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CHASING GHOSTS: THE NATURE OF THE TERRORIST ADVERSARY

Mark G Stewart[1] and John Mueller[2]

[*1]Centre for Infrastructure Performance and Reliability, The University of Newcastle, Australia
email: mark.stewart@newcastle.edu.au

[2]Ohio State University, United States
email: bbbb@osu.edu

Abstract. *A key motivation for much research on protective structures is terrorism or insurgency attacks. Risk is the integration of threat, vulnerability and consequences, but threat is often based on worse-case thinking about the capability of terrorists to successfully plan and execute large scale bombings. The paper looks at the nature of the terrorist adversary by exploring their capabilities and motivation, technical skills, and target selection. Key among this is the myth of the mastermind, the risk of progressive collapse, and the track record of terrorists attacking targets in the West. This is contrasted to terrorist or insurgent attacks in the Middle East. An improved understanding of the threat allows decision-makers to more effectively deploy resources to counter such threats, which includes appropriate design and assessment of civilian and military protective structures.*

Keywords: terrorism, risk, protective structures, acceptable risk

1 INTRODUCTION

The United States currently spends $115 billion annually on domestic homeland security measures, and Australia in the region of $1-2 billion annually (Mueller and Stewart 2011, 2016). These are significant expenditures that rarely are subject to cost-benefit or risk analysis. This lack of scrutiny leads to risk-averse and costly counterterrorism policies. Some counterterrorism measures may not even be needed because the capacities of Islamist extremists seeking, aspiring, or vaguely thinking about terrorism in the West generally seem, whether based in Australia or abroad, to be unimpressive, and any threat they present appears to be quite limited. The tragic attacks in Paris in November 2015 shows that the terrorist threat is real. However, there is a natural tendency to over-react to such events, and to massively inflate the capabilities of the perpetrators. This article seeks to evaluate the capacities of Islamist terrorists in the West, and the risks they pose to human life. It specifically looks at the nature of the terrorist adversaries by exploring their capabilities and motivation, technical skills, and target selection. An improved understanding of the threat allows decision-makers to more effectively deploy resources to counter such threats, which includes appropriate design and assessment of civilian and military protective structures.

The investments in protective structures and measures to mitigate blast effects is considerable. These efforts focus on vulnerability and consequence modelling as many research challenges remain for these topics. However, do many buildings or structures require enhanced levels of protection? It has been shown by Stewart (2008) and Stewart and Grant (2015) that the existing annual fatality risk for large government building occupants are conservatively lower than acceptable risk criteria, and

that progressive collapse is an exceedingly rare event in Western countries. A cost-benefit analysis of design provisions to mitigate against progressive collapse showed that these measures only becomes cost-effective when the threat likelihood is a very high one in a thousand per building per year. It might be reasonable to conclude that protective structures have had little or no effect on reducing the terrorism risks to human life. They may have a deterrent effect in some cases, but there is little evidence that the provision of protective design to buildings has saved lives.

2 RISK FRAMEWORK

The standard definition of risk adopted by the U.S. Department of Homeland Security and risk analyses for many applications (e.g., Stewart and Melchers 1997) is:

$$(\text{Risk}) = (\text{Threat}) \times (\text{Vulnerability}) \times (\text{Consequences}) \tag{1}$$

where

- Threat - annual probability there will be a terrorist attempt
- Vulnerability - probability of loss (that the explosive will be successfully detonated or the gun will fire leading to damage and loss of life) given the attempt
- Consequences - loss or consequence if the attack is successful in causing damage. This includes not only the economic costs and lives lost, but the indirect and intangible losses as well.

Security or protective measures seek to reduce risk by reducing the threat, vulnerability and/or consequences of a terrorist attack. For any security measure the risk reduction can vary from 0% to 100% (or even a negative number for an ill-suited security measure).

3 THREAT

3.1 Capacities of the Terrorist Adversary

In 2009, the Department of Homeland Security issued a lengthy report on protecting the homeland. Key to achieving such an objective, it would seem, should be a careful assessment of the character, capacities, and desires of potential terrorists targeting that homeland. However, it devotes but two sentences to an assessment of the actual nature of the adversary it is so concerned about: “The number and high profile of international and domestic terrorist attacks and disrupted plots during the last two decades underscore the determination and persistence of terrorist organisations. Terrorists have proven to be relentless, patient, opportunistic, and flexible, learning from experience and modifying tactics and targets to exploit perceived vulnerabilities and avoid observed strengths” (DHS 2009).

The Australian 2010 Counter-Terrorism White Paper is equally dire: “These groups are a determined and capable adversary that has proved highly adaptive. They have the capacity to learn from their mistakes, adapt to counter-terrorism measures, and to regenerate. And they are innovative in their tactics and methods and have shown a dogged persistence in pursuing their goals, repeatedly following up failed attempts with successful attacks” (AG 2010).

