Aircraft as a Weapon

A hostile non-state actor(s) crashes a commercial or general aviation aircraft into a physical target within the U.S. resulting in at least one fatality or injury other than to the attacker(s).

Data Summary

In the following table, note that the low and high likelihoods do not correspond to the low and high impacts. In addition, low and high impacts are not necessarily correlated with each other between different impact categories.

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities[1]	Number of Fatalities	2	290	2,800
	Injuries and Illnesses[2]	Number of Injuries or Illnesses	3	640	5,100
Economic	Direct Economic Loss[3]	U.S. Dollars (2011)	$4.0 million	$2.5 billion	$27 billion
Social	Social Displacement[4]	People Displaced from Home ≥ 2 Days	0	3,000	32,000
Psychological	Psychological Distress	Qualitative Bins	See text		
Environmental	Environmental Impact[5]	Qualitative Bins	Low		
LIKELIHOOD	Frequency of Events[6]	Number of Events per Year	0.036	0.13	0.27

Overview

Frequency estimates for the 2015 SNRA Aircraft as a Weapon event were derived from unclassified analysis published by the Federal Bureau of Investigation (FBI).[7] For impact estimates, these primary FBI sources were supplemented with data and research from multiple

[1] Low, average (293), and high (2,753) fatalities from the list of historical incidents in Table 1.
[2] Low, average (643), and high (5,124) injuries from the list of historical incidents in Table 1.
[3] Low, average, and high direct economic loss estimates for the list of historical incidents in Table 1. For 9/11 attack, DDP and business interruption costs are taken from Hartwig (2013), other incidents per-fatality multiplier from RMS scenario in Carroll et al (2005); all incidents include medical and fatality lost-spending estimates. See text for details.
[4] Low, average (5,124), and high displacement from historical incidents in Table 1. The SNRA measure of social displacement was defined as the number of people forced to leave home for a period of two days or longer.
[5] In 2011, the U.S. Environmental Protection Agency (EPA) convened an ad hoc group of environmental experts representing the fields of environmental science, ecological risk, toxicology, and disaster field operations management to estimate environmental impacts for this event for the 2011 SNRA. The comments and rankings presented in this Risk Summary Sheet have not undergone review by the EPA and only represent the opinions of the group. Estimates pertain to the potential for adverse effects on living organisms associated with pollution of the environment; they are grouped into high, moderate, low, and de minimus (none) categories. Experts provided both first and second choice categories, allowing the experts to express uncertainty in their judgments as well as reflect the range of potential effects that might result depending on the specifics of the event. The first choice represents the 'Best' estimate.
[6] 5th, mean, and 95th percentile of the uncertainty distribution for frequency parameter λ for aircraft as a weapon attacks treated as a Poisson process: gamma(3,23) posterior from gamma(1,0) prior updated with two event counts in 23 years (01/01/1992–12/31/2014). Best estimate reflects mean and range represents central 90% credible interval. See text for discussion.
[7] FBI (2006), FBI (2011).

secondary public sources including insurance studies and models, the START Global Terrorism Database (GTD),[8] peer-reviewed literature, and U.S. and foreign press sources.

Event Background

Terrorists have long viewed aviation as a target for attack and exploitation. Successful attacks in the air domain can inflict mass casualties and grave economic damage and attract significant public attention. Historically, large passenger aircraft have been at the greatest risk to terrorism, whether bombings, taking of hostages, traditional hijacking, and attack using human-portable surface-to-air missiles. Aircraft have also been used as weapons against targets on the ground, most notably, but not limited to, the attacks of September 11, 2001.[9]

Use of aircraft as a weapon for suicide attacks goes back to at least the Japanese kamikaze attacks of World War II. Attacks by non-state actors resulting in fatalities or injuries other than the attacker include the 9/11 attacks and the 2010 attack on the Austin, Texas IRS building represented in Table 1. Failed attempts include at least one attack by the Tamil Tigers in Sri Lanka,[10] a 1972 attempt to commandeer a commercial aircraft to crash into the White House,[11] and a 2002 suicide attack on the Bank of America corporate building in Tampa, Florida, by a teenager in a light plane.[12] Leaders of the Rajneeshee community considered a suicide airplane attack upon the county courthouse as one of several options for resolving their political dispute with the Oregon county where they had established their commune, before settling on the *Salmonella* contamination plan for which they are better known.[13]

For this incident, the SNRA only considered the risk of aircraft being used as a kinetic mode of attack (e.g., a 9/11 style attack) rather than the risk of an improvised explosive device (IED) being detonated on an aircraft. The latter risk is considered under the explosives incident category in the SNRA.

