# Has Successful Terror Gone to Ground?

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This article considers all 87 attacks worldwide against air and rail transport systems that killed at least two passengers over the 30-year period of 1982–2011. The data offer strong and statistically significant evidence that successful acts of terror have "gone to ground" in recent years: attacks against aviation were concentrated early in the three decades studied whereas those against rail were concentrated later. Recent data are used to make estimates of absolute and comparative risk for frequent flyers and subway/rail commuters. Point estimates in the "*status quo*" case imply that mortality risk from successful acts of terror was very low on both modes of transportation and that, whereas risk per trip is higher for air travelers than subway/rail commuters, the rail commuters experience greater risk per year than the frequent flyers.

**KEY WORDS:** Passenger death risk; terrorism; transportation safety

## 1. INTRODUCTION

In a 2004 article, Martonosi and Barnett[1] argued that the terrorist obsession with aviation long preceded the 9/11 attacks. We focused on the period of 1968 to September 10, 2001, and estimated that U.S. air travel within the United States entailed a greater risk of falling victim to an act of terror than virtually any other activity. Recently, however, many of the most publicized acts of terror have taken place on subways, commuter trains, and long-distance rail services. This apparent shift raises the question of whether successful terror against transportation systems has "gone to ground" since the September 11 attacks against aviation.

This article attempts to go beyond general impressions to review the recent data more systematically. Considering all 87 fatal attacks against air/rail systems around the world over the years 1982–2011 that killed at least two passengers, we assess the strength of evidence that successful air and rail terrorism have followed opposite time trends over that period. Then we consider the absolute and comparative mortality risk that criminal/terrorist acts pose to air and rail passengers in the developed world, using recent data for "snapshot" calculations and other projections. We emphasize subway/rail commuters (as opposed to long-distance rail travelers) in the calculations about railroad passengers.

## 2. SOME PRELIMINARIES

This article concerns *successful* acts of terror against air and rail passengers. We define "terror" to comprise all deliberate acts that cause multiple deaths to passengers. Worldwide, there were 87 such acts over the 30-year period of 1982–2011. Most such acts have political motivation, but not all. In 1987, for example, a disgruntled airline employee shot his supervisor and then the cockpit crew of a Pacific Southwest Airlines jet in California, causing a crash that killed everyone aboard. We classify that crime as an act of terror and include it among the events we consider here.

We apply this broader definition of terror for three reasons. Foremost is the belief that successful acts of multiple homicide are inherently terrifying, and that potential passengers feel no less unnerved

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because the act was directed at (say) the transport company rather than the government. Furthermore, it is not always clear where an attack falls on the spectrum between political terror and apolitical violence.[1] Finally, successful attacks with no links to politics reveal vulnerabilities that political terrorists could try to exploit in the future, making them relevant to assessments about future political terror. In Appendix A, however, we replicate some of our calculations using a narrower definition of acts of terror.

Some further conventions in this analysis are as follows.

- The calculations do not include deaths to third parties who were not passengers (although we will discuss the attack of September 11, 2001, which caused nearly 2,800 deaths on the ground). Passengers who were killed in airports or railroad stations are included in death tolls.
- Events in which a passenger plane was mistakenly shot down by military sources unaware of the plane's identity are also not included.
- When a terrorist event consists of several simultaneous acts (e.g., 10 separate explosions in 2004 on four Madrid commuter trains), we count it once in tallies about the number of fatal attacks.

## 3. COUNTS OF EVENTS AND FATALITIES

As noted, we analyze data concerning all successful acts of terror worldwide over the 30-year period of 1982–2011. There were a total of 87 such acts. (Under the definition of "successful," we do not consider attempts to cause harm that either failed or caused at most one passenger death.) To offer an overview of the key patterns, Table I summarizes passenger deaths in terror attacks against aviation and railroads, in three successive decades: 1982–1991, 1992–2001, and 2002–2011. The table further breaks down rail victims into subway/rail commuters and long-distance travelers. Table I makes it clear that aviation deaths dropped steadily over these decades, whereas deaths on railroads increased steadily. Between 1982–1991 and 2002–2011, the number of air travelers killed in acts of terror fell by a factor of seven, whereas rail deaths increased over that period

[1]For example, there is controversy about whether a 1995 sarin gas attack against the Tokyo subway was an act of religious fanaticism or an attempt to bring down the government.