In stark contrast, when seeking to describe their terrorist subjects, the authors of a set of 76 case studies of Islamist terrorists focused on the United States since 9/11 chiefly apply different descriptors: incompetent, ineffective, unintelligent, idiotic, ignorant, inadequate, unorganised, misguided, muddled, amateurish, dopey, unrealistic, moronic, irrational, foolish, and gullible (Mueller 2016). Not all the terrorist perpetrators or would-be perpetrators reach the level of “buffoon of Shakespearian proportions,” used by the judge to describe the “leader” of a plot to bomb Bronx Synagogues in 2009, but a strikingly high percentage do qualify for the distinction.

The capabilities of actual or wanabee terrorists in Australia are also less than impressive. The perpetrator of the Martin Place Siege in 2014 wasn’t organised enough to acquire an Islamic State flag, was labelled by his lawyer as “not very intelligent,” and by counsel assisting the coroner as “as a man spiralling downwards” and with “few friends” (Safi 2015). Convicted terrorist Khaled Sharrouf, who left Australia to fight for Islamic State in Iraq and Syria, was characterised by Justice Whealy as “He's clearly over there playing a role of the master terrorist – but he's anything but, of course," and "He's a very sad, pathetic figure. He remains a highly unintelligent man who has no perception of himself” (Rubinsztein-Dunlop 2014).

In all, to be effective, would-be terrorists need to be “radicalized enough to die for their cause; Westernised enough to move around without raising red flags; ingenious enough to exploit loopholes

in the security apparatus; meticulous enough to attend to the myriad logistical details that could torpedo the operation; self-sufficient enough to make all the preparations without enlisting outsiders who might give them away; disciplined enough to maintain complete secrecy, and—above all—psychologically tough enough to keep functioning at a high level without cracking in the face of their own impending death" (Dalmia 2011). The terrorism cases in Australia and the United States certainly do not abound with people like that.

The terrorism problem in Europe is similar. Michael Kenney has interviewed dozens of government officials and intelligence agents, and has analysed court documents in Europe and other Western locations. He finds that Islamist militants in those locations are operationally unsophisticated, short on know-how, prone to make mistakes, poor at planning, and limited in their capacity to learn (Kenney 2010). For example, there was the neo-Nazi terrorist in Norway who, on his way to bomb a synagogue, took a tram going the wrong way and dynamited a mosque instead (Horgan 2009). The lack of success of terrorists in the United Kingdom, Canada, and Australia mirrors that in the United States. The number of people killed by Islamist extremist terrorists in the UK is, as for the US, less than four per year, while for Canada and Australia, it is two or three in the last decade.

Suggestive of their capacities is the rather impressive inability of the terrorists to create and set off a bomb. In many instances, the only explosive on the scene was a fake one supplied by the police, and it is clear that many would-be terrorists generally lacked the capacity to create or acquire one on their own. As a result, with only one exception, the only method by which Islamist terrorists have killed anyone in the United States since 9/11 was through the firing of guns as in the cases of Fort Hood in 2009 and San Bernardino in 2015. In the exception, the Boston Marathon terrorists did manage to set off a pair of crude homemade bombs in 2013, killing three in a crowded area.

This inability to fabricate bombs is impressive because, in principle, an improvised explosive device, or IED, is relatively simple to design and manufacture if done by well-trained personnel and results in reliabilities in excess of 90 percent (Grant and Stewart 2012). However, analysis of the Global Terrorism Database shows that the probability that an IED will inflict damage is only 19 percent for terrorists in Western countries, where there is less opportunity for IED operational skills to be acquired. By contrast, the probability that a terrorist or insurgent IED attack will be successful is more than three times higher in the Middle East (Grant and Stewart 2012, 2015). Former TSA director Kip Hawley notes that even world-class laboratories are able to get the explosive mixture right only one time in three when making hydrogen peroxide bombs (Hawley and Means 2012). This difficulty may help explain why no terrorist (however innovative, adaptive, masterly, and quick moving) has been able successfully to detonate a bomb of that sort in the United States since 2001, and why, except for the four bombs set off in London in 2005, neither has anyone in the United Kingdom. The detonation of suicide vests by seven terrorists in Paris in November 2015 seemingly ended up claiming a single victim, and succeed only in killing the wearer. The explosions in Brussels in March 2016 marked the first time terrorists have been able to set off explosives on the continent in over a decade.

There has been a tendency to exaggerate not only the skills of the terrorists, but the importance and potential destructiveness of their plots. A *New York Times* article in 2009 was engaging in considerable understatement when it observed, "Since the terrorist attacks of Sept. 11, 2001, senior government officials have announced dozens of terrorism cases that on close examination seemed to diminish as legitimate threats" (Johnston and Shane 2009). And Garrett Graff considers as "almost routine" a pattern in which "a breath-taking high-profile announcement of a terrifying scheme against the United States" is "gradually downgraded as more information trickle[s] out afterward" (Graff 2011).

In this spirit, the bumbling efforts of the Times Square bomber of 2010 are blithely held to have "almost succeeded" (Sofan 2013). However, the bomb was reported from the start to be "really amateurish," with some analysts charitably speculating when it was first examined that it might be "some sort of test run" created by "someone who's learning how to make a bomb and will learn from what went wrong with this [one]." Apparently because it is difficult to buy explosive fertiliser, the bomber purchased the nonexploding kind instead. It is not clear why he didn't use dirt or dried figs for his explosive material, as these are cheaper, easier to find, and will fail to explode with same alacrity as nonexplosive fertiliser. He also threw in some gasoline—which doesn't explode, either, though it does burn—and some propane, which will explode only when it is mixed precisely with the right amount of air—the latter a bomb-design nicety he apparently never learned in his weeks of training (Mueller and Stewart 2011).

