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AIRCRAFT CRASHWORTHINESS*—PLAINTIFF'S VIEWPOINT

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CRASHWORTHINESS—THE PROBLEM AND THE CONCEPT

IN HIS 1970 preface to *Crash Safety in General Aviation Aircraft*,[1] Ralph Nader wrote of the then state of aircraft crashworthiness development, "the problem is one of technological stagnation surrounded by managerial ignorance, industry intransigence and the paralytic hand of the FAA bureaucracy." Five years later a comment on the Nader Report advises us that "significant increases in aircraft crashworthiness technology have evolved since that report. Moreover, there is much greater awareness of the feasibility of better design to minimize crash-related injury."[2] While the technology has, indeed, evolved and while it is true that the feasibility of crashworthy design has been demonstrated to the aviation community, comparatively little appears to have been done to incorporate the advanced technology into production aircraft.[3] Apparently, "industry intransigence" and the "paralytic hand of the FAA bureaucracy" still prevail.

Crashworthiness is the characteristic of a vehicle which protects its occupants from death in a survivable crash and otherwise pro-

* This article will address itself to general aviation crashworthiness. The principles discussed herein, however, are equally applicable to transport category aircraft crashworthiness.

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[1] BRUCE & DRAPER, CRASH SAFETY IN GENERAL AVIATION AIRCRAFT (Nader Student Group 1970).

[2] Perone, *An Overview of Aircraft Crashworthiness Research and Development*, AIRCRAFT CRASHWORTHINESS 11 (1975).

[3] This failure to employ advanced crashworthiness technology is evidenced, in part, by the fact that the percentage of accidents (as defined in 49 C.F.R. §

tects its occupants from injury or cumulative injury.[4] In a survivable crash, a crashworthy vehicle will provide its occupants with an

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830.2 (1975)) resulting in fatalities has not dramatically decreased since 1970, as the figures below demonstrate.

ACCIDENTS
U.S. GENERAL AVIATION 1968-1975

	Total	*Fatal*	*% Fatal*
1968	4,965#	689#	13.88
1969	4,767	647	13.57
1970	4,711#	640#	13.59
1971	4,648	661	14.22
1972	4,253#	692#	16.27
1973	4,253#	721#	16.95
1974	4,425#	729#	16.47
1975P	4,575	662	14.47

#—Does not include suicide/sabotage accidents (1968—3, 1970—1, 1972—3, 1973—2, 1974—2).

P—Preliminary.

Source: Safety Information Release, S.B. 76-4, Table 10, National Transportation Safety Board, January 24, 1976.

The annual fatality rate for U.S. general aviation during the same years, according to the same source, was as follows:

1968	1399	1972	1421##
1969	1413##	1973	1412
1970	1310	1974	1438
1971	1355	1975P	1324

##—Does not include air carrier fatalities when in collision with general aviation aircraft (1969—82; 1972—5).

P—Preliminary.

Prior to publication of the *Nader Report,* it had been suggested by several authorities that one half of all general aviation fatalities were attributable to uncrashworthy aircraft. Hasbrook, *Crash Safety,* 34 AEROSPACE MEDICINE 537 (1963); Mohler & Swearingen, *Cockpit Design for Impact Survival,* REP. NO. AM 66-3 at 1 (FAA Office of Aviation Medicine 1966).

In 1973 it was estimated that ninety-four per cent of fatal and serious injuries could be avoided by utilization of an adequate occupant restraint system. Dille, The Contribution of Pioneer Aircraft Accident Investigation to Improved Transportation Safety (VIII International Symposium on Aviation Medicine, Civil Aviation Medical Association 1973).

Even if one were to utilize the lower estimate that a fifty percent reduction in fatalities could be achieved by making aircraft crashworthy, since 1970 alone approximately 4,130 lives might have been saved. This is a sufficient number of people to fill more than nine 747's. The magnitude of the crashworthiness problem both from the standpoint of failure to implement existing technology and in terms of human lives should be apparent to all.

[4] Crashworthiness accidents have been defined as "accidents in which the vehicle is not causally related to the accident itself, but in which the severity of the injuries is attributable to the design or construction of the vehicle." L. FRUMER & M. FRIEDMAN, 1 PRODUCTS LIABILITY § 104.28 (1975). In Dreisonstok v. Volkswagenwerk, A.G., 489 F.2d 1066, 1069 (4th Cir. 1974) the court defined a crashworthy vehicle as "one which, in the event of a collision, resulting accidentally or negligently from the act of another and not from any defect or malfunction in the vehicle itself, protects against unreasonable risk of injury to the occupants.[3]" Footnote 3 alluded to four additional definitions of crashworthiness.

"island of safety"; it will restrain critical portions of their bodies from colliding with the interior of the occupant compartment; and it will afford its occupants protection from debilitating and fatal post-crash injuries. A crashworthy vehicle affords its occupants an "island of safety" by assuring that the occupant compartment will not collapse; that there will be no intrusion into the cabin of aircraft components which will jeopardize the occupants; and that its interior is delethalized in the event its occupants collide with the interior in a "second collision." Inasmuch as longitudinal, vertical, and lateral decelerative forces of considerable magnitude may be exerted even in a survivable crash, the crashworthy vehicle will incorporate adequate restraints, particularly upper torso restraints and seating which will collapse symmetrically and not bottom out, resulting in instantaneous vertical deceleration. In addition, the vehicle will facilitate expeditious egress in emergency and will not subject its occupants to hazard from fire, smoke, or noxious fumes from burning fuel or cabin materials.