**Table I.** Worldwide Passengers Killed in Acts of Terror Against Railroads and Aviation, 1982–2011

| Period | Aviation | Rail | | |
| | | Subway/ Commuter | Long Distance | Rail Total |
| --- | --- | --- | --- | --- |
| 1982–1991 | 1,367 | 0 | 161 | 161 |
| 1992–2001 | 759 | 127 | 361 | 488 |
| 2002–2011 | 206 | 906 | 425 | 1,331 |

*Note*: Includes passenger deaths on 9/11/01 but not other deaths.

**Table II.** Successful Acts of Terror Worldwide against Air/Rail Systems, 1982–2011

| Period | Number of Events | % Against Aviation | Total Passenger Death Toll |
| --- | --- | --- | --- |
| 1982–1991 | 27 | 63.0 | 1,528 |
| 1992–2001 | 28 | 28.6 | 1,247 |
| 2002–2011 | 32 | 9.4 | 1,537 |

by a factor of seven. The increase was especially dramatic for subway/rail commuters.

Table II reports the total number of fatal attacks against air/rail over the three decades, as well as combined death tolls for each period. The table is striking in the constancy that it depicts: the total number of events showed scant variation from decade to decade, as did the total passenger death toll. However, the percentage of fatal attacks with aviation targets dropped sharply over the period. Tables I and II suggest a purely arithmetical rule of thumb: each fewer death in aviation over time was concurrent with roughly one additional death on the railroads. this negative correlation, however, does not demonstrate a causal pattern in which individual criminals and terrorists shifted the venue for attacks from air to rail.

### 3.1 A Test of Statistical Significance

Are the temporal shifts summarized in Tables I and II statistically significant? More precisely, are the data inconsistent with the hypothesis that the time distributions of events for air and rail arose from a common probability distribution? In this setting, it is natural to perform a one-sided rank-sum test of the null hypothesis $H_0$ that follows:

$H_0$: The data about the timing of air attacks and of rail attacks over 1982–2011 constitute two independent random samples from a common temporal distribution against the alternative $H_a$:

$H_a$: The temporal distribution of rail attacks over 1982–2011 is shifted to the right of the period 1982–2011 (i.e., toward the end) relative to the temporal distribution of air attacks.

Such a test does not depend on partitioning the period into subperiods like decades, and it would explore whether random fluctuations might explain a tendency of rail events to gravitate toward the end of the pooled ranked sample.

When such a test is performed—with the first event in August 1982 getting the rank 1 and the last in April 2011 getting 87—the results are decisive. The rank sum for the 28 events against aviation is 4.04 standard deviations below its expected value under $H_0$ (reflecting their intense concentration toward the start of the period). The one-sided $p$-value of the outcome is 0.00003. (The corresponding two-sided $p$-value is 0.00006.) At any familiar threshold of significance, therefore, the timing of fatal attacks against aviation and railroads diverge to a statistically significant extent. This divergence does not prove that successful terror plots shifted over time from aviation to railroads, but it does imply that speaking about opposite time trends is not merely capitalizing on chance fluctuations.

## 4. SOME RISK PROJECTIONS FOR AIR AND RAIL TRAVELERS

### 4.1. A "*Status Quo*" Projection

But what do the statistics in Tables I and II suggest about the risks to individual travelers? To illustrate the risk implications of the data about successful attacks, we first make a "snapshot" estimate of the mortality risk caused to travelers by acts of terror against air and rail travelers. This snapshot estimate effectively assumes that recent patterns will persist in the immediate future. We would stress that we are *not* forecasting that recent patterns will continue, but simply suggesting what those patterns imply. In the same way, a life-expectancy projection does not insist that no future progress will be made in cancer research; rather, it offers a "*status quo*"

**Table III.** Passengers Killed in Acts of Terror Against Railroads and Aviation in the Developed World, 1982–2011

| Period | Aviation | Rail | | |
| --- | --- | --- | --- | --- |
| | | Subway/ Commuter | Long Distance | Rail Total |
| 1982–1991 | 593 | 0 | 29 | 29 |
| 1992–2001 | 332 | 27 | 0 | 27 |
| 2002–2011 | 0 | 442 | 0 | 442 |
| Total | 925 | 469 | 29 | 498 |

*Note:* Includes passenger deaths on 9/11/01 but not other deaths.

projection that is construed as a baseline tied to patterns that prevail now.