3.2 The Myth of the Mastermind

Arthur Conan Doyle invented Moriarty to give his hero, Sherlock Holmes, an opponent worthy of the efforts of the great, if equally imaginary, detective. The counterterrorism establishment has been similarly inclined—as have those responsible for producing such imaginative products as television's

24 and *Homeland*. Early on, officials even invited Hollywood scriptwriters to spin out tales of what the "universal adversary" out there might be up to. The enemy was assumed to be fully worthy of the stupendous and exceedingly expensive countering efforts being made.

Central to this exercise was the identification of a few evil "masterminds" who were dominating the show. Since it made for good copy, journalists helped spread the word.

Ramzi Yousef was primarily responsible for the February 1993 attack on the World Trade Center. Journalist Simon Reeve repeatedly uses the word 'mastermind' to describe him, as well as an "explosives genius," a "genius bomb maker," a "master of explosives," and an "evil genius" possessed of "an obscene brilliance as a terrorist" (Reeve 1999).

The praise seems to be excessive. As a bomb maker, Yousef was given to splashing acid in his face and starting fires that drew the police. His attack on the World Trade Center in early 1993 did manage to kill six people, but for the most part it was a tragicomedy of errors. Indeed, notes Kenney, one of his main collaborators "became the poster boy for 'stupid' terrorists" by repeatedly trying to claim a $400 refund on the van he and his fellow conspirators had just blown up in their failed effort to topple the Twin Towers: he needed the cash for a plane ticket to Jordan. Moreover, the bomb Yousef put together was not nearly big enough to topple the tower—which was his goal. Obviously, if he wanted simply to kill six people, there were much easier ways to do so.

After that venture, Yousef engaged in a wide variety of terrorist efforts before his arrest two years later. These resulted in the deaths of twenty-eight more people, all but two of these from a bomb he created on hire for an Iranian rebel group. Thus, an examination of his record as a terrorist during this period suggests a continuing propensity for viciousness, but scarcely genius or mastermindhood.

Working on building bigger and better bombs to place on some eleven U.S.-bound airliners (a plot he labelled "Bojinka"), Yousef and a friend (the sole members of what Yousef called a "Liberation Army") started a small fire in a cooking pot in his Manila apartment. Both men fled when firefighters arrived. After the police and firefighters left, Yousef persuaded his accomplice to go back to the apartment to remove files, books, manuals, and a computer, but the accomplice was arrested when the police returned with a search warrant. From the chemical-stained apartment, the police seized books, manuals, containers of sulphuric acid, wires, timing devices, Bibles, priests' garments, and a large photograph of Pope John Paul II, as well as a laptop containing plans for the Bojinka plot. Deleted files were still stored on the computer's hard drive.

Then, when he ordered another accomplice to take a mysterious parcel to a mosque in the Shiite sector of Islamabad, the terrified accomplice called the U.S. embassy in hopes of receiving the $2 million reward for Yousef's capture. Yousef was arrested, and the accomplice became rich.

Khalid Shaikh Mohammed, in addition to being the principal architect of the 9/11 attacks, apparently was the 'mastermind' behind dozens of other schemes. What is impressive is that, except for the Bali bombings, just about *all* of KSM's many schemes either failed or did not even begin to approach fruition. In addition, the role of the "mastermind" in the Bali case was simply to supply some money (McDermott and Meyer 2012). Overall, as a terrorism planner, KSM has a fertile mind but a feeble record of accomplishment, one characterised by fanciful scheming and stunted execution. In this context, 9/11 clearly stands out as an aberration.

3.3 Threat Likelihood

Stewart (2008, 2011) has suggested that the annual terrorist threat probability for large US commercial buildings (excluding government and military buildings) with greater than five stories is approximately 5.1×10^{-6}/building/year, for buildings subject to a non-specific threat. This level of threat was calculated from five attacks on an average of 108,000 large US commercial buildings across the period 1993 to 2001. It should be noted that this was a period of active terrorism in the US - these attacks included the World Trade Centre (1993) bombing, Oklahoma City (1995) bombing, and September 11 attacks (counted as three attacks on buildings). Ellingwood (2006) suggests that the threat probability may be increased to 10^{-4}/building/year for high density occupancies, infrastructure close to economic centres, key governmental and international institutions, monumental or iconic buildings or other critical facilities with a specific threat. It is notable that these annual threat probabilities cover the entire spectrum of plausible terrorist attacks, and will over-estimate actual threat likelihood due to a VBIED (vehicle borne improvised explosive device) attack.

Since 9/11, dozens of cases have come to light of Islamist extremist terrorism, whether based in the United States or abroad, in which the United States itself has been, or apparently has been, targeted (Mueller 2016). Eight of these cases, or just over one case every two years, involved planning to detonate a VBIED against a building. Targets included a Bronx Synagogue, a Dallas skyscraper, the Sears Tower in Chicago, Times Square, a military recruitment centre in Maryland, an Irish bar in Tampa, a Chicago bar, and the Wichita airport. Note that only one of the targets was a

large government building (Dallas), and only one threat resulted in an IED actually being built (Times Square).