Function of Plaintiff's Lawyer In a Crashworthiness Case

The technological function of the plaintiff's lawyer, in a situation in which death or injury is believed to be attributable to an aircraft's being uncrashworthy, is multifaceted and will include the following: identifying the crash as survivable; proving the aircraft was uncrashworthy; establishing that the state of the art at the time the aircraft was produced included technology which could have made the aircraft crashworthy; and demonstrating the causal relationship between the failure to incorporate this technology and injury or death. In addition, counsel must secure experts to prove, among other factors, the dynamics of the crash, the biomechanics of the injuries sustained, and the state of the art.

While the bulk of case law upholding the doctrine of crashworthiness relates to automotive vehicles,[5] the doctrine is equally

[5] *See, e.g.*, Wooten v. White Trucks, 514 F.2d 634 (5th Cir. 1975); Nanda v. Ford Motor Co., 509 F.2d 213 (7th Cir. 1974); Perez v. Ford Motor Co., 497 F.2d 82 (5th Cir. 1974); Huddell v. Levin, 395 F. Supp. 64 (D.N.J. 1975); Bremier v. Volkswagen of America, Inc., 340 F. Supp. 949 (D.C. Cir. 1972); Dyson v. General Motors Corp., 298 F. Supp. 1064 (E.D. Pa. 1969); Frericks v. General Motors Corp., 274 Md. 288, 336 A.2d 118 (1975); Rutherford v. Chrysler Motors

applicable to other vehicles, including aircraft.[6] Its adoption has not been without dissent, however.[7] Those jurisdictions refusing to adopt the doctrine are in the minority, and their reasoning in rejecting the doctrine has been severely criticized by courts and writers alike.[8]

When plaintiff's counsel's investigation indicates that injury or death was caused by an uncrashworthy aircraft, he may proceed

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Corp., 60 Mich. App. 392, 231 N.W.2d 413 (1975); Arbet v. Gussarson, 66 Wis. 2d 551, 225 N.W.2d 431 (1975).

[6] Powell v. Brantly Helicopter Corp., Civ. No. 6522, 11 JURY VERDICT RPTS. 38, 17 ATLA NEWSLETTER 314 (Dist. Ct. of Jefferson Cty., Tex. 1974); Fuller v. Capitol Sky Park, Civ. No. 203674, 10 JURY VERDICT RPTS. 161, 16 ATLA NEWSLETTER 331 (Super. Ct. of Sacramento Cty., Cal. 1973); Smith v. Cessna Aircraft Co., Civ. No. 70-9255-L, 16 ATLA NEWSLETTER 30 (Dist. Ct. of Dallas Cty., 193d Judicial Dist. of Tex. 1972); *contra,* Williams v. Cessna Aircraft Corp., 376 F. Supp. 603 (N.D. Miss. 1974). (Mississippi, however, has not adopted the crashworthiness doctrine for any vehicles. Turner v. Big Four Automotive Equip. Corp., 511 F.2d 133 (5th Cir. 1975).)

Recovery has also been allowed for malfunctioning ejection seats, an aspect of crashworthiness outside the scope of this paper. Moyer v. Martin Marietta Corp., 481 F.2d 585 (5th Cir. 1973); Orr v. Talley Industries, Inc., 17 ATLA NEWSLETTER 361 (D. Ariz. 1974). Priddy v. Talley, Inc., 15 ATLA NEWSLETTER 208, 396 (W.D. Tex. 1972).

Recovery is allowed in aircraft cases because automotive vehicles, to which the doctrine is most commonly applied, are not a special class of vehicle alone deserving of the doctrine (Larsen v. General Motors Corp., 391 F.2d 495, 504 (8th Cir. 1968); Arbet v. Gunnarson, 66 Wis. 2d 551, 225 N.W.2d 431 (1975)), nor are the physics and biomechanics of automotive and aircraft crashes dissimilar. *See, e.g.,* Mickle v. Blackmon, 252 S.C. 202, 166 S.E.2d 173 (1969).

[7] The following jurisdictions have rejected the doctrine: Indiana—Schemel v. General Motors Corp., 384 F.2d 802 (7th Cir. 1967); Evans v. General Motors Corp., 359 F.2d 822 (7th Cir.), *cert. denied,* 385 U.S. 836 (1966); Mississippi—Turner v. Big Four Automotive Equip. Corp., 511 F.2d 133 (5th Cir. 1975); Williams v. Cessna Aircraft Corp., 376 F. Supp. 603 (N.D. Miss. 1974); North Carolina—Alexander v. Seaboard Air Line R.R. Co., 346 F. Supp. 320 (W.D.N.C. 1971); Ohio—Shumard v. General Motors Corp., 270 F. Supp. 311 (S.D. Ohio 1967); Gleich v. General Motors Corp., 29 Ohio App. 2d 28, 277 N.E.2d 566 (1971); West Virginia—McClung v. Ford Motor Co., 333 F. Supp. 17 (S.D.W. Va. 1971), *aff'd,* 472 F.2d 240 (4th Cir.), *cert. denied,* 412 U.S. 940 (1973).