We restrict the estimation to the developed world and to two groups of travelers: (i) frequent flyers and (ii) subway/rail commuters. By the developed world, we mean the traditional first-world countries in North America (Canada and the United States), western Europe, Oceania (Australia and New Zealand), and Asia (Japan and Israel), as well as other countries that now meet first-world standards of both life expectancy and gross domestic product per capita (e.g., Singapore, South Korea). More specifically, we include all 30 countries that World Health Organization statistics show had life expectancies of at least 80 years and that International Monetary Fund statistics show had GDP per capita of at least $20,175 in 2012. We use these thresholds because they are the lower bounds in 2012 for the traditional first-world countries (Denmark has lowest life expectancy, whereas Portugal had lowest GDP per capita). All 30 developed world countries are listed in Appendix A.

We limit attention to the developed world for two reasons, one of which is purely practical: statistics about air and (especially) rail passenger traffic are often missing or unreliable in developing countries. Even in the developed world, statistics about subway/rail commuters are more detailed than those about long-distance rail travelers. It follows that the most trustworthy risk analyses concern subway/commuter rail (hereafter SCR) and aviation systems in the developed world. We refer to Table III, the analog for the developed world of Table I.

The second reason is that countries in the developed world form a fairly homogeneous group, both on general criteria and on involvement in rail and aviation terror. Such terror has struck even such generally placid countries as Canada and Japan,

**Table IV.** Successful Acts of Terror Worldwide Against Air/Rail Systems in the Developed World, 1982–2011

| Period | Number of Events | % Against Aviation | Total Passenger Death Toll |
|---|---|---|---|
| 1982–1991 | 12 | 75 | 622 |
| 1992–2001 | 6 | 50 | 359 |
| 2002–2011 | 4 | 0 | 442 |

and yet has not been especially common even in Israel, which until recently suffered greatly from other forms of terror. At the same time, the risk posed by air/rail terror to developed world citizens has been less than that experienced in Russia, with its separatist movements, and in India, with its intense sectarian tensions between Hindus and Muslims. That circumstance illustrates the point that, in making risk estimates in developed nations, it is hazardous to move outside the developed world (except in contemplating worst-case scenarios).

To estimate the death risks posed to air and rail passengers by criminal/terrorist acts, we need to contrast death counts with measures of total exposure to risk, like passenger counts or passenger-miles traveled. We consider four distinct risk metrics:

- death risk per trip;
- death risk per hour of exposure;
- death risk per mile traveled; and
- death risk per year.

We will provide risk estimates for subway/rail commuters and frequent flyers for all four of these metrics, but will argue that that "risk per trip" and "risk per year" are the most illuminating.

### 4.1.1. Assumptions for a "Status Quo" Risk Projection in the Developed World

- An average of approximately 47 passenger deaths per year will occur on SCR/aviation systems because of acts of terror in the developed world.

Table IV shows that, from 1982 to 2011, there were a total of 1,423 SCR/aviation deaths in the developed world, which averages to 47 deaths per year. Moreover, that number was fairly stable over the period. We therefore use 47 as the baseline level of combined air/SCR deaths per year.

- Approximately 60% of these annual air/rail passenger deaths will occur on SCR systems and 40% in aviation networks.

From 1982 to 2011, 66% of the SCR/aviation passenger deaths in acts of terror in the developed world occurred in airports or airplanes. However, the time trend in the developed world has moved very sharply toward SCR over that period. For a baseline calculation, we will weigh the proportion of these deaths on SCR in the ratio 4:2:1 in reverse chronological order for the three decades starting with 1982–1991 (i.e., the weight given to 1992–2001 is 2/7). Doing so yields a weighted average of 59.3% SCR, which we round off to 60%.

