the art, cost effective and available COTS.

The following was the project action plan:

1. Identify the problem:
   Consider the available/probable agents and their method of disemmination. While their effects are different, the methods of use/attack are very similar. It is from this that we shall develop our defensive plans.

2. Assess the vulnerabilities of the potential targets.
3. Develop several attack scenarios to exploit these vulnerabilities and maximize damage.
4. Deny access to vulnerable points by fences, grilles, locks and alarms or by relocation.
5. Deter attackers by CCTV and other surveillance methods to make attack without apprehension or identification unlikely.
6. Detect the attempted intrusion of Chemical – Biological Agents by developing broad spectrum, multiple agent and toxic material detectors.
   There are no existing, deployable biological agent detectors.
   Existing detection/identification devices can identify 5 or 6 militarized chemical agents in 1 to 2 minutes.
   Deficiencies in detection must be supplanted by increased awareness.
   A DOD study in 1962 estimated that the entire Pentagon Building (built in the early 1940s) could be successfully attacked to LD50/LCt50 dosages within 15 minutes.(12)
   In modern high rise buildings, HVAC air velocities will vary from 500 to 2500 feet per minute. The tallest building can be contaminated in a minute. Attacking the air intakes using a moderately efficient dissemination device and an Iraqi level powdered or liquid slurry agent,
   lethal/incapacitating dosage can be reached in under 6 minutes.

   To protect occupants, we must separate detection and identification and act on detection alone. These defensive measures should be of "low regret" cost, to compensate for false alarms.

   In the absence of detection, defensive measures should be of passive type, operating 24/7/365.

7. If we can identify the existence of an attack, we can take active measures:
   A. Evacuation
   B. Shelter in place
   C. Defensive operation of the existing HVAC plant
      - Shut down
      - Reversal of flow
      - Zone isolation and closure
      - Venting of agents
      - Other measures
8. Installation of HEPA Filtration and HEGA Adsorption (Currently available off the shelf)
      - First cost
      - Pressure Drops and operating problems
      - Compensating fans
      - Operating costs
      - Filter replacement
9. Encourage the development of promising technologies
   A. Detection/Early Warning
      - Continuous sampling
      - Flourescent Laser Automatic Particle Sizer
      - Time of Flight spectrometer
      - GA Tech Food processing scanners
      - NYC Public Health Reporting System - rapid collection of non-traditional data
   B. Defensive measures
      - Suppressive Sprinklers
      - Sandia Foam
      - Continuous on-line prophylaxis
      - Pulsed UV Light
      - Corona Plasma
      - Cathodic Oxidation

It is anticipated the findings of JWG:CBT will result in the development of guidelines for the defense of new and existing buildings and their occupants against chemical and biological attack.

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