According to the Global Terrorism Database, in the 14 year period 1998-2011 there were five bombing and shooting attacks on large airport terminals in Europe (one every 2 or 3 years), the same number of attacks in the Asia-Pacific area, and one in the U.S. If we assume there are 70-75 large airports in Europe and in the Asia-Pacific area, the probability an individual airport will be attacked is approximately 0.5% per year for each area. In the U.S. the attack probability is considerably lower at approximately 0.2% per year. Of the 11 attacks, most failed to inflict any casualties or significant damage at all; that is, the yearly likelihood an individual airport will be successfully attacked is lower by more than a half.

One study points out that the average number of fatalities from a truck bomb is 36 and that only 0.5 % of bomb attacks had more than 30 fatalities (Mueller and Stewart 2016).

Moreover, in many cases, target selection is effectively a random process, not one worked out with guile and careful planning. Often, it seems, targets have been chosen almost capriciously and simply for their convenience. Thus, a would-be bomber targeted a mall in Rockford, Illinois, in 2006 because it was nearby. Terrorist plotters from the "JIS" cult in Los Angeles in 2005 drew up a list of targets that were all within a twenty-mile radius of their shared apartment, some of which didn't exist. And one of the Boston Marathon bombers of 2013 lived within three miles of the attack. Or, there was the terrorist who, after several failed efforts, went home and, with no plan at all, shot at a military recruiting centre three miles from his apartment.

A shooting attack is much easier to accomplish because guns are generally easier to acquire and discharge than bombs. With the exception of the London, Madrid, and Brussels bombings, all deaths from terrorists in the West have resulted from shooting attacks. The ability of terrorists to acquire, place and successfully detonate a bomb is often lacking, and is borne out in the historical record.

4 VULNERABILITY

Grant and Stewart (2012) found that the likelihood that an IED attack will cause damage or casualties is approximately 15-20% for terrorists operating in Western countries. A more recent study considered the Global Terror Database (GTD) dataset for the US domestic and Western environments by considering how many IED Attacks were successful (caused >USD$1 million in economic damage and/or casualties) compared to how many IED Attacks were perpetrated in the period 1998 - 2008 (Grant and Stewart 2015). The dataset contained over 5,300 incidents of IED attack worldwide in the period 1998 - 2008, with 220 of these incidents involving significant building damage arising from a broad range of IED attacks, including Vehicle and Personnel Borne IEDs that were placed in and around buildings. Given that there was too much uncertainty in the dataset specifically relating to attacks aimed at causing significant building damage, the general figure across all IED attacks (of all sizes) for the US was used, and found to be 15% chance of a 'successful attack' (Grant and Stewart 2015). Note that this is lower than for the Western average of 23%. That is, IED attacks in the US are less likely to succeed than those in other areas in the Western world.

The likelihood that a one tonne or larger IED (which in all likelihood would be needed to cause progressive collapse) would successfully detonate, and reach maximum energetic output will be lower than 15%, particularly taking into account the difficulty of obtaining explosives and preparing them for maximum energetic output. This is particularly apt for "home made" Ammonium Nitrate Fuel Oil (ANFO). For example, Netherton and Stewart (2010) have found that ANFO has an energetic output typically less than that of the same mass of TNT. The explosive output of ANFO is also highly sensitive to mix proportions, and energetic output can reduce by 50% or more if mix ratio is not optimal, if poorly mixed, or if agricultural AN (fertiliser) is used instead of the mining variant.

The likelihood of progressive collapse will be very low. This is partly due to the large size of a VBIED necessary to cause progressive collapse, and also the robustness of many structures against progressive collapse. Damage to building facades is more likely, but this will result in far less casualties.

One of the largest VBIED attacks was on the U.S. Marines barracks in Beirut, Lebanon, in 1983, when a suicide bomber detonated a truck bomb containing more than 4,000 kg of TNT equivalent that caused a partial progressive collapse, killing 241 U.S. military personnel while wounding more than 100 others. A larger 9,000 kg VBIED attack on the Khobar Towers in Saudi Arabia in 1996 resulted in massive damage to the building killing 19 people, but there was no progressive collapse (Byfield 2006). The death toll in Khobar was lower due to the warning of a security guard which allowed some in the building to be evacuated prior to detonation.

A VBIED attack on the U.S. Embassy in Kenya in 1998 killed 213 people, including 44 American embassy personnel. Up to 1,000 kg of explosives were used. Although there was little structural

damage to the five-story reinforced-concrete embassy, the explosion reduced much of the interior to rubble, destroying windows, window frames, internal office partitions, and other fixtures on the building. It was secondary fragmentation from flying glass, internal concrete-block walls, furniture, and fixtures that caused most of the embassy casualties. The majority of the casualties, however, resulted from the collapse of an adjacent building and from flying glass from other buildings located within a two- to three-block radius.