[8] That rejection of the doctrine is the minority view was noted in Huddell v. Levin, 395 F. Supp. 64, 71 (D.N.J. 1975) in which the court wrote, "The rationale of *Evans* [Evans v. General Motors Corp., 359 F.2d 822 (7th Cir.), *cert. denied,* 385 U.S. 836 (1966)], however, has been rejected by the majority of jurisdictions and has met with uniform criticism by commentators." *Accord,* Baumgardner v. American Motors Corp., 83 Wash. 2d 751, ___, 522 P.2d 829, 832 (Wash. 1972) wherein the court wrote "We find the rationale of the *Evans* line of cases to be faulty to the point of being specious," *see also* Nader & Page, *Automobile Design and the Judicial Process,* 55 CALIF. L. REV. 645 (1967); Note, 42 NOTRE DAME LAWYER 111 (1966); Note, 80 HARV. L. REV. 688 (1967).

either in negligence[9] or in strict liability in tort in the form of breach of warranty[10] or otherwise,[11] all in accordance with what applicable law allows. Counsel will most probably predicate his claim on defective design or construction,[12] but he should not ignore a manufacturer's liability based on failure to warn of the existence of an uncrashworthy feature discovered after the aircraft left the manufacturer's plant[13] and perhaps its liability, in such a situation, for failing to make available and to encourage the utilization of crashworthiness enhancing devices that had became technologically feasible.[14] Manufacturers appear particularly accountable for failure to warn through service bulletins, or service letters because of the increase in aircraft crashworthiness technology which has evolved since the 1970 Nader Report and the manufacturer's now "much greater awareness of the feasibility of better design to minimize crash-related injury."[15] Regardless of which of these basic theories

[9] Nanda v. Ford Motor Company, 509 F.2d 313 (7th Cir. 1974); Perez v. Ford Motor Co., 497 F.2d 82 (5th Cir. 1972); Larsen v. General Motors Corp., 391 F.2d 495 (8th Cir. 1968); Huddell v. Levin, 395 F. Supp. 64 (D.N.J. 1975); Dyson v. General Motors Corp., 298 F. Supp. 1064 (E.D. Pa. 1969); Volkswagen of America, Inc. v. Young, 272 Md. 201, 321 A.2d 737 (1974); Rutherford v. Chrysler Motors Corp., 60 Mich. App. 392, 231 N.W.2d 413 (1975); Bolm v. Triumph Corp., 33 N.Y.2d 151, 305 N.E.2d 769, 350 N.Y.S.2d 644 (1973).

[10] Evancho v. Thiel, 297 So. 2d 40 (Fla. App. 1974); Friend v. General Motors Corp., 118 Ga. App. 763, 165 S.E.2d 734 (1968); Frericks v. General Motors Corp., 274 Md. 288, 336 A.2d 118 (1975); Rutherford v. Chrysler Motors Corp., 60 Mich. App. 392, 231 N.W.2d 413 (1975); Bolm v. Triumph Corp., 33 N.Y.2d 151, 305 N.E.2d 769, 350 N.Y.S.2d 644 (1973).

[11] Nanda v. Ford Motor Co., 509 F.2d 213 (7th Cir. 1974); Perez v. Ford Motor Co., 497 F.2d 82 (5th Cir. 1974); Turcotte v. Ford Motor Co., 494 F.2d 173 (1st Cir. 1974); Huddell v. Levin, 395 F. Supp. 64 (D.N.J. 1975); Dyson v. General Motors Corp., 298 F. Supp. 1064 (E.D. Pa. 1969); May v. Portland Jeep, Inc., 265 Ore. 307, 502 P.2d 24 (1973); Turner v. General Motors Corp., 514 S.W.2d 497 (Tex. Civ. App.—Houston [14th Dist.] 1974, writ ref'd n.r.e.); Baumgardner v. American Motors Corp., 83 Wash. 2d 751, 522 P.2d 829 (1974).

[12] In applying the crashworthiness doctrine, the court in Larsen v. General Motors Corp., 391 F.2d 495, 503 (8th Cir. 1968), observed that "neither reason, logic nor controlling precedents compel the courts to make a distinction between negligent design and negligent construction."

[13] Larsen v. General Motors Corp., 391 F.2d 495 (8th Cir. 1968); Friend v. General Motors Corp., 118 Ga. App. 763, 165 S.E.2d 734 (1968); Comstock v. General Motors Corp., 358 Mich. 163, 99 N.W.2d 627 (1959); Braniff Airways, Inc. v. Curtiss-Wright Corp., 411 F.2d 451 (2d Cir.), *cert. denied*, 369 U.S. 959 (1969).

[14] *Cf.*, Braniff Airways, Inc. v. Curtiss-Wright Corp., 411 F.2d 451 (2d Cir.), *cert. denied*, 396 U.S. 959 (1969); Noel v. United Aircraft Corp., 342 F.2d 232 (3d Cir. 1964).