To complete the projections consistent with these assumptions, we use the following parameter estimates.

In the immediate future in the developed world:

- There will be approximately 1.4 billion air passengers and 52 billion passengers on SCR per year.

Around 2011, data collected by the World Bank show about 1.4 billion annual passengers trips by air in the developed world (hereafter DW), a figure that is relatively stable (as opposed to sharp annual growth outside the DW). Determining how many annual passengers use SCR in the DW is less straightforward. The number of yearly travelers on DW subway systems is approximately 22 billion. Finding the number of railway commuters, however, is more difficult because routine statistics about railway usage do not partition passengers between commuters (or, more precisely, users of commuter trains) and long-distance travelers.

To estimate numbers of rail commuters, one must sift through various documents that offer statistics about individual regions. A report about Europe[2] included the statement that "the passengers on regional or commuter trips represent by far the biggest share of all rail trips in Europe: they account for about 90% out of the total number of rail passengers (including long distance trips) and 50% of the total number of passenger kilometers per year." One can similarly deduce that commuter trains carry 94% of U.S. rail passengers (approximately 470 of 500 million), and an even greater share of Australian passengers. The statistic for Japan is especially important because Japanese railroads carry as many passengers than all other railroads in the developed world combined.[3] Here, we estimate that

90% of the 22 billion annual rail passengers in Japan use commuter trains, adopting the European figure because Japan, like Europe, has many commuters but also a well-developed network of long-distance trains. When the tabulations are complete, we reach the estimate of 30 billion DW rail commuters per year in the DW. Adding this number to the 22 billion subway passengers, we reach a DW total of 52 billion SCR passengers. We assume that figure will continue to apply in the near future.

- The average trip on SCR will be 10 miles long and have duration of one-half hour.

It is hard to find statistics for average trip length or duration on subway/commuter rail (though individual data points do arise, such as the average trip distance on commuter trains of 23 miles in the United States and 10 in Europe). For subway/rail (SCR), we might assume an average trip duration of 30 minutes and distance of 10 miles. The rough statistics seem adequate because comparing "risk per mile" or "risk per hour" for SCR and air is of limited relevance when neither form of transportation can serve as substitute for the other.

- The average air journey will cover 1,000 miles and take five hours. These five hours include time not just in flight but also in the airport of origin, the destination airport, and the intermediate airport if the passenger made a connection.

Mean trip distance in the United States is close to 1,000 miles and, following Martonosi and Barnett,[1] we estimate trip duration of five hours from arrival at the airport of origin to departure from the destination airport. (This statistic includes connection times at hub airports for about 40% of trips.)

- The SCR commuter will make an average of 600 one-way SCR trips per year, whereas the frequent flyer will on average make 20 one-way air journeys per year.

If an SCR commuter uses the train for weekday round trips between home and work each day, that is 10 one-way trips per week and—assuming some vacation—roughly 500 trips per year. However, it seems plausible that the commuter also takes some leisure SCR trips: in New York City, for example, the subway carries 5 million passengers over the weekend, which is about the same as the number of passengers on a weekday (i.e., the weekend total is 20%

of the weekday total). To account for leisure trips, we raise the work-related figure here by 20%, which brings it to 600.

The advertiser Arbitron did a survey of U.S. frequent flyers in 2010, which it defined as those travelers who made at least four trips by air during a year.[4] (About 7% of U.S. air travelers meet that criterion.) The mean number of trips per year among frequent flyers in its survey was 9.12. Similarly, an affiliate of Airlines for America offered the statistic that U.S. frequent flyers (defined the same way) take an average of 8.84 trips per year.[5] These trips are generally "home-away-home," which usually means a round trip and thus 18 one-way trips. However, because a minority of trips involve more than two legs, we assume 20 one-way trips per year. We are also assuming that the pattern in the United States approximates that throughout the DW.

