On July 19, 1967, a spectacular aviation disaster near Hendersonville, North Carolina, claimed eighty-two lives, including that of Assistant Secretary of Defense John T. McNaughton and two members of his family. The accident, a midair collision between a private twin-engine plane and a Piedmont Airlines Boeing 727, focused renewed public attention on and concern over the current and prospective dangers of air travel. It led to congressional hearings and gave impetus to a number of pending Federal Aviation Administration (FAA) regulations to reduce the possibility of accidents and fatalities.

But these rules are insufficient by themselves to cope with the problem of maintaining and improving air safety in the next decade. Symptomatic of this problem is the recent "slowdown" by air controllers to dramatize the need for more personnel and revision of operating procedures. Given rapidly increasing air traffic, without additional measures and public and private expenditures, the present chaos of earth-bound transportation may well be extended to the airspace of the future.

This paper reviews the growth of aviation activity, estimates accident rates and costs (including the value of human life), and describes some potential measures for accident prevention. Finally, there is a discussion of a proposal to compensate accident victims.

I

Growth of Aviation Activity

The growth of aviation activity since the Wright brothers' first sustained flight on December 17, 1903, has been nothing short of phenomenal, although it did take nearly twenty-five years before passenger service began to assume any significance. In 1926, marked by passage of the Air Commerce Act to regulate safety and relieve carriers of making large investments in ground facilities, only 5,782 passengers were carried in domestic operations, which accounted for only 1,272,000 passenger-miles. But, by 1929, after introduction of a much safer, three-engine aircraft and Charles A. Lindbergh's publicly exciting solo flight across the Atlantic two years earlier, domestic passenger-miles had soared to 35,396,000. In addition, 2,696,000 passenger-miles were reported in U.S. international operations. Today, forty years later, domestic passenger-miles have increased more than 2,300 times over the 1929 figure, and the international traffic nearly 10,000 times. In fiscal 1968 it is expected that United

*Senior Fellow, The Brookings Institution.
I am indebted to personnel of the Civil Aeronautics Board, the Federal Aviation Administration, and the National Transportation Safety Board for assistance, and to Clark C. Havighurst, George Lanka, and Ronald W. Pulling for comments on an earlier draft of this paper.
States scheduled flights will carry 80.2 and 26.1 billion passenger-miles in domestic and international operations, respectively. In the next decade, by fiscal 1979, the FAA forecasts that these figures will grow by approximately 220 per cent, to 258 billion and 84 billion passenger-miles. In that year, the 444 million passengers carried will substantially exceed the U.S. population.

The growth in airline passenger traffic has been accomplished by a far less dramatic increase in the number of air carrier aircraft. In 1926 there were fewer than 100, in 1929 about 400, and in 1967 more than 2,250. By January 1979, it is expected that there will be approximately 3,800 fixed-wing aircraft in the service of U.S. carriers.

Thus, given the relatively small increase in the number of planes, what has made the transport revolution and shrinkage of the world possible is the increasing reliability, speed, and capacity of aircraft. The first regularly scheduled passenger service from St. Petersburg to Tampa on New Year's Day, 1914, was at fifty-five miles per hour. One passenger was carried; by lapsitting a second could sometimes be accommodated. By contrast, in 1967, a typical long-range turbojet could carry from ninety-six to 180 passengers, climb to 30,000 feet to cruise at more than 600 miles per hour, and fly nonstop (depending on the payload) from 2500 to 5,000 miles. In 1971 stretched versions of these jets will carry from 350 to 490 passengers on short and medium distance trips. At about the same time, the French Concorde transport will double the speed of the present jets and carry about the same number of passengers. By the end of the 1970s U.S. supersonic transports will triple current jet speeds and have a maximum passenger capacity of at least 226 persons.

Consequently, because of greater speed and passenger demand, and notwithstanding an increased average number of seats per aircraft, airline takeoffs and landings (termed “operations”) are forecasted to increase markedly in the next ten years. In 1948 there were approximately four million air carrier operations. Twenty years later, in fiscal 1968, these had more than doubled to an estimated 9.9 million. And in the next ten years, operations will nearly double again, reaching an estimated 20.6 million in fiscal 1979.

“General aviation,” which term covers all civil aviation except certificated airlines—for example, business, instructional, and personal flying, the use of aircraft for scheduled and nonscheduled air taxi service, aerial photography, crop dusting, surveying, and so forth—will witness even more astonishing growth. In 1931 there were 1.1 million hours flown in general aviation. In 1957, 65,300 general aviation aircraft logged 10.9 million hours of flying time. In fiscal 1968, there were approxi-

1 FAA, AVIATION FORECASTS: FISCAL YEARS 1967-1977, at 23 (1968) [hereinafter cited as AVIATION FORECASTS].
2 Id. at 25. In addition, it is estimated that the number of air carrier helicopters will increase from 21 in 1967 to 40 in 1979.
3 Id. at 35.
FIGURE 1

COMPARATIVE GROWTH INDEX OF TOTAL AIRCRAFT OPERATIONS AT AIRPORTS HAVING FAA TRAFFIC CONTROL SERVICE

Calendar Years 1957-1967

(1960 = 100)

mately 112,000 aircraft that logged about twenty-three million hours. If there are no government restrictions on the growth of general aviation, during the next ten years the number of aircraft is expected to reach 203,000 and flying hours about forty-one million. While in this decade the hours flown will approximately double, operations will triple. Itinerant operations (aircraft arrivals and departures other than local operations) at airports with FAA traffic control service will grow from 20.7 million in fiscal 1968 to 66.5 million in fiscal 1979. Local operations (those at a single airport—for example, for training purposes) are expected to rise from 19.3 million to an astonishing 78.0 million.

It is the rapid growth in both air carrier and general aviation operations (cf. Figure 1) that poses the greatest challenge for maintaining and improving present accident rates. Without strong FAA action and continuing efforts by aircraft manufacturers and aviation operators, the probability of accidents and fatalities is sure to rise appreciably.

II

Comparative Accident Rates

While aviation accidents are generally spectacular, the aviation accident rate compares favorably with conventional modes of ground transportation. For the last twenty years passenger fatalities per 100 million passenger-miles has been lower for domestic scheduled airlines than for passenger automobiles and taxis. (See Table 1.) Within the last decade, too, in some years the domestic airline fatality rate has been lower than that for buses. Basically, due to greater public insistence on safety as air travel became more widespread, better vigilance on the part of aviation operators, and increased Civil Aeronautics Board (CAB) and FAA supervision of safety procedures, flying as a passenger on a scheduled air carrier flight now is quite safe. In fact, there probably is greater danger in crossing the street to the airline terminal or in racing to the airport in one's own car than in taking the flight itself.

Relatively few passengers are killed in scheduled air carrier service. For example, in 1967 there were 53,100 deaths due to motor vehicle accidents (9,400 of which were pedestrians). By contrast (see Table 2), there were eight fatal accidents, in which 226 passengers died, in scheduled domestic airline service. (There were four bystander deaths, and in addition twenty-four crew members were killed.)

———

5 AVIATION FORECASTS 29-30.
6 Id. at 35-36. Local operations are performed by aircraft which (a) operate within the local traffic pattern or within sight of the tower; (b) are known to be departing for, or arriving from, flight in local practice areas within a 20-mile radius of the control tower; or (c) execute simulated instrument approaches or low passes at the airport.
7 Safety functions of the CAB were transferred to the National Transportation Safety Board of the newly created Department of Transportation in October 1966. Dep't of Transportation Act, § 6, 80 Stat. 938-39 (1966).
8 NATIONAL SAFETY COUNCIL, ACCIDENT FACTS 240-41 (1968 ed.).
In the same year, scheduled international operations were virtually accident-free, and had no fatal incidents.

However, in general aviation, fatal accidents have continued their rise from the trough experienced in the mid-1950s. In 1965 there were 1,029 fatalities, including passengers, pilots, and other crew members, in 538 accidents. There were also 4,658 accidents, some of which resulted in serious injuries (564 persons were seriously hurt).

Traditionally, safety comparisons between and within transportation modes have been conducted, as in Table 1, on a mileage basis—miles flown or traveled, revenue passenger-miles completed, and so forth. This standard, however, is valid only if a mishap is equally likely at any juncture during a trip. For travel by car, bus, or train, such a measure probably is more accurate than others. But, in the case of aviation, this assumption is invalid. Accidents per passenger mile is a biased indicator of safety performance.