[15] *See* note 2 *supra*. The crashworthiness doctrine has not been limited to manu-

of liability is available on the facts of a given case, plaintiff's counsel should be certain the forum he selects will apply the law of a jurisdiction which has adopted the doctrine of crashworthiness or is likely to do so.[16]

Rarely is counsel retained until after the victims of the uncrashworthy aircraft have been buried and the wreckage of the aircraft hauled from the crash site to the premises of some fixed-base operator or to some aircraft bone-yard. This may greatly complicate counsel's task of investigating the crashworthiness

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facturers alone. It has been applied to dealers, distributors and importers. *See, e.g.*, Frericks v. General Motors Corp., 274 Md. 288, 336 A.2d 118 (1975); Brandenberger v. Toyota Motor Sales, U.S.A., Inc., 162 Mont. 506, 513 P.2d 268 (1973); Bolm v. Triumph Corp., 33 N.Y.2d 151, 305 N.E.2d 769, 350 N.Y.S.2d 644 (1973); Turner v. General Motors Corp., 514 S.W.2d 497 (Tex. Civ. App.—Houston [14th Dist.] 1974, writ ref'd n.r.e.); Seattle-First Nat'l Bank v. Volkswagen of America, 11 Wash. App. 929, 525 P.2d 286 (1974).

[16] The crashworthiness doctrine appears to be the law in the following jurisdictions: California—Cronin v. Olson Corp., 8 Cal.3d 121, 501 P.2d 1153, 104 Cal. Rptr. 433 (1972); Culpepper v. Volkswagen of America, Inc., 33 Cal. App. 3d 510, 109 Cal. Rptr. 110 (1973); District of Columbia—Bremier v. Volkswagen of America, Inc., 340 F. Supp. 949 (D.C. Cir. 1972); Florida—Evancho v. Thiel, 297 So. 2d 40 (Fla. App. 1974); Georgia—Friend v. General Motors Corp., 118 Ga. App. 763, 165 S.E.2d 734 (1968); Illinois—Nanda v. Ford Motor Co., 509 F.2d 213 (7th Cir. 1974); Iowa—Passwaters v. General Motors Corp., 454 F.2d 1270 (8th Cir. 1972); Kentucky—Wooten v. White Trucks, 514 F.2d 634 (5th Cir. 1975); Louisiana—Perez v. Ford Motor Co., 497 F.2d 82 (5th Cir. 1974); Maryland—Frericks v. General Motors Corp., 274 Md. 288, 336 A.2d 118 (1975); Volkswagen of America v. Young, 272 Md. 201, 321 A.2d 737 (1974); Michigan—Rutherford v. Chrysler Motors Corp., 60 Mich. App. 392, 231 N.W.2d 413 (1975); Minnesota—Larsen v. General Motors Corp., 391 F.2d 495 (8th Cir. 1968); Ford Motor Co. v. Zahn, 265 F.2d 729 (8th Cir. 1959); Montana—Brandenberger v. Toyota Motor Sales, U.S.A., Inc., 162 Mont. 506, 513 P.2d 268 (1973); Nebraska—Friedrich v. Anderson, 191 Neb. 724, 217 N.W.2d 831 (1974); New Jersey—Huddell v. Levin, 395 F. Supp. 64 (D.N.J. 1975); New York—Bolm v. Triumph Corp., 33 N.Y.2d 151, 305 N.E.2d 769, 350 N.Y.S.2d 644 (1973); North Dakota—Johnson v. American Motors Corp., 225 N.W.2d 57 (N.D. 1974); Oklahoma—Marshall v. Ford Motor Co., 446 F.2d 712 (10th Cir. 1971); Oregon—May v. Portland Jeep, Inc., 265 Ore. 307, 509 P.2d 24 (1973); Pennsylvania—Dyson v. General Motors Corp., 298 F. Supp. 1064 (E.D. Pa. 1969); Rhode Island—Turcotte v. Ford Motor Co., 494 F.2d 173 (1st Cir. 1974); South Carolina—Mickle v. Blackmon, 252 S.C. 202, 166 S.E.2d 173 (1969); South Dakota—Engberg v. Ford Motor Co., 205 N.W.2d 104 (S.D. 1973); Tennessee—Ellithorpe v. Ford Motor Co., 503 S.W.2d 516 (Tenn. 1973); Texas—Turner v. General Motors Corp., 514 S.W.2d 497 (Tex. Civ. App.—Houston [14th Dist.] 1974, writ ref'd n.r.e.); Virginia—Driesonstok v. Volkswagenwerk A.G., 489 F.2d 1066 (4th Cir. 1974); Washington—Baumgardner v. American Motors Corp., 83 Wash. 2d 751, 522 P.2d 829 (1974); Seattle-First Nat'l Bank v. Volkswagen of America, 11 Wash. App. 929, 525 P.2d 286 (1974); Wisconsin—Arbet v. Gussarson, 66 Wis. 2d 551, 225 N.W.2d 431 (1974); Grundmanis v. British Motor Corp., 308 F. Supp. 303 (E.D. Wis. 1970).

aspects of the crash. Particularly is this true inasmuch as the investigators of the National Transportation Safety Board tend to focus primarily on the cause of the crash and not on its survivability.