In 1993, six people were killed when a van containing 600 kg of explosives was driven into an underground car park at the World Trade Center in New York and then detonated, carving out a crater of nearly 30 m that was several stories deep and several more high. The 1995 Oklahoma City bombing resulted from a VBIED of approximately 1,000 kg of TNT equivalent, in which partial progressive collapse killed 165 people. The 2011 bombing of a Norwegian government building was a VBIED reportedly carrying 100 kg of ANFO. No major structural damage was reported. Large truck bombs detonated in London by the IRA in 1992, 1993 and 1996, reputedly up to 1 tonne of ANFO, damaged many buildings, but no major structural damage was reported.

The evidence to date shows, then, that no modern or well-designed tall or large building has fully collapsed as a result of an VBIED; the 4,000 kg truck bomb on the Marine Barracks in Beirut in 1983, and the several tonne truck bomb in Oklahoma City in 1995 caused only partial progressive collapse. Moreover, experience in the UK shows that intense blast loadings cause little structural damage to reinforced concrete (RC) or steel framed buildings designed to modern codes. Most damage occurs to the building facade, particularly glazed areas (Smith and Rose 2002). This is not to say, though, that blast loadings cannot cause severe structural damage, such as that experienced by the Murrah Building in Oklahoma City. However, in this case, partial collapse of the building was caused by disintegration of a critical column causing progressive collapse. If the building had been designed as a Special Moment Frame for earthquake design then loss of floor area would have been reduced by between 50-80% (Corley, et al. 1998). Damage to the Pentagon on September 11 2001 was contained by the structures' robustness to progressive collapse, namely, its continuity, redundancy and energy-absorbing capacity (ASCE 2003). Because of this, progressive collapse provisions are now being incorporated into US design codes (UFC 4-020-01, GSA 2013). However, with the exception of extraordinarily large blasts, a moment resisting RC or structural steel frame designed and detailed for alternative load paths should provide significant structural resistance to prevent collapse (Grant and Stewart 2015). This is confirmed by Song and Sezen (2013) and Sezen et al. (2014) where columns were removed from soon to be demolished steel framed buildings without causing progressive collapse.

This is an important observation because it follows that it is very difficult for a single VBIED, even one as massive as the ones in Beirut and Khobar, to totally destroy a properly designed and engineered multistorey building normally comprised of structural steel and reinforced concrete floors, beams, and columns. Nearly all properly engineered buildings show an ability to absorb extraordinary blasts and have significant reserve capacity. Therefore, it is very difficult (and very rare) indeed to "destroy" a building. This also helps explain why there is more terrorist devastation in Iraq, Afghanistan, and Pakistan: many buildings are made of unreinforced masonry or inadequate construction quality, which is more vulnerable to explosive blast loading, just as it is to earthquakes and other natural hazards (Stewart 2012, Mueller and Stewart 2011). Given a typical attack, the probability of progressive collapse is very low indeed.

5 CONSEQUENCES

The probability that an individual will be killed in a damaged building is, in most cases, quite low. Stewart (2010) showed this probability to be 0.03% for the World Trade Center bombing in 1993, 45.1% for the 1995 Oklahoma City bombing, 6.9% for the 2001 World Trade Center attacks, and 0.8% for the 2001 attack on the Pentagon.

Loss comprises of (i) direct costs including loss of life and physical damage, (ii) indirect costs such as business losses, loss of tourism, reduction in GDP, etc., and (iii) social losses is the effect of the level of fear and anxiety within society (and perhaps on civil liberties). The losses are interconnected, for example, a fearful public may be reluctant to travel and so contribute to business and tourism losses, or may be reluctant to invest. People often effectively place a higher value on a life lost to terrorism than on one lost to more mundane and less sensational hazards (Mueller and Stewart 2011). A value of statistical life (VSL) approach concluded that the best estimate is about $7.5 million in 2015 dollars (Robinson et al. 2010). Most VSL studies focus on relatively common risks (e.g., workplace or motor vehicle accidents), and Robinson et al. (2010) suggests that "more involuntary, uncontrollable, and dread risks may be assigned a value that is perhaps twice that of more familiar risks," a process that essentially adds into the analysis much of the substantial indirect and ancillary

costs associated with a terrorist event. The differentiation between direct, indirect, and social losses is less precise, hence, aggregate losses presented in this section tend to err on the conservative side by placing a high premium on indirect and social losses as “increased fear and anxiety within society may be one of the most important consequences of terrorist attacks” (Robinson, et al. 2010).

Losses from VBIED attacks on the World Trade Center in 1993, and Oklahoma City in 1995 come to several billion dollars. It is important to stress, however, that very few terrorist attacks exact damage on the scale of these. Analysis of the GTD shows that of 219 terrorist incidents in the U.K. involving explosives, only two inflicted damage that the GTD considered “catastrophic” - a bombing in London that killed three people in 1992 and the 1993 London financial area bombing, each causing losses of $1 to 2 billion (Stewart and Mueller 2011).