Although, on the average, eighty-five per cent of the flight time of fixed-wing aircraft between origin and destination is spent in the cruise phase of a trip, approximately seventy per cent of air carrier accidents take place in the terminal area and

### Table 1
**Comparative Accident Statistics by Mode of Transportation: 1947-1967**

<table>
<thead>
<tr>
<th>Year</th>
<th>Automobiles and Taxis</th>
<th>Buses</th>
<th>Railroad Passenger Trains</th>
<th>Domestic Scheduled Airline Services</th>
<th>International Scheduled U.S. Airline Passenger Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>2.3</td>
<td>0.21</td>
<td>0.16</td>
<td>3.20</td>
<td>1.07</td>
</tr>
<tr>
<td>1948</td>
<td>2.1</td>
<td>0.18</td>
<td>0.13</td>
<td>1.33</td>
<td>1.01</td>
</tr>
<tr>
<td>1949</td>
<td>2.7</td>
<td>0.20</td>
<td>0.08</td>
<td>1.32</td>
<td>0.00</td>
</tr>
<tr>
<td>1950</td>
<td>2.9</td>
<td>0.18</td>
<td>0.68</td>
<td>1.15</td>
<td>2.05</td>
</tr>
<tr>
<td>1951</td>
<td>3.0</td>
<td>0.24</td>
<td>0.43</td>
<td>1.50</td>
<td>1.13</td>
</tr>
<tr>
<td>1952</td>
<td>3.0</td>
<td>0.21</td>
<td>0.04</td>
<td>0.35</td>
<td>2.95</td>
</tr>
<tr>
<td>1953</td>
<td>2.9</td>
<td>0.18</td>
<td>0.16</td>
<td>0.56</td>
<td>0.05</td>
</tr>
<tr>
<td>1954</td>
<td>2.7</td>
<td>0.11</td>
<td>0.08</td>
<td>0.09</td>
<td>0.00</td>
</tr>
<tr>
<td>1955</td>
<td>2.7</td>
<td>0.18</td>
<td>0.07</td>
<td>0.76</td>
<td>0.04</td>
</tr>
<tr>
<td>1956</td>
<td>2.7</td>
<td>0.16</td>
<td>0.20</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>1957</td>
<td>2.6</td>
<td>0.19</td>
<td>0.07</td>
<td>0.12</td>
<td>0.00</td>
</tr>
<tr>
<td>1958</td>
<td>2.3</td>
<td>0.17</td>
<td>0.27</td>
<td>0.43</td>
<td>0.10</td>
</tr>
<tr>
<td>1959</td>
<td>2.3</td>
<td>0.21</td>
<td>0.05</td>
<td>0.69</td>
<td>0.81</td>
</tr>
<tr>
<td>1960</td>
<td>2.2</td>
<td>0.13</td>
<td>0.16</td>
<td>0.93</td>
<td>0.12</td>
</tr>
<tr>
<td>1961</td>
<td>2.1</td>
<td>0.19</td>
<td>0.10</td>
<td>0.38</td>
<td>0.00</td>
</tr>
<tr>
<td>1962</td>
<td>2.9</td>
<td>0.11</td>
<td>0.14</td>
<td>0.34</td>
<td>0.00</td>
</tr>
<tr>
<td>1963</td>
<td>2.3</td>
<td>0.23</td>
<td>0.07</td>
<td>0.12</td>
<td>0.50</td>
</tr>
<tr>
<td>1964</td>
<td>2.4</td>
<td>0.15</td>
<td>0.05</td>
<td>0.14</td>
<td>0.03</td>
</tr>
<tr>
<td>1965</td>
<td>2.4</td>
<td>0.16</td>
<td>0.06</td>
<td>0.38</td>
<td>0.12</td>
</tr>
<tr>
<td>1966</td>
<td>2.5</td>
<td>0.23</td>
<td>0.16</td>
<td>0.09</td>
<td>0.00</td>
</tr>
<tr>
<td>1967*</td>
<td>2.4</td>
<td>0.20</td>
<td>0.09</td>
<td>0.30</td>
<td>0.00</td>
</tr>
</tbody>
</table>


*Excludes service to the coterminous United States by Alaskan air carriers prior to 1959.

*Preliminary

# Aviation Safety

## Table 2

**Fatal Accidents and Fatalities for U.S. Scheduled Air Carriers Service and General Aviation: 1948-1967**

| Year | Domestic Air Carrier | | | | U.S. International Air Carriers | | | | General Aviation | | |
|------|----------------------|---|---|---|----------------------|---|---|---|----------------------|---|---|---|---|---|---|
|      | Fatal Accidents | Passenger Fatalities | Fatal Accidents | Passenger Fatalities | Fatal Accidents | Total Fatalities | Fatal Accidents | Passenger Fatalities | Fatal Accidents | TotalFatalities | |
| 1948 | 5 | 83 | 1 | 20 | 850 | 1384 | |
| 1949 | 5 | 93 | 1 | 0 | 562 | 896 | |
| 1950 | 4 | 96 | 2 | 48 | 499 | 871 | |
| 1951 | 8 | 142 | 1 | 31 | 441 | 750 | |
| 1952 | 5 | 46 | 3 | 94 | 401 | 691 | |
| 1953 | 4 | 86 | 2 | 2 | 387 | 635 | |
| 1954 | 4 | 16 | 0 | 0 | 393 | 684 | |
| 1955 | 8 | 195 | 1 | 2 | 384 | 619 | |
| 1956 | 4 | 143 | 0 | 0 | 356 | 609 | |
| 1957 | 4 | 32 | 1 | 36 | 438 | 717 | |
| 1958 | 4 | 114 | 2 | 10 | 384 | 717 | |
| 1959 | 9 | 209 | 1 | 59 | 450 | 823 | |
| 1960 | 10 | 326 | 2 | 10 | 429 | 767 | |
| 1961 | 5 | 124 | 0 | 0 | 426 | 761 | |
| 1962 | 5 | 153 | 0 | 0 | 430 | 857 | |
| 1963 | 4 | 48 | 1 | 73 | 482 | 853 | |
| 1964 | 6 | 106 | 3 | 94 | 526 | 1083 | |
| 1965 | 6 | 205 | 1 | 21 | 538 | 1029 | |
| 1966 | 4 | 89 | 0 | 0 | 573 | 1181 | |
| 1967 | 8 | 226 | 0 | 0 | 676 | 1186 | |

*aIncludes sabotage deaths

*bIncludes mild air collisions nonfatal to air carrier occupants (2 in 1960)

*cIncludes accident in which aircraft ran over ground crewman.

**Preliminary**


are incident to takeoffs and landings or the ascent to, or descent from, cruise altitude. Thus, if the number of departures and accident prevention efforts are held constant while the average length of trip is increased substantially, the accident rate will appear to be falling dramatically even though no corrective safety actions have been taken. Given the nature of the distribution of aviation accidents (that is, their prevalence in the terminal area) and the trend toward longer journeys, a better measure of safety achievement is the accident rate per departure. (Of course, an indicator that combined takeoffs, landings, and distance flown, weighted by their

---

6 For example, in 1966 only 16 of 71 moving accidents, or 23%, took place under normal cruise conditions, National Transportation Safety Board, Dept. of Transportation, Annual Review of U.S. Air Carrier Accidents: Calendar Year 1966, at 25 (1967).

10 This was suggested nearly six years ago in G. Fromm, Economic Criteria for Federal Aviation Agency Expenditures (FAA, 1962). Subsequently, an unpublished FAA study came to a similar conclusion. R. Dressier, New Approach to Air Safety Statistics, Dec. 1965. It was also found, using 1961-64 air carrier accident data, that there were significant differences between aircraft types (jet, turboprop, or piston) in accidents per departure, but that the accident rate per cruise mile was essentially identical. In other words, aside from the takeoff and landing, the risk of flying between any two cities by jet, turboprop, or piston aircraft, at least as judged by the 1961-64 fleet and experience, is the same irrespective of the speed of the plane. This is a justification for using aircraft miles flown as a partial, comparative safety measure over time.
LAW AND CONTEMPORARY PROBLEMS

TABLE 3
COMPARATIVE ACCIDENT RATES PER MILLION DEPARTURES FOR U.S. SCHEDULED AIR CARRIER PASSENGER SERVICE AND GENERAL AVIATION: 1949-1967

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic Air Carriersa</th>
<th>U.S. International Air Carriers</th>
<th>General Aviationb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fatal Accidents</td>
<td>Passenger Fatalities</td>
<td>Fatal Accidents</td>
</tr>
<tr>
<td>1949</td>
<td>1.9</td>
<td>44.3</td>
<td>6.5</td>
</tr>
<tr>
<td>1950</td>
<td>1.8</td>
<td>42.0</td>
<td>14.3</td>
</tr>
<tr>
<td>1951</td>
<td>3.3</td>
<td>58.9</td>
<td>6.9</td>
</tr>
<tr>
<td>1952</td>
<td>2.0</td>
<td>15.0</td>
<td>20.2</td>
</tr>
<tr>
<td>1953</td>
<td>1.4</td>
<td>31.0</td>
<td>12.9</td>
</tr>
<tr>
<td>1954</td>
<td>1.4</td>
<td>5.7</td>
<td>0.0</td>
</tr>
<tr>
<td>1955</td>
<td>2.3</td>
<td>50.8</td>
<td>5.7</td>
</tr>
<tr>
<td>1956</td>
<td>1.2</td>
<td>43.8</td>
<td>0.0</td>
</tr>
<tr>
<td>1957</td>
<td>0.9</td>
<td>8.8</td>
<td>4.9</td>
</tr>
<tr>
<td>1958</td>
<td>1.2</td>
<td>33.7</td>
<td>9.0</td>
</tr>
<tr>
<td>1959</td>
<td>2.5</td>
<td>57.1</td>
<td>4.4</td>
</tr>
<tr>
<td>1960</td>
<td>1.9</td>
<td>83.5</td>
<td>9.4</td>
</tr>
<tr>
<td>1961</td>
<td>1.4</td>
<td>35.1</td>
<td>0.0</td>
</tr>
<tr>
<td>1962</td>
<td>1.2</td>
<td>35.1</td>
<td>0.0</td>
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<tr>
<td>1963</td>
<td>1.1</td>
<td>13.5</td>
<td>0.0</td>
</tr>
<tr>
<td>1964</td>
<td>1.4</td>
<td>17.6</td>
<td>8.4</td>
</tr>
<tr>
<td>1965</td>
<td>1.5</td>
<td>52.3</td>
<td>3.9</td>
</tr>
<tr>
<td>1966</td>
<td>1.0</td>
<td>14.4</td>
<td>0.0</td>
</tr>
<tr>
<td>1967</td>
<td>1.7</td>
<td>48.3</td>
<td>0.0</td>
</tr>
</tbody>
</table>

aExcludes accidents and fatalities involving sabotage or midair collisions nonfatal to air carrier occupants.
bExcludes accident in 1964 when aircraft ran over ground crewman.
cPer departures at airports with FAA operated airport traffic control towers.