Ideally, counsel and his investigator should be at the site of the wreckage prior to removal of the wreckage and examine, photograph, and diagram both the wreckage and the site. Of particular importance is the nature of the damage to the aircraft components. The integrity of the occupant compartment must be observed, noting the mode of any failure. Attention must be given to what occupant restraints had been installed, whether they failed, and, if so, the mode of failure. The occupants' seats must be similarly examined. Careful attention must be given to any evidence of impact of the occupants with the interior of the cabin[17] and the location, extent, and manner of any such impact must be meticulously documented. In examining the wreckage, care must be taken to distinguish post-crash damage caused by rescue personnel or others. As to the site itself, the configuration of the aircraft's impact with the terrain or obstacles should be diagrammatically and photographically recorded and the location of these impact points in relation to the various parts of the wreckage noted.

Of paramount importance is preservation for trial of the wreckage after its removal from the crash site. Equally important to wreckage and site documentation is injury documentation. As soon as practicable, witnesses should be consulted as to the exact locations and positions of the victims in the wreckage. In the case of death, a thorough autopsy should be performed, including x-rays and chemical studies, and a complete report prepared and made available to your bioengineer.[18] Care should be taken to distinguish between ante- and post-mortem damage to the body.[19]

As part of his investigation, counsel should thoroughly familiarize

[17] In examining the cabin interior, the glare shield, radio stack, and the control yoke will be of particular interest. It should be observed whether the horns of the control yoke are broken off. The underside of the instrument panel should be examined for evidence of impact caused by the flailing of the lower extremities.

[18] Evaluation of vertebral fractures is often valuable in determining the magnitude and direction of decelerative forces.

[19] When post-crash fire occurs, heat frequently produces bone fractures through muscle contraction and may cause extensive skull fractures due to pressure created by intracranial steam. McMeekin, *Patterns of Injury in Fatal Aircraft Accidents*, 1973 AEROSPACE PATHOLOGY 86-95.

himself with the type of aircraft involved in the crash and, together with his structural or materials engineer, ascertain the energy absorption capabilities of the aircraft; the limitations of the restraint system and its conduciveness to pilot use; the engineering and materials utilized in the seats; the extent to which the occupant compartment, through design and material selection, had been delethalized; and the fuel system's crash integrity. The aspects requiring familiarization with the same type aircraft as that involved in the crash will be dictated by the results of the wreckage and wreckage site investigation and the injury pattern observed on the victims.

All of this investigation and familiarization will be utilized to determine whether the crash was survivable; whether the aircraft was crashworthy; and whether a causal relationship existed between the lack of crashworthiness and the injuries sustained by the victims.

As part of his discovery from the defendant manufacturer, counsel should ascertain what crashworthiness studies, if any, had previously been conducted by the manufacturer on the type aircraft involved. Counsel should also explore the extent to which the manufacturer had conducted investigations of crashes involving this type of aircraft to determine what dynamic loading the aircraft and its components were capable of sustaining and what aspects of that type aircraft consistently failed to provide protection for its occupants.

PROVING THE CRASHWORTHINESS CASE

To impose liability based on a claim of uncrashworthiness, in addition to proving injury or death was caused by an uncrashworthy aircraft, plaintiff's counsel must prove the crash was survivable (when the injuries sustained because of uncrashworthiness resulted in death);[20] the statistical foreseeability of the aircraft's being involved in an accident (particularly if the claim is based on negligent design and construction); and the state of the art of producing crashworthy aircraft at the time of the specific aircraft's production was advanced to a degree that the aircraft involved in the crash could have been made crashworthy.

[20] Dyson v. General Motors Corp., 298 F. Supp. 1064, 1073 (E.D. Pa. 1969). Plaintiff's counsel need not prove the survivability of the crash to a certainty. Huddell v. Levin, 395 F. Supp. 64, 76 (D.N.J. 1975).

Logic dictates that a survivable crash is one in which the decelerative forces experienced by the occupant's body do not exceed human tolerance. Critical, therefore, in a given crash is the magnitude and direction of the decelerative forces exerted on the least tolerant portion of the human body. Today, the upper limits of human impact tolerance are known for bony components, although information on soft tissue response including the heart, circulatory system, the lungs, and the liver are much less clearly defined; moreover, crude guides have been developed with reference to intracranial impact injury.[21] Counsel need not concern himself with the upper limits, however, unless the decelerative forces in his case are in that area.[22] It is generally recognized that the human body can survive dynamic longitudinal decelerative forces of forty g's and lateral and vertical forces of twenty g's (dynamic).[23]

The statistical foreseeability requirement[24] is met by demonstrating that, as of the time the aircraft was produced, the probability existed that it was likely to be involved, over its useful life, in a crash which carried with it the potential for serious or fatal injury. The degree of probability will vary, of course, among aircraft types. The 1970 Nader Report concluded that the overall statistical forseeability of general aviation aircraft being involved in such an accident (even allowing for one aircraft's being involved in more than one accident) was, at least, seventy percent.[25] A statistical forseeability of twenty-five to thirty-three and one-third percent was found sufficient to satisfy this crashworthiness doctrine requirement as to automobiles in *Larsen v. General Motors Corp.*[26]

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[21] Perone, *supra* note 2, at 8.