The 2001 attack on the Pentagon resulted in repair costs of $500 million, compensating the families of the 184 victims reached $1.2 billion, and when additional costs of social and business disruptions, loss of tourism, etc, are included the total loss approaches $10 billion (Mueller and Stewart 2011). The 2001 attacks on the World Trade Center caused close to $200 billion in total losses including $20 billion for loss of life, $30 billion in direct physical damage including rescue and clean-up costs, and social and indirect losses to the economy reaching up to $140 billion due to people’s reluctance to travel, invest, feeling confident about the future, and other risk-averse behaviour (Mueller and Stewart 2011). These attacks, however, represent very much an outlier of losses from terrorism. Scarcely any terrorist attack before or after, in war zones or outside, has inflicted even one-tenth as much damage.

The fatalities per terrorist attack for the 1968-2009 period and for various regions around the world from the RAND Database are shown in Figure 1. The number of attacks that have killed more than one or two people in North America and Europe is low, while the threat environment is more dire in other regions. Yet, although Southeast Asia and Oceania suffer more frequent attacks, few of these kill more than three people. As we would expect, attacks in the Middle East and Persian Gulf are the most deadly, with 511 attacks killing 10 to 50 people, and 65 attacks killing 50 to 500 people. The worst attack, the second largest in history, killed nearly 800 people in a poor rural area Iraq in 2007, when four truck bombs were detonated in two towns in Yazidi.

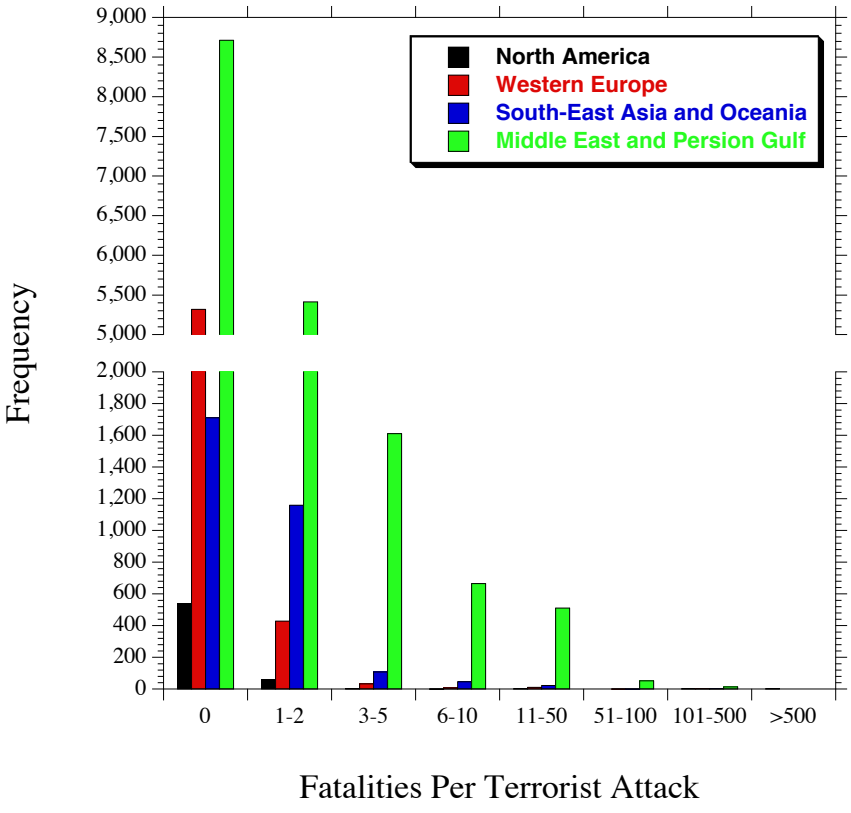

Figure 1: Frequency of Fatalities per Terrorist Attack, 1968–2009.
Source: RAND Database of Worldwide Terrorism Incidents

Terrorism inflicts not only casualties and human suffering but economic loss as well. In addition to direct physical damage, economic costs can arise from drops in tourism, business, or other economic activity, and these losses can be considerable.

The GTD provides estimates of property damage that has been inflation-adjusted to 2014 dollars. We then add to this Robinson's value of life of $7.5 million for each fatality, and estimate other indirect losses, such as loss of tourism and loss of GDP, to arrive at a total loss for each large terrorist attack in the GTD for the United States and the United Kingdom. A summary of total losses for such attacks is shown in Table 1.

Country	Location	Year	Fatalities[1]	Total Economic Loss
UNITED STATES				
LaGuardia Airport Bombing	New York	1975	11	$250 million
World Trade Center	New York	1993	6	$1 billion
Murrah Federal Building	Oklahoma City	1995	168	$3 billion
9/11: World Trade Center	New York	2001	2,751	$180 billion
9/11: Pentagon	Washington	2001	184	$10 billion
9/11: UA Flight 93	Pennsylvania	2001	40	$5 billion
Anthrax Postal Attacks	-	2001	5	$6 billion
Fort Hood Shooting	Texas	2009	13	$100 million
Boston Marathon Bombing	Boston	2013	4	$500 million
San Bernardino	California	2015	14	$100 million
UNITED KINGDOM				
Pub Bombings	Birmingham	1974	21	$200 million
Omagh Bombing	Omagh	1998	28	$250 million
Pan Am Flight 103	Lockerbie	1988	270	$3 billion
Baltic Exchange Bombing	London	1992	3	$4 billion
Bishopgate Bombing	London	1993	1	$3 billion
Shankill Road Bombing	Belfast	1993	9	$150 million
Manchester City Bombing	Manchester	1996	0	$1.5 billion
Kings Cross Station	London	2005	27	$1 billion
Tavistock Square	London	2005	14	$1 billion
Liverpool Street Station	London	2005	8	$1 billion
Edgeware Road Station	London	2005	7	$1 billion

[1] Global Terrorism Database.