Source: Derived from Table 2 and FAA, Air Traffic Activity (1967).

respective risks, would be even more preferable; its derivation is beyond the scope of this paper.)

Furthermore, since the load factor (percentage occupancy) of a plane involved in a crash or collision is, within limits, almost purely random and seating capacity has an upward trend, the number of fatal accidents is a superior indicator to the number of fatalities in representing the effectiveness of private and government safety efforts. Nevertheless, a fatality index still has great appeal since the primary cost of fatal accidents is the loss of life. It is also of interest to passengers for assessing trip safety. For want of a weighted risk, take-off-landing-distance activity measure, this indicator, too, should be computed with departures as the scaling standard.

Fatal accidents and fatalities per departure for U.S. scheduled domestic and international air carrier service and for general aviation are shown in Table 3. It can be seen that, although general aviation flying has by far the worst record of all aviation groups (nearly thirty times as many fatal accidents per departure in the last four years as domestic air carriers), it has enjoyed an almost steady decline in fatal mishaps and individual fatalities per departure; the 1967 rates are only about one-third those of 1949.11

11 Because the departures for general aviation in this computation are only at airports with FAA traffic control tower service, this may be an overestimate of the relative degree of danger in general aviation
For domestic air carriers, there does not seem to have been much of an improvement in safety performance in the fifteen years as judged by fatal accidents per departure. The average rate from 1953 through 1958, 1.40, is nearly the same as from 1962 through 1967, 1.32. Jet aircraft and the Electra turboprop went into service in late 1958 and early 1959; the higher intervening accident rates for 1959-60 reflect shakedown problems with these planes.

However, the greater power, range, and ceiling of the jets apparently has enhanced safety in international air carrier operations. In four of the seven years since 1961 there were no fatal accidents. Of the four fatal accidents that occurred in 1963-65, two were during the takeoff phase of the flights. This again strengthens the presumption that most of the risks are at the terminal ends of a trip and not in between.

It is interesting to note the relative values of various accident measures in 1949 and 1967. Because of larger and faster planes and longer trips, passenger-miles grew rapidly during this period, rising from 6.8 to 76.6 billion in scheduled domestic service. (For example, in 1949 the average craft in domestic airline operations had 34.7 seats and the average passenger flew 448 miles; in 1964, the comparable figures were 86.1 seats and 605 miles.) With ninety-three passenger deaths in 1949 and 226 in 1967, the accident indicator, fatalities per 100 million passenger-miles, falls from 1.32 to 0.30. However, the alternative index, fatalities per departure, increases by approximately ten per cent. Similar results can be derived for the number of fatal accidents per million aircraft miles flown (nearly quadrupled from 1949 to 1967) and per departure; the former figure falls sharply while the latter decreases slightly. In other words, while on a distance basis, it was much safer to travel in 1967 than in 1949, on a per fixed distance, nonstop trip basis the danger of accidental death had remained about the same.

This is not to say that safety has not improved. For long trips, because the number of stops for a given distance has decreased, the likelihood of a safe flight between remote city-pairs may be greater today than it was eighteen years ago. Also, comparisons of accident statistics in individual years are highly influenced by stochastic factors, and extreme values are likely. A moving average to smooth fluctuations in rates would yield a truer picture. The important point is that the usual fatalities per passenger-mile figures are clearly misleading as a safety indicator.

Fatal incidents, of course, are not the only type of mishap. Approximately sixty per cent of the accidents experienced by all U.S. air carriers in 1965 and 1966 were minor in nature, involving little, if any, personal injury. Aircraft, too, were rarely completely destroyed and more frequently were substantially damaged. Statistics

flying. However, other indicators show the same great disparity. For example, fatal accidents per 100,000 flying hours in 1966 were 0.11 for scheduled service of domestic air carriers and 2.73 for general aviation. Disaggregation by type of flying would, of course, show that some segments of general aviation have experienced superior safety levels and trends to that of other segments.

12 CAB, HANDBOOK OF AIRLINE STATISTICS 83-85 (1965). The average flight stage length (distance between takeoff and landing) increased from 168 to 261 miles over the same period.
### TABLE 4
**ACCIDENT DATA FOR ALL U.S. CIVIL FLYING: 1965-1966**

<table>
<thead>
<tr>
<th>Category</th>
<th>U.S. Air Carriers</th>
<th>General Aviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1965</td>
<td>1966</td>
</tr>
<tr>
<td>Total Accidents</td>
<td>83</td>
<td>75</td>
</tr>
<tr>
<td>Fatal</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Serious Injury Only</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>Minor or No Injury</td>
<td>49</td>
<td>45</td>
</tr>
<tr>
<td>Aircraft Involved</td>
<td>84</td>
<td>75</td>
</tr>
<tr>
<td>Destroyed</td>
<td>16</td>
<td>12(^d)</td>
</tr>
<tr>
<td>Substantial Damage</td>
<td>46</td>
<td>47</td>
</tr>
<tr>
<td>Minor or none</td>
<td>22</td>
<td>16</td>
</tr>
<tr>
<td>Persons Abroad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal Injuries</td>
<td>261</td>
<td>272</td>
</tr>
<tr>
<td>Passengers</td>
<td>226</td>
<td>137</td>
</tr>
<tr>
<td>Crew Members</td>
<td>35</td>
<td>27</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>108</td>
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<tr>
<td>Serious Injuries</td>
<td>128</td>
<td>41</td>
</tr>
<tr>
<td>Minor or no Injuries</td>
<td>8496</td>
<td>9529</td>
</tr>
</tbody>
</table>

\(^a\) Revenue and non-revenue operators, scheduled and nonscheduled service, domestic and international, passenger and cargo operations.

\(^b\) Detail may not add to totals because of non-reporting.

\(^d\) Difference between aircraft involved and total accidents is collisions between aircraft.

Differences between aircraft involved and total accidents is collisions between aircraft. Minor or none.


showing the 1965-66 total accident experience for air carriers and general aviation may be found in Table 4.

### III
#### Accident Costs

**A. Property Damage**

The cost of these events was substantial, running into several hundred million dollars per year. Most of the losses stem from the high value of life and personal injury. Property damage losses are almost inconsequential. This arises because many aviation accidents occur on airport grounds (runways, taxiways, ramps, etc.) or in their proximity. Therefore, any damages generally are not expensive to repair. It is only in rare instances when a plane crashes in a heavily populated area that losses are great.

Information on the value of property damage arising from aviation accidents is quite limited. Under an FAA contract, the Flight Safety Foundation conducted a study of general aviation accidents in 1964.\(^{12}\) The results of their analysis of property damage may be found in Table 5. As can be seen, they are minimal. For all general aviation accidents in 1964 involving property damage, the average cost per inci-

\(^{12}\) FLIGHT SAFETY FOUNDATION, DEVELOPMENT OF A TECHNIQUE FOR ESTIMATING GENERAL AVIATION ACCIDENTS (1966).
TABLE 5
COST OF PROPERTY DAMAGE IN GENERAL AVIATION ACCIDENTS: 1964

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>Average cost per accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of directional control, ground, water, loop, swerve</td>
<td>$20.00</td>
</tr>
<tr>
<td>Collisions between aircraft, one airborne</td>
<td>4,642.30</td>
</tr>
<tr>
<td>Collisions between aircraft, both on ground</td>
<td>249.13</td>
</tr>
<tr>
<td>Collisions with wires and poles</td>
<td>159.00</td>
</tr>
<tr>
<td>Collisions with trees</td>
<td>8.00</td>
</tr>
<tr>
<td>Collisions with residences</td>
<td>5,962.50</td>
</tr>
<tr>
<td>Collisions with other buildings</td>
<td>1,475.67</td>
</tr>
<tr>
<td>Collisions with fences, fence posts</td>
<td>49.00</td>
</tr>
<tr>
<td>Collisions with electronic towers</td>
<td>422.00</td>
</tr>
<tr>
<td>Collisions with runway and approach lights</td>
<td>61.20</td>
</tr>
<tr>
<td>Collisions with airport hazards</td>
<td>225.00</td>
</tr>
<tr>
<td>Collisions with other objects</td>
<td>517.46</td>
</tr>
</tbody>
</table>


The cost of damage to general aviation aircraft, too, per occurrence, generally is minor. The Flight Safety Foundation study analyzed 1964 general aviation aircraft (hull) damage in great detail, determining average losses for eighty-nine makes and models of planes, by average age. Given the 1964 distribution of accidents among plane types, the average cost of substantially damaged or destroyed aircraft in that year was $6,155. The current price of new general aviation aircraft has a broad range, running from about $6,000 for a single-engine Champion Citabria, seating two, to $2.5 million for a twin jet Grumman Gulfstream II, seating 19. The typical plane sale, however, is a single-engine, four-seat aircraft costing from $15,000 to $30,000. The weighted average market value, per aircraft, of the present general aviation fleet is probably about $15,000. Thus, the total loss of an average plane hardly compares with even the most conservative estimate (for example, the training cost of a replacement) of the value of the life of the pilot.