*4.1.2. Results*

The risk calculations are straightforward and linear, as we illustrate by presenting some formulas for SCR commuters. If there are $d_{SC}$ terror deaths per year on first-world SCR among $Q_{SC}$ annual passengers, then a reasonable estimate of $\varepsilon_{SC}$, the passenger death risk per SCR trip, would follow:

$$\varepsilon_{SC} = d_{SC}/Q_{SC}.$$

Analogous formulas arise for death risk per hour and death risk per mile.

Assuming that each trip independently presents a risk of $\varepsilon_{SC}$, then the annual risk $R_{SC}$ for a SCR passenger who takes $N$ trips per year would follow:

$$R_{SC} = 1 - (1 - \varepsilon_{SC})^N.$$

If $N\varepsilon_{SC}$ is very small, we can invoke the approximation $(1 - \varepsilon_{SC})^N \approx 1 - N\varepsilon_{SC}$ to write:

$$R_{SC} = 1 - (1 - \varepsilon_{SC})^N \approx 1 - (1 - N\varepsilon_{SC}) = N\varepsilon_{SC}.$$

For an SCR commuter, we are assuming $d_{SC} = 47 \times 0.6 = 28.2$, $Q_{SC} = 52$ billion, and $N = 600$. These numbers and others mentioned above (including those for frequent flyers) yield the point estimates of risk that appear in Table V.

Because the measurements in Table V are expressed in billionths, all its numbers imply exceedingly low levels of risk. The highest entry—325 per billion—means that recent data suggest that an SCR commuter in the DW has an annual risk below one in 3 million of perishing in an act of terror. In contrast, the chance of dying per year in a workplace accident

**Table V.** Estimated Mortality Risk from Acts of Terror for SCR Commuters and Frequent Flyers in the Developed World, Under "*Status Quo*" Projections

| Risk Metric | SCR Commuters | Frequent Flyers |
|---|---|---|
| Per trip | 0.6 (billionths) | 13.4 |
| Per hour | 1.0 | 2.6 |
| Per mile | 0.06 | 0.013 |
| Per year | 326 | 269 |

**Table VI.** Deaths from Accidents and Terror Attacks Among Subway Commuter Rail Passengers, Developed World 1982–2011

| Period | Accidents | Terror | % Terror |
|---|---|---|---|
| 1982–1991 | 167 | 0 | 0 |
| 1992–2001 | 43 | 27 | 38.6 |
| 2002–2011 | 197 | 442 | 69.2 |
| Total | 407 | 469 | 53.5 |

**Table VII.** Passenger Deaths from Accidents and Terror Attacks on DW Airlines, 1982–2011

| Period | Accidents | Terror | % Terror |
|---|---|---|---|
| 1982–1991 | 2,433 | 593 | 19.6 |
| 1992–2001 | 1,909 | 332 | 14.8 |
| 2002–2011 | 666 | 0 | 0 |
| Total | 5,008 | 925 | 15.6 |

is about one in 31,000 in the United States, nearly 100 times as high. This estimate is based on 2012 data from the U.S. Bureau of Labor Statistics that show 4,628 "fatal work injuries" among 142 million people in the U.S. workforce[6] National Safety Council data show that American SCR commuters and frequent flyers face lower annual death risks from acts of terror than from a huge variety of hazards, which include falls from ladders and contact with "hornets, wasps, and bees."

It is natural to compare the death tolls among SCR and air passengers caused by acts of terror with those caused by air/rail accidents. Tables VI and VII summarize the relevant data, and show that accidents were consistently responsible for at least four times as many deaths in DW aviation as deliberate acts. In SCR operations, however, the two sources of risk accounted for approximately equal numbers of deaths from 1982 to 2011. In the most recent decade, more than two-thirds of the fatalities arose from acts of terror.

As for SCR/frequent flyer comparisons, metrics like risk per hour and risk per mile traveled are of limited interest because there are no journeys when passengers actually choose between commuter trains and airplanes. "Risk per trip" and "risk per year" are more plausible bases for comparison. Table V implies that death risk per trip is about 22 times as high under the "*status quo*" assumptions for frequent flyers as for SCR commuters. That outcome arises because, while 60% of SCR/aviation deaths per year are attributed to rail systems, 37 times as many passenger trips take place on subway/commuter rail as on airplanes. However, Table III also implies SCR commuters face approximately 1.2 times the annual risk of frequent flyers because they take roughly 30 times as many trips per year (600/20).