Table 1: Total Economic Loss, Including Loss of Life, for Large Terrorist Attacks in the United States and the United Kingdom.

Figure 2 shows that the total loss is generally less than $1 million for the average terrorist attack in the United States, while catastrophic damage in excess of $1 billion is limited to a few isolated instances. And while any death is tragic, the most likely outcome from a deadly terrorist attack is one or perhaps two fatalities. The average loss per successful attack in the United States is skewed to a high $400 million, owing to the large influence of the 9/11 attacks on the average, but it is only $10 million if we omit the 9/11 attacks. For the United Kingdom, the mean loss is around $20 million per attack, which increases to $50 million if we exclude Northern Ireland from the calculations

For more details see Mueller and Stewart (2011, 2016).

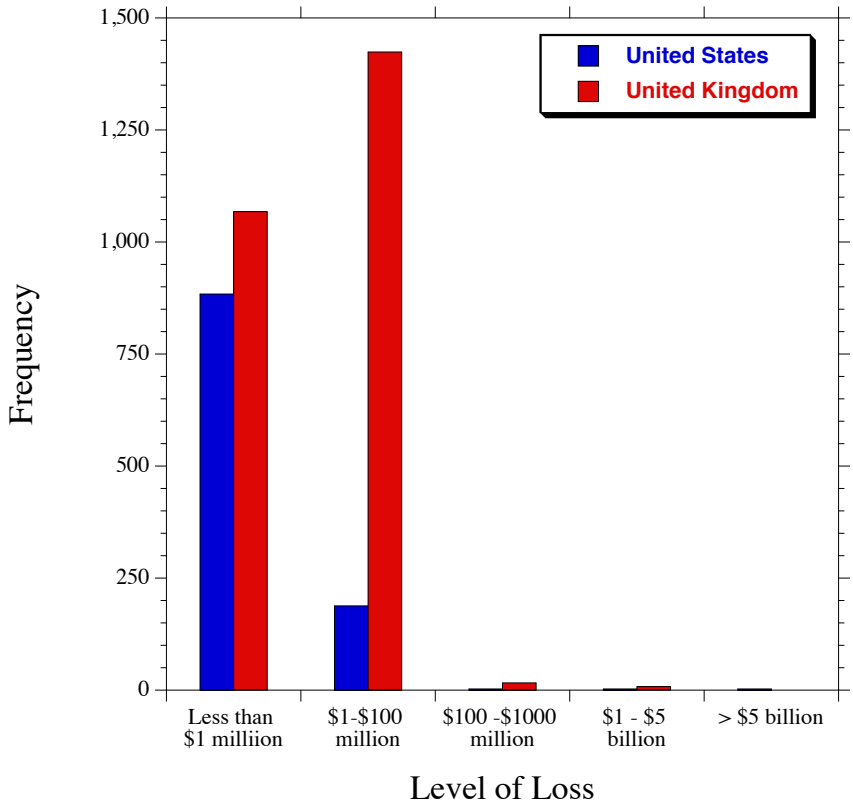

Figure 2: Total Losses, 1970–2013, for the United States and the United Kingdom.

6 TERRORISM AS A RISK TO HUMAN LIFE

The consensus risk acceptance criteria for involuntary fatality risk to an individual is that annual fatality risks for a hazard that are smaller than one in a million are deemed to be acceptable or at least tolerable, and further regulation is generally not warranted (Stewart and Melchers 1997, Mueller and Stewart 2011, 2016). These considerations, substantially accepted for years, even decades, by public regulatory agencies after extensive evaluation and considerable debate and public discussion, are designed to provide a viable, if somewhat rough guideline for public policy. Clearly, hazards that fall into the unacceptable range (traffic accidents, for example) should generally command the most attention and the most resources, while those hazards in the acceptable range would generally be deemed of far less concern—that is, they are risks we can live with—and further precautions would scarcely be worth pursuing unless they are quite remarkably inexpensive.

Overall, then, it is clear that governments have been able to set out, and agree upon, risk-acceptance criteria for use in decision making in regard to a wide variety of hazards, including ones that are highly controversial and emotive, such as pollution, nuclear and chemical power plant accidents, and public exposure to nuclear radiation and environmental carcinogens.

The annual fatality risks from terrorism in the developed world are, in almost all cases, less than one in 1 million per year. For the United States from 1970 through 2015 (which includes, of course, the 9/11 attacks), they are one in 4 million per year. For the period from 2002 through 2015, they are one in 90 million per year. Even including the 2015 attacks in Paris, the annual fatality risk in France is one in 5.5 million for the period 2002 to 2015. For Australia the risks are lower, at one in 8 million from 1970 through 2015 if one includes the Bali attacks; removing the Bali attacks from the count and considering post-9/11 attacks only reduces the annual fatality risks for Australians to one in 55 million in the years since 2002. The annual fatality risks from terrorism of all kinds in the developed world are a thousand times lower than the current murder rate. The odds of being killed in a traffic accident are 4,000 times higher than perishing from a terrorist attack.