A similar conclusion of low aircraft damage as compared to human costs applies to air carrier accidents. The weighted average market value of the existing U.S. air carrier fleet (which still includes many piston planes) may be about $1.3 million, and the average repair cost for substantially damaged aircraft about one-half that amount. A new Boeing 737, seating eighty to 101 passengers, sells for approximately $3 million, a Boeing 727, with a capacity of 131, costs $5.5 million, and the 400-passenger Boeing 747, about $21.2 million. The average load of a 747 flight will probably be on the order of 360 persons. (Thus, if the people on the plane were only valued at the cost of the aircraft, they would be worth $60,000 apiece.) It is estimated that the total value of aircraft destroyed in fatal air carrier accidents in

14 These average values, and those for general aviation, are taken from G. FROMM, supra note 10, at 419-19.
1966 was about $18-20 million. In the same incidents, 272 lives of passengers, crew, and other persons were lost. How are they to be valued?

B. The Value of Human Life

At first, putting a specific monetary value on human life may seem immoral, if not monstrous. Many would say that life is priceless, and its value infinite. But this disregards everyday experience. Society is continually making economic decisions that place an implicit value on human life, even if no explicit judgments are expressed. Automobile accident fatalities, for example, could be greatly reduced by more sturdily reinforced cars, pedestrian over- and underpasses, stricter speed limits (time is money), greater police supervision of traffic, and so forth. Yet, such measures have not been taken, apparently because their cost, in relation to the value of the lives that would be saved, appears prohibitive. Thus, the value of a life is considered limited.

1. Using Life Values in Aviation Safety Decisions

For the aviation industry an explicit set of values for human life should be derived, since investment and operating expenditures must be made regarding facilities that promote safety. Also, operating procedures, such as those with respect to minimum visibility landing requirements, maximum takeoff weight, and reserve fuel carried, affect the profitability of airline operations but also impinge on the probability of accidents. Once estimated, the set of human life values can be used to satisfy several purposes.

(i) As an indicator of the amount that aviation users might be willing to pay for increased safety. Individuals do not place infinite values on their lives. If they did, they would not expose themselves to dangerous avocations such as skydiving or mountain climbing, would not work in hazardous occupations to earn higher pay, or otherwise risk their lives for presumed personal psychic or financial gain. Thus, many individuals implicitly assign a finite value to their lives.

For two situations that are identical except for the possibility of death (assuming that only the expected values of the outcomes enter the individual's utility function and that the latter is linear, homogeneous, and independent of risk), this life value would be the amount the person was willing to pay for the safer choice, divided by the increase in the probability of survival. Conversely, if this life value were given, the amount that an individual would be willing to pay to decrease the probability of a fatal aviation accident per trip (or per passenger-mile) could be determined.

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15 This discussion is based in part on Fromm, Civil Aviation Expenditures, in Measuring Benefits of Government Investments (R. Dorfman ed. 1965).

16 A distinction must, of course, be made between the viewpoint of society as a whole and the individual subjected to risk. Any particular person might consider the value of the certain loss of his life as infinite.

17 Psychic gains have finite values because, presumably, an individual could be bribed to forgo hazardous activities.
For example, in 1967 among 120.5 million passengers carried over 76.6 billion passenger-miles in air carrier scheduled domestic service, there were 226 passenger fatalities. Thus there were 0.295 fatalities per 100 million passenger miles flown—or, with an assumed median trip length of about 550 miles, the probability of a passenger being killed on a trip was approximately 0.00016 per cent.\(^\text{18}\) If he valued his life at $400,000, he should be willing to pay at least sixty-four cents per trip to reduce this probability to zero. Note that this is not insurance to be paid in the event of death but an expenditure to be made to reduce the probability of a fatal accident.

Many persons are willing to pay as much as twenty-five cents per $5000 for specific air trip insurance. (These high charges are due, not to indemnification payments, but to the costs—including profits—of providing the insurance service.) This willingness probably stems partly from gambling propensities and lack of knowledge of accident probabilities. But mostly it reflects a person's assessments of the high value of his life to his family, inadequate ordinary life insurance in his investment portfolio, and the desire to protect the family.\(^\text{10}\)

(2) As a benchmark against which the implicit human life values of projects and procedures that increase safety can be compared. Almost every air traffic control expenditure or procedural change affects a spectrum of aviation operating characteristics. For each project a calculation can be made of the average expected value of its nonsafety gains, such as reducing delays, diversions, and cancellations, and of property damage avoided. Users' willingness to pay for these reductions in service ineffectiveness (that is, the losses from delays, and so forth) can then be estimated and subtracted from the cost of the project. (Negative gains would thus be added to costs.) The remaining amount can then be divided by the expected number of lives saved (fractional units may be used since this number is based on expected probabilities of fatality rates to obtain an implicit project value per human life saved. This information can be used in ranking the relative desirability of projects, those with the lowest implicit values, other things being equal, being preferred. The ultimate criterion for project selection and public subsidy beyond users' willingness to pay for increased safety is, of course, the absolute excess of total social benefits over costs.

(3) As a guide and justification for public subsidy, if social welfare benefits over and above users' "willingness to pay" are to be ascribed to a potential safety expenditure. There are many fields of activity where government subsidy might save lives. The mere existence of such potential benefits in aviation does not in itself justify a subsidy. The value of safety gains in aviation should be shown to be at least

\(^{18}\) The average on-line passenger trip length in scheduled domestic service was 620 miles. CAB, HANDBOOOF AIRLINE STATISTICS 17 (1967).

equal to those in other areas. In other words, the cost and value of saving a life in aviation can be contrasted with the outlays technically necessary to accomplish the same end in nonaviation situations and the willingness of the community, in practice, to achieve this purpose.

2. Estimating Life Values of Potential Victims

While the derivation of specific values for human life is difficult, controversial, and necessarily somewhat arbitrary, it is not capricious. An indirect method (which measures desired expenditures for saving lives) that has been suggested is to interview individuals asking them to indicate their willingness to pay to reduce probabilities of death by small, finite amounts. While not completely unworkable, this proposal is fraught with great difficulties, especially when the probability differences to be evaluated are for hypothetical and not actual situations. An alternative is to approach the problem directly, deriving a value for life and then deciding how much to spend to save lives.

Since the definition of a social welfare function limits the component losses to be included in this value, it is a critical ingredient in this process. Some economists have argued that the relevant social welfare concept should encompass the losses of all remaining members of society but exclude those of the victim himself. They maintain that the loss suffered is equal to the output that the individual would have produced had he lived, less the cost of his own consumption. In other words, they agree that he should be valued only for the taxes he pays and for what he invests (this is highly akin to Russian policy during the Stalinist era). Even if this made sense ex post, it would not ex ante, since the prospective victim could drastically reduce his consumption (to zero if others were willing to make transfers for his subsistence) thereby increasing his "value." Extending this reasoning would lead to the conclusion that society should practice euthanasia on all those unable to produce more than they consume—the old, infirm, profligate, and so forth. Clearly, the welfare function must encompass the individual himself and include his consumption, and should not be purely materialistic. The value of life itself should not be zero, with people's worth evaluated only by their production of livelihood. It must encompass livelihood; but, in addition, must also reflect the utility of its consumption.

This approach to assigning value to life involves some double-counting, since the individual derives satisfactions from his total income, as does his family. For example, a man might get as much satisfaction from giving his wife a mink coat as she derives from wearing it. The total monetary value of these satisfactions could

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21 Willingness to pay for lifesaving programs would be one of the considerations in deciding on the proper level of expenditures. However, merely basing expenditures on individuals' willingness to pay yields a downward biased estimate of that level. Fromm, *Comment*, in *id.* at 166.
exceed the cost of the coat, but could never be less than it or the coat would not be purchased. (In essence, this approach which sums both sets of utilities is analogous to the treatment accorded public collective goods—the consumption of one person need not detract from another.) While this double-counting would be fallacious for some purposes—for example, for calculating the economy’s loss in output—as an indicator of the effects of aviation safety programs, it may be considered valid. Care should be exercised so as not to misuse the figures as a basis for compensation of accident victims or in justifying government aviation expenditures without comparison to alternative uses of resources.