[22] Some idea of the upper limits of human tolerance for longitudinal deceleration may be gleaned from the work of Colonel Stapp and his associates in 1951. Colonel Stapp rode a rocket sled in a deceleration test wearing only a shoulder harness-seat belt restraint system with his wrists, feet, and knees tied down to prevent flailing. As a result of the deceleration, the only injuries which Colonel Stapp sustained were minor eye injuries which were corrected. Colonel Stapp had decelerated from 632 m.p.h. to a complete stop in 1.4 seconds. BRUCE & DRAPER, *supra* note 1, at 17-21.

[23] *Id.* at 22.

[24] The requirement of establishing statistical foreseeability is discussed in Larsen v. General Motors Corp., 391 F.2d 495, 501-02 (8th Cir. 1968) and in Mickle v. Blackmon, 252 S.C. 202, 166 S.E.2d 173, 185 (S.C. 1969). It is also alluded to in Dreisonstok v. Volkswagenwerk, A.G., 489 F.2d 1066, 1071 (4th Cir. 1974).

[25] BRUCE & DRAPER, *supra* note 1, at 4.

[26] Larsen v. General Motors Corp., 391 F.2d 495 (8th Cir. 1968).

In any crashworthiness case, except perhaps one involving merely a negligent failure to warn, plaintiff's counsel will be required to prove that, at the time complained of, the state of the art of crashworthiness afforded technology which could have made the particular aircraft crashworthy.[27] The "art" of producing crashworthy aircraft has been systematically studied for over thirty years. The first such research project dates back to 1942 and was undertaken by Hugh DeHaven at Cornell University Medical College.[28] The results of his pioneering work were published as early as 1953 in his *Development of Crash Survival Design in Personal, Executive and Agricultural Aircraft*[29] in which he recommended, in essence, the incorporation of the following design features and devices into aircraft to make them crashworthy:

1. Locate the occupant compartment as far aft as possible and incorporate in the design an optimum of energy absorbing structure forward of that compartment;
2. Design the occupant compartment as the strongest portion of the aircraft which would include providing protection against collapse in a roll-over;
3. Design the engine compartment to allow the engine to be displaced rearward in a crash without its impinging into the occupant compartment;
4. Locate heavy structural components below and forward of the occupant compartment;
5. Design into the fuselage a keel to reduce abruptness of decelerations on impact with the terrain;
6. Locate the fuel tanks away from the occupant compartment and powerplants to reduce the hazard of lethal post-impact fire; and
7. Include, for the occupants, lap and upper torso restraints of fail-resistant strength through the point where the occupant compartment will totally collapse.

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[27] *Id.*

[28] DeHaven, Injuries in Thirty Light-Aircraft Accidents (Crash Injury Project, Committee on Aviation Medicine of the National Research Council, Division of Medical Science).

[29] DeHaven, Development of Crash Survival Design in Personal, Executive and Agricultural Aircraft (Crash Injury Research, Cornell University Medical College 1953).

The state of the art with reference to delethalization of the instrument panel was advanced in the 1950's to the extent that one of the three major general aviation manufacturers had designed and installed an instrument panel with shearable shock mounts on the basic panel with a thin-gauge, soft-metal head shield. In a crash, the impact forces sheared the shock mounts allowing the structure on which the instruments were mounted to recede several inches into a space behind the head shield, removing all the knobs and switches from their particular holes in the shield, and leaving the thin, soft-metal head shield to absorb the occupant's head impact.[30]

In 1966 John Swearingen, another pioneer in aircraft crashworthiness, suggested, as a result of extensive studies he had conducted,[31] that the top of the instrument panel could be delethalized by retrofitting aircraft with a light-weight aluminum semi-cylinder which would weigh approximately one and one-half pounds and cost, at that time, approximately fifty dollars to install.

The "art" of crashworthiness, therefore, is not a new art. Counsel can readily demonstrate that the technology has long existed to manufacture control yokes without horns on which the chests of the front seat occupants can be impaled and to design aircraft without push-pull control rods to inflict similar injuries when these rods are forced back into the cockpit by the rearward displacement of the engine and its accessories. Similarly, he should have no difficulty demonstrating the technological feasibility of protecting the lower extremities of the front seat occupants from injury due to flailing by rounding the lower edge of the panel, constructing it of soft metal, and padding it. This protection of the bottom of the panel may prove particularly significant in a case in which the front seat occupants could not escape a burning aircraft after receiving immobilizing injuries to their lower extremities.

Post-crash fire occurs after impact in approximately seven percent of general aviation accidents[32] and it has been observed that "the basic principles of crash fire initiation and prevention have

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[30] *Id.* at 4.

[31] Swearingen, *Tolerances of the Human Face to Crash Impact*, REP. NO. AM 65-20 (FAA Office of Aviation Medicine 1965).