Assumptions

The 2015 SNRA used the same historical incident data as the 2011 SNRA for fatalities and injuries, with the addition of a 1945 incident where a B-25 bomber crashed into the Empire State Building. Social displacement estimates were also based upon this data set for the 2015 SNRA. Direct economic loss estimates leveraged historical data and published insurance models for property damage and business interruption, and literature sources for medical costs.

Frequency estimates were based upon the U.S. subset of these incidents identified as terrorist incidents by the Federal Bureau of Investigation (FBI).[14]

[8] The Global Terrorism Database (GTD) is an open-source database including information on terrorism events around the world (including domestic, transnational, and international incidents) from 1970 to 2010. For each GTD incident, information is available on the date and location of the incident, the weapons used and nature of the target, the number of casualties, and—when identifiable—the group or individual responsible.

START, the National Consortium for the Study of Terrorism and Responses to Terrorism, is a DHS Center of Excellence and network of scholars coordinated from the University of Maryland. Since 2011 when the first SNRA was executed the START GTD has become the most commonly cited source for global terrorism statistical data, and is now used as the primary data source (with similar parameters as the 2011 SNRA) for the U.S. Government's annual Statistical Annex on Terrorism published for the U.S. State Department's Country Reports on Terrorism. START GTD (2013).

[9] DHS (2007).

[10] 20 February 2009: START GTD 200902200005.

[11] 9/11 Commission Report (2004) endnote 21, p. 561; Jenkins (2014).

[12] 5 January 2002: START GTD 200201050007. This did not result in injuries or fatalities other than to the pilot.

[13] Zeitz (2011). See Biological-Chemical Terrorism Attack (small-scale) risk summary sheet.

[14] FBI (2006, 2011).

Frequency

Aircraft as a weapon attacks were treated in a fashion similar to other adversarial and non-adversarial events in the 2015 SNRA.[15] Low, best, and high frequency estimates represent the 5th percentile, mean, and 95th percentile of the uncertainty distribution for the annual frequency[16] of aircraft as a weapon attacks.[17] For events with few or no historical observations, representation of the unknown likelihood by a distribution encoding the information from these observations allows the uncertainty in the event's true underlying frequency of occurrence to be strongly bounded within the credible interval of frequencies that is consistent with the observational evidence. Given the choice of observation period, number of incidents meeting the counting threshold, and the desired credible (confidence[18]) range of uncertainty expressed as a percentage, the mean, lower, and upper bounds of this interval are uniquely determined in an objective and repeatable manner.

The SNRA project team selected the 23-year period of 1992–2014 as the observation period for determining the frequency estimates for similar reasons as the SNRA 2015 large-scale chemical, biological, radiological, nuclear (CBRN) attack events.[19] Two historical aircraft-as-a-weapon attacks in this period, the 9/11 attacks[20] and the 2010 suicide attack on the Austin, Texas, IRS building,[21] met the threshold criteria of this event and are categorized as terrorist attacks by the FBI. The 9/11 attacks were treated as a single attack for the purposes of the SNRA, following the counting convention of the FBI.

The frequency parameter λ (annual frequency of successful attacks) was parameterized by a gamma(3,23) distribution. This distribution was obtained by updating the gamma(1,0) agnostic prior distribution, with two event counts in the 23 years from 01/01/1992 to 12/31/2014.