Aside from losses to the individual and his family, other costs of a fatal accident include losses in contributed community service time, employer recruiting and training costs, and accident prevention and investigation costs. Based on the above methodology and the income and age characteristics of the average air passenger in 1966, a value of $450,000 is estimated for an air carrier fatality and $502,000 for a general aviation fatality in that year. The $450,000 is the sum of the “value” of the individual’s life to himself, $250,000, and the following losses: to his family, $150,000; to the community, $35,000; to his employer, the government, and airlines and air frame manufacturers, about $5,000 apiece.22 Of the same total, $225,000 represents the loss to the economy of the individual’s output (presumed equal to his discounted income stream). Thus, a conservative estimate (without double-counting) of the value of life based only on lost productive services and resources expended would be $275,000 ($225,000 plus the $50,000 of losses to community, employer, and so forth noted above).23

It might be noted that the amount of insurance paid to a victim’s estate is irrelevant in calculating the cost of accidents or the value of life. There are many factors that determine the amount of insurance an individual maintains, including the number of his dependents, their age and financial self-sufficiency, and his degree of risk

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22 The present value of the individual’s earning stream ($225,000) and assets is computed from a median income of $16,000, a yearly increase in income of 2.5%, assets of $25,000, age as the average age of the passenger (a lower age would raise expected lifetime earnings and the present value), and a discount rate of 6%. These figures are in constant, 1966 dollars. The average age and median income are based on a number of surveys of the air passengers: Fortune Airlines Study (1959), conducted by Fortune magazine for the Travel Research Association and Port of New York Authority; New York’s Domestic Air Passenger Market: April 1963-March 1964; New York’s Overseas Air Passenger Market: April 1963-March 1964; Clark Assocs., Summary of Data, 3 Washington-Baltimore Airport Access Survey (1968).

23 This value is substantially higher, about double that for the average person, because air travelers have a higher median income. From a moral standpoint, each person should, of course, be valued equally; from an economic standpoint, the valuations will tend to differ. For example, saving the life of the president of a major corporation would be considered more valuable than saving that of a junior clerk. For further justification of the above procedures, see Fromm, Economic Criteria for Federal Aviation Expenditures, supra note 10, ch. VI.
aversion. Moreover, while death is an insurable event, it also is a noncompensatory one. Insurance can compensate the living for the loss of the dead but not the dead for the loss of the enjoyment of life. More importantly, ignoring administrative costs, insurance is nothing more than a transfer payment. Those who pay premiums have a decrease in their incomes (consumption), while those who collect benefits enjoy an increase in theirs. Assuming that the utility of income of the two groups is identical, there is no net gain or loss.

C. Injury Costs

The determination of serious injury costs is similar to that for the loss of life. The individual is unable to work and earn his salary and, in addition, must pay medical expenses. His family loses their share of the income too. (Again, as above, any insurance, other compensation, or employer continuance of salary is irrelevant since it represents a transfer of assets.) There are also accident investigation costs and losses of contributed community services.

Unfortunately, aside from numbers, very little is known about the extent of injuries, the average length of hospitalization, medical costs, and so forth.24 It is assumed here that the average interval that the individual requires to recuperate from the accident is about half a year.25 Thus, for air carrier passengers the income loss is $8,000. Other losses are $5,000 for family satisfactions and $1,000 for community services. Government agencies and airlines and airframe manufacturers, on average, are assumed to spend as much for investigation of serious injuries as for fatalities (both are frequently found in the same accident), $5,000 per person for each group. Medical expenses are assumed to average $50 per day for six months, or approximately $9,000. Neglecting employer costs (which are assumed negligible due to temporary realignment of company responsibilities), this gives a total cost per serious injury of $33,000. Because of lower (per incident) accident investigation costs, the estimated cost per serious injury in general aviation is, despite the average victim's higher income, somewhat lower, $28,000. The respective amounts based only on lost productive services and resources expended are $28,000 and $22,000.

For minor injuries, assuming that the individual is incapacitated for one month, the estimated costs are about $4,500 for both air carrier and general aviation occurrences. The allowance for the family in each instance is approximately $1,000.

24 The CAB defines these as

"any injury which (1) requires hospitalization for more than 48 hours commencing within seven days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes or nose); (3) involves lacerations which cause severe hemorrhages, nerve, muscle or tendon damage; (4) involves injury to any internal organ; or (5) involves second or third degree burns, or any burns affecting more than five per cent of the body surface."

FLIGHT SAFETY FOUNDATION, supra note 13, at 7.

25 Because of lack of information, complete recovery is assumed. Any life-long physical or economic impairment, if they occur, should, of course, be taken into account in computing accident losses.
### Table 6
**Losses in U.S. Civil Aviation Accidents: 1966a**
(Thousands of dollars)

<table>
<thead>
<tr>
<th></th>
<th>U.S. Air Carriers</th>
<th>General Aviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property</td>
<td>$2,250</td>
<td>$1,714</td>
</tr>
<tr>
<td>Aircraft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destroyed</td>
<td>13,000</td>
<td>14,805</td>
</tr>
<tr>
<td>Damaged</td>
<td>29,845</td>
<td>29,162</td>
</tr>
<tr>
<td>Injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal</td>
<td>35,100</td>
<td>577,802</td>
</tr>
<tr>
<td>Serious Injuries</td>
<td>1,363</td>
<td>16,464</td>
</tr>
<tr>
<td>Minor Injuries</td>
<td></td>
<td>4,442</td>
</tr>
<tr>
<td>Totalb</td>
<td>881,548</td>
<td>644,388</td>
</tr>
<tr>
<td>(Resource content of total)</td>
<td>($67,693)</td>
<td>($413,126)</td>
</tr>
</tbody>
</table>

*Excludes fatal accidents involving military charters of civil aircraft.

bDetail may not sum to totals due to rounding.

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**D. Total Accident Costs**

With the above unit value estimates, it is possible to estimate the total cost of U.S. civil aviation accidents in 1966. For U.S. air carriers the cost is about $81.5 million; for general aviation, $644.4 million (see Table 6). Taking the resource content alone gives figures of $67.7 and $413.1 million, respectively. On either basis, fatality and injury costs are clearly the most significant item. They constitute about ninety per cent of general aviation accident losses.

For air carriers the 1966 proportion of fatality and injury to total losses is from thirty-five to forty-five per cent. But this is an atypical year in that there were only seventy-eight fatalities (excluding those in military charter operations). In 1967, there were 286 fatalities in U.S. air carrier operations which would be valued at from $78 million to $127 million. Consequently, with about the same number of accidents, fatality and injury costs were about seventy per cent of total losses.

**IV**

**Accident Prevention**

Given these substantial costs, and especially the loss of life, measures to further reduce aviation accidents and fatalities deserve serious consideration. Such measures are continuously under study by FAA, the agency charged by law with formulating and enforcing air safety regulations. (Accident investigation is the responsibility of the National Transportation Safety Board—NTSB.) These regulations cover the gamut of certification of the airworthiness of aircraft and airmen, aircraft maintenance standards, aircraft operating procedures, and rules and controls for takeoffs, landings, and flying, for all civil aviation.

Certification of aircraft is one of the most critical activities of FAA. Airframe
manufacturers obviously have a great stake, and have done an outstanding job, in supplying aircraft that will not fail in flight. Unsafe planes will cause a loss in acceptance, cancellation of orders, expensive modifications, or even loss of certification if the faults cannot be rectified. Yet market incentives alone are not sufficient to ensure that the socially optimum degree of safety will be designed and produced into aircraft. Since the manufacturer is in competition with other firms and has already promised delivery (sometimes with penalty clause liabilities) of a plane at a fixed price with a stated profitable range, speed, and payload, he seeks to have it certificated at the earliest possible date. An example of this competition is the current rivalry between McDonnell-Douglas and Lockheed for the 250-passenger Airbus market. The manufacturers' thousands of engineers, over several years and with FAA surveillance, may have taken every possible precaution and subjected component parts to extensive tests (some even to destruction); but the few handfuls of FAA inspectors (there are only 110 in the western United States) have only a few hundred hours of operating the plane as a complete system in which to determine whether it is airworthy. Consequently, there is a chance that potential fatigue strains, dynamic instabilities, and other likely failures in the aircraft will be missed, especially when these are only encountered in turbulent weather or other critical conditions. Such failures marked the introduction of the Lockheed Electra in 1959 and the Boeing 720B in 1961 and resulted in fatal crashes. It is for this reason that many seasoned air travelers will not fly in a new aircraft type until the "bugs" have been shaken out.

Unfortunately, there probably is not much that can be done to completely eliminate such catastrophes. More inspectors and an increase in shakedown time required for certification certainly would help. Some improvement in anticipating and diagnosing potential accidents also might be realized by installation of flight recorders such as the MIDAS system, which can monitor 300 parameters simultaneously throughout the life of an aircraft and can provide a complete and permanent record of faults, damage, stress, and fatigue. Airborne computers to monitor the recorder and the aircraft's inflight performance might be beneficial as well.

At present the FAA only requires highly simplified, rugged recorders which report time, air speed, altitude, direction (heading), lateral and longitudinal acceleration, G forces, and cockpit voice communications. To determine the cause of most accidents more precisely, many more indicators are required. Since the installed cost of the more complex recorders and computers for the entire U.S. air carrier fleet is not more than the cost of one or two major jet accidents, the investment would be readily justified, if their use could avert a few such incidents.28

28 An ancillary benefit is that the use of such computers and recorders could greatly aid inspection and maintenance operations and ease the FAA's safety control burden. Whereas inspection and overhaul are now scheduled after a maximum, FAA-specified, standard number of operating hours (which includes
Another step that might be taken is to amend the Federal Aviation Act to provide criminal penalties for knowingly withholding information on aircraft defects. At best, such failure presently is subject only to civil penalties and a maximum fine of $1000 per violation of FAA Civil Air Regulations.\(^2\) Loss or suspension of certification is also potentially possible but can feasibly be invoked against an airline or manufacturer only under rare circumstances.