Is "risk per trip" or "risk per year" the more germane comparative statistic? The author would give greater weight to annual risk. If a life insurance company were asked to insure an individual against terrorism over a fixed period, it might reasonably raise the premium a bit more if it learns that the person is a subway/rail commuter than if the person is a frequent flyer. (In either case, however, the increase in the premium would presumably be very small.) That SCR commuters are exposed to risk far more often per year than frequent flyers seems a legitimate component of a risk assessment.

## 5. SOME ALTERNATE RISK PROJECTIONS

It is obviously possible that both the level of air/rail terrorism and its split between aviation and railroads will change in the years ahead. Although acts of terror might diminish in frequency and consequences, the risk levels in Table III are so low that performing more optimistic calculations seem of limited interest. Of greater concern is the possibility that the future might be worse than the past, and that contingency is the basis of the alternate projections here.

In addition to assuming higher overall levels of risk, we explore opposite possibilities about how future acts of terror in aviation/SCR will be split between the two transportation modes. It is conceivable that the "pendulum" will swing back to aviation in the years ahead. In December 2013, British officials expressed fears that "bomb makers in Yemen are determined to develop ever harder to detect devices to be smuggled on board planes bound for Western countries."[7] These devices would rely on new "low vapor" explosives that could thwart existing security

measures. However, one can imagine a greater swing toward SCR systems than was assumed in the "*status quo*" projection. Some researchers have posited (e.g., Jackson and Frelinger[8]) that terrorists take account of the probability of success in selecting targets. If so, recent evidence might work against a renewed focus on aviation. Countermeasures after the spectacular 9/11 attack—which killed 2,765 people on the ground in addition to passengers aboard the four planes used as weapons—have apparently led terrorists to revert to their pre-9/11 tactic of trying to blow up airplanes. Yet among the highly publicized recent attempts to attack aviation—the shoe bomber plot, the underwear bomber plot, the liquid-explosives plot, the ink-cartridge plot—all have failed. In contrast, terror attacks against subways and commuter railroads have achieved larger successes recently than ever before, and have done so around the world. By far the most deadly air/rail terror attacks over 2002–2011 were against subway/commuter rail systems, and they took 200 lives apiece.

To make pessimistic projections, we use annual death tolls from aviation/SCR terror based on recent experiences first in India and then in Russia, two countries with high levels of air/rail terror attacks. To reflect uncertainty about the split between SCR and air, we make projections assuming that the SCR/air split is 30%/70%, then 60%/40% (the "*status quo*" split), and then 90%/10%.

We first posit that annual passenger deaths from aviation/SCR terror in the DW will reach the same level per capita as India experienced over 2002–2011, its worst decade of the last three. With a population that averaged 1.15 billion over 2002–2011, India suffered an average of 72 deaths per year in air/rail terror. (This figure includes long-distance rail, which is a far larger contributor to air/rail terror in India than elsewhere.) That works out to about 63 deaths per billion citizens per year. At that rate, the DW with its 2012 population of 970 million would suffer 61 deaths per year. That figure is higher than the 47 used in the "*status quo*" projection based on DW data, but not that much higher.

A more ominous projection arises from the Russian data for 2002–2011, a decade over which 263 passengers died in air/rail terror. Because Russia's population averaged 143 million over that period, the annual death rate associated with these numbers is 18.2 per 100 million citizens. Extrapolated to the far more populous DW, that rate would imply 177 deaths per year.

**Table VIII.** Some Alternate Projections of Annual Terror-Related Death Risk Among DW Frequent Flyers and SCR Commuters

| Annual Terror Deaths | % Against SCR | Annual Risk, Frequent Flyers | Annual Risk, SCR Commuters |
|---|---|---|---|
| 61 | 90% | 1 in 11.5 million | 1 in 1.6 million |
| | 60% | 1 in 2.9 million | 1 in 2.4 million |
| | 30% | 1 in 1.6 million | 1 in 4.8 million |
| 177 | 90% | 1 in 4.0 million | 1 in 600,000 |
| | 60% | 1 in 1.0 million | 1 in 800,000 |
| | 30% | 1 in 600,000 | 1 in 1.7 million |

*Note:* These projections tend toward pessimism, and are based on applying in the DW the annual death rates per capita in air/rail terror for India (extrapolated to 61) and Russia (177) over 2002–2011.