[32] Walhout, *Crashworthiness Observations in General Aviation Accident Investigations—A Statistical Overview*, AIRCRAFT CRASHWORTHINESS 39 (1975).

been known for some twenty years."[33] Moreover, it has been recently observed that:

> Today, the CWFS [crashworthy fuel system] has been demonstrated and it would not take any scientific breakthrough to apply it to the civilian aircraft industry. The CWFS is applicable to most civilian aircraft of the general aviation category.
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> * * *
>
> It is generally recognized that a price must be paid for safety. One of the merits of the crashworthy fuel system is that the price of implementing this system is minor.[34]

With reference to occupant restraint systems and crashworthy seats, it has been observed that

> developments with respect to restraints and energy-absorbing seats have been most productive and are in a fairly usable and refined state at this time.[35]

Indeed, it has been stated that "the technology currently exists to reduce significantly or even eliminate fatalities in crashes at speeds less than two hundred knots."[36]

DEFENSE TO CLAIMS BASED ON UNCRASHWORTHINESS

Plaintiff's counsel can anticipate a plethora of arguments being interposed to thwart his client's claim based on the crashworthiness doctrine, among them that the manufacturer has no obligation to produce a "crash proof" or an "injury proof" aircraft. The courts have rejected such arguments as "strawmen,"[37] observing that the test is reasonable suitability within the limits of feasibility.[38] As was observed in *Turner v. General Motors Corp.*:

> While we agree that there is no duty to design a crash-proof car,

[33] Pinkel, Merrit & Pessman, Mechanism of the Start and Development of Aircraft Crash Fire, Nat'l Advisory Committee for Aeronautics, Research Memorandum No. R.M. E52F06 (1952).

[34] Robertson & Adamczyk, *Crashworthy Fuel Systems*, AIRCRAFT CRASHWORTHINESS 680 (1975).

[35] Perone, *supra* note 2, at 8.

[36] McMeekin, *General Investigation of Accident*, AIRCRAFT CRASHWORTHINESS 25 (1975).

[37] Volkswagen of America, Inc. v. Young, 272 Md. 201, 217, 321 A.2d 737, 745 (1974).

[38] Huddell v. Levin, 395 F. Supp. 64, 74 (D.N.J. 1975); *accord*, Seattle-First Nat'l Bank v. Volkswagen of America, 11 Wash. App. 800, 525 P.2d 286 (1974).

one has termed it a "non-sequitur" to use this truism as a basis for thus saying there is no duty to design a crashworthy car. Badorek v. General Motors Corp. 11 Cal. App. 3rd 902, 919, 90 Cal. Rptr. 305, 316 (1970).[39]

As to defenses based on prohibitive cost and weight penalty, plaintiff's counsel must meet these arguments on the facts and then leave it to the jurors to balance these factors against the foreseeable consequences of having pilots and passengers crash in uncrashworthy aircraft. More often than not, the true cost or weight penalty will be minor.

The argument is often made in crashworthiness cases that the manufacturer has conformed to industry custom and practice, or that he has complied with the applicable standards promulgated by the administrative agency charged with the responsibility of setting the standards for an industry. While evidence that the manufacturer-defendant conformed to industry custom and practice may be admissible, such evidence, of itself, does not exonerate the manufacturer.[40] Plaintiff may rebut such evidence by demonstrating that the custom and practice itself was negligent.[41] Any evidence that the manufacturer complied with pertinent aviation regulations[42] relating to crashworthiness[43] can be rebutted in similar manner by

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[39] 514 S.W.2d 497, 503 (Tex. Civ. App.—Houston [14th Dist.] 1974, writ ref'd n.r.e.).

[40] *Cf.*, Northwest Airlines v. Glen L. Martin Co., 224 F.2d 120, 129 (6th Cir. 1955), *cert. denied*, 350 U.S. 937 (1956).

[41] Turner v. General Motors Corp., 514 S.W.2d 497, 506 (Tex. Civ. App.—Houston [14th Dist.] 1974, writ ref'd n.r.e.).

[42] The applicable regulations governing the granting of a type certificate for a general aviation aircraft are those which were in effect at the time the application for the certificate was filed with the CAA or the FAA (*see, e.g.*, 14 C.F.R. § 21.17(a)(1) (1976). In a crashworthiness case, this should not mean, however, that a manufacturer should be allowed to exonerate itself from liability as to a specific aircraft manufactured many years after the application was filed when the regulations under which the aircraft had been type certificated are recognized as being clearly inadequate from the standpoint of crashworthiness, at the time the particular aircraft was actually manufactured.

[43] As to those regulations of the Federal Aviation Administration, which are presently in effect and which relate, at least in part, to crashworthiness see 14 C.F.R. § 23.561 (1976) (structural integrity to protect occupants under specified decelerative forces); *id.* § 23.785 (seats, occupant restraints, cockpit interior); *id.* § 23.787 (cargo compartments); *id.* § 23.807 (Emergency exits); *id.* § 23.853 (fire protection of compartment interiors; *id.* § 23.963 (fuel tanks); *id.* § 23.967 (fuel tank installation); *id.* § 23.1411 (accessibility of safety equipment); *id.* § 23.1413 (strength of safety belts and harnesses); *id.* § 23.1415 (ditching equip-

demonstrating that the regulatory standards are inadequate.[44] The non-preemptiveness of regulatory standards was discussed in *Volkswagen of America, Inc. v. Young*[45] wherein the court reasoned:

> Legislative or administrative requirements that persons or businesses conduct their operations in a particular manner, and adhere to specified standards, have never been viewed as supplanting tort liability. On the contrary, such statutory or regulatory requirements are deemed to furnish standards by which courts or juries determine, along with other circumstances, whether or not conduct is negligent.[46]