A more basic difficulty is dealing with FAA's attitudes toward safety regulation. David Hoffman in a *Washington Post* article\(^2\) asks, "But must the aviation establishment await the impetus of tragedy before ridding air transportation of hazards long identified by engineers and pilots?" Hoffman put this question to Lee Warren, deputy director of FAA's Western Regional Office, who replied, "You can't just junk the whole [air transportation] system just because you've developed a mathematical model that predicts the likelihood of an accident. . . . In promulgating safety rules, FAA holds its ground best when it has the precise facts in hand."\(^2\)

The implication of this remark appears to be that pilots and the public must risk their lives and suffer fatalities in order to demonstrate to FAA, the airlines, and aircraft manufacturers that a given situation is unsafe. This is not to say that FAA has not been sincerely dedicated to protecting air travelers. Within the limitations of its resources, it has taken a broad range of actions in virtually every area that impinges on air safety. But its imprecise approach to rulemaking and facility investments is a cause for concern. Sometimes it requires one or a number of fatal incidents to precipitate revisions in previous standards, and then only after extensive government-industry discussions.

For example, in September 1967 new rules—to be effected over a two-year period, to speed passenger emergency evacuation—were issued.\(^3\) The number, size, and arbitrary safety factors), with the use of the more complex flight recorders and computers, maintenance could be ordered as required (within less stringent standards), thus reaping considerable economies and increasing safety. All problems would not be solved by these machines, but they would do much to eliminate some of the greatest uncertainties as to the reliability of equipment and the condition of the aircraft at the time of the accident.\(^2\)

The Boeing Company was recently ordered to pay $1.6 million in damages after a Chicago jury decided that the firm knew of a defect prior to a fatal crash of a 720B but only warned pilots of its existence after the accident. More recently Boeing and BOAC agreed to an out-of-court settlement reportedly totaling over $8 million, for fatalities from the crash in Japan in March 1966. This settlement was for only half of the passengers who lost their lives (54 out of 113). *Newsweek*, July 29, 1968, at 83. The complaint alleged Boeing and BOAC had prior knowledge of defects.\(^2\)

\(^2\) For example, despite reasonable a priori notions and an in-house statistical analysis of actual data, certain FAA personnel doubt the existence of a statistically significant correlation between landing speed and accidents. This relationship was advanced and tested by Robert F. Dressler, supra note 10; and Dressler, Aircraft Landing Speed and Accident Correlation (May 1966). This lack of faith in mathematical and statistical models is perplexing in light of the extremely complex equations used in aircraft design by airframe manufacturers. Moreover, even for air traffic control situations, computer and actual simulation experiments can be run to validate the models for planning use.

\(^2\) The Boeing Company was recently ordered to pay $1.6 million in damages after a Chicago jury decided that the firm knew of a defect prior to a fatal crash of a 720B but only warned pilots of its existence after the accident. More recently Boeing and BOAC agreed to an out-of-court settlement reportedly totaling over $8 million, for fatalities from the crash in Japan in March 1966. This settlement was for only half of the passengers who lost their lives (54 out of 113). *Newsweek*, July 29, 1968, at 83. The complaint alleged Boeing and BOAC had prior knowledge of defects.

accessibility of exits were increased, cabin linings with self-extinguishing properties for improved resistance to fire were ordered, restraints for stowing carry-on baggage were required, and other provisions were made to enhance the probability of survival after impact. Instead of 120 seconds, ninety seconds will be the new time requirement for a full load of passengers to exit from one side of a plane. Moreover, the burden of proof of meeting this requirement will be placed on aircraft manufacturers, and they must use a representative group of people rather than aviation employees in the test. One wonders why it took so long for FAA also to order that passenger seatbacks and trays be in an upright position during takeoff and landing, that flight attendants be uniformly spaced and stationed near floor level exits at those times, and that the passenger briefing instruction cards on emergency evacuation procedures describe only the specific type of aircraft on which they are carried.

The recent controversy over runway length requirements for jet operations is another illustration of long time delays and industry pressures on FAA in safety regulation. On July 15, 1963, FAA issued a Notice of Proposed Rule Making that would have increased runway requirements by 800 feet at all U.S. airports with turbojet air carrier service; an extra 1200 feet were to be added whenever rain or snow make a runway slippery. The industry reacted strongly and the rules were watered down so that in mid-1965 FAA withdrew the 800-foot increase. In a regulation effective in January 1966, the agency increased runway length requirements by fifteen per cent when a landing on a wet or slippery runway was anticipated. But, in lieu of the added percentage, a lesser additional distance based on a showing using actual operating landing techniques under those conditions would be acceptable.

The exception does not stipulate that the tires used must have normal tread wear or that tests be run under adverse circumstances such as heavy rain, darkness, and poor visibility.

An increase in required runway length would mean either that longer runways would have to be built, that the payload (passengers and fuel) would have to be reduced, or that jet service would have to be limited or curtailed altogether. Any of these alternatives would cost the airlines money in increased landing fees to pay for runway construction or in decreased revenues. (As Hoffman notes, too, “it is unnecessary to remind FAA that few things annoy Congress more [because of personal inconvenience and constituents’ reactions] than curtailment of airline service back home.”)

Thus, there is an implicit balance being struck between the cost of accidents and the cost of runway extensions or airline revenue and service reductions. The

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81 It is true that under normal circumstances (because of lower landing than takeoff weight—due to fuel consumption), runway takeoff length requirements are more than fifteen per cent greater than landing requirements at many airports. But, a priori, it would seem that errors of judgment would tend to be greater and more prevalent for landing than takeoff, thereby reducing engineering margins of safety far more for landings than takeoffs.
possibility of accidents is far from negligible; in 1966 there were several overshoot incidents and on November 6, 1967 in Cincinnati, Ohio, one passenger was killed when a Boeing 707 ran off the runway during an aborted takeoff. This was not an instance of pilot error or of aircraft malfunction; the runway was simply too short.

At least that one passenger has a right to question the criteria by which FAA establishes safety standards, aircraft operating and air traffic control procedures, and makes facility investments. For the most part, in the past, the criteria were specified unscientifically, based on experience and rough judgments. Moreover, the emphasis was on hardware (equipment) solutions to problems with too little attention to statistical and economic analyses of alternatives.32

Perhaps this is partly attributable to the background of FAA’s management personnel. Many learned to fly in the 1930s and in the military during the Second World War, when aircraft were slow and relatively simple, when there was no congestion, and when the air traffic control system was elementary. Partially due to FAA’s stimulus, as the industry grew, aircraft became more complex, traffic increased, and the burdens of air traffic control rose dramatically. FAA’s response has been to expend ever increasing amounts of public funds for equipment, airports, and air traffic control personnel. Also, to reduce the possibility of collisions, restrictions on the use of the airspace have increased significantly.33 But merely increasing FAA expenditures and air traffic control restrictions is an inadequate and inappropriate approach for dealing with the traffic problems of the next decade. What is needed is an economical, integrated system of providing safe ground and air carrier and general aviation transportation services.

This requires the consideration of the total costs (including government subsidies and the value of passenger time) of traveling between initial origin and ultimate destination, and not just the out-of-pocket costs between airports. This is sometimes done by the CAB and FAA. It also requires consideration of the costs of using other modes of travel (for example, high-speed rail service in the northeast corridor) and nontransport alternatives such as communications (perhaps in the future, closed-circuit conference television) and relocation of economic and governmental activities.

**In the past few years the U.S. Bureau of the Budget has requested that the FAA perform more benefit-cost evaluations for its investment outlays. Such studies are now being undertaken more frequently.**

**For example, in late 1967, FAA set a speed limit of 250 knots (288 miles per hour) for all aircraft operating below 10,000 feet mean sea level; in 1968 it adopted higher weather minimums for flights operating under VFR (visual "see and avoid" rules) above 10,000 feet and banned limited visibility (special) visual flight operations at 33 hub airports. This year FAA also proposed a reduction in visual flying in controlled airspace where instrument flight rules (IFR) are in force. IFR flights must file a flight plan and operate in accordance with air traffic control (ATC) instructions. Separation between IFR aircraft is provided by ATC. FAA already prohibited, as of November 1967, VFR operations from 18,000 to 60,000 feet over the busy northeastern and northcentral United States (24% of the country) and from 24,000 to 60,000 feet over virtually the rest of the country. The proposed rule would reduce the mix of VFR and IFR traffic below these levels.**
Such an approach would be fruitful in dealing with the huge forecasted growth of air travel demand, which has been viewed with some alarm.\textsuperscript{34} Certainly there is cause for concern, for without remedial action the major hub airports may become so congested with ground and air traffic that they may be virtually unable to function. For example, with the existing runways, by 1970, the typical peak-hour delay at New York's Kennedy airport is forecasted by FAA to be nearly two hours.\textsuperscript{35} The total passenger time lost due to delays at Kennedy in that year would be approximately 6.3 million hours.

Excluding restrictions to limit the total number of operations, the alternative means for reducing such delays are many:

1. new airports, new runways, and runway extensions
2. restrictions on airline schedules and general aviation operations during peak hours (recently introduced at some locations), either by administrative actions or by raising landing fees to levels that limit congestion during these periods
3. computer-aided-approach-spacing (CASS) to inform controllers when to instruct a pilot to speed up, slow down, or make a turn behind another aircraft
4. restricting runways and airports to specific types of operations so as to reduce the mixing of fast and slow aircraft, which reduces over-all capacity
5. reduced radar spacing for IFR operations departing or arriving on parallel runways
6. use of alternative air traffic control procedures such as granting priorities and sequencing aircraft by speed and type of plane
7. improved taxiway exits
8. close, parallel, general aviation runways at air carrier airports and general aviation "reliever" airports at major hubs with congested air carrier airports.