As noted earlier, annual risk for SCR commuters in the DW is essentially linear in the average number of SCR deaths per year in successful acts of terror. The same holds true for frequent flyers. The specific linear approximations for terror-related passenger death in the DW can be shown to follow:

$$R_{SC} = \left(1.14 \times 10^{-8}\right) X_{SC},$$

$$R_{FF} = \left(1.43 \times 10^{-8}\right) X_{FF},$$

where $R_{SC}$ is the annual risk to SCR commuters; $X_{SC}$ is the annual deaths on SCR; $R_{FF}$ is the annual risk to frequent flyers; and $X_{FF}$ is the annual aviation deaths.

The alternate projections appear in Table VIII. They continue to show extremely low annual risk levels for both frequent flyers and SCR commuters. The highest projected risk in the table is about 1 in 600,000 per year. On reaching age 45—which is roughly an average age for SCR commuters and frequent flyers—the overall chance an American citizen will die within the year was 3.396 per 1,000 in 2009,[9] which works out to 1 in 294. Thus, even a pessimistic estimate of annual death risk from acts of terror is only about 1/2,000th as high as the yearly mortality risk that a mid-career traveler already faces.

These risk calculations do not count the 2,765 ground fatalities on September 11, 2001, the worst terrorist attack in American history although horrific, these third-party casualties (like those in other attacks) do not pertain in themselves to the theme of this article, namely, the risk posed by terror attacks to

air/rail passengers. Moreover, including these deaths in the calculations would give September 11, 2001, an overwhelming dominance in the analysis, for there were nearly twice as many third-party casualties on that date than there were total deaths for all other successful attacks in the DW over 1982–2011. Accordingly, such emphasis on September 11, 2001, seems unnecessary here because what happened that day is already well known; indeed, it could be unhelpful because the understandable preoccupation with that calamity can serve to obscure less extreme patterns related to acts of terror. Identifying such a pattern is the main point of this article.

## 6. SO WHAT?

But given the minimal risk posed by acts of terror to both air and rail travelers, why are statistics in this article of any interest? Arguably, pointing out how minuscule the risk is has some value in itself because the wide attention to terrorist threats might suggest that successful attacks pose greater danger than they actually do. However, a stronger reason is that the full ramifications of successful acts of terror go well beyond their immediate consequences. Had the 9/11 terrorists been thwarted at airport checkpoints, the wars in Iraq and Afghanistan might never have taken place. Many observers believe that the 2004 commuter train bombings in Madrid changed the outcome of the Spanish national election a few days later.[10]

Data about temporal patterns in successful acts of terror presumably have some relevance to strategies to prevent future attacks. Simplistic data analysis could be unhelpful. Reducing security measures at airports because attacks on aviation have diminished could be ill-advised because these very measures might explain the decrease. But if terrorists give weight to demonstrated success, then the growing risk to SCR travelers would warrant attention. Encouraged by recent "triumphs" in locales as diverse as London and Colombo, terrorists might see SCR as a promising target for further violence.

What are the policy implications of increased risk to SCR commuters in the DW? Recent events suggest that, although undetected plots against aviation can sometimes be thwarted at the airport or on airplanes, attacks on rail are far less likely to be stopped once in progress. Actions by passengers and crew prevented the shoe bomber from igniting his explosive aboard a TransAtlantic flight, whereas an El Al agent at Heathrow Airport intercepted a bomb in the lining of a suitcase before it was loaded on a flight to Tel Aviv. One looks in vain for comparable examples of attacks against rail systems that were thwarted on the train or in the terminal. Indeed, two weeks after the 2005 suicide bombings on the London underground, a very similar attack also involving three trains was attempted there. Although the plot failed because the explosives were faulty, no precautions after the earlier event succeeded in averting a near-recurrence.