Health and Safety

The SNRA project team used the following to estimate health and safety impacts resulting from an aircraft-as-a-weapon attack:

- Historical events: the SNRA project team analyzed a set of 11 historical events in which aircraft intentionally or unintentionally crashed into buildings or crowds of people. These include the two aircraft-as-a-weapon terrorist attacks in the historical data set used as the basis of the frequency estimates, as well as additional historical incidents. A detailed listing of these events is found in Table 1 under "Additional Relevant Information."

[15] Each SNRA 2015 event is modeled as a Poisson (random and 'memory-less') process. This reflects both 1) agnosticism regarding the relative dominance of factors acting to increase (demonstration of feasibility, copy-cat attacks) and decrease (suppressive actions by USG and law enforcement agencies in reaction) the frequency of subsequent attacks following a first successful attack, and 2) the multiple independent processes driving aircraft-as-a-weapon attack attempts as evidenced by the historical record of repeated attacks by multiple, independent non-state actors with differing ideologies and motives. See Mohtadi et al (2005, 2009a).

[16] The frequency parameter λ of the modeled Poisson process.

[17] In most cases, events in the SNRA having a large data set of historical incidents generally estimate low and high frequencies as the inverses of the longest and shortest inter-arrival times between incidents. For rare events where the number of historical incidents is too small to support a meaningful estimate of inter-arrival time, low and high frequency estimates usually represent the 5th and 95th percentiles of the distribution modeling the uncertainty in the event's underlying frequency of occurrence. See appendices B (Frequency) and I (Thresholds).

[18] This interval, corresponding to the confidence interval of frequentist statistics, is referred to as the 'Bayesian confidence interval' or 'credible interval' by different authors. The latter will be used here for clarity. NRC (2003) B-11.

[19] Although successful and unsuccessful suicide attacks using aircraft have a long history as noted above, this choice of observation period was motivated by an analytic assumption that the underlying frequency of this mode of attack is strongly influenced by factors particular to the 'new age of suicide terrorism' following the fall of the Soviet Union and the end of the Cold War at the end of 1991. This differs from the 1980–2012 observation period used for the other conventional terrorism attacks and for small-scale chemical-biological attacks, which have a longer demonstrated history of successful attacks in this country. It is the same observation period used for the large-scale CBRN terrorism events, which share similar assumptions regarding a fundamental difference in the underlying conditions driving frequency of successful attacks before and since 1991.

[20] FBI (2006) 65.

[21] FBI (2011). Also Obama (2013) [description as terrorist], GTD 201002180013 [incident detail].

- This list comprises the same data set used for SNRA 2011, with the addition of the 1945 incident where a B-25 bomber crashed into the Empire State Building (incident 1, Table 1).
- The analysis does not take into account possible higher-impacts events that have not yet occurred, but rather assumes maximum fatalities and injured counts from the 9/11 attacks in New York.

Direct Economic Loss

Direct economic costs in the SNRA include decontamination, disposal, and physical destruction (DDP) costs; business interruption costs; medical costs; and lost demand from fatalities.

The SNRA project team used the following assumptions to estimate the direct economic costs resulting from an aircraft-as-a-weapon attack:

- **Business Interruption and DDP Costs:** For the 9/11 attacks, the historical DDP and business interruption costs were used.[22]
- For the other historical attacks, proxy estimates for property damage including structure, contents, and aircraft hull loss costs and direct business interruption costs were taken from the insurance model in Carroll et al (2007). These were applied as multipliers of $1.20 million DDP and $0.723 million direct business interruption per fatality.[23]
- **Medical Costs:** The numbers of injured were based on the set of events listed above. To account for the distribution of injuries and corresponding medical costs from single events, the SNRA project team multiplied total injuries from the events in the historical data set by $5,200 per fatal injury and $24,000 per non-fatal injury.[24] These estimates, based upon the average medical costs for gunshot injuries due to deliberate assault or homicide in the U.S., were judged to be most representative of injuries due to other extreme violence and were used for each of the conventional terrorism events of the 2015 SNRA.[25]
- **Lost Demand from Fatalities:** To estimate the costs of lost demand from deaths, the SNRA project team multiplied the number of deaths listed in Table 1 by $42,500, the same figure used across the SNRA 2011 events.[26]

[22] In USD$2011 (CPI 2012-2011 0.9797) $12.7 billion DDP including property damage to World Trade Center, aviation hull loss, and other property damage, and $12.7 billion business interruption, from Hartwig (2013).
[23] In $2011 (CPI 1.152 2005–2011): building property damage $1.95 billion, contents property damage $1.12 billion, aircraft hull $144 million, for 2,632 fatalities (model) and 35,524 non-fatal injuries. As Carroll do not report passenger fatalities, 68 fatalities were added to this fatality number representing the average number (59.3) of passenger fatalities per plane in fatal U.S. airline passenger airplane crashes 1982-2009 (NTSB (2013a)) excluding the 9/11 hijackers increased in proportion by 0.16, the ratio of total crew to non-hijacker passenger fatalities on the 9/11 flights, to account for crew fatalities not reported in these statistics. The scenario of Carroll et al represents the 93rd casualty (fatalities + injuries) percentile of the RMS (Risk Management Solutions) aircraft as a weapon scenario space (scenario counts as opposed to probability weighted scenarios). Additional information is given but without breakdown by fatalities and injuries: this scenario was selected as representative because of its use by the authors and citation by other RAND studies (e.g., Morral et al (2012) 51) as representative. DDP/BI values were calculated in proportion to fatalities as opposed to total fatalities plus injuries, because was unclear what subset of the injuries reported in Carroll corresponded to the injuries in the SNRA historical data set.
[24] Medical cost per fatal and non-fatal injury for gunshot injuries in the United States from Corso et al (2007), adjusted from 2000 to 2011 dollars using the general CPI-U inflator (1.306). Estimated costs from lost labor productivity are not included.
[25] Medical costs from Explosives/Kinetic/Incendiary (E/K/I) injuries taken as a class are comparatively well studied and were used as a proxy for medical costs in the Aircraft as a Weapon attack SNRA event. SNRA 2011 also used E/K/I medical costs for the AAW event, but these were represented by a uniform distribution over $13,490 to $122,802, the distribution used by the RAPID assessment for medical costs associated with E/K/I injuries, by repeated random sampling from each distribution. This distribution represents the range of average medical costs for fifteen blast related injuries from nonspecific chest pain ($13,490) to spinal cord injury ($122,802) from the 2009 National Inpatient Survey (see AHRQ (2011) for corresponding 2011 estimates). As this distribution averages to $68,150 per injury, the SNRA 2015 medical cost estimates for conventional terrorism events are approximately 2–3 times smaller than those of SNRA 2011.
[26] This number originates from the 2008 Bioterrorism Risk Assessment (BTRA 2008) (the BTRA as a whole is classified Secret, but its economic methodology appendix is U//FOUO), and represents the midpoint (the expected value of a linear uniform distribution over the interval) of the

All cost estimates were converted to constant 2011 dollars to maintain comparability with SNRA 2011 events.

The 2015 SNRA project did not attempt to calculate indirect, induced, or total economic cost estimates.

Social Displacement

For the purposes of the SNRA, social displacement was defined as the number of people forced to leave home for a period of two days or longer. Note that there are limitations to this measure of social displacement, as the significant differences between temporary evacuations and permanent displacement due to property destruction are not captured.

- Low, best, and high estimates represent the minimum, average, and maximum estimates of persons from the historical incidents in Table 1.
- Several of these incidents resulted in no displacement from homes, confirming the SNRA 2011 low estimate of 0.
- The SNRA 2015 high estimate of 32,000 displaced represents the number of residents of Lower Manhattan who evacuated their homes following the 9/11 attacks who had not returned by September 13.[27]

Psychological Distress

Psychological impacts for the SNRA focus on significant distress and *prolonged distress*, which can encompass a variety of outcomes serious enough to impair daily role functioning and quality of life. An index for significant distress was created that reflected empirical findings that the scope and severity of an event is more important than the type of event.[28] The equation for this index uses the fatalities, injuries, and displacement associated with an event as primary inputs. A multiplicative factor elicited from subject matter experts weights the index for differing psychological impact based on the type of event, but as a secondary input.

- The Significant Distress Index is calculated from these inputs using a formula proposed by subject matter experts consulted for the SNRA project: $N_{SD} = C_{EF} \times (5\ Fat + Inj + \frac{1}{2}\ D)$, where N_{SD} represents the number of persons significantly distressed, C_{EF} is the expert assessed Event Familiarity Factor, *Fat* is the number of fatalities, *Inj* is the number of injuries and/or illnesses, and *D* is the number of persons displaced (Social Displacement).
- In words, this formula suggests that there are 5 significantly distressed persons for each life lost; 1 for each person injured; and 1 for each 2 people displaced. This formula was constructed to reflect the empirical finding that the most severe stressor of a disaster is losing a loved one, followed by injury, followed by displacement.

$35,000–$50,000 median household income band in 2011. DHS (2008) pp. E2.7-34. (Appendix reference is UNCLASSIFIED//FOR OFFICIAL USE ONLY; Extracted information is UNCLASSIFIED.)

[27] Extrapolated from data provided by the 25% of Lower Manhattan residents responding to the World Trade Center Health Registry Survey. 61% of respondents evacuated their homes, of whom 91.2% had not returned to their homes by September 13: this proportion was extrapolated to the 57,511 total resident population of Lower Manhattan. Farfel et al (2008). These evacuating residents represented a small fraction of the 1 million people (the SNRA 2011 high estimate) who left Lower Manhattan on September 11, the majority of whom were returning to homes elsewhere. The SNRA 2015 best estimate of 32,000 is on the order of the SNRA 2011 best estimate of 50,000 (SNRA 2011 draft Unclassified Documentation of Findings, Appendix F).

[28] See Appendix G for references and additional discussion of the SNRA Psychological Distress metric.

- The Event Familiarity Factor is intended to capture the extent to which the event entails an ongoing threat with uncertainty regarding long-term effects, is unfamiliar, or that people dread, exacerbating psychological impacts. This factor, ranging from 1.0 for familiar events to 1.3 for unfamiliar events, was provided by subject matter experts for each national-level event included in the SNRA: Aircraft as a Weapon was given a C_{EF} of 1.2.
- Uncertainty was captured by applying the index formula to the low, best, and high estimates of these three human impact metrics.

The numerical outputs of this index formula were used to assign events to bins of a risk matrix for a semi-quantitative analysis of psychological risk in the SNRA.

Environmental Impact

In 2011, the U.S. Environmental Protection Agency (EPA) convened an ad hoc group of environmental experts representing the fields of environmental science, ecological risk, toxicology, and disaster field operations management to estimate environmental impacts for this event in the 2011 SNRA. Estimates are based on the following assumptions:

- Experts were elicited to provide estimates in the environmental impact category based on assumptions. Actual environmental/ecological harm that occurs as a result of the events described in a given scenario may vary considerably, and will depend on numerous variables (e.g., chemical or biological agent, contamination extent, persistence, toxicity—both chronic and acute toxicity—and infectivity).
- EPA defined environmental consequence (impact)[29] as the potential for adverse effects on living organisms associated with pollution of the environment by effluents, emissions, wastes, or accidental chemical releases; energy use; or the depletion of natural resources.
- The environmental assessment included effects resulting from terrorism threats, but did not include human health effects or effects in urban areas, because these effects are already reflected in other impact measures.
- Experts identified the best estimate for environmental impacts as "Low." Experts indicated that one airplane could cause tens of acres of environmental impact of a limited duration but the identified event would likely occur in an urban environment. Impacts could be elevated to "Medium" depending on the target (e.g., a chemical plant).

Potential Mitigating Factors

The frequency estimates related to this event depend on the ability of potential terrorists to gain access to an airplane through either hostile takeover or other means using illicit documents, or a legal process. The nature of the impacts is related to the size of the airplane and the ability to direct it to a desired target.

[29] The 2011 SNRA referred to impacts as 'consequences' because of prior usage in quantitative risk assessment (Kaplan and Garrick [1981, March], On the quantitative definition of risk: *Risk Analysis* 1(1) 11-32). Except where it will cause confusion, 'impact' is used synonymously in this document because of pre-existing connotations of the word 'consequence' within FEMA.

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Additional Relevant Information

Table 1: List of Analyzed Events

#	Event	Date	Fatalities	Injuries	Displaced	Direct Economic Loss ($2011)[1]
1	USAAF B-25 Bomber Crashes into Empire State Building (New York, NY, USA)	7/28/1945	14[2]	26[3]	0[4]	$28,060,000
2	Ramstein Air Show Disaster (Ramstein, Germany)	8/28/1988	70[5]	1,500[6]	0[7]	$173,200,000
3	Flight 1862 Crash (Amsterdam, Netherlands)	10/4/1992	47[8]	26[9]	250[10]	$92,740,000
4	Air France Concorde Crash (Paris, France)	7/25/2000	113[11]	6[12]	0[13]	$221,600,000
5	September 11th Attacks (New York, Virginia, Pennsylvania, USA)	9/11/2001	2,753[14]	5,124[15]	32,000[16]	$26,900,000,000
6	Small Plane Hits the Pirelli Tower (Milan, Italy)	4/18/2002	3[17]	30[18]	0[19]	$6,600,000
7	Small Plane Crashes in Park (San Dimas, CA, USA)	7/4/2002	4[20]	9[21]	0[22]	$8,060,000
8	Ukraine Air Show Disaster (Lviv, Ukraine)	7/27/2002	77[23]	241[24]	0[25]	$156,700,000
9	Military Plane Crashes into Building (Tehran, Iran)	12/6/2005	115[26]	90[27]	250[28]	$227,600,000
10	Small Plane Hits Apartment Complex (New York, NY, USA)	10/11/2006	2[29]	3[30]	80[31]	$3,992,000
11	Suicide Attack on IRS Building (Austin, TX, USA)	2/18/2010	2[32]	13[33]	0[34]	$4,232,000

[1] See text for description of the method used to calculate representative direct economic loss estimates. Estimates are rounded to nearest thousand to avoid (reduce) communicating false precision.
[2] Barron (1995).
[3] Washington Post (1998b).
[4] Barron (1995), Resner (1945).
[5] Bulau (2008).
[6] Ibid.
[7] Planes crashed into crowd at airshow and forest: Ibid.
[8] Netherlands (1994).
[9] Ibid.
[10] Residents of destroyed apartments initially missing. BBC (1992, October 4), Montgomery (1992).
[11] France (2002).
[12] Ibid.
[13] Aircraft crashed into a hotel, no other property damage. France (2000) 14, 18.
[14] AP (2011, June 18).
[15] FEMA (2001).
[16] SNRA 2015 project team estimate from World Trade Center Health Registry counts: 61% of respondent residents evacuated homes of which 91.2% did not return within two days, times 57,511 total residents of lower Manhattan (12,371 residents of lower Manhattan, 25% of total population, registered with survey: 7,458/12,371 responding residents evacuated). Farfel et al (2008).
[17] NTSB (2002).
[18] Ibid.
[19] Office building: Ibid.
[20] NTSB (2004).
[21] Ibid.
[22] Ibid.
[23] Ukraine (2002).
[24] BBC (2005, June 24).
[25] Aircraft crashed into crowd at airshow: Ibid.
[26] USA Today (2011, July 16).
[27] Ibid.
[28] Reuters (2005, December 6).
[29] NTSB (2007)
[30] Ibid.
[31] SNRA 2015 project team estimate: 100 of 137 apartments affected, many residents in temporary quarters elsewhere for months; approximately ¼ of building floors (38th to 47th floors) most affected by fire and breakage, times 2.3 average residents per apartment = approximately 70–80 residents. Upper end of range taken as estimate for residents forced to leave home for 2 days or more. Barron (2007).
[32] Fox (2010, February 19).
[33] Ibid.
[34] Ibid. (Pilot burned family home prior to attack, but this was not a consequence of the attack itself.)