These alternatives vary greatly in their effectiveness and costs. According to FAA, the greatest increase in total airport capacity and the greatest reduction in airport delays are achieved by parallel runways and new airports. On the other hand, when comparing the value of reductions in delays (benefits) to costs of the delay-reducing measures, the greatest return is achieved by automation of specific air traffic control functions and by air traffic procedural improvements. Safety considerations are not quantified for these alternatives, although presumably there are gains from segregating traffic of different speeds.\textsuperscript{36}

\textsuperscript{34} Schriever & Seifert, The Impending Crisis in Air Transportation, 70 Technology Rev. 18 (1968).
\textsuperscript{35} FAA Staff, Alternative Approaches for Reducing Delays in Terminal Areas, II-5 (1967).
\textsuperscript{36} Safety gains are found to be the principal benefit of certain airport approach aids, FAA, Staff Study of Costs vs. Benefits of Airport Approach Aids (August 1967). On the other hand, the potential safety losses of lowering weather minimums (announced in January 1967 for 23 airports) have been stated by FAA. The aim of achieving lower minimums, fewer flight diversions and delays and
The Aircraft Owners and Pilots Association (AOPA), representing 147,000 general aviation members, has reacted vigorously to the suggestion that general aviation traffic be separated from air carrier operations. In an editorial entitled “War...?,” the AOPA states,\(^{37}\)

The time has come to put a stop to accepting “separate but equal” airport facilities. We refuse to accept “reliever” airports by that definition; who are these arrogant commercial companies to demand that additional public funds be spent on outlying airports for us, to “relieve” them of our presence on existing public airports? But such a move, for reasons of both safety and delays, is underway in many cities. For example, in September 1967, the Port of New York Authority joined with major airlines in moves to ease congestion by inducing private and corporate planes to use peripheral airports.\(^{38}\) During peak hours when delays are most severe and the danger of collisions is greatest, such planes account for sixty-two per cent of the total traffic at LaGuardia, fifty-two per cent at Newark, and thirty-one per cent at Kennedy.\(^{39}\) Aside from developing the peripheral airports, frequent non-stop bus service from Teterboro to Manhattan was instituted to make that airport more attractive to private fliers. Airlines will meet any deficits of the bus service.

Inducements to move, of course, are a different matter than simply banning general aviation operations at major airports. The man flying from a location without air carrier service to New York to catch a flight at Kennedy does not want to land forty miles away at Teterboro, New Jersey, and spend another ninety minutes in an inter-airport trip. Perhaps, on this score, AOPA’s objection is justified. On the other hand, if the general aviation plane delays or endangers an air carrier flight of 100 to 400 passengers by as little as three minutes, the costs of permitting the operation into Kennedy overwhelmingly favor the diversion to Teterboro. Solutions to the dilemma may be to (1) provide a short, parallel runway for some general aviation movements; (2) charge higher landing fees during congested periods; and (3) inaugurate inter-airport helicopter service for those general aviation passengers who are diverted to “reliever” fields.

The need for an integrated view of transportation requirements should be clear. It should also be evident that the present fragmented framework of split responsibilities for transportation regulation, and planning between many govern-
ment agencies (the Secretary’s office of the Department of Transportation, CAB, FAA, NTSB, ICC, and others) and the pressures from different vested interest groups (aircraft manufacturers, airlines, general aviation, and airport operators) have hardly resulted in a system that best meets the public interest. Especially neglected are the interests, as taxpayers, of the eighty-five per cent of adults that do not fly in any given year. This is illustrated by the same AOPA editorial:

As for the attitude of the present administration of our Government toward general aviation, our role here also is clear. The White House demands that all civil aviation pay for 100% of the public system they use. This bizarre notion has been fed to the President by the Bureau of the Budget and the Department of Transportation, both distinguished by their lack of knowledge or concern for general aviation; they’re after every cent they can get to feed the inflated national budget. In all of this, FAA now runs a poor third, carrying out helplessly the edicts handed them by the Department of Transportation, their immediate boss. No longer an independent agency, FAA has its expertise brushed aside by indifferent superiors.

AOPA knows from long experience that there is just one defense against such tactics: Congress. Which, in turn, means the individual member, the voter. It is to Congress general aviation must turn for the ultimate solution. Congress must make it clear that no commercial combine can take over any national resource for its own profit, and that all citizens using that national resource have equal rights to do so. And it’s Congress that is going to have to get straight this business of taxing the public for a costly transportation system (our airspace system in this case), then trying to collect 100% of the cost in addition, for the use of that system—already paid for by the public.

This position does not have much public merit, either on equity or economic efficiency grounds. Certainly it is inequitable for the nonflying public to subsidize flying activities. If government expenditures are made for civil aviation, then those who benefit by availing themselves of the service should pay the costs. This has historically been true in ground transportation (governmental toll roads go back to ancient times) and communications (for example, the postal service).

As important is the matter of resource allocation. Where the government provides a good or service that is competitive with other consumer or producer expenditures, and where the national defense, education, economy of scale, and other benefits to the public at large are no greater than from the production of other goods or services (termed “external effects” by economists), the failure to charge for the item results in its disproportionate use. Perhaps the services provided to general aviation are an illustration. This segment of civil flying pays only a minor share of the costs incurred in its behalf by the FAA. The estimated costs of the domestic

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40 Survey Research Center, University of Michigan, The Travel Market, 1964-65 (1965). Approximately half the adult population has never taken an air trip.
federal airways system allocated to general aviation in recent years total approximately $140 million. An even more conservative allocation, which neglects the costs of radar, instrument landing systems, and en route traffic control centers, totals over $100 million.

The recovery of these costs is practically nil. General aviation pays only about $7 million in federal aviation gasoline taxes or about five to seven per cent of the costs. In contrast (cf. Table 8), for air carriers the recovery is far greater. In fiscal 1968, the estimated yield of the domestic passenger transportation tax (five per cent of fares) plus the aviation gasoline tax totaled nearly $230 million, or about ninety per cent of the domestic federal airway costs allocated to air carriers. This may help to explain why general aviation operations and hours flown have grown more

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These costs are derived by amortizing investment in traffic control towers, radars, and other facilities over their useful lives. Operating expenses, interest costs, and overhead are charged on a current basis. The allocation to segments of flying is made by average use of facilities, by type and cost, in each fiscal year. The respective percentages are roughly: air carriers, 45%; general aviation, 30%; and military aviation, 25%.

The included costs encompass FAA operated airport traffic control towers, the VORTAC and LM/F systems, and flight service stations.
rapidly than those of air carriers in the last decade. Even currently, taking the rising number of midair collisions as one indication, the disproportionate growth of general aviation is causing severe problems for maintaining air safety. Certainly charges to recover the costs of federally provided air traffic control and airway services are justified, not only on grounds of equity and economic efficiency in resource allocation, but also to shift demand and ease safety burdens. Such user charges have been strongly opposed by aviation interest groups—witness the AOPA editorial quoted above. There has also been opposition to proposed FAA fees for pilot licenses and aircraft certification, even though the fees are very modest. FAA's April 1967 proposal had a schedule of thirty airman fees ranging from one dollar to thirty-five dollars and hardware fees with a top charge of $244,000 for an original certificate for a large four-engine jet.

General aviation pilots and the AOPA have also vigorously protested other FAA measures to increase safety. For several years, FAA proposed periodic flight instruction and proficiency checks for general aviation pilots. (Such checks are now mandatory only for air carrier pilots.) But, in the face of the opposition, it has successively withdrawn and retrenched from rules proposed in 1966 to a simple announcement of its intention to restudy the problem. This is in spite of an agency review of accident records that shows that "many accidents can be ascribed to deterioration of basic airmanship and skills and to pilots' failure to keep abreast of new developments and operational procedures." The agency noted that its efforts to encourage general aviation pilots to secure periodic refresher training and proficiency checks voluntarily have been only partially successful. (The AOPA offers such courses; over the past five years some 20,000 persons have attended its training clinics.) Accordingly, FAA believes some rule-making action in this area "may be appropriate."

It may also be desirable to require pilot training and instruction with regard to the use of weather information and forecasts and flying procedures under adverse weather conditions. Many pilots, for example, do not appreciate the destructiveness

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44 FAA and the Department of Transportation have been considering revisions in present user charge schedules. In a speech on June 11, 1968 at the FAA Report-to-Industry Luncheon, Frank W. Lehan, Assistant Secretary for Research and Development of DOT outlined a proposal to Congress for four changes in the tax laws:
1. An increase in the passengers tax from the present 5% to 8%.
2. A new tax on freight waybills of 8%.
3. An increase in the tax on general aviation gasoline from the present two cents a gallon to ten cents by 1972; and
4. A new tax on jet fuels used by general aviation of seven cents per gallon in 1969 graduating to ten cents by 1972.

The fuel taxes on general aviation were said to add less than an estimated three per cent to operating costs in most cases; they would raise the percentage of cost recovery to about 20%.