High priority is already given to intercepting terror plots before attempts are made to execute them. Greater terrorist interest in rail systems would appear to heighten the urgency of such emphasis. It was good intelligence work that averted a planned 2009 attack on the New York subway, not security measures at Times Square or Grand Central.

## APPENDIX A: COUNTRIES INCLUDED IN "DEVELOPED WORLD" CATEGORY

| | | | | | |
|---|---|---|---|---|---|
| Australia | Austria | Belgium | Canada | Cyprus | Denmark |
| Finland | France | Germany | Greece | Hong Kong | Iceland |
| Ireland | Israel | Italy | Japan | Luxembourg | Netherlands |
| New Zealand | Norway | Portugal | Singapore | Slovenia | South Korea |
| Spain | Sweden | Switzerland | Taiwan | United Kingdom | United States |

## APPENDIX B: AIR/RAIL PASSENGER DEATHS IN ACTS OF "POLITICAL" TERROR, 1982–2011

It is not always certain when a homicidal attack against aviation or railroads has political motivation, but the tabulation below excludes seven events over 1982–2011 that were carried out by a single person for reasons that news stories suggest were apolitical. The death tolls in these eight attacks averaged 87, which was higher than the average of 46 for the other 79 successful attacks over the period.

**Table B1.** Worldwide Passengers Killed in Acts of Political Terror Against Railroads and Aviation, 1982–2011

| Period | Aviation | Rail | | |
| --- | --- | --- | --- | --- |
| | | Subway/ Commuter | Long Distance | Rail Total |
| 1982–1991 | 1,329 | 0 | 161 | 161 |
| 1992–2001 | 420 | 121 | 361 | 482 |
| 2002–2011 | 103 | 697 | 425 | 1,122 |

*Note:* Includes passenger deaths on 9/11/01 but not other deaths.

**Table B2.** Passengers Killed in Acts of Political Terror Against Railroads and Aviation in the DW, 1982–2011

| Period | Aviation | Rail | | |
| --- | --- | --- | --- | --- |
| | | Subway/ Commuter | Long Distance | Rail Total |
| 1982–1991 | 555 | 0 | 29 | 29 |
| 1992–2001 | 235 | 21 | 0 | 27 |
| 2002–2011 | 0 | 233 | 0 | 233 |
| Total | 790 | 254 | 29 | 289 |

*Note:* Includes passenger deaths on 9/11/01 but not other deaths.

## REFERENCES

1. Martonosi S, Barnett A. Terror is in the air. Chance, 2004; 17(2):22–24.
2. European Rail Research Advisory Council. Suburban and regional railways landscape in Europe, 2011. Available at: http://www.uitp.org/Public-Transport/regional-suburbanrailways/pics/Suburban_and_Regional_Railw.pdf, Accessed July 24, 2012.
3. Ministry of Internal Affairs and Communications, Government of Japan. Statistics Bureau Home Page. Ch. 9, Transport, 2012. Available at: http://www.stat.go.jp/english/data/handbook/c09cont.htm, Accessed July 24, 2012.
4. Arbitron. The Arbitron airport advertising study, 2012. Available at: http://www.arbitron.com/downloads/arbitron_airport_study.pdf, Accessed October 3, 2012.
5. Heimlich, J. Air trip frequency. Personal communication; Oct. 3, 2012.
6. U.S. Bureau of Labor Statistics. 2012 Census of Fatal Occupational Injuries. Available at: http://www.bls.gov/lif/oshcfoi1.htm#charts, Accessed February 15, 2014.
7. BBC News Middle East. Yemen Bomb-Makers "Working on New Devices." Available at: http://www.bbc.co.uk/news/world-middle-east-25206462, Accessed December 3, 2013.
8. Jackson B, Frelinger D. Understanding why terrorist operations succeed or fail. RAND Corporation, OP-257-RC, 2009.
9. U.S. Social Security Administration. Actuarial life table, 2013. Available at: http://www.ssa.gov/oact/STATS/table4c6.html, Accessed June 22, 2014.
10. Richburg KB. Madrid attacks may have targeted election. Washington Post. Oct. 17, 2004, p. A16.