Rarely is the lack of crashworthiness in an aircraft obvious to the passengers or even the pilots of general aviation aircraft. This is partly a result of the failure of the industry and the FAA to educate effectively the flying community about such hazardous conditions and partly because many of the design and construction factors affecting crashworthiness cannot be seen. It has even been ventured that the manufacturers themselves do not know the extent to which their own aircraft are crashworthy:

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ment); *id.* § 23.1561 (marking of method of operation and of stowage provisions of safety equipment). These are also the regulations which presently govern normal category multi-engine aircraft for more than ten occupants which are intended for use in operations under Part 135 of the Federal Aviation Regulations, 14 C.F.R. pt. 135 (1976) (Air Taxis). Special Federal Regulation 23, ¶ 1, 14 C.F.R. vol. 2 at 380 (1976).

[44] Berkibile v. Brantley Helicopter Corp., 218 Pa. Super. 479, 281 A.2d 707 (1971). In *Berkibile* the court observed:

> In this case, however, we are not faced with a violation of the regulations, we are faced with compliance. Compliance with a law or administrative regulation . . . does not establish as a matter of law that due care was exercised. 281 A.2d at 710.

Accord, Wolford v. General Cable Co., 58 F.R.D. 583 (E.D. Pa. 1973).

[45] 272 Md. 201, 218, 321 A.2d 737, 746 (1974). The doctrine has been rejected, in fact, in New York. Micallef v. The Miehle Co. (N.Y. April 8, 1976), in 175 N.Y.L.J. No. 76 at 1 (1976).

[46] The inadequacy of the present day regulatory standards relating to aircraft structural integrity, 14 C.F.R. § 23.561 (1976), and restraint system strength, *id.* at § 24.1413, is apparent when one compares the limits of human tolerance (longitudinal 40 g's, lateral 20 g's, vertical 20 g's) with the force contemplated by these regulations in the same axes (longitudinal 9 g's, lateral 1.5 g's, vertical 3 g's). While it is true that inasmuch as the former are dynamic and the latter are static (and therefore the dynamic values of the latter are greater than 9 g's, 1.5 g's, 3 g's), they are not truly comparable. One wonders why the FAA utilizes static standards when in a crash the forces exerted on the structure of the aircraft and the restraint systems are dynamic. Could not this be the touch of the "paralytic hand" alluded to by Mr. Nader?

> It is impossible to report here, on the basis of the interviews [with representatives of the three major general aviation aircraft manufacturers] how much crashworthiness the customer is getting in his light aircraft today. The reason for this is that the manufacturers themselves don't know to what extent they are protecting the public.[47]

Even if the pilot is aware of the lack of sufficient crashworthiness features in one aircraft, he seldom is afforded a feasible alternative in other aircraft. These realities must be dramatized by plaintiff's counsel to the triers of fact in those jurisdictions which deny recovery when the defect is patent.[48]

The defendant's contention in crashworthiness cases that the difficulty in assessing those injuries attributable alone to the aircraft's not being crashworthy precludes any recovery at all has been roundly rejected.[49] The task of apportionment is well within the recognized capability of juries.

CONCLUSION

Plaintiffs lawyers, together with their brothers at the bar who serve as counsel to aircraft manufacturers, the insurance industry and the Federal Aviation Administration, can do much to encourage the production of crashworthy aircraft. Can we do otherwise?

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[47] Bruce & Draper, *supra* note 1, at 24.

[48] *See, e.g.*, Turcotte v. Ford Motor Co., 494 F.2d 173 (1st Cir. 1974); Frericks v. General Motors Corp., 274 Md. 288, 336 A.2d 118 (1975). (Recovery may be denied where lack of crashworthiness is patent.)

The patency defense, frequently referred to as the doctrine of Campo v. Scofield, 301 N.Y. 468, 95 N.E.2d 802 (1950), has been criticized by courts (Palmer v. Massey-Ferguson, 3 Wash. App. 508, 517, 476 P.2d 713, 719 (1970). "The law, we think, ought to discourage misdesign rather than encourage its obviousness.") and commentators alike. *See, e.g.*, Marshall, *An Obvious Wrong Does Not Make a Right: Manufacturers' Liability for Patently Dangerous Products*, 48 N.Y.U. L. REV. 1065 (1973).

Where patency is a defense, however, evidence reflecting the lack of obviousness of an uncrashworthy condition is certainly relevant. Seattle-First Nat'l Bank v. Volkswagen of America, 11 Wash. App. 929, 934, 525 P.2d 286, 289 (1974).

Evidence demonstrating that the aircraft's occupants had no reasonable alternative because all comparable aircraft reasonably available had equally uncrashworthy features should also be considered. "Of course, a purchaser might not be found to have assumed the risk of a known defect if the defect also existed in all other models, so that he had no meaningful choice on the matter." Turcotte v. Ford Motor Co., 494 F.2d 173, 183 (1st Cir. 1974).

[49] Larsen v. General Motors Corp., 391 F. Supp. 495, 503 (8th Cir. 1968); Huddell v. Levin, 395 F. Supp. 64, 77 (D.N.J. 1975); May v. Portland Jeep, Inc., 265 Ore. 307, 311-12, 509 P.2d 24, 26-27 (1973).