45 In another approach to the problem, FAA recently assigned thirty-one specialists in accident prevention to field offices in the central and southwestern United States to counsel general aviation pilots and make them "more safety conscious and thus promote a general upgrading of flying skills." FAA Information Release No. 44, July 16, 1968.
of turbulent weather or know how to deal with it. More frequent weather condition
reports and forecasts for some locations and greater ease of obtaining weather data
would also be beneficial. In 1966, weather was a cause of eleven, and a factor in 313,
of the 573 general aviation fatal accidents. Low ceiling, rain, and fog were factors
in three of the eight fatal air carrier incidents in that year.

Another problem that deserves attention is pilot drinking. In a recent study
based on toxicological examinations, FAA found that ethyl alcohol was associated
in 1963-65 with about one-third of fatal general aviation accidents. This conclusion
was vigorously challenged by AOPA, which decided that a much smaller
percentage of fatal accidents was attributable to drunkenness. However, even the
more "conservative" findings of the CAB, which AOPA cites and seems to accept,
show that a significant percentage (e.g., thirty-eight of 504 fatal accidents in 1965)
of pilot deaths was attributable to alcoholic impairment of efficiency and judgment.
Because widespread enforcement of a regulation banning drinking before flying is
virtually impossible, the principal focus of accident prevention in this area, already
partially initiated by FAA, probably should be an aggressive airman education pro-
gram.

Finally, a number of actions can be taken to decrease the possibility of midair
collisions. Cockpit visibility can be increased (rear view mirrors are a simple but
effective device for some aircraft); flying and visibility rules can be further modified;
descent and climb corridors can be established; aircraft can be painted and lighted
for improved conspicuousness; radar advisories on traffic conditions, especially for
en route VFR flights, can be made more readily available; and various types of
proximity warning and collision avoidance equipment can be required. All these
measures to improve safety, of course, have costs. In each instance it is necessary
to compare the costs with the value of safety and nonsafety gains with and without
the measures.

Even with greater precautions, due to higher traffic densities, collisions and
other accidents are bound to occur. The question then arises as to who is to com-
pensate the families of accident victims and in what amounts.

V

Compensation for Accident Victims

Several years ago, effective May 16, 1966, international airlines operating to or
from the United States agreed to pay plaintiffs up to $75,000 for each death resulting

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47 S. Mohler, Recent Findings on the Impairment of Airmanship by Alcohol (FAA, Office of
Aviation Medicine, 1966).

48 Best, What is the Truth About Drunken Flying, Part I, AOPA Pilot, May 1967, at 29-34; Part II,
June 1967, at 38-43. See also the rebuttal comment by Heise, AOPA Pilot, Sept. 1967, at 31-33.

49 Federal Aviation Regulations prohibit flying while in a state of intoxication, whatever the source
(drugs, alcohol, etc.). Most airlines enforce rules prohibiting aircraft crews from flying if they have
been drinking in the preceding 12 to 24 hours before a flight.
from an accident. The payment is automatic, and not subject to proof of airline negligence. For domestic airlines, there is no such agreement or requirement by the CAB for indemnification of victims. Typically, fatal accidents result in legal proceedings by estates to recover damages. Moreover, the federal government, because of its air traffic control functions, is frequently a third party defendant.

There are several problems with this tort approach to compensation. It involves proof of culpability of airlines and the government. This requires extensive investigation (beyond that of the proximate cause of accidents established by FAA and NTSB) and long delays before claims are adjudicated. The process is costly to plaintiffs and defendants alike. Also, for those families of victims not adequately covered by insurance, the period before payment is made can be one of hardship.

Additionally, in cases where neither an airframe manufacturer, airline, or the government are to blame, no common law right to compensation can be established. Such instances can arise due to acts of God in the form of accidents caused by freakish, unpredictable weather disturbances. A collision fatal to air carrier passengers in which a private general aviation pilot solely is at fault (for example, where he violates air traffic control instructions and evasive action of an airliner is impossible) also leaves little basis for compensation. The resources of all but the wealthiest pilots generally are insufficient to cover the damages involved.

At present, the financial position and insurance coverage of most airlines is inadequate to bear the liability of a major disaster, such as the crash of a full 490-passenger jet. Consequently, the Justice Department is considering legislation to establish a government trust fund to provide automatic compensation for the families of persons killed in U.S. airline accidents. Aside from the humane aspects of such a bill, part of its rationale is to limit the rapidly rising burden of compensation claims on the nation's taxpayers. In recent years, the trend of decisions of judges and juries has been to find the FAA at fault in airline accident litigation. Awards by the government in fiscal 1967 were more than $658,000 and the outstanding claims for alleged government negligence in air accidents at the end of that year totaled over $200 million.

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60 CAB, Docket No. 17325.
61 There is a requirement that plaintiffs show that damages equal or exceed $75,000. For the kin of most passengers this is not difficult, but it might prove so for the family of a penniless elderly person.
62 As private aircraft ownership becomes more widespread, there is an increasing possibility that some pilots may act irresponsibly by deliberately disobeying federal air regulations, by passing dangerously close to airliners, or by engaging in other acts which endanger other aircraft. The motivations for flying are many, and it cannot simply be assumed that all pilots are rational and would not foolishly risk their own lives or those of others. Just as some people express their aggressions by reckless driving, a small minority of aviators, too, may be reckless. See D. Bond, THE LOVE AND FEAR OF FLYING (1952).
Moreover, since the government’s loss of the “Eastern 512” case on appeal, there has been increasing tendency by the Justice Department not to litigate cases but rather to settle them out of court. The suit arose from an accident at Kennedy International Airport on November 30, 1962, in which Eastern Air Lines flight 512 crashed while attempting to land in a swirling ground fog. Twenty-one passengers and four crew members were killed, and twenty-eight to thirty other persons were injured. The asserted liability of the government was based on the claim that poor visibility was a factor in the crash and that a substantial contributing and concurrent cause of the accident was the negligence of the air traffic controllers and the U.S. Weather Bureau in failing to provide accurate, up-to-date weather information. The action was brought as a “test case” to determine the issues of liability and the right to indemnity. The government lost its appeal on the ground that its employees had failed to perform a duty they had undertaken, that is, to provide information and warnings to protect travelers of the airways. Thus, virtually every collision and many other accidents can in part be blamed on the government. Under these circumstances, a means should be found of limiting the public’s liability and yet protecting victims’ families. The fixed maximum amount, waiver-of-defense, automatic compensation procedure, a precedent already established for international airline operations, seems ideal for both purposes.

However, as contrasted to the international airline agreement, the requirement that damages be proven to exceed the fixed amount might also be waived except in accidents involving actual or probable sabotage. Besides having the former advantages, this procedure may also be more equitable than litigated payments based on estimated future lifetime earnings of the deceased. From a nonpecuniary standpoint, the loss of any family member is the same, whether the household is rich or poor. Grief is not proportional to income.

According to Hoffman, lawyers specializing in aviation say the average settlement for an accidental aviation death approximates $150,000. Coincidentally, this is the same amount as the estimated loss of utility of lost earnings of the average victim’s family postulated above. If per fatality payments of this magnitude had been made in 1967, the total payoff for all deaths (including crew members and bystanders)

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66 In order to reduce incentives for sabotage by potential heirs, automatic payments could be eliminated for fatal crashes caused by deliberate destruction. Under the agreement by international carriers, airlines have waived the right of defense except for claims “brought by, on behalf of, or in respect of any person who has wilfully caused damage which resulted in death, wounding or other bodily injury of a passenger.” Also, for crashes involving sabotage, proof of damages might be required.
67 Hoffman, supra note 53, at A14. See also, Newsweek, July 29, 1968, at 83, reporting out-of-court settlement totaling $8,282,786 for 54 passengers, or an average of just over $150,000 per passenger.
would have been $42.9 million. If only passengers' families were compensated, the total would have been $33.9 million.

In a sense, it is possible to regard the payments as death benefits on airline trip insurance policies. If they had been financed from current premiums, in 1967, they would have required only a modest increase in fares—about one per cent. Thus, it would not have been necessary for the government to participate directly except, perhaps, as a guarantor of adequate reserves to meet liabilities. In other words, a consortium of private insurance companies (or a company established by the airlines) could underwrite the policies. Also, airlines with operations of higher than average inherent risk or with poorer accident performance could be charged higher premiums.

CONCLUSION

Compensation for the families of accident victims can cushion losses; but, of course, it does nothing to reduce fatalities, the ultimate desideratum. To increase safety, the concerted efforts of all users and providers of aviation services are required.

In part, some of the problems of the past have been due to conflicts among various interest groups of the industry, especially general aviation and air carriers. These should be resolved. Also, stronger CAB, FAA, and congressional leadership might have averted the dangerous congestion and inadequate air traffic control system which exists today.

As frequent travelers on airlines and as users of general aviation, members of Congress should be vitally concerned from a personal standpoint about air safety. Moreover, since their most influential and wealthy constituents are also intensive users of aviation services, there should be strong additional incentives for them to take an interest in aviation matters. After a decade, the time has come for review of the Federal Aviation Act of 1958 and some basic reforms. The task is too vital, and the dangers too great, to be left to the vagaries of interest group pressures and the whims of government bureaucrats, however dedicated and competent they may be.

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88 Since, as noted above, the risks of a trip largely are incident to takeoffs and landings, the charge might better be assessed on a trip rather than a mileage (i.e., fare) basis. For the average domestic round-trip on scheduled airliners, this means that the premium would be about $0.75. By comparison, various credit card companies offer $100,000 of automatic flight insurance for a charge of $3.00 per trip.