Applying conventional standards, then, under current conditions terrorism presents a threat to human life in the Western world that is, in general, acceptable. And efforts, particularly expensive ones, to further reduce its likelihood or consequences are scarcely justified Indeed, a legitimate policy

consideration might be to wonder whether expenditures designed to keep the terrorism risk that low have been excessive, and whether some of them might be better focused on dealing with hazards with higher risk. Ignoring this policy option comes at the expense of considerable opportunity costs.

Finally, in the post-9/11 threat environment, nearly 80% of Islamist threats against the United States involved the planned use of explosives. Yet, as noted, successful attacks generally use guns as the means to kill victims. Protective structures have had little or no effect on reducing the terrorism risks to human life in the Western World. Moreover, most attacks involving explosives have taken place inside of buildings, trains or buses, not outside of them. It could be argued that they may have had a deterrent effect of course, but there is little evidence to support this.

7 DISCUSSION

Some organisations, such as the US Department of Homeland Security, tend to be more risk averse because of the emotional and controversial nature of terror attacks (Mueller and Stewart 2011, 2016). However, these should in principle be treated no differently than other man-induced threats – like those related to nuclear power – in terms of risk aversion, public policy etc. Reducing the annual probability of threat would be the most effective countermeasure to reducing the effects of VBIED attacks upon buildings. Mueller and Stewart (2011) conclude that protecting against essentially random conventional terrorist attacks is futile; and that only target sets with quite large physical, economic, psychological and/or political consequences warrant specific protective measures. Infrastructure protective measures are only the 'last line of defence'. The Federal Bureau of Investigation (FBI) and other police and intelligence services (and tip-offs from the public) are responsible for foiling or preventing most terrorist plots (Mueller and Stewart 2014, 2016). Spending on policing and intelligence measures (such as the FBI) to warn or prevent terrorist attacks is likely to be the more cost-effective countermeasure as this would have the greatest impact on the threat probability for buildings (Mueller and Stewart 2011, 2014, 2016).

Other terrorist threats to buildings may have higher likelihoods. These include, shooter attacks, detonating IEDs inside a building, or glazing and facade damage from a range of IEDs. In most cases, most casualties will result from exposure to blast overpressure (lung rupture, whole body displacement, or skull fracture), and debris or fragmentation (primary debris from the device itself, secondary debris from non-structural building components such as glazing, cladding and fencing, and crater ejecta). If progressive collapse is avoided, as it nearly always is, casualties seldom result from structural (load carrying capacity) damage to buildings. On the other hand, designing against progressive collapse may improve building robustness against seismic, vehicle impact or other hazards. Such a co-benefit may add to the benefit side of the ledger, thus improving the cost-effectiveness of protective measures to prevent progressive collapse.

This assessment has been heavily reliant upon historical open-source data and as a result it has not been possible to consider all of the complexities associated with VBIED attacks upon buildings. One significant reason for this is the low frequency of terrorist incidents in Western countries that cause significant damage to buildings. It is entirely possible that threat, vulnerability and loss probabilities could change significantly as a result of a series of large-scale, well designed and planned terror events. Or perhaps more likely, the catastrophic attacks on September 11 2001 were an aberration rather than a harbinger of things to come, as evidenced by the low incidence of terrorist attacks in the U.S. since 9/11. However, although there is no guarantee that the terrorism frequencies of the past will necessarily persist into the future. To date, there is little evidence that terrorists are becoming any more destructive, particularly in the West, and that the terrorist attacks to most fear are ones that are on a smaller scale (Mueller and Stewart 2012, 2016). These can inflict painful losses, of course, as in the attacks on Paris in 2015. But even if they do occur, they will not change the overall risk very much, and one attack is not necessarily an indicator of more to come. Those who wish to discount such arguments and projections need to demonstrate why they think terrorists will become more capable and inflict increased violence, and visiting savage discontinuities on the historical data series.

8 CONCLUSIONS

It has essentially become officially accepted that the likelihood of a large-scale organised attack like 9/11 has declined, and that the terrorist attacks to most fear in the developed world are ones that are on a smaller scale. These can still inflict tragic losses. But even if they do occur, they will not change the overall fatality risk very much, and one attack is not necessarily an indicator of more to come. In the aftermath of the Madrid and London train bombings in 2004 and 2005 there was much speculation that these attacks heralded a start of a new terror campaign. Ten years on, no successful

attacks eventuated in these countries. In the past decade most deaths from terrorists in the West have arisen from shooting attacks, and not from the bombs. In this case, there is little or no need to protect civilian buildings, bridges and other infrastructure from bombs. Existing infrastructure has been proven to be highly resilient and robust against bombs, and progressive collapse is an extremely rare event. There may be increased need for protective structures for iconic or monumental buildings, embassies, or other infrastructure which serves an important government, military or national security role. However, these comprise a very small sub-set of existing infrastructure, and in most cases, are already sufficiently